

## Product Overview

The NSi6601M is a single-channel isolated gate driver designed to drive IGBTs, power MOSFETs and SiC MOSFETs in many applications. It provides split output that controls the rise and fall times individually. It can source and sink 5A peak current.

The NSi6601M is available in SOP8(150 mil) or SOP8(300 mil) package, and can support 3000VRMS and 5700VRMS isolation per UL1577 respectively. System robustness is supported by 150kV/us minimum common-mode transient immunity (CMTI).

The driver operates with a maximum supply voltage of 32V, while the input-side accepts from 3.1V to 17V supply voltage. Under voltage lock-out (UVLO) protection is supported by all the power supply voltage pins.

Because of high driving current ability, excellent robustness, wide supply voltage range and fast signal propagation, NSi6601M is suitable for high reliability, power density and efficient switching power system.

## Key Features

- Isolated single-channel driver
- Miller Clamp options (NSi6601MB/MC/WC)
- Input side supply voltage: 3.1V to 17V
- Driver side supply voltage: up to 32V with 9V, and 12V UVLO options
- 5A peak source and sink output current
- Minimum CMTI:  $\pm 150\text{kV/us}$
- 80ns typical propagation delay
- Operation ambient temperature:  $-40^\circ\text{C} \sim 125^\circ\text{C}$
- RoHS-compliant packages:  
SOP8(150 mil), SOP8(300 mil)

## Safety Regulatory Approvals

- UL recognition: Isolation rating of 3000VRMS SOP8(150 mil) and 5700VRMS SOP8(300 mil) for 1 minute per UL1577
- DIN VDE V 0884-11:2017-01
- CSA component notice 5A
- CQC certification per GB4943.1-2011

## Applications

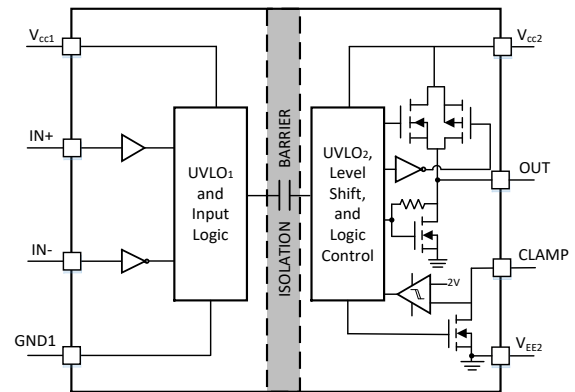
- Isolated DC/DC and AC/DC Power Supplies
- High Voltage PFC
- Solar Inverters
- Motor Drives and EV Charging
- UPS and Battery Chargers

## Device Information <sup>(1)</sup>

Part Number	UVLO Level	Package	AEC-Q100
NSi6601MB-DSPR	9V	SOP8 (150 mil)	NO
NSi6601MB-DSWVR	9V	SOP8 (300 mil)	NO
NSi6601MC-DSPR	12V	SOP8 (150 mil)	NO
NSi6601MC-DSWVR	12V	SOP8 (300 mil)	NO
NSi6601MC-Q1SWVR	12V	SOP8 (300 mil)	YES
NSi6601WC-DSWVR	12V	SOP8 (300 mil)	NO

1) For all available packages, and order information refer to the end of datasheet.

## Block Diagram



NSi6601M Diagram

## INDEX

1. PIN CONFIGURATION AND FUNCTION .....	3
2. ABSOLUTE MAXIMUM RATINGS .....	4
3. RECOMMENDED OPERATING CONDITIONS .....	4
4. THERMAL INFORMATION .....	4
5. SPECIFICATIONS .....	5
5.1. DC ELECTRICAL CHARACTERISTICS .....	5
5.2. SWITCHING CHARACTERISTICS .....	7
5.3. TYPICAL PERFORMANCE CHARACTERISTICS .....	8
5.4. PARAMETER MEASUREMENT INFORMATION .....	11
6. HIGH VOLTAGE FEATURE DESCRIPTION .....	13
6.1. INSULATION AND SAFETY RELATED SPECIFICATIONS .....	13
6.2. INSULATION SPECIFICATION PER DIN VDE V 0884-11:2017-01 FOR SOP8(150 MIL) PACKAGE .....	14
6.3. SAFETY LIMITING VALUES FOR SOP8(150 MIL) PACKAGE .....	15
6.4. REGULATORY INFORMATION FOR SOP8(150 MIL) PACKAGE .....	16
6.5. INSULATION SPECIFICATION PER DIN VDE V 0884-11:2017-01 FOR SOP8(300 MIL) PACKAGE .....	17
6.6. SAFETY LIMITING VALUES FOR SOP8(300 MIL) PACKAGE .....	18
6.7. REGULATORY INFORMATION FOR SOP8(300 MIL) PACKAGE .....	19
7. FUNCTION DESCRIPTION .....	20
7.1. OVERVIEW .....	20
7.2. FUNCTIONAL BLOCK DIAGRAM .....	20
7.3. TRUTH TABLES .....	21
7.4. OUTPUT STAGE .....	21
7.5. $V_{CC1}$ , AND $V_{CC2}$ UNDER VOLTAGE LOCK OUT (UVLO) .....	22
7.6. ACTIVE PULL-DOWN .....	22
7.7. SHORT CIRCUIT CLAMPING .....	22
7.8. ACTIVE MILLER CLAMP .....	22
8. APPLICATION NOTE .....	23
8.1. TYPICAL APPLICATION CIRCUIT .....	23
8.2. INTERLOCK PROTECTION .....	23
8.3. PCB LAYOUT .....	24
9. PACKAGE INFORMATION .....	25
10. ORDERING INFORMATION .....	27
11. DOCUMENTATION SUPPORT .....	27
12. TAPE AND REEL INFORMATION .....	28
13. REVISION HISTORY .....	30

### 1. Pin Configuration and Function

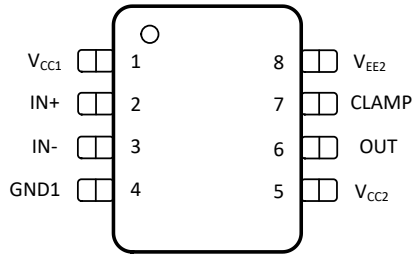


Figure 1.2 NSi6601MC/MB Versions (Top View)

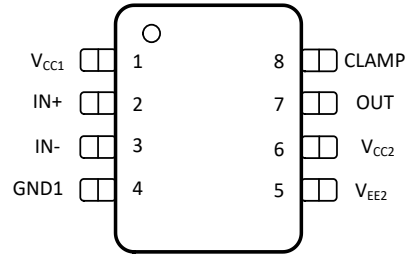


Figure 1.3 NSi6601WC (Top View)

Table 1.1 NSi6601 Pin Configuration and Description

PIN NAME	NSi6601MC/MB PIN NO.	NSi6601WC PIN NO.	TYPE	FUNCTION
V <sub>CC1</sub>	1	1	P	Input-side supply rail
IN+	2	2	I	Non-inverted input signal with internal pull down to GND1
IN-	3	3	I	Inverted input signal with internal pull up to V <sub>CC1</sub>
GND1	4	4	G	Input-side ground reference
V <sub>CC2</sub>	5	6	P	Positive output supply rail
OUT	6	7	O	Gate Driver Output
CLAMP	7	8	I	Active Miller-Clamp input
V <sub>EE2</sub>	8	5	G	Driver-side ground reference

## 2. Absolute Maximum Ratings

Parameters	Symbol	Min	Max	Unit
Input Side Supply Voltage	$V_{CC1-GND1}$	-0.3	18	V
Input Signal Voltage	$V_{IN+ -GND1}, V_{IN- -GND1}$	-0.3	18	V
Driver Side Supply Voltage	$V_{CC2-V_{EE2}}$	-0.3	35	V
Output Signal Voltage	$V_{OUT-} - V_{EE2}, V_{CLAMP-} - V_{EE2}$	$V_{EE2}-0.3$	$V_{CC2}+0.3$	V
Operating Junction Temperature	$T_J$	-40	150	°C
Storage Temperature	$T_{stg}$	-65	150	°C
Electrostatic discharge	$V_{ESD\_HBM}$ , Per AEC-Q100-011 Rev B	-2000	+2000	V
	$V_{ESD\_CDM}$ , Per AWC-Q100-002 Rev D	-1500	+1500	V

## 3. Recommended Operating Conditions

Parameters	Symbol	Min	Max	Unit
Input Side Supply Voltage	$V_{CC1-GND1}$	3	17	V
Input Signal Voltage	$V_{IN+ -GND1}, V_{IN- -GND1}$	-0.3	17	V
Driver Side Supply Voltage	$V_{CC2-V_{EE2}}$ (NSi6601MB)	10	32	V
	$V_{CC2-V_{EE2}}$ (NSi6601MC, NSi6601WC)	13	32	
Ambient Temperature	$T_A$	-40	125	°C

## 4. Thermal Information

Parameters	Symbol	SOP8(150 mil)	SOP8(300 mil)	Unit
Junction-to-ambient thermal resistance <sup>(1)</sup>	$R_{JA}$	110	120	°C/W
Junction-to-top characterization parameter <sup>(2)</sup>	$\Psi_{JT}$	18	38	°C/W

1) Tested using High Effective Thermal Conductivity Test Board (2s2p) described in JESD51-7

2) Tested following the environment described in JESD51-7

## 5. Specifications

### 5.1. DC Electrical Characteristics

Use  $V_{CC1}=5V$ , with a bypass capacitor of  $1\mu F$  from  $V_{CC1}$  to GND1, and  $V_{CC2}=15V$  with a capacitor of  $10\mu F$  from  $V_{CC2}$  to  $V_{EE2}$  where  $V_{EE2}=GND2$ . Positive and negative symbols represent the current into and out of the specified terminal (unless otherwise noted).

Parameter	Symbol	Min	Typ	Max	Unit	Condition
<b>Supply Currents</b>						
Input Supply Quiescent Current	$I_{CC1}$		0.9	1.5	mA	$V_{IN+}=GND1, V_{IN-}=5V$
Output Supply Quiescent Current	$I_{CC2}$		1.6	3	mA	$V_{IN+}=GND1, V_{IN-}=GND1$
<b>Input Side Supply UVLO Threshold</b>						
VCC1 UVLO Rising Threshold	$V_{CC1\_ON}$		2.9	3.1	V	$V_{IN+}=5V, V_{IN-}=GND1$
VCC1 UVLO Falling Threshold	$V_{CC1\_OFF}$	2.55	2.78		V	$V_{IN+}=5V, V_{IN-}=GND1$
VCC1 UVLO Hysteresis	$V_{CC1\_HYS}$		0.12		V	
<b>Driver Side Supply UVLO Threshold (NSi6601MB 9V UVLO Level)</b>						
VCC2 UVLO Rising Threshold	$V_{CC2\_ON}$		9.2	10	V	$V_{IN+}=5V, V_{IN-}=GND1$
VCC2 UVLO Falling Threshold	$V_{CC2\_OFF}$	8	8.5		V	$V_{IN+}=5V, V_{IN-}=GND1$
VCC2 UVLO Hysteresis	$V_{CC2\_HYS}$		0.7		V	
<b>Driver Side Supply UVLO Threshold (NSi6601MC, NSi6601WC 12V UVLO Level)</b>						
VCC UVLO Rising Threshold	$V_{CC2\_ON}$		12.2	13	V	$V_{IN+}=5V, V_{IN-}=GND1$
VCC UVLO Falling Threshold	$V_{CC2\_OFF}$	10.3	11.2		V	$V_{IN+}=5V, V_{IN-}=GND1$
VCC UVLO Hysteresis	$V_{CC2\_HYS}$		1		V	
<b>Input Pin Characteristics</b>						
Logic High Input Threshold (IN+, IN-)	$V_{IN+H}, V_{IN-H}$		$0.55 \times V_{CC1}$	$0.7 \times V_{CC1}$	V	
Logic Low Input Threshold (IN+, IN-)	$V_{IN+L}, V_{IN-L}$	$0.3 \times V_{CC1}$	$0.45 \times V_{CC1}$		V	
Input Hysteresis Voltage (IN+, IN-)	$V_{IN\_hys}$		$0.1 \times V_{CC1}$		V	
IN+ Input Current	$I_{IN+}$		55	70	$\mu A$	$V_{IN+}=V_{CC1}$
IN- Input Current	$I_{IN-}$		-55	-70	$\mu A$	$V_{IN-}=GND1$
<b>Output Pin Characteristics</b>						
High Level Output Voltage ( $V_{CC2}-V_{OUT}$ )	$V_{OH}$		140	240	mV	$I_{OUT}=-50mA, V_{IN+}=High, V_{IN-}=Low$
Low Level Output Voltage (OUT)	$V_{OL}$		30	60	mV	$I_{CLAMP}=50mA, V_{IN+}=Low, V_{IN-}=High$

Parameter	Symbol	Min	Typ	Max	Unit	Condition
Output Pull-up Resistance	$R_{OH}$		2.8		$\Omega$	$V_{OH}/50mA$
Output Pull-down Resistance	$R_{OL}$		0.6		$\Omega$	$V_{OL}/50mA$
Peak Source Current	$I_{OH}$		5		A	$V_{IN+}=High, V_{IN-}=Low, pulse\ width<10us$
Peak Sink Current	$I_{OL}$		5		A	$V_{IN+}=Low, V_{IN-}=High, pulse\ width<10us$
<b>Active Miller Clamp (NSi6601MC, NSi6601WC, NSi6601MB)</b>						
Clamp Low Level Voltage	$V_{LL\_CLAMP}$		11.2	24	mV	$I_{CLAMP}=20mA, V_{IN-}=V_{IN+}=Low$
Clamp Threshold Voltage	$V_{CLAMP\_TH}$		2.1	2.3	V	Referred to $V_{EE2}$
Low Level Clamp Current (Peak)	$I_{LL\_CLAMP}$		5		A	$V_{IN+}=V_{IN-}=Low, V_{CLAMP}=15V\ pulse$
Clamp Delay Falling	$T_{CD}$		46		ns	
<b>Short Circuit Clamping</b>						
Clamping Voltage (OUT) ( $V_{OUT} - V_{CC2}$ )	$V_{CLP\_OUT}$		1	1.3	V	$I_{OUT}=500mA\ with\ t_{pulse}=10us,$ $V_{IN+}=High, V_{IN-}=Low$
Clamping Voltage (CLAMP) ( $V_{CLAMP} - V_{CC2}$ )	$V_{CLP\_CLAMP}$		1.2	1.5	V	$I_{CLAMP}=500mA\ with\ t_{pulse}=10us,$ $V_{IN+}=High, V_{IN-}=Low$
			0.7	1	V	$I_{CLAMP}=20mA,$ $V_{IN+}=High, V_{IN-}=Low$
<b>Active Pulldown</b>						
Active Pulldown Voltage on CLAMP ( $V_{CLAMP}$ to $V_{EE2}$ )	$V_{ACTPD}$		2.3		V	$I_{CLAMP}=0.1 * I_{CLAMP(typ)},$ $V_{CC1} = V_{CC2} = Open$

## 5.2. Switching Characteristics

Switching characteristics are measured by using  $V_{CC1}=5V$ , 1uF capacitor from  $V_{CC1}$  to GND1, and  $V_{CC2}=15V$  with 10uF bypass capacitor from  $V_{CC2}$  to  $V_{EE2}$ ,  $T_J = -40^{\circ}C$  to  $125^{\circ}C$  (unless otherwise noted)

<i>Parameter</i>	<i>Symbol</i>	<i>Min</i>	<i>Typ</i>	<i>Max</i>	<i>Unit</i>	<i>Condition</i>
Minimum Pulse Width	$t_{PWmin}$		30	60	ns	
Propagation Delay	$t_{pLH}$	50	80	110	ns	$C_{LOAD}=100pF$
Propagation Delay	$t_{pHL}$	50	80	110	ns	$C_{LOAD}=100pF$
Pulse Width Distortion $ t_{pLH}-t_{pHL} $	$t_{PWD}$		2	25	ns	$C_{LOAD}=100pF$
Output Rise Time (20% to 80%)	$t_R$		9	20	ns	$C_{LOAD}=1nF$
Output Fall Time (80% to 20%)	$t_F$		8	18	ns	$C_{LOAD}=1nF$
Common Mode Transient Immunity	CMTI	150			kV/us	

### 5.3. Typical Performance Characteristics

Typical characteristics are measured by using  $V_{CC1}=5V$ , 1uF capacitor from  $V_{CC1}$  to GND1, and  $V_{CC2}=15V$  with 10uF bypass capacitor from  $V_{CC2}$  to  $V_{EE2}$   $T_J = -40^{\circ}C$  to  $125^{\circ}C$  (unless otherwise noted).

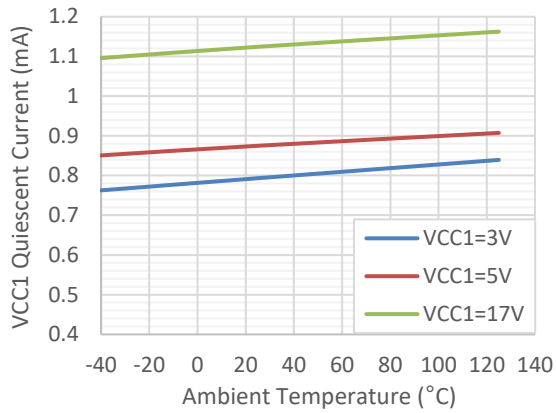


Figure 5.1 Input supply quiescent current Vs Temperature

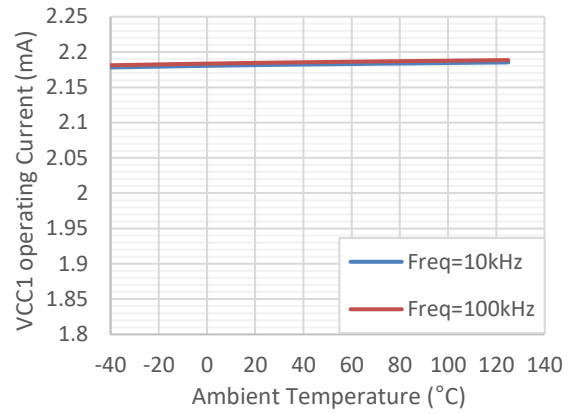


Figure 5.2 Input supply operating current Vs Temperature

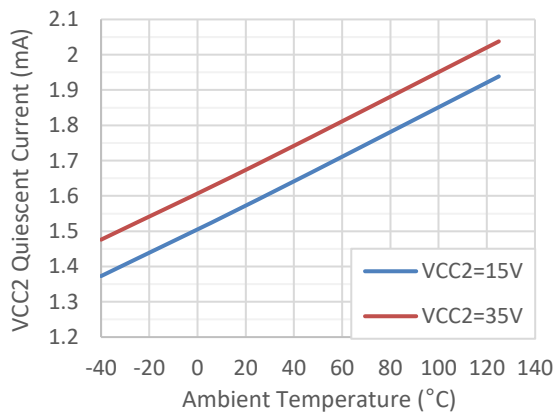


Figure 5.3 Output supply quiescent current Vs Temperature

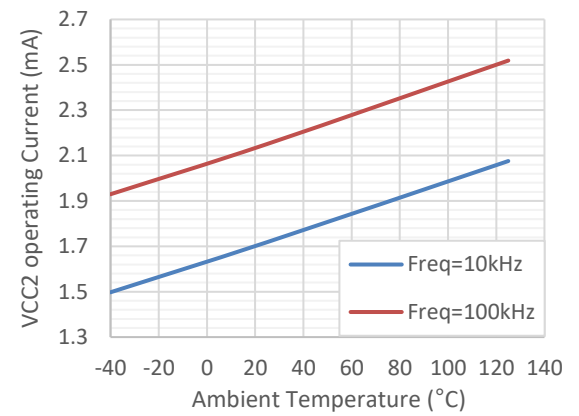


Figure 5.4 Output supply operating current Vs Temperature

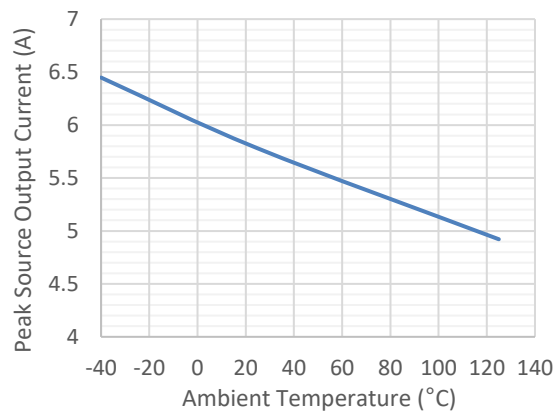


Figure 5.5 Peak source output current Vs Temperature

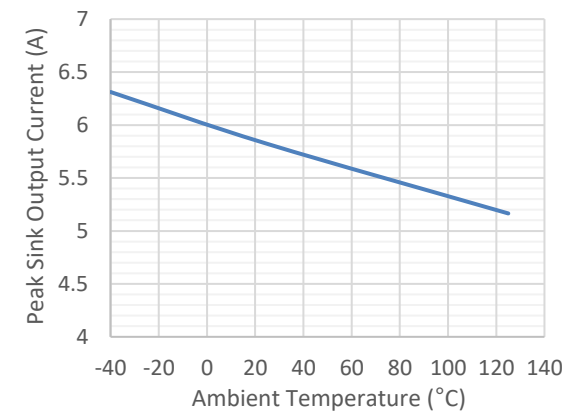


Figure 5.6 Peak sink output current Vs Temperature



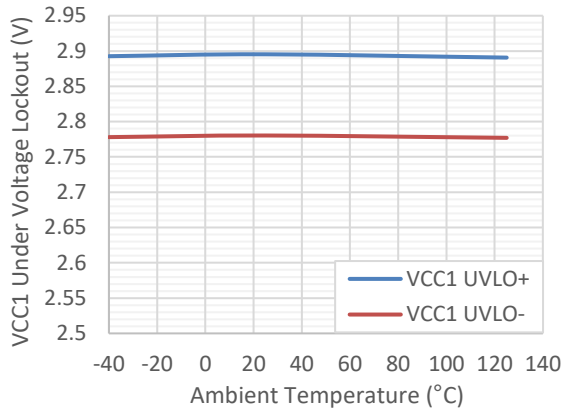


Figure 5.7 VCC1 UVLO Threshold Vs Temperature

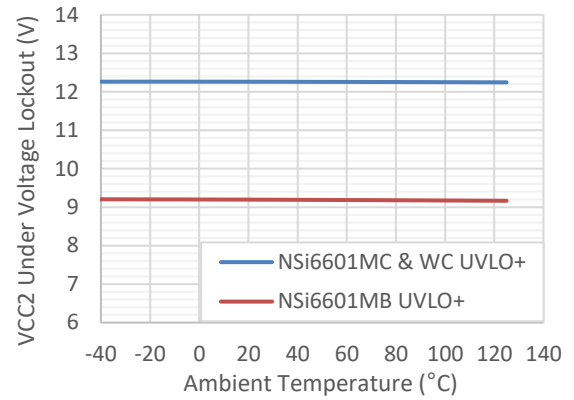


Figure 5.8 VCC2 UVLO\_ON Vs Temperature

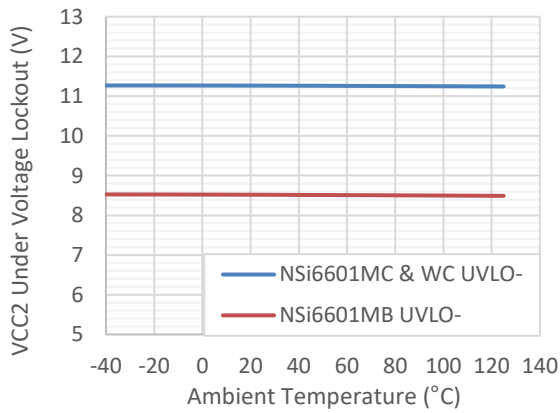


Figure 5.9 VCC2 UVLO\_OFF Vs Temperature

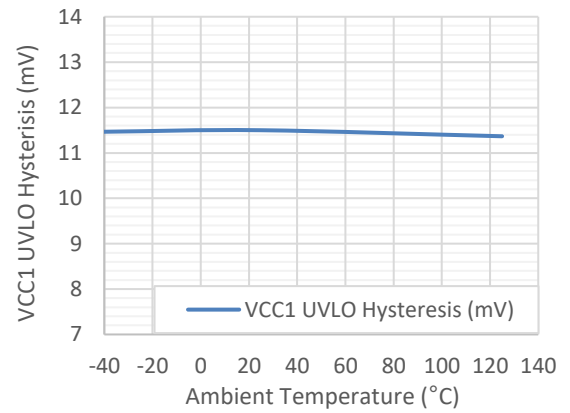


Figure 5.10 VCC1 UVLO Hysteresis Vs Temperature

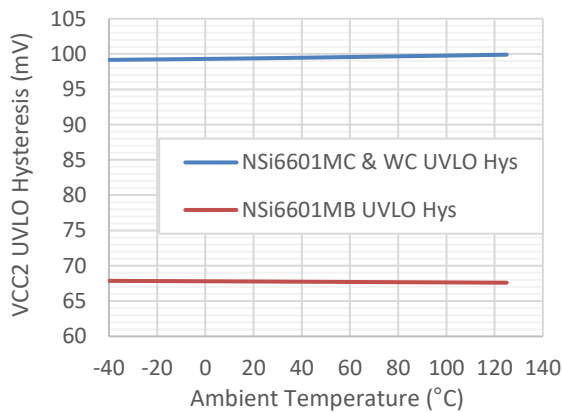


Figure 5.11 VCC2 UVLO Hysteresis Vs Temperature

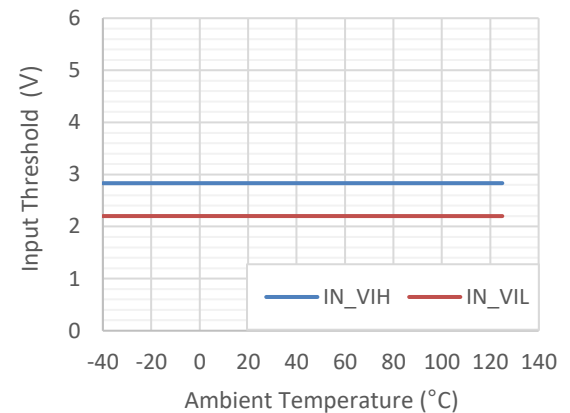


Figure 5.12 Input Threshold Vs Temperature

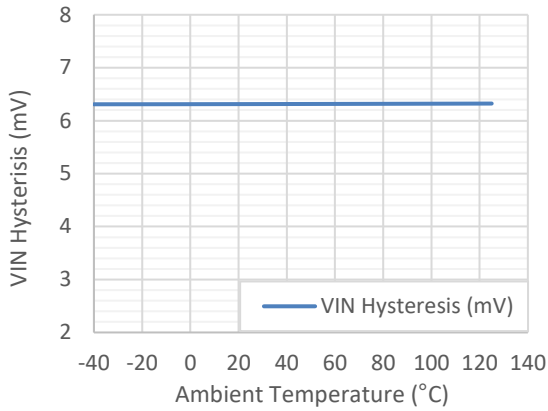


Figure 5.13 Input Hysteresis Vs Temperature

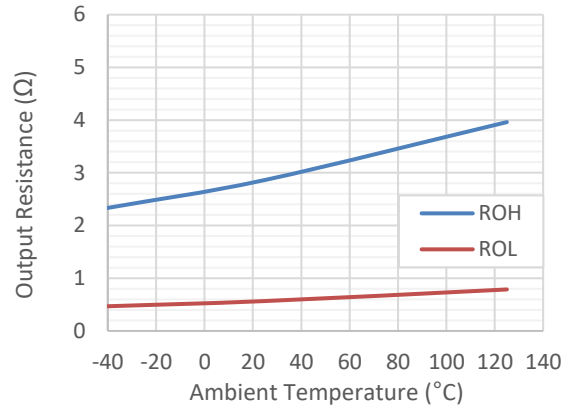


Figure 5.14 Output Resistance Vs Temperature

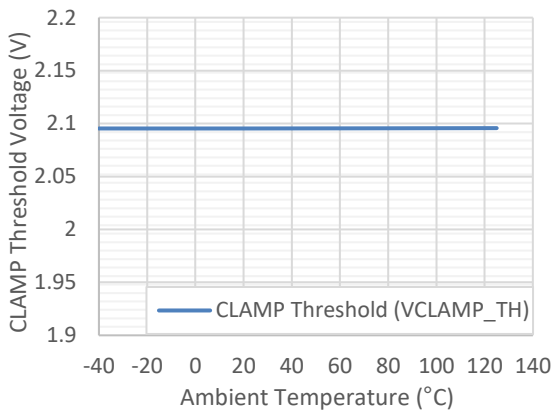


Figure 5.15 CLAMP Threshold Voltage Vs Temperature

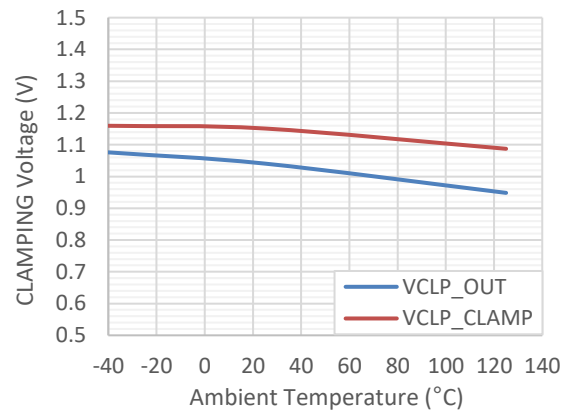


Figure 5.16 CLAMPING Voltage Vs Temperature

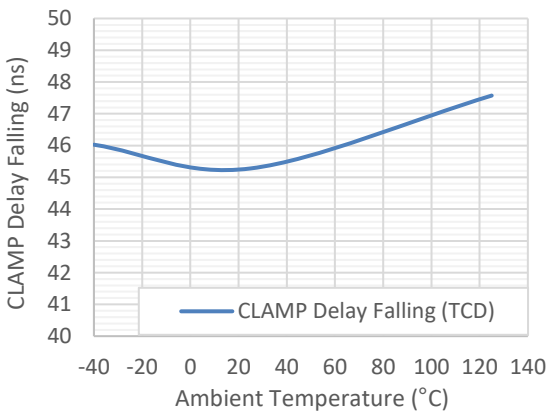


Figure 5.17 CLAMP Delay Falling Vs Temperature

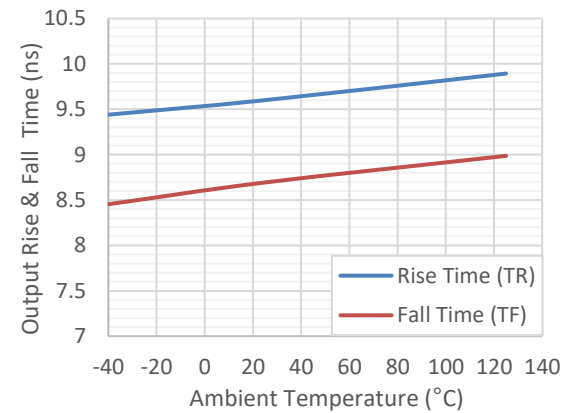


Figure 5.18 Output rise and fall time Vs Temperature

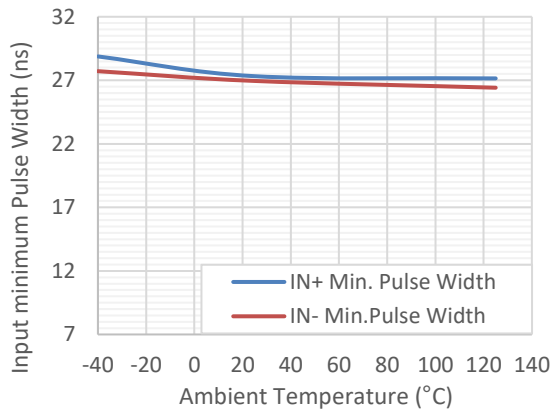


Figure 5.19 Minimum Pulse Width Vs Temperature

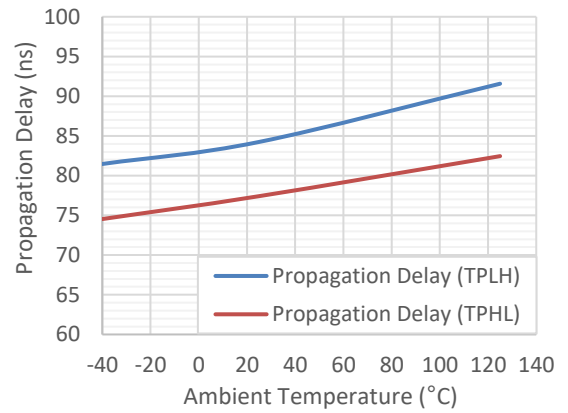


Figure 5.20 Propagation Delay Vs Temperature

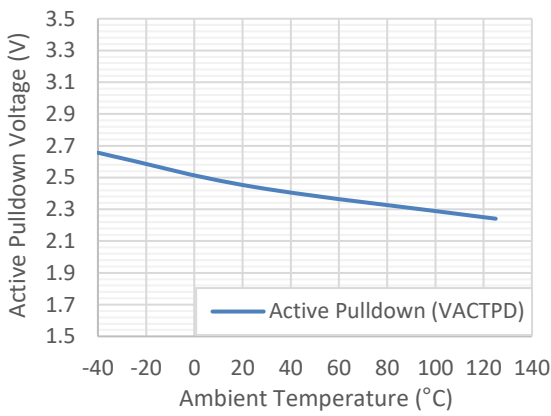


Figure 5.21 Active Pulldown Voltage Vs Temperature

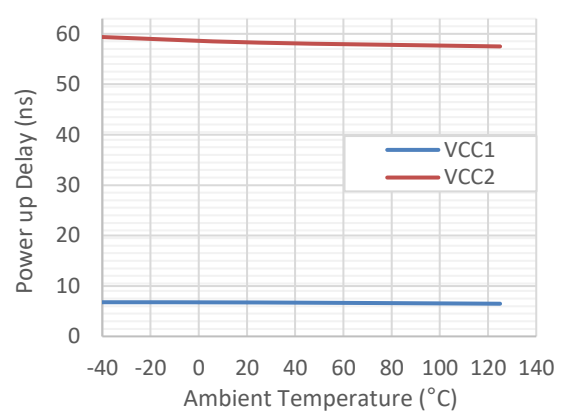


Figure 5.22 Power up Delay Vs Temperature

### 5.4. Parameter Measurement Information

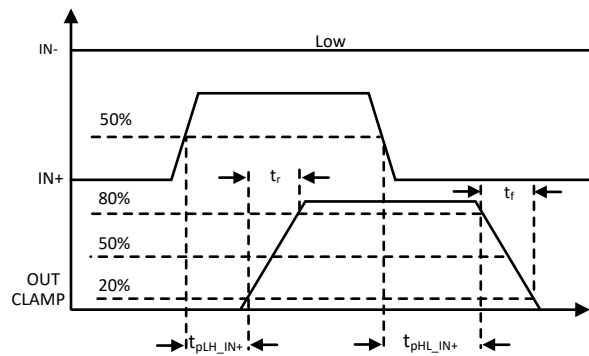


Figure 5.23 Propagation Delay, Rise Time and Fall Time (For Non-Inverting Configuration)

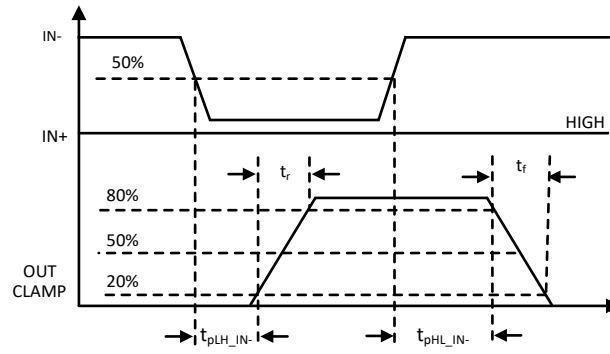


Figure 5.24 Propagation Delay, Rise Time and Fall Time (For Inverting Configuration)

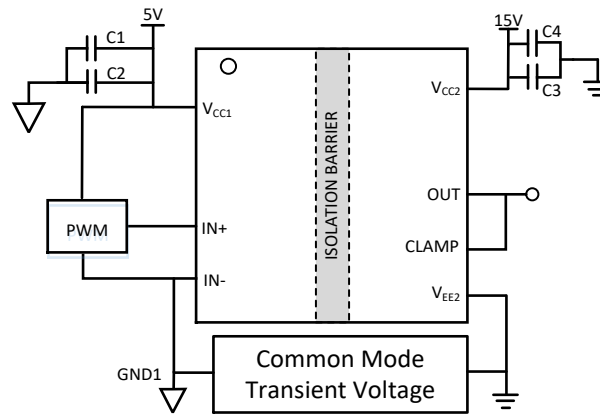


Figure 5.25 Common-Mode Transient Immunity Test Circuit

## 6. High Voltage Feature Description

### 6.1. Insulation and Safety Related Specifications

<i>Parameters</i>	<i>Symbol</i>	<i>SOP8(150 mil)</i>	<i>SOP8(300 mil)</i>	<i>Unit</i>	<i>Comments</i>
Min. External Air Gap (Clearance)	CLR	4.0	8.0	mm	Shortest pin-to-pin distance through air
Min. External Tracking (Creepage)	CPG	4.0	8.0	mm	Shortest pin-to-pin distance across the package surface
Distance Through the Insulation	DTI	20	20	um	Minimum internal gap
Tracking Resistance (Comparative Tracking Index)	CTI	>600	>600	V	
Material Group		I	I		IEC 60664-1

## 6.2. Insulation Specification per DIN VDE V 0884-11:2017-01 for SOP8(150 mil) Package

Description	Test Condition	Symbol	Value	Unit
Installation Classification per DIN VDE 0110				
For Rated Mains Voltage $\leq 150 V_{RMS}$			I to IV	
For Rated Mains Voltage $\leq 300 V_{RMS}$			I to III	
Climatic Category			40/125/21	
Pollution Degree			2	
Maximum Working Isolation Voltage		$V_{IOWM}$	700	$V_{RMS}$
			990	$V_{DC}$
Maximum Repetitive Peak Isolation Voltage		$V_{IORM}$	990	$V_{PEAK}$
Input to Output Test Voltage, Method B1	$V_{pd(m)}=V_{IORM}\times 1.5$ , 100% production test, $t_{ini}=t_m=1s$ , partial discharge $<5pC$	$V_{pd(m)}$	1485	$V_{PEAK}$
Input to Output Test Voltage, Method A				
After Environmental Tests Subgroup 1	$V_{pd(m)}=V_{IORM}\times 1.2$ , $t_{ini}=60s$ , $t_m=10s$ , partial discharge $<5pC$	$V_{pd(m)}$	1188	$V_{PEAK}$
After Input and Output Safety Test Subgroup 2 and Subgroup 3	$V_{pd(m)}=V_{IORM}\times 1.2$ , $t_{ini}=60s$ , $t_m=10s$ , partial discharge $<5pC$	$V_{pd(m)}$	1188	$V_{PEAK}$
Maximum Transient Isolation Voltage	$t = 60 s$	$V_{IOTM}$	4242	$V_{PEAK}$
Maximum Withstanding Isolation Voltage	$V_{TEST}=V_{ISO}$ , $t = 60 s$ (qualification); $V_{TEST}= 1.2 \times V_{ISO}$ , $t = 1 s$ (100%production)	$V_{ISO}$	3000	$V_{RMS}$
Maximum Surge Isolation Voltage	Test method per IEC60065,1.2/50us waveform, $V_{TEST}=V_{IOSM}\times 1.3$	$V_{IOSM}$	4242	$V_{PEAK}$
Isolation Resistance	$V_{IO}=500V$ at $T_A=T_S=150^\circ C$	$R_{IO}$	$>10^9$	$\Omega$
	$V_{IO}=500V$ at $100^\circ C \leq T_A \leq 125^\circ C$		$>10^{11}$	$\Omega$
Isolation Capacitance	$f = 1MHz$	$C_{IO}$	0.6	pF

6.3. Safety Limiting Values for SOP8(150 mil) Package

Description	Test Condition	Symbol	Value	Unit	
Maximum Safety Temperature		$T_S$	150	°C	
Maximum Safety Power Dissipation	$R_{\theta JA}=110^{\circ}\text{C}/\text{W}$ , $T_J=150^{\circ}\text{C}$ , $T_A=25^{\circ}\text{C}$	$P_S$	Total	1.14	W
			Input Side	0.05	
			Output Side	1.09	
Maximum Safety Current	$R_{\theta JA}=110^{\circ}\text{C}/\text{W}$ , $V_{CC2}=15\text{V}$ , $T_J=150^{\circ}\text{C}$ , $T_A=25^{\circ}\text{C}$	$I_S$	Output Side	73	mA
	$R_{\theta JA}=110^{\circ}\text{C}/\text{W}$ , $V_{CC2}=30\text{V}$ , $T_J=150^{\circ}\text{C}$ , $T_A=25^{\circ}\text{C}$		Output Side	36	

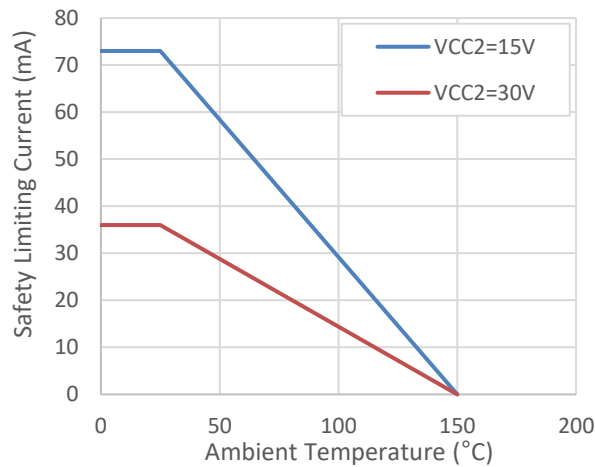


Figure 6.1 Thermal Derating Curve for Limiting Current per DIN VDE V 0884-11 for SOP8(150 mil) Package

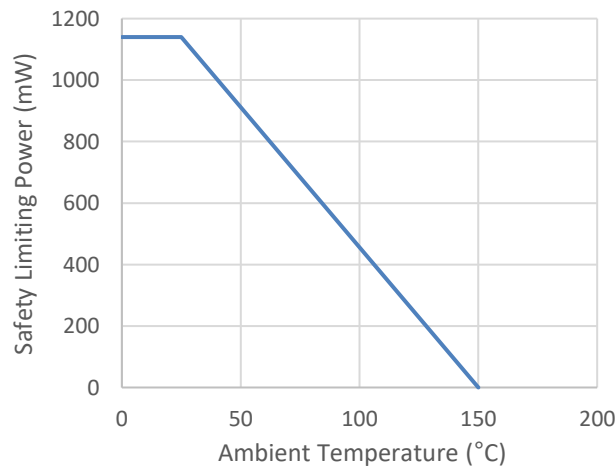


Figure 6.2 Thermal Derating Curve for Limiting Power per DIN VDE V 0884-11 for SOP8(150 mil) Package

**6.4. Regulatory Information for SOP8(150 mil) Package**

<i>UL</i>		<i>VDE</i>		<i>CQC</i>	
UL 1577 Component Recognition Program	Approved under CSA Component Acceptance Notice 5A	DIN VDE V 0884-11(VDE V 0884-11):2017-01		Certified by CQC11-471543-2012 GB4943.1-2011	
Single Protection, 3000V <sub>RMS</sub> Isolation Voltage	Single Protection, 3000V <sub>RMS</sub> Isolation voltage	Basic Insulation V <sub>IORM</sub> =990V <sub>PEAK</sub> , V <sub>IOTM</sub> =4242V <sub>PEAK</sub> , V <sub>IOSM</sub> =4242V <sub>PEAK</sub>		Basic Insulation at 700V <sub>RMS</sub> (990V <sub>PEAK</sub> )	
File (pending)	File (pending)	File (pending)		File (pending)	



## 6.5. Insulation Specification per DIN VDE V 0884-11:2017-01 for SOP8(300 mil) Package

Description	Test Condition	Symbol	Value	Unit
Installation Classification per DIN VDE 0110				
For Rated Mains Voltage $\leq 600V_{RMS}$			I to III	
For Rated Mains Voltage $\leq 1000V_{RMS}$			I to II	
Climatic Category			40/125/21	
Pollution Degree			2	
Maximum Working Isolation Voltage		$V_{IOWM}$	1500	$V_{RMS}$
			2121	$V_{DC}$
Maximum Repetitive Peak Isolation Voltage		$V_{IORM}$	2121	$V_{PEAK}$
Input to Output Test Voltage, Method B1	$V_{pd(m)}=V_{IORM}\times 1.875$ , 100% production test, $t_{ini}=t_m=1s$ , partial discharge $<5pC$	$V_{pd(m)}$	3977	$V_{PEAK}$
Input to Output Test Voltage, Method A				
After Environmental Tests Subgroup 1	$V_{pd(m)}=V_{IORM}\times 1.6$ , $t_{ini}=60s$ , $t_m=10s$ , partial discharge $<5pC$	$V_{pd(m)}$	3394	$V_{PEAK}$
After Input and Output Safety Test Subgroup 2 and Subgroup 3	$V_{pd(m)}=V_{IORM}\times 1.2$ , $t_{ini}=60s$ , $t_m=10s$ , partial discharge $<5pC$	$V_{pd(m)}$	2545	$V_{PEAK}$
Maximum Transient Isolation Voltage	$t = 60 s$	$V_{IOTM}$	8000	$V_{PEAK}$
Maximum Withstanding Isolation Voltage	$V_{TEST}=V_{ISO}$ , $t = 60 s$ (qualification); $V_{TEST}= 1.2 \times V_{ISO}$ , $t = 1 s$ (100%production)	$V_{ISO}$	5700	$V_{RMS}$
Maximum Surge Isolation Voltage	Test method per IEC60065,1.2/50us waveform, $V_{TEST}=V_{IOSM}\times 1.6$	$V_{IOSM}$	6250	$V_{PEAK}$
Isolation Resistance	$V_{IO}=500V$ at $T_A=T_S=150^\circ C$	$R_{IO}$	$>10^9$	$\Omega$
	$V_{IO}=500V$ at $100^\circ C \leq T_A \leq 125^\circ C$		$>10^{11}$	$\Omega$
Isolation Capacitance	$f = 1MHz$	$C_{IO}$	0.6	pF

6.6. Safety Limiting Values for SOP8(300 mil) Package

Description	Test Condition	Symbol	Value	Unit
Maximum Safety Temperature		$T_S$	150	°C
Maximum Safety Power Dissipation	$R_{\theta JA}=120^{\circ}\text{C}/\text{W}$ , $T_J=150^{\circ}\text{C}$ , $T_A=25^{\circ}\text{C}$	$P_S$	Total	1.04
			Input Side	0.05
			Output Side	0.99
Maximum Safety Current	$R_{\theta JA}=120^{\circ}\text{C}/\text{W}$ , $V_{CC2}=15\text{V}$ , $T_J=150^{\circ}\text{C}$ , $T_A=25^{\circ}\text{C}$	$I_S$	Output Side	66
	$R_{\theta JA}=120^{\circ}\text{C}/\text{W}$ , $V_{CC2}=30\text{V}$ , $T_J=150^{\circ}\text{C}$ , $T_A=25^{\circ}\text{C}$		Output Side	33

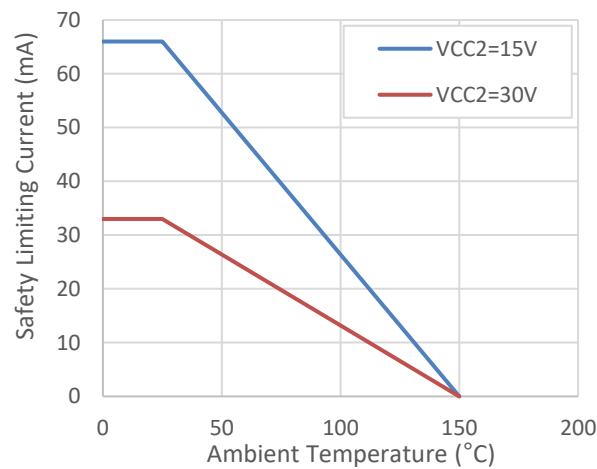


Figure 6.3 Thermal Derating Curve for Limiting Current per DIN VDE V 0884-11 for SOP8(300 mil) Package

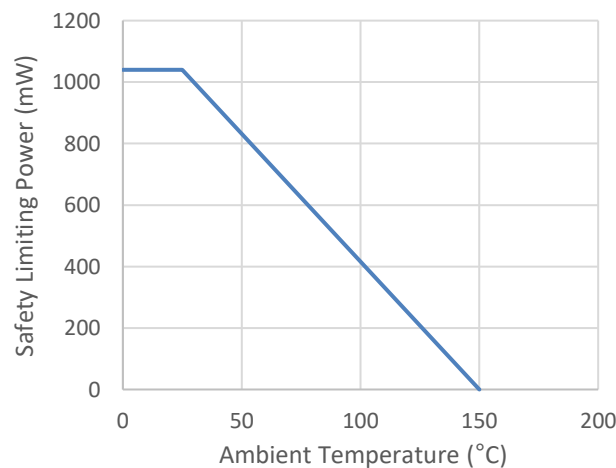


Figure 6.4 Thermal Derating Curve for Limiting Power per DIN VDE V 0884-11 for SOP8(300 mil) Package

**6.7. Regulatory Information for SOP8(300 mil) Package**

<i>UL</i>		<i>VDE</i>	<i>CQC</i>
UL 1577 Component Recognition Program	Approved under CSA Component Acceptance Notice 5A	DIN VDE V 0884-11(VDE V 0884-11):2017-01	Certified by CQC11-471543-2012 GB4943.1-2011
Single Protection, 5700V <sub>RMS</sub> Isolation Voltage	Single Protection, 5700V <sub>RMS</sub> Isolation voltage	Reinforced Insulation V <sub>IORM</sub> =2121V <sub>PEAK</sub> , V <sub>IOTM</sub> =8000V <sub>PEAK</sub> , V <sub>IOSM</sub> =6250V <sub>PEAK</sub>	Reinforced Insulation
File (pending)	File (pending)	File (pending)	File (pending)

## 7. Function Description

### 7.1. Overview

The NSi6601M is a highly reliable isolated gate driver with 9V, and 12V UVLO versions, which is suitable to drive MOSFET, IGBT, and SiC. The NSi6601M is available in SOP8 narrow body and wide body package, which can support 3000VRMS or 5700VRMS isolation per UL1577. System robustness is supported by 150kV/us minimum common-mode transient immunity (CMTI).

The functional block diagram of NSi6601M is shown in Figure 7.1. Two Input pins with non-inverting and inverting logic support interlock and shoot through protection. Low resistance of high side and low side MOSFET in the output stage ensures high driving capability. Split outputs help to control the rise and fall time individually. Active pull-down and short circuit clamping features are implemented to protect power transistor.

The isolation barrier inside NSi6601M is based on a capacitive isolation. The signal across the isolation barrier transmit through OOK (on-off keying) modulation with key benefits of high noise immunity and low radiation EMI. The transmitter sends a high-frequency carrier across the isolation barrier to represent one digital state and sends no signal to represent the other digital state. As shown in Figure 7.2, the digital signal is modulated with RF carrier generated by the internal oscillator at the transmitter side, then it is transferred through the capacitive isolation barrier and demodulated at the receiver side.

### 7.2. Functional Block Diagram

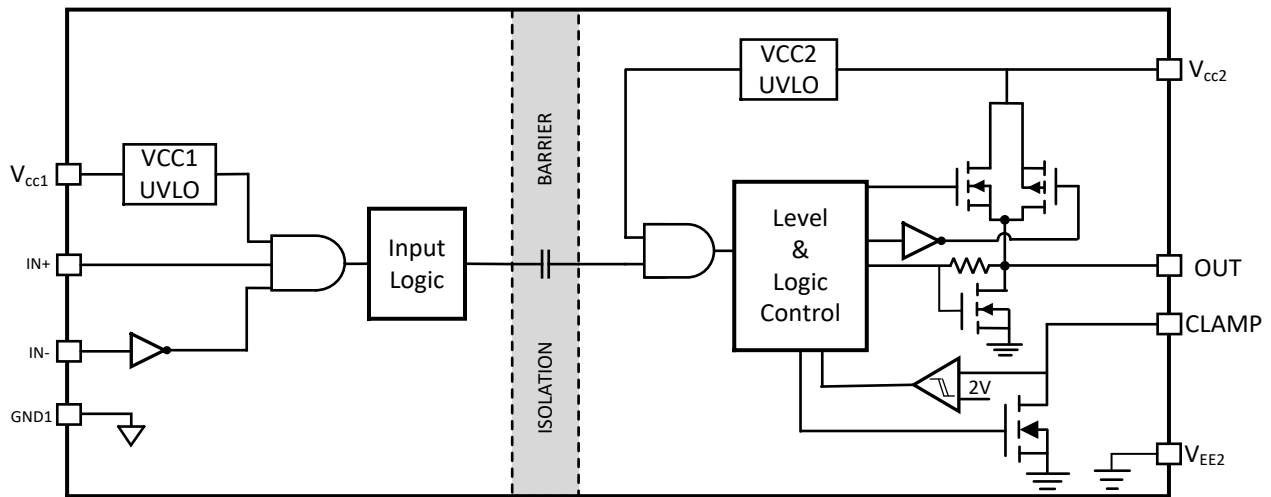


Figure 7.1 NSi6601MB/MC/WC Functional Block Diagram

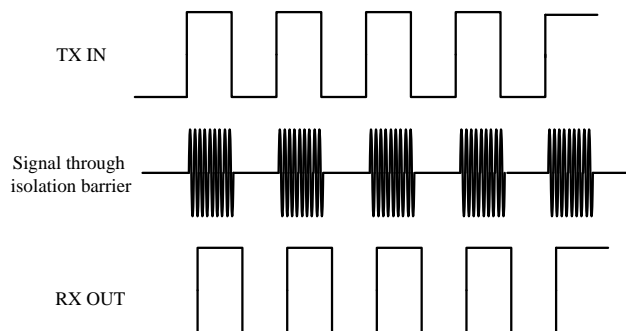


Figure 7.2 OOK based Modulation

### 7.3. Truth Tables

Table 7.1 Driver Function Table <sup>(1)</sup>

$V_{CC1}$ status	$V_{CC2}$ status	Inputs			Comment
		IN+	IN-	OUT	
PU	PU	H	L	H	
PU	PU	L	H	L	
PU	PU	H	H	L	Interlock protection
PU	PU	L	L	L	
PD	PU	X	X	L	
PU	PD	X	X	L	Active pull-down
PD	PD	X	X	L	Active pull-down

(1) PD = Powered Down; PU = Powered Up; H = Logic High; L = Logic Low; X = Irrelevant

The IN+ pin is internally pulled down to GND1, while IN- pin is internally pulled up to VCC1, making the output of NSi6601 is low by default. To improve noise immunity, grounding an input or tying to VCC1 is recommended.

### 7.4. Output Stage

The voltage and current of external power transistor drain to source or collector to emitter change during low to high output signal transition. At that moment, the N-channel MOSFET turns-ON to pull up OUT more quickly to provide a transitory boost in the sourcing current during the period of turning the output state from low to high. It results external power transistor faster turn on time, lower turn on power loss, also leads to smaller temperature increase of NSi6601M. The equivalent pull-up resistance of NSi6601M is the parallel combination of  $R_{OH} || R_{NMOS}$ . This equivalent resistance results a very small value, indicating the strong driving capability of NSi6601M. The pull-down resistance  $R_{OL}$  of N-channel MOSFET is also very small. That also indicates the strong driving capability of NSi6601M. Since the P-channel MOSFET only conducts during the dc measurement while the N-channel MOSFET remain OFF for this interval. So the  $R_{OH}$  parameter is associated with the on-resistance of P-channel MOSFET in dc measurements.

Typical values of pull-up and pulldown internal resistance are listed in table 7.2.

Table 7.2 NSi6601M Output Stage On-Resistance

$R_{NMOS}$	$R_{OH}$	$R_{OL}$	$R_{CLAMP}$	Unit
0.8	2.8	0.6	0.6	$\Omega$

In miller-clamp output configuration as shown in Figure 7.3, the pulldown structure works as two parallel N-channel MOSFETs structure when the CLAMP and OUT pins connect to the gate of the IGBT or MOSFET.

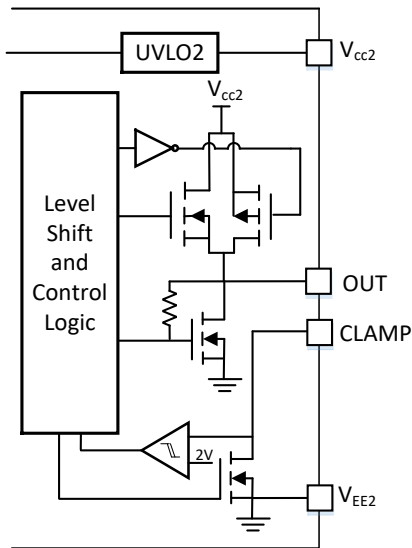


Figure 7.3 NSi6601M Output Stage

### 7.5. $V_{CC1}$ , and $V_{CC2}$ Under Voltage Lock Out (UVLO)

The NSI6601M has an internal under voltage lock out (UVLO) protection on both input and output side source blocks. The driver output is held low by an active clamp circuit when the supply voltage of  $V_{CC1}$  or  $V_{CC2}$  is lower than  $V_{CC\_ON}$  at power-up status or lower than  $V_{DD\_OFF}$  after power-up, regardless of the status of the input pins.

The  $V_{CC1\_GND1}$  and  $V_{CC2\_VEE2}$  ULVO protections have hysteresis ( $V_{CC1\_HYS}$  &  $V_{CC2\_HYS}$ ) to prevent chatter noise from VCC supply and allow small drops in supply power which are usually happened in startup. It also prevents sags in the VCC, cause by sudden increase in ICC current while system commences switching.

### 7.6. Active Pull-Down

This function helps to pull the IGBT or MOSFET gate to the off-state when  $V_{CC2}$  is not connected to the power supply. This feature prevents the false turn-on of OUT and CLAMP pins by clamping the output to approximately 2V.

### 7.7. Short Circuit Clamping

Short circuit is used to clamp the deriver output voltage as well as to pull the miller clamp pins to a bit higher than  $V_{CC2}$ . This function helps to protect the gate of a MOSFET or IGBT from overvoltage breakdown. The short circuit clamping is implemented by adding an additional circuit between the dedicated pins and the  $V_{CC2}$ . The internal diode circuitry can conduct 500mA current to the supply for 10us. Use of external shottky diode may be added to improve the current capability and tighter clamping.

### 7.8. Active Miller Clamp

The active miller clamp function helps to prevent the false turn-on of the power switches caused by the miller current in applications such as half bridge configuration. Where switched off IGBT turns to dynamically turn-on during turn on period of the opposite IGBT. It usually happens when a unipolar power supply is used. To avoid such false turn-on of switches a miller clamp allows sinking the miller current across a low impedance path in this  $dv/dt$  situation. During turn-off the gate voltage is monitored and the power-switch gate voltage is clamped to less than 2V referred to  $V_{EE2}$ . The clamp is designed for a miller current in the same range as the nominal output current.

## 8. Application Note

### 8.1. Typical Application Circuit

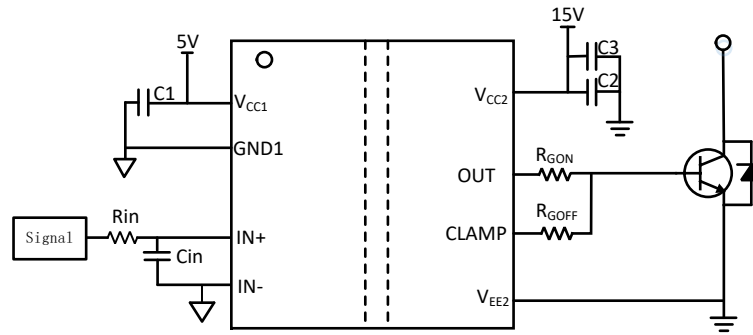


Figure 8.1 NSi6601M Typical Application Circuit

Bypassing capacitors for  $V_{CC1}$  and  $V_{CC2}$  supplies are needed to achieve reliable performance. To filter noise,  $0.1\mu\text{F}/50\text{V}$  ceramic capacitor is recommended to place as close as possible to NSi6601M, both at  $V_{CC1}$  and  $V_{CC2}$  side. For  $V_{CC2}$  supply, additional  $10\mu\text{F}/50\text{V}$  ceramic capacitor is recommended, to support high peak currents when turning on external power transistor. If the  $V_{CC1}$  or  $V_{CC2}$  power supply is located long distance from the IC, bigger capacitance is needed.

The input filter composed by  $R_{in}$  and  $C_{in}$  can be used if input PWM has ring due to long traces or bad PCB layout. However, it will introduce longer propagation delay.

### 8.2. Interlock Protection

For applications to drive power transistors in half bridge configuration, two NSi6601M can be used. Interlock protection is possible as shown in Figure 8.2. If the controller has some mistake, leading to negative dead time, the output PWM of NSi6601M is adjusted to avoid power transistor shoot through.

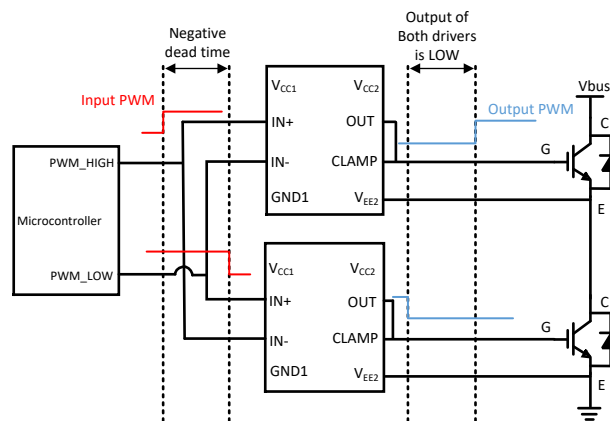


Figure 8.2 Interlock Protection using NSi6601M

### 8.3. PCB Layout

Careful PCB layout is essential for optimal performance. Some key guidelines are:

- The bypass capacitors should be placed close to NSi6601, between  $V_{CC1}$  to GND1, or  $V_{CC2}$  to  $V_{EE2}$ .
- There is high switching current that charges and discharges the gate of external power transistor, leading to EMI and ring issues. The parasitic inductance of this loop should be minimized, by decreasing loop area and place NSi6601 close to power transistor.
- Place large amount of copper connecting to  $V_{EE2}$  pin and  $V_{CC2}$  pin for thermal dissipation, with priority on  $V_{EE2}$  pin. If the system has multi  $V_{EE2}$  or  $V_{CC2}$  layers, use multiple vias of adequate size for connection.
- To ensure isolation performance between primary and secondary side, the space under the chip should keep free from planes, traces, pads or via.



### 9. Package Information

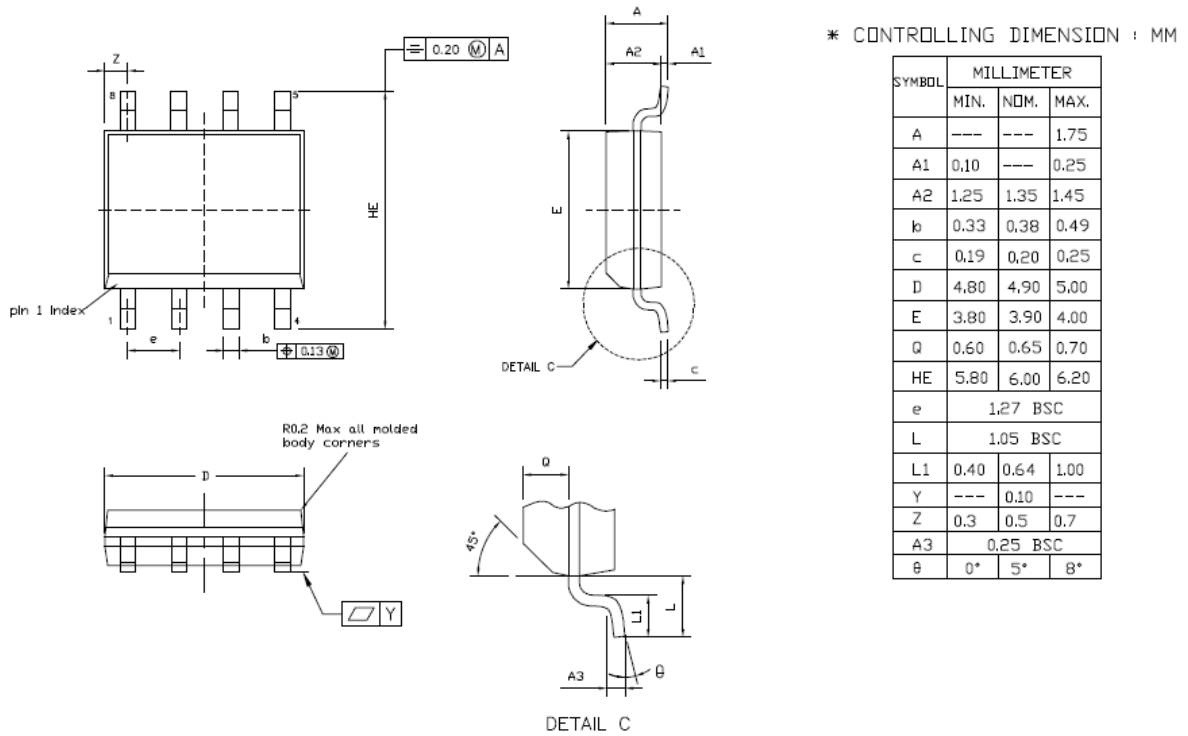


Figure 9.1 SOP8(150 mil) Package Shape and Dimension in millimeters (inches)

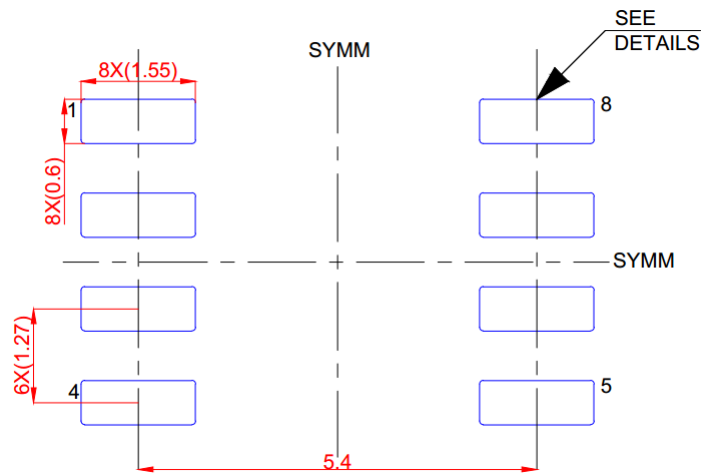


Figure 9.2 Land Pattern Example of SOP8\_150mil (mm)

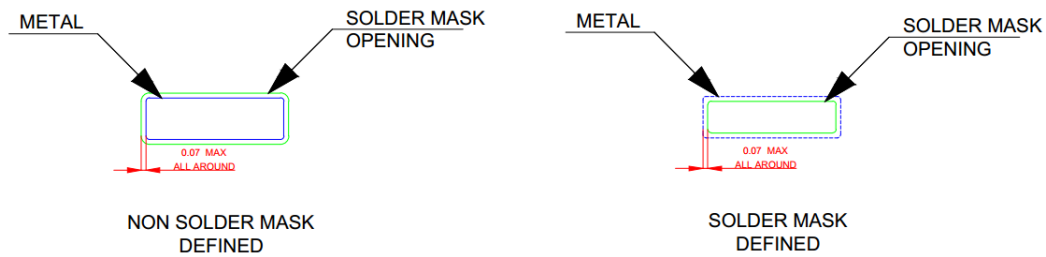


Figure 9.3 Solder Mask Detail of SOP8\_150mil (mm)

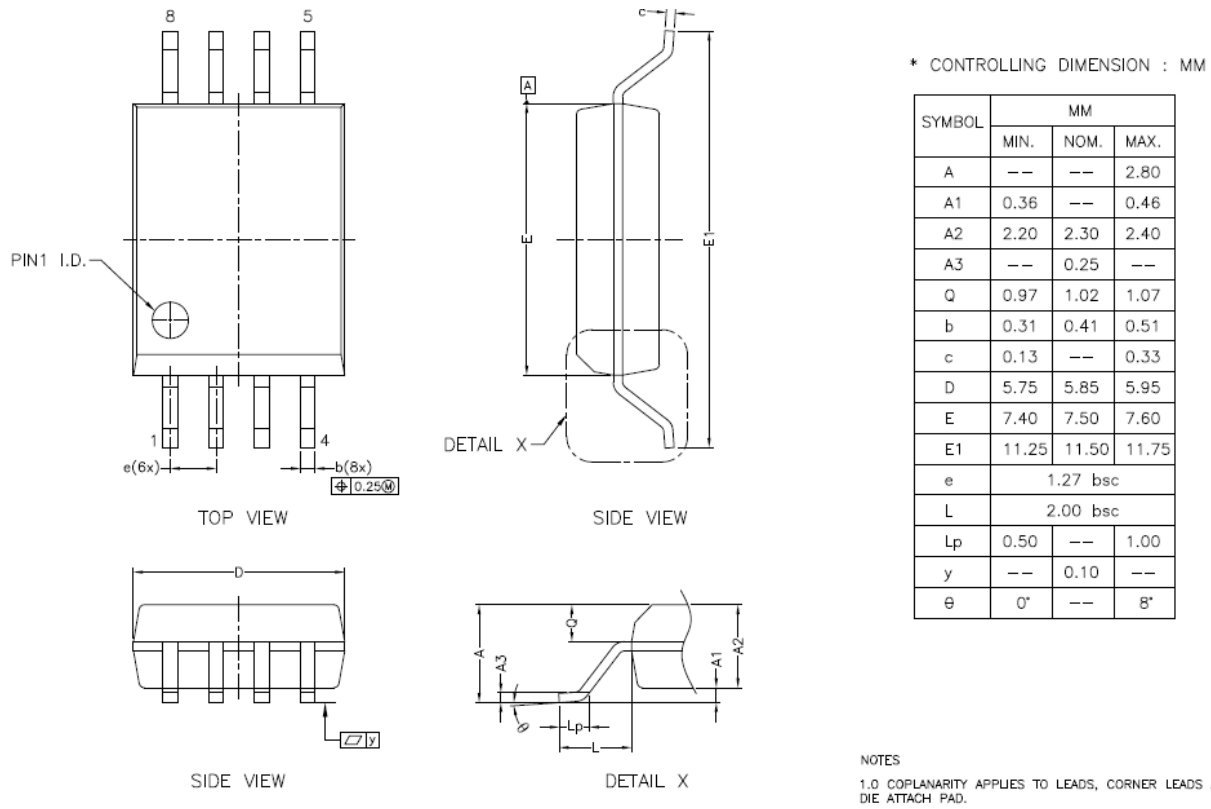


Figure 9.4 SOP8 (300 mil) Package Shape and Dimension in millimeters and (inches)

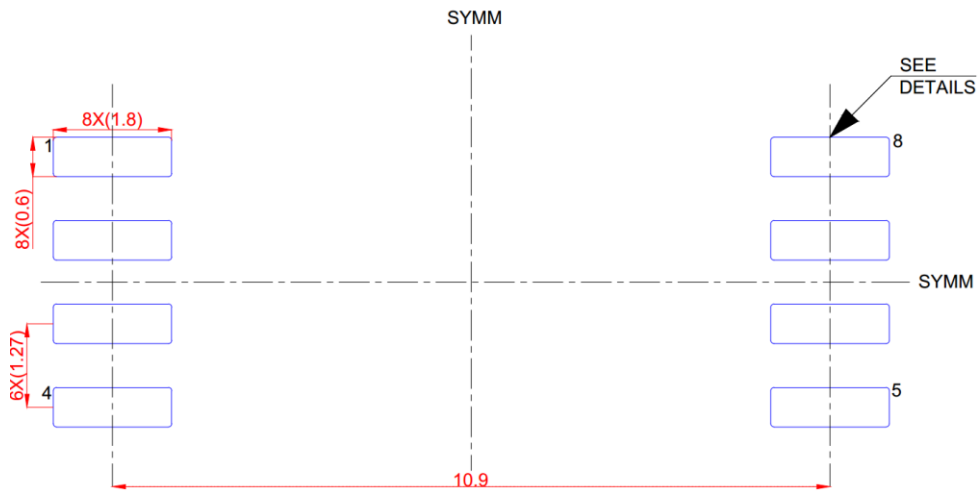


Figure 9.5 Land Pattern Example of SOP8\_300mil (mm)

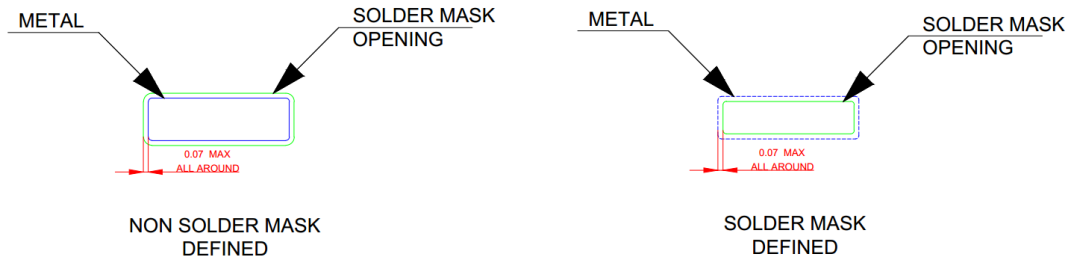


Figure 9.6 Solder Mask Detail of SOP8\_300mil (mm)

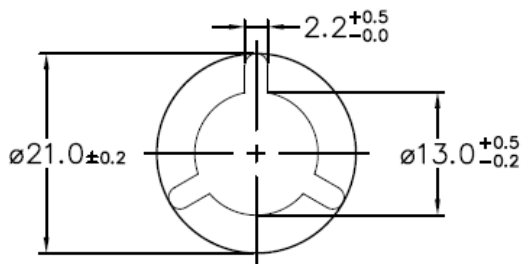
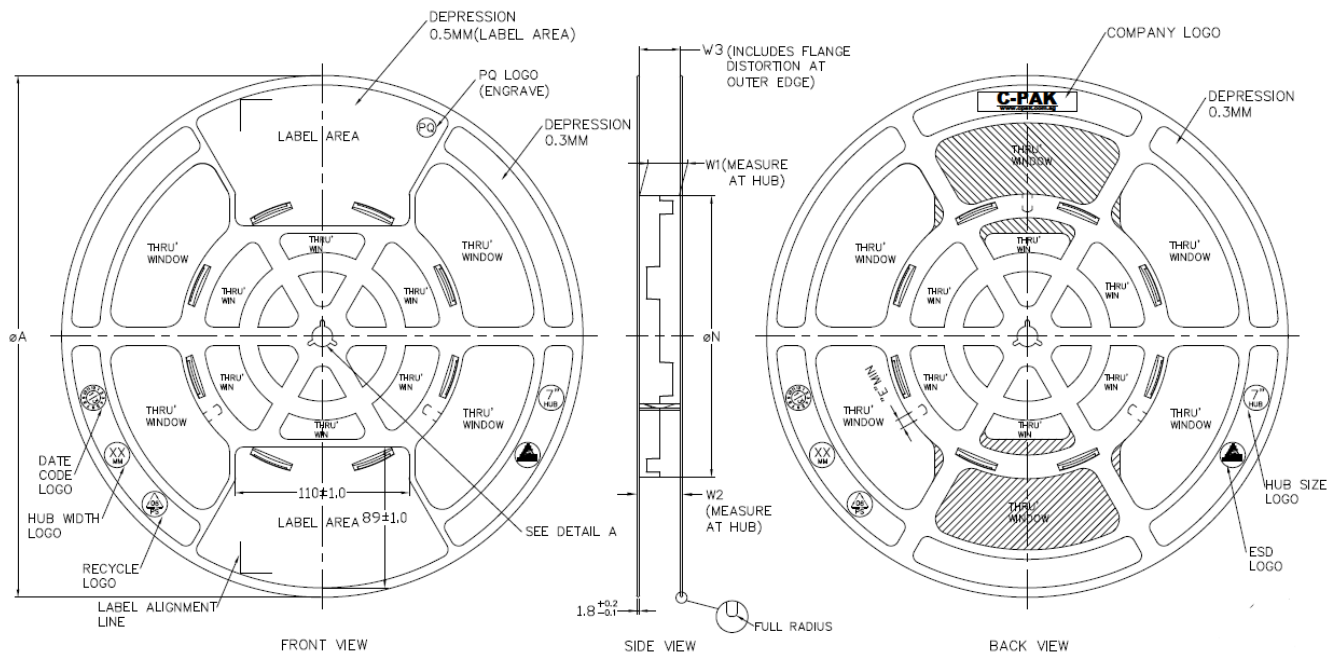
## 10. Ordering Information

<i>Part Number</i>	<i>Isolation Rating (kV)</i>	<i>UVLO Level</i>	<i>Temperature</i>	<i>MSL</i>	<i>Package Type</i>	<i>Package Drawing</i>	<i>SPQ</i>
NSi6601MB-DSPR	3	9V	-40 to 125°C	3	SOP8 (150 mil)	SOP8	2500
NSi6601MC-DSPR	3	12V	-40 to 125°C	3	SOP8 (150 mil)	SOP8	2500
NSi6601MB-DSWVR	5	9V	-40 to 125°C	3	SOP8 (300 mil)	SOW8	1000
NSi6601MC-DSWVR	5	12V	-40 to 125°C	3	SOP8 (300 mil)	SOW8	1000
NSi6601MC-Q1SWVR	5	12V	-40 to 125°C	3	SOP8 (300 mil)	SOW8	1000
NSi6601WC-DSWVR	5	12V	-40 to 125°C	3	SOP8 (300 mil)	SOW8	1000

## 11. Documentation Support

<i>Part Number</i>	<i>Product Folder</i>	<i>Datasheet</i>	<i>Technical Documents</i>	<i>Isolated Driver Selection Guide</i>
NSi6601M	<a href="#">Click here</a>	<a href="#">Click here</a>	<a href="#">Click here</a>	<a href="#">Click here</a>

### 12. Tape and Reel Information



ARBOR HOLE  
DETAIL A  
SCALE : 3:1

PRODUCT SPECIFICATION						
TAPE WIDTH	$\phi A$ $\pm 2.0$	$\phi N$ $\pm 2.0$	W1	W2 (MAX)	W3	E (MIN)
08MM	330	178	$8.4^{+1.5}_{-0.0}$	14.4	SHALL ACCOMMODATE TAPE WIDTH WITHOUT INTERFERENCE	5.5
12MM	330	178	$12.4^{+2.0}_{-0.0}$	18.4		5.5
16MM	330	178	$16.4^{+2.0}_{-0.0}$	22.4		5.5
24MM	330	178	$24.4^{+2.0}_{-0.0}$	30.4		5.5
32MM	330	178	$32.4^{+2.0}_{-0.0}$	38.4		5.5

SURFACE RESISTIVITY			
LEGEND	SR RANGE	TYPE	COLOUR
A	BELOW $10^{12}$	ANTISTATIC	ALL TYPES
B	$10^8$ TO $10^{11}$	STATIC DISSIPATIVE	BLACK ONLY
C	$10^5$ & BELOW $10^5$	CONDUCTIVE (GENERIC)	BLACK ONLY
E	$10^9$ TO $10^{11}$	ANTISTATIC (COATED)	ALL TYPES

Figure 12.1 Tape Information

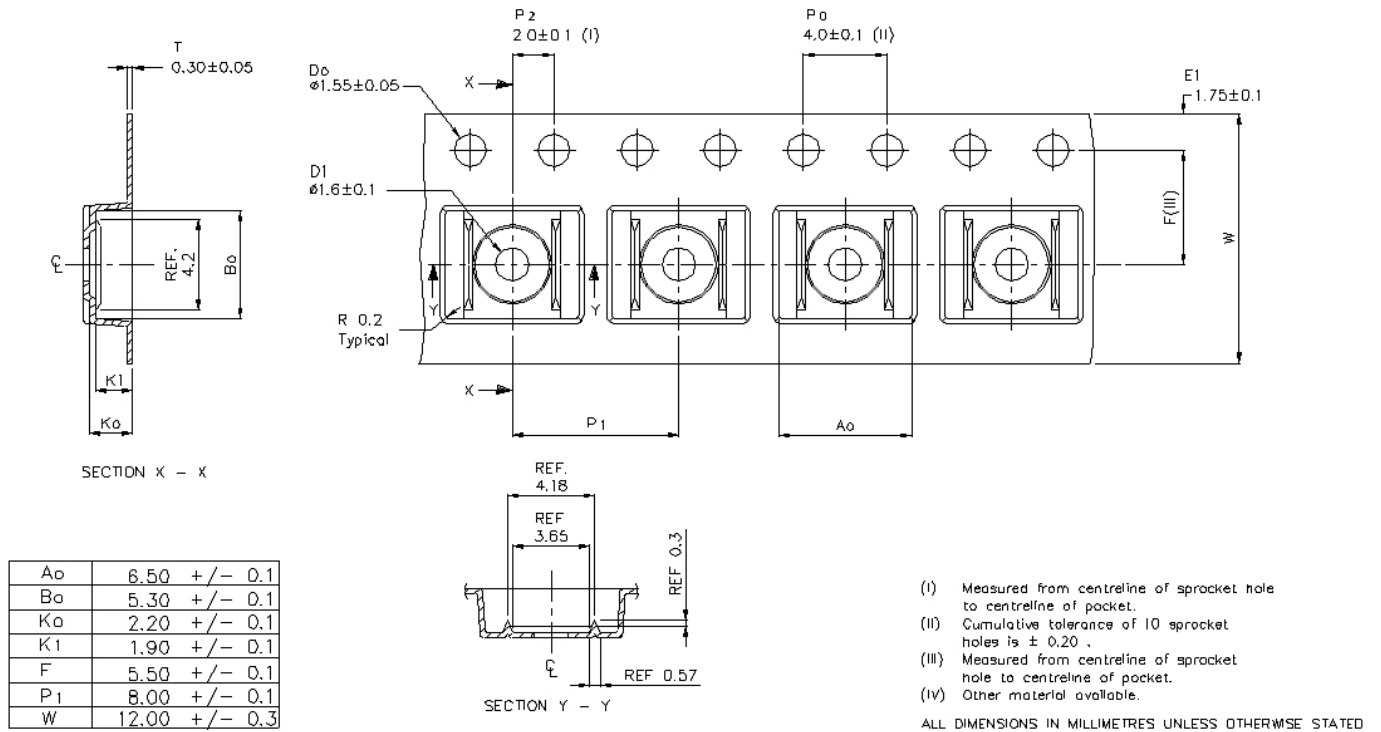


Figure 12.2 Reel Information of SOP8 (150 mil)

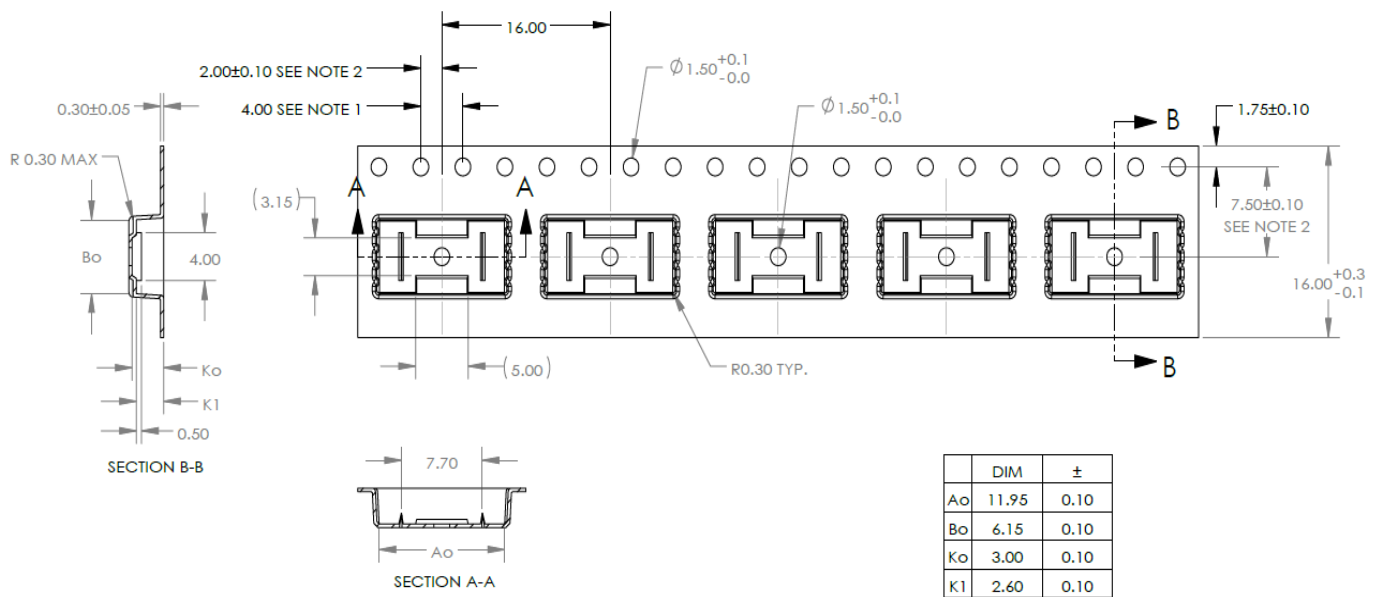


Figure 12.3 Reel Information of SOP8 (300 mil)

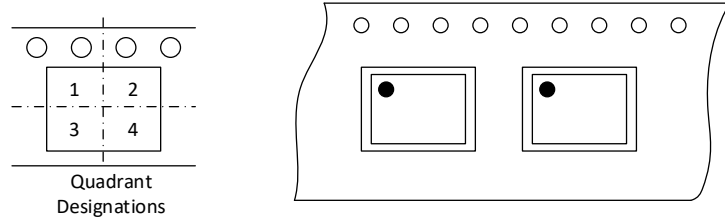


Figure 12.4 Quadrant Designation for Pin1 Orientation in Tape

### 13. Revision History

Revision	Description	Date
1.0	Initial version	2021/9/17
1.1	Updated the MSL (Page 27)	2022/01/10
1.2	Revised the test condition for $I_{LL\_CLAMP}$ (Page 6)	2022/03/10

## X-ON Electronics

Largest Supplier of Electrical and Electronic Components

*Click to view similar products for [Gate Drivers](#) category:*

*Click to view products by [NOVOSENSE](#) manufacturer:*

Other Similar products are found below :

[00053P0231](#) [56956](#) [57.404.7355.5](#) [LT4936](#) [57.904.0755.0](#) [5882900001](#) [00600P0005](#) [5951900000](#) [0131700000](#) [00-2240](#) [LTP70N06](#)  
[LVP640](#) [5J0-1000LG-SIL](#) [LY2-US-AC240](#) [LY3-UA-DC24](#) [00576P0020](#) [LZNQ2-US-DC12](#) [LZP40N10](#) [0207100000](#) [0207400000](#)  
[60100564](#) [60249-1-CUT-TAPE](#) [0134220000](#) [6035](#) [60713816](#) [M15730061](#) [61161-90](#) [61278-0020](#) [6131-204-23149P](#) [6131-205-17149P](#)  
[6131-209-15149P](#) [6131-218-17149P](#) [6131-220-21149P](#) [6131-260-2358P](#) [6131-265-11149P](#) [CS1HCPU63](#) [6150300002](#) [6150-5001](#) [CSK-38-](#)  
[60006](#) [CSK-38-60008](#) [621A](#) [622-4053LF](#) [6273](#) [M37730026](#) [M40N08MA-H](#) [M55155/29XH06](#) [64-807](#) [65003](#) [65-1930-6](#) [M82310002](#)