RS-485 Reference Guide

Texas Instruments

Factory Automation
Building Automation and HVAC
Industrial Process Control
Motor Control
Telecommunications Equipment
Security Networks
Metering

www.ti.com/rs485

2014

RS-485 Reference Guide

Introduction to RS-485

RS-485 is the most versatile communication standard that can connect data terminal equipment (DTE) directly without the need of modems. TI's RS-485 interface devices are widely used in applications such as:

- Factory automation
- Building automation and HVAC
- Industrial Process Control
- Motor Control
- Telecommunications Equipment
- Security Networks
- Metering

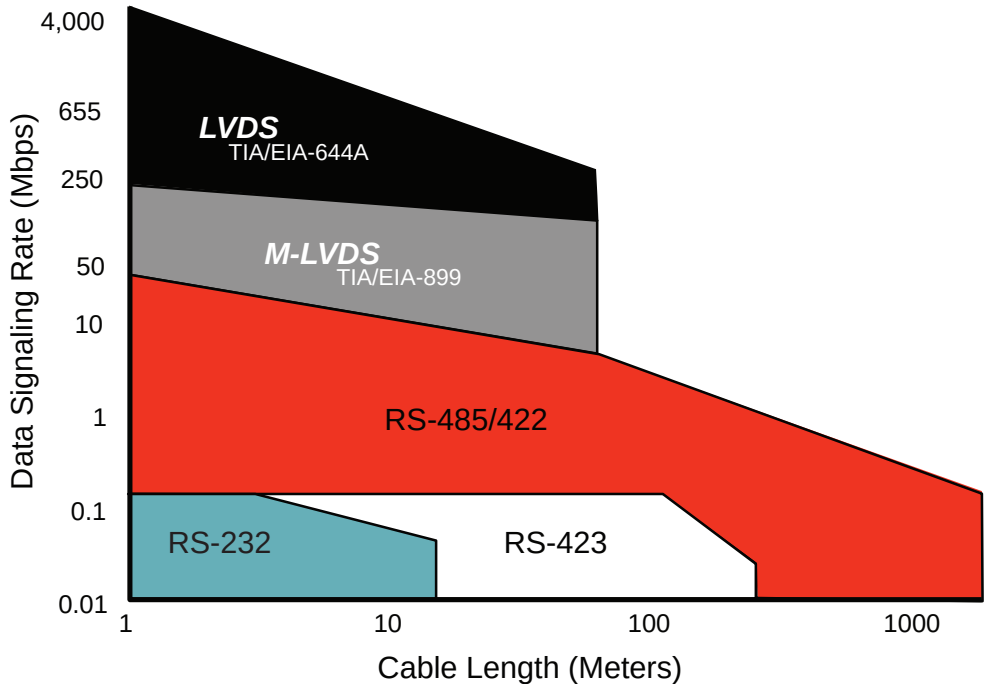
TI's broad portfolio offers a wide selection of different supply voltages, data rates, and special features such as high transient protection, high speed, fault protection, IEC ESD protection, crosswire immunity, low power and wide common-mode operation.

TI's isolated RS-485 devices provide up to 2.5kVrms (V_{ISO}) galvanic isolation for immunity to noise and ground loop improvements. Devices supporting ProfiBus™, ControlNet™, ModBus™, and many other protocols are available.

RS-485 Features

- Balanced interface
- Multipoint operation from single 5V or 3.3V supply
- -7V to +12V bus common mode range
- Up to 256 nodes on a single bus
- Ability to communicate over long distances (up to 1200m)
- Fast communication rates (up to 50Mbps)
- Receiver input resistance: 12kΩ (min)
- Receiver sensitivity: ±200mV
- Driver load: 60Ω
- Driver output short-circuit limit: 250mA

Comparison of Standards



Standards Using RS-485 Signaling

ProfiBus – popular for factory automation, signaling up to 12Mbps *http://www.profibus.com/*
ModBus – popular for process control and building automation *http://www.modbus.org/*
BACnet – popular for HVAC and building automation *http://www.bacnet.org/*
CompoNet – popular for motion control and robotics *http://www.odva.org/*
EnDat – for position encoders in motion control *http://www.heidenhain.com/en_US/fundamentals/endat-22/*
BiSS – open source interface for sensors and actuators *http://www.biss-interface.com/interfaces/*

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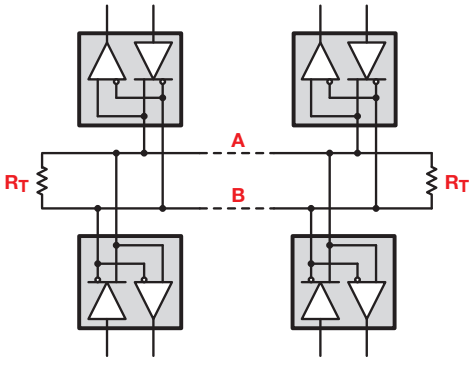
RS-485 Portfolio

	Half-duplex Transceivers	Features	Full-duplex Transceivers
5V	HVD3082E, HVD3085E, HVD3088E	Economical, Small Packages	HVD3080E, HVD3083E, HVD3086E
	HVD20, HVD21, HVD22	-20 to +25 Common Mode	
	HVD23, HVD24	-20 to +25 CM, Equalization	
	HVD1785, HVD1786, HVD1787	±70V Protection, Wide Common Mode	HVD1791, HVD1792, HVD1793
	HVD82	IEC 61000-4-2 +12kV ESD rating	
	LBC184	Toughest, IEC 61000-4-2 +12kV ESD rating, TVS	
	HVD1176	ProfiBus	
	HVD888	Cross Wire Immunity	ISO3080, ISO3086, ISO3086T
	ISO3082, ISO3088	4kVpk Isolated RS-485	
	ISO1176, ISO1176T	4kVpk Isolated ProfiBus	
3.3V - 5V	HVD1780, HVD1781, HVD1782	±70V Protection, 3-5V V_{CC}	
3.3V	HVD10, HVD11, HVD12	±16kV HBM ESD, Small Packages	
		No Enables	HVD30, HVD31, HVD32
		Enables	HVD33, HVD34, HVD35
		Low Power	HVD37
		IEC 61000-4-2 ±16kV, +30kV HBM ESD rating — Enables	HVD1470, HVD1473, HVD1476
		IEC 61000-4-2 ±16kV, +30kV HBM ESD rating — No-Enables	HVD1471, HVD1474, HVD1477
	HVD72, HVD75, HVD78	IEC 61000-4-2 ±12kV, +30kV HBM ESD rating — Enables	HVD70, HVD73, HVD76
		IEC 61000-4-2 ±12kV, +30kV HBM ESD rating — No-Enables	HVD71, HVD74, HVD77
	HVD01	IEC 61000-4-2 ±16kV ESD, Low-Voltage I/O, Switchable Data Rate	
	ISO15, ISO15M	4kV Isolated RS-485	ISO35, ISO35M, ISO35T

New | Existing

Terminations

Parallel Termination

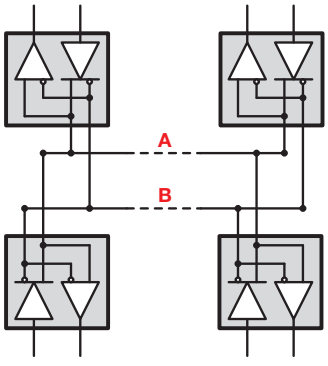


$R_T = Z_0$

↑ Minimized Reflections

↓ Increased Power Dissipation in R_T

Un-terminated
slow data rates only or short distance
(not recommended)



$R_T \rightarrow \infty$

↑ Lowest Power

↓ Increased Reflection

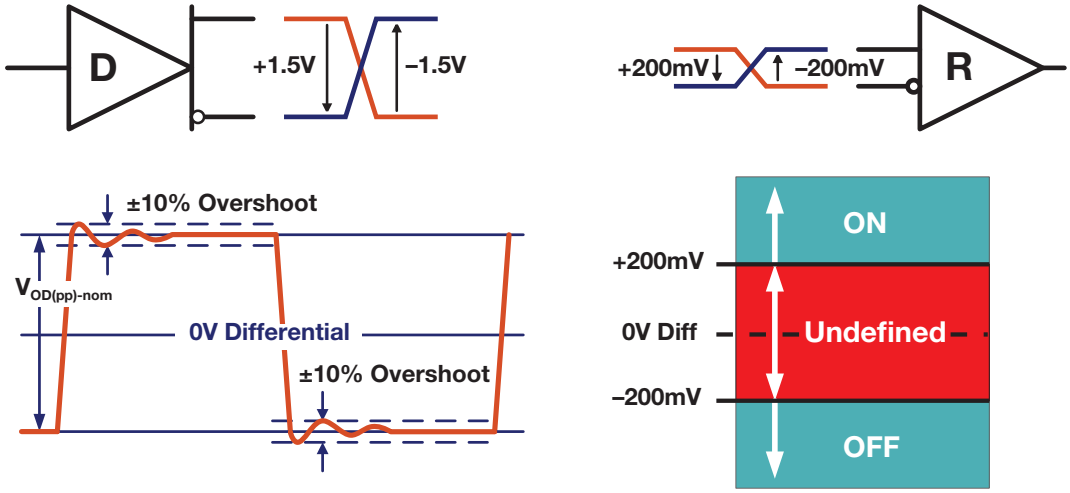
RS-485 Reference Guide

Selection Table

Device	TX/ RX	Duplex	Supply (V)	Features	Signaling Rate (Mbps)	HBM ESD (kV)	Receiver Fail-Safe	Nodes	Package(s)
RS-485 Transceivers									
High ESD-Protected Transceivers									
SN65HVD1470/1473/1476	1/1	Full	3.3	±16kV IEC 61000-4-2 ESD, ±30kV HBM, ±4kV EFT, w/Enables	0.4, 20, 50	30	Short, Open, Idle	256	SOIC-14, MSOP-10
SN65HVD1471/1474/1477	1/1	Full	3.3	±16kV IEC 61000-4-2 ESD, ±30kV HBM, ±4kV EFT, No Enables	0.4, 20, 50	30	Short, Open, Idle	256	SOIC-8, MSOP-8
SN65HVD70/73/76	1/1	Full	3.3	±12kV IEC 61000-4-2 ESD, ±30kV HBM, ±4kV EFT, w/Enables	0.4, 20, 50	30	Short, Open, Idle	256	SOIC-14, MSOP-10
SN65HVD71/74/77	1/1	Full	3.3	±12kV IEC 61000-4-2 ESD, ±30kV HBM, ±4kV EFT, No Enables	0.4, 20, 50	30	Short, Open, Idle	256	SOIC-8, MSOP-8
SN65HVD01	1/1	Half	3.3	±16kV IEC 61000-4-2 ESD, 1.8/3.3V IO, Selectable data rate	0.25, 20	15	Short, Open, Idle	256	SON-10
SN65HVD72/75/78	1/1	Half	3.3	±12kV IEC 61000-4-2 ESD, ±4kV EFT, High Hysteresis	0.25, 20, 50	15	Short, Open, Idle	256	SOIC-8, MSOP-8, SON-8
SN65HVD888	1/1	Half	5	±12kV IEC 61000-4-2 ESD, ±4kV EFT, Auto polarity	0.25	16	Short, Open, Idle	256	SOIC-8
SN65HVD82	1/1	Half	5	±12kV IEC 61000-4-2 ESD, ±4kV EFT, Low Power	0.25	16	Short, Open, Idle	256	SOIC-8
SN65LBC184	1/1	Half	5	±30kV IEC 4-2 ESD, IEC 4-5 Surge, Transient Voltage Suppression	0.25	15	Open	128	SOIC-8, PDIP-8
Fault Robust Transceivers									
SN65HVD1780/1/2	1/1	Half	3.3 to 5	Up to ±70V Protected, Wide Supply Range: 3.3V to 5V	0.115, 1, 10	16	Short, Open, Idle	320	SOIC-8, PDIP-8
SN65HVD1785/6/7	1/1	Half	5	Up to ±70V Protected, Wide –20V to +25V Common Mode	0.115, 1, 10	16	Short, Open, Idle	256	SOIC-8, PDIP-8
SN65HVD1791/2/3	1/1	Full	5	Up to ±70V Protected, Wide –20V to +25V Common Mode	0.115, 1, 10	16	Short, Open, Idle	256	SOIC-14
SN65HVD1794	1/1	Half	5	±70V Protected, Bus-Pin Invert/Wide Common Mode	0.115	16	Short, Open, Idle	256	SOIC-8, PDIP-8
SN65HVD20/21/22	1/1	Half	5	Wide Common Mode –20V to +25V	25, 5, 0.5	16	Short, Open, Idle	256	SOIC-8, PDIP-8
SN65HVD23/24	1/1	Half	5	Wide Common Mode –20V to +25V with Receiver Equalization	25, 3	16	Short, Open, Idle	256	SOIC-8, PDIP-8
RS-485 Transceivers									
SN65HVD10/11/12	1/1	Half	3.3	High/Mid/Low Speed Slew-Rate Control	32, 10, 1	16	Short, Open, Idle	256	SOIC-8, PDIP-8
SN65HVD3082E/5E/8E	1/1	Half	5	Ultra-Low Power, Optimized for Low, Medium & High Speeds	0.2, 1, 20	15	Short, Open, Idle	256	SOIC-8, MSOP-8, PDIP-8
SN65HVD485E	1/1	Half	5	Half-Duplex Transceiver	10	15	Open	64	SOIC-8, MSOP-8, PDIP-8
SN65HVD37	1/1	Full	3.3	High Signaling Rate, Low Power, High Hysteresis	20	15	Short, Open, Idle	256	SOIC-14
SN65HVD30/31/32/33/34/35	1/1	Full	3.3	High/Mid/Low Speed, Enables/No Enables	26, 5, 1	15	Short, Open, Idle	256	SOIC-8, SOIC-14, QFN-20
SN65HVD3080E/3E/6E	1/1	Full	5.0	Ultra-Low Power, Optimized for Low, Medium & High Speeds	0.2, 1, 20	16	Short, Open, Idle	256	SOIC-14, MSOP-10
Multi-channel Transceivers									
SN65LBC172A/174A	4/0	NA	5	Quad Differential Drivers, High Signaling Rate	30	12	—	—	PDIP-16, SOIC-16, SOIC-20
AM26LV31E	4/0	NA	3.3	Quad Drivers, High Signaling Rate, IEC 4-2 ESD	64	15	—	—	SO-16, SOIC-16, TSSOP-16, QFN-16
SN65LBC173A/175A	0/4	NA	5	Quad Differential Receivers, High Signaling Rate, Low Power	50	6	Short, Open, Idle	32	PDIP-16, SOIC-16
AM26LV32E	0/4	NA	3.3	Quad Receivers, High Signaling Rate, IEC 4-2 ESD	64	15	Short, Open, Idle	10	SO-16, SOIC-16, TSSOP-16, QFN-16
PROFIBUS Transceivers									
SN65HVD1176	1/1	Half	5	PROFIBUS (EN 50170) Transceiver	40	10	Short, Open, Idle	160	SOIC-8
ISO1176/1176T	1/1	Half	5	Isolated PROFIBUS Transceiver, Transformer Driver option	40	16	Short, Open, Idle	160	SOIC-16
Isolated RS-485 Transceivers									
ISO15/15M	1/1	Half	3.3	±4kVpk Isolated RS-485, Extended Operating Temperature	1	16	Short, Open, Idle	256	SOIC-16 (W)
ISO35/35M/35T	1/1	Full	3.3	±4kVpk Isolated RS-485, Transformer Driver Option	1	16	Short, Open, Idle	256	SOIC-16 (W)
ISO3082/8	1/1	Half	5	±4kVpk Isolated RS-485 Optimized for Low & High Speeds	0.2, 20	16	Short, Open, Idle	256	SOIC-16 (W)
ISO3080/6	1/1	Full	5	±4kVpk Isolated RS-485, Optimized for Low & High Speeds	0.2, 20	16	Short, Open, Idle	256	SOIC-16 (W)
ISO3086T	1/1	Full	5	Isolated 5V RS-485 Transceiver with Transformer Driver	20.00	16	Short, Open, Idle	256	SOIC-16 (W)

*New products are listed in **bold red.***

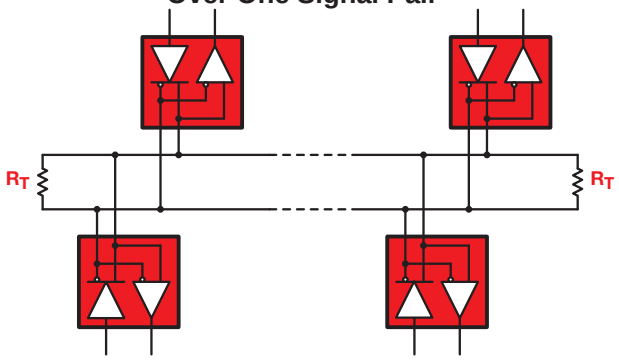
Signal Levels Specified by Standard



Minimum Driver Output | **Receiver Sensitivity**

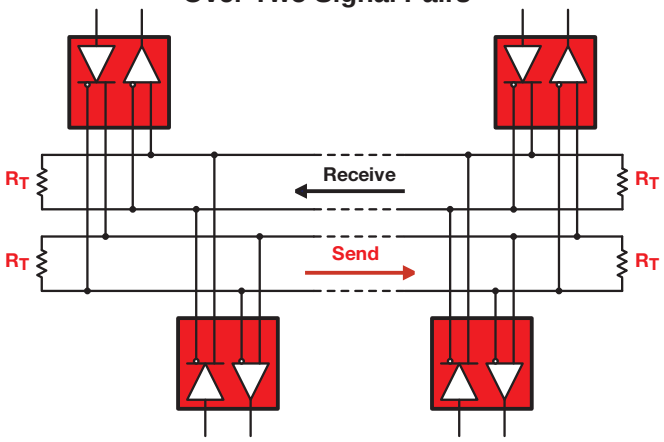
Half-Duplex Versus Full-Duplex

Sequential Transmitting and Receiving Over One Signal Pair



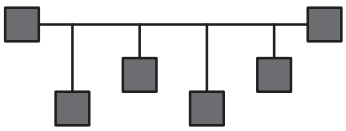
Vast Majority of Applications use Half-Duplex

Simultaneous Transmitting and Receiving Over Two Signal Pairs

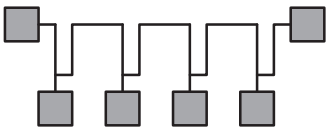


Network Topology

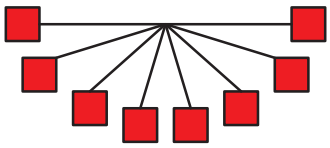
RS-485 suggests its nodes to be networked in a daisy-chain, or bus topology. In this topology, the participating drivers, receivers, and transceivers connect to a main cable trunk via short network stubs. The interface bus can be designed for full-duplex or half-duplex transmission.



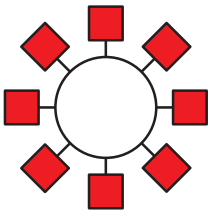
Backbone with stubs (works)



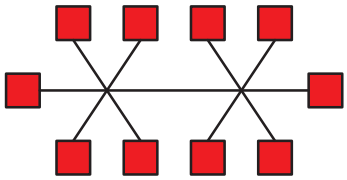
Daisy chain (best)



Star network (avoid)

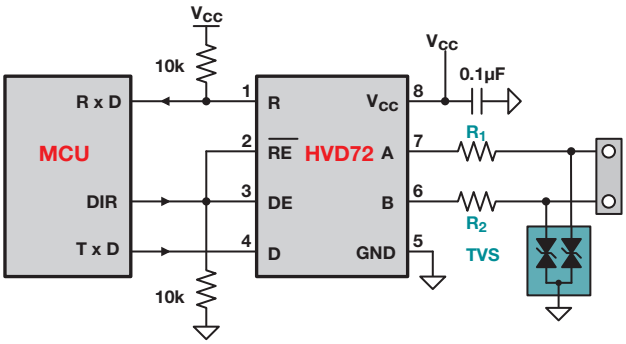


Ring network (avoid)



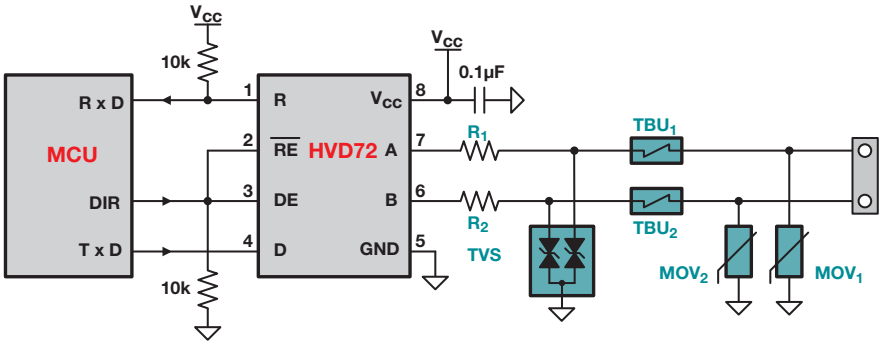
Backbone with stars or clusters (avoid)

Transient Protection



Device	Function	Order Number	Manufacturer
R_1, R_2	10Ω, Pulse-Proof Thick-Film Resistor	CRCW0603010RJNEAHP	Vishay
TVS	Bidirectional 400W Transient Suppressor	CDSOT23-SM712	Bourns
TBU_1,TBU_2	Bidirectional. 200mA Transient Blocking Unit	TBU-CA-065-200-WH	Bourns
MOV_1,MOV_2	200V, Metal-Oxide Varistor	MOV-10D201K	Bourns

ESD: 12kV IEC Contact, 15kV HBM; EFT: 4kV; Surge: 1kV

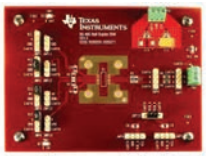


ESD: 12kV IEC Contact, 15kV HBM
EFT: 4kV
Surge: 5kV
Power Cross: 125Vrms

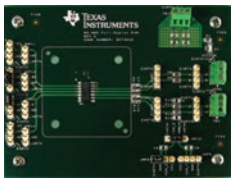
Transient protection against ESD, EFT and surge transients – www.ti.com/transientprotection

Evaluation Boards

RS-485 Half-Duplex Evaluation Module



RS-485 Full-Duplex Evaluation Module



RS-485 EVM SN65HVD22EVM Evaluation Module

Isolated RS-485 EVM ISO1176EVM Evaluation Module

Isolated RS-485 EVM ISO3086T Small EVM Evaluation Module

Design Resources and References

TI provides many tools and resources, such as videos and TI Designs, to help designers create systems faster and to save money. TI offers designers a worldwide support community to help them get their questions answered quickly and to find more efficient ways to work.

RS-485 Videos

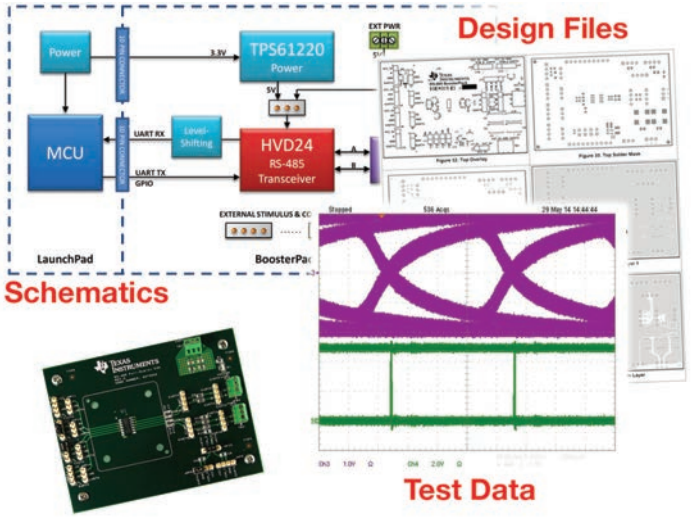
TI's Support & Community at **www.ti.com/RS485** educates designers on essentials of RS-485.

- One Minute RS-485 Introduction
- One Minute RS-485: Supply Current
- One-Minute RS-485: Common Mode Voltage
- One-Minute RS-485: Selecting Speed Grade
- One Minute RS-485: PROFIBUS
- One Minute RS-485: Receiver Failsafe
- RS-232, RS-422, RS-485: What Are the Differences?
- Engineer It - How to isolate a power supply for RS485 & CAN

TI Designs

TI's Tools and Software at **www.ti.com/RS485** give designers quick and easy ways to find evaluation modules and TI Designs to jump start their projects. TI designs enable engineers to find the schematics, test data, design files and bill of materials featuring RS-485 transceivers.

- **TIDA-00263** Isolated auto-polarity RS-485 transceiver
- **TIDA-00256** 16kV IEC ESD Full-duplex 20Mbps RS-485 transceiver
- **TIDA-00214** Half-duplex, Non-isolated RS-485 Booster Pack Reference Guide
- **TIDA-00193** RS-485 interface with integrated 1.8V level-shift capability
- **TIDA-00191** Analog Front End for Motor Electronic Overload Relays with enhanced current range
- **TIDA-00172** Interface to EnDat 2.2 Digital Encoder
- **TIDA-00123** Programmable Logic Controller (PLC) I/O Module Front-end Controller



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	Domestic	www.tij.co.jp/pic

Asia

Phone Toll-Free Number

Note: Toll-free numbers may not support mobile and IP phones.

Australia	1-800-999-084
China	800-820-8682
Hong Kong	800-96-5941
India	000-800-100-8888
Indonesia	001-803-8861-1006
Korea	080-551-2804
Malaysia	1-800-80-3973
New Zealand	0800-446-934
Philippines	1-800-765-7404
Singapore	800-886-1028
Taiwan	0800-006800
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TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

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