I. RS485 Bus Basics

1. RS485 Basic Characteristics of the Bus
   According to RS485 Industrial Bus Standards, RS485 industrial buses use differential method to transmit signal. This half-duplex communication bus has a characteristic impedance of 120 Ω with a maximum load of 32 payloads (including controller device and controlled device).

2. RS485 Transmission Distance
   When using 0.56mm (24AWG) twisted-pair line, according to different baud rate, the maximum transmission distance theory table is as shown below:

<table>
<thead>
<tr>
<th>Baud Rate</th>
<th>Maximum Distance</th>
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</table>

   But in reality, the actual transmission distance cannot reach the theoretical values due to factors like quality of the cable, diameter of the cable, the distribution network, the electrical environment, the actual number of nodes. Generally, the more nodes it has, the shorter the transmission distance is.

3. RS485 Bus Connection and Terminal Resistor
   RS485 industrial bus standard required the usage of daisy-chain connection method between the devices. The two ends must be connected to a 120 Ω terminal resistor (As shown in figure 1).

![Figure 1]

Figure 1
A common use of the simplified connection is shown in Figure 2. Must ensure cable length is as short as possible. So during PCB layout, if possible, place the 485 transceiver in the interface and ensure that the trace from A and B of 485 to the device port is as short as possible.

![Figure 2](image)

4. Factors Affecting the Quality of Communication in Actual Wiring.

1. The shorter the communication distance, the better the communication quality is. If communication distance is beyond 500 meters, it is recommended to increase the 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 increase the repeater.
3. The lower the communication baud rate, the better the communication quality is. In cases 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, consideration of the equivalent capacitance parameters is needed in the selection of the protection device of ports (TVS tubes, varistors, etc).
5. Every branch of a communication node must be as short as possible to reduce the impact of signal reflection of the branches on the bus.
6. Appropriate terminal resistor can effectively reduce signal reflection. It is generally recommended to connect 120 Ω 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.

II. Problems to take note of on using TD_485 products for interfacing hardware design

1. CON Pin Transceiver Control Logic
   The transceiver control logic level of TD_485 products and ordinary 485 chips are just the opposite. When CON pin is 0, the bus is in a sending state. While when CON pin is 1, the bus is in a receiving state.
   According to the characteristics of 485 bus, as power of the product is turned on at the beginning, each communication node linked to 485 bus must be configured to a receiving state to prevent the bus from remaining on a sending state when multiple machines are operated simultaneously, resulting in confusion in bus signals. On the initial power-up of some I/O ports of the commonly used MCU (like 51 series microcontroller), the default output is high. When this kind of MCU is connectedly used with ordinary 485 chips, the I/O port has not been initialized during initial power-up and 485 chips easily remain on a sending state, causing confusion in bus signals. Among the TD_485 products, the transceiver control logic of CON pin can manage to 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 has to ensure that during the initial power-up, the bus status of TD_485 products is on a receiving state, that is, the CON pin is high or is on a high impedance state.

2. RXD, TXD Default Interface Level
Asynchronous communication data is transmitted in bytes. Every byte has to pass through a low start bit to achieve a handshake first before it is transmitted. To prevent interference signals false triggering RXD (receiver output) to produce negative transition, causing receiver MCU to enter a communication waiting state, it is recommended that a 10k Ω pull-up resistor be externally connected to RXD.

3. Pull-Down Resistor Design on A and B Bus Ports
A and B ports of TD_485 products have a weak pull-up resistor and a weak pull-down resistor within the module to ensure that when bus is idle, the bus logic level is 1.

4. Isolation Design on A and B bus ports
485 bus nodes commonly use daisy chain or network topology for networking. Once a failure occurs in the interface chip of a node, it is possible to “pull dead” the entire bus. Thus, isolation must be made between bus ports A and 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 and B ports to form an isolation. When a short circuit or a power breakdown of A and B occurs on a node, interface chip, a potential barrier forms between the bus and the nodes, thereby reducing the impact on the bus.

5. A and B Bus Port Lightning Protection Design
485 bus communication generally uses long-distance transmission, so the lightning protection design of A and B bus ports is also something the designer must consider. A conventional design of the lightning protection circuit is as shown in Figure 3. For the parameters of corresponding devic, please refer to the technical manual of TD_485products.
6. Connections of Bus Reference Ground

Although 485 bus uses differential method to transmit signals, seems that it does not need to be relative to a reference point to determine signal. The system only needs to detect the potential difference between the two lines. However, the designer must also consider the common mode voltage tolerance range of the interface module, such as the general -7～+12 V. Only through satisfying this condition will the entire network work properly. When the network line common mode voltage exceeds this range, the reliability of communication will be affected, and the interface will even be damaged.

Using isolation technology can effectively solve the problem of common mode noise, so using 485 isolated transceiver of TD_ 485 products to build bus hardware port can be a good partition of ground loops on each node on the bus, decreasing ground loop currents between nodes and, as a result, reduce common mode interference. But regarding serious interference, harsh electrical environments, it is still recommended that designer use shielded twisted-pair, linking together the bus reference ground of each communication node on the bus through the shield to moderate common mode and radiation interference and to improve system communication reliability. (As shown in Figure 4)
7. Omit Wiring Applications of CON Pin Control

In some special occasions, the designer may choose to use the transmit signal of TXD as CON pin input to save on I/O overhead of MCU (As shown in Figure 5). When TXD is sending the logic “0” signal, CON pin becomes “0” on a sending state, sending the “0” signal of TXD to the bus; when TXD, on the other hand, is sending the logic “1” signal, CON pin becomes “1” on a receiving state, relying on the bus default idle level “1” indicating that TXD is sending a logic “1” signal. This application needs to focus on the following points of consideration:

① Baud Rate Settings: Try to choose the baud rate that is relatively lower, at least allow 1 bit signal to have time greater than the delay time of 485 transceiver switching and the sampling time of the MCU receiver.

② Bus Drive Capability: Because of this application, sending logic “1” signal relies on the bus default idle level “1” indicates that its drive capacity is far less than the drive capacity of 485 transceiver directly driving output, so the designer must choose appropriate communication nodes and communication distance according to the actual 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 must also not simply configure the terminal resistor based on the recommended value of 120Ω. An appropriate terminal resistor must be selected to ensure that the differential signal amplitude will be approximately 1.2 V whenever there is communication on the bus.
## III. Commonly Seen Failures and Solutions in the Usage of TD_485 Products

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<th>Failure Phenomenon</th>
<th>Possible Causes</th>
<th>Solutions</th>
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<tr>
<td>Unable to Communicate</td>
<td>1. CON pin transceiver control logic error; 2. 485 Bus interface A and B reverse polarity; 3. Inconsistent baud rate of transmitter and receiver; 4. Insufficient CON pin drive capacity;</td>
<td>1. Revise CON pin transceiver control logic; 2. Switch polarity of 485 bus interface A and B; 3. Adjust baud rate of the transmitter and receiver as the same value; 4. Increase CON pin drive capacity through pull-down resistor;</td>
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<tr>
<td>High Communication Error Rate</td>
<td>1. Inaccurate baud rate timer clock; 2. Excessive communication baud</td>
<td>1. Use a crystal oscillator with the appropriate frequency (eg. 11.0592M); 2. Decrease communication baud rate;</td>
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<td>3. Mismatch of terminator resistor</td>
<td>3. Select an appropriate terminal resistor, ensure that the differential signal amplitude will be approximately 1.2 V whenever there is communication on the bus;</td>
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<tr>
<td>4. Excessive communication nodes;</td>
<td>4. Increase 485 repeaters;</td>
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<td>5. Communication distance too far;</td>
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