

High Speed Dual-Channel, Bi-Directional Ceramic Digital Isolator

Product Preview

NCID9210 / NCID9216

Description

The NCID9210 and NCID9216 are galvanically isolated full duplex, bi-directional, high-speed dual-channel digital isolators. These devices support isolated communications thereby allowing digital signals to communicate between systems without conducting ground loops or hazardous voltages.

They utilize ON Semiconductor patented galvanic off-chip capacitor isolation technology and optimized IC design to achieve high insulation and high noise immunity, characterized by high common mode rejection and power supply rejection specifications. The thick ceramic substrate yields capacitors with ~25 times the thickness of thin film on-chip capacitors and coreless transformers. The result is a combination of the electrical performance benefits that digital isolators offer with the safety reliability of a >0.5 mm insulator barrier similar to what has historically been offered by optocouplers.

The device is housed in a 16-pin wide body small outline package.

Features

- Off-Chip Capacitive Isolation to Achieve Reliable High Voltage Insulation
 - ◆ DTI (Distance Through Insulation): ≥ 0.5 mm
 - ◆ Maximum Working Insulation Voltage: $2000 V_{peak}$
- Full Duplex, Bi-directional Communication
- 100 KV/ μs Minimum Common Mode Rejection
- High Speed:
 - ◆ 50 Mbit/s Data Rate (NRZ)
 - ◆ 25 ns Maximum Propagation Delay
 - ◆ 10 ns Maximum Pulse Width Distortion
- 8 mm Creepage and Clearance Distance to Achieve Reliable High Voltage Insulation.
- Specifications Guaranteed Over 2.5 V to 5.5 V Supply Voltage and $-40^{\circ}C$ to $125^{\circ}C$ Extended Temperature Range
- Over Temperature Detection
- NCIV Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC-Q100 Qualified and PPAP Capable (Pending)
- Safety and Regulatory Approvals
 - ◆ UL1577, $5000 V_{RMS}$ for 1 Minute
 - ◆ DIN VDE V 0884-11 (Pending)

Typical Applications

- Isolated PWM Control
- Industrial Fieldbus Communications
- Microprocessor System Interface (SPI, I²C, etc.)
- Programmable Logic Control
- Isolated Data Acquisition System
- Voltage Level Translator

This document contains information on a product under development. ON Semiconductor reserves the right to change or discontinue this product without notice.



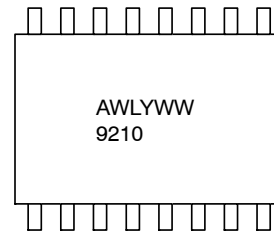
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SOIC16 W
CASE 751EN

MARKING DIAGRAM



A = Assembly Location
WL = Wafer Lot
Y = Year
WW = Work Week
9210/9216 = Specific Device Code

ORDERING INFORMATION

See detailed ordering and shipping information on page 10 of this data sheet.

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PIN CONFIGURATION

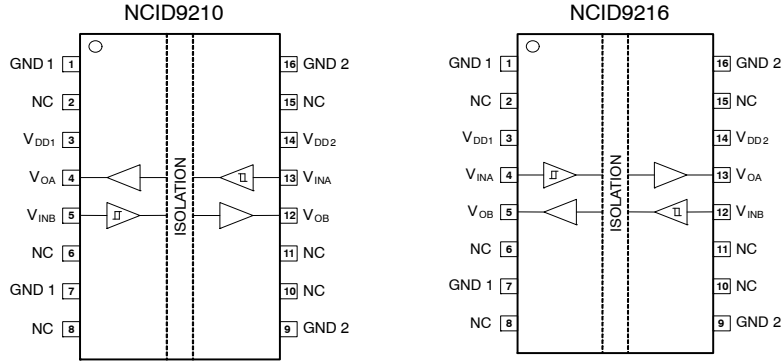


Figure 1. Pin and Channel Configuration

BLOCK DIAGRAM

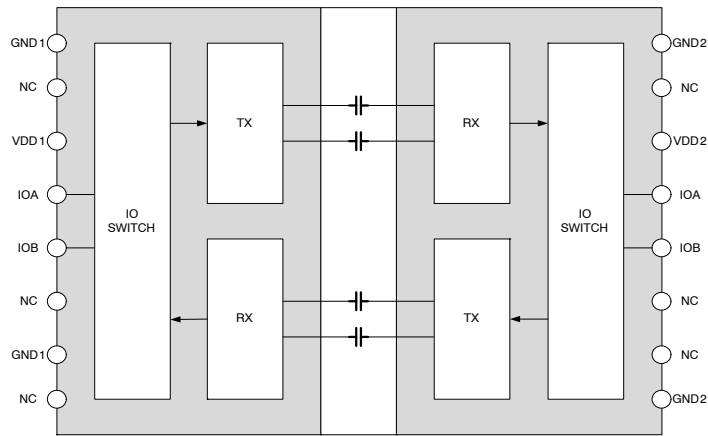


Figure 2. Functional Block Diagram

PIN DEFINITIONS

Name	Pin No. NCID9210	Pin No. NCID9216	Description
GND1	1	1	Ground, Primary Side
NC	2	2	No Connect
V _{DD1}	3	3	Power Supply, Primary Side
V _{OA}	4	13	Output, Channel A
V _{INB}	5	12	Input, Channel B
NC	6	6	No Connect
GND1	7	7	Ground, Primary Side
NC	8	8	No Connect
GND2	9	9	Ground, Secondary Side
NC	10	10	No Connect
NC	11	11	No Connect
V _{OB}	12	5	Output, Channel B
V _{INA}	13	4	Input, Channel A
V _{DD2}	14	14	Power Supply, Secondary Side
NC	15	15	No Connect
GND2	16	16	Ground, Secondary Side

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TRUTH TABLE (Note 1)

V _{INX}	V _{DDI}	V _{DDO}	V _{Ox}	Comment
H	Power Up	Power Up	H	Normal Operation
L	Power Up	Power Up	L	Normal Operation
X	Power Down	Power Up	L	Default low; V _{Ox} return to normal operation when V _{DDI} change to Power Up
X	Power Up	Power Down	Undetermined (Note 2)	V _{Ox} return to normal operation when V _{DDO} change to Power Up

- V_{INX} = Input signal of a given channel (A or B). V_{Ox} = Output signal of a given channel (A or B). V_{DDI} = Input-side V_{DD}. V_{DDO} = Output-side V_{DD}. X = Irrelevant. H = High level. L = Low level.
- The outputs are in undetermined state when V_{DDO} < V_{UVLO}.

SAFETY AND INSULATION RATINGS

As per DIN VDE V 0884-11, this digital isolator is suitable for “safe electrical insulation” only within the safety limit data. Compliance with the safety ratings must be ensured by means of protective circuits.

Symbol	Parameter	Min	Typ	Max	Units
	Installation Classifications per DIN VDE 0110/1.89 Table 1 Rated Mains Voltage	< 150 V _{RMS}	I-IV		
		< 300 V _{RMS}	I-IV		
		< 450 V _{RMS}	I-IV		
		< 600 V _{RMS}	I-IV		
		< 1000 V _{RMS}	I-III		
	Climatic Classification		40/100/21		
	Pollution Degree (DIN VDE 0110/1.89)		2		
CTI	Comparative Tracking Index (DIN IEC 112/VDE 0303 Part 1)	600			
V _{PR}	Input-to-Output Test Voltage, Method b, V _{IORM} × 1.875 = V _{PR} , 100% Production Test with t _m = 1 s, Partial Discharge < 5 pC	3750			V _{peak}
	Input-to-Output Test Voltage, Method a, V _{IORM} × 1.6 = V _{PR} , Type and Sample Test with t _m = 10 s, Partial Discharge < 5 pC	3200			V _{peak}
V _{IORM}	Maximum Working Insulation Voltage	2000			V _{peak}
V _{IOTM}	Highest Allowable Over Voltage	8000			V _{peak}
E _{CR}	External Creepage	8.0			mm
E _{CL}	External Clearance	8.0			mm
DTI	Insulation Thickness	0.50			mm
T _{Case}	Safety Limit Values – Maximum Values in Failure; Case Temperature	150			°C
P _{S,INPUT}	Safety Limit Values – Maximum Values in Failure; Input Power	100			mW
P _{S,OUTPUT}	Safety Limit Values – Maximum Values in Failure; Output Power	600			mW
R _{IO}	Insulation Resistance at TS, V _{IO} = 500 V	10 ⁹			Ω

ABSOLUTE MAXIMUM RATINGS (T_A = 25°C unless otherwise specified)

Symbol	Parameter	Value	Units
T _{STG}	Storage Temperature	-55 to +150	°C
T _{OPR}	Operating Temperature	-40 to +125	°C
T _J	Junction Temperature	-40 to +150	°C
T _{SOL}	Lead Solder Temperature (Refer to Reflow Temperature Profile)	260 for 10sec	°C
V _{DD}	Supply Voltage (V _{DDx})	-0.5 to 6	V
V	Voltage (V _{INx} , V _{Ox})	-0.5 to 6	V
I _O	Average Output Current	15	mA
PD	Power Dissipation	210	mW

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.

RECOMMENDED OPERATING CONDITIONS

Symbol	Parameter	Min	Max	Unit
T _A	Ambient Operating Temperature	-40	+125	°C
V _{DD1} V _{DD2}	Supply Voltage (Notes 3, 4)	2.5	5.5	V
V _{INH}	High Level Input Voltage	0.7 × V _{DDI}	V _{DDI}	V
V _{INL}	Low Level Input Voltage	0	0.1 × V _{DDI}	V
V _{UVLO+}	Supply Voltage UVLO Rising Threshold	2.2		V
V _{UVLO-}	Supply Voltage UVLO Falling Threshold	2.0		V
UVLO _{HYS}	Supply Voltage UVLO Hysteresis	0.1		V
I _{OH}	High Level Output Current	-2	-	mA
I _{OL}	Low Level Output Current	-	2	mA
DR	Signaling Rate	0	50	Mbps

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.

- During power up or down, ensure that both the input and output supply voltages reach the proper recommended operating voltages to avoid any momentary instability at the output state.
- For reliable operation at recommended operating conditions, V_{DD} supply pins require at least a pair of external bypass capacitors, placed within 2 mm from V_{DD} pins 3 and 14 and GND pins 1 and 16. Recommended values are 0.1 μF and 1 μF.

ISOLATION CHARACTERISTICS

Apply over all recommended conditions. All typical values are measured at T_A = 25°C.

Symbol	Parameter	Conditions	Min	Typ	Max	Units
V _{ISO}	Input–Output Isolation Voltage	T _A = 25°C, Relative Humidity < 50%, t = 1.0 minute, I _{I-O} ≤ 10 μA, 50 Hz (Notes 5, 6, 7)	5000			V _{RMS}
R _{ISO}	Isolation Resistance	V _{I-O} = 500 V (Note 5)		10 ¹¹		
C _{ISO}	Isolation Capacitance	V _{I-O} = 0 V, Frequency = 1.0 MHz (Note 5)		1		pF

- Device is considered a two–terminal device: pins 1 to 8 are shorted together and pins 9 to 16 are shorted together.
- 5,000 V_{RMS} for 1–minute duration is equivalent to 6,000 V_{RMS} for 1–second duration.
- The input–output isolation voltage is a dielectric voltage rating per UL1577. It should not be regarded as an input–output continuous voltage rating. For the continuous working voltage rating, refer to equipment–level safety specification or DIN VDE V 0884–11 Safety and Insulation Ratings Table on page 3.

ELECTRICAL CHARACTERISTICS

Apply over all recommended conditions, T_A = -40°C to +125°C, V_{DD1} = V_{DD2} = 2.5 V to 5.5 V, unless otherwise specified. All typical values are measured at T_A = 25°C.

Symbol	Parameter	Conditions	Min	Typ	Max	Units	Figure
V _{OH}	High Level Output Voltage	I _{OH} = -4 mA	V _{DDO} - 0.4	V _{DDO} - 0.1		V	7
V _{OL}	Low Level Output Voltage	I _{OL} = 4 mA		0.11	0.4	V	8
V _{INT+}	Rising Input Voltage Threshold				0.7 × V _{DDI}	V	
V _{INT-}	Falling Input Voltage Threshold		0.1 × V _{DDI}			V	
V _{INT(HYS)}	Input Threshold Voltage Hysteresis		0.1 × V _{DDI}	0.2 × V _{DDI}		V	
I _{INH}	High Level Input Current	V _{IH} = V _{DDI}			1	μA	
I _{INL}	Low Level Input Current	V _{IL} = 0 V	-1			μA	
CMTI	Common Mode Transient Immunity	V _I = V _{DDI} or 0 V, V _{CM} = 1500 V	100	150		kV/μs	10
C _{IN}	Input Capacitance	V _{IN} = V _{DDI} /2 + 0.4 × sin(2πft), f = 1 MHz, V _{DD} = 5 V		2		pF	

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.

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SUPPLY CURRENT CHARACTERISTICS

Apply over all recommended conditions, $T_A = -40^{\circ}\text{C}$ to $+125^{\circ}\text{C}$ unless otherwise specified. All typical values are measured at $T_A = 25^{\circ}\text{C}$.

Symbol	Parameter	Conditions	Min	Typ	Max	Units	Figure
I_{DD1}	DC Supply Current Input Low	$V_{DD} = 5\text{ V}, V_{IN} = 0\text{ V}$		4.5	6.3	mA	
I_{DD2}				5.0			
I_{DD1}		$V_{DD} = 3.3\text{ V}, V_{IN} = 0\text{ V}$		4.4	6.1		
I_{DD2}				4.9			
I_{DD1}		$V_{DD} = 2.5\text{ V}, V_{IN} = 0\text{ V}$		4.3	6		
I_{DD2}				4.8			
I_{DD1}	DC Supply Current Input High	$V_{DD} = 5\text{ V}, V_{IN} = 5\text{ V}$		11.8	14.5	mA	
I_{DD2}				12.1			
I_{DD1}		$V_{DD} = 3.3\text{ V}, V_{IN} = 3.3\text{ V}$		11.7	14.3		
I_{DD2}				11.9			
I_{DD1}		$V_{DD} = 2.5\text{ V}, V_{IN} = 2.5\text{ V}$		11.6	14.3		
I_{DD2}				11.8			
I_{DD1}	AC Supply Current 1 Mbps	$V_{DD} = 5\text{ V}, C_L = 15\text{ pF}$ $V_{IN} = 5\text{ V Square Wave}$		8.3	10.5	mA	3,4
I_{DD2}				8.7			
I_{DD1}		$V_{DD} = 3.3\text{ V}, C_L = 15\text{ pF}$ $V_{IN} = 3.3\text{ V Square Wave}$		8.1	10.3		
I_{DD2}				8.5			
I_{DD1}		$V_{DD} = 2.5\text{ V}, C_L = 15\text{ pF}$ $V_{IN} = 2.5\text{ V Square Wave}$		8.0	10.1		
I_{DD2}				8.4			
I_{DD1}	AC Supply Current 10 Mbps	$V_{DD} = 5\text{ V}, C_L = 15\text{ pF}$ $V_{IN} = 5\text{ V Square Wave}$		9.9	12	mA	
I_{DD2}				10.2			
I_{DD1}		$V_{DD} = 3.3\text{ V}, C_L = 15\text{ pF}$ $V_{IN} = 3.3\text{ V Square Wave}$		8.9	11		
I_{DD2}				9.3			
I_{DD1}		$V_{DD} = 2.5\text{ V}, C_L = 15\text{ pF}$ $V_{IN} = 2.5\text{ V Square Wave}$		8.6	10.5		
I_{DD2}				9.0			
I_{DD1}	AC Supply Current 50 Mbps	$V_{DD} = 5\text{ V}, C_L = 15\text{ pF}$ $V_{IN} = 5\text{ V Square Wave}$		14.8	17.5	mA	
I_{DD2}				15.2			
I_{DD1}		$V_{DD} = 3.3\text{ V}, C_L = 15\text{ pF}$ $V_{IN} = 3.3\text{ V Square Wave}$		12.1	14.3		
I_{DD2}				12.6			
I_{DD1}		$V_{DD} = 2.5\text{ V}, C_L = 15\text{ pF}$ $V_{IN} = 2.5\text{ V Square Wave}$		11.1	13		
I_{DD2}				11.6			

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SWITCHING CHARACTERISTICS

Apply over all recommended conditions, $T_A = -40^{\circ}\text{C}$ to $+125^{\circ}\text{C}$ unless otherwise specified. All typical values are measured at $T_A = 25^{\circ}\text{C}$.

Symbol	Parameter	Conditions	Min	Typ	Max	Units	Figure
t_{PHL}	Propagation Delay to Logic Low Output (Note 8)	$V_{\text{DD}} = 5\text{ V}$, V_{IN} Square Wave, $C_L = 15\text{ pF}$		17.0	25	ns	6,9
		$V_{\text{DD}} = 3.3\text{ V}$, V_{IN} Square Wave, $C_L = 15\text{ pF}$		18.3			
		$V_{\text{DD}} = 2.5\text{ V}$, V_{IN} Square Wave, $C_L = 15\text{ pF}$		20.0			
t_{PLH}	Propagation Delay to Logic High Output (Note 9)	$V_{\text{DD}} = 5\text{ V}$, V_{IN} Square Wave, $C_L = 15\text{ pF}$		13.0	25	ns	
		$V_{\text{DD}} = 3.3\text{ V}$, V_{IN} Square Wave, $C_L = 15\text{ pF}$		14.5			
		$V_{\text{DD}} = 2.5\text{ V}$, V_{IN} Square Wave, $C_L = 15\text{ pF}$		16.0			
PWD	Pulse Width Distortion $t_{\text{PHL}} - t_{\text{PLH}}$ (Note 10)	$V_{\text{DD}} = 5\text{ V}$, V_{IN} Square Wave, $C_L = 15\text{ pF}$		3.6	10	ns	
		$V_{\text{DD}} = 3.3\text{ V}$, V_{IN} Square Wave, $C_L = 15\text{ pF}$		3.8			
		$V_{\text{DD}} = 2.5\text{ V}$, V_{IN} Square Wave, $C_L = 15\text{ pF}$		3.8			
$t_{\text{PSK(PP)}}$	Propagation Delay Skew (Part to Part) (Note 11)	$V_{\text{DD}} = 5\text{ V}$, V_{IN} Square Wave, $C_L = 15\text{ pF}$	-10		10	ns	
		$V_{\text{DD}} = 3.3\text{ V}$, V_{IN} Square Wave, $C_L = 15\text{ pF}$					
		$V_{\text{DD}} = 2.5\text{ V}$, V_{IN} Square Wave, $C_L = 15\text{ pF}$					
t_{R}	Output Rise Time (10% to 90%)	$V_{\text{DD}} = 5\text{ V}$, V_{IN} Square Wave, $C_L = 15\text{ pF}$		1.1		ns	
		$V_{\text{DD}} = 3.3\text{ V}$, V_{IN} Square Wave, $C_L = 15\text{ pF}$		1.5			
		$V_{\text{DD}} = 2.5\text{ V}$, V_{IN} Square Wave, $C_L = 15\text{ pF}$		2.2			
t_{F}	Output Fall Time (90% to 10%)	$V_{\text{DD}} = 5\text{ V}$, V_{IN} Square Wave, $C_L = 15\text{ pF}$		1.1		ns	
		$V_{\text{DD}} = 3.3\text{ V}$, V_{IN} Square Wave, $C_L = 15\text{ pF}$		1.4			
		$V_{\text{DD}} = 2.5\text{ V}$, V_{IN} Square Wave, $C_L = 15\text{ pF}$		3.0			

8. Propagation delay t_{PHL} is measured from the 50% level of the falling edge of the input pulse to the 50% level of the falling edge of the V_{O} signal.

9. Propagation delay t_{PLH} is measured from the 50% level of the rising edge of the input pulse to the 50% level of the rising edge of the V_{O} signal.

10. PWD is defined as $|t_{\text{PHL}} - t_{\text{PLH}}|$ for any given device.

11. Part-to-part propagation delay skew is the difference between the measured propagation delay times of a specified channel of any two parts at identical operating conditions and equal load.

TYPICAL PERFORMANCE CHARACTERISTICS

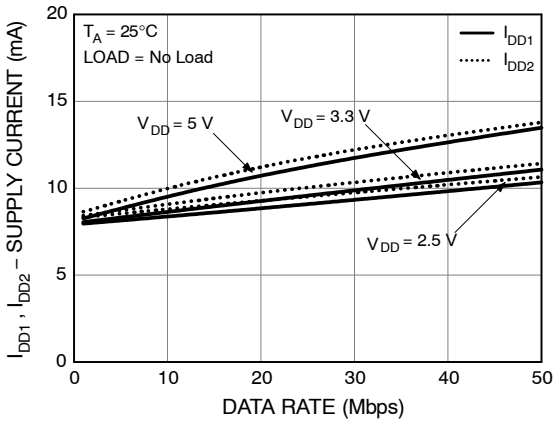


Figure 3. Supply Current vs. Data Rate (No Load)

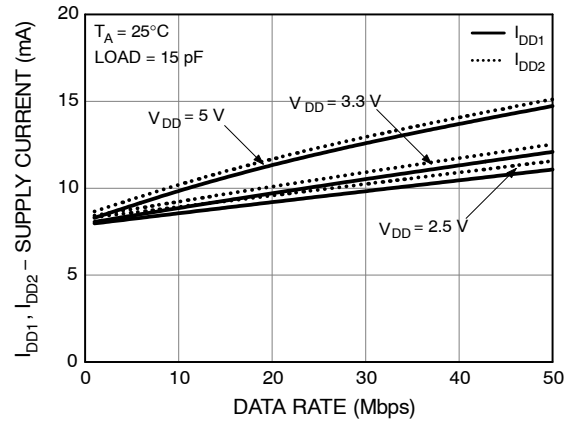


Figure 4. Supply Current vs. Data Rate (Load = 15 pF)

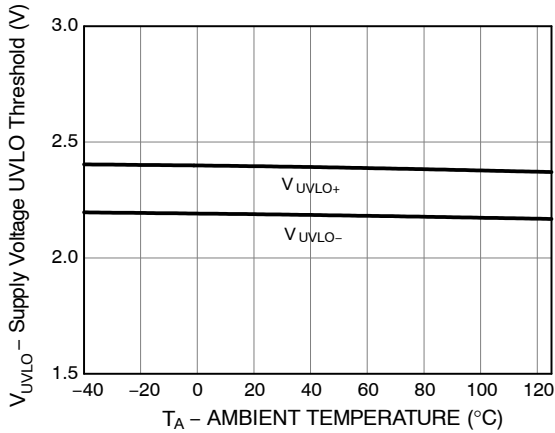


Figure 5. Supply Voltage UVLO Threshold vs. Ambient Temperature

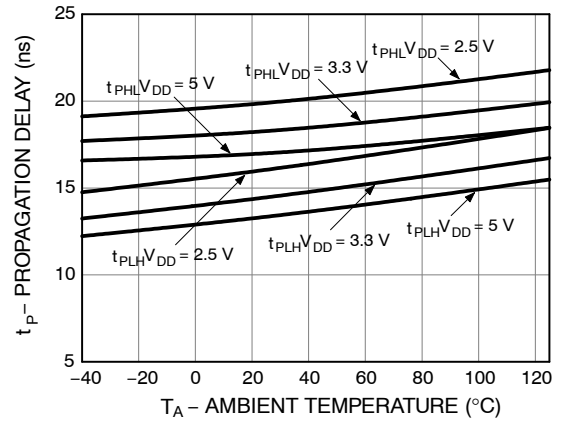


Figure 6. Propagation Delay vs. Ambient Temperature

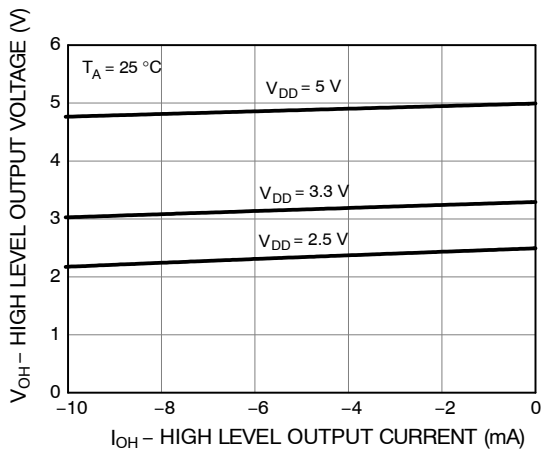


Figure 7. High Level Output Voltage vs. Current

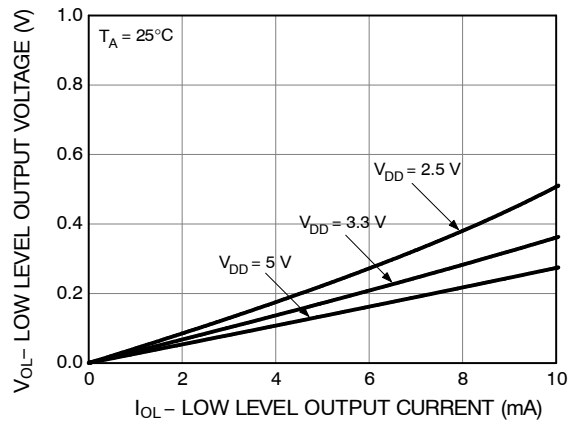


Figure 8. Low Level Output Voltage vs. Current

TEST CIRCUITS

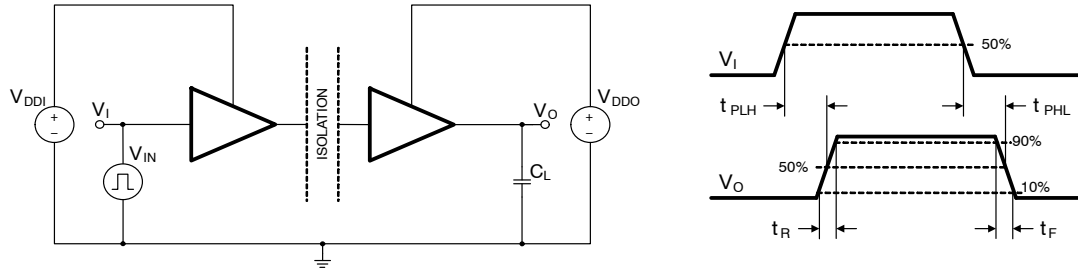


Figure 9. V_{IN} to V_O Propagation Delay Test Circuit and Waveform

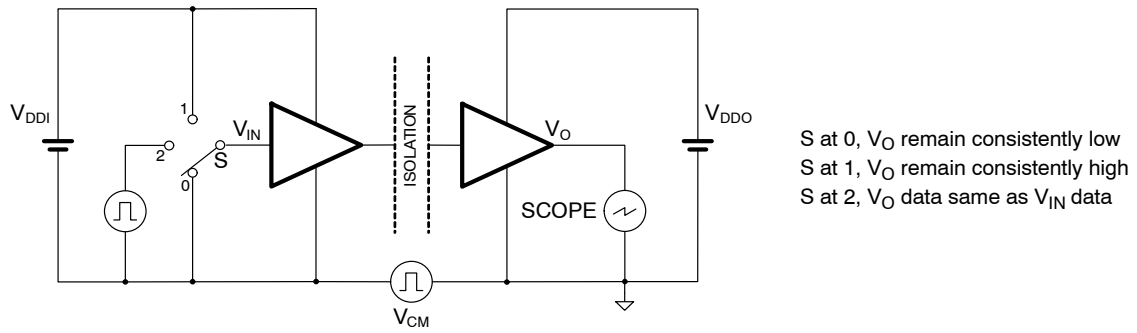


Figure 10. Common Mode Transient Immunity Test Circuit

APPLICATIONS INFORMATION

Theory of Operation

NCID9210 and NCID9216 are dual-channel digital isolators that enable bi-directional communication between two isolated circuits. They use off-chip ceramic capacitors that serve both as the isolation barrier and as the medium of transmission for signal switching using On-Off Keying (OOK) technique, illustrated in the single channel operational block diagram in Figure 11.

At the transmitter side, the V_{IN} input logic state is modulated with a high frequency carrier signal. The resulting signal is amplified and transmitted to the isolation barrier. The receiver side detects the barrier signal and demodulates it using an envelope detection technique. The output signal determines the V_O output logic state. V_O is at default state low when the power supply at the transmitter side is turned off or the input V_{IN} is disconnected.

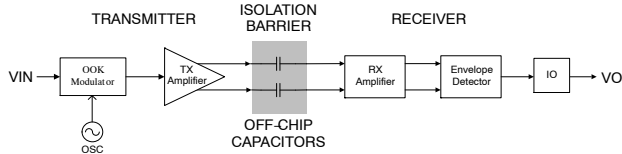


Figure 11. Operational Block Diagram of Single Channel

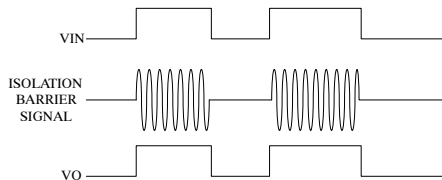


Figure 12. On-Off Keying Modulation Signals

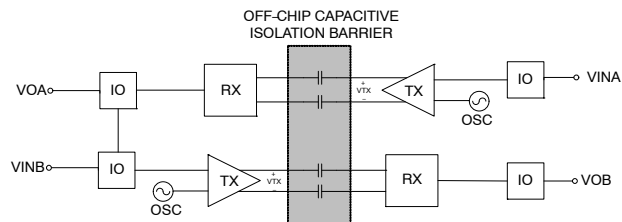


Figure 13. NCID9210 Operational Block Diagram

Layout Recommendation

Layout of the digital circuits relies on good suppression of unwanted noise and electromagnetic interference. It is recommended to use 4-layer FR4 PCB, with ground plane below the components, power plane below the ground plane,

signal lines and power fill on top, and signal lines and ground fill at the bottom. The alternating polarities of the layers creates interplane capacitances that aids the bypass capacitors required for reliable operation at digital switching rates.

In the layout with digital isolators, it is required that the isolated circuits have separate ground and power planes. The section below the device should be clear with no power, ground or signal traces. Maintain a gap equal to or greater than the specified minimum creepage clearance of the device package.

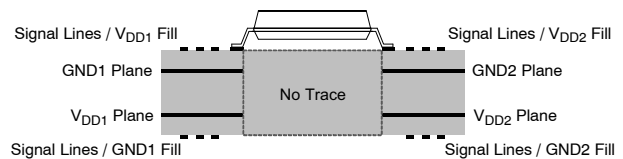


Figure 14. 4-Layer PCB for Digital Isolator

For NCID9210 and NCID9216, it is highly advised to connect at least a pair of low ESR supply bypass capacitors, placed within 2 mm from the power supply pins 3 and 14 and ground pins 1 and 16. Recommended values are 1 μF and 0.1 μF , respectively. Place them between the V_{DD} pins of the device and the via to the power planes, with the higher frequency, lower value capacitor closer to the device pins. Directly connect the device ground pins 1, 7, 9 and 16 by via to their corresponding ground planes.

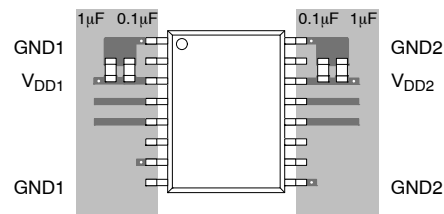


Figure 15. Placement of Bypass Capacitors

Over Temperature Detection

NCID9210 and NCID9216 have built-in Over Temperature Detection (OTD) feature that protects the IC from thermal damage. The output pins will automatically switch to default state when the ambient temperature exceeds the maximum junction temperature at threshold of approximately 160°C. The device will return to normal operation when the temperature decreases approximately 20°C below the OTD threshold.


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ORDERING INFORMATION

Part Number	Grade	Package	Shipping [†]
NCID9210	Industrial	SOIC16 W	50 Units / Tube
NCID9210R2	Industrial	SOIC16 W	750 Units / Tape & Reel
NCID9216 (pending)	Industrial	SOIC16 W	50 Units / Tube
NCID9216R2 (pending)	Industrial	SOIC16 W	750 Units / Tape & Reel
NCIV9210* (pending)	Automotive	SOIC16 W	50 Units / Tube
NCIV9210R2* (pending)	Automotive	SOIC16 W	750 Units / Tape & Reel
NCIV9216* (pending)	Automotive	SOIC16 W	50 Units / Tube
NCIV9216R2* (pending)	Automotive	SOIC16 W	750 Units / Tape & Reel

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

*NCIV Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC – Q100 Qualified and PPAP Capable.

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