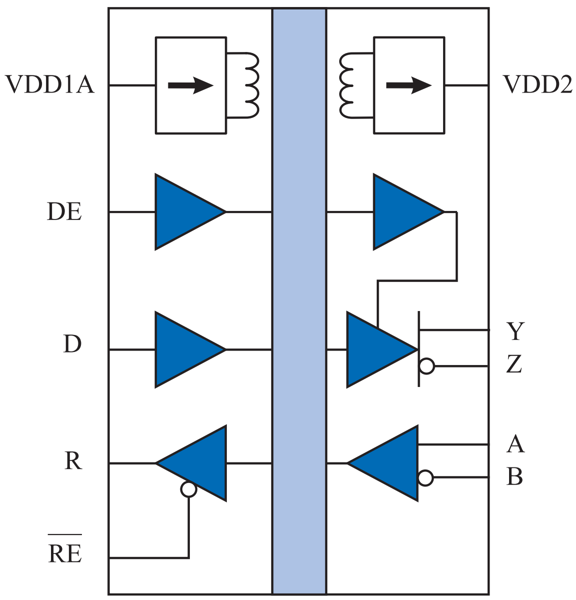
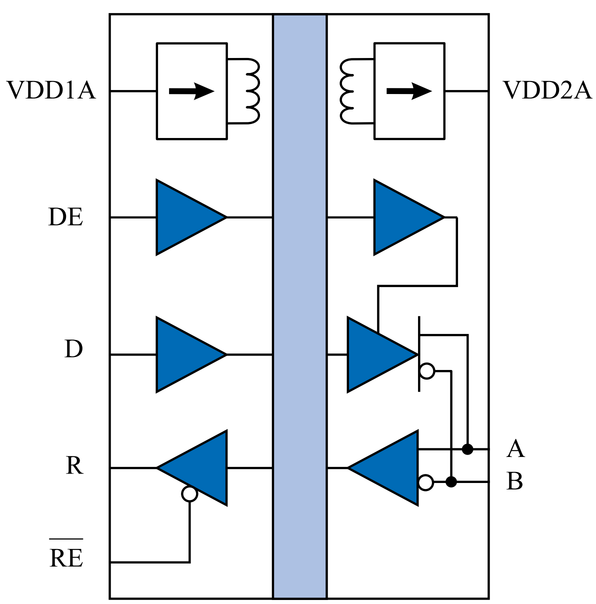
High-Speed Isolated RS-422 / RS-485 Transceivers with Integrated DC-to-DC Convertors

Block Diagrams



IL4x22



IL4685

Features

- 40 Mbps transceiver
- Integrated ¼ watt, DC-to-DC convertor
- 3.3 V or 5 V bus supplies; both fully compatible and interoperable with 5 V buses
- 1/5 Unit Load; 160 node fanout
- Fully PROFIBUS compliant (IL4822)
- 2500 V_{RMS} isolation voltage
- Up to 16.5 kV bus ESD protection
- Full failsafe
- Overcurrent and thermal shutdown protection
- –40 °C to 85 °C temperature range
- VDE 0884-17 certified; UL1577 registered
- EN 55032 CISPR 32 Class B compliant
- 0.3" True 8™ mm 16-pin SOIC package

Applications

- Factory automation
- Industrial control networks
- Medical instruments

Description

IL4xxx-Series Transceivers are high-speed, fully-isolated, differential bus transceivers with integrated DC-to-DC convertors to provide fully-isolated bus supplies from the 3.3 V controller supply.

The IL4822 generates a 5 V bus supply; the IL46xx versions generate 3.3 V bus supplies. The 3.3 V versions can provide more current than 5 V bus supplies.

Despite their 3.3 V bus supplies, IL46xx versions are fully compatible and interoperable with 5 V buses.

IL4x22 versions have full-duplex connections for RS-422 or RS-485 buses; the IL4685 has a half-duplex transceiver generally used with RS-485. The IL4822 is fully PROFIBUS compliant.

The devices use NVE's proven, patented* spintronic Giant Magnetoresistance (GMR) isolation technology and IsoLoop® high-efficiency micro-scale isolation transformers.

A unique ceramic/polymer composite barrier provides full isolation and virtually unlimited barrier life.

Integrated shielding and DC-to-DC convertor frequency hopping minimize EMI. Parts are EN 55032 CISPR 32 Class B compliant with just a small amount of stitching capacitance.

Current limiting and thermal shutdown features protect against bus short circuits and contention to prevent excessive power dissipation.

IsoLoop® is a registered trademark of NVE Corporation.
*U.S. Patent number 5,831,426; 6,300,617 and others.

Rev. E

Truth Tables

IL4x22 Receiver

$\overline{RE}$	R	$V_{(A-B)}$
H	Z	X
L	H	≥ 200 mV
L	L	≤–200 mV
L	H	Open

IL4x22 Driver

DE	D	$V_{(Y-Z)}$
L	X	Z
H	H	≥ 2 V
H	L	≤–2 V

IL4685

V_{ID} (A-B)	DE	$\overline{RE}$	R	D	Mode	Notes
≥ 200 mV	L	L	H	X	Receive	
≤–200mV	L	L	L	X		
Open	L	L	H	X		A/B failsafe
≥ 1.5 V	H	L	H	H	Drive	R reads back D information
≤–1.5 V	H	L	L	L		
≥ 1.5 V	H	H	Z	H		R tri-state (no output)
≤–1.5 V	H	H	Z	L		
X	L	H	Z	X	Disabled	R tri-state; A/B failsafe

Absolute Maximum Ratings[1]

Parameter	Symbol	Min.	Typ.	Max.	Units	Test Conditions
Storage temperature	T_S	−55		150	°C	
Junction temperature	T_J	−55		150	°C	
Voltage range at A or B bus pins		−7		12	V	
Supply voltage	V_{DD1A}, V_{DD1B}, V_{DD2A}, V_{DD2B}	−0.5		6	V	
Digital input voltage		−0.5		V_{DD} + 0.5	V	
Digital output voltage		−0.5		V_{DD} + 1	V	
ESD (bus nodes)						
IL4685 or IL4x22 configured as half-duplex		±16.5			kV	IEC61000-4-2
IL4x22 configured as full-duplex		±12			kV	IEC61000-4-2
EFT (bus nodes)		4			kV	IEC61000-4-4 Level 4

Recommended Operating Conditions

Parameter	Symbol	Min.	Typ.	Max.	Units	Test Conditions
DC-to-DC convertor input voltage	V_{DD1A}	3	3.3	3.6	V	
Transceiver controller-side supply	V_{DD1B}	3	3.3	5.5	V	
Transceiver bus-side supply voltage	V_{DD2B}	3	3.3	3.5	V	
Ambient operating temperature	T_{min}; T_{max}	−40		85	°C	
Junction temperature	T_J	−40		140	°C	
High-level digital input voltage	V_{IH}	2.4		V_{DD1}	V	V_{DD1} = 3.3 V
Low-level digital input voltage	V_{IL}	0		0.8	V	
Differential input voltage[2]	V_{ID}			+12 / −7	V	
High-level output current (driver)	I_{OH}			60	mA	
High-level digital output current (receiver)	I_{OH}			8	mA	
Low-level output current (driver)	I_{OL}	−60			mA	
Low-level digital output current (receiver)	I_{OL}	−8			mA	
Digital input signal rise and fall times	t_{IR}, t_{IF}	DC Stable				

IEC 60747-17 (VDE 0884-17):2021-10 (Basic Isolation; VDE File Number 5016933-4880-0001)

- Working Voltage (V_{IORM}) 600 V_{RMS} (848 V_{PK}); basic insulation; pollution degree 2
- Isolation voltage (V_{ISO}) 2500 V_{RMS}
- Transient overvoltage (V_{IOTM}) 4000 V_{PK}
- Surge rating 4000 V
- 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
- Working Voltage 600 V_{RMS}

Safety-Limiting Values	Symbol	Value	Units
Safety rating ambient temperature	T_S	180	°C
Safety rating power (180°C)	P_S	270	mW
Supply current safety rating (total of supplies)	I_S	54	mA

UL 1577 (Component Recognition Program File Number E207481)

Each part tested at 3000 V_{RMS} (4240 V_{PK}) for 1 second; each lot sample tested at 2500 V_{RMS} (3530 V_{PK}) for 1 minute

IEC 60601-1 (medical systems)

- 1 x MOPP compliant under for medical systems (isolation voltage ≥ 1.5 kV_{RMS}; creepage ≥ 4 mm).

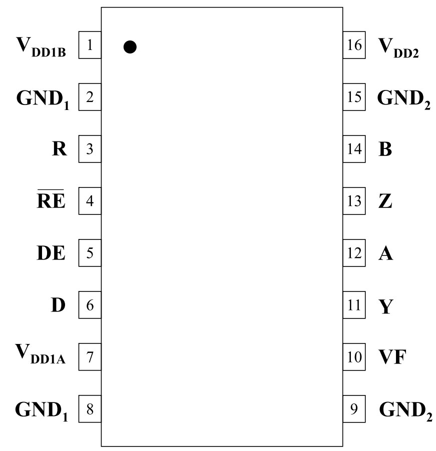
Compliant with **IEC 60950-1** and **IEC 62368-1** end equipment standards.

Soldering Profile

Per JEDEC J-STD-020C, MSL 1

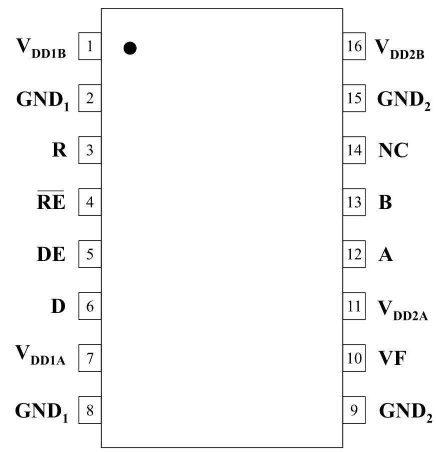
IL4x22 Pin Connections

1	VDD1B	Transceiver controller-side power supply input (3.3 V nominal).
2	GND_1	Input power supply ground (pin 2 is internally connected to pin 8).
3	R	Output data from bus.
4	$\overline{RE}$	Read data enable. If $\overline{RE}$ is high, R = high impedance; has a 500 kΩ nominal internal pulldown.
5	DE	Drive enable (has a 1 MΩ nominal internal pulldown).
6	D	Data input to bus.
7	VDD1A	DC-to-DC convertor input voltage (3.3 V nominal); bypass with 0.1 µF.
8	GND_1	Input power supply ground (pin 8 is internally connected to pin 2).
9	GND_2	Output power supply ground (pin 9 is internally connected to pin 15).
10	VF	Output-side rectifier output / regulator input; connect to a 0.1 µF/16 V external filter capacitor.
11	Y	Non-inverting bus driver.
12	A	Non-inverting bus receiver.
13	Z	Inverting bus driver.
14	B	Inverting bus receiver.
15	GND_2	Output power supply ground (pin 15 is internally connected to pin 9).
16	VDD2	DC-to-DC convertor output (5 V typical for IL4822; 3.3 V for IL4622); internally powers transceiver functions. Bypass with 10 µF ceramic.



IL4685 Pin Connections

1	VDD1B	Transceiver controller-side power supply input (3.3 V nominal).
2	GND_1	Input power supply ground (pin 2 is internally connected to pin 8).
3	R	Output data from bus.
4	$\overline{RE}$	Read data enable (if $\overline{RE}$ is high, R = high impedance).
5	DE	Drive enable (has a 1 MΩ nominal internal pulldown).
6	D	Data input to bus.
7	VDD1A	DC-to-DC convertor input voltage (3.3 V nominal); bypass with 0.1 µF.
8	GND_1	Input power supply ground (pin 8 is internally connected to pin 2).
9	GND_2	Output power supply ground (pin 9 is internally connected to pin 15).
10	VF	Output-side rectifier output / regulator input; connect to a 0.1 µF/16 V external filter capacitor.
11	VDD2A	DC-to-DC convertor output (3.3 V typical); bypass with 10 µF ceramic.
12	A	Non-inverting bus line.
13	B	Inverting bus line.
14	NC	No internal connection.
15	GND_2	Output power supply ground (pin 15 is internally connected to pin 9).
16	VDD2B	Transceiver power supply input (connect to pin 11 to use DC-to-DC convertor).



NVE Corporation 11409 Valley View Road, Eden Prairie, MN 55344 (952) 829-9217 www.nve.com YouTube.com/NveCorporation iso-apps@ www.nve.com

Transceiver Bus Driver

T_{min} to T_{max} unless otherwise stated						
Parameter	**Symbol**	**Min.**	**Typ.**(5)	**Max.**	**Units**	**Test Conditions**
Output voltage	V_O			V_{DD}	V	$I_O = 0$
Differential output voltage	$\|V_{OD1}\|$			V_{DD}	V	$I_O = 0$
Differential output voltage	$\|V_{OD2}\|$	2.1	3	3.5	V	$R_L = 60\ \Omega$
Differential output voltage	$\|V_{OD3}\|$	1.9		3.5	V	$R_L = 54\ \Omega$
Change in magnitude of differential output voltage(3)	$\Delta\|V_{OD}\|$			±0.2	V	$R_L = 54\ \Omega$ or $100\ \Omega$
Common mode output voltage	V_{OC}			3	V	$R_L = 54\ \Omega$ or $100\ \Omega$
Change in magnitude of common mode output voltage(3)	$\Delta\|V_{OC}\|$			±0.2	V	$R_L = 54\ \Omega$ or $100\ \Omega$
High level input current	I_{IH}			10	μA	$V_I = 3.5$ V
Low level input current	I_{IL}			−10	μA	$V_I = 0.4$ V
Absolute |short-circuit output current|	I_{OS}			250	mA	$-7\text{ V} < V_O < 12\text{ V}$

Transceiver Bus Receiver

T_{min} to T_{max} and V_{DD2B} = 3.1 V to 3.5 V unless otherwise stated						
Parameter	**Symbol**	**Min.**	**Typ.**(5)	**Max.**	**Units**	**Test Conditions**
Positive-going input threshold voltage	V_{IT+}			0.2	V	$-7\text{ V} < V_{CM} < 12\text{ V}$
Negative-going input threshold voltage	V_{IT-}	−0.2			V	$-7\text{ V} < V_{CM} < 12\text{ V}$
Input hysteresis voltage	$(V_{IT+} - V_{IT-})$		28		mV	$V_{CM} = 0$ V, T = 25°C
Differential bus input capacitance	C_D		9	12	pF	
High-level output voltage	V_{OH}	$V_{DD} - 0.2$	V_{DD}		V	$V_{ID} = 200$ mV $I_{OH} = -20$ μA
Low-level output voltage	V_{OL}			0.2	V	$V_{ID} = -200$ mV $I_{OH} = 20$ μA
High-impedance-state bus output current	I_{OZ}			±1	μA	$V_O = 0.4$ to $(V_{DD2}-0.5)$ V
Bus line input current	I_I			220	μA	$V_I = 12$ V
				−160	μA	$V_I = -7$ V
Bus line input resistance	R_I	60	80		kΩ	

Transceiver Switching Specifications

T_{min} to T_{max}; V_{DD1B} = 3 V to 3.45 V						
Parameter	**Symbol**	**Min.**	**Typ.**(5)	**Max.**	**Units**	**Test Conditions**
Data rate		40			Mbps	$R_L = 54\ \Omega$, $C_L = 50$ pF
Propagation delay(4)	t_{PD}		25	35	ns	$V_O = -1.5$ to 1.5 V, $C_L = 15$ pF
Pulse skew(5)	$t_{SK}(P)$		2	5	ns	$V_O = -1.5$ to 1.5 V, $C_L = 15$ pF
Skew limit(6)	$t_{SK}(LIM)$		4	10	ns	$R_L = 54\ \Omega$, $C_L = 50$ pF
Output enable time to high level	t_{PZH}		17	30	ns	$C_L = 15$ pF
Output enable time to low level	t_{PZL}		17	30	ns	$C_L = 15$ pF
Output disable time from high level	t_{PHZ}		17	30	ns	$C_L = 15$ pF
Output Disable Time From Low Level	t_{PLZ}		17	30	ns	$C_L = 15$ pF
Common mode transient immunity (output logic high to logic low)	$\|CM_H\|,\|CM_L\|$	30	50		kV/μs	$V_{CM} = 1500\ V_{DC}$ $t_{TRANSIENT} = 25$ ns

Transceiver Section Power Consumption

Parameter	Symbol	Min.	Typ.(5)	Max.	Units	Test Conditions
T_{min} to T_{max}; V_{DD1B} = 3 V to 3.45 V unless otherwise specified						
Controller-side Quiescent supply V_{DD1B} = 3.3 V V_{DD1B} = 5 V	I_{DD1B}		1 1.7	2 4	mA	No load (R_T = ∞); Outputs Enabled; f_{IN} = 0 Hz
Bus-side quiescent supply current	I_{DD2B}		4	6		
Controller-side dynamic supply current	I_{DD1B}		0.18		mA/Mbps	
Bus-side dynamic supply current	I_{DD2B}		0.75			R_T = ∞
			0.55			R_T = 60 Ω
Transceiver power dissipation	I_{DD1B} x V_{DD1B} + I_{DD2B} x V_{DD2B}		17		mW	R_T = ∞; f_{IN} = 0 Hz
			150			R_T= 60Ω; f_{IN}=40 Mbps; excludes R_T power dissipation

Transceiver Field Immunity(7)

Parameter	Symbol	Min.	Typ.	Max.	Units	Test Conditions
V_{DD1B} = 3.3 V						
Power frequency magnetic immunity	H_{PF}		1500		A/m	50 Hz / 60 Hz
Pulse magnetic field immunity	H_{PM}		2000		A/m	t_p = 8 µs
Damped oscillatory magnetic field	H_{OSC}		2000		A/m	0.1 Hz – 1 MHz
Cross-axis immunity multiplier(8)	K_X		2.5			

DC-to-DC Convertor

Parameter		Symbol	Min.	Typ.	Max.	Units	Test Conditions
T_{min} to T_{max} and V_{DD1A} = 3.0 V to 3.6 V unless otherwise stated							
Output voltage IL46xx IL4822		V_{DD2A}	3 4.5	3.3 5	3.45 5.5	V	I_{DD2A} < 65 mA I_{DD2A} < 40 mA
Output current (total available to internal transceiver and external load)	IL46xx	$I_{DD2A-MAX}$	65			mA	
			80				T_J < 85 °C
	IL4822		40				
			50				T_J < 85 °C
Short-circuit protection limited current			115	125	135	mA	
Input quiescent supply current		I_{DD1AQ}		200	240	mA	I_{DD2A} = 0
Input supply current IL46xx IL4822		I_{DD1A}		380 312	440 360	mA	I_{DD2A} = $I_{DD2A-MAX}$
Line regulation		$\Delta V_{DD2A}/\Delta V_{DD1A}$		32	40	mV/V	25 °C
				16			125 °C
Load regulation		$\Delta V_{DD2A}/V_{DD2A}$		5	6	%	I_{DD2A} = 0 to $I_{DD2A-MAX}$.
Output voltage temperature coefficient		$(\Delta V_{DD2A}/V_{DD2A})/\Delta T$		0.017 0.03		%/C	I_{DD2} = 12% x $I_{DD2A-MAX}$ I_{DD2} = 60% x $I_{DD2A-MAX}$
Capacitive load		C_{DD2A}			1000	µF	
Output voltage ripple		$V_{DD2BRIPPLE}$			5	mV_{P-P}	20 MHz bandwidth; I_{DD2A} = $I_{DD2A-MAX}$.
				1			1 kHz bandwidth; I_{DD2A} = $I_{DD2A-MAX}$.
Start-up time		t_{SU}	2			ms	I_{DD2A} = 0
					6		I_{DD2A} = $I_{DD2A-MAX}$
Convertor frequency		f_{OSC}	105	113	120	MHz	

Shutdown Specifications

Parameter	Symbol	Min.	Typ.	Max.	Units	Test Conditions
DC-to-DC convertor Overcurrent threshold	I_{DD2A}		120		mA	
Brownout threshold voltage	V_{DD2B}		2.5		V	Power-up
			2.3			Power-down
Bus driver shutdown temperature	T_J		140		°C	Junction Temperature
Bus driver re-enable temperature			135			

Isolation Specifications

Parameter	Symbol	Min.	Typ.	Max.	Units	Test Conditions
Creepage distance (external)		8.03	8.3		mm	Per IEC 60601
Total barrier thickness (internal)		0.013	0.016		mm	
Barrier resistance	R_{IO}		$>10^{14}$		Ω	500 V_{RMS}
Barrier capacitance	C_{IO}		7		pF	f = 1 MHz
Leakage current			0.2		μA_{RMS}	240 V_{RMS}, 60 Hz
Comparative tracking index	CTI	≥600			V_{RMS}	Per IEC 60112
Barrier life			44000		Years	100°C, 1000 V_{RMS}, 60% CL activation energy

Thermal Characteristics

Parameter	Symbol	Min.	Typ.	Max.	Units	Test Conditions
Junction–ambient thermal resistance	θ_{JA}		67		°C/W	Double-sided PCB with thermal vias in free air
Junction–case (top) thermal resistance	θ_{JC}		12		°C/W	Double-sided PCB with thermal vias in free air
Junction–ambient thermal resistance	θ_{JA}		46		°C/W	2s2p PCB with thermal vias per JESD51 with thermal vias in free air
Junction–case (top) thermal resistance	θ_{JC}		9		°C/W	2s2p PCB with thermal vias per JESD51 with thermal vias in free air
Power dissipation	P_D			1.5	W	

Notes:

1. Absolute Maximum specifications mean the device will not be damaged if operated under these conditions. It does not guarantee performance.
2. Differential input/output voltage is measured at the noninverting terminal A with respect to the inverting terminal B.
3. $\Delta|V_{OD}|$ and $\Delta|V_{OC}|$ are the changes in magnitude of V_{OD} and V_{OC}, respectively, that occur when the input is changed from one logic state to the other.
4. Includes 10 ns read enable time. Maximum propagation delay is 25 ns after read assertion.
5. Pulse skew is defined as $|t_{PLH} - t_{PHL}|$ of each channel.
6. Skew limit is the maximum propagation delay difference between any two devices at 25°C.
7. The relevant test and measurement methods are given in the "High Magnetic Immunity" section on p. 11.
8. External magnetic field immunity is improved by this factor if the field direction is "end-to-end" rather than to "pin-to-pin" (see diagram on p. 14).

Device Operation

The IL4xxx detailed block diagram is shown below. The major elements are a DC-to-DC convertor, an RS-485 / RS-422 transceiver, and GMR isolation:

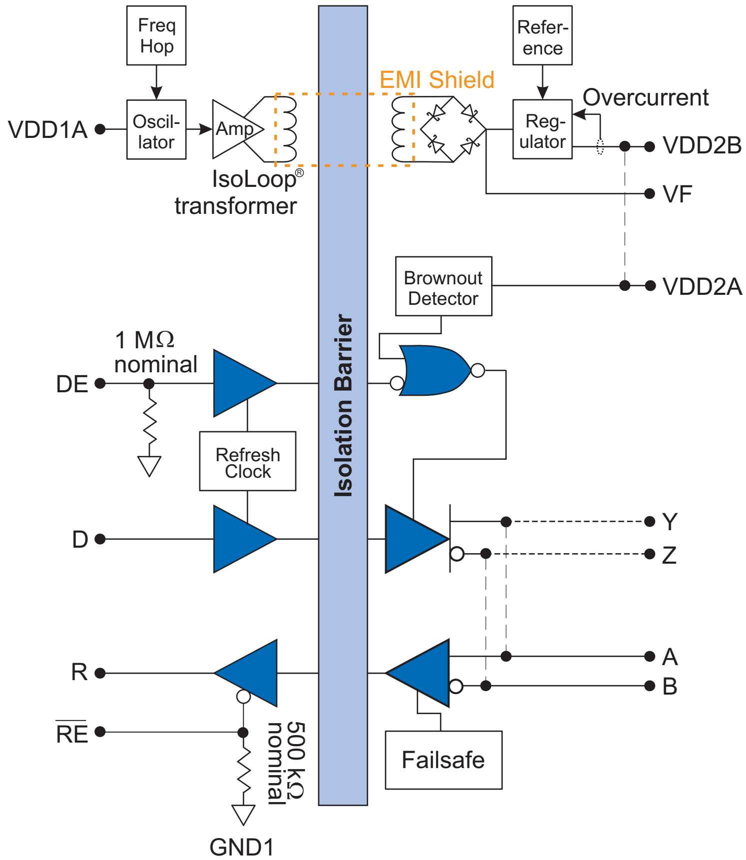


Figure 1. IL4xxx detailed block diagram.

DC-to-DC Convertor Operation

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.

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

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.

Simple Capacitive Decoupling

The only external parts required are a 0.1 µF capacitor placed as close as possible to the VDD1A pin, a 10 µF ceramic capacitor for the VDD2 or VDD2B pin, and a 0.1 µF/16 V filter capacitor near the V_F pin. This low external parts count reduces board area and cost.

Soft Start

A smooth output ramp-up with a minimum two millisecond startup allows the control electronics to start up before the bus is powered.

Short-Circuit Protection

The DC-to-DC convertor output will shut down at a current of approximately 120 mA. Short-circuit protection automatically resets and the output recovers when the fault is removed.

Optional External Regulation
An external regulator can be connected to the VF pin and used in addition to the parts' internal low drop-out regulator for voltages up to approximately 7.5 volts. The maximum output current decreases at higher regulator output voltages, but the output power capacity remains approximately 250 milliwatts.

Transceiver Operation

Receiver Features
The receiver output "R" has tri-state capability via the active low $\overline{RE}$ input.

Driver Features
The driver features low propagation delay skew to maximize bit width and minimize EMI. Drivers have tri-state capability via the active-high DE input.

True 3.3-volt Bus Operation
IL46xx parts are guaranteed to provide the minimum RS-485 / RS-422 differential voltages with a 3.0-volt bus supply, providing true 3.3-volt bus operation with ample design margins.

Deterministic Power Up and Brownout Detection
IL46xx parts have circuitry to disable the transceiver bus until the driver-side voltage (VDD2B, normally provided by the DC-to-DC convertor) reaches approximately 2.5 volts on power-up. The transceiver is disabled when the voltage drops below approximately 2.3 volts on power-down. This brownout circuitry ensures the transceiver does not "crash" the bus on power up, power down, or brownout, and eliminates the need for external power supply monitors. In addition, a patented refresh circuit maintains the correct transceiver output state with respect to data input (DC correctness). The refresh circuit ensures the bus outputs will follow the Function Table shown on Page 1 after power up.

Hot Plug Operation
Deterministic power-up allows IL46xx nodes to "hot plug" into the bus since the bus driver will be in a high-impedance state until the DC-to-DC convertor output is enough for the bus driver to operate.

Unpowered Nodes
The bus driver reverts to high impedance when VDD2 is not present so that unpowered nodes do not disturb bus operation.

Full Fail-Safe
The receiver is fully fail-safe, meaning it guarantees a logic high state on "R" if the "A" and "B" bus inputs are unconnected, shorted together, or connected to a terminated bus with all the transmitters disabled (terminated/undriven).

Rigorous PROFIBUS Compatibility
Unlike most other transceivers, IL4822 transceivers meet stringent PROFIBUS standards for maximum differential output voltage as well as other PROFIBUS requirements.

Thermal Shutdown
Internal DC-to-DC convertor thermal management circuitry gradually limits the output voltage and power output to approximately 250 mW as the junction temperature increases to avoid thermal overload (see Figure 10).

In addition, the bus driver is disabled when the driver die temperature exceeds approximately 150 °C, and re-enabled when the die temperature drops below approximately 135 °C. The receiver and DC-to-DC convertor sections continue to operate during thermal shutdown.

Internal Connections

Ground Connections
There are two pins for each ground connection: pin 2 is internally connected to pin 8 and pin 15 is internally connected to pin 9. All four ground pins should be soldered to circuit board traces to maximize power dissipation.

Power Connections
The controller-side DC-to-DC convertor and transceiver functions have separate power connections, VDD1A and VDD1B respectively, which should be connected externally for normal operation. The bus-side DC-to-DC convertor and transceiver functions have separate power connections (VDD2A and VDD2B) in the IL4685. The bus-side transceiver supply is internally connected to the DC-to-DC convertor in the IL4x22.

Bus Connections
The IL4685 has a half-duplex transceiver generally used with RS-485. Bus input “A” is internally connected to “Y” and “B” is connected to “Z.” The IL4x22 has full-duplex connections for RS-422 buses. For a half duplex RS-485 network with the IL4x22, “A” can be externally connected to “Y” and “B” connected to “Z.”

GMR Isolator Operation
An equivalent circuit for each of the Giant Magnetoresistor (GMR) isolator channels is shown in Figure 2:

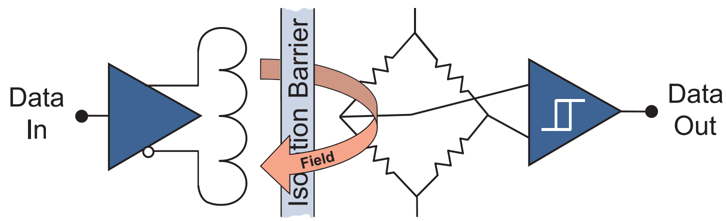


Figure 2. Isolator model signal path.

The GMR isolator signal path starts with a buffered input signal that is driven through an ultraminiature coil. This generates a small magnetic field that changes the electron spin polarization of GMR resistors, which are configured as a Wheatstone bridge. The change in spin polarization of the resistors creates a bridge voltage which drives an output comparator to construct an isolated version of the input signal. GMR is inherently high speed and low distortion.

High Magnetic Immunity
GMR provides large signals which improve magnetic immunity, and the Wheatstone bridge configuration cancels ambient common-mode magnetic fields, further enhancing immunity to external magnetic fields.

Thermal Management

An IL46xx transceiver node can be operated at worst-case loading, data rate, and ambient temperature without exceeding the maximum DC-to-DC convertor output current, maximum die temperature or package power rating. As shown in Figure 18, worst-case power consumption for a node such as that shown in Figure 20 is less that 1.2 watts. Junction-to-ambient thermal resistance is 46 °C/W with a 2s2p circuit board, so the temperature rise is 55 °C and the die temperature is within the 140 °C maximum at the 85 °C maximum ambient.

If additional nodes are powered by the DC-to-DC convertor or additional power is needed from the DC-to-DC convertor, however, care should be taken to ensure the die temperature does not exceed its 140 °C maximum operating temperature, and that the total power dissipation does not exceed the 1.5 watt package maximum. The following sections summarize some thermal management considerations in these situations.

Board Layout
If possible, use a double sided, double buried power plane (“2s2p”) board to maximize thermal performance. Thermal vias should be used between the power plane and the board surfaces. All four IC ground pins should be connected, with wide traces to help cool the leadframe.

Use Low-Power, Fractional-Load Transceivers
Transceivers such as the NVE IL3685P are fractional load to minimize the drive current required by transmitting nodes and, if powered by the IL46xx, uses less bus power than other transceivers.

Avoid Termination Resistors with Shorter Bus Cables
Termination resistors minimize reflections, which can be important for long cable lengths. However, these resistors significantly increase output drive current and may not be necessary with short bus cables.

Full Duplex Uses Less Power
Full-duplex RS-422 buses have only one transmitter per bus and therefore only need one termination resistor, typically 120 Ω. Half-duplex RS-485 networks with long cables, however, are generally terminated on both ends because either end can receive data. This doubles the power dissipated in the termination resistors.

No External “Fail-Safe” Resistors
The transceivers are designed to be “full fail-safe,” so “fail-safe” pull-up and pull-down bias resistors are generally unnecessary and use power.

Minimize Data Rate
The transceiver draws more power at higher frequency, so the data rate should not be higher than necessary to minimize transceiver power.

Limit Transmission Time
The transceivers use less power receiving than transmitting, and much less if there are termination resistors. Average power dissipation can be reduced considerably by disabling the driver (DE = LOW) when not transmitting data.

Maintaining Creepage

Creepage distances are often critical in isolated circuits. In addition to meeting JEDEC standards, NVE isolator packages have unique creepage specifications. Standard pad libraries often extend under the package, compromising creepage and clearance. Similarly, ground planes, if used, should be spaced to avoid compromising clearance. Package drawings and recommended pad layouts are included in this datasheet.

Inherently Low EMI

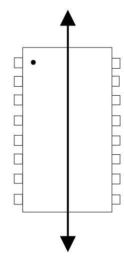
Electromagnetic compatibility is regulated by international standards such as IEC 61000-4-x and CISPR 32. Although system-level performance depends on board design and layout, these components incorporate features to reduce radiated EMI.

The DC-to-DC convertor oscillator operates above 88 MHz, where emission limits are higher since there is less risk of interference with 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. This inherently low EMI eliminates the need for shielding or external mitigation components such as ferrite beads. The parts are fully EN 55032 CISPR 32 Class B compliant with no EMI mitigation components and only 12 pF of input-to-output stitching capacitance. The capacitance can be created in a four-layer PCB by extending the GND1 and GND2 ground planes into the PCB isolation area. External stitching capacitor components are generally not recommended due to parasitic inductance above one gigahertz. See Fig. 23 for a typical schematic, and Application Bulletin AB-29 for a recommended PCB layout.

High Magnetic Immunity

These parts are fully compliant with IEC 61000-6-1 and IEC 61000-6-2 magnetic immunity standards.



The IsoLoop Isolator's Wheatstone bridge configuration and differential magnetic field signaling ensure excellent EM immunity. Immunity to external magnetic fields is even higher if the field direction is "end-to-end" (rather than to "pin-to-pin") as shown at right.

Typical Performance Graphs

The following graphs show typical performance:

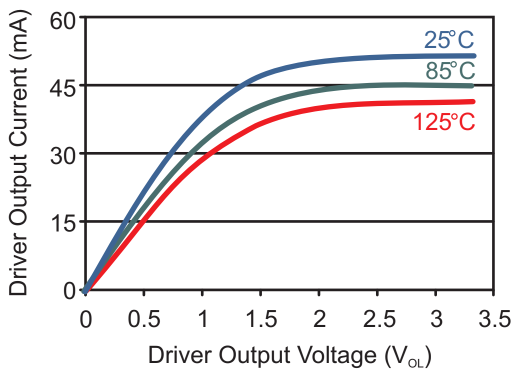


Figure 3. Typ. driver output current vs. driver output voltage (V_{OL}).

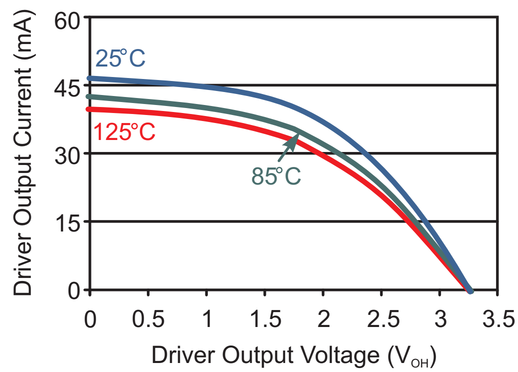


Figure 4. Typ. driver output current vs. driver output voltage (V_{OH}).

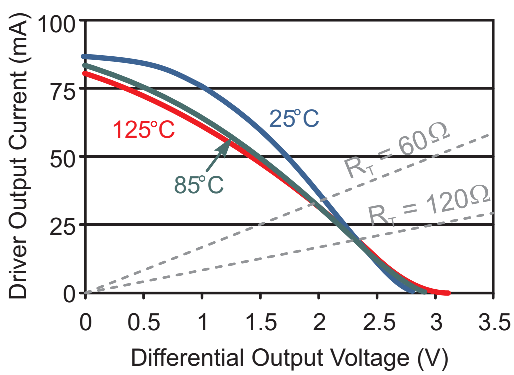


Figure 5. Typical transceiver differential output versus driver output current.

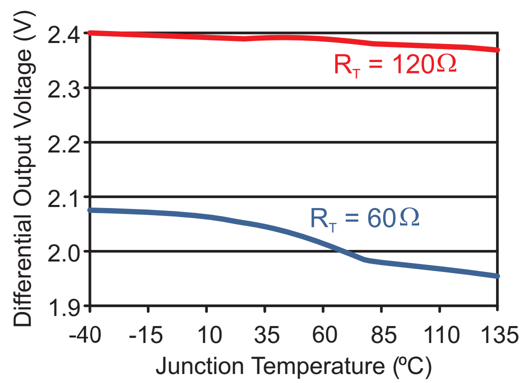


Figure 6. Typical transceiver differential output versus temperature.

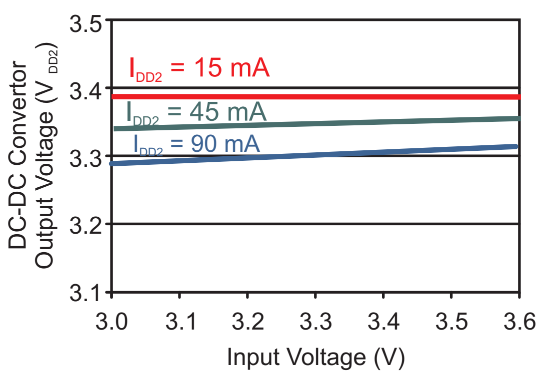


Figure 7. Typical DC-DC convertor line regulation.

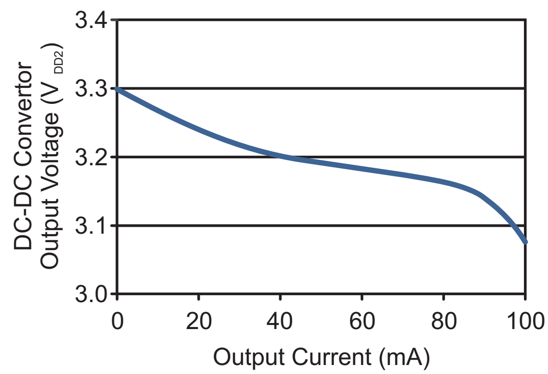


Figure 8. Typical DC-DC convertor load regulation (V_{DD1A} = 3.3 V).

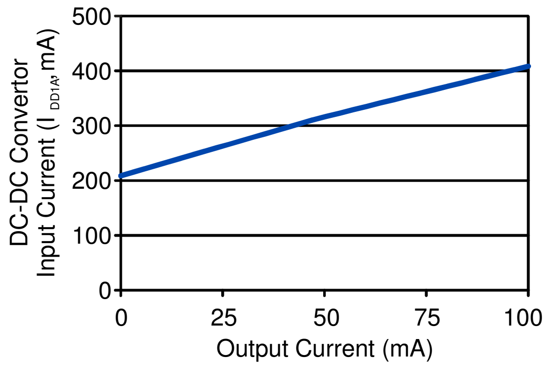


Figure 9. Typ. DC-DC convertor supply current vs. output current (IL46xx).

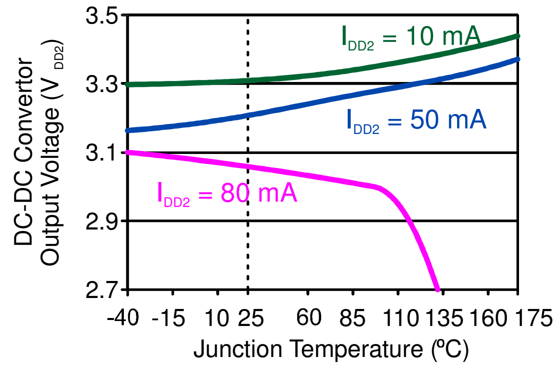


Figure 10. Typical DC-DC convertor output versus temperature (IL46xx).

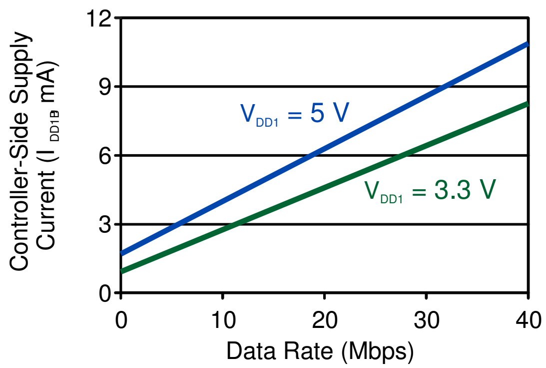


Figure 11. Transceiver controller-side supply current versus data rate.

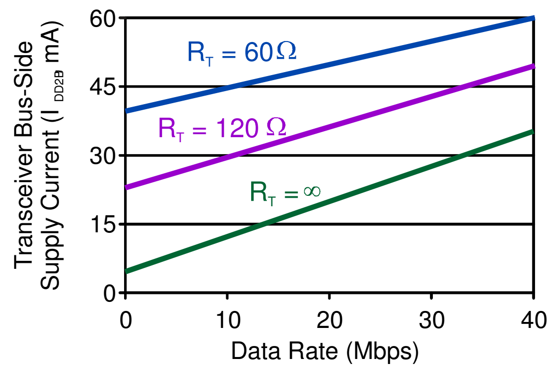


Figure 12. Typical transceiver bus-side supply current (I_{DD2}) versus aggregate termination resistance (IL46xx).

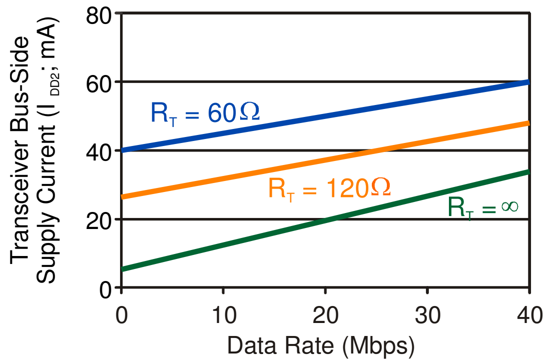


Figure 13. Typical transceiver bus-side supply current (I_{DD2}) versus operating speed.

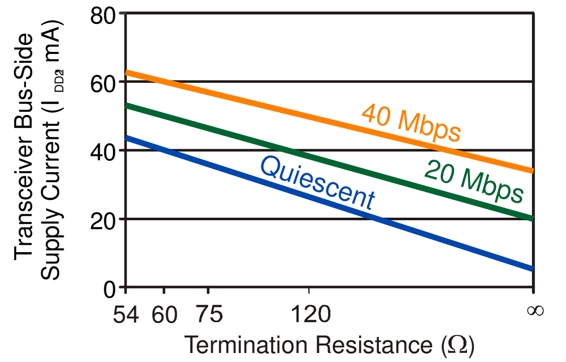


Figure 14. Typ. transceiver bus-side supply current (I_{DD2}) vs. aggregate termination resistance.

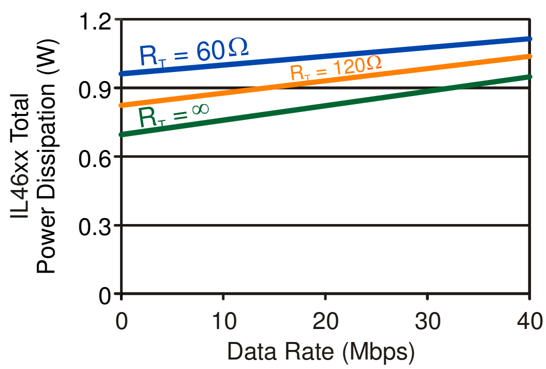


Figure 15. Total power dissipation versus operating speed (V_{DD1A} = V_{DD1B} = 3.3 V; V_{DD2A} connected to V_{DD2B}).

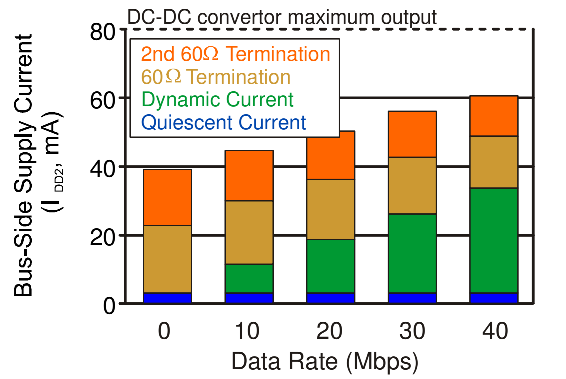


Figure 16. IL46xx bus-side supply current budget.

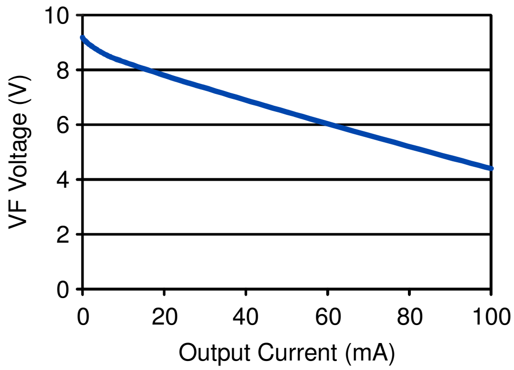


Figure 17. Typical unregulated output vs. output current (V_{DD1A} = 3.3 V; 25 °C).

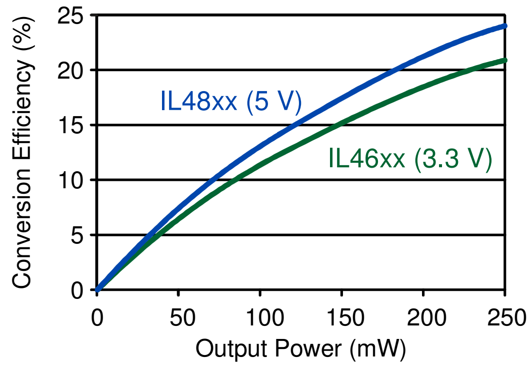


Figure 18. Typical DC-to-DC convertor power efficiency (V_{DD1A} = 3.3 V; 25 °C).

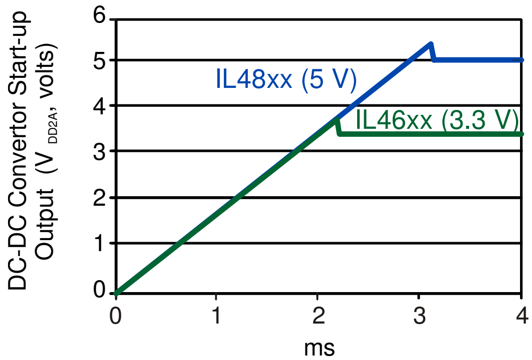


Figure 19. Typical DC-to-DC convertor start-up voltage (no load).

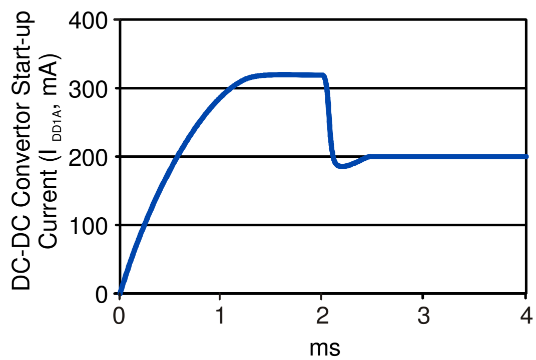


Figure 20. Typical DC-to-DC convertor start-up current (no load).

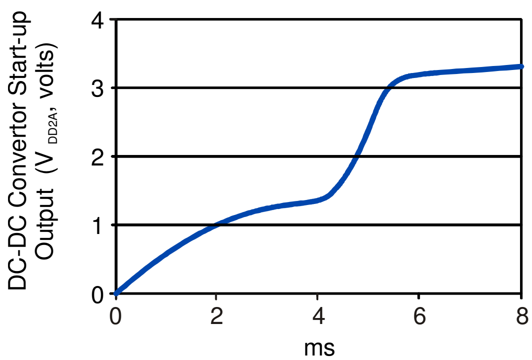


Figure 21. Typical DC-to-DC convertor start-up voltage (IL46xx; maximum load).

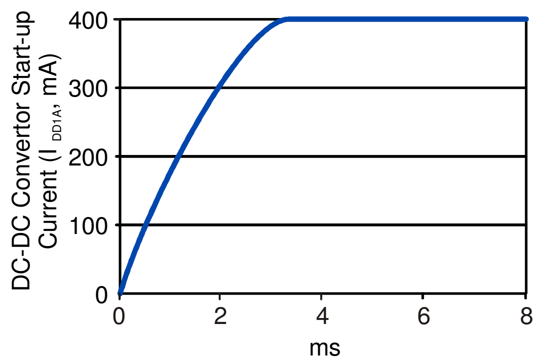


Figure 22. Typical DC-to-DC convertor start-up current (maximum load).

Application Circuits

Bypass capacitors are required on the VDD1, VDD2, and VF as shown. A small amount of input-to-output ground stitching capacitance is recommended for EMI mitigation. This can be a discrete capacitor or created using PCB ground-plane overlap:

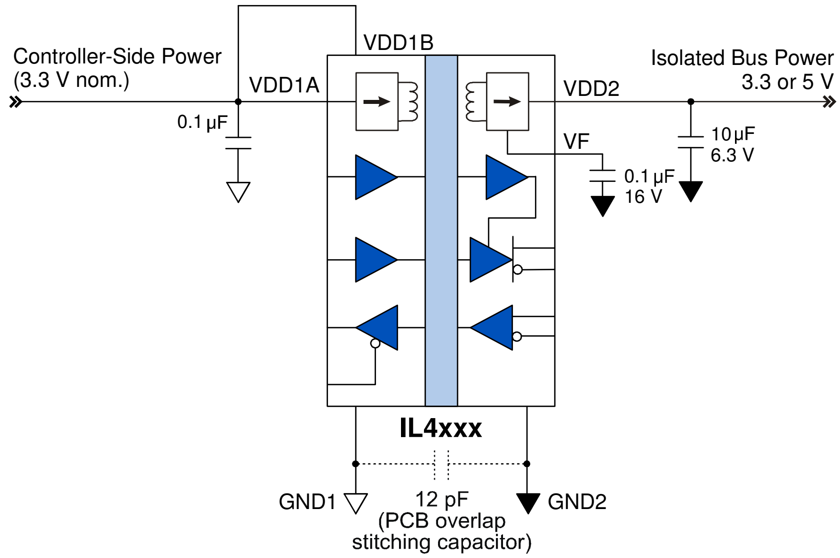


Figure 23. Recommended basic circuit.

IL4xxx transceivers form complete, isolated, independent bus nodes. Termination resistors are optional:

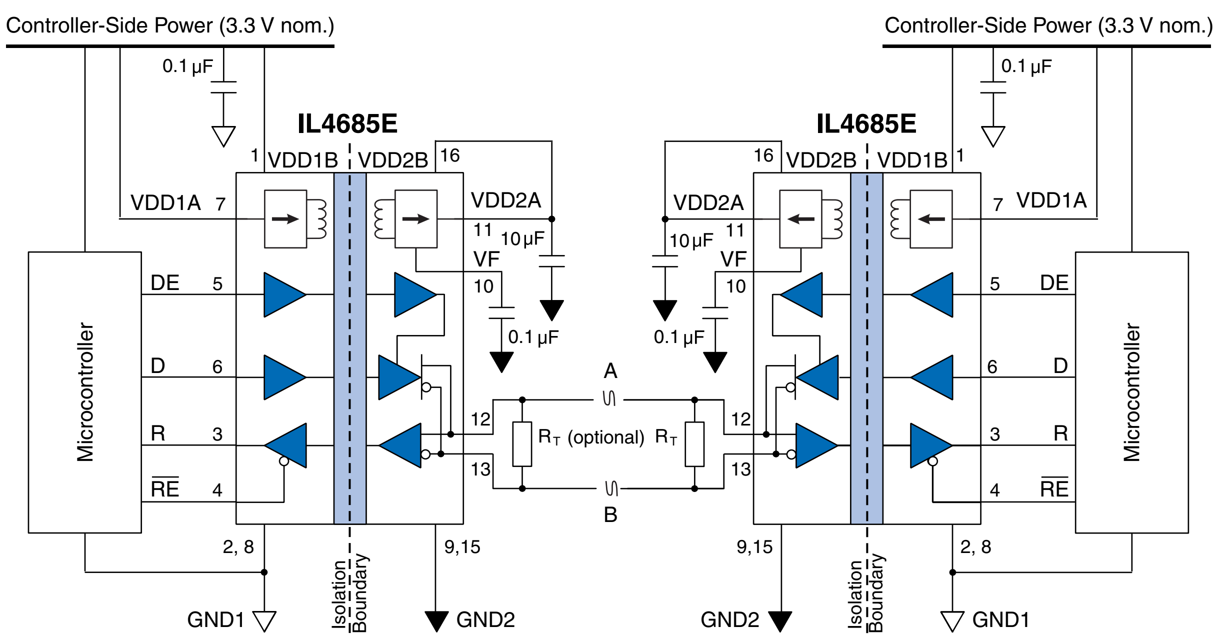


Figure 24. Two typical IL4685 nodes.

An IL4822 can drive (and optionally power) five-volt nodes:

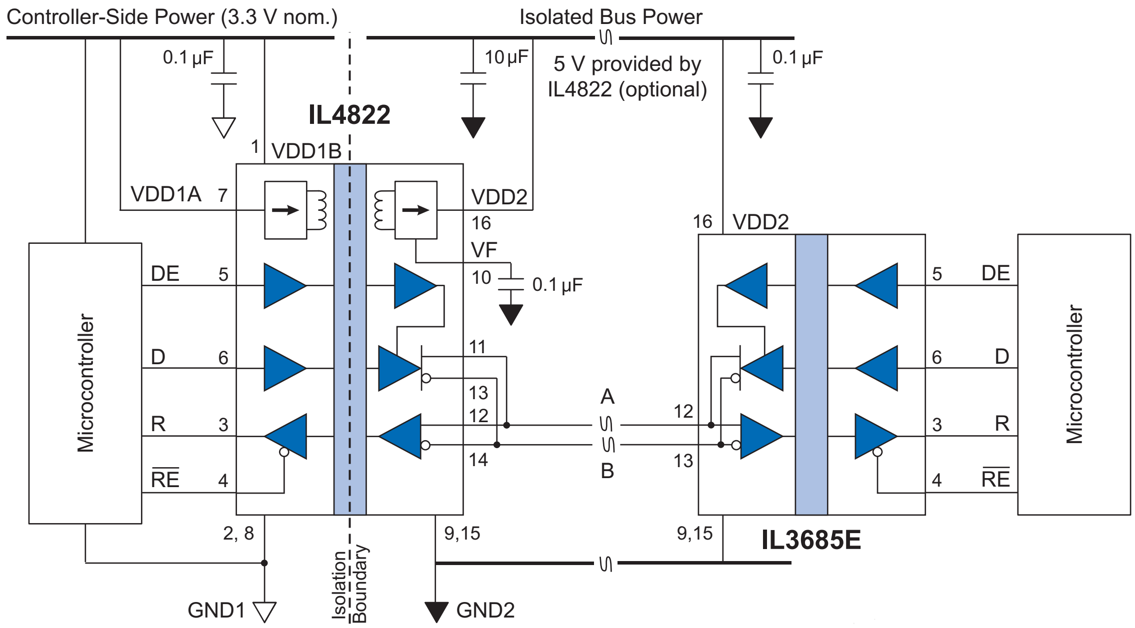


Figure 25. A typical RS-485 node using an IL4822.

An IL4822 provides rigorous PROFIBUS compatibility, including stringent PROFIBUS standards for maximum as well as minimum differential output voltage and other PROFIBUS requirements. PROFIBUS termination resistors are typically 220 Ω:

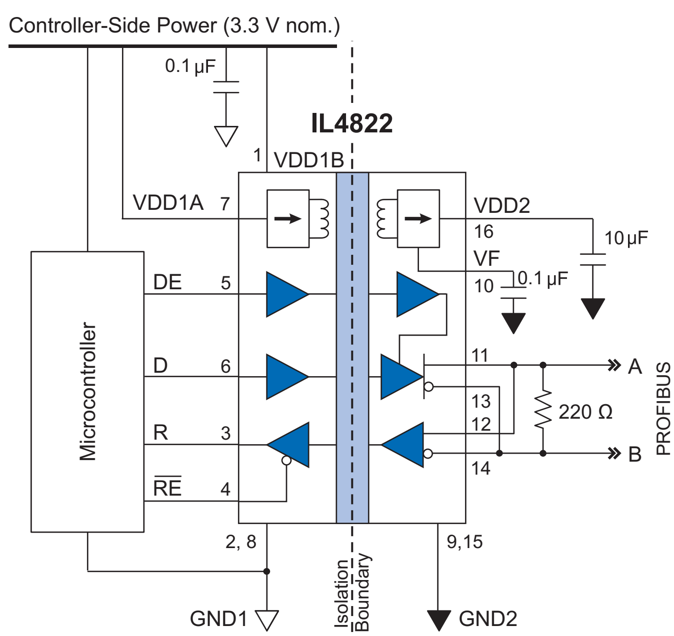


Figure 26. A typical PROFIBUS node using an IL4822.

Although they have 3.3-volt bus supplies, IL46xx transceivers can drive five-volt or 3.3-volt nodes.

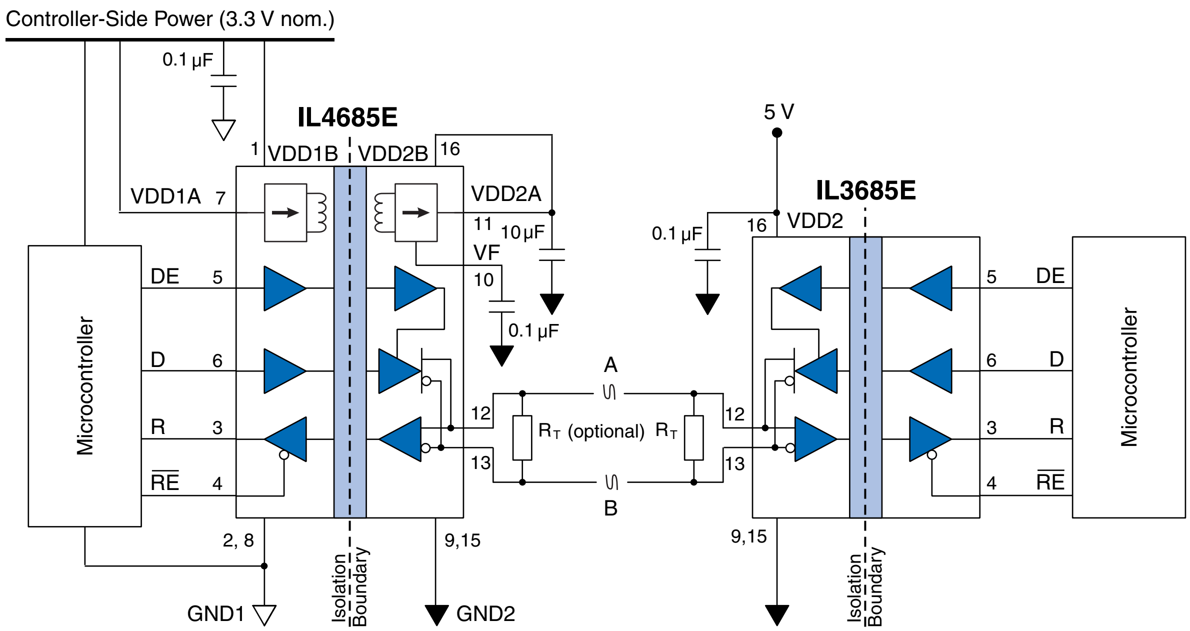


Figure 27. A typical IL4685 node driving a 5-volt-powered node.

IL4x22 transceivers can create full-duplex RS-422 networks where one node broadcasts and multiple nodes can receive.

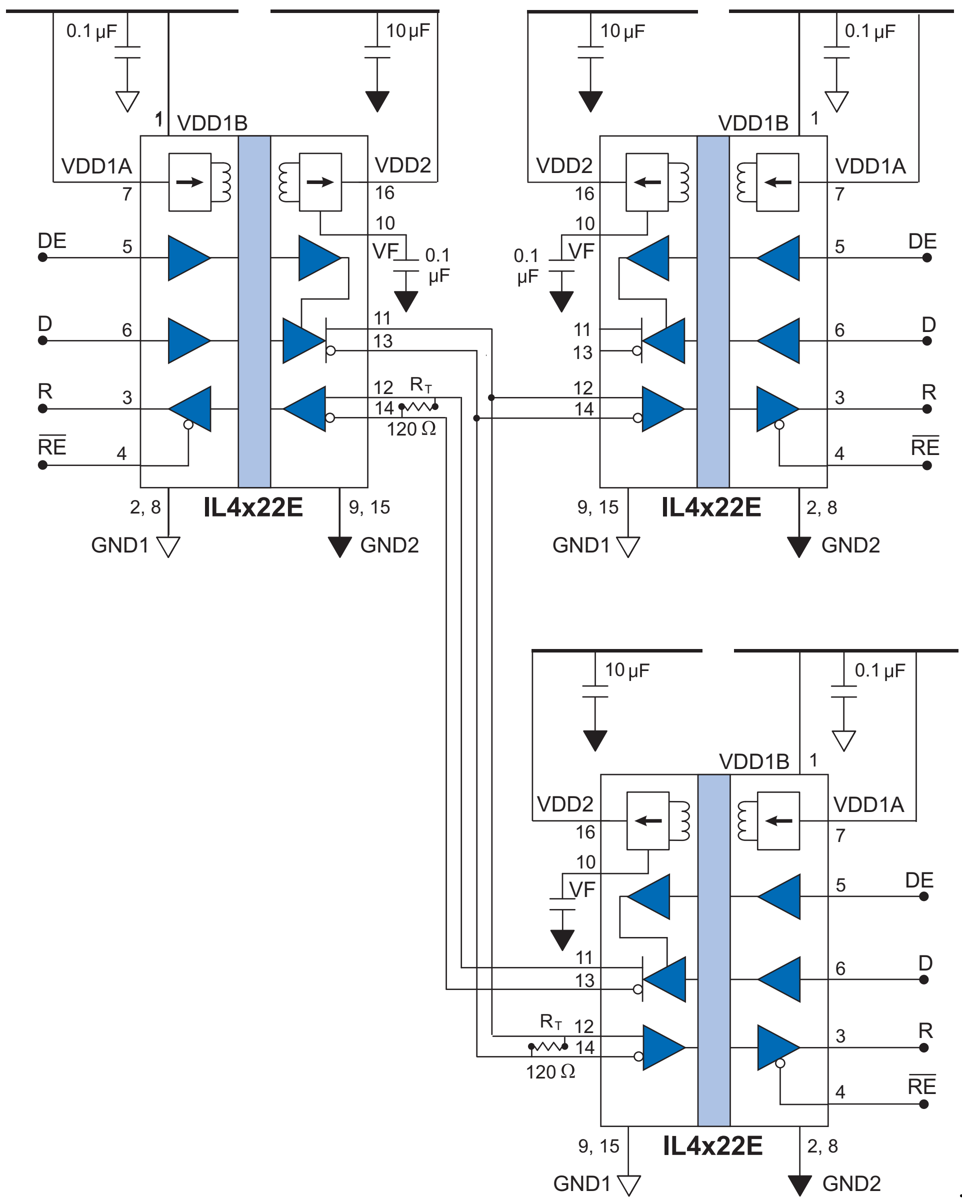


Figure 28. A full-duplex multi-drop RS-422 network.

The IL46xx integrated DC-to-DC convertor produces enough current to power multiple bus nodes. Isolated transceivers provide isolation from the bus. In the circuit below, the IL3685PE isolated transceiver uses the same transceiver circuitry as the IL4685, and is fully compatible and interoperable with the 3.3-volt bus power. Bus loading is 1/5 Unit Load, which minimize bus power. Termination resistors are not used in this example to minimize power consumption.

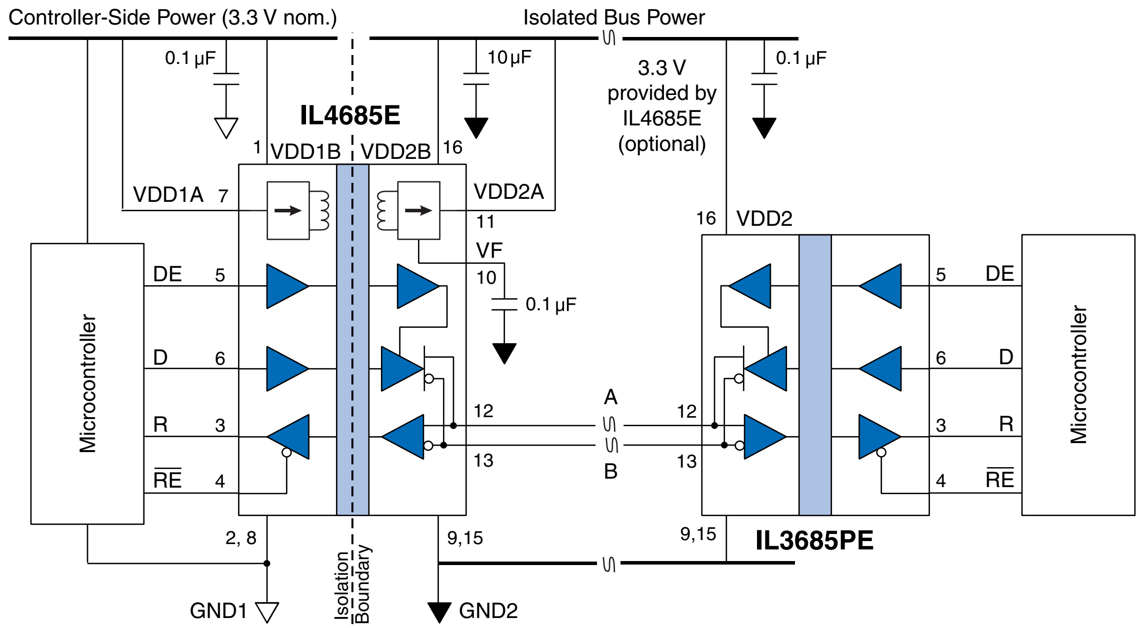


Figure 29. IL4685 powered bus with two fully-isolated nodes. The IL4685 powers both nodes.

If double isolation is not required, a non-isolated 3.3-volt transceiver such as the ISL3179E can be used. The IL4685 can power the remote node if desired. A similar circuit can be used with common five-volt RS-485 / RS-422 transceivers such as the ISL3159E and powered by an IL4822.

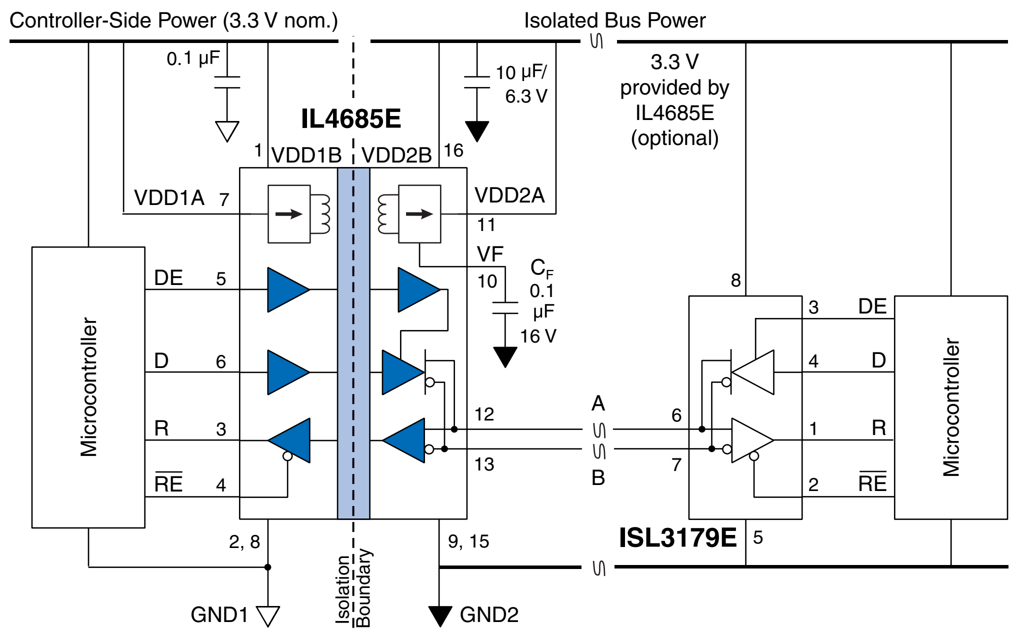


Figure 30. IL4685 powered bus with a non-isolated node.

Combining a single Means Of Operator Protection (1 x MOOP) medical-grade power supply with a 1 x MOOP compliant IL4822 provides cost-effective compliance with IEC 60601 for medical systems operator interfaces. The DC-to-DC convertor section isolates the power while the transceiver section isolates the data to the operator interface:

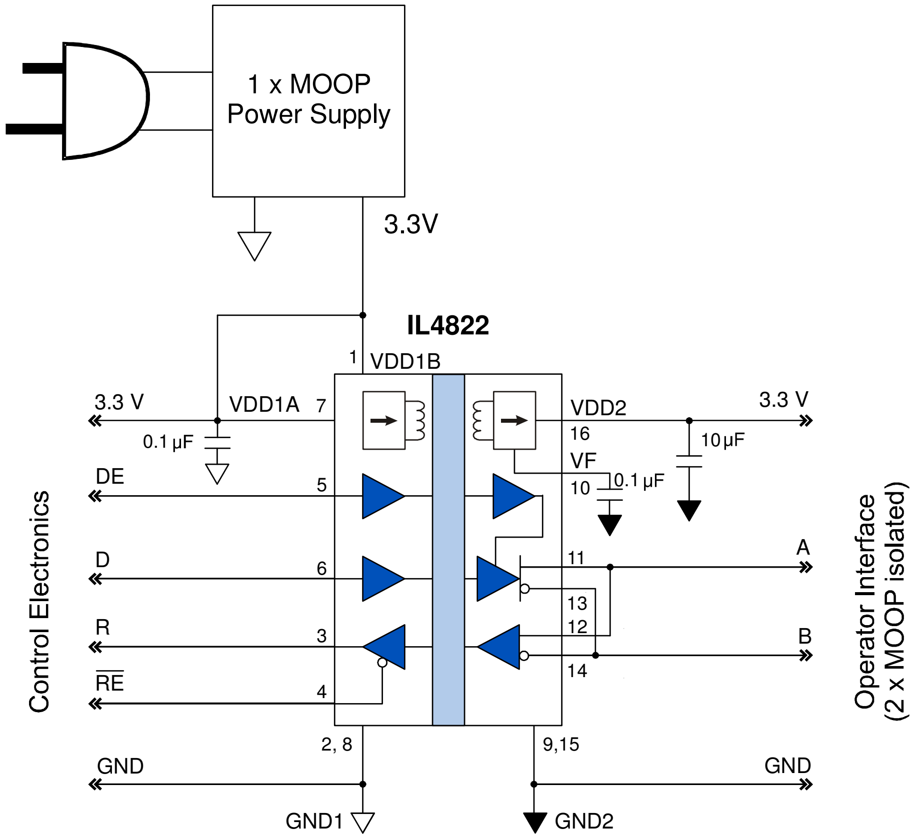


Figure 31. Medical system operator interface.

Evaluation Board

The IL4622-01 Evaluation Board provides a complete isolated RS-485 or RS-422 node using the IL4622.

The 4 by 3 inch (100 x 75 mm) board provides uses a 2s2p board with thermal vias to optimize thermal performance. There are screw terminals for bus connections and test points for checking voltages and waveforms. Jumpers allow the board to be used as full duplex (separate A/B bus receiver from the Y/Z bus driver connections), or half duplex (“A” jumpered to “Y” and “B” jumpered to “Z”). Each board has a place for a bus termination resistor.

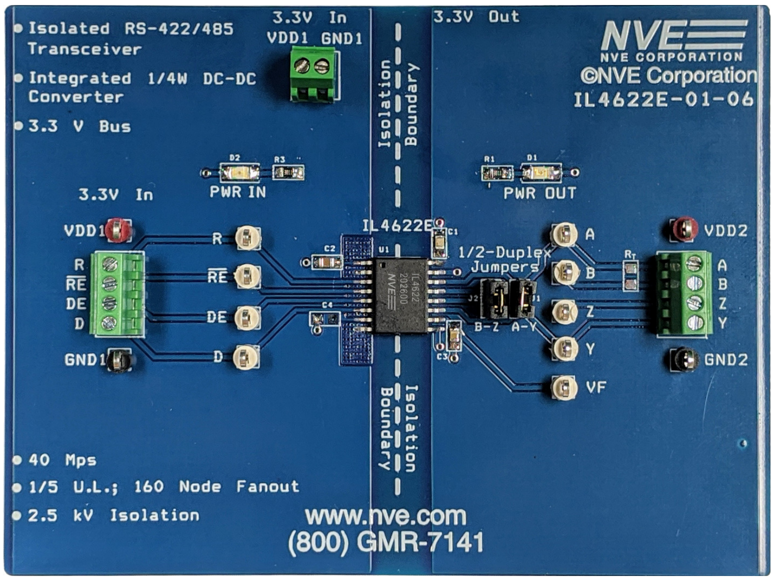
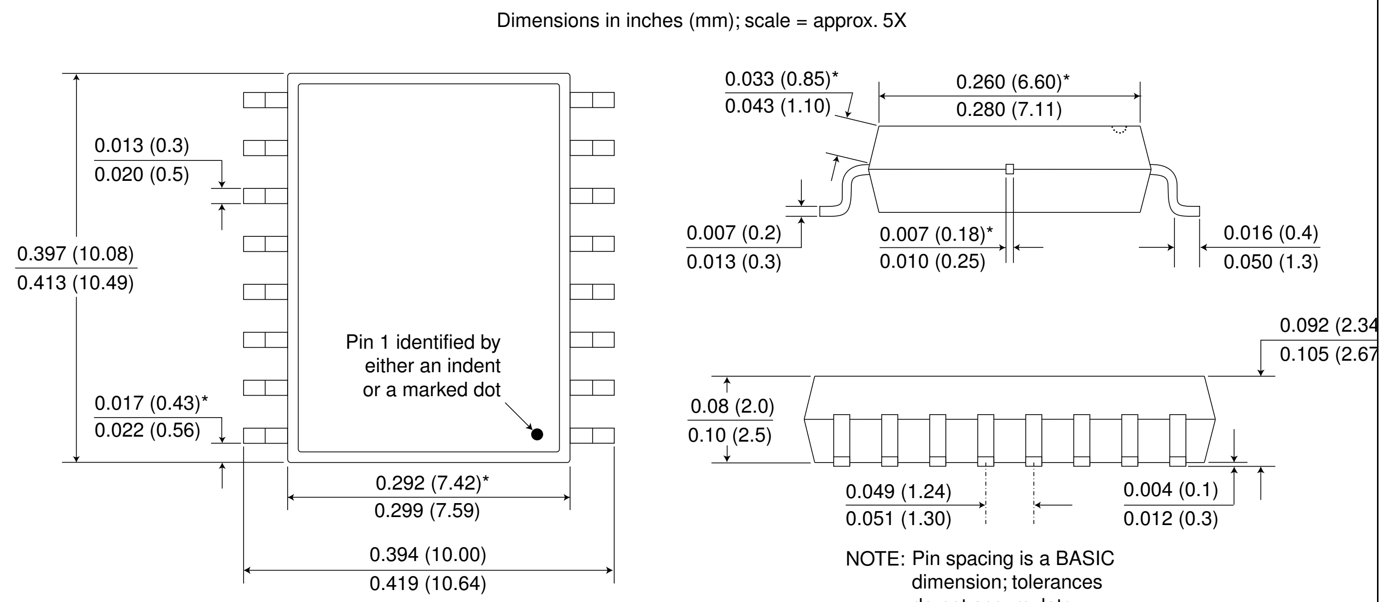


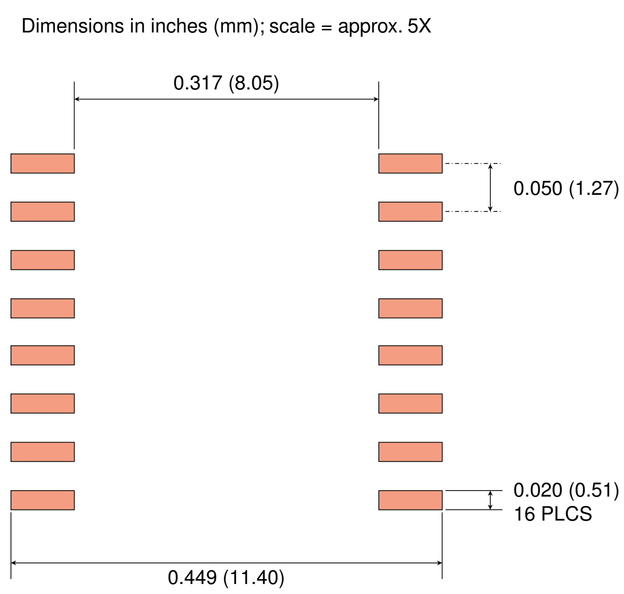
Figure 32. IL4622-01 Evaluation Board (actual size).

Package Drawing



*Specified for True 8™ package to guarantee 8 mm creepage per IEC 60601.

Recommended Pad Layout



Available Part Numbers

Part Number	Bus	Duplex	Bus Supply	Bulk Packaging	RoHS?
IL4622E	RS-422 / RS-485	Full	3 V	Tubes (50 pcs.)	RoHS
IL4685E	RS-485	Half	3 V		
IL4822E	RS-422 / RS-485	Full	5 V		
IL4622E-TR7	RS-422 / RS-485	Full	3 V	7-inch reels (up to 450 pcs.)	
IL4685E-TR7	RS-485	Half	3 V		
IL4822E-TR7	RS-422 / RS-485	Full	5 V		
IL4622E-TR13	RS-422 / RS-485	Full	3 V	13-inch reels (up to 1500 pcs.)	
IL4685E-TR13	RS-485	Half	3 V		
IL4822E -TR13	RS-422 / RS-485	Full	5 V		
IL4622	RS-422 / RS-485	Full	3 V	Tubes (50 pcs.)	SnPb finish (non-RoHS; Special Order)
IL4685	RS-485	Half	3 V		
IL4822	RS-422 / RS-485	Full	5 V		
IL4622-TR7	RS-422 / RS-485	Full	3 V	7-inch reels (up to 450 pcs.)	
IL4685-TR7	RS-485	Half	3 V		
IL4822-TR7	RS-422 / RS-485	Full	5 V		
IL4622-TR13	RS-422 / RS-485	Full	3 V	13-inch reels (up to 1500 pcs.)	
IL4685-TR13	RS-485	Half	3 V		
IL4822-TR13	RS-422 / RS-485	Full	5 V		

NVE Corporation 11409 Valley View Road, Eden Prairie, MN 55344 (952) 829-9217 www.nve.com YouTube.com/NveCorporation iso-apps@ www.nve.com

Revision History

ISB-DS-001-IL4xxx-RevE
Sept. 2023

Changes
- Clarified IL4x22 bus driver output voltage (p. 2).
- Added CISPR 32 Class B compliance and stitching capacitor recommendation (p. 14).
- Added recommended basic circuit (Fig. 23).

ISB-DS-001-IL4xxx-RevD
Sept. 2022

Changes
- VDE 0884-17 approval (p. 4).
- Increased VDE Working Voltage to 600 V_{RMS} based on VDE testing (p. 4).
- Added IEC 60601-1 medical systems and equipment-level standards compliance (p. 4).
- Eliminated startup current specification with soft-start on lots 22xxxx and higher (p. 7).
- Replaced DC-to-DC convertor "Start-up" paragraph with soft start-up description (p. 9).
- Changed typical performance graphs with the addition of soft-start (Figs. 19-22).
- Added medical system application (Fig. 30).

ISB-DS-001-IL4xxx-RevC
Sept. 2021

Changes
- Added 5-volt version (IL4822).
- Clarified IL4685 truth table.
- Added VF vs. output current typical performance graph.
- Added description of external regulator option.

ISB-DS-001-IL46xx-RevB
July 2020

Changes
- Description of internal DC-to-DC convertor thermal circuitry (p. 10) and graph (Figure 10).
- Added start-up current specification (p. 7) and typical graph (Figure 15).

SB-DS-001-IL46xx-RevA
July 2020

Changes
- Initial release.
- Table corrections and final specifications (pp. 3 – 8).
- Changed IL4622 pinout (p. 5).
- Specification notes (p. 8).
- Added electrical fast transient (EFT) specification per IEC61000-4-4 for bus nodes (p. 3).
- Added overcurrent protection to DC-to-DC convertor detailed block diagram (Fig. 3).
- Added Shutdown Specifications table (p. 7).
- Added detailed block diagram (Fig. 1) and GMR isolator diagram (Fig. 2).
- More details on power up, hot plug, brownout detection, and unpowered nodes (p. 10).
- Added and finalized performance graphs (pp. 14 – 16).
- Added 120 Ω aggregate termination resistance (common for RS-422) to performance graphs.
- Added RS-422 application diagram (Figure 21).

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NVE Corporation
11409 Valley View Road
Eden Prairie, MN 55344-3617 USA
Telephone: (952) 829-9217
www.nve.com
e-mail: iso-info@nve.com

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September 2023