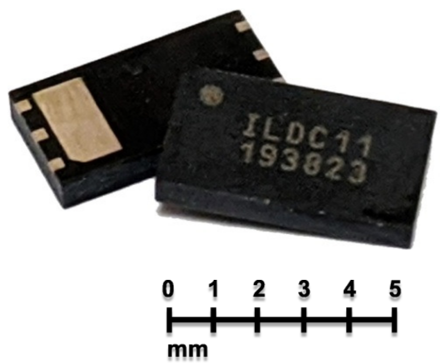
ILDC11 Ultraminiature DC-DC Convertor



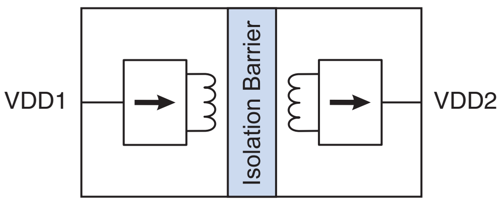
Features

- World's smallest DC-DC convertor
- Ultraminiature 3 x 5.5 x 0.9 mm (0.015 cm³) DFN package
- 3.3 V input to 3.3 V output
- 80 mA (¼ W) output
- Fully-regulated output
- No minimum load
- Ultralow ripple
- Low EMI without ferrite beads or inductors
- Short-circuit protection
- Thermal protection
- Full 2.5 kV_{RMS} isolation
- Full −40 °C to 125 °C operating range with no derating

Applications

- Ground loop mitigation
- RS-485 / RS-422 bus power supplies
- Isolated SPI / Microwire interfaces
- Isolated analog power supplies

Block Diagram



Description

The ILDC11 is an ultraminiature one-third watt fully-regulated 3.3V-to-3.3V DC-DC convertor that generates an independent, isolated 3.3-volt bus supply.

NVE's proven IsoLoop® isolation technology and a unique ceramic/polymer composite barrier provide full 2.5 kV isolation and virtually unlimited barrier life.

The device minimizes board space and parts count, requiring just three external capacitors. No additional regulation is required and there is no minimum load.

Frequency hopping and shielding reduce EMI and eliminate the need for ferrite beads.

A high-temperature process allows up to 175 °C junction temperature for full power up to 125 °C operating temperature with no derating. Continuous short-circuit protection avoids excessive power dissipation.

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Absolute Maximum Ratings

Parameter	Min.	Max.	Units
Supply voltage	–0.6	6	Volts
Storage temperature	–55	180	°C
Junction temperature	–55	180	°C

Recommended Operating Conditions

Parameter	Symbol	Min.	Typ.	Max.	Units	Test Conditions
Ambient operating temperature	T_{min}; T_{max}	–40		125	°C	
Junction temperature	T_J	–40		175	°C	
Input supply voltage	V_{DD1}	3	3.3	3.6	V	
Output current	I_{DD2}	0		80	mA	

Electrical Specifications

T_{min} to T_{max} and V_{DD1} = 3 V to 3.6 V unless otherwise stated

Parameter	Symbol	Min.	Typ.	Max.	Units	Test Conditions
Output voltage	V_{DD2}	3	3.3	3.45	V	T_{min} to T_{max}; full V_{DD1} and I_{DD2} operating range
Output current	I_{DD2}	80			mA	
Short-circuit protection limited current	$I_{DD2\text{-}SC}$	115	125	135	mA	
Input quiescent supply current	I_{DD1Q}		200	240	mA	$I_{DD2} = 0$
Input supply current	I_{DD1}		380	440	mA	I_{DD2} = max.
Line regulation	$\Delta V_{DD2}/\Delta V_{DD1}$		32	40	mV/V	25 °C
			16			125 °C
Load regulation	$\Delta V_{DD2}/V_{DD2}$		5	6	%	I_{DD2} = 0 to max.
Output voltage temperature coefficient	$(\Delta V_{DD2}/V_{DD2})/\Delta T$		0.017 0.03		%/°C	I_{DD2} = 10 mA I_{DD2} = 50 mA
Capacitive load	C_{DD2}			1000	µF	
Output voltage ripple	$V_{DD2RIPPLE}$			5	$mV_{P\text{-}P}$	20 MHz bandwidth; I_{DD2} = max.
			1			1 kHz bandwidth; I_{DD2} = max.
Start-up current	$I_{DD1\text{-}SU}$		600	750	mA	700 ns max.
Start-up time	t_{SU}		200		µs	No load
			400			Full load (resistive)
Convertor frequency	f_{OSC}	105	113	120	MHz	

Thermal Specifications

Parameter	Symbol	Min.	Typ.	Max.	Units	Test Conditions
Junction-to-ambient thermal resistance	θ_{JA}		46		°C/W	2s2p PCB per JESD51; leadframe pad grounded; free air.
Junction-to-case (top) thermal resistance	θ_{JC}		12			
Junction-to-ambient thermal resistance	θ_{JA}		52.5			2-sided PCB with 2 oz Cu and thermal vias; leadframe pad grounded.
Junction-to-case (top) thermal resistance	θ_{JC}		8			
Package power dissipation	P			1.5	W	

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Isolation Specifications

Parameter	Symbol	Min.	Typ.	Max.	Units	Test Conditions
Isolation voltage*	V_{ISO}	2500			V_{RMS}	Per VDE V 0884-11
Working voltage	V_{IORM}	400			V_{RMS}	
Transient overvoltage	V_{IOTM}	4000			V_{PK}	
Surge immunity		6666			V_{PK}	
Creepage distance (external)		3.5			mm	Per IEC 60601
Total barrier thickness (internal)		0.013	0.016		mm	
Isolation barrier resistance	R_{IO}		$>10^{14}$		Ω	500 V_{RMS}
Isolation barrier capacitance	C_{IO}		7		pF	f = 1 MHz
Leakage current			0.2		μA_{RMS}	240 V_{RMS}, 60 Hz
Comparative tracking index	CTI	≥175			V_{RMS}	Per IEC 60112
Barrier life			44000		Years	100°C, 1000 V_{RMS}, 60% CL activation energy

*Each part tested at 1590 V_{PK} for 1 second, 5 pC partial discharge limit.
Samples tested at 4000 V_{PK} for 60 sec.; then 1358 V_{PK} for 10 sec. with 5 pC partial discharge limit.
UL 1577 approval pending under Component Recognition Program File Number E207481.

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Features

True Isolation
A unique ceramic/polymer composite barrier provides full 2.5 kV isolation with virtually unlimited barrier life.

Low Parts Count
The only external components required are three inexpensive bypass capacitors on the VDD1, VDD2, and VF pads. This low external parts count reduces board area and cost.

Fully Regulated with no Minimum Load
Unlike other DC-DC convertors, the ILDC11 has a fully-regulated output specified over the full input voltage and output current operating ranges. This eliminates the need for an external regulator or load resistor.

Ultralow Ripple
An inexpensive external filter capacitor (VF) and excellent line regulation ensure output ripple voltage is less than 5 mV_{P-P}.

Short-Circuit Protection
The output current is internally limited to approximately 125 mA. This provides short-circuit protection and eliminates the need for external protection circuitry.

Inherently Low EMI
The DC-DC convertor oscillator operates above 88 MHz, where emission limits are higher since there is less risk of interference with some common commercial radio and television broadcasting.

Frequency-hopping technology dramatically reduces peak EMI, and synchronous rectification and PWM control are avoided, resulting in inherently low EMI. Ferrite beads are not required for EMI mitigation.

These features allow CISPR and FCC compliance without external components or shielding.

Operation

An ILDC11 block diagram is shown below:

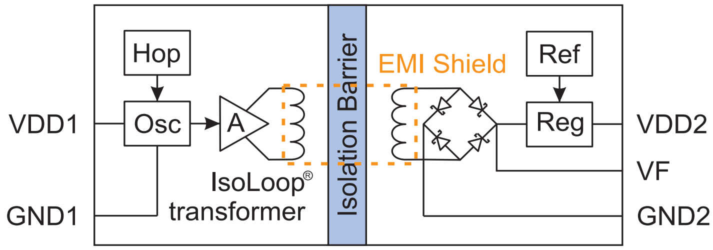


Figure 1. ILDC11 detailed block diagram.

A 113 MHz oscillator drives a high-frequency power amplifier, which in turn drives an IsoLoop® microtransformer primary. Frequency hopping reduces EMI peak amplitudes, and embedded magnetic shielding further reduces radiated EMI.

On the other side of the isolation barrier, the transformer secondary output is filtered, rectified, and regulated by a low-EMI low drop-out regulator with a precision bandgap voltage reference.

A high-temperature process allows up to 175 °C junction temperature for full power up to 125 °C operating temperature with no derating.

Application Information

Low Parts Count
The only external components required are three inexpensive bypass capacitors: a 0.1 µF ceramic capacitor placed as close as possible to the VDD1 pad, a 10 µF ceramic capacitor for the VDD2 pad, and a 0.1 µF/16 V filter capacitor near the VF pad.

Start-Up Current
The input power supply to the DC-DC convertor must be able to supply a start-up surge current of 750 mA for at least 700 ns for the DC-DC convertor to start up properly. If the input current is supplied by a regulator (such as shown in Figure 16) a one-amp regulator provides adequate current.

Fully Regulated with no Minimum Load
The ILDC11 has a fully-regulated output specified over the full input voltage and output current operating ranges, eliminating the need for an external regulator or load resistor.

Inherently Low EMI
Inherently low EMI eliminates the need for ferrite beads or other EMI mitigation.

No Temperature Derating
A double sided, double buried power plane ("2s2p") printed-circuit board optimizes thermal performance, allowing full power up to 125 °C operating temperature with no derating. Thermal vias should be used between the power plane and the board surfaces. Both input-side ground pads (pads 1 and 3) and the leadframe pad should be grounded using wide traces to help cool the leadframe.

At the full output current with the recommended PCB, the ILDC11 dissipates approximately one watt and the resultant junction temperature rise is 46 °C, so at 125 °C ambient the junction temperature is less than the 175 °C maximum junction temperature.

A simple double-sided PCB with thermal vias can be used rather than a 2s2p PCB with some derating (see Figure 6).

Maintaining Creepage
Creepage distances are often critical in isolated circuits. Therefore power planes should be spaced to avoid compromising creepage or clearance, and board pads should not extend past the part pads to avoid compromising clearance.

Typical Performance Graphs

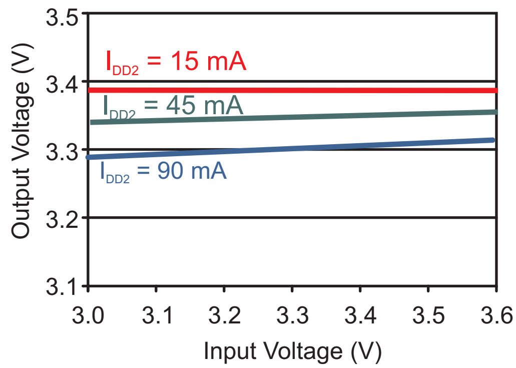


Figure 2. Typical line regulation (25 °C).

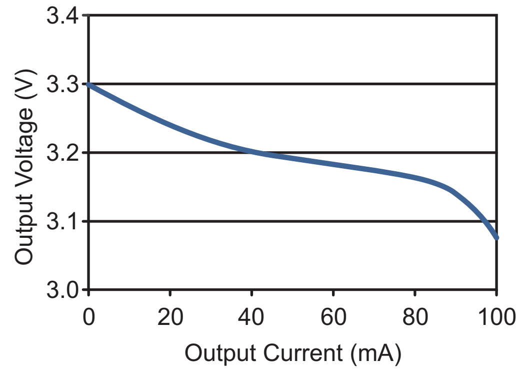


Figure 3. Typical load regulation (V_{DD1} = 3.3 V; 25 °C).

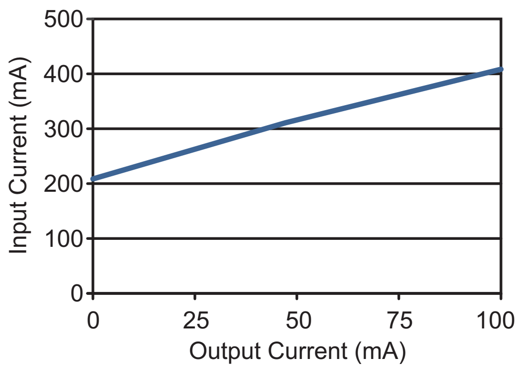


Figure 4. Typical input current versus output current (V_{DD1} = 3.3 V; 25 °C).

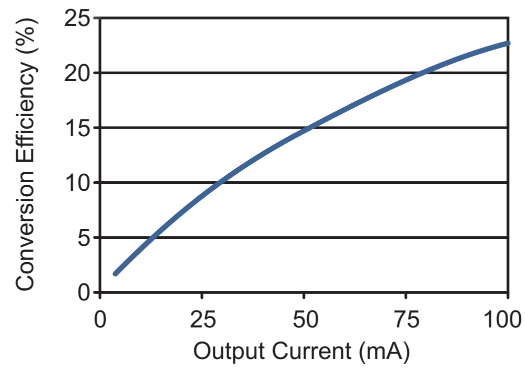


Figure 5. Conversion power efficiency (V_{DD1} = 3.3 V; 25 °C).

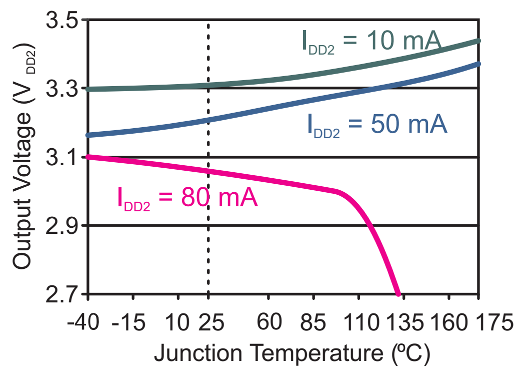


Figure 6. DC-DC convertor output vs. temperature and self-limiting current.

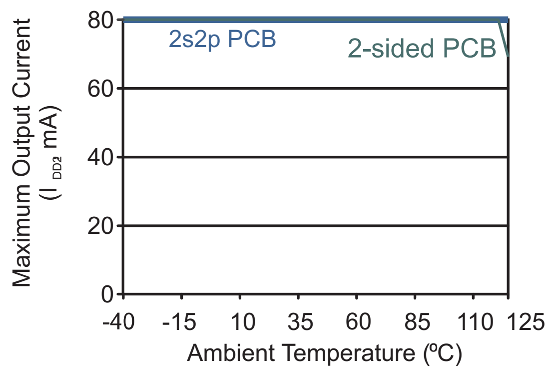


Figure 7. Temperature derating curve (V_{DD1} = 3.3 V).

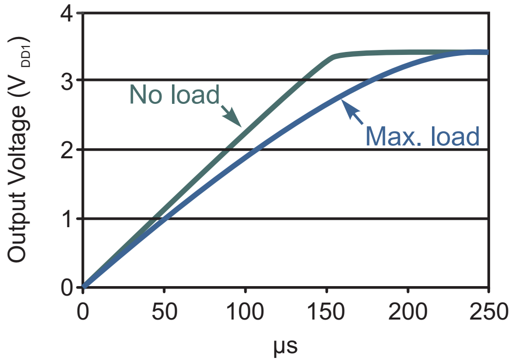


Figure 8. Typical output startup (C_L = 10 µF).

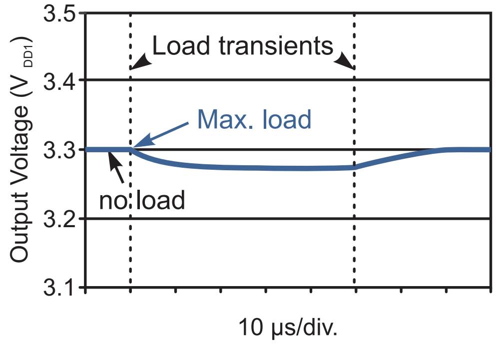


Figure 9. Typical output transient load response (C_L = 10 µF).

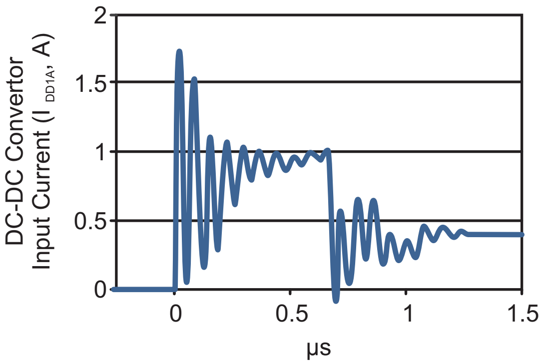


Figure 10. Typical start-up current (max. load; no V_{DD1} bypass capacitor).

Typical Applications

Typical isolated RS-485 bus power supply and node:

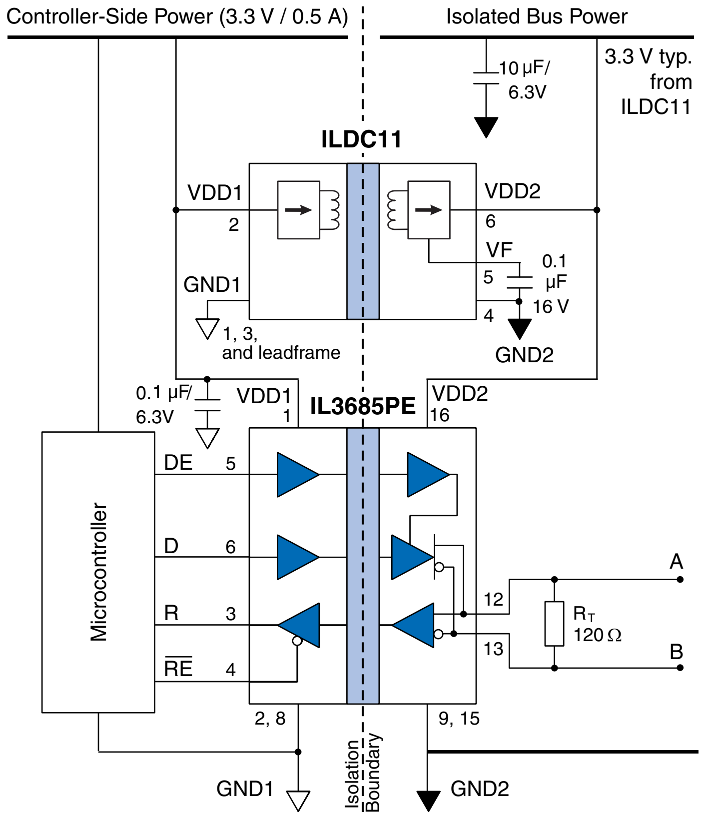


Figure 11. An isolated 3.3-volt RS-485 bus supply and node.

An isolated 3.3 volt bus supply is generated from the controller supply. The ILDC11 generates enough power for an RS-485 bus and termination resistors.

Isolated controller supply from a 3.3-volt bus:

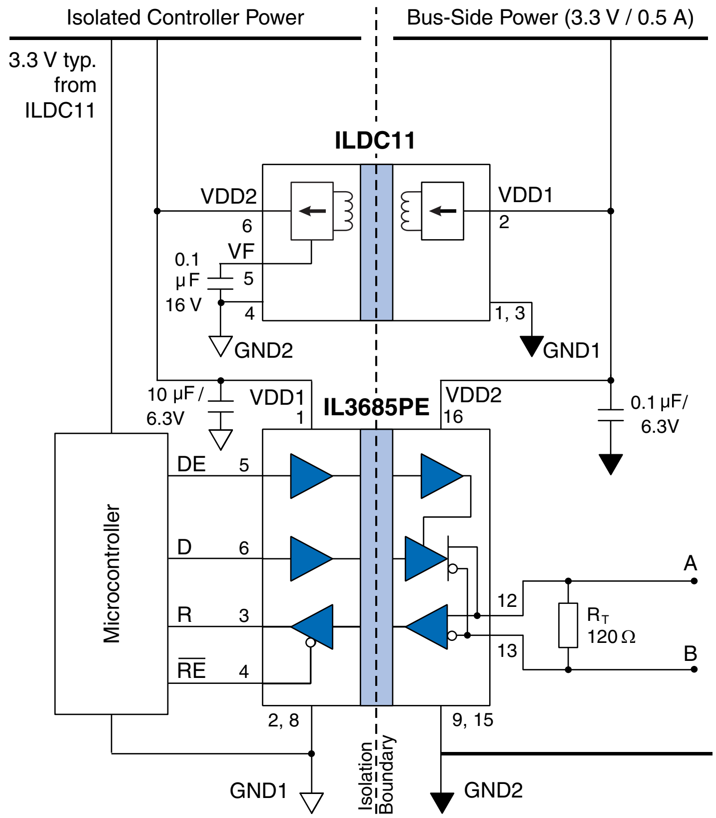


Figure 12. Reversed configuration: isolated controller supply from a 3.3-volt bus.

Normally the bus supply is generated from the controller supply, but the reverse is also possible. An advantage of this configuration is that since the DC-DC convertor does not need to supply the bus-side power, the bus can have two 120Ω termination resistors with the transceiver running at maximum speed, a combination that would exceed the ILDC11's maximum output current if it were powering the bus. The ILDC11 generates enough power to supply a microcontroller and other circuitry in addition to a transceiver.

Isolated SPI sensor interface:

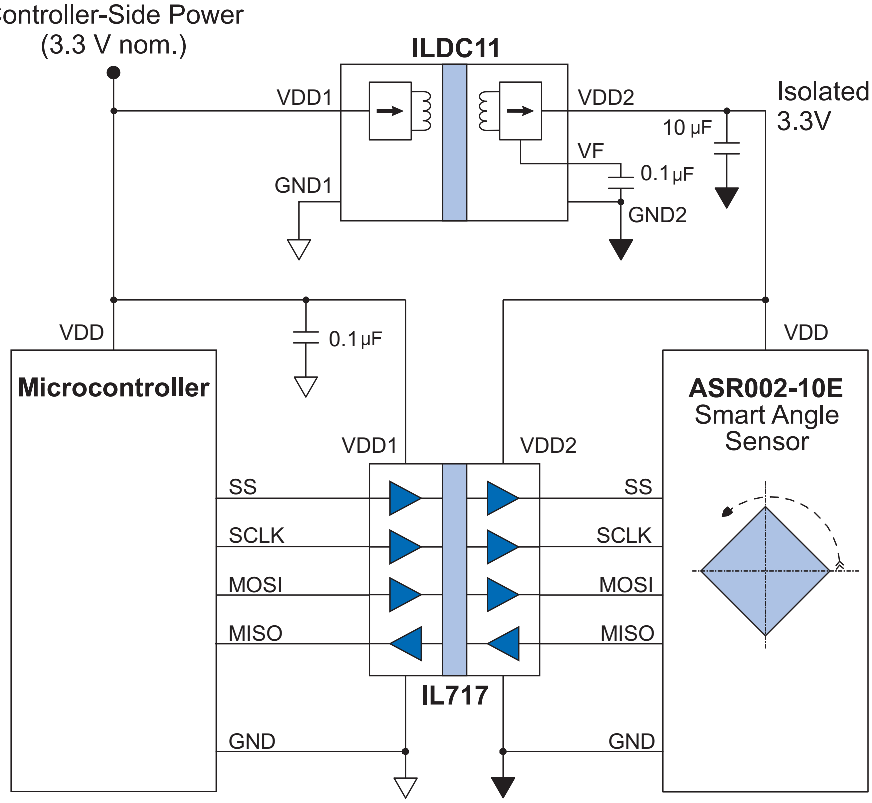


Figure 13. An isolated SPI sensor interface.

Isolation reduces noise by eliminating ground loops, and improves safety by providing another insulation level. The ILDC11 generates an isolated power supply to independently power the sensor. The four-channel IL717 isolator transmits the SPI signals while maintaining galvanic isolation. A five-channel IL261 isolator can be used to select between two sensors A similar circuit can be used for a variety of four-wire interface sensors, including angle, magnetic field, current, temperature, or pressure sensors.

Isolated SPI / MICROWIRE ADC interface:

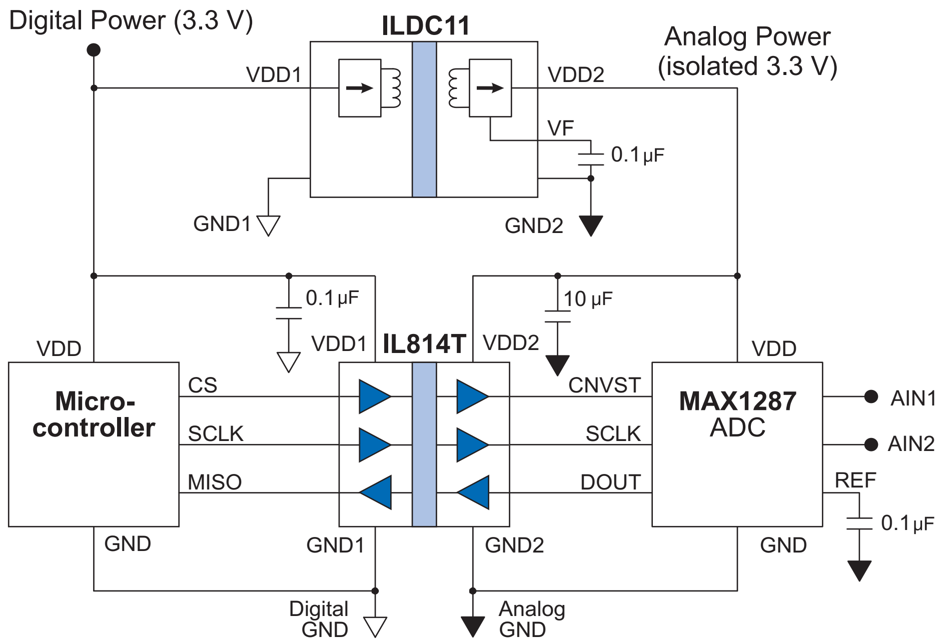


Figure 14. Isolated ADC serial interface.

An isolated analog power supply generated by the ILDC11 significantly improves the noise performance of a successive-approximation ADC. The three-channel IL814TE isolates the ADC's serial interface. A similar circuit can be used for other three-wire SPI or MICROWIRE peripherals such as DACs or sensors.

5-volt input:

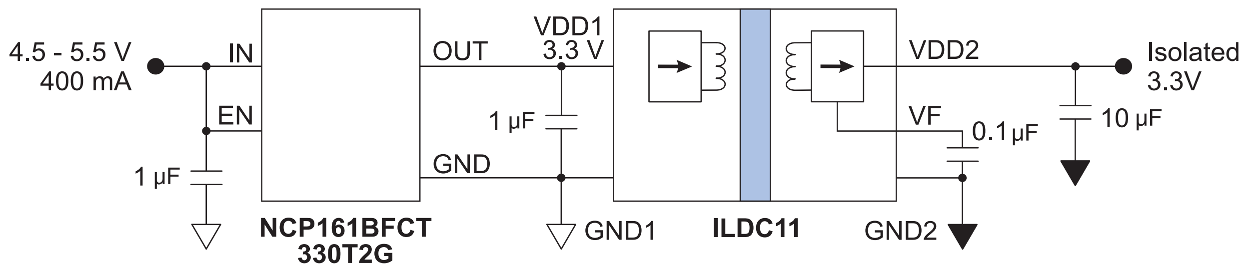


Figure 15. A 5-volt input / 3.3-volt output isolated supply.

An inexpensive chip-scale linear regulator such as an NCP161 can be used for a 5-volt input.

High-efficiency 5-volt input:

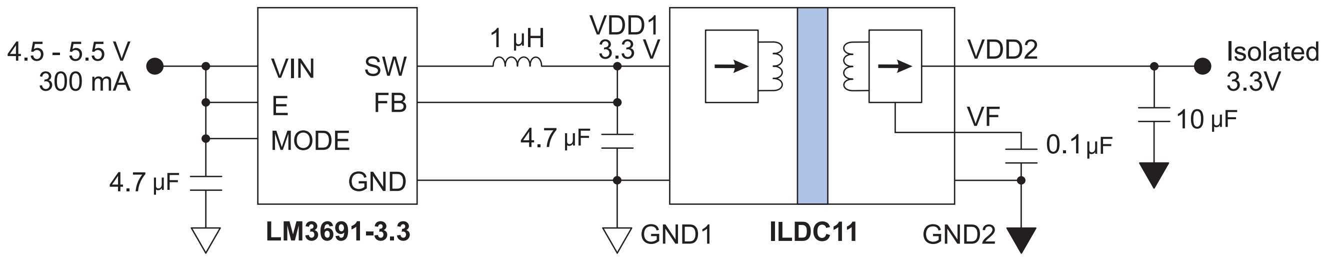


Figure 16. A 5-volt input / 3.3-volt with a buck regulator.

A step-down (buck) switching regulator can be used with a 5-volt input for higher efficiency than a linear regulator. A 1 A regulator is used to accommodate the ILDC11's start-up current.

Isolated 5-volt output:

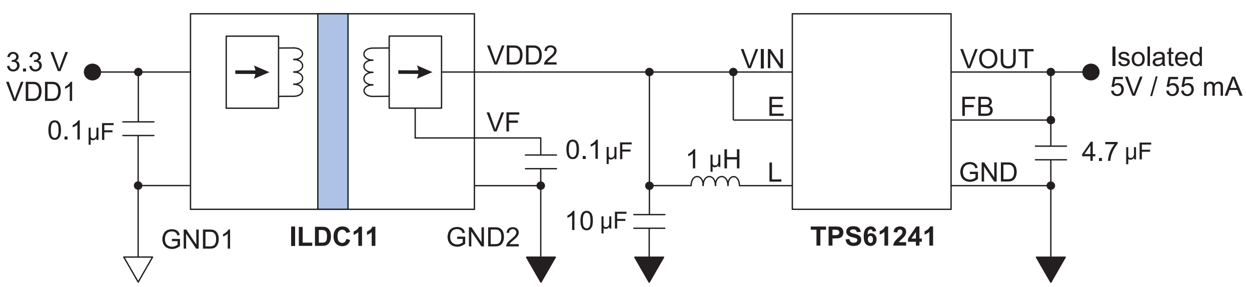
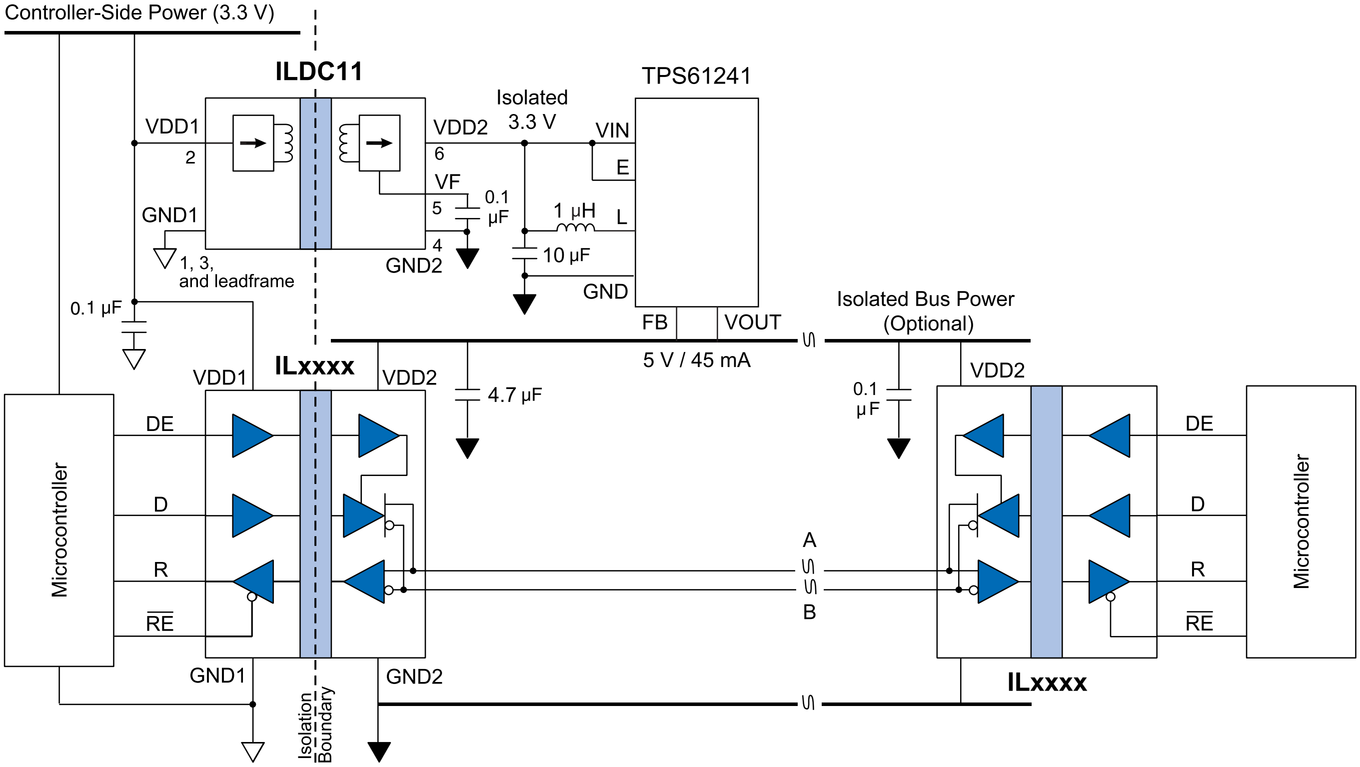


Figure 16. A 3.3-volt input / 5-volt output isolated supply.

An inexpensive boost regulator can be added to the ILDC11 to provide an isolated 5-volt output. The ILDC11's inherent stability allows it to directly drive the inductive load required for the boost regulator.

Isolated 5-volt bus system:



5-Volt Isolated Transceivers							
Model	**Duplex**	**Inputs**	**Mbps**	**Nodes**	**Bus ESD**	**Key Features**	**Available Packages**
IL3022	Full	Digital	4	32	7.5 kV	Low Cost	0.3" SOIC16
IL2985	Half	Digital	4	32	15 kV	Low Power	0.3" SOIC16
IL3085	Half	Digital	4	32	15 kV	Low Cost	QSOP16; 0.15" SOIC16; 0.3" SOIC16
IL3522	Full	Digital	40	50	15 kV	Very High Speed	0.3" SOIC16
IL3585	Half	Digital	40	50	15 kV	Very High Speed	0.15" SOIC16; 0.3" SOIC16
IL3685	Half	Digital	40	50	15 kV	PROFIBUS	QSOP16; 0.15" SOIC16; 0.3" SOIC16

Figure 17. An isolated 5-volt RS-485 bus system.

An ILDC11 plus a boost regulator provides isolated 5 volts for a traditional RS-485 bus. The 5-volt capacity is 45 mA, which is enough to power an RS-485 transceiver without termination resistors. It can also power a number of additional low-power nodes if desired. Low-power IL2985 transceivers have a maximum bus-side quiescent supply current of less than 2 mA. Other 5-volt isolated transceiver options include the 40 Mbps IL3585, the 40 Mbps PROFIBUS IL3685, the low-cost IL3085, and the full-duplex IL3522 or IL3022. Ultraminiature IL3685-1E or IL3085-1E QSOP16 versions are available to minimize board area.

Isolated H-Bridge Driver:

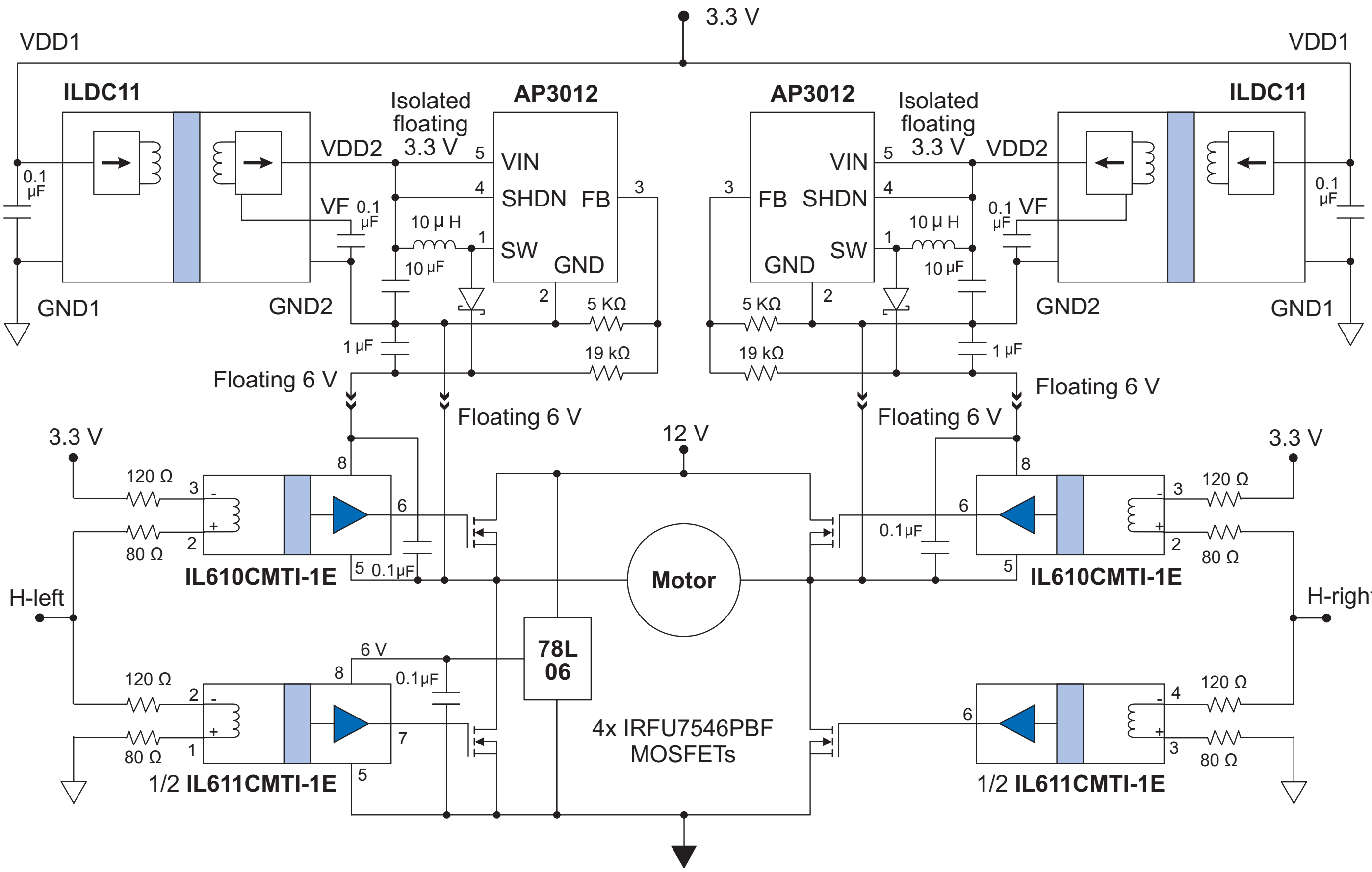
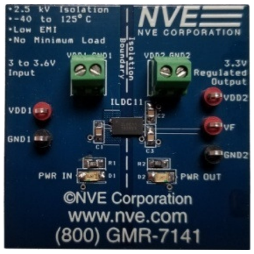


Figure 18. Isolated H-Bridge Driver.

The ILDC11 isolates and floats the high-side gate power, and commodity regulators boost the output to the six volts needed to drive the MOSFET gates.

Four channels of isolation in three MSOP-8 isolators allow referencing the high-side gate signals to the floating MOSFET source pins, plus they level-shift low-voltage controller inputs to six volts to drive MOSFET gates. These isolators have low-impedance outputs to directly drive MOSFETs, so separate MOSFET drivers are not required. The IL600CMTI isolators are the world's smallest isolators, with the highest common-mode transient immunity in the industry. With up to 350 kV/μs guaranteed transient immunity, the IL610CMTI prevents spurious isolator switching when the high-side MOSFET switches.

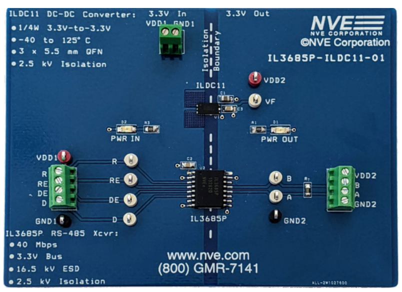
Evaluation Board



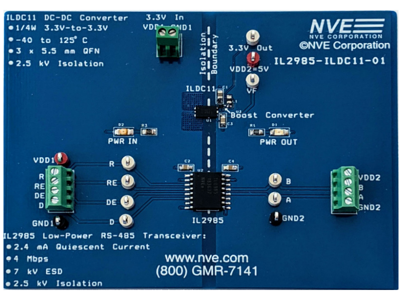
ILDC11-01 Evaluation Board
This board uses a 2s2p PCB with thermal vias for optimal thermal performance.
The 1.75 by 1.75 inch (45 by 45 mm) board has an ILDC11-15E plus the three required external bypass capacitors as well as LEDs to show the DC-DC convertor is operating. Screw terminals provide easy connections.

RS-485 / DC-DC Convertor Demonstration Boards

The ILDC11 is ideal for generating isolated bus supplies for RS-485 nodes. These 4 x 3 inch (100 x 75 mm) boards demonstrate complete isolated RS-485 nodes using isolated transceivers and ILDC11-15Es. The boards demonstrate recommended layout practices, and provide screw terminal and test point connections.

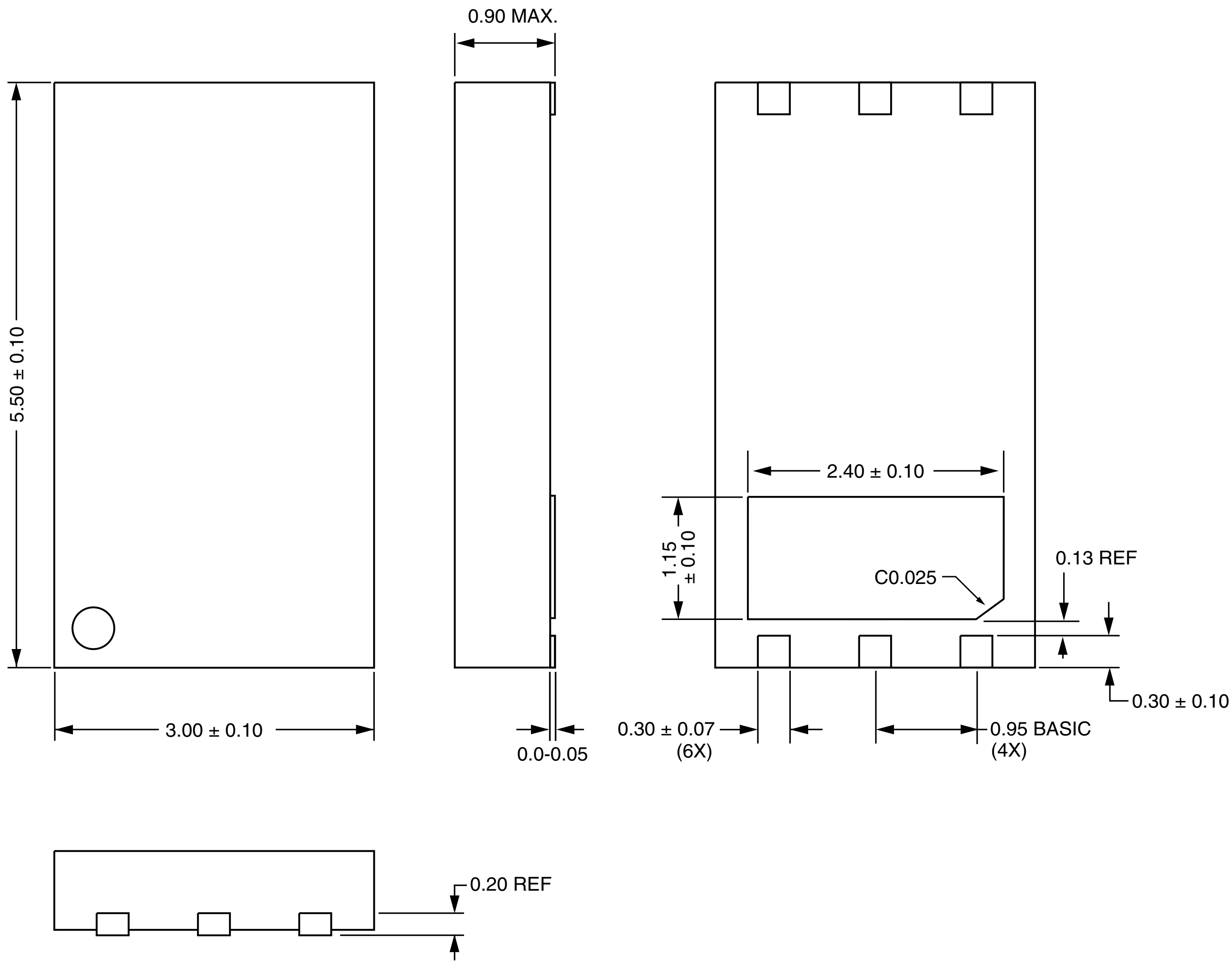


***IL3685P-ILDC11-01*: Isolated 3.3 V RS-485 Node**
This Demonstration Board is a complete isolated 3.3-volt RS-485 node using an IL3685PE 40 Mbps isolated transceiver and an ILDC11-15E DC-DC convertor.



***IL2985-ILDC11-01*: Isolated 5 V RS-485 Transceiver Node**
This board is an isolated 5-volt RS-485 node using an IL2985E low-power transceiver and an ILDC11-15E. The ILDC11-15E isolates the 3.3-volt controller supply and a commodity boost regulator provides a five-volt bus supply. The IL2985E is a 4 Mbps low-power, fully-isolated, 5-volt bus transceiver.

3 mm x 5.5 mm DFN6 Package



Pad	Symbol	Description
1	GND1	Input-Side Ground (internally connected to pad 3)
2	VDD1	Input Supply (bypass with a 0.1 µF capacitor)
3	GND1	Input-Side Ground (internally connected to pad 1)
4	GND2	Output-Side Ground
5	VF	Filter capacitor (connect to a 0.1 µF / 16 V external capacitor)
6	VDD2	Output (bypass with a 10 µF / 6.3 V capacitor)
Leadframe pad	GND1	Input-side leadframe connection (connect to GND1 to optimize thermal performance)

Notes:
- Dimensions in millimeters.
- Soldering profile per JEDEC J-STD-020C, MSL 1.

RoHS COMPLIANT

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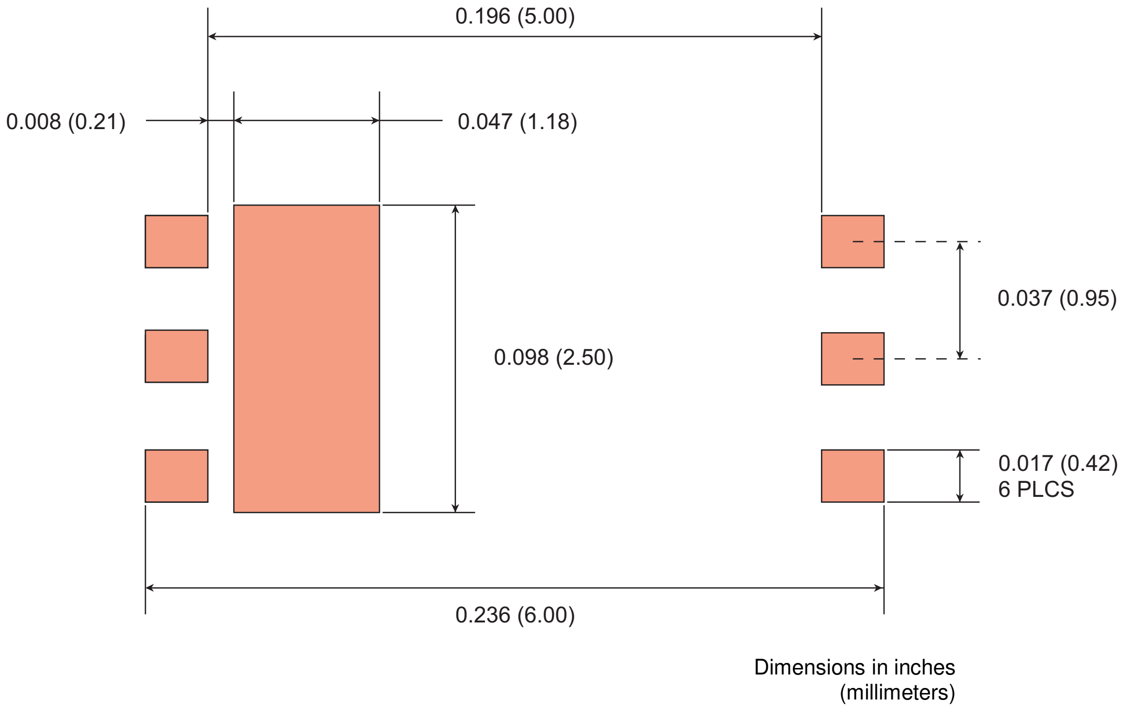
Recommended Layout Footprint



Ordering Information

ILDC11-15E TR7

Product Line
IL = Isolation products

Product Family
DC = DC-DC convertor

Part Number
11 = 3.3 V in / 3.3 V out

Part Package
15E = 3 x 5.5 mm DFN package, RoHS-compliant

Bulk Packaging
Blank = Bulk
TR7 = 7" Tape and Reel
TR13 = 13" Tape and Reel

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Revision History

ISB-DS-001-ILDC11-RevD
Sept. 2020

Change
- More detailed Figure 18 (isolated H-bridge driver).

ISB-DS-001-ILDC11-RevC
July 2020

Changes
- Added start-up current specification (p. 2) and typical graph (Figure 10).
- Added thermal protection description (p. 2) and typical graph (Figure 10).
- Updated step-down regulator reference design with higher-current regulator (Figure 16).

ISB-DS-001-ILDC11-RevB
June 2020

Change
- Added efficiency performance graph (Figure 5).

ISB-DS-001-ILDC11-RevA
June 2020

Changes
- Finalized performance graphs.
- Changed package description from QFN to DFN.
- Additional application circuits.
- Initial release.

ISB-DS-001-ILDC11-PRELIM3
February 2020

Changes
- Updated and expanded thermal resistance specifications.
- Added a derating curve for a double-sided PCB.
- Added application circuits.
- Added Evaluation Boards.

ISB-DS-001-ILDC11-PRELIM2
January 2020

Changes
- Updated and expanded thermal resistance specifications.
- Added application circuits with external regulators.
- Added recommended pad footprint layout (p. 12).

ISB-DS-001-ILDC11-PRELIM
December 2019

Change
- Preliminary release.

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Datasheet Limitations
The information and data provided in datasheets shall define the specification of the product as agreed between NVE and its customer, unless NVE and customer have explicitly agreed otherwise in writing. All specifications are based on NVE test protocols. In no event however, shall an agreement be valid in which the NVE product is deemed to offer functions and qualities beyond those described in the datasheet.

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ISB-DS-001-ILDC11

Sept. 2020