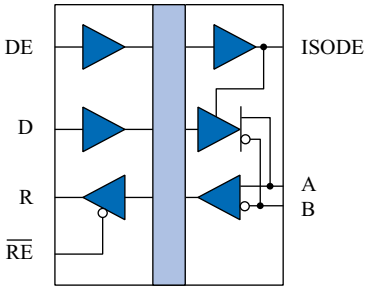
High-Speed Isolated 3.3V Bus RS-485 Transceiver

Functional Diagrams



IL3685P

V_{ID} (A-B)	DE	$\overline{RE}$	R	D	Mode
≥ 200 mV	L	L	H	X	Receive
≤−200 mV	L	L	L	X	Receive
≥ 1.5 V	H	L	H	H	Drive
≤−1.5 V	H	L	L	L	Drive
X	X	H	Z	X	Hi-Z R
Open	L	L	H	X	Receive

Features

- 3.3 V Bus
- 40 Mbps data rate
- 1/5 unit load U.L. (supports up to 160 nodes)
- 20 ns propagation delay
- 5 ns pulse skew
- 50 kV/µs typ.; 30 kV/µs min. common mode transient immunity
- 600 V_{RMS} working voltage
- 2500 V_{RMS} isolation voltage
- 44000 year barrier life
- 16.5kV bus ESD protection
- Low EMC footprint
- Thermal shutdown protection
- −40°C to +85°C temperature range
- Meets or exceeds ANSI RS-485 and ISO 8482:1987(E)
- VDE V 0884-10 and UL 1577 pending
- 0.3" True 8™ mm 16-pin SOIC package
- VDE V 0884-10 and UL 1577 pending

Applications

- Factory automation
- Industrial control networks
- Building environmental controls

Description

IL3685-Series galvanically isolated, high-speed differential bus transceivers are designed for bidirectional data communication on balanced transmission lines. The devices use NVE's patented* IsoLoop spintronic Giant Magnetoresistance (GMR) technology.

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

The IL3685P delivers at least 1.5 V into a 54 Ω load for excellent data integrity over long cable lengths. The device is compatible with 3.3 V RS-485 busses and 3.3 V or 5 V controller interfaces.

Current limiting and thermal shutdown features protect against output short circuits and bus contention that may cause excessive power dissipation. Receiver inputs feature a "fail-safe if open" design, ensuring a logic high R-output if A/B are floating.

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Absolute Maximum Ratings[11]

Parameter	Symbol	Min.	Typ.	Max.	Units	Test Conditions
Storage Temperature	T_S	−55		150	°C	
Junction Temperature	T_J	−55		150	°C	
Ambient Operating Temperature	T_A	−40		85	°C	
Voltage Range at A or B Bus Pins		−7		12	V	
Supply Voltage[1]	V_{DD1}, V_{DD2}	−0.5		7	V	
Digital Input Voltage		−0.5		V_{DD} + 0.5	V	
Digital Output Voltage		−0.5		V_{DD} + 1	V	
ESD (all bus nodes)		15			kV	HBM

Recommended Operating Conditions

Parameter	Symbol	Min.	Typ.	Max.	Units	Test Conditions
Supply Voltage	V_{DD1} V_{DD2}	3.0 4.5		5.5 5.5	V	
Junction Temperature	T_J	−40		110	°C	
High-Level Digital Input Voltage	V_{IH}	2.4 3.0		V_{DD1}	V	V_{DD1} = 3.3 V V_{DD1} = 5.0 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	
Ambient Operating Temperature	T_A	−40		85	°C	Data Rate = 40 Mbps; R_L = 54 Ω
Digital Input Signal Rise and Fall Times	t_{IR}, t_{IF}	DC Stable				

Insulation 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
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
High Voltage Endurance (Maximum Barrier Voltage for Indefinite Life)	AC DC	V_{IO}	1000 1500			V_{RMS} V_{DC}	At maximum operating temperature
Surge Immunity (“V” Version)		V_{IOSM}	12.8			kV_{PK}	Per IEC 61000-4-5
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}		31		°C/W	Soldered to double-sided board; free air
Junction–Case (Top) Thermal Resistance	θ_{JT}		17		°C/W	
Power Dissipation	P_D			800	mW	

Safety and Approvals

VDE V 0884-11 (pending under VDE File Number 5016933-4880-0001)
Basic Isolation

- 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

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 (Pending under Component Recognition Program File Number E207481)
Each part tested at 3000 V_{RMS} (4243 V_{PK}) for 1 second; each lot sample tested at 2500 V_{RMS} (3536 V_{PK}) for 1 minute

Soldering Profile

Per JEDEC J-STD-020C, MSL 1

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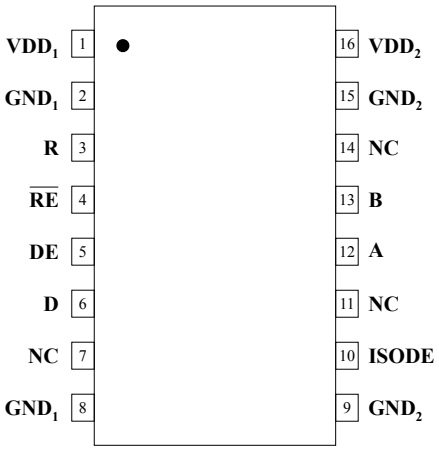
Pin Connections

1	V_{DD1}	Input power supply.
2	GND_1	Input power supply ground return (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.
6	D	Data input to bus.
7	NC	No internal connection.
8	GND_1	Input power supply ground return (pin 8 is internally connected to pin 2).
9	GND_2	Output power supply ground return (pin 9 is internally connected to pin 15).
10	ISODE	Isolated DE output for use in PROFIBUS applications where the state of the isolated drive enable node needs to be monitored.
11	NC	No internal connection.
12	A	Non-inverting bus line.
13	B	Inverting bus line.
14	NC	No internal connection.
15	GND_2	Output power supply ground return (pin 15 is internally connected to pin 9).
16	V_{DD2}	Output power supply.



Driver Section

Electrical Specifications (T_{min} to T_{max} and V_{DD} = 2.7 V to 3.3 V 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[2]	$\|V_{OD1}\|$			V_{DD}	V	I_O = 0
Differential Output Voltage[2]	$\|V_{OD2}\|$	2.1	3	3.5	V	R_L = 54 Ω
Differential Output Voltage[2][6]	V_{OD3}	1.9		3.5	V	R_L = 60 Ω
Change in Magnitude of Differential Output Voltage[7]	$\Delta\|V_{OD}\|$			±0.2	V	R_L = 54 Ω or 100 Ω
Common Mode Output Voltage	V_{OC}			3	V	R_L = 54 Ω or 100 Ω
Change in Magnitude of Common Mode Output Voltage[7]	$\Delta\|V_{OC}\|$			±0.2	V	R_L = 54 Ω or 100 Ω
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 V < V_O < 12 V
Supply Current V_{DD1} = 5 V V_{DD1} = 3.3 V	I_{DD1} I_{DD1}		4 3	6 4	mA	No load (Outputs Enabled)

Notes (apply to both driver and receiver sections):

1. All voltages are with respect to network ground except differential I/O bus voltages.
2. Differential input/output voltage is measured at the noninverting terminal A with respect to the inverting terminal B.
3. Skew limit is the maximum propagation delay difference between any two devices at 25°C.
4. Typical values are at V_{DD1} = V_{DD2} = 3.3 V; T_A = 25°C.
5. −7 V < V_{CM} < 12 V; 4.5 V < V_{DD} < 5.5 V.
6. $\Delta|V_{OD}|$ 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.
7. This applies for both power on and power off, refer to ANSI standard RS-485 for exact condition. The EIA/TIA-422-B limit does not apply for a combined driver and receiver terminal.
8. Includes 10 ns read enable time. Maximum propagation delay is 25 ns after read assertion.
9. Pulse skew is defined as $|t_{PLH} - t_{PHL}|$ of each channel.
10. Absolute Maximum specifications mean the device will not be damaged if operated under these conditions. It does not guarantee performance.
11. The relevant test and measurement methods are given in the Electromagnetic Compatibility section on p. 6.
12. 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. 6).

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Receiver Section

Electrical Specifications (T_{min} to T_{max} and V_{DD2} = 3.0 V to 3.6 V unless otherwise stated)						
Parameter	**Symbol**	**Min.**	**Typ.**[5]	**Max.**	**Units**	**Test Conditions**
Positive-going Input Threshold Voltage	V_{IT+}			0.2	V	−7 V < V_{CM} < 12 V
Negative-going Input Threshold Voltage	V_{IT-}	−0.2			V	−7 V < V_{CM} < 12 V
Hysteresis Voltage (V_{IT+} − V_{IT-})	V_{HYS}		28		mV	V_{CM} = 0 V, T = 25°C
Differential Bus Input Capacitance	C_D		9	12	pF	
High Level Digital Output Voltage	V_{OH}	V_{DD} − 0.2	V_{DD}		V	V_{ID} = 200 mV I_{OH} = −20 µA
Low Level Digital Output Voltage	V_{OL}			0.2	V	V_{ID} = −200 mV I_{OH} = 20 µA
High-impedance-state output current	I_{OZ}			±1	µA	V_O = 0.4 to (V_{DD2}−0.5) V
Line Input Current[8]	I_I			220	µA	V_I = 12 V
				−160	µA	V_I = −7 V
Input Resistance	R_I	60			kΩ	
Supply Current	I_{DD2}		5	16	mA	No load; Outputs Enabled; V_{DD2X} connected to V_{DD2I} if applicable

Switching Characteristics

V_{DD1} = 5 V, V_{DD2} = 3.3 V						
Parameter	**Symbol**	**Min.**	**Typ.**[5]	**Max.**	**Units**	**Test Conditions**
Data Rate		40			Mbps	R_L = 54 Ω, C_L = 50 pF
Propagation Delay[2, 9]	t_{PD}		20	30	ns	V_O = −1.5 to 1.5 V, C_L = 15 pF
Pulse Skew[2, 10]	t_{SK}(P)		1	5	ns	V_O = −1.5 to 1.5 V, C_L = 15 pF
Skew Limit[3]	t_{SK}(LIM)		2	10	ns	R_L = 54 Ω, C_L = 50 pF
Output Enable Time To High Level	t_{PZH}		15	30	ns	C_L = 15 pF
Output Enable Time To Low Level	t_{PZL}		15	30	ns	C_L = 15 pF
Output Disable Time From High Level	t_{PHZ}		15	30	ns	C_L = 15 pF
Output Disable Time From Low Level	t_{PLZ}		15	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
V_{DD1} = 3.3 V, V_{DD2} = 3.3 V						
Parameter	**Symbol**	**Min.**	**Typ.**[5]	**Max.**	**Units**	**Test Conditions**
Data Rate		40			Mbps	R_L = 54 Ω, C_L = 50 pF
Propagation Delay[2, 9]	t_{PD}		25	35	ns	V_O = −1.5 to 1.5 V, C_L = 15 pF
Pulse Skew[2, 10]	t_{SK}(P)		2	5	ns	V_O = −1.5 to 1.5 V, C_L = 15 pF
Skew Limit[3]	t_{SK}(LIM)		4	10	ns	R_L = 54 Ω, 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

Magnetic Field Immunity[12]

V_{DD1} = 5 V, V_{DD2} = 5 V						
Power Frequency Magnetic Immunity	H_{PF}		3500		A/m	50Hz/60Hz
Pulse Magnetic Field Immunity	H_{PM}		4500		A/m	t_p = 8µs
Damped Oscillatory Magnetic Field	H_{OSC}		4500		A/m	0.1Hz – 1MHz
Cross-axis Immunity Multiplier[13]	K_X		2.5			
V_{DD1} = 3.3 V, V_{DD2} = 5 V						
Power Frequency Magnetic Immunity	H_{PF}		1500		A/m	50Hz/60Hz
Pulse Magnetic Field Immunity	H_{PM}		2000		A/m	t_p = 8µs
Damped Oscillatory Magnetic Field	H_{OSC}		2000		A/m	0.1Hz – 1MHz
Cross-axis Immunity Multiplier[13]	K_X		2.5			

Electrostatic Discharge Sensitivity

This product has been tested for electrostatic sensitivity to the limits stated in the specifications. However, NVE recommends that all integrated circuits be handled with appropriate care to avoid damage. Damage caused by inappropriate handling or storage could range from performance degradation to complete failure.

Dynamic Power Consumption

IsoLoop Isolators achieve their low power consumption from the way they transmit data across the isolation barrier. By detecting the edge transitions of the input logic signal and converting these to narrow current pulses, a magnetic field is created around the GMR Wheatstone bridge. Depending on the direction of the magnetic field, the bridge causes the output comparator to switch following the input logic signal. Since the current pulses are narrow, about 2.5 ns, the power consumption is independent of mark-to-space ratio and solely dependent on frequency. This has obvious advantages over optocouplers, which have power consumption heavily dependent on frequency and time.

Data Rate (Mbps)	I_{DD1}	I_{DD2}
1	150 µA	150 µA
10	1.5 mA	1.5 mA
20	3 mA	3 mA
40	6 mA	6 mA

Table 2. Typical Dynamic Supply Currents.

Power Supply Decoupling

Both V_{DD1} and V_{DD2} must be bypassed with 47 nF ceramic capacitors. These should be placed as close as possible to V_{DD} pins for proper operation. Additionally, V_{DD2} should be bypassed with a 10 µF tantalum capacitor.

DC Correctness

The IL3685 incorporates a patented refresh circuit to maintain the correct output state with respect to data input. At power up, the bus outputs will follow the Function Table shown on Page 1. The DE input should be held low during power-up to eliminate false drive data pulses from the bus. An external power supply monitor to minimize glitches caused by slow power-up and power-down transients is not required.

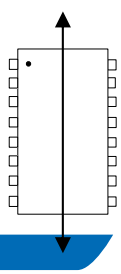
Maintaining Creepage

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.

Electromagnetic Compatibility

IL3685-Series Transceivers are fully compliant with generic EMC standards EN50081, EN50082-1 and the umbrella line-voltage standard for Information Technology Equipment (ITE) EN61000. The IsoLoop Isolator's Wheatstone bridge configuration and differential magnetic field signaling ensure excellent EMC performance against all relevant standards. NVE conducted compliance tests in the categories below:

EN50081-1
Residential, Commercial & Light Industrial
Methods EN55022, EN55014
EN50082-2: Industrial Environment
Methods EN61000-4-2 (ESD), EN61000-4-3 (Electromagnetic Field Immunity), EN61000-4-4 (Electrical Transient Immunity), EN61000-4-6 (RFI Immunity), EN61000-4-8 (Power Frequency Magnetic Field Immunity), EN61000-4-9 (Pulsed Magnetic Field), EN61000-4-10 (Damped Oscillatory Magnetic Field)



ENV50204
Radiated Field from Digital Telephones (Immunity Test)

Immunity to external magnetic fields is even higher if the field direction is “end-to-end” (rather than to “pin-to-pin”) as shown in the diagram above.

Application Information

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

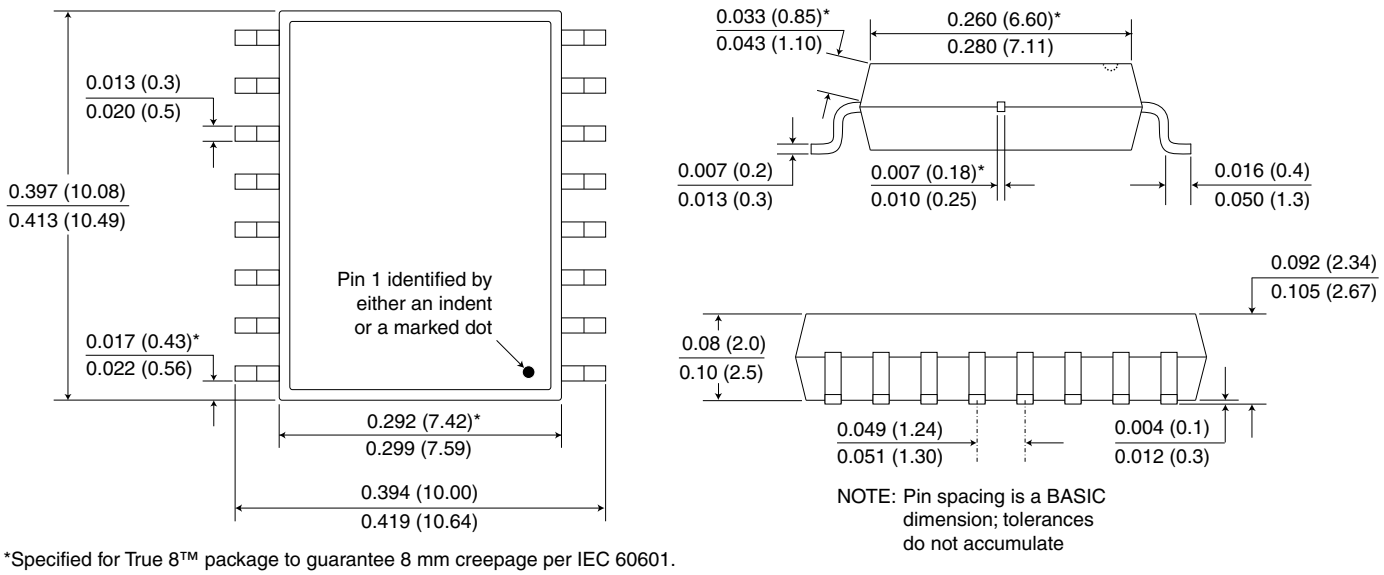
Driver Features
The RS-485 driver has a differential output and delivers at least 2.1 V across a 54 Ω load. In addition, unlike most other transceivers, IL3685-Series transceivers meet stringent PROFIBUS standards for maximum differential output voltage.

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

Receiver Data Rate, Cables and Terminations
PROFIBUS Type A bus cable is recommended for high transmission speeds (more than 500 Kbps). Type B should only be used at low baud rates and low requirements on the network distances. IL3685-Series transceivers are intended for networks up to 4,000 feet (1,200 m) with Type A bus cable and proper termination. The maximum data rate decreases as cable length increases.

Package Drawing

Dimensions in inches (mm); scale = approx. 5X

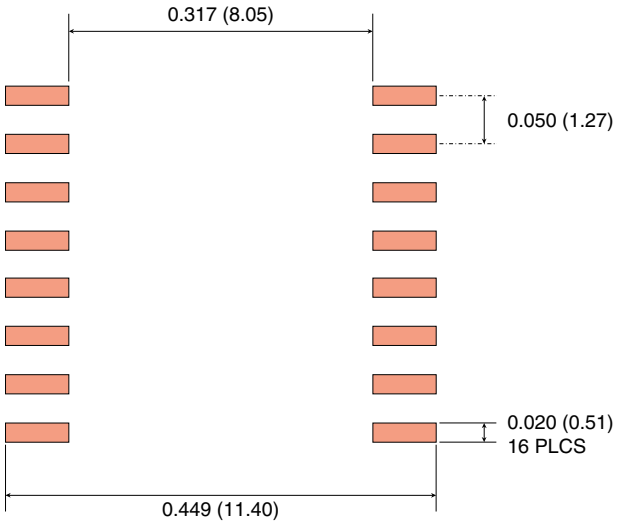


NOTE: Pin spacing is a BASIC dimension; tolerances do not accumulate

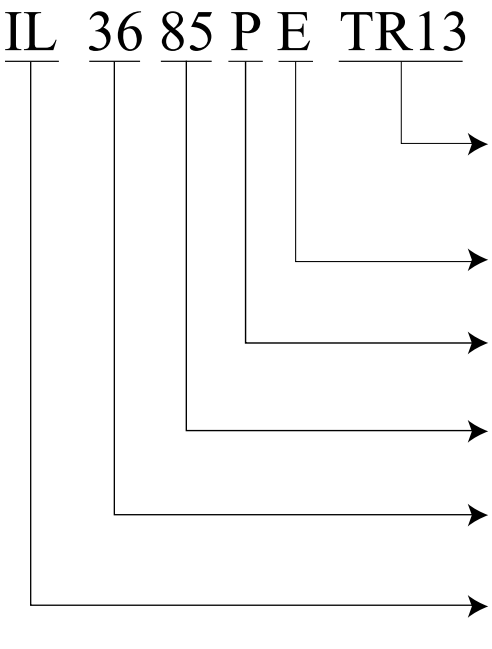
*Specified for True 8™ package to guarantee 8 mm creepage per IEC 60601.

Recommended Pad Layout

Dimensions in inches (mm); scale = approx. 5X



Ordering Information and Valid Part Numbers



Bulk Packaging
Blank = Tube
TR13 = 13" Tape and Reel

Package
E = RoHS Compliant 0.3" SOIC

Variant Designator
P = 3.3V Bus Version

Channel Configuration
85 = RS-485

Base Part Number
36 = High-Speed Transceiver

Product Family
IL = Isolators

Valid Part Numbers
IL3685PE
IL3685PE TR13

RoHS COMPLIANT

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Revision History

ISB-DS-001-IL3685P-A **December 2017**	**Change** • Revised thermal specifications • Initial release.
ISB-DS-001-IL3685P-PRELIM **May 2017**	**Change** • Preliminary release.

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ISB-DS-001-IL3685P-A

December 2017