TD_485 Transceiver Modules' Application Guide 2022

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1. RS485 basic knowledge

1.1. RS485 BUS basic Characteristics

According to RS485 Industrial Bus Standards, RS485 industrial bus use differential mode to transmit signal. This half-duplex master-slave communication bus has a characteristic impedance of 120Ω (typ.) with a maximum load of 32 payloads (including controller device and controlled device). In order to accommodate more nodes, the input impedance of certain chips are designed to be 1/2 load (≥24kΩ), 1/4 load (≥48kΩ) or even 1/8 load (≥96kΩ). The corresponding number of nodes can be increased to 64, 128 and 256.

1.2. RS485 Transmission Distance

When using 0.56mm (24AWG) twisted-pair cable, according to different baud rate, the maximum transmission distance theoretical values is shown as below:

Table 1-1 Comparison table of baud rate and transmission distance

Baud rate	Maximum distance
2400 bps	1800m
4800 bps	1200m
9600 bps	800m
19200 bps	600m

But in practical application, the actual transmission distance cannot reach the theoretical values due to factors such as quality of the cable, diameter of the cable, the network layout, the electrical environment, the actual number of nodes. Generally, the more nodes it has, the shorter the transmission distance is.

1.3. RS485 bus connection and termination resistance

RS485 industrial bus standard requires a daisy-chain connection between devices and the both two ends must be connected to a 120Ω terminal resistor (as shown in figure 1), except for

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automatic transceiver.

Figure 1-1 RS485 bus connection and termination resistance

A commonly simplified connection is shown in Figure 2. It must ensure cable length as short as possible. So during PCB layout, if possible, place the 485 transceiver in the interface and ensure that the cable length from A and B of 485 to the device port is as short as possible.

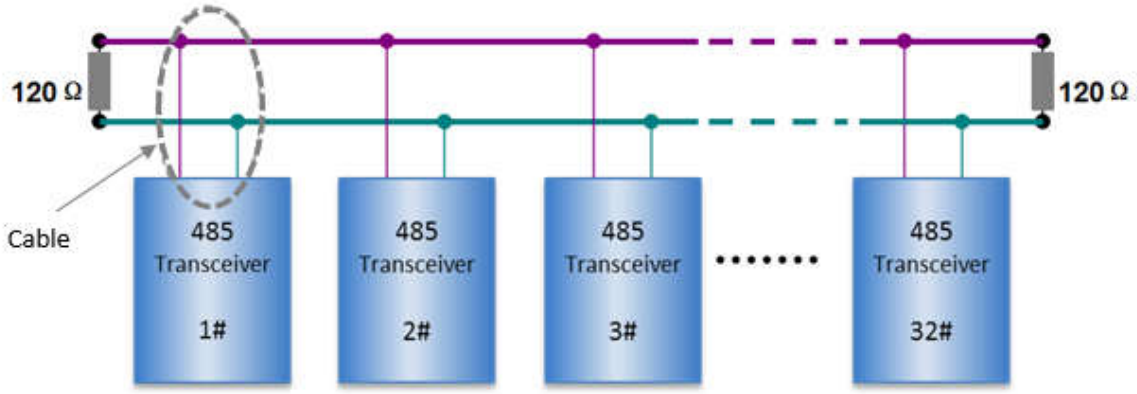

Figure 1-2 Simplified Connection of RS485 Bus

1.4. Factors affecting communication quality in practical wiring

(1) The shorter the communication distance, the better the communication quality is. If communication distance is beyond 500 meters, it is recommended to add a repeater.

(2) The fewer the communication nodes, the better the communication quality is. If the number of nodes is more than 32, it is recommended to add a repeater.

(3) The lower the communication baud rate, the better the communication quality is. In cases

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where application requirements are met, select the lower communication baud rate as much as possible. It is recommended to select between 1200~9600bps.

(4) The smaller the equivalent capacitance of the protection device between A and B ports, the lesser it affects communication. Thus, it is necessary to consider the equivalent capacitance when selecting protection device of ports (TVS tubes, varistors, etc.).

(5) Branch of each communication node must be as short as possible to reduce the impact of signal reflection of the branches to the bus.

(6) Appropriate terminal resistor can effectively reduce signal reflection. It is generally recommended to connect 120Ω resistors.

(7) Using the shielded twisted-pair, connect all communication node reference ground through the shield and ground at one point. This will reduce interference, as well as improve communication quality.

2. Precautions for hardware interface design

2.1. CON Pin's transceiver control logic

The transceiver control logic level of MORNSUN TD_485 products is just the opposite to other ordinary 485 chips'. When CON pin is 0, the bus is in a transmitting status. While when CON pin is 1, the bus is in a receiving status.

According to the characteristics of 485 bus, upon the initial power-up of the product, each communication node linked to 485 bus must be configured in a receiving status. It prevents disorder bus signals as a result of the bus remaining in a sending status when multiple machines are operated simultaneously. Upon the initial power-up of some I/O ports of the commonly used MCU (like 51 series microcontroller), the default output is high level. When this kind of MCU is connected with ordinary 485 chips, the I/O port has not been initialized upon initial power-up and 485 chips easily remain in a sending status, thus causing disorder bus signals. MORNSUN TD_485 transceivers' control logic of CON pin can solve this problem well.

At the same time, the designer also has to consider the initial power-up of the port hardware design and the bus transceiver status of TD_485 products. He or she has to ensure that the bus

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status of TD_485 products is in a receiving status, that is, the CON pin is in high level or high impedance status, upon the initial power-up.

2.2. RXD, TXD Interface Default Voltage Level

Asynchronous communication data is transmitted in bytes. Every byte has to pass through a low start bit to achieve a handshake first before transmitted. To prevent interference signals wrongly triggering RXD (receiver output) to produce negative transition status, it is recommended to connect a 10kΩ pull-up resistor to RXD in case receiver MCU entering a communication receiving waiting status. When the MCU I/O selects open-drain output or when the TXD drive capability is insufficient, the TXD pull-up resistor needs to be increased according to the actual situation.

2.3. Pull-up and pull-down resistor design on A&B Bus ports

A and B ports of TD_485 products have a weak pull-up resistor and a weak pull-down resistor in the module to ensure that bus logic level is 1 when the bus is idle. In actual application, external pull-up or pull-down resistors could be added if needed according to specific load, node and other factors.

2.4. Isolation Design on A and B bus ports

485 bus nodes are commonly networked in daisy chain or bus topology. Once a failure occurs in the interface chip of a node, it is possible to “pull dead” the entire bus. Thus, it a must to isolate bus ports A & B and the bus. Usually a 4~10 Ω of PTC resistor or 10~47 Ω ordinary resistor is connected in series between the bus and A, B ports to form an isolation. When short circuit or power breakdown of A and B occurs on a node interface chip, potential barrier forms between the bus and the nodes, thereby reducing the impact on the bus.

2.5 Lighting Protection Design on A and B Bus Ports

485 bus communications generally uses long-distance transmission, so the lightning protection design of A and B bus ports is also considered by the designer. A conventional design of the lightning protection circuit is as shown in Figure 3. For the parameters of corresponding device,

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please refer to the technical datasheet of TD_485 products. The recommended circuit diagram and parameters are for reference only. In the actual situation, it is necessary to determine whether the devices and in the recommended circuit diagram are required and whether the parameters are appropriate.

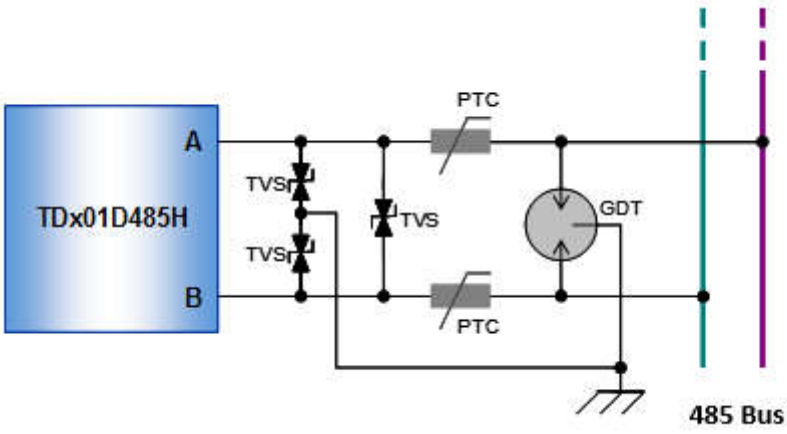

Figure 2-1 RS485 Lighting Protection Design on Bus Ports

2.6. Connections of Bus Reference Ground

Although 485 bus uses differential mode to transmit signals, it seems to no need a relative reference point to determine the signal and the system only needs to detect the potential difference between the two lines. However, the designer should also consider the common mode withstand voltage range of the interface module, such as the general -7～+12V. Only to meet this condition will the entire network work properly. When the common-mode voltage in the network line exceeds this range, it will affect the stability and reliability of communication, and even damage the interface. Using isolation technology can effectively solve the problem of common mode noise, so using isolated TD_485 transceivers to build bus hardware port can isolate ground loops on each node on the bus and reduce the ground loop current between nodes thereby reducing common mode interference. But regarding serious interference and harsh electrical environments, it recommends designers to use shielded twisted-pair. The bus reference ground of each communication node on the bus is connected through the shield to moderate common mode and radiation interference and to improve system communication reliability (as shown in Figure 4).

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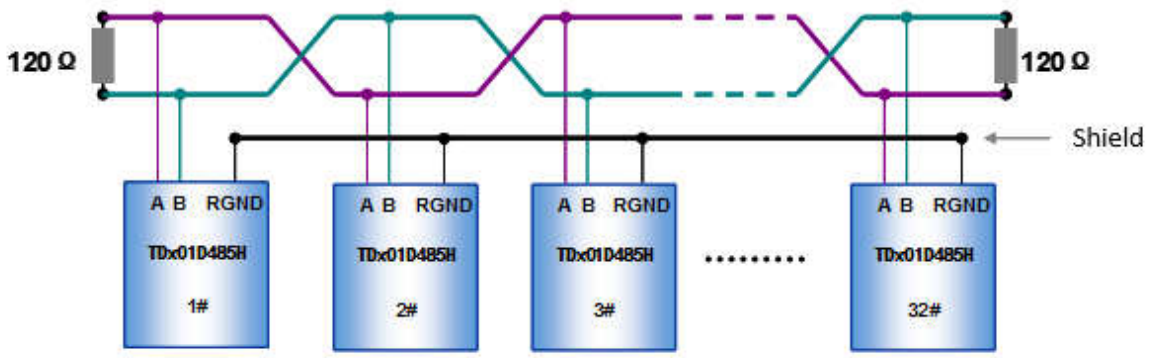

Figure2-2 Bus Reference ground wiring diagram

2.7. Wiring Applications Omitting CON Pin Control (Leave CON out)

In some special occasions, the designer may choose the transmit signal of TXD as CON pin input to save on I/O overhead of MCU (as shown in Figure2-3). When TXD is sending the logic signal "0", CON pin becomes "0" in a sending status and sends the signal "0" of TXD to the bus. When TXD is sending the logic signal "1", on the other hand, , CON pin becomes "1" in a receiving status and sends the logic signal "1" based on the bus default idle level "1" This application needs to considering following points:

(1) Baud Rate Settings: Try to choose a relatively lower baud rate. Since the delay due to the use of optocoupler control on the CON pin, at least the holding time of 1 bit should be more than the delay time of 485 transceiver switching plus the sampling time of the MCU receiver plus the delay time of line transmission.

(2) Bus Drive Capability: In this application, sending logic signal "1" relies on the bus default idle level "1", which indicates that its drive capacity is far less than 485 transceiver's. So the designer must choose appropriate communication nodes and communication distance according to the practical situation in order to guarantee the reliability of communication. At the same time, the bus terminal resistor will reduce the amplitude of the signal. Therefore, the designer cannot simply configure the terminal resistor based on the recommended value 120Ω. An appropriate terminal resistor must be selected to ensure that the differential signal amplitude will be approximately 1.5V whenever there is communication on the bus.

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(3) Using TXD to control the CON pin, RXD power failure may trigger the MCU RXD reception by mistake due to the problem of signal transmission timing, so in the actual application, the RXD level in the sending state needs to be dealt with to prevent it from false triggering.

(4) The application of TXD to control the CON pin is risky. If the CON pin control is not a must in the system, it is recommended to choose the TDxxxx485x-A (automatic transceiver) series.

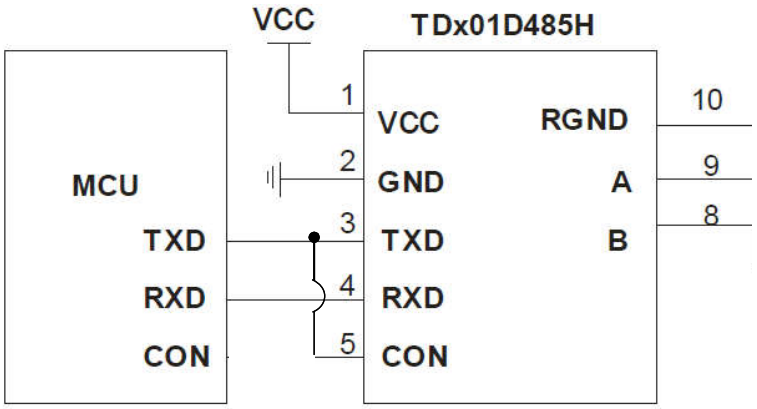

Figure 2-3 Wiring Applications Omitting CON Pin Control (Leave CON out)

3. FAQs and solutions

Table 3-1 FAQs and solutions

Customer Issues	Analysis of Cause	Solutions
Unable to Communicate	CON pin transceiver control logic error	Correct CON pin transceiver control logic
	485 Bus interface A and B polarity reverse	Switch polarity of 485 bus interface A and B
	Wrong selection of the modules (e.g. 3Vdc input products and 5Vdc input products are incompatible)	Select the compatible module according to the power supply of the SCM (e.g. select TD3xx series if 3.3V power supply needed, select TD5xx series if 5V power supply needed)
	Too large output load of the isolated power supply	The output load capacity of the isolated power module Vo is limited, which is generally used for power supply of the pull-up resistor. It is recommended to use a special isolated power supply (B0505 series) when a large load needs power supply.
	Inconsistent baud rate of transmitter and receiver	Adjust baud rate of the transmitter and receiver as the same value
	Insufficient CON pin	Increase CON pin drive capacity through pull-down

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	drive capacity	resistor
High communication error rate	Inaccurate baud rate timer clock	Use a crystal oscillator with the appropriate frequency (e.g. 11.0592M)
	Excessive communication baud rate	Decrease communication baud rate
	Too large parasitic capacitor from peripheral devices	Use the devices with smaller parasitic capacitor
	non-matched pull-up and pull-down resistances	Select the appropriate terminal matching resistor
	Mismatch of terminator resistor	Select an appropriate terminal resistor, ensure that the differential signal amplitude will be approximately 1.2 V whenever there is communication on the bus
	Excessive communication nodes	Add 485 repeaters
	Communication distance too far	Add 485 repeaters
	Too small transmit and receive delay	Set reasonable time of transmit and receive delay
	The use of repeater with the first generation RS485 transceiver module	Select Mornsun's third generation products

4. Recommendation of TD_485 Products

Table 4-1 Product selection

Feature	Channel	Series	Vin	Isolated Power output	Transmission rate (max.) (bps)	Rate level	Nodes	Isolation	Package
Chip-level	1	TD041S485H	3.3V, 5V	-	1M	high	256	3750VDC	DFN
Chip-level	1	TD541S485H	3.3V, 5V	-	1M	high	256	3000VDC	DFN
Chip-level, high isolation	1	TDH541S485H	3.3V, 5V	-	1M	high	256	5000VDC	DFN
high rate	1	TDx01D485	3.3V, 5V	-	9.6K	low	32	2500VDC	DIP10
high rate	1	TDx01D485H	3.3V, 5V	-	200K	high	32	2500VDC	DIP10
automatic switch	1	TDx01D485H-A	3.3V, 5V	-	115.2K	high	32	2500VDC	DIP10
enhanced	1	TDx01D485H-E	3.3V, 5V	-	500K	high	256	2500VDC	DIP10

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high isolation	1	TD301D485H-AB	3.3V	-	115.2k	high	128	2500VDC	DIP10
high isolation	1	TDHx01D485H	3.3V, 5V	-	115.2K	high	32	3750VAC	DIP10
high isolation	1	TDHx01D485H2	3.3V, 5V	-	1M	high	128	5000VDC	DIP
high isolation	1	TDHx01D485H-E	3.3V, 5V	-	1M	high	256	5000VDC	DIP
compact size, automatic switch	1	TDx01M485	3.3V, 5V	√	500K	high	64	2500VDC	DIP8
high isolation	1	TDx11D485H	3.3V, 5V, 12V, 24V	√	115.2K	high	32	2500VDC	DIP10
duplex	2	TDx12P485	3.3V, 5V	√	9.6K	low	32	2500VDC	DIP24
duplex	2	TDx12P485H	3.3V, 5V	√	115.2K	high	32	2500VDC	DIP24
duplex isolation	2	TDx1IP485H	3.3V, 5V	√	115.2K	high	32	2500VDC	DIP24
open-frame	1	TDx21D485	3.3V, 5V	√	9.6K	low	64	2500VDC	DIP10
High rate	1	TDx21D485H	3.3V, 5V	√	200K	high	64	3000VDC	DIP10
automatic switch	1	TDx21D485H-A	3.3V, 5V	√	500K	high	128	3000VDC	DIP10
enhanced	1	TDx21D485H-E	3.3V, 5V	√	500K	high	256	3000VDC	DIP10
duplex isolation, automatic switch	2	TDx22D485H-A	3.3V, 5V	√	120K	high	32	2500VDC	DIP12
Enhanced	1	TDx21S485H-E	3.3V, 5V	√	500K	high	256	3000VDC	SMD10
Automatic switch	1	TDx21S485H-A	3.3V, 5V	√	500K	high	128	3000VDC	SMD10
Open-frame	1	TDx21S485H	3.3V, 5V	√	200K	high	64	3000VDC	SMD10
Open-frame	1	TDx21S485	3.3V, 5V	√	19.2K	low	64	2500VDC	SMD10
Open-frame	1	TDxB1D485	3.3V, 5V	√	19.2K	low	64	2500VDC	DIP10
Ultra-low power consumption	1	TDx21D485-L	3.3V, 5V	√	19.2K	low	16	3000VDC	DIP10
ACDC converter built in isolated RS485	1	TLA03-03K485	3.3V, 5V, 12V	√	500K	high	128	4000VAC	DIP34
Open-frame	1	TDx31S485	3.3V, 5V	√	19.2K	low	64	2500VDC	SMD12
Ultra-low power consumption	1	TDx31S485-L	3.3V, 5V	√	19.2K	low	16	2500VDC	SMD12
Compact size	1	TDx31S485H	3.3V, 5V	√	150K	high	128	2500VDC	SMD12
Automatic switch	1	TDx31S485H-A	3.3V, 5V	√	150K	high	128	2500VDC	SMD12
Enhanced	1	TDx31S485H-E	3.3V, 5V	√	500K	high	256	2500VDC	SMD12
high rate	1	TD541S485H	5V	√	1M	high	256	3000VDC	DFN16

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high isolation	1	TDH541S485H	5V	√	1M	high	256	5000VDC	DFN16
high rate	1	TD041S485H	3.3/5V	-	1M	high	256	3750Vrms	DFN16
high isolation	1	TDHx01D485H2	3.3/5V	√	1M	high	128	5000VAC	DIP10
Enhanced	1	TDHx01D485H-E	3.3/5V	√	1M	high	256	5000VAC	DIP10
Automatic switch	1	TD041S485H-A	3.3/5V	-	1M	high	256	3750Vrms	DFN16
Automatic switch	1	TD541S485H-A	5V	√	1M	high	256	3000VDC	DFN16
Automatic switch	1	TDH541S485H-A	5V	√	1M	high	256	5000VDC	DFN16
Full Duplex	1	TD041S485S-F	3.3/5V	-	1M	high	256	3750Vrms	DFN16
Full Duplex	1	TD541S48S-F	5V	√	1M	high	256	3000VDC	DFN16
Chip-level	1	TDH541S485S-F	5V	√	1M	high	256	5000VDC	DFN16
Full Duplex		F				high			
Chip-level, high isolation	1	TDA51S485HC	3.3/5V	√	500kbps	high	256	5000Vrms	SOIC16

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