RS-485 Reference Guide

Texas Instruments

- Metering
- Point-of-sales
- Building automation
- Security electronics
- Digital Video Recorders (DVRs)
- Motion control
- Factory automation

www.ti.com/rs485

2012

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. Texas Instruments is the world leader in RS-485 differential line transceivers. TI's RS-485 interface devices are widely used in applications such as:

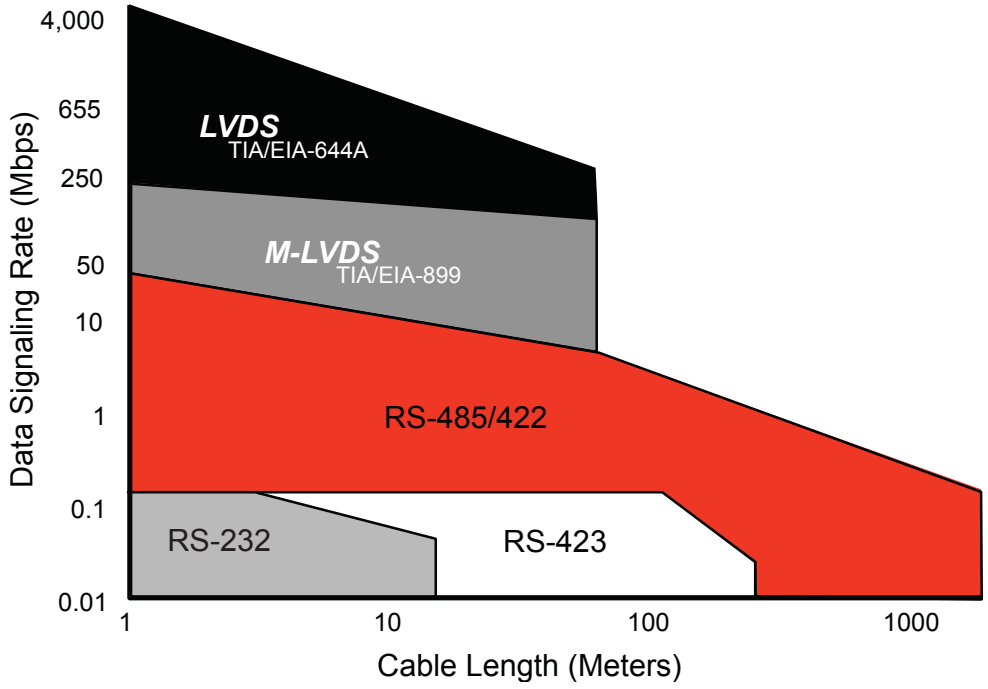
- Metering
- Point-of-sales
- Building automation
- Security electronics
- Digital Video Recorders (DVRs)
- Motion control
- Factory automation

TI provides a broad portfolio of devices with a selection of different supply voltages, number of channels, and special features such as high transient protection, high output voltage, cross-wire immunity, and wide common-mode operation. TI's isolated parts provide up to 4kVpk of galvanic isolation for immunity to noise and ground loop improvements. Devices supporting ProfiBus™, ControlNet™, ModBus™, and many other protocols are available.

Key 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



List of standards which use 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/*

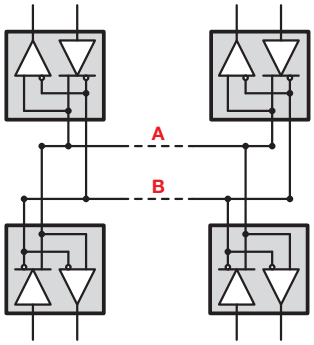
RS-485 Portfolio

	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
	LBC184	Toughest, IEC ESD Rating, TVS	
	HVD1176	ProfiBus	
	HVD96	Cross Wire Immunity (SymPol)	
	HVD09	9 Channel RS-485/422	
	ISO3082 ISO3088	4kVpk Isolated RS-485	ISO3080 ISO3086 ISO3086T
	ISO1176 ISO1176T	4kVpk Isolated ProfiBus	
3.3V - 5V	HVD08	3-5V Operating Range	
	HVD1780 HVD1781 HVD1782	70V Protection, 3-5V V_{CC}	
3.3V	HVD10 HVD11 HVD12	16kV ESD, Small Packages	
		No Enables	HVD30 HVD31 HVD32
		Enables	HVD33 HVD34 HVD35
		Low Power, High Noise Immunity	HVD37
	HVD72 HVD75 HVD78	IEC ESD Rating	
	ISO15 ISO15M	4kVpk Isolated RS-485	ISO35 ISO35M ISO35T

Preview | New | Existing

Terminations

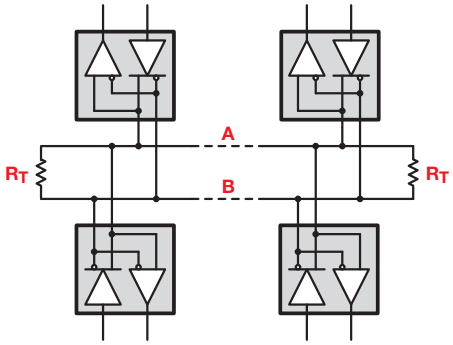
Un-terminated (not recommended)



$R_T \rightarrow \infty$

- ↑ Lowest Power
- ↓ Increased Reflection

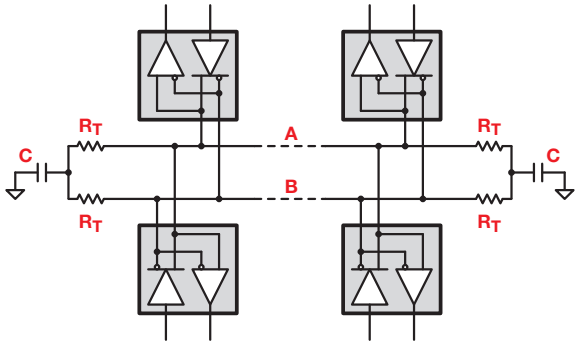
Parallel Termination



$R_T = Z_0$

- ↑ Minimized Reflections
- ↓ Increased Power Dissipation in R_T

Parallel Termination with Common-Mode Filter



$R_T = Z_0/2 \quad C = 1/(2\pi f_{s\text{-}max} \cdot R_T)$

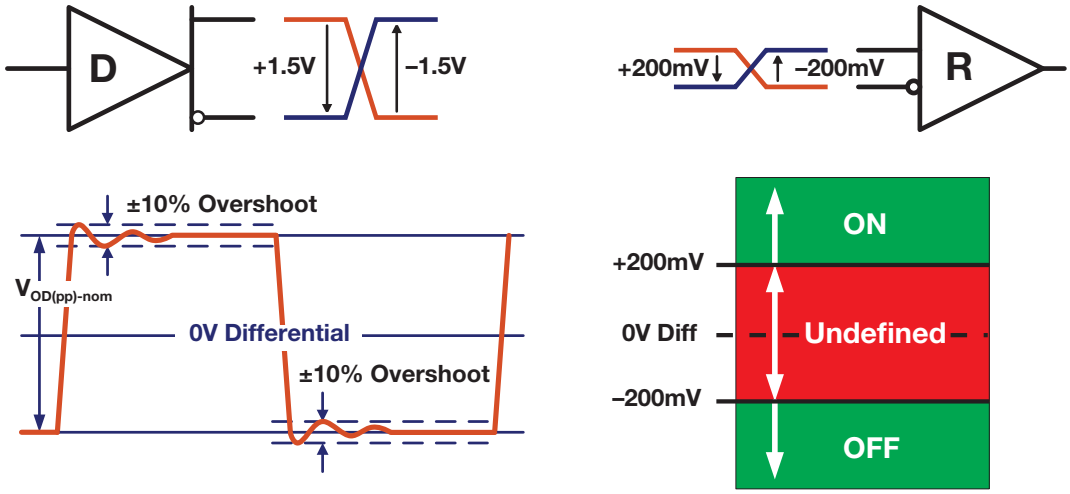
- ↑ Filters Common-Mode Noise
- ↓ Requires Precision Resistors

Selection Table

Device	DR/ RX	Duplex	Supply (V)	Features	Isolated	Signaling Rate (Mbps)	ESD (kV)	Receiver Fail-Safe	Nodes	Package
SN65HVD10/11/12	1/1	Half	3.3	High/Mid/Low Speed Slew-Rate Control	No	32, 10, 1	16	Short, Open, Idle	256	PDIP-8, SOIC-8
SN65HVD30/31/32	1/1	Full	3.3	No Enables	No	26, 5, 1	16	Short, Open, Idle	256	SOIC-8
SN65HVD33/34/35	1/1	Full	3.3	With Enables	No	26, 5, 1	16	Short, Open, Idle	256	SOIC-14, QFN-20
SN65HVD37	1/1	Full	3.3	High Signaling Rate, Low Power, High Hysteresis	No	20	7	Short, Open, Idle	256	SOIC-14
SN65HVD72/75/78	1/1	Half	3.3	IEC ESD Protection	No	0.25, 20, 50	15	Short, Open, Idle	>200	SOIC-8, MSOP-8, SON-8
ISO15/15M	1/1	Half	3.3	Isolated 3.3V Half-Duplex Transceiver	Yes	1	16	Short, Open, Idle	256	SOIC-16
ISO35/35M	1/1	Full	3.3	Isolated 3.3V Full-Duplex Transceiver	Yes	1	16	Short, Open, Idle	256	SOIC-16
ISO35T	1/1	Full	3.3	Isolated 3.3V Transceiver with Transformer Driver	Yes	1	16	Short, Open, Idle	256	SOIC-16
SN65HVD08	1/1	Half	3 to 5.5	Wide Supply Range: 3V to 5.5V	No	10	16	Short, Open, Idle	256	PDIP-8, SOIC-8
SN65HVD1780/1/2	1/1	Half	3.3 to 5	Up to ±70V Protected, Wide Supply Range: 3.3V to 5V	No	0.115, 1, 10	16	Short, Open, Idle	320	PDIP-8, SOIC-8
SN65HVD1785/6/7	1/1	Half	5	±70V Protected, Wide –20V to +25V Common Mode	No	0.115, 1, 10	16	Short, Open, Idle	256	PDIP-8, SOIC-8
SN65HVD1794	1/1	Half	5	±70V Protected, Bus-Pin Invert/Wide Common Mode	No	0.115	16	Short, Open, Idle	256	PDIP-8, SOIC-8
SN65HVD3082E/5E/8E	1/1	Half	5	Ultra-Low Power, Optimized for Low, Medium & High Speeds	No	0.2, 1, 20	16	Short, Open, Idle	256	PDIP-8, SOIC-8, MSOP-8
SN65HVD82	1/1	Half	5	IEC ESD Protection, Low Power	No	0.25	15	Short, Open, Idle	256	SOIC-8
ISO3082/8	1/1	Half	5	±4kVpk Isolated RS-485 Optimized for Low & High Speeds	Yes	0.2, 20	16	Short, Open, Idle	256	SOIC-16 (W)
SN65HVD485E	1/1	Half	5	Half-Duplex Transceiver	No	10	15	Open	64	PDIP-8, SOIC-8, MSOP-8
SN65HVD20/21/22	1/1	Half	5	±27V Protected and –20V to +25V Common Mode	No	25, 5, 0.5	16	Short, Open, Idle	256	PDIP-8, SOIC-8
SN65HVD23/24	1/1	Half	5	Receiver Equalization and –20V to +25V Common Mode	No	25, 3	16	Short, Open, Idle	256	PDIP-8, SOIC-8
SN65LBC176A	1/1	Half	5	Low Power, Fast Signaling, ESD Protection	No	30	12	Open	32	PDIP-8, SOIC-8
SN65LBC184	1/1	Half	5	ESD Protection IEC 4-2 Air, Contact & IEC 4-5 Surge	No	0.25	30	Open	128	PDIP-8, SOIC-8
SN65LBC182	1/1	Half	5	ESD Protection HBM, IEC 4-2 Air and Contact	No	0.25	15	Open	128	PDIP-8, SOIC-8
SN65HVD1791/2/3	1/1	Full	5	±70V Protected, Wide –20V to +25V Common Mode	No	0.115, 1, 10	16	Short, Open, Idle	256	SOIC-14
SN65HVD3080E/3E/6E	1/1	Full	5	Ultra-Low Power, Optimized for Low, Medium & High Speeds	No	0.2, 1, 20	15	Short, Open, Idle	256	SOIC-14, MSOP-10
ISO3080/6	1/1	Full	5	±4kVpk Isolated, Optimized for Low & High Speeds	Yes	0.2, 20	16	Short, Open, Idle	256	SOIC-16 (W)
ISO3086T	1/1	Full	5	Isolated 5V Transceiver with Transformer Driver	Yes	20	16	Short, Open, Idle	256	SOIC-16 (W)
SN65LBC180A	1/1	Full	5	High Signaling Rate, w/Enables	No	30	15	Open	32	PDIP-14, SOIC-14
SN65LBC172A/174A	4/0	NA	5	Quad Drivers, High Signaling Rate	No	30	12	—	—	PDIP-16, SOIC-16, SOIC-20
AM26LV31E	4/0	NA	3.3	Quad Drivers, High Signaling Rate, IEC 4-2 ESD	No	64	15	—	—	SO-16, SOIC-16, TSSOP-16, QFN-16
SN65LBC173A/175A	0/4	NA	5	Quad Receivers, High Signaling Rate, Low Power	No	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	No	64	15	Short, Open, Idle	10	SO-16, SOIC-16, TSSOP-16, QFN-16
SN65HVD09	9/9	Half	5	9-Channel Parallel Bus Transceivers	No	20	12	Open	32	TSSOP-56
PROFIBUS Transceivers										
SN65HVD1176	1/1	Half	5	ProfiBus™ (EN 50170) Transceiver	No	40	10	Short, Open, Idle	160	SOIC-8
ISO1176	1/1	Half	5	Isolated ProfiBus Transceiver	Yes	40	16	Short, Open, Idle	160	SOIC-16
ISO1176T	1/1	Half	5	Isolated ProfiBus Transceiver with Transformer Driver	Yes	40	10	Short, Open, Idle	160	SOIC-16
ControlNet Transcievers										
SN65HVD61	1/1	Half	5	ControlNet Transceiver	No	10	16	Short	64	SOIC-14
Sympol Transceivers										
SN65HVD96	1/1	Half	5	SymPol Transceiver	No	5	12	Short, Open, Idle	32	SOIC-8

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

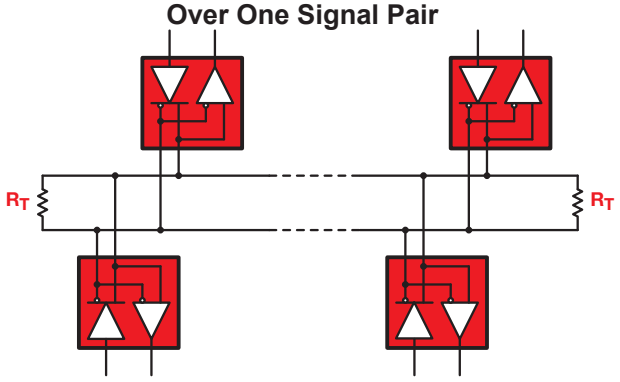
Signal Levels Specified by Standard



Minimum Driver Output | **Receiver Sensitivity**

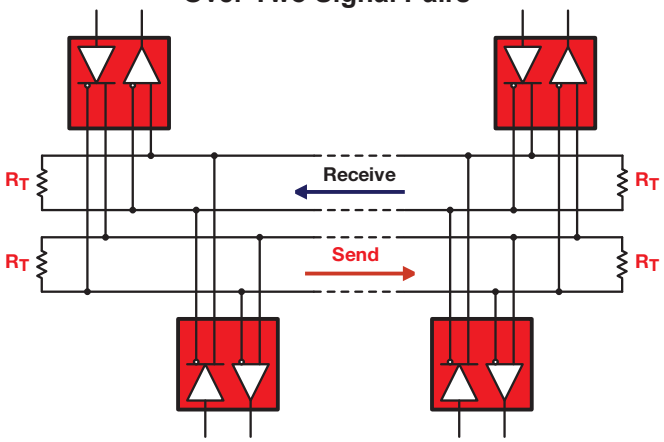
Half-Duplex versus Full-Duplex

Sequential Transmitting and Receiving Over One Signal Pair



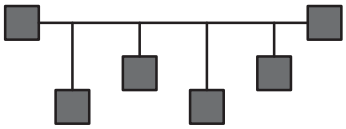
Vast Majority of Applications use Half-Duplex

Simultaneous Transmitting and Receiving Over Two Signal Pairs

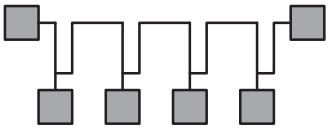


Network Topology

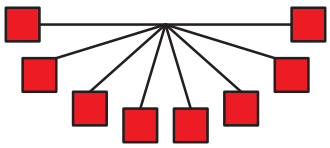
RS-485 suggests its nodes to be networked in a daisy-chain, or bus topology. In this topology, the participating drivers, receivers, and transceivers connect to a main cable trunk via short network stubs. The interface bus can be designed for full-duplex or half-duplex transmission.



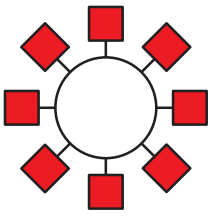
Backbone with stubs (works)



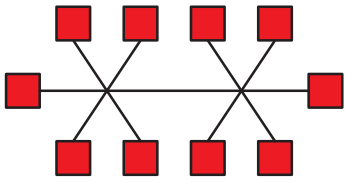
Daisy chain (best)



Star network (avoid)



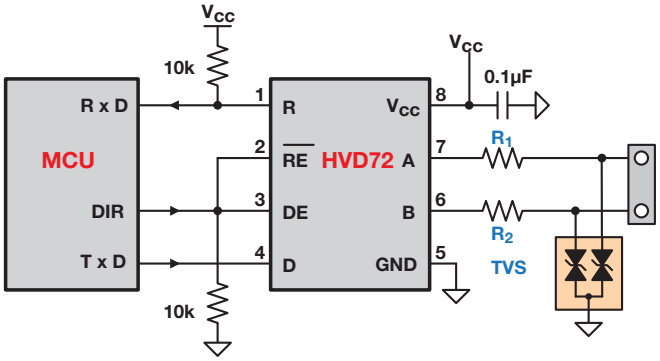
Ring network (avoid)



Backbone with stars or clusters (avoid)

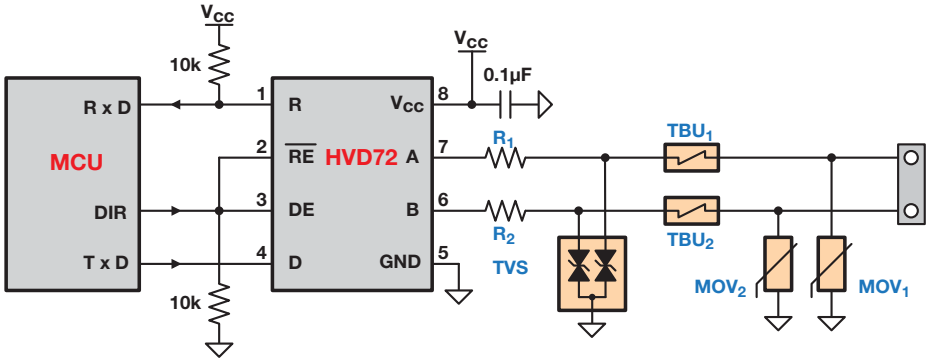
RS-485 Reference Guide

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 contact, 15kV air; EFT: 4kV; Surge:1kV

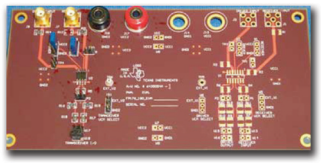


ESD:12kV contact, 16kV air
EFT: 4kV
Surge: 5kV
Power Cross: 125Vrms

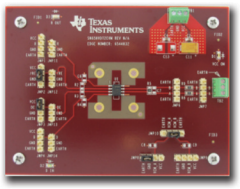
Transient protection against ESD, EFT and surge transients – www.ti.com/transientprotection

Evaluation Boards

RS-485 EVM
SN65HVD22EVM
Evaluation Module

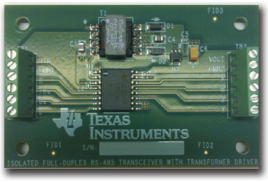


RS-485 EVM
SN65HVD72EVM
Evaluation Module



Isolated RS-485 EVM
ISO1176EVM
Evaluation Module

Isolated RS-485 EVM
ISO3086T Small EVM
Evaluation Module



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