Half Bridge Gate Driver(Isolated High & Non-Isolated Low)

NCV57200

The NCV57200 is a high voltage gate driver with one non−isolated low side gate driver and one galvanic isolated high or low side gate driver. It can directly drive two IGBTs in a half bridge configuration. Isolated high side driver can be powered with an isolated power supply or with Bootstrap technique from the low side power supply.

The galvanic isolation for the high side gate driver guarantees reliable switching in high power applications for IGBTs that operate up to 800 V, at high dv/dt. The optimized output stages provide a mean of reducing IGBT losses. Its features include two independent inputs with deadtime and interlock, accurate asymmetric UVLOs, and short and matched propagation delays. The NCV57200 operates with its V_{CC}/V_B up to 20 V.

Features

- High Peak Current Output (+1.9 A / −2.3 A)
- Low Output Voltage Drop for Enhanced IGBT Conduction
- Secured Output Low State without V_{DD}/V_B
- Floating Channel for Bootstrap Operation up to +800 V
- CMTI up to 50 kV / μs
- Reliable Operation for V_S Negative Swing to −800 V
- V_{DD} & V_{BS} Supply Range up to 20 V
- 3.3 V, 5 V, and 15 V Logic Input
- Asymmetric Under Voltage Lockout Thresholds for High Side and Low Side
- Matched Propagation Delay 90 ns
- Built−in 20 ns Minimum Pulse Width Filter (or Input Noise Filter)
- Built−in 340 ns Dead−Time and High and Low Inputs Interlock
- Output in Phase with Input Signal
- AEC−Q100 Qualified and PPAP Capable
- This Device is Pb−Free, Halogen Free/BFR Free and is RoHS Compliant

Typical Applications

- OBC
- PTC Heater
- e−Compressors
- Automotive Power Supplies

ON Semiconductor®

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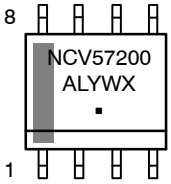
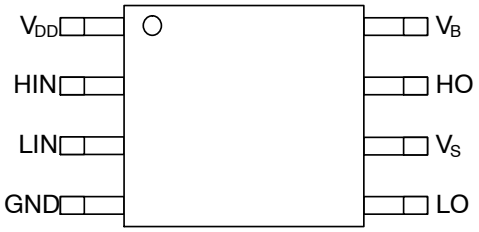
SOIC−8 NB
CASE 751−07

MARKING DIAGRAM



NCV57200	= Specific Device Code
A	= Assembly Location
L	= Wafer Lot
Y	= Year
W	= Work Week
▪	= Pb−Free Package

PIN CONNECTIONS



ORDERING INFORMATION

See detailed ordering and shipping information on page 8 of this data sheet.

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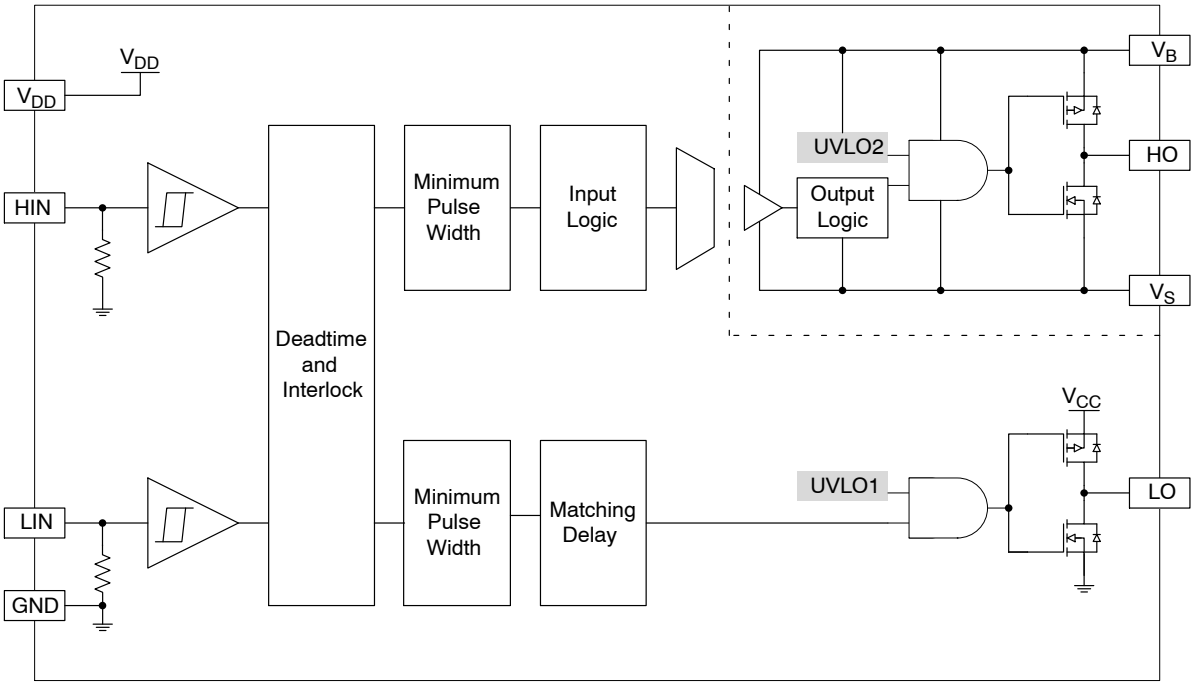

Figure 1. Simplified Block Diagram

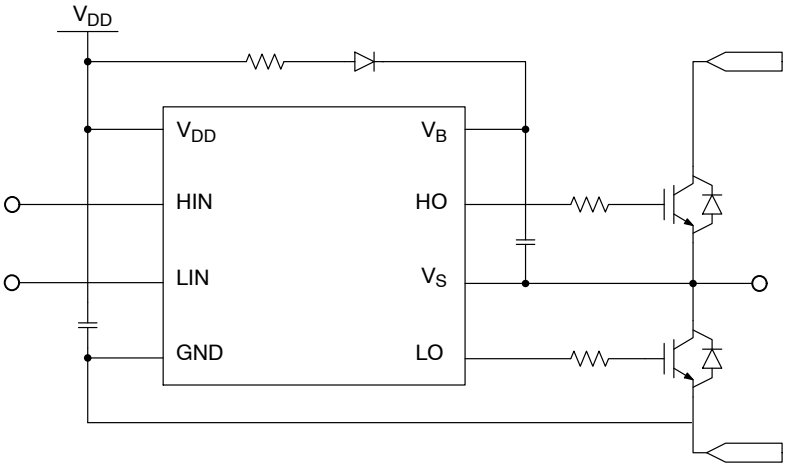

Figure 2. Simplified Application Schematics

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Table 1. FUNCTION DESCRIPTION

Pin Name	No.	I/O	Description
V_{DD}	1	Power	Low side and main power supply. A good quality bypassing capacitor is required from this pin to GND and should be placed close to the pins for best results. The under voltage lockout (UVLO) circuit enables the device to operate at power on when a typical supply voltage higher than $V_{UVLO1−OUT−ON}$ is present. Please see Figure 5 for more details. A filter time of typical 1.5 μs helps to suppress noise on V_{DD} pin.
HIN	2	I	High side non-inverting gate driver input. It has an equivalent pull−down resistor of 125 kΩ to ensure that output is low in the absence of an input signal. A minimum positive or negative going pulse width is required at HIN before HO reacts. It adopts 3.3 V logic signal thresholds for input voltage up to V_{DD}. There is deadtime and interlocking logic between HIN and LIN.
LIN	3	I	Low side non-inverting gate driver input. It has an equivalent pull−down resistor of 125 kΩ to ensure that output is low in the absence of an input signal. A minimum positive or negative going pulse width is required at LIN before LO reacts. It adopts 3.3 V logic signal thresholds for input voltage up to V_{DD}. There is deadtime and interlocking logic between HIN and LIN.
GND	4	Power	Logic ground and low side driver return.
LO	5	O	Low side driver output that provides the appropriate drive voltage and source/sink current to the IGBT gate. LO is actively pulled low during startup and under UVLO1 condition. There is deadtime and interlocking logic to prevent unintended HO and LO cross conduction.
V_S	6	Power	Bootstrap return or high side floating supply offset.
HO	7	O	Galvanic isolated high side driver output that provides the appropriate drive voltage and source/sink current to the IGBT gate. HO is actively pulled low during startup and under UVLO2 condition. There is deadtime and interlocking logic to prevent unintended HO and LO cross conduction.
V_B	8	Power	Bootstrap or high side floating power supply. A good quality bypassing capacitor is required from this pin to V_S and should be placed close to the pins for best results. The under voltage lockout (UVLO) circuit enables the device to operate at power on when a typical supply voltage higher than $V_{UVLO2−OUT−ON}$ is present. Please see Figure 5 for more details. A filter time of typical 1.5 μs helps to suppress noise on V_B pin.

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Table 2. ABSOLUTE MAXIMUM RATINGS (Note 1) Over operating free−air temperature range unless otherwise noted

Parameter	Symbol	Minimum	Maximum	Unit
High−Side Offset Voltage	V_S	−900	900	V
High−Side Offset Voltage (t_p < 500 ns)		−900	900	
High−Side Supply Voltage	V_B	−900	900	V
High−Side Supply Voltage (t_p < 500 ns)		−900	900	
Low−Side and Logic−Fixed Supply Voltage	V_{DD}	−0.3	25	V
High−Side Floating Supply Voltage	V_{BS}	−0.3	25	V
High−Side Floating Output Voltage V_{HO}	V_{HO}	V_S−0.3	V_B+0.3	V
Low−Side Floating Output Voltage V_{LO}	V_{LO}	−0.3	V_{DD}+0.3	V
Logic Input Voltage (HIN, LIN)	V_{IN}	−0.3	V_{DD}+0.3	V
Allowable Offset Voltage Slew Rate	dV_S/dt		±50	V/ns
Maximum Junction Temperature	TJ(max)	−40	150	°C
Storage Temperature Range	TSTG	−65	150	°C
ESD Capability, Human Body Model (Note 2)	ESDHBM		±4	kV
ESD Capability, Charged Device Model (Note 2)	ESDCDM		±2	kV
Moisture Sensitivity Level	MSL		1	−
Lead Temperature Soldering Reflow (SMD Styles Only), Pb−Free Versions (Note 3)	TSLD		260	°C

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

1. Refer to ELECTRICAL CHARACTERISTICS and APPLICATION INFORMATION for Safe Operating Area.
2. This device series incorporates ESD protection and is tested by the following methods:
   ESD Human Body Model tested per AEC−Q100−002 (EIA/JESD22−A114).
   ESD Charged Device Model tested per AEC−Q100−011 (EIA/JESD22−C101).
   Latchup Current Maximum Rating: ≤ 100 mA per JEDEC standard: JESD78, 125°C.
3. For information, please refer to our Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

Table 3. THERMAL CHARACTERISTICS

Parameter	Symbol	Value	Unit
Thermal Characteristics, SOIC−8 (Note 4) Thermal Resistance, Junction−to−Air (Note 5)	$R_{\theta JA}$	167	°C/W

4. Refer to ELECTRICAL CHARACTERISTICS and APPLICATION INFORMATION for Safe Operating Area.
5. Values based on copper area of 100 mm^2 (or 0.16 in^2) of 1 oz copper thickness and FR4 PCB substrate.

Table 4. RECOMMENDED OPERATING RANGES (Note 6)

Parameter	Symbol	Min	Max	Unit
High−Side Supply Voltage	V_B	V_S+UVLO2	V_S+20	V
High−Side Supply Offset Voltage	V_S	−800	800	V
High−Side (HO) Output Voltage	V_{HO}	V_S	V_B	V
Low−Side (LO) Output Voltage	V_{LO}	GND	V_{DD}	V
Logic Input Voltage (HIN, LIN)	V_{IN}	GND	V_{DD}	V
Low−Side Supply Voltage	V_{DD}	UVLO1	20	V
Ambient Temperature	T_A	−40	+125	°C

Functional operation above the stresses listed in the Recommended Operating Ranges is not implied. Extended exposure to stresses beyond the Recommended Operating Ranges limits may affect device reliability.

6. Refer to ELECTRICAL CHARACTERISTICS and APPLICATION INFORMATION for Safe Operating Area.

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Table 5. ELECTRICAL CHARACTERISTICS V_{DD} = V_{BS} = 15 V.
For typical values T_A = 25°C, for min/max values, T_A is the operating ambient temperature range that applies, unless otherwise noted.

Parameter	Test Conditions	Symbol	Min	Typ	Max	Unit
VOLTAGE SUPPLY						
V_{BS} Supply Under Voltage Output Enabled		$V_{UVLO2-OUT-ON}$	11	11.5	12	V
V_{BS} Supply Under Voltage Output Disabled		$V_{UVLO2-OUT-OFF}$	10	10.5	11	V
V_{BS} Supply Voltage Output Enabled/Disabled Hysteresis		$V_{UVLO2-HYST}$		1.0		V
V_{DD} Supply Under Voltage Output Enabled		$V_{UVLO1-OUT-ON}$	12	12.5	13	V
V_{DD} Supply Under Voltage Output Disabled		$V_{UVLO1-OUT-OFF}$	11	11.5	12	V
V_{DD} Supply Voltage Output Enabled/Disabled Hysteresis		$V_{UVLO1-HYST}$		1.0		V
Leakage Current Between V_S and GND	V_S = ± 800 V, T_A = 25°C V_S = ± 800 V, T_A = −40°C to 125°C	I_{HV_LEAK1} I_{HV_LEAK2}		20	200 600	nA
Quiescent Current V_{BS} Supply (V_B Only)	HO = Low	I_{QBS1}		260	325	μA
Quiescent Current V_{BS} Supply (V_B Only)	HO = High	I_{QBS2}		330	440	μA
Quiescent Current V_{DD} Supply (V_{DD} Only)	V_{LIN} = Float, V_{HIN} = 0 V,	I_{QDD1}		380	440	μA
Quiescent Current V_{DD} Supply (V_{DD} Only)	V_{LIN} = 3.3 V, V_{HIN} = 0 V,	I_{QDD2}		440	500	μA
Quiescent Current V_{DD} Supply (V_{DD} Only)	V_{LIN} = 0 V, V_{HIN} = 3.3 V,	I_{QDD3}		2.4	3	mA
LOGIC INPUT						
Low Level Input Voltage		V_{IL}			0.9	V
High Level Input Voltage		V_{IH}	2.4			V
Logic “1” Input Bias Current	V_{LIN} = 3.3 V, V_{HIN} = 3.3 V	I_{LIN1+}, I_{HIN1+}		25	50	μA
Logic “1” Input Bias Current	V_{LIN} = 20 V, V_{HIN} = 20 V, V_{DD} = V_{BS} = 20 V	I_{LIN2+}, I_{HIN2+}		100	150	μA
Logic “0” Input Bias Current	V_{LIN} = 0 V, V_{HIN} = 0 V	I_{LIN-}, I_{HIN-}		40	100	nA
DRIVER OUTPUT						
Output Low State	I_{SINK} = 200 mA, T_A = 25°C	V_{OL1}		0.2	0.3	V
	I_{SINK} = 200 mA, T_A = −40°C to 125°C	V_{OL2}			0.5	
Output High State	I_{SRC} = 200 mA, T_A = 25°C	V_{OH1}	14.4	14.5		V
	I_{SRC} = 200 mA, T_A = −40°C to 125°C	V_{OH2}	14			
Peak Driver Current, Sink (Note 7)	V_{HO} = V_{LO} = 15 V	$I_{PK-SNK1}$		2.3		A
	V_{HO} = V_{LO} = 9 V (near Miller Plateau)	$I_{PK-SNK2}$		2.1		
Peak Driver Current, Source (Note 7)	V_{HO} = V_{LO} = 0 V	$I_{PK-SRC1}$		1.9		A
	V_{HO} = V_{LO} = 9 V (near Miller Plateau)	$I_{PK-SRC2}$		1.5		

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Table 5. ELECTRICAL CHARACTERISTICS V_{DD} = V_{BS} = 15 V.
For typical values T_A = 25°C, for min/max values, T_A is the operating ambient temperature range that applies, unless otherwise noted.

Parameter	Test Conditions	Symbol	Min	Typ	Max	Unit
IGBT SHORT CIRCUIT CLAMPING						
Clamping Voltage (V_{HO} − V_B) / (V_{LO} − V_{DD})	I_{HO} = 100 mA, I_{LO} = 100 mA (pulse test, t_{CLPmax} = 10 μs)	$V_{CLAMP-OUT}$		0.8	1.3	V
DYNAMIC CHARACTERISTIC						
HO High Propagation Delay	C_{LOAD} = 1 nF, V_{IH} to 10% of Output Change for PW > 150 ns	$t_{PD-ON-H}$	60	90	110	ns
HO Low Propagation Delay	C_{LOAD} = 1 nF, V_{IL} to 90% of Output Change for PW > 150 ns	$t_{PD-OFF-H}$	60	90	110	ns
Propagation Delay Distortion(HS) (= t_{PD-ON} − t_{PD-OFF})	PW >150 ns	$t_{DISTORT-H}$	−25	0	25	ns
LO High Propagation Delay	C_{LOAD} = 1 nF, V_{IH} to 10% of Output Change for PW > 150 ns	$t_{PD-ON-L}$	60	90	110	ns
LO Low Propagation Delay	C_{LOAD} = 1 nF, V_{IL} to 90% of Output Change for PW > 150 ns	$t_{PD-OFF-L}$	60	90	110	ns
Propagation Delay Distortion(LS) (= t_{PD-ON} − t_{PD-OFF})	PW >150 ns	$t_{DISTORT-L}$	−25	0	25	ns
High Prop Delay Distortion between High and Low Sides	PW > 150 ns	$t_{DISTORT-HLH}$	−25	0	25	ns
Low Prop Delay Distortion between High and Low Sides	PW > 150 ns	$t_{DISTORT-HLL}$	−25	0	25	ns
Rise Time(HS) (see timing diagram)	C_{LOAD} = 1 nF, 10% to 90% of Output Change	t_{RISE-H}		13		ns
Fall Time(HS) (see timing diagram)	C_{LOAD} = 1 nF, 90% to 10% of Output Change	t_{FALL-H}		8		ns
Rise Time(LS) (see timing diagram)	C_{LOAD} = 1 nF, 10% to 90% of Output Change	t_{RISE-L}		13		ns
Fall Time(LS) (see timing diagram)	C_{LOAD} = 1 nF, 90% to 10% of Output Change	t_{FALL-L}		8		ns
Deadtime, HO Delays	$V_{LIN/HIN}$ = 0 V and 3.3 V	t_{DT1}		340		ns
Deadtime, LO Delays	$V_{LIN/HIN}$ = 0 V and 3.3 V	t_{DT2}		350		ns
Deadtime Matching		t_{MDT}		10		ns
Minimum Pulse Width Filtering Time	T_A = 25°C	t_{MIN1}, t_{MIN2}	10		40	ns
UVLO Fall Delay (HO and LO)		t_{UV1}		1300		ns
UVLO Rise Delay (HO and LO)		t_{UV2}		1100		ns

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.
7. Values based on design and/or characterization.

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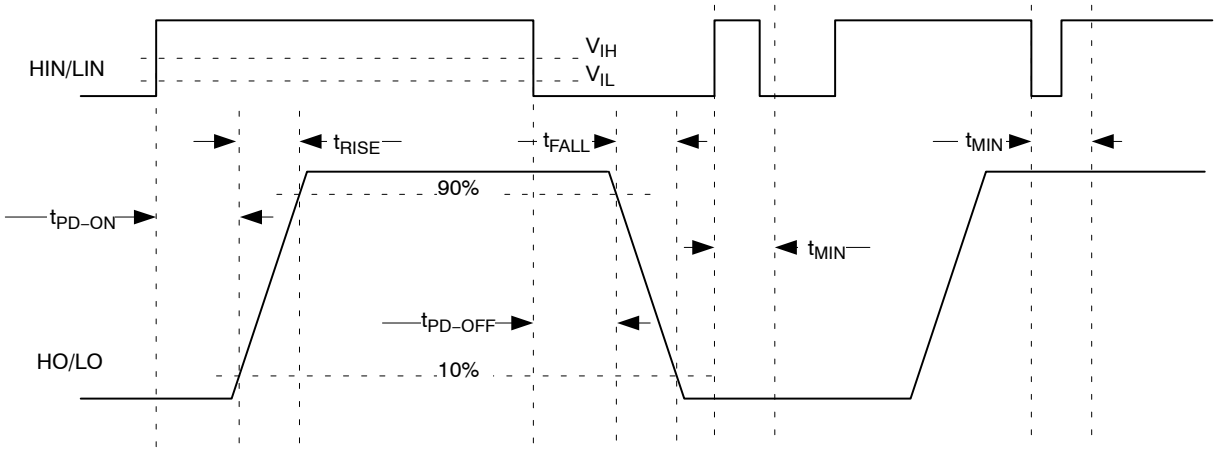

Figure 3. Propagation Delay, Rise and Fall Time

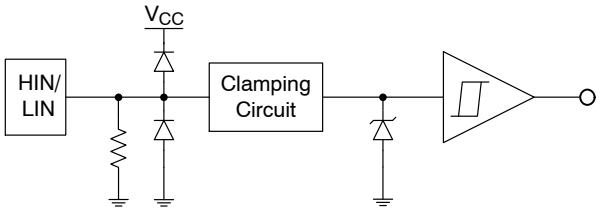

Figure 4. Input Pin Structure

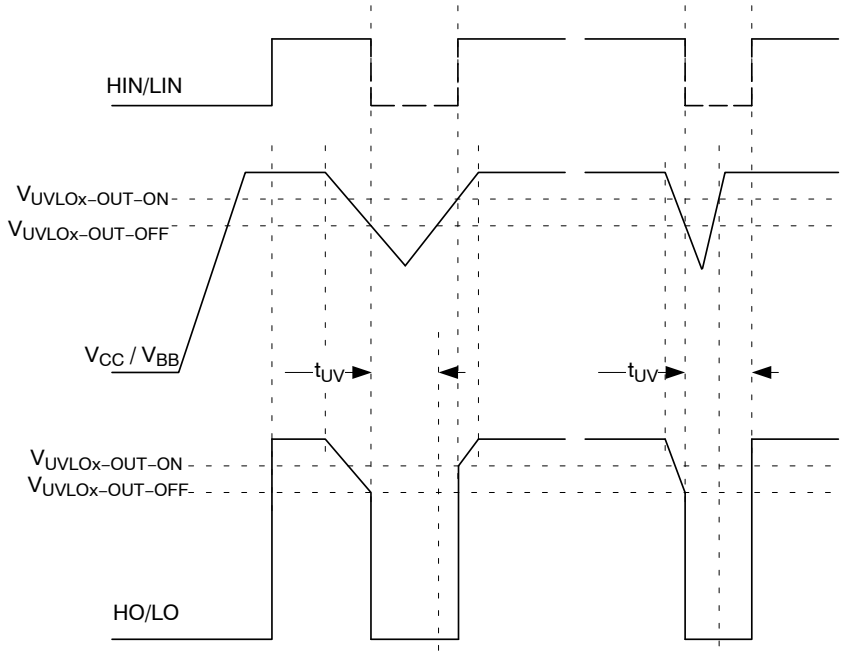

Figure 5. UVLO

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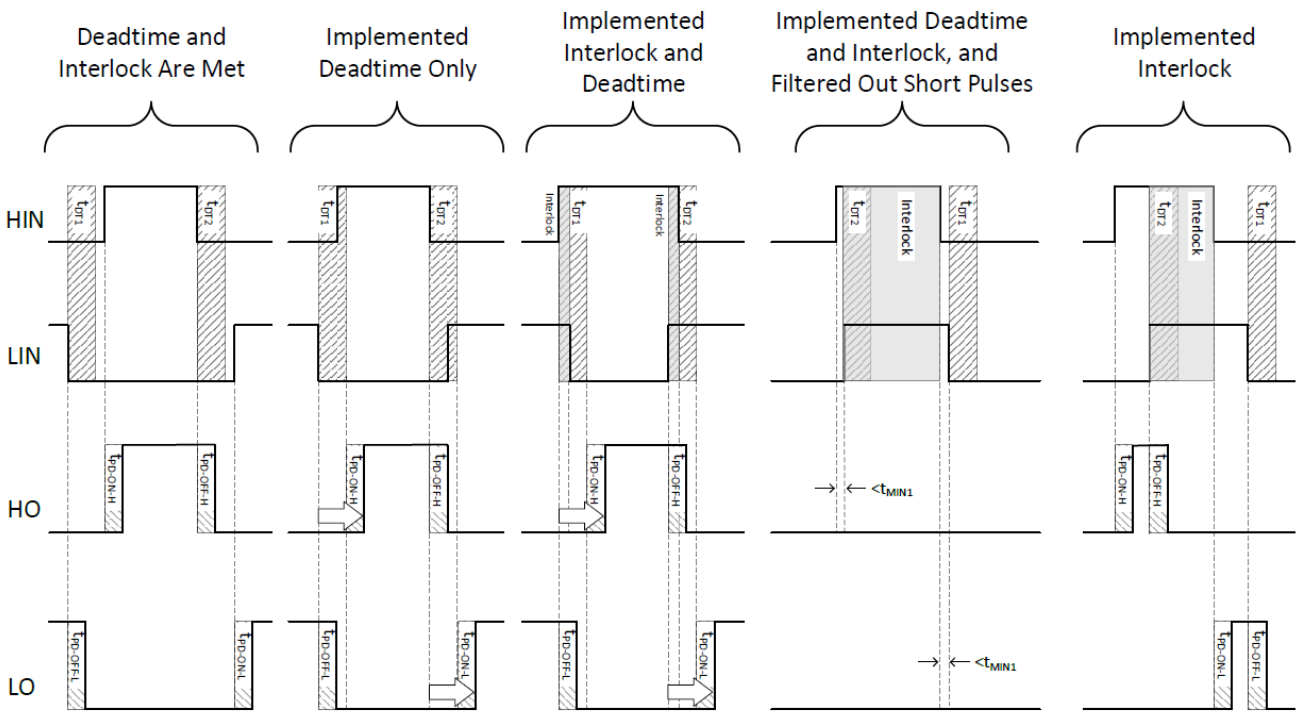

Figure 6. Deadtime, Interlock and Output Minimum Pulse Width

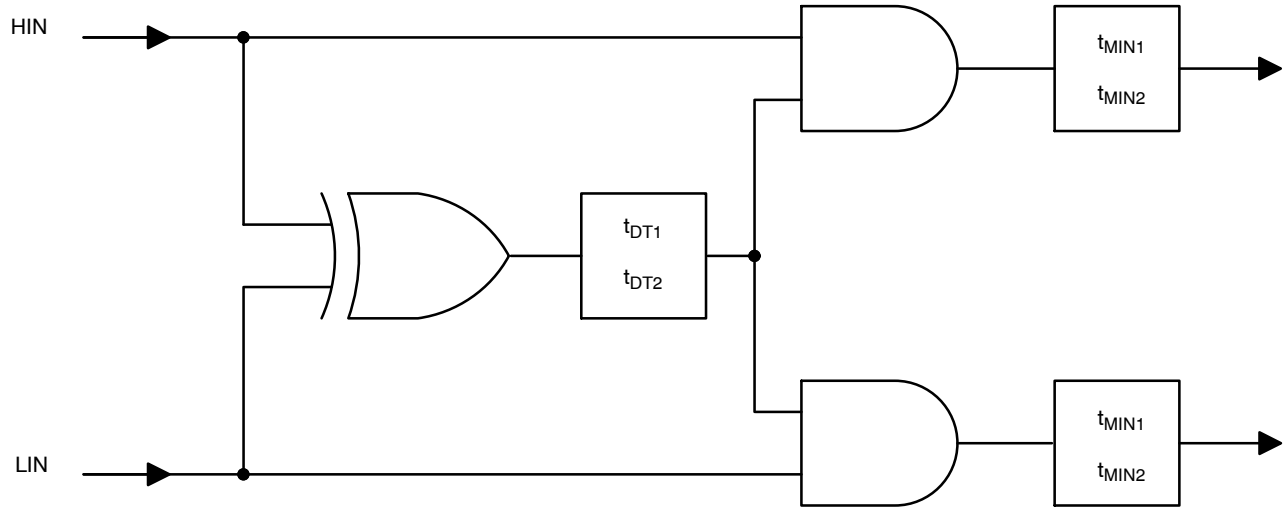

Figure 7. Input Circuit

ORDERING INFORMATION

Device	Package	Shipping†
NCV57200DR2G	SOIC−8 (Pb−Free)	2500 / Tape & Reel

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

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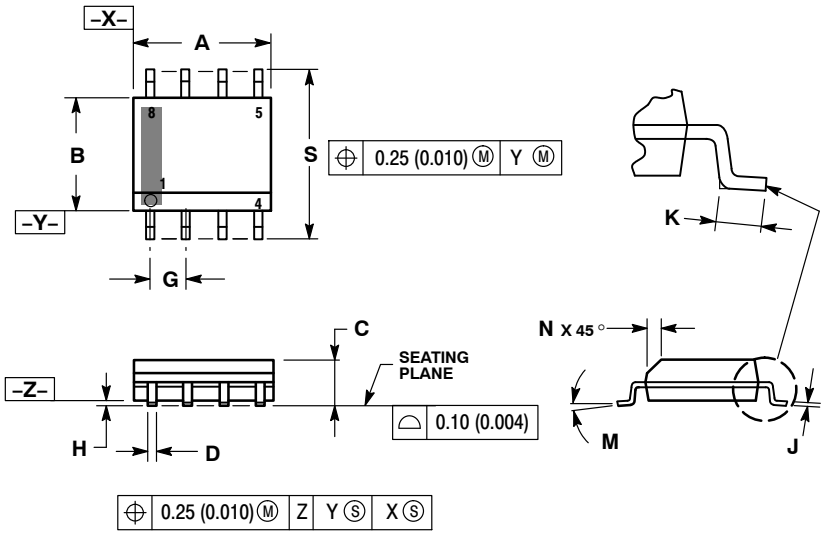
PACKAGE DIMENSIONS

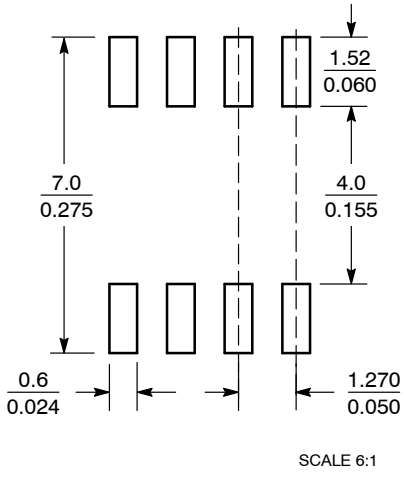
SOIC−8 NB
CASE 751−07
ISSUE AK



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSION A AND B DO NOT INCLUDE MOLD PROTRUSION.
4. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.
5. DIMENSION D DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.127 (0.005) TOTAL IN EXCESS OF THE D DIMENSION AT MAXIMUM MATERIAL CONDITION.
6. 751−01 THRU 751−06 ARE OBSOLETE. NEW STANDARD IS 751−07.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.80	5.00	0.189	0.197
B	3.80	4.00	0.150	0.157
C	1.35	1.75	0.053	0.069
D	0.33	0.51	0.013	0.020
G	1.27 BSC		0.050 BSC	
H	0.10	0.25	0.004	0.010
J	0.19	0.25	0.007	0.010
K	0.40	1.27	0.016	0.050
M	0 °	8 °	0 °	8 °
N	0.25	0.50	0.010	0.020
S	5.80	6.20	0.228	0.244

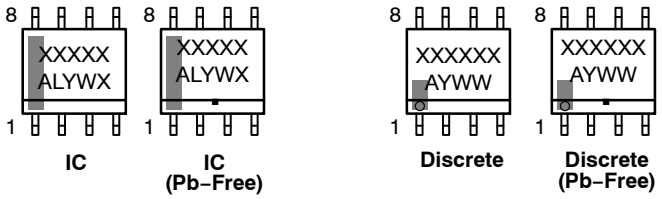
SOLDERING FOOTPRINT*



SCALE 6:1 (mm / inches)

*For additional information on our Pb−Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

GENERIC MARKING DIAGRAM*



IC | IC (Pb−Free) | Discrete | Discrete (Pb−Free)

XXXXX = Specific Device Code
A = Assembly Location
L = Wafer Lot
Y = Year
W = Work Week
▪ = Pb−Free Package

XXXXXX = Specific Device Code
A = Assembly Location
Y = Year
WW = Work Week
▪ = Pb−Free Package

*This information is generic. Please refer to device data sheet for actual part marking. Pb−Free indicator, “G” or microdot “▪”, may or may not be present. Some products may not follow the Generic Marking.

STYLES ON PAGE 2

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SOIC−8 NB
CASE 751−07
ISSUE AK

DATE 16 FEB 2011

STYLE 1:
PIN 1. EMITTER
2. COLLECTOR
3. COLLECTOR
4. EMITTER
5. EMITTER
6. BASE
7. BASE
8. EMITTER

STYLE 2:
PIN 1. COLLECTOR, DIE, #1
2. COLLECTOR, #1
3. COLLECTOR, #2
4. COLLECTOR, #2
5. BASE, #2
6. EMITTER, #2
7. BASE, #1
8. EMITTER, #1

STYLE 3:
PIN 1. DRAIN, DIE #1
2. DRAIN, #1
3. DRAIN, #2
4. DRAIN, #2
5. GATE, #2
6. SOURCE, #2
7. GATE, #1
8. SOURCE, #1

STYLE 4:
PIN 1. ANODE
2. ANODE
3. ANODE
4. ANODE
5. ANODE
6. ANODE
7. ANODE
8. COMMON CATHODE

STYLE 5:
PIN 1. DRAIN
2. DRAIN
3. DRAIN
4. DRAIN
5. GATE
6. GATE
7. SOURCE
8. SOURCE

STYLE 6:
PIN 1. SOURCE
2. DRAIN
3. DRAIN
4. SOURCE
5. SOURCE
6. GATE
7. GATE
8. SOURCE

STYLE 7:
PIN 1. INPUT
2. EXTERNAL BYPASS
3. THIRD STAGE SOURCE
4. GROUND
5. DRAIN
6. GATE 3
7. SECOND STAGE Vd
8. FIRST STAGE Vd

STYLE 8:
PIN 1. COLLECTOR, DIE #1
2. BASE, #1
3. BASE, #2
4. COLLECTOR, #2
5. COLLECTOR, #2
6. EMITTER, #2
7. EMITTER, #1
8. COLLECTOR, #1

STYLE 9:
PIN 1. EMITTER, COMMON
2. COLLECTOR, DIE #1
3. COLLECTOR, DIE #2
4. EMITTER, COMMON
5. EMITTER, COMMON
6. BASE, DIE #2
7. BASE, DIE #1
8. EMITTER, COMMON

STYLE 10:
PIN 1. GROUND
2. BIAS 1
3. OUTPUT
4. GROUND
5. GROUND
6. BIAS 2
7. INPUT
8. GROUND

STYLE 11:
PIN 1. SOURCE 1
2. GATE 1
3. SOURCE 2
4. GATE 2
5. DRAIN 2
6. DRAIN 2
7. DRAIN 1
8. DRAIN 1

STYLE 12:
PIN 1. SOURCE
2. SOURCE
3. SOURCE
4. GATE
5. DRAIN
6. DRAIN
7. DRAIN
8. DRAIN

STYLE 13:
PIN 1. N.C.
2. SOURCE
3. SOURCE
4. GATE
5. DRAIN
6. DRAIN
7. DRAIN
8. DRAIN

STYLE 14:
PIN 1. N−SOURCE
2. N−GATE
3. P−SOURCE
4. P−GATE
5. P−DRAIN
6. P−DRAIN
7. N−DRAIN
8. N−DRAIN

STYLE 15:
PIN 1. ANODE 1
2. ANODE 1
3. ANODE 1
4. ANODE 1
5. CATHODE, COMMON
6. CATHODE, COMMON
7. CATHODE, COMMON
8. CATHODE, COMMON

STYLE 16:
PIN 1. EMITTER, DIE #1
2. BASE, DIE #1
3. EMITTER, DIE #2
4. BASE, DIE #2
5. COLLECTOR, DIE #2
6. COLLECTOR, DIE #2
7. COLLECTOR, DIE #1
8. COLLECTOR, DIE #1

STYLE 17:
PIN 1. VCC
2. V2OUT
3. V1OUT
4. TXE
5. RXE
6. VEE
7. GND
8. ACC

STYLE 18:
PIN 1. ANODE
2. ANODE
3. SOURCE
4. GATE
5. DRAIN
6. DRAIN
7. CATHODE
8. CATHODE

STYLE 19:
PIN 1. SOURCE 1
2. GATE 1
3. SOURCE 2
4. GATE 2
5. DRAIN 2
6. MIRROR 2
7. DRAIN 1
8. MIRROR 1

STYLE 20:
PIN 1. SOURCE (N)
2. GATE (N)
3. SOURCE (P)
4. GATE (P)
5. DRAIN
6. DRAIN
7. DRAIN
8. DRAIN

STYLE 21:
PIN 1. CATHODE 1
2. CATHODE 2
3. CATHODE 3
4. CATHODE 4
5. CATHODE 5
6. COMMON ANODE
7. COMMON ANODE
8. CATHODE 6

STYLE 22:
PIN 1. I/O LINE 1
2. COMMON CATHODE/VCC
3. COMMON CATHODE/VCC
4. I/O LINE 3
5. COMMON ANODE/GND
6. I/O LINE 4
7. I/O LINE 5
8. COMMON ANODE/GND

STYLE 23:
PIN 1. LINE 1 IN
2. COMMON ANODE/GND
3. COMMON ANODE/GND
4. LINE 2 IN
5. LINE 2 OUT
6. COMMON ANODE/GND
7. COMMON ANODE/GND
8. LINE 1 OUT

STYLE 24:
PIN 1. BASE
2. EMITTER
3. COLLECTOR/ANODE
4. COLLECTOR/ANODE
5. CATHODE
6. CATHODE
7. COLLECTOR/ANODE
8. COLLECTOR/ANODE

STYLE 25:
PIN 1. VIN
2. N/C
3. REXT
4. GND
5. IOUT
6. IOUT
7. IOUT
8. IOUT

STYLE 26:
PIN 1. GND
2. dv/dt
3. ENABLE
4. ILIMIT
5. SOURCE
6. SOURCE
7. SOURCE
8. VCC

STYLE 27:
PIN 1. ILIMIT
2. OVLO
3. UVLO
4. INPUT+
5. SOURCE
6. SOURCE
7. SOURCE
8. DRAIN

STYLE 28:
PIN 1. SW_TO_GND
2. DASIC_OFF
3. DASIC_SW_DET
4. GND
5. V_MON
6. VBULK
7. VBULK
8. VIN

STYLE 29:
PIN 1. BASE, DIE #1
2. EMITTER, #1
3. BASE, #2
4. EMITTER, #2
5. COLLECTOR, #2
6. COLLECTOR, #2
7. COLLECTOR, #1
8. COLLECTOR, #1

STYLE 30:
PIN 1. DRAIN 1
2. DRAIN 1
3. GATE 2
4. SOURCE 2
5. SOURCE 1/DRAIN 2
6. SOURCE 1/DRAIN 2
7. SOURCE 1/DRAIN 2
8. GATE 1

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