Application Notes of TD5(3)USPCAN

Project	Content
Product function	CAN controller, isolated transmission, signal conversion, protocol conversion and port expansion
Summary of notes	Application description and detailed explanation of functions

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1.Function introduction

1.1 Summary

TD5(3)USPCAN series isolated UART/SPI to CAN module is a communication module integrating microprocessor, CAN transceiver, DC-DC isolated power supply and signal isolation. It has the advantages of high speed, high isolation, low power consumption and multi-protocol conversion function. It can expand more CAN interfaces through UART/SPI interface when the CAN control resources on the user master control board are in short supply.

This product has various functions and is easy to embed. Users can embed in devices with UART/SPI without changing their hardware devices, so that users can get more CAN communication interfaces and realize convenient data communication between UART/SPI devices and CAN bus.

1.2 Product characteristics

- Built-in high-efficiency isolated power supply
- Isolation at both ends (3kVDC)
- UART baud rate up to 921.6Kbps
- SPI rate up to 1.5Mbps
- CAN baud rate up to 1Mbps
- Support transparent conversion, transparent conversion with identification and custom protocol conversion.
- Support bidirectional data communication between UART/SPI and CAN interface
- Operating temperature range: -40℃ ~ +85℃
- The same network can support connecting 110 nodes.
- It integrates the functions of isolation and ESD bus protection

1.3 Product model

Product	Power input (VDC)	Level (VDC)	UART rate (bps)	SPI rate (bps)	CAN rate (bps)	Number of nodes	Package
TD3USPCAN	3.3	3.3	300-921.6k	0-1.5M	5k-1M	110	DIP-24
TD5USPCAN	5	3.3	300-921.6k	0-1.5M	5k-1M	110	DIP-24

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1.4 Applications

- Charging Station
- BMS
- Communication
- Coal mining industry
- Electrical industry
- Instrument
- Smart homes

2. Hardware description

2.1 Product appearance

The appearance of the product is shown in Figure 2.1.

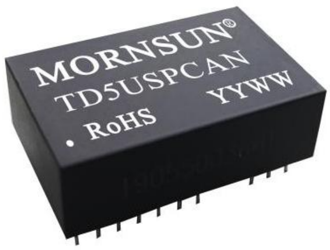

Figure 2.1 product appearance drawing (TD5USPCAN)

2.2 Pin definition

TD5(3)USPCAN has three communication interfaces, namely SPI interface, UART interface and CAN interface. Product definition is shown in Figure 2.2. The pin functions are defined in Table 2.1.

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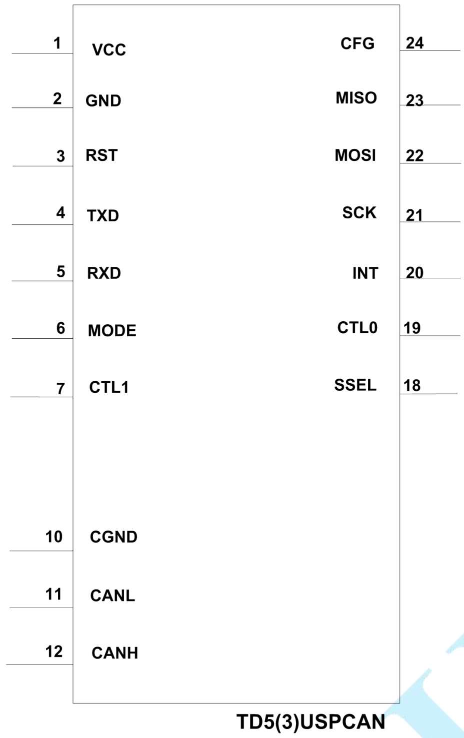

Figure 2.2 Pin arrangement

Table 2.1 Pin function (defintion)

Pin	Name	Function	Pin	Name	Function
1	VCC	Input power supply positive	12	CANH	CANH pin
2	GND	Input power ground	18	SSEL	SPI chip select pin
3	RST	Reset pin	19	CTL0	SPI master control pin 0
4	TXD	UART sending pin	20	INT	Slave feedback pin
5	RXD	UART receiving pin	21	SCK	SPI SCK pin
6	MODE	Mode control pin	22	MOSI	SPI MOSI pin
7	CTL1	SPI master control pin 1	23	MISO	SPI MISO pin
10	CGND	Isolated output power ground	24	CFG	Configuration pin
11	CANL	CANL pin			

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2.3 IO description

Table 2.2 Product Pin Description Table

Pin	Name	Type	Explain	Pin	Name	Type	Explain
1	VCC	Input	--	12	CANH	Input/Output	--
2	GND	Input	--	18	SSEL	Input	5V voltage tolerance
3	RST	Input	Low-level reset, supporting open-drain input	19	CTL0	Input	5V voltage tolerance
4	TXD	Input	--	20	INT	Output	
5	RXD	Input	5V voltage tolerance	21	SCK	Input	5V voltage tolerance
6	MODE	Input	5V voltage tolerance	22	MOSI	Input	5V voltage tolerance
7	CTL1	Input	5V voltage tolerance	23	MISO	Output	5V voltage tolerance
10	CGND	--	--	24	CFG	Input	5V voltage tolerance
11	CANL	Input/Output	--				

2.4 UART to CAN hardware circuit

When using the UART-to-CAN function, it is necessary to connect the MODE pin to low level. The UART of MCU is connected to the UART interface of TD5(3)USPCAN, and a GPIO is connected to the RST pin. If you need to configure TD5(3)USPCAN through MCU, you need to connect additional GPIO to the CFG pin. Figure 2.3 and Figure 2.4 are the reference circuits of TD3USPCAN and TD5USPCAN respectively.

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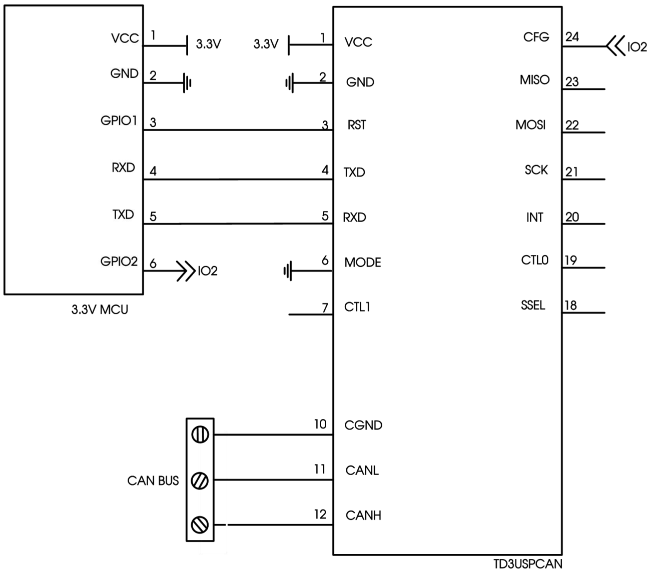

Figure 2.3 UART to CAN reference circuit (TD3USPCAN)

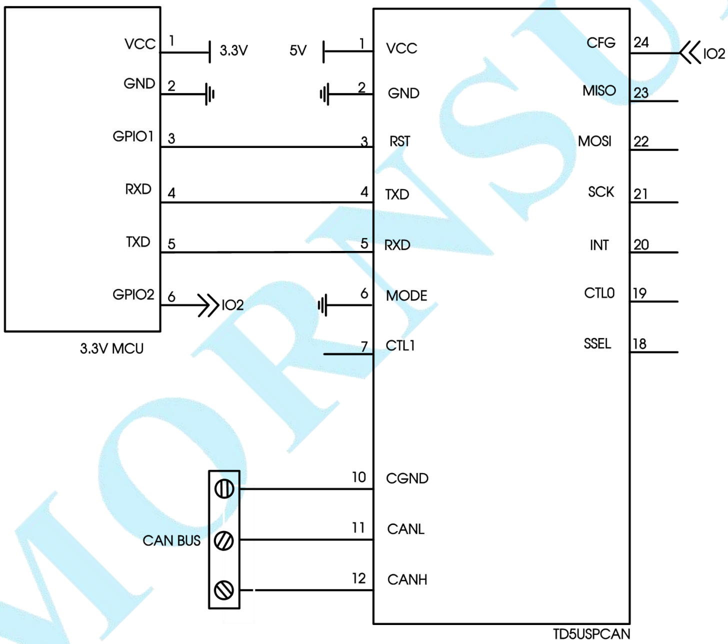

Figure 2.4 UART to CAN reference circuit (TD5USPCAN)

2.5 SPI to CAN hardware circuit

When using the SPI-to-CAN function, it is necessary to connect the MODE pin to the high level. The SPI interface of MCU is connected with the SPI interface of TD5(3)USPCAN. At the same time, MCU needs to provide the connection between GPIO and RST, INT, CTL0, CTL1 pins to realize the effective monitoring and control of TD5(3)USPCAN. If TD5(3)USPCAN needs to be configured by MCU, additional GPIO is needed to connect with the CFG pin. Figure 2.5 and Figure 2.6 are the reference circuits of TD3USPCAN and TD5USPCAN respectively.

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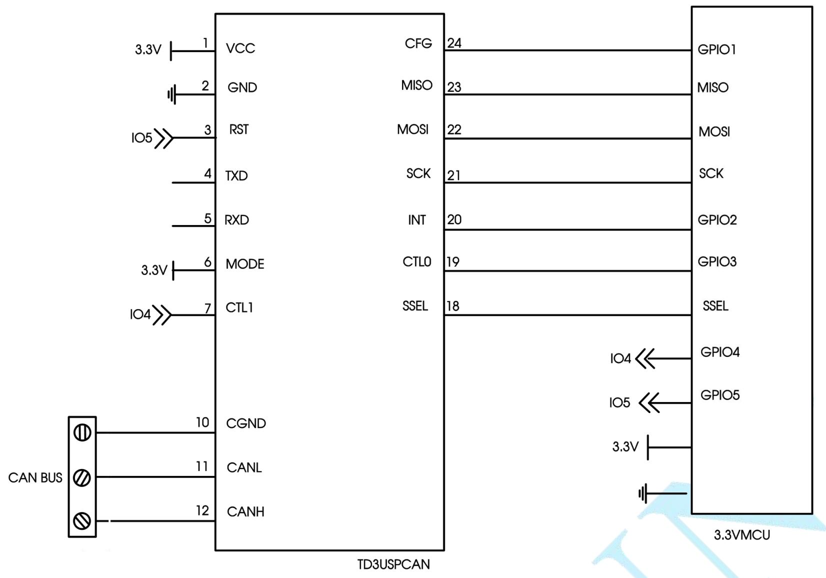

Figure 2.5 TD3USPCAN SPI to CAN hardware reference circuit

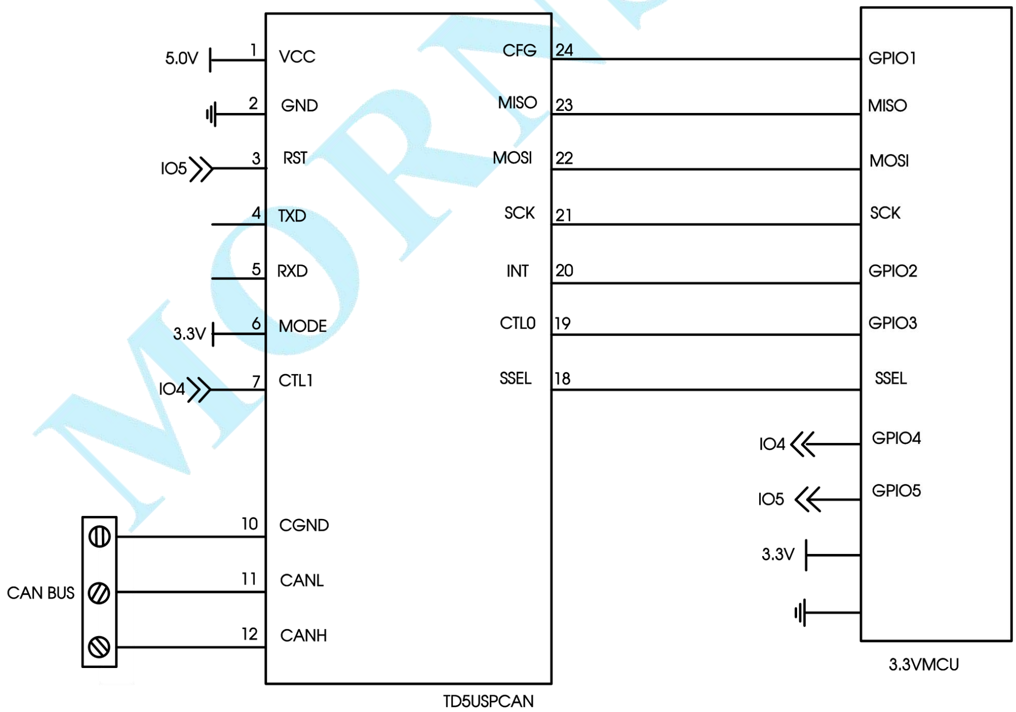

Figure 2.6 TD5USPCAN SPI to CAN hardware reference circuit

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2.6 Peripheral protection circuit

TD5(3)USPCAN products can be used in various CAN bus occasions, and in harsh environments (such as high voltage, lightning surge, and other environments), we recommend add protection circuits, which can absorb the surge that interferes with the products in harsh environments and prevent the products from being damaged. Figure 2.7 shows recommended peripheral protection circuit. Table 2.3 shows the value of recommended protection circuit. Please determine whether to add peripheral protection circuit according to the actual situation.

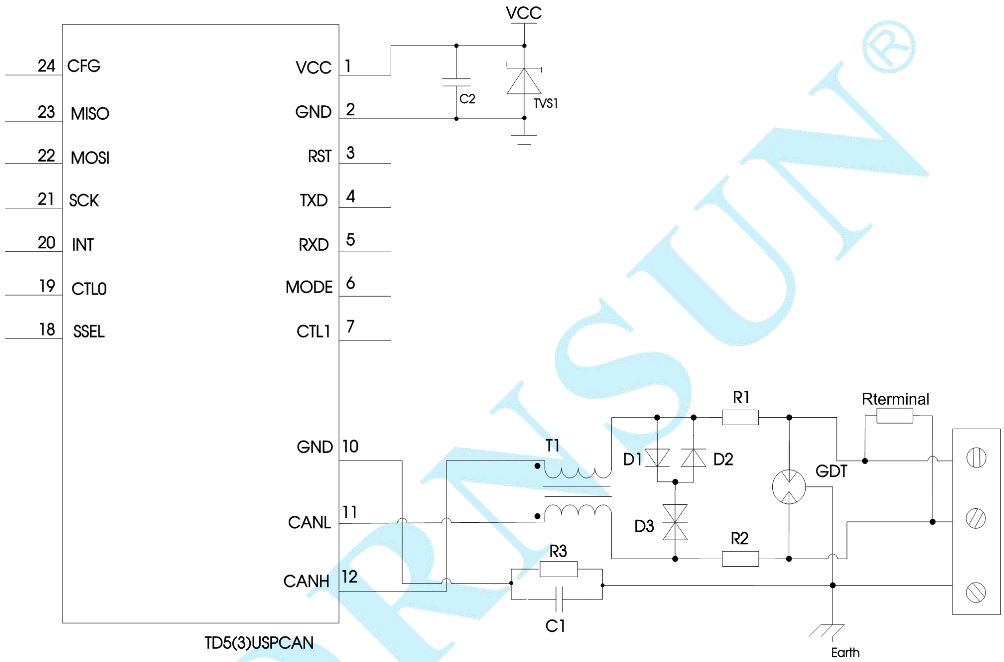

Figure 2.7 Peripheral protection circuit

Table 2.3 Recommended Parameter Table

Components	Recommended parameters	Components	Recommended parameters
R3	1MΩ	R1、R2	2.7Ω/2W
C1	1nF, 2kV	D1、D2	1N4007
T1	ACM2520-301-2P	D3	SMBJ30CA
GDT	B3D090L	TVS1	TD3USPCAN TVS tube SMBJ5.0A

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			TD5USPCAN TVS tube SMBJ6.5A
C2	10uF, 25V	Rterminal	120Ω

2.7 Recommended networking mode

CAN bus generally uses linear wiring, and the number of bus nodes can reach 110. Shielded twisted pair is recommended for wiring, CANH and CANL are connected with twisted pair core, CGND is connected with the shielding layer, and finally shielding layer is grounded at a single point. Regardless of the length of the bus, both ends of the bus need to be connected with terminal resistors, which can be adjusted according to the actual wiring, and the recommended value is generally 120 ohm. Because the lowest baud rate of TD5(3)USPCAN is 5kbps, the longest communication distance of the bus can reach 10km. Figure 2.8 shows the schematic diagram of recommended networking.

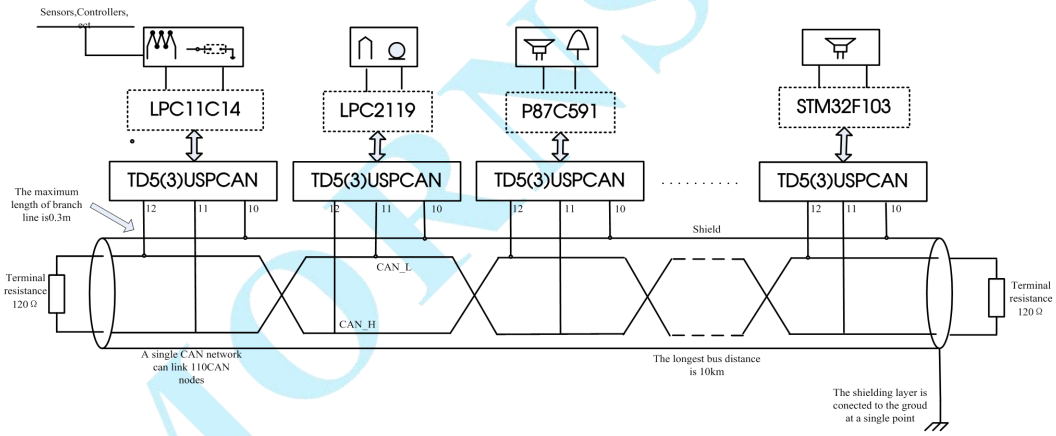

Figure 2.8 Schematic diagram of recommended networking

3.Product application

3.1 Glossary

1. UART

UART is the abbreviation of Universal Asynchronous Receiver/Transmitter. UART is a universal serial data bus, which can realize full-duplex serial asynchronous communication.

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2. SPI

SPI is the abbreviation of Serial Peripheral Interface. SPI is a high-speed, full-duplex and synchronous communication bus.

3. CAN bus

CAN is the abbreviation of Controller Area Network. CAN bus is field bus, it is a serial communication network that effectively supports distributed control or real-time monitoring.

4. Serial frame

That is, serial bus frame is the general name of SPI bus communication frame (hereinafter referred to as SPI frame) and UART bus communication frame (hereinafter referred to as UART frame).

5. CAN frame

That is, CAN bus frame, which is the general name of standard frame and extended frame of CAN interface.

6. Standard frame

The type of CAN frame, the frame ID of standard frame is 11 bits in total, and the range is 0x000-0x7ff.

7. Extended frame

The type of CAN frame, the frame ID of the extended frame is 29 bits in total, and the range is 0x00000000-0x1fffffff.

8. Transparent conversion

A data transmission mode of TD5 (3)USPCAN, which means that the data between UART/SPI and CAN bus is converted and transmitted immediately without processing.

9. Transparent conversion with identification

A data transmission mode of TD5(3)USPCAN, which adds the processing of bus identification (ID) on the basis of transparent conversion. When the serial bus is converted to the CAN bus, the ID of the serial frame determines the ID of the CAN frame; conversely, when the CAN bus is converted to the serial bus, the ID of the CAN frame determines the ID of the serial frame.

10. Custom protocol conversion

A data transmission mode of TD5(3)USPCAN. Under the custom protocol conversion mode, the serial frame must conform to the specified frame format. The valid serial frame consists of frame header, frame length, frame type, frame ID, data field and frame trailer.

3.2 Working mode

After TD5(3)USPCAN is powered on, the pin level of MODE and CFG will determine that the product is in one of four different working modes: UART to CAN mode, SPI to CAN mode, UART configuration mode and SPI configuration mode. Table 3.1 lists the working modes of the product at different pin levels.

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Table 3.1 Selection Table of TD5(3)USPCAN Working Mode

Pin level			Working mode
MODE	CFG	RST	
0	1	1	UART to CAN
1	1	1	SPI to CAN
0	0	1	UART configuration
1	0	1	SPI configuration
X	X	0	reset

If it is necessary to switch the working mode of the product, after changing the pin level, the product must be reset before it can enter the set working mode. It should be noted that in order to ensure the successful reset of the product, the reset holding time is at least 100us, and after the reset, the waiting time for the product initialization is at least 3ms, and the normal operation can only be carried out after the product initialization is completed, as shown in Figure 3.1. Figure 3.2 is a schematic diagram of product working mode switching.

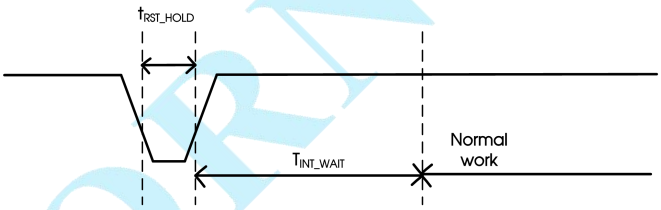

Figure 3.1 Schematic diagram of reset timing

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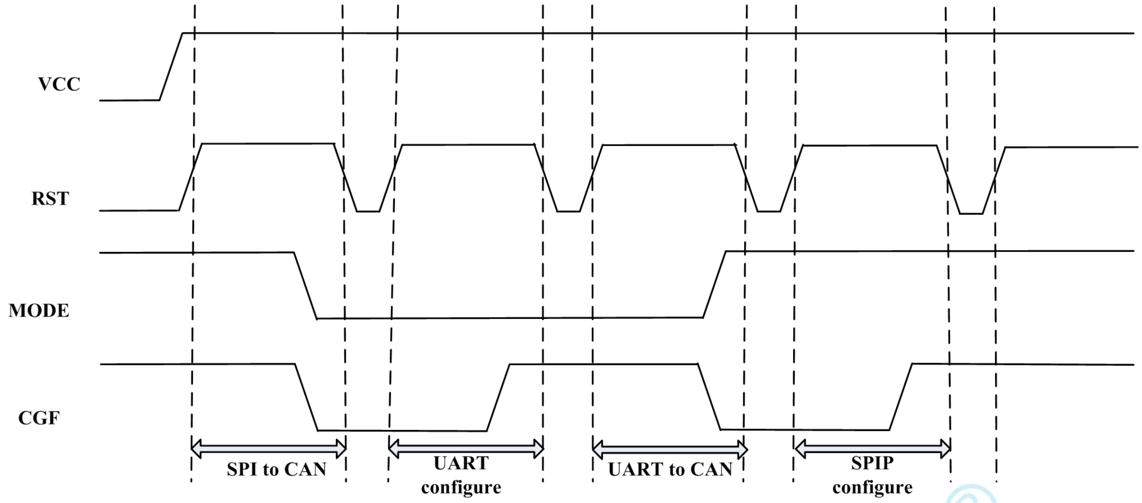

Figure 3.2 Schematic diagram of working mode switching

3.2.1 UART to CAN mode

In this mode, TD5(3)USPCAN can only send or receive data to CAN bus through UART. UART communication format is fixed as: 1 start bit, 8 data bits and 1 stop bit, which cannot be changed. Communication rate of UART ranges from 300 bps to 921600 bps. In this mode, the SPI interface is invalid, and it will not process any data appearing in the SPI interface, nor will it return the data received by the CAN bus to the SPI.

1. UART frame

From the moment UART receives the first data, until it waits for n characters (this parameter is set by the user) before it receives new data, the data in this period is defined as one frame of data, and this period of time is defined as "frame interval". Because the character time changes with the baud rate, the frame interval time of the same number of characters is different under different baud rates. For example, the user sets the UART frame interval to be 2 characters and the baud rate to be 9600bps. Since each character consists of 10 bits, the interval time is 2 * 10/9600 = 2.083 ms. The first data on the bus represents the start of a frame, and the last data before waiting for more than n characters is the last data of the frame; wait for more than n characters and no new data appears, which means the end of a frame. UART communication frame format is shown in Figure 3.3

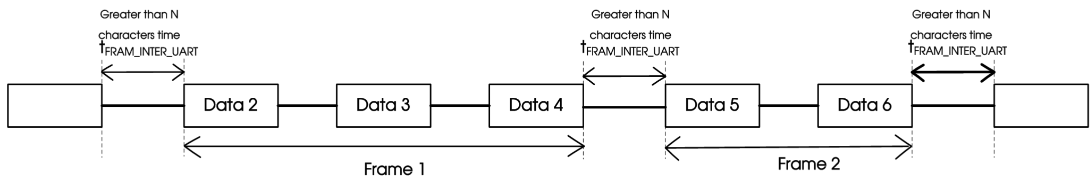

Figure 3.3 UART Communication frame format diagram

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3.2.2 SPI to CAN mode

In this working mode, TD5(3)USPCAN always acts as SPI slave, SPI is limited to work in mode 3(CPOL and CPHA are both 1), the data length is limited to 8 bits, and the MSB bits are transmitted first. Highest communication rate under transparent conversion and transparent conversion with identification is 1.5Mbps, and the highest communication rate of custom protocol conversion is 1Mbps.

The SPI can send data to the CAN bus terminal and receive data received by the CAN bus terminal. At this time, the UART interface is invalid, and it will not process any data appearing in the UART interface, nor will it return the data received by the CAN bus to the UART.

1. SPI frame

The data between the valid and invalid SPI chip selection is defined as one frame of data. Read data and write data frames are defined in Figure 3.4 and Figure 3.5. There should be a time interval of 40us for reading and writing buffer data between frames, as shown in Figure 3.6.

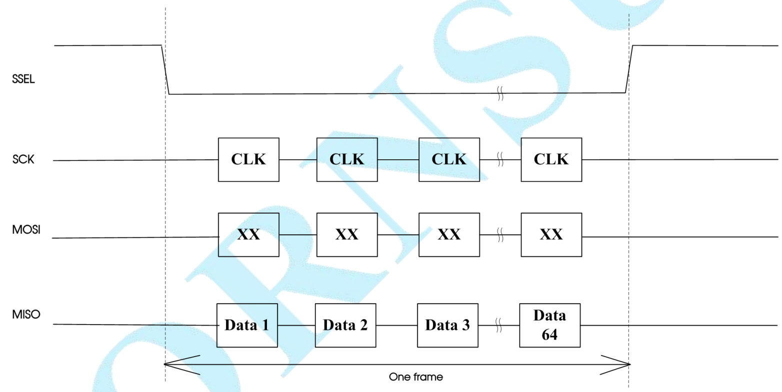

Figure 3.4 Schematic diagram of master reading data frame

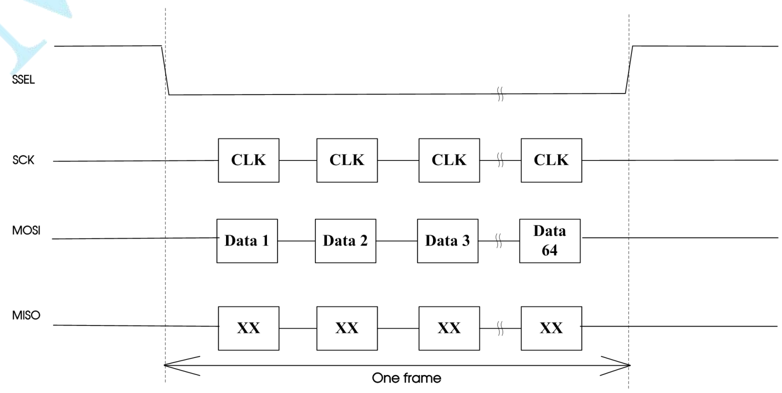

Figure 3.5 Schematic diagram of master writing data frame

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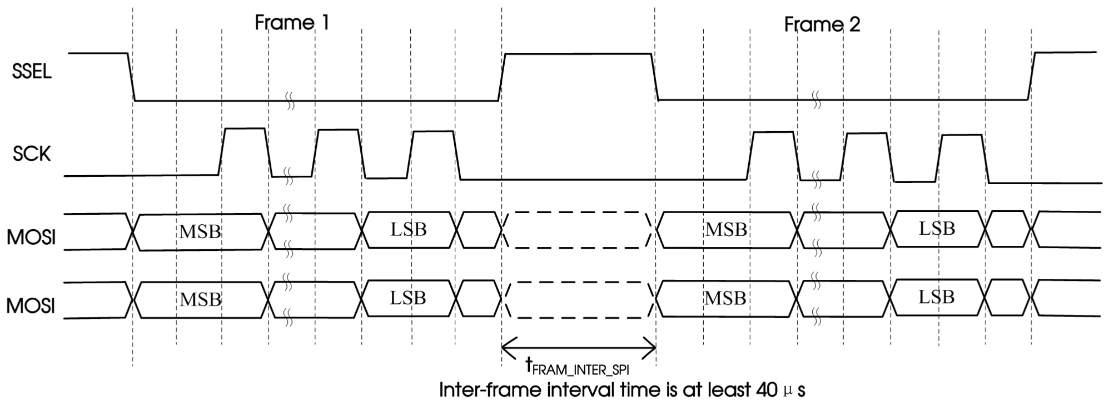

Figure 3.6 Schematic diagram of SPI frame interval

2. Master control

TD5(3)USPCAN has two SPI Master control pins CTL0 and CTL1, which are controlled by the master. By controlling the CTL0 and CTL1 pins, the master make TD5(3)USPCAN enter different functional states, and achieve different operation purposes for TD5(3)USPCAN. The corresponding functions of different levels of mastercontrol pins are shown in Table 3.2.

Table 3.2 Master Control Function in SPI Mode

CTRL0	CTRL1	Function
0	0	Inactive
0	1	master read status
1	0	master read data
1	1	master write data

The master can read the current state of the slave to obtain the number of bytes that the product can read and write. Select the master function as the master read state, and then read out 4 bytes through SPI, which is the status code. The status code consists of 32 bits, and the specific definition is shown in Table 3.3.

Table 3.3 Composition of status codes in SPI mode

Bit	Meaning	Symbol	Describe
0	Readable identification bit	read	When the CAN receiving buffer is not empty, this bit is 1, otherwise it is 0.
12:1	Number of readable bytes	read_bytes	Number of bytes of CAN data that the master can read from TD5(3)USPCAN.

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13	Writable identification bit	write	This bit is 1 when the CAN buffer is not full, otherwise it is 0.
25:14	Number of writable bytes	write_bytes	Number of serial bytes that the master can write to TD5(3)USPCAN.
31:26	Reserved bit	reserved	Reserved.

If the status() array is defined as an 8-bit integer, and the data sequentially read out through SPI reading status are status(0), status(1), status(2) and status(3), its data structure is shown in Figure 3.7.

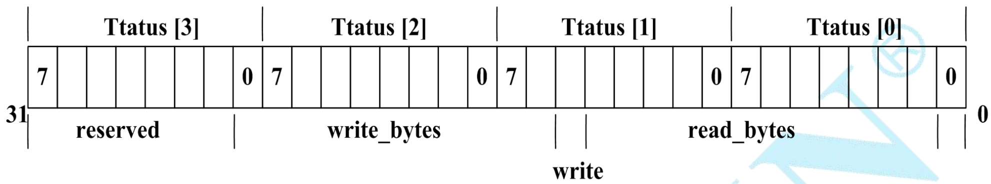

Figure 3.7 Status byte data structure

After obtaining these four bytes, the user should separate the corresponding bits and use them as the judgment benchmark for subsequent processing. Example code is as follows:

```
read = status[0] & 0x01;                                   // Separate out the readable identifier bits
read_bytes    = ((status[0] & 0xFE) >> 1) + ((status[1] & 0x1F) << 7);// Separate out the number
                                                                      readable bytes
write = (status[1] & (1 << 5)) ? 1 : 0;                    // Separate out the writable identifier bits
write_bytes = ((status[1] & 0xC0) >> 6) + ((status[2] & 0xFF) << 2) +((status[3] & 0x03) << 10);
                                                            // Separate out the number readable bytes
```

In actual use, the data in the CAN send buffer of TD5(3)USPCAN will be sent out quickly, so the write_bytes will generally return to the maximum value.

When the master does not need to read or write TD5(3)USPCAN, the control state should be switched to the idle state. After the state is switched through the host CTL0 and CTL1 pins, it must take at least 50us to enable TD5(3)USPCAN to read and write. Especially, after writing, it is necessary to keep the writing state for at least 5us to ensure that the data CAN be correctly converted to CAN bus. Figure 3.8.

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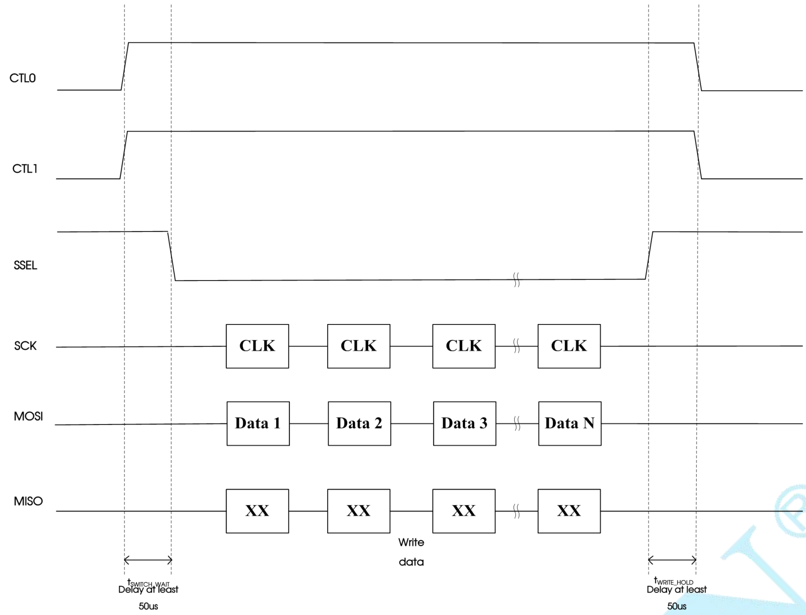

Figure 3.8 Schematic diagram of switching delay of host control function

3. Feedback mechanism

TD5(3)USPCAN only be used as an SPI slave, and can't actively control other SPI bus devices. If TD5(3)USPCAN needs the master to check the status every time it receives the data sent by CAN, the efficiency of the whole communication process will be very low, so we have added a feedback mechanism for it. TD5(3)USPCAN has an INT feedback pin on the hardware, which is connected with the master. When the following two situations occur, the INT pin will change from high level to low level, informing the master to read data (to avoid data loss, it is recommended that the master use the falling edge trigger to detect):

(1) When the number of CAN frames in the CAN buffer reaches the set trigger point

When the number of CAN frames received in the receiving buffer of the product CAN bus reaches the trigger point, the level of the INT pin is set low, and the INT pin will not return to the high level until the buffer is cleared. Users can query the status of TD5(3)USPCAN after obtaining the INT signal, get the number of readable bytes, and then read the buffer CAN data.

(2) When the CAN buffer data is less than the trigger frame number and the master does not read it within the set time.

When the CAN buffer has data but less than the trigger frame number, if the bus has not added data for a long time and the master has not read, the data in the CAN receiving buffer may not be processed for a long time, which leads to low real-time performance of the data. In order to solve the real-time problem of a small amount of data, TD5(3)USPCAN has a timer inside. If the data in the CAN buffer is not read within a certain period of time, the INT pin will be triggered to be set low to inform the master to read the data. When TD5 (3) USPCAN receives the last frame of data, the timer starts, and the timer is reset when the master reads.

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3.2.3 UART configuration mode

In this mode, TD5(3)USPCAN is in the waiting configuration state and cannot send or receive data to the CAN terminal. This mode can only be configured through UART interface. Please refer to Section 4 for specific configuration instructions.

3.2.4 SPI configuration mode

In this mode, TD5(3)USPCAN is in the waiting configuration state and cannot send or receive data to the CAN terminal. This mode can only be configured through SPI interface. Please refer to Section 4 for specific configuration instructions.

3.3 Data conversion mode

The data conversion mode of TD5 (3)USPCAN refers to the basic rules of data conversion between serial bus and CAN bus. At the same time, the product can only work in one data conversion mode. If you need to change the data conversion mode, you need to change the configuration. When the product is configured with a conversion mode, it acts on SPI to CAN mode and UART to CAN mode at the same time. There are three data conversion modes of TD5(3)USPCAN: transparent conversion, transparent conversion with identification, and custom protocol conversion.

3.3.1 Transparent conversion

Transparent conversion means that as soon as any side bus receives data, it is immediately sent to the other side bus without any processing. In the transparent conversion mode, TD5(3)USPCAN does not need additional data processing, which greatly improves the speed of data conversion and the utilization rate of buffer, because TD5(3)USPCAN is also converting and sending at the same time of receiving, and the buffer that can be received is also vacant. In the transparent conversion mode, the detailed description of data conversion is as follows.

1. Serial frame to CAN frame conversion（UART/SPI→CAN）

All the data of the serial frame are sequentially filled into the data field of the CAN frame. When the product detects that there is data on the serial bus, it immediately receives and converts it. Because the maximum data length of CAN frame is 8 bytes, when the data length of serial frame is less than or equal to 8 bytes, the data is forwarded through a CAN frame. If the data length of the serial frame is longer than 8 characters, the product starts with the first character of the serial frame, takes 8 characters at a time and forwards them out through a CAN frame until all the data are forwarded, at which time one serial frame data is converted into multiple CAN frame data. Schematic diagrams of data conversion are shown in Figure

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3.9 and Figure 3.10. CAN frames only indicate the following useful information: frame type, frame ID, data length and data field. The "Frame Type" and "Frame ID" in the CAN frame are determined by the user's configuration and remain unchanged all the time unless the user reconfigures the product. The "data length" in the CAN frame is determined according to the actual number of bytes of data allocated to the CAN frame.

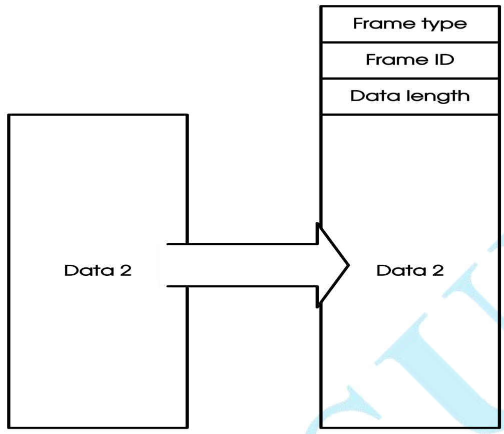

Figure 3.9 Schematic diagram of serial frame to CAN frame

(transparent conversion, data no more than 8 bytes)

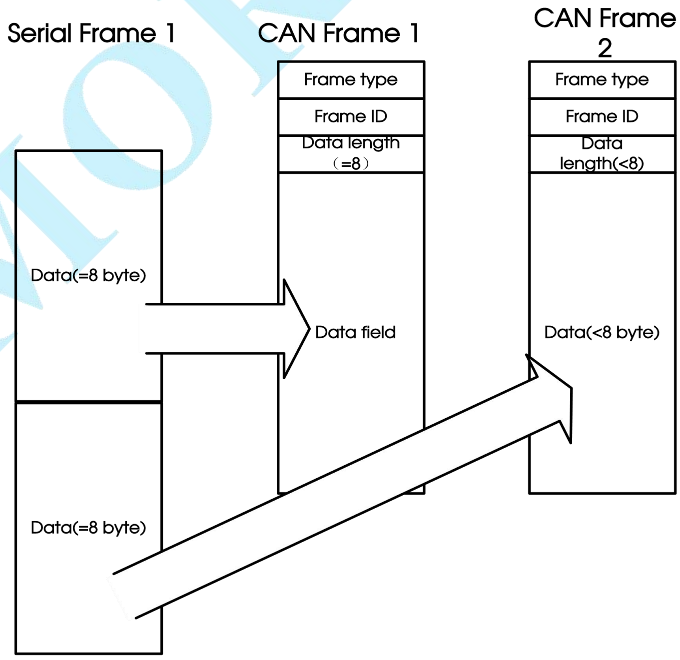

Figure 3.10 Conversion from serial frame to CAN frame (transparent conversion, data greater than 8 bytes)

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Conversion instance:

Example 1: Assuming that the frame type of the converted CAN frame is "Standard Frame", the frame ID1 and ID0 are "0x00 and 0x01" respectively, and the data of the serial frame is 0x11, 0x22, 0x33, 0x44, 0x55, 0x66, 0x77 and 0x88, the format of the serial frame to CAN frame is shown in Figure 3.11.

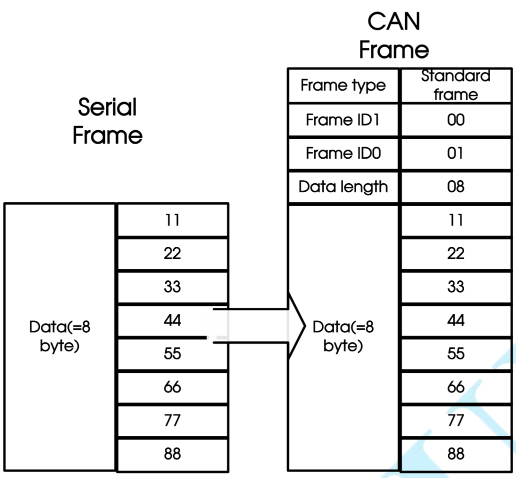

Figure 3.11 Example 1 from serial frame to CAN frame (transparent conversion)

Example 2: It is assumed that the frame type of the converted CAN frame is "Extended Frame", the frame ID1 and ID0 are "0x00 and 0x01" respectively, and the serial frame data are 0x11, 0x22, 0x33, 0x44, 0x55, 0x66, 0x77, 0x88, 0x09, 0x0A, 0x0B and 0x0C.

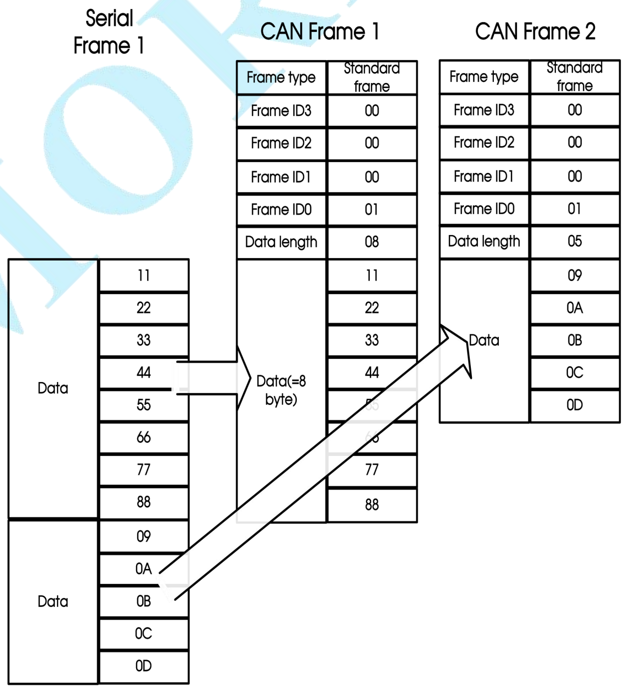

Figure 3.12 Example 2 serial frame to CAN (transparent conversion)

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2. CAN frame UART frame conversion(CAN→UART)

TD5(3)USPCAN immediately forwards a frame of data from CAN bus to UART interface. During conversion, the product will convert all the data in the CAN frame data field into UART frames in sequence, and each CAN frame data will be converted into one UART frame data. At this time, the data length of each serial frame is the same as that of the forwarded CAN frame. Data format correspondence is shown in Figure 3.13.

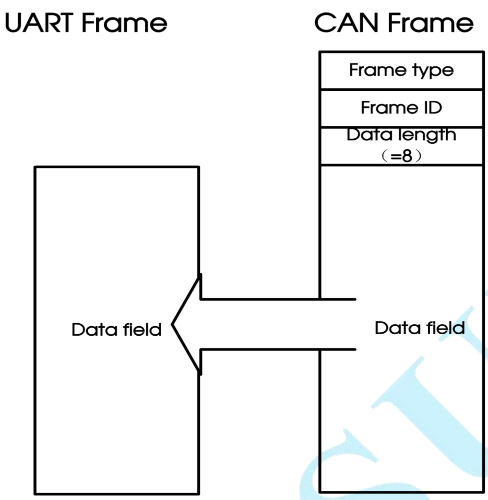

Figure 3.13 CAN frame to UART frame (transparent conversion)

(1) Frame information conversion enable

Frame information refers to the "frame type" and "data length" information of CAN frame, with the length of one byte. The frame conversion is enabled, that is, when the CAN frame is converted into a UART frame, the information of the "frame type" and "data length" of the CAN frame is expressed by a byte with a specific meaning, and this byte is used as the starting byte of the UART frame and forwarded to the UART interface, followed by data. The information is represented by one byte, in which 7~4 bits refer to the frame type: 0000 represents the standard frame and 1000 represents the extended frame; 3~0 bits refer to "data length": "0000~1000" respectively represent "0~8" bits of data. For example, the frame information is 0x05, which means that the CAN frame type is a standard frame, and the data length of the CAN frame is 5 bytes. The frame information is 0x86, which means that the CAN frame type is extended frame, and the data length of CAN frame is 6 bytes. If the user enables frame information conversion, the converted data mode is shown in Figure 3.14.

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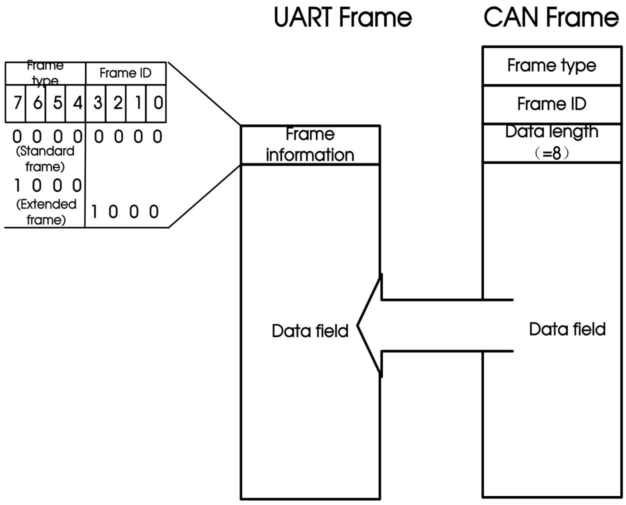

Figure 3.14 CAN frame to UART frame (transparent conversion, frame information enabled)

(2) Frame ID conversion enable

The frame ID is the "ID" of the CAN frame.

The frame conversion is enabled, that is, when the CAN frame is converted into UART frame, the ID of the CAN frame is forwarded to the UART interface in 2 bytes (standard frame) or 4 bytes (extended frame) at the same time, and the ID byte is sent before the data byte, with the high bit of the ID byte in front. When the frame ID conversion is enabled, the frame information conversion is enabled by default. The frame type is sent first, then the frame ID is sent, and finally the data is sent. If the user enables frame ID conversion, the converted data format is shown in Figure 3.15.

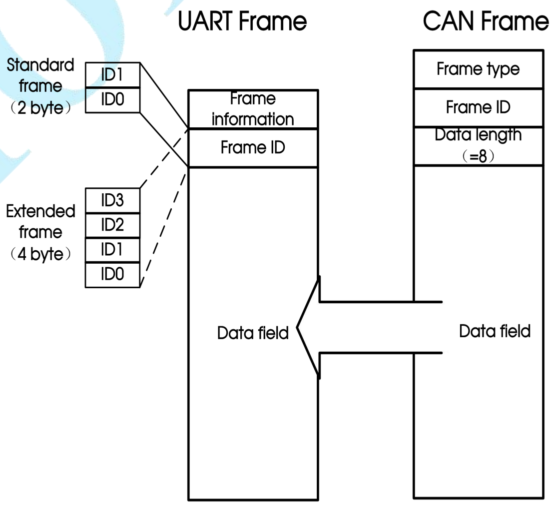

Figure 3.15 CAN frame to UART frame (transparent conversion, frame ID conversion enabled)

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If the data length of CAN frame is 0, when the frame type or frame ID needs to be converted, the corresponding conversion will be made, but the data field is empty. If there is no need to convert the frame type or frame ID, no conversion will be done.

Conversion instance:

Example 1: Assume that the user configuration is as follows: frame information conversion is enabled and frame ID conversion is enabled. If the CAN frame received by the CAN interface is an extended frame with the frame ID of 0x00000001 and the data of 0x11, 0x22, 0x33, 0x44, 0x55, 0x66 and 0x77, the CAN frame and the converted UART frame are shown in Figure 3.16.

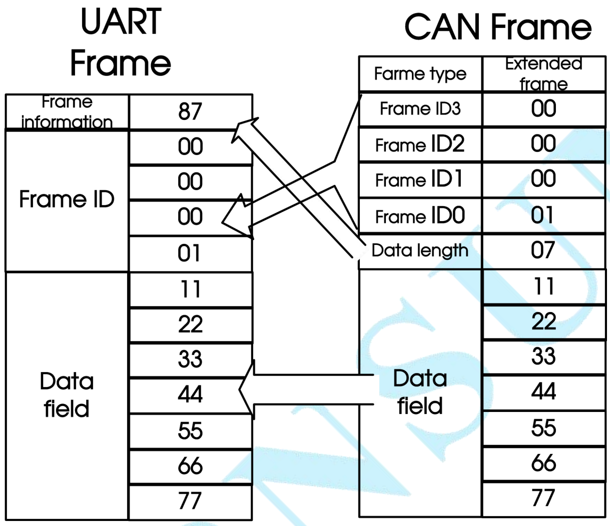

Figure 3.16 Example of converting CAN frame to UART frame (transparent conversion, frame information and frame ID conversion enabled)

3. CAN to SPI frame conversion(CAN→SPI)

TD5(3)USPCAN, as an SPI slave, can't actively control SPI peripherals. When the product receives a frame of data from the CAN bus, it can only be stored in the CAN receiving buffer immediately. When the number of CAN frames in the CAN buffer reaches the feedback trigger frame number or trigger time, the INT pin outputs a low level to inform the SPI host to read data.

After the SPI master obtains the size of the CAN buffer from TD5(3)USPCAN, SPI can read out all the CAN frame data contained in the CAN buffer by one frame, as shown in Figure 3.17.

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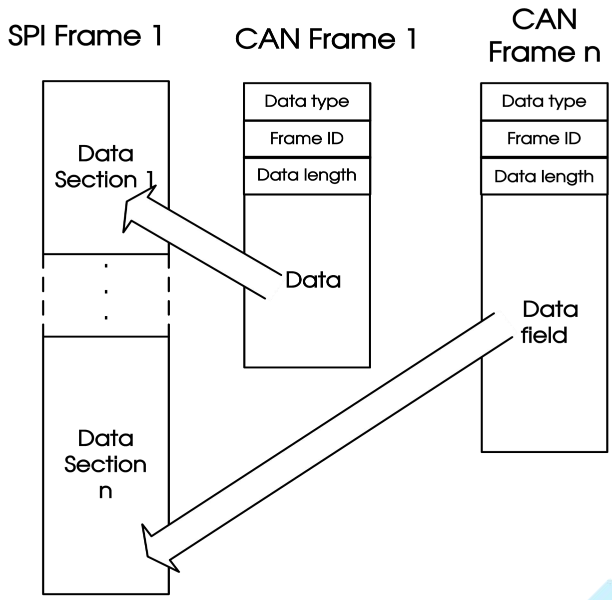

Figure 3.17 CAN frame to SPI frame (transparent conversion)

(1) Frame information conversion enable

Frame information refers to the "frame type" and "data length" information of CAN frame, with the length of one byte.

When frame conversion is enabled, the data in CAN receiving buffer is a collection of frame information and frame data. When the CAN terminal receives a CAN data frame, the product puts the frame information and frame data into the buffer at the same time. Frame information bytes and frame data bytes form a "byte segment". Each byte segment includes information and data of an independent CAN frame, in which frame information is the first byte of the byte segment, followed by data. After acquiring the size of the CAN receiving buffer, the master can read out the N byte segments stored in the buffer by one SPI frame at a time. The information is represented by one byte, in which 7~4 bits represent the frame type, 0000 represents the standard frame and 1000 represents the extended frame. 3~0 bits represent "data length", and "0000~1000" respectively represent "0~8" bits of data.

For example, the frame information is 0x05, which means that the CAN frame type is a standard frame, and the data length of the CAN frame is 5 bytes. The frame information is 0x86, which means that the CAN frame type is extended frame, and the data length of CAN frame is 6 bytes.

If the user enables frame information conversion, the converted data mode is shown in Figure 3.18.

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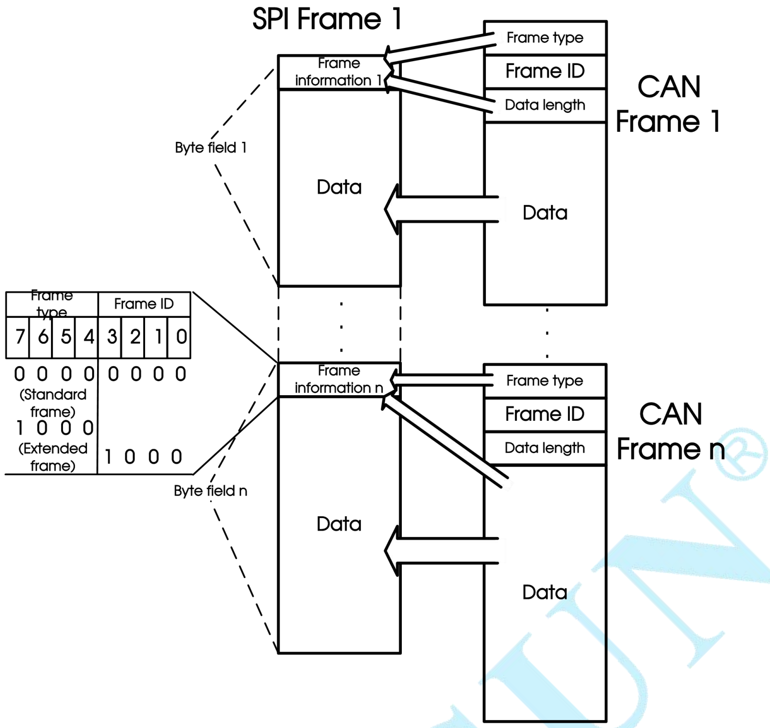

Figure 3.18 CAN frame to SPI frame (transparent conversion, frame information conversion enabled)

(2) Frame ID conversion enable

The frame ID is the "ID" of the CAN frame.

In SPI to CAN mode, it is considered that one SPI frame data is a collection of multiple CAN frame data most of the time. In order to effectively distinguish CAN frame ID from data, after the frame ID conversion is enabled, the frame information conversion is enabled by default, and the CAN receiving buffer is a collection of frame information, frame ID and frame data. When the CAN terminal receives a CAN data frame, the product simultaneously places the frame information, frame ID and frame data into the buffer. The ID of CAN frame is stored in 2 bytes (standard frame) or 4 bytes (extended frame). The frame information byte, frame ID byte and frame data byte form a "byte segment", and each byte segment includes the information, ID and data of an independent CAN frame. In which the frame information comes first, followed by the frame ID, the high bit of the frame ID comes first, and the data comes after the frame ID byte. After acquiring the size of the CAN receiving buffer, the master can read out the N byte segments stored in the buffer by one SPI frame at a time.

If the user enables frame ID conversion, the converted data format is shown in Figure 3.19. Since the frame information conversion is enabled by default, a byte segment contains frame information bytes, frame ID bytes and frame data bytes in order.

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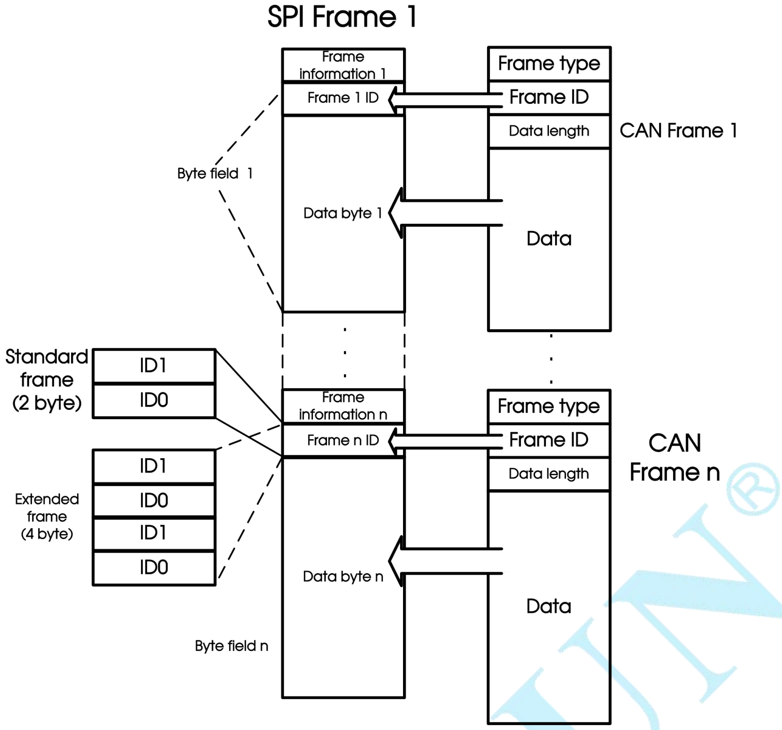

Figure 3.19 CAN frame to SPI frame (transparent conversion, frame ID conversion enabled)

Conversion instance:

Example 1: Assume that the user configuration is as follows: frame information conversion is enabled and frame ID conversion is enabled. If the CAN frame received by the CAN interface is a standard frame, the first frame ID is 0x0001 and the data is 0x11, 0x22, 0x33, 0x44 and 0x55; The n frame ID is 0x0009, and the data are 0x11, 0x22, 0x33, 0x44, 0x55, 0x66, 0x77; Then the CAN frame and the converted SPI frame are shown in Figure 3.20.

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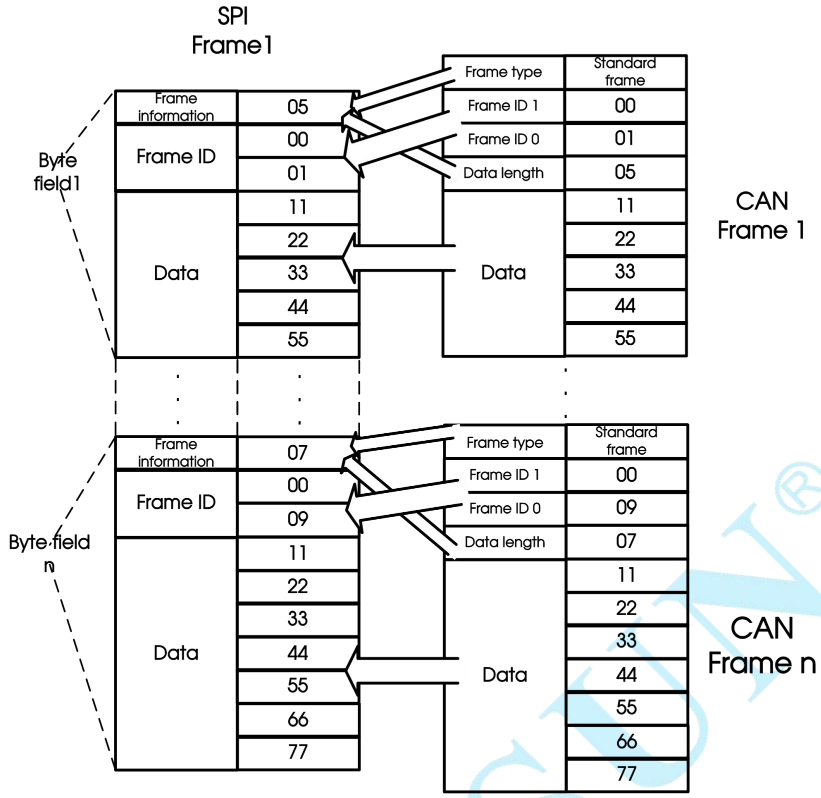

Figure. 3.20 Example 1 CAN frame to SPI frame (transparent conversion, frame information, frame ID enabled)

3.3.2 Transparent conversion with identification

Transparent conversion with identification is derived from transparent conversion, which means that the serial frames sent or received contain valid CAN frame ID bytes. In this way, the "frame ID" in the serial frame is automatically converted into the frame ID in the CAN frame. As long as the product is told the starting position and length of the serial frame, the product extracts this "frame ID" during conversion and fills it in the frame ID field of the CAN frame as the frame ID of the CAN frame when the serial frame is forwarded. When the CAN frame is converted into a serial frame, the product converts the frame ID of the CAN frame to the corresponding position of the serial frame and returns the frame information at the same time. In the mode of transparent identification conversion, users CAN control the CAN frame ID of data sent by serial frames, which is convenient for users to send CAN data with different IDs at the same node. The user CAN also obtain the hidden CAN frame ID from the received serial frame.

1. Serial frame to CAN frame conversion(UART/SPI→CAN)

The "Frame ID" of the CAN frame in the serial frame, the "start address" and "length" in the serial frame can be set by user configuration. The starting address ranges from 0 to 7, and the length ranges from 1 to 2

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(standard frame) or 1 to 4 (extended frame), respectively. If the start address is set to 1 and the length is 2, the 1st and 2nd bytes in the serial frame (counting from 0) will be the CAN frame ID.

During the conversion, according to the user's configuration information, all the frame ID correspondences of CAN frames in serial frames are converted into the frame ID field of CAN frames (if the number of ID bytes is less than the number of frame ID bytes of CAN frames, then the filling sequence of CAN frames is frames ID3～ID0, and the remaining IDs are filled with 0), and other data are sequentially converted, as shown in Figure 3.21.

Because the maximum data length of CAN frame is 8 bytes, when the data length of serial frame is less than or equal to 8 bytes, the data is forwarded through a CAN frame. If a CAN frame does not convert the serial frame data completely, the same ID is still used as the frame ID of the CAN frame to continue the conversion until the serial frame conversion is completed. The schematic diagram of data conversion is shown in Figure 3.21. CAN frames only indicate the following useful information: frame type, frame ID, data length and data field. In which CAN.

The "Frame Type" in the frame, the starting address and length of "Frame ID" in the serial frame are determined by the user's configuration, and remain unchanged all the time unless the user reconfigures the product again. The "data length" in the CAN frame is determined according to the actual number of bytes of data allocated to the CAN frame.

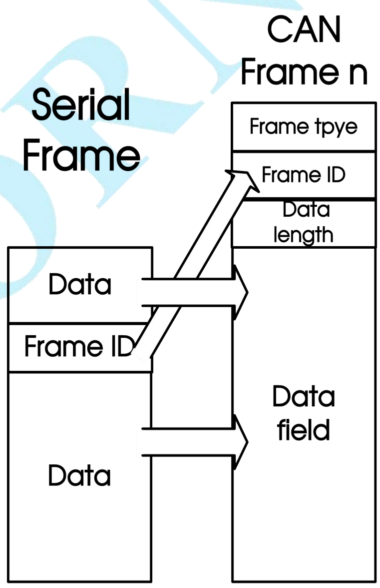

Figure 3.21 Serial frame to CAN frame (transparent generation identification conversion, data less than or equal to 8 bytes)

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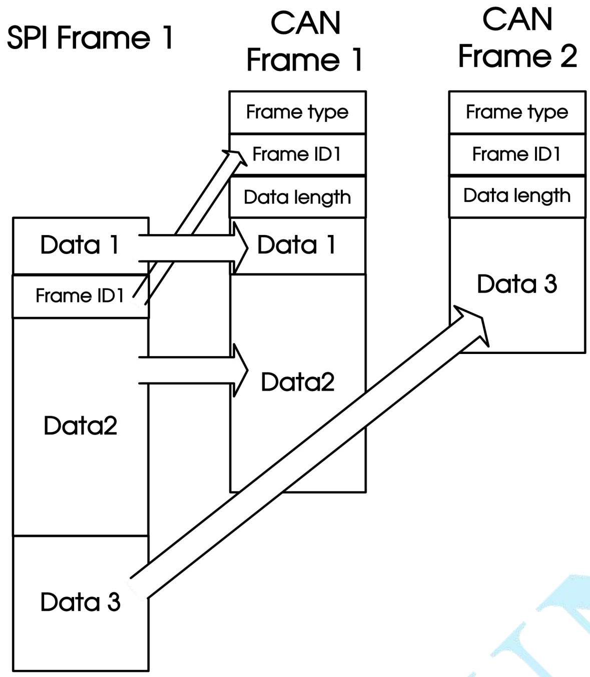

Figure 3.22 Serial frame to CAN frame (transparent conversion with identification , data greater than 8 bytes)

Conversion instance:

Since the configured CAN frame is an extenExample 1: Assume that the user configures the frame type of the converted CAN frame as "Extended Frame", the starting address of "Frame ID" in the serial frame is 2 and the length is 3, and the data sent by the serial frame is 0x00, 0x11, 0x22, 0x33, 0x44, 0x55, 0x66, 0x77, 0x88, 0x99, 0xAA and 0xBB respectively ded frame, the frame ID in the serial frame to CAN frame is 4 bytes. Since the starting address in the configuration serial frame is 2 and the length is 3, three bytes are taken continuously from the second byte in the serial frame, which are 0x22, 0x33 and 0x44 respectively in this example. When the product is converted, these three bytes are sequentially filled into frame ID3, frame ID2 and frame ID1 of the CAN frame, but frame ID0 is filled with 00. The rest of the data in the serial frame is converted to the data field of the CAN frame without any modification.

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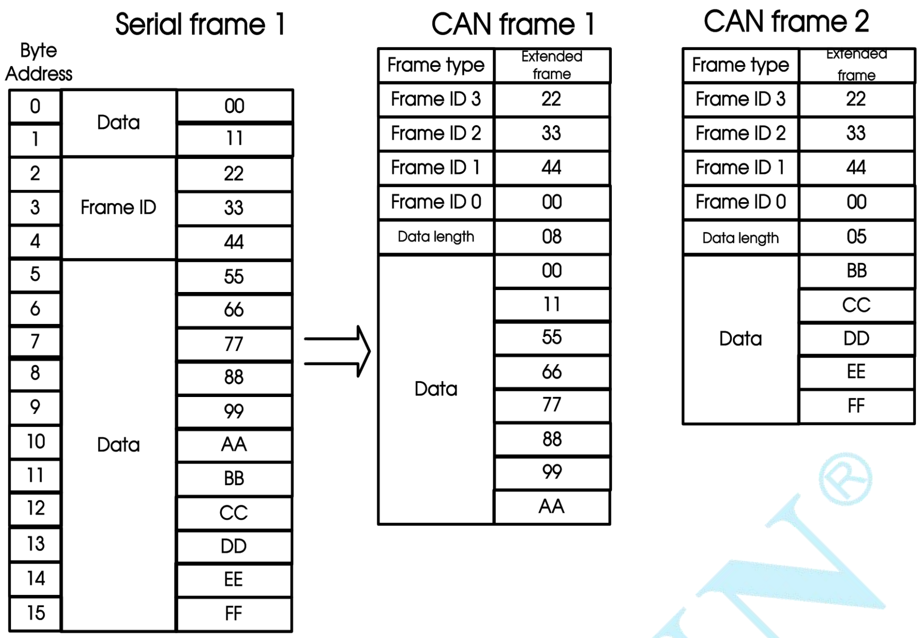

Figure 3.23 Example of serial frame to CAN frame

2. CAN frame to UART frame conversion (CAN→UART)

For CAN frames, it is also to forward a frame to the UART interface immediately after receiving a frame. When forwarding each time, the ID in the received CAN frame is correspondingly converted according to the position and length of the CAN frame ID configured by the user in the UART frame, and other data are forwarded in sequence. In this mode, the frame information of CAN frame is converted to the first byte of UART frame by default. As shown in Figure 3.24.

The information is represented by one byte, in which 7~4 bits represent the frame type, 0000 represents the standard frame and 1000 represents the extended frame. 3~0 bits represent "data length", and "0000~1000" respectively represent "0~8" bits of data.

For example, the frame information is 0x05, which means that the CAN frame type is a standard frame, and the data length of the CAN frame is 5 bytes. The frame information is 0x86, which means that the CAN frame type is extended frame, and the data length of CAN frame is 6 bytes.

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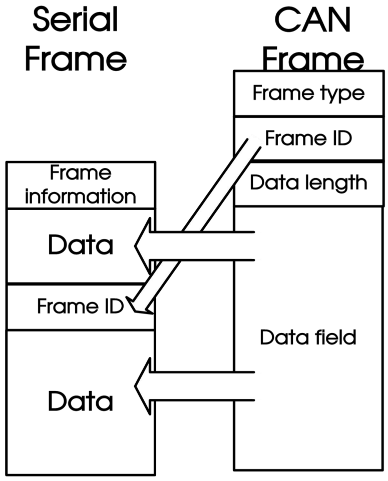

Figure 3.24 CAN frame to UART frame (transparent conversion with identification)

Conversion instance:

Example 1: Assume that the user configures the frame type of the converted CAN frame as "Extended Frame", and the starting address of "Frame ID" in UART frame is 2 and the length is 3. The frame ID of the received CAN frame is 0x00112233, and the data is 0x11, 0x22, 0x33, 0x44, 0x55, 0x66, 0x77 and 0x88. The conversion format is shown in Figure 3.25. Frame ID3, frame ID2 and frame ID1 in the CAN frame are sequentially converted into serial frames as the 2nd, 3rd and 4th bytes, and the data field of the CAN frame is sequentially converted into the unfilled part of the UART frame without any modification.

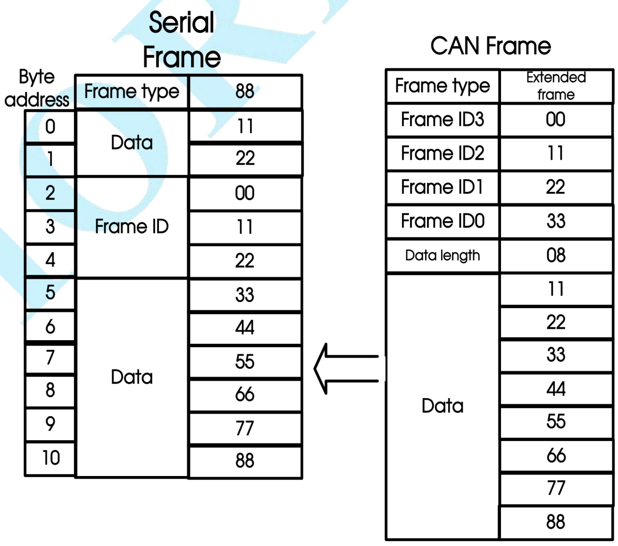

Figure 3.25 Example from CAN frame to UART frame

(transparent conversion with identification mode)

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3. CAN frame to SPI frame conversion(CAN→SPI)

TD5(3)USPCAN, as an SPI slave, can't actively control SPI peripherals. When the product receives a frame of data from the CAN bus, it can only be stored in the CAN receiving buffer immediately. When the number of CAN frames in the CAN buffer reaches the feedback trigger frame number or trigger time, the INT pin outputs a low level to inform the SPI master to read data.

After the SPI master acquires the size of the CAN buffer from TD5(3)USPCAN, SPI CAN read out all the CAN frame data contained in the CAN buffer by one frame.

In SPI-to-CAN mode, it is considered that one SPI frame data is a collection of multiple CAN frame data most of the time. In order to effectively distinguish CAN frame ID from data, CAN receiving buffer is a collection of frame information, frame ID and frame data. In the transparent conversion with identification mode, the CAN receiving buffer is a collection of frame information, frame ID and frame data. When the CAN terminal receives a CAN data frame, the product simultaneously places the frame information, frame ID and frame data into the buffer. CAN frame information is stored as the first byte, and the frame ID is stored at the specified location according to the user-configured starting address and length. Frame information, frame ID bytes and frame data bytes form a "byte segment", and each byte segment includes the frame information, frame ID and data of an independent CAN frame, in which the high bit of the frame ID comes first.

The information is represented by one byte, in which 7~4 bits refer to the frame type, 0000 represents the standard frame and 1000 represents the extended frame. 3~0 bits represent "data length", and "0000~1000" respectively represent "0~8" bits of data.

For example, the frame information is 0x05, which means that the CAN frame type is a standard frame, and the data length of the CAN frame is 5 bytes. The frame information is 0x86, which means that the CAN frame type is extended frame, and the data length of CAN frame is 6 bytes.

After acquiring the size of the CAN receiving buffer, the master can read out the N byte segments stored in the buffer by one SPI frame at a time. Its conversion data format is as follows.

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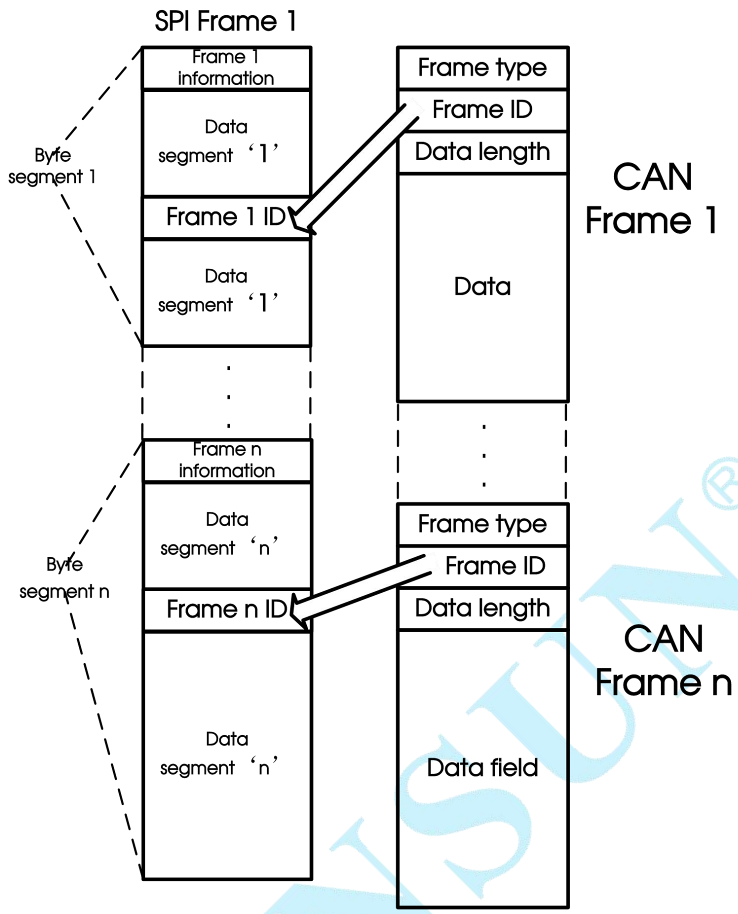

Figure. 3.26 CAN frame to SPI frame (transparent conversion with identification)

Conversion instance:

Example 1: It is assumed that the frame type of the CAN frame converted from user configuration is "Standard Frame", and the starting address of "Frame ID" in SPI frame is 1 and the length is 2. If the CAN frame received by the CAN interface is a standard frame, the first frame ID is 0x0122 and the data is 0x11, 0x22, 0x33, 0x44 and 0x55; The nth frame ID is 0x0234 and the data are 0x11, 0x22, 0x33, 0x44, 0x55, 0x66 and 0x77；. Then the CAN frame and the converted SPI frame are shown in Figure 3.27.

Frame ID1 and frame ID0 in the CAN frame are sequentially converted to the 2nd and 3rd bytes of each byte segment, and the data field of the CAN frame is sequentially converted to the unfilled part of the serial frame without any modification.

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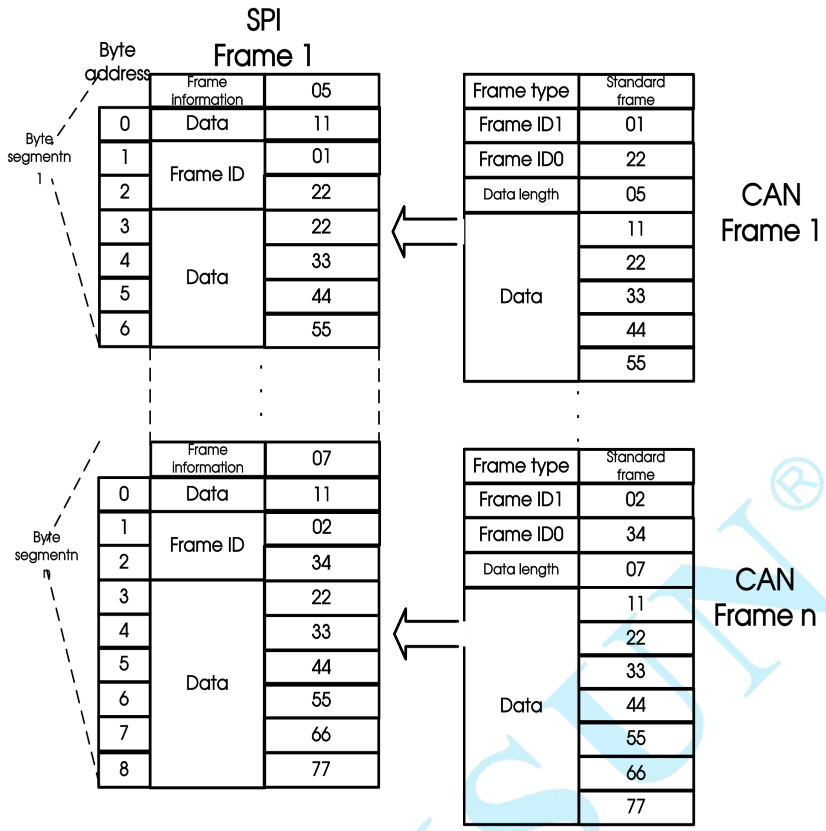

Figure 3.27 Example CAN frame to SPI frame (transparent conversion with identification)

3.3.3 Custom protocol conversion

Under the custom protocol conversion mode, the serial frame must conform to the specified frame format. The valid serial frame consists of frame header, frame length, frame type, frame ID, data field and frame trailer of paintings or calligraphy.

Header: is the start byte of a serial frame, ranging from 0x00~0xFF, which is configured by the user. Frame length: refers to the frame type, frame ID and the total number of bytes contained in the data field.

Frame type: refers to the frame type for sending CAN frames. 0x00 stands for standard frame and 0x08 stands for extended frame of paintings or calligraphy.

ID: refers to the frame ID of sending the CAN frame. When the frame type is 0x00, the frame ID consists of 2 bytes, with the highest bit first; When the frame type is 0x08, the frame ID consists of 4 bytes, with the high bits first.

Data field: the data to be sent, which is converted to the data field of CAN frame.

Tail: the end byte of a serial frame, ranging from 0x00~0xFF, which is configured by the user.

TD5(3)USPCAN only receive the serial frame data and forward it when the serial frame sent by the user completely conforms to the defined format, otherwise it will be discarded without any processing.

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1. Serial frame to CAN frame conversion(UART/SPI→CAN)

After the serial interface receives a valid serial frame, "Frame Type" determines the frame type of the CAN frame to be sent, "Frame ID" is used as the CAN frame ID, and "Data Field" is filled into the CAN frame data field. Figure 3.28 and Figure 3.29 are schematic diagrams of serial frame to CAN frame. Fig. 3.28 shows that the number of bytes in the serial frame data field is less than or equal to 8, and all data are forwarded through a CAN frame. Figure 3.29 The number of bytes in the serial frame data field is greater than 8, and the data is forwarded through multiple CAN frames.

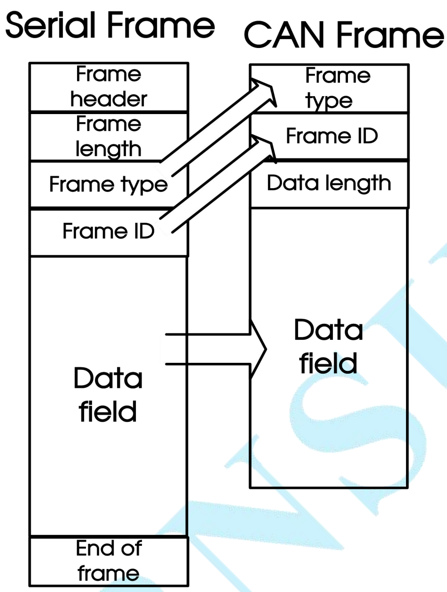

Figure 3.28 Serial frame to CAN frame 1 (custom protocol conversion)

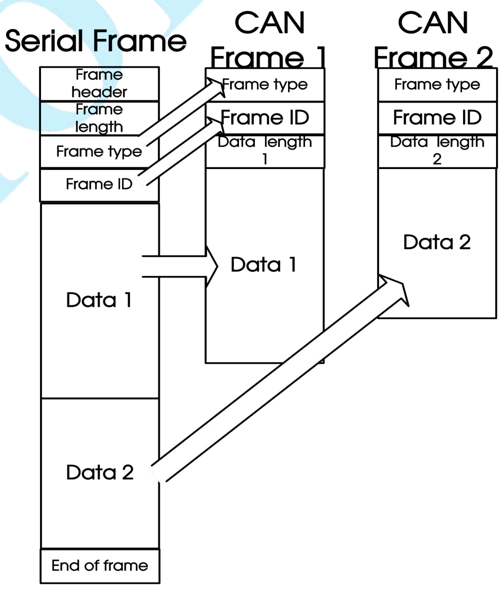

Figure 3.29 Serial frame to CAN frame 2 (custom protocol conversion)

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Conversion instance:

Example 1: Assume that the serial frame header configured by the user is 0x40 and the frame trailer is 0x1A. The user sends a standard frame (0x00), the frame ID is 0123, the data is 0x11, 0x22, 0x33, 0x44, 0x55, 0x66, 0x77, 0x88, 0x99, 0xAA, 0xBB, and the frame length is 0x0E. Example of conversion is shown in Figure 3.30.

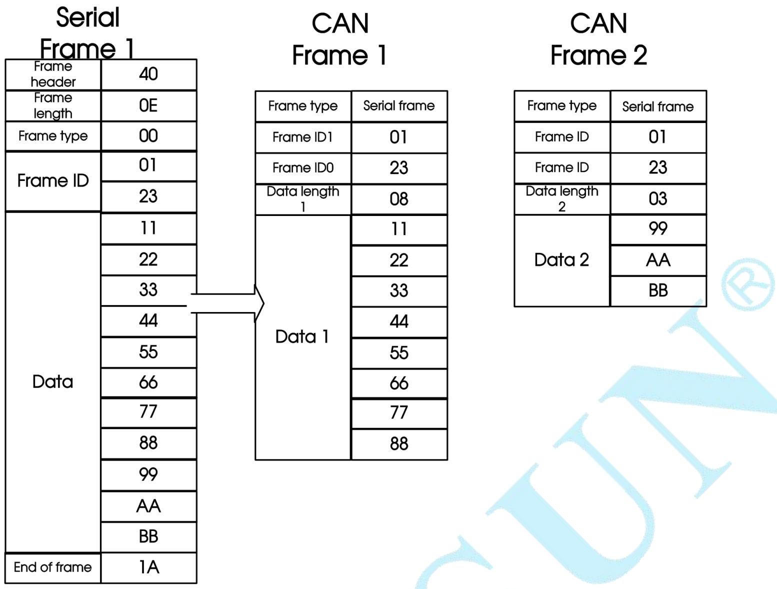

Figure 3.30 Example of Serial Frame to CAN Frame (Custom Protocol Conversion)

2. CAN frame to UART frame conversion(CAN→UART)

In UART to CAN mode, the CAN bus will forward a frame as soon as it receives a CAN frame. Data format correspondence is shown in Figure 3.31. During conversion, the CAN frame type is converted to UART frame type byte, the frame ID is converted to UART frame ID byte, and all data in the CAN frame data field are sequentially converted to serial frame data field.

In order to ensure the integrity of the serial frame, when the CAN frame is converted into a serial frame, the frame header and the frame trailer are consistent with the user settings, and the serial frame at this time is completely consistent with the frame format when the serial frame is converted into the CAN frame.

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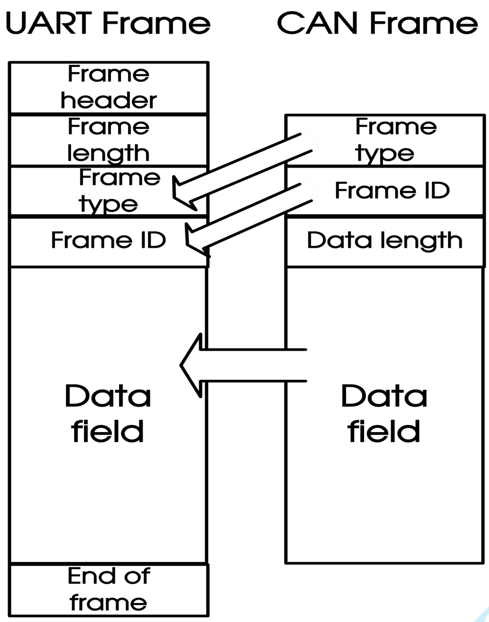

Figure 3.31 CAN frame to UART frame (custom protocol conversion)

Conversion instance:

Example 1: Assume that the serial frame header configured by the user is 0x40 and the frame trailer is 0x1A. Example of conversion is shown in Figure 3.32.

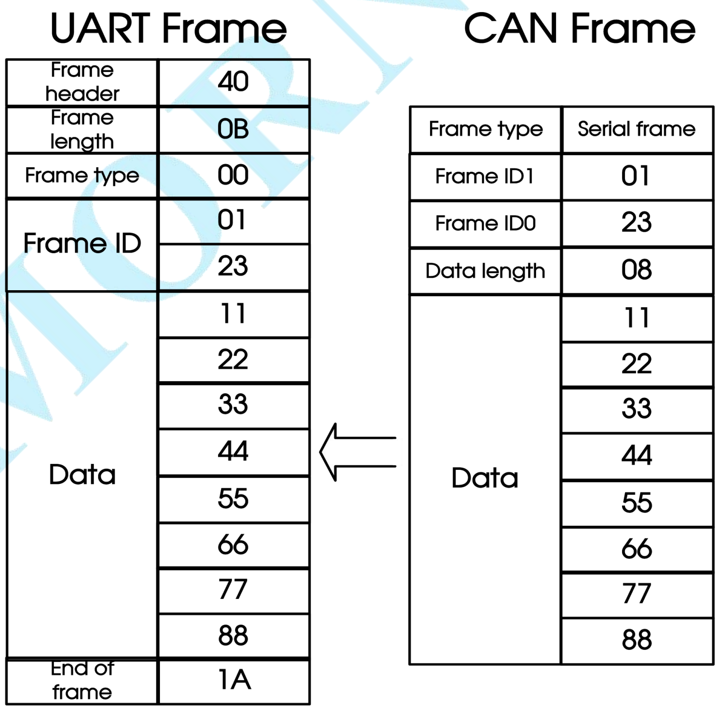

Figure 3.32 Example of Can frame to UART frame (custom conversion)

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3. CAN frame to SPI frame conversion(CAN→SPI)

TD5(3)USPCAN, as an SPI slave, can't actively control SPI peripherals. When the product receives a frame of data from the CAN bus, it can only be stored in the CAN receiving buffer immediately. When the number of CAN frames in the CAN buffer reaches the feedback trigger frame number or trigger time, the INT pin outputs a low level to inform the SPI master to read the data. After the SPI master acquires the size of the CAN buffer from TD5(3)USPCAN, SPI CAN read out all the CAN frame data contained in the CAN buffer by one frame. In the custom conversion mode, the CAN receiving buffer stores a collection of bytes in multiple valid formats. When the CAN terminal receives a CAN data frame, it converts it into a byte segment conforming to the user-defined format and places it in the buffer.

After acquiring the size of the CAN receiving buffer, the master can read out the N byte segments stored in the buffer by one SPI frame at a time. The converted data format is shown in Figure 3.33.

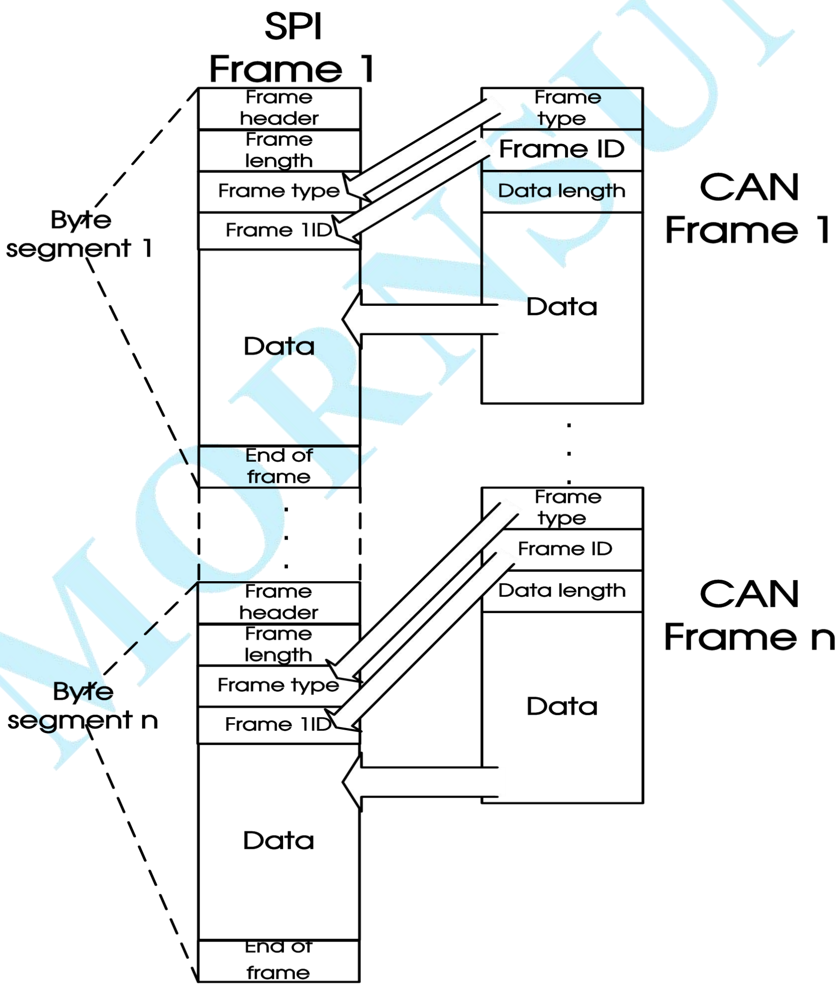

Figure 3.33 CAN frame to SPI frame (custom protocol conversion)

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Conversion instance:

Example 1: Assume that the serial frame header configured by the user is 0x40 and the frame trailer is 0x1A. Example of conversion is shown in Figure 3.34.

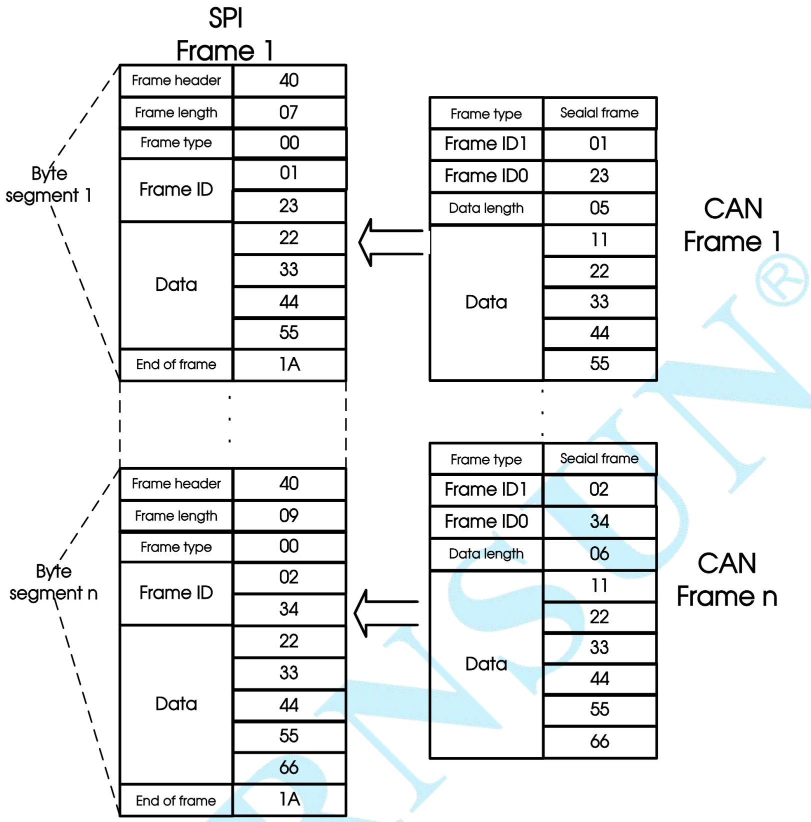

Figure 3.34 Example of Can frame to SPI frame (custom protocol conversion)

4. Product configuration

4.1 Configuration parameter

4.1.1 Conversion parameter

1. Conversion mode

The data conversion mode of TD5 (3)USPCAN refers to the basic rules of data conversion between serial bus and can bus. At the same time, the product can only work in one data conversion mode. If you need to change the data conversion mode, you need to change the configuration. When the product is configured with a conversion mode, it acts on SPI to CAN mode and UART to CAN mode at the same time.

There are three ways of data conversion: transparent conversion, transparent conversion with identification and custom protocol conversion.Transparent conversion means that as soon as any side bus

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receives data, it is immediately sent to the other side bus without any processing. See section 3.3.1 for a detailed description of this method.

Transparent conversion with identification is derived from transparent conversion, which means that the serial frames sent or received contain valid CAN frame ID bytes. See section 3.3.2 for a detailed description of this method.

Custom protocol conversion, serial frames must conform to the specified frame format. The valid serial frame consists of frame header, frame length, frame type, frame ID, data field and frame trailer. See section 3.3.3 for a detailed description of this method.

2. Change direction

Change direction, which refers to the allowed direction of data conversion. TD5(3)USPCAN has three conversion directions: bidirectional, only UART/SPI to CAN, only CAN to UART/SPI.

3. CAN frame information is allowed to be converted into serial frames

This configuration parameter is only valid in transparent conversion mode. If enabled, when CAN is converted to UART/SPI, the frame information of CAN frame will be converted to UART/SPI at the same time. See for details Section 3.3.1.

4. Allows the CAN frame ID to be converted into a serial frame

This configuration parameter is only valid in transparent conversion mode. If it is enabled, the frame information conversion will be enabled by default. When CAN is converted to UART/SPI, the frame ID and frame information of CAN frame will be converted to UART/SPI at the same time. See section 3.3.1 for details.

5. Position of CAN identifier in serial frame

This configuration parameter is only valid in the transparent conversion with identification mode, including the setting of the starting address and length of the CAN identifier. See section 3.3.2 for details.

6. Frame header, frame trailer

This configuration parameter is only valid in the custom protocol conversion mode, and is used to set the frame start and frame end of serial frames.

4.1.2 UART parameters

1. Baud rate

Refers to the working baud rate of serial port. The effective baud rate of serial port is shown in Table 4.6.

2.Frame interval

Refers to the time interval between UART communication frames. See the definition of UART frames in section 3.2.2 for details.

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4.1.3 SPI parameters

1. Feedback trigger frame number

This configuration parameter is only valid in SPI to CAN mode. TD5(3)USPCAN, as an SPI slave, can't actively send data to the host, so when TD5(3)USPCAN receives a certain amount of can frame data, it needs to inform the master to get the data through the INT pin. The number of feedback trigger frames is based on the received CAN frames. When the CAN buffer receives a set number of CAN frames, feedback is triggered.

2. Feedback trigger time

This configuration parameter is only valid in SPI toCAN mode. TD5(3)USPCAN can't actively send data to the master because it is the slave of SPI. When the number of CAN frames received by the CAN buffer does not reach the number of feedback trigger frames, and it is not read within the feedback trigger time, the master is informed to obtain data through the INT pin.

The feedback triggering time takes 100ms as the unit. When the CAN feedback triggering time reaches the set value, the feedback is triggered.

4.1.4 CAN parameters

1. Baud rate

Refers to the working baud rate of CAN. The effective baud rate of CAN is shown in table 4.6.

Send frame type

2. Send frame type

This configuration parameter is only valid in transparent conversion and transparent conversion with identification modes. Refers to the type of CAN frame sent, including two types: standard frame and extended frame.

3. Send identifier

This configuration parameter is only valid in transparent conversion mode. In transparent conversion mode, the ID of the frame sent by CAN is subject to the set ID. The frame ids are ID3, ID2, ID1 and ID0 from left to right. Frame ID3 is the highest byte. If it is a standard frame, its range is 0x000~0x7FF, and the extended frame range is 0x00000000~1FFFFFFF. If a standard frame with frame ID 0x0123 is sent during transparent conversion, its sending identifier should be set to 00 00 01 23.

4. Filter enable

Only when this option is selected, the receiving and filtering mode and the corresponding shielding and acceptance codes will be open. If you don't want to use the filtering function, don't select this item to receive all CAN frames.

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5. Receiving filtering mode

This option is divided into extended frame filtering and standard frame filtering. If you only want to receive CAN frames in extended frame format, you should choose extended frame filtering. If you only want to receive CAN frames in standard frame format, you should choose standard frame filtering.

6. Masking code

The mask code is used to manage the "acceptance code", which is managed according to bits. When a bit of the mask code has a value of 1, the acceptance code corresponding to this bit will be enabled. Only when the enabled acceptance code is the same as the Frame ID of the CAN frame to be received by the product will the CAN frame be received in the receiving buffer. When the bit value of "mask code" is 0, the acceptance code does not work, and the frame identification of the corresponding bit is that any value can be received. The padding data format is hexadecimal, and each 8-bit byte is separated by a "space character".

7. Acceptance code

Acceptance codes include acceptance code 0~ acceptance code 5, totally 6 groups.

The comparison value when the CAN "frame ID" is accepted corresponds to the "mask code" according to the bit relationship. When the mask code is set to 1, the frame data will be received in the receiving buffer only when the receiving frame ID and the receiving code are the same, otherwise it will not be received.

The padding data format is hexadecimal, and each 8-bit byte is separated by a "space character". Table 4.1 shows the true value relationship between mask bit and acceptance bit filter frame ID.

Table 4.1 Truth Table of Filtering and Masking Codes

Mask bit	Acceptance position	Frame ID	Receive or reject bit
0	X	X	receive
1	0	0	receive
1	0	1	reject
1	1	0	reject
1	1	1	receive

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4.2 Factory default configuration

Table 4.2 Factory Default Configuration Parameters

Parameter	Default	Explain	Remarks
UART baud rate	115200 bps	Serial port operating baud rate	--
UART data bits	8	Serial data bit, fixed at 8	Unable to change
UART stop bit	1	Serial port stop bit, fixed to 1	
UART parity bit	0	Serial check bit, fixed at 0	
CAN baud rate	125 kbps	CAN working baud rate	--
Filter enable	Disable	CAN acceptance filter function selection	--
Receiving filtering mode	Extended frame filtering	Selection of filter mode for CAN acceptance	--
Masking code	FF FF FF FF	CAN acceptance filter mask code	--
Acceptance code 0	00 00 00 00	CAN acceptance filter arbitration code 0	--
Acceptance code 1	00 00 00 00	CAN acceptance filter arbitration code 1	--
Acceptance code 2	00 00 00 00	CAN acceptance filter arbitration code 2	--
Acceptance code 3	00 00 00 00	CAN acceptance filter arbitration code 3	--
Acceptance code 4	00 00 00 00	CAN acceptance filter arbitration code 4	--
Acceptance code 5	00 00 00 00	CAN acceptance filter arbitration code 5	--
Conversion mode	transparent conversion with identification	Data conversion mode	--

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Change direction	Two-way	Data conversion mode	--
UART frame interval	2 characters	UART frame time interval characters	--
CAN frame information is forwarded to serial frame.	Disable	Forwarding enable of CAN frame information when converting to serial frame	Only applicable to transparent conversion.
The forwarding of CAN frame ID to serial frame	Disable	Forwarding enable of frame ID when converting to serial frame	Only applicable to transparent conversion.
Send frame type	Extended frame	Type of CAN frame configured when converting to CAN	Suitable for transparent conversion and transparent conversion with identification.
Send identifier	00 00 00 00	ID3~ID0 from UART/SPI to CAN	Only applicable to transparent conversion.
The length of CAN identification in serial frame	4 bytes	The length of CAN identification in serial frame	Only applicable to transparent conversion with identification.
CAN identifies the starting address in the serial frame	0 bytes	CAN identifies the starting address in the serial frame	
Frame header	0x40	Serial frame header	Only applicable to custom protocol conversion.
Frame tail	0x1A	Serial frame tail	
Feedback trigger frame number	15 frames	CAN buffer feedback trigger frame number	Only applicable to SPI- to-CAN mode
Feedback trigger time	500ms	CAN buffer feedback trigger time	

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Data bit length	8 bits	SPI data length is fixed at 8 bits.	Unable to change
Bit transmission mode	MSB	Bit transmission is high priority.	
CPOL	1	SPI working mode parameter CPOL (fixed at 1)	
CPHA	1	SPI working mode parameter CPHA (fixed at 1)	

4.3 Configure communication protocol

To configure TD5(3)USPPAN, it is necessary to reset the product and enter "SPI configuration mode" or "UART configuration mode". Send the corresponding command frame to SPI interface or UART interface of user TD5(3)USPCAN. After receiving the configuration command, the product operates itself and returns a response frame.

It should be noted that in "UART configuration mode", the product will actively return a response frame to UART after receiving the data and processing it. However, when the product is in "SPI configuration mode", TD5(3)USPCAN, as a slave, can't actively return the response frame. Therefore, the SPI master sends a command frame. After receiving and processing correctly, TD5(3)USPCAN set the INT pin low to inform the master that the processing is completed and the response frame can be read.

If users don't want to test the INT pin, they should wait for a certain time after the master sends the command frame. After TD5(3)USPCAN processing is completed, SPI master can read the response frame data or change the working state of the product. The waiting time of command processing is shown in Table 4.3.

Table 4.3 Waiting Time for Command Frame Processing

Command frame type	Waiting time for processing
Write configuration	150ms
Read configuration	3ms
Verify product identification	3ms

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1. Command frame

The command frame is sent from the main control terminal (host computer, MCU, etc.) to the controlled terminal TD5(3)USPCAN, and the TD5(3)USPCAN performs corresponding operation after receiving the command frame.

2. Response frame

The response frame refers to the response information returned by TD5(3)USPCAN to the main control terminal after TD5(3)USPCAN receives the command frame.

4.3.1 Write configuration parameters

1. Write configuration command frame

A configuration command frame is used to configure the parameters of TD5(3)USPCAN, which contains all the data needed to configure TD5(3)USPCAN. The format of the configuration command frame is shown in Table 4.4.

Table 4.4 Write Configuration Command Frame Format

Frame start	Command word	Data length	Data field	Check word
2 bytes	1 byte	1 byte	60 bytes	1 byte
0xF7, 0xF8	0x01	0x3C	As defined in Table 4.5.	XOR of all previous bytes

Description:

Frame start: 2 bytes, followed by 0xF7 and 0xF8.

Command word: 1 byte. Fixed at 0x01.

Data length: 1 byte, the number of data bytes in the data field in the frame, fixed at 60 (i.e. 0x3C).

Data: 60 bytes, configuration information.

Check word: 1 byte, which is exclusive OR of all previous bytes.

Table 4.5 Definition of write configuration command frame data field

Byte position	Definition	Scope of data	Explain
0	UART baud rate	0x00~0x10	The correspondence is shown in Table 4.6.

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1	UART data bit	0x08	Fixed at 8
2	UART stop bit	0x01	Fixed at 1
3	UART parity bit	0x00	Fixed at 0
4	CAN baud rate	0x00~0x0F	The correspondence is shown in Table 4.6.
5	(reserved bytes)	--	Not used, invalid.
6	(reserved bytes)	--	Not used, invalid.
7	(reserved bytes)	--	Not used, invalid.
8	Filter enable	0x00 / 0x01	0x00: Disabled; 0x01: Enabled.
9	Receiving filtering mode	0x08 / 0x00	0x08: Extended frame filtering only; 0x00: Standard frame filtering only.
10~13	Masking code	00 00 00 00 ~ FF FF FF FF	--
14~17	Acceptance code 0	00 00 00 00 ~ FF FF FF FF	--
18~21	Acceptance code 1	00 00 00 00 ~ FF FF FF FF	--
22~25	(reserved bytes)	--	Not used, invalid.
29~29	Acceptance code 2	00 00 00 00 ~ FF FF FF FF	--
30~33	Acceptance code 3	00 00 00 00 ~ FF FF FF FF	--
34~37	Acceptance code 4	00 00 00 00 ~ FF FF FF FF	--
38~41	Acceptance code 5	00 00 00 00 ~ FF FF FF FF	--

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42	Conversion mode	0x01~0x03	0x01: transparent conversion; 0x02: transparent conversion with identification. 0x03: Custom protocol conversion.
43	Change direction	0x00~0x02	0x00: bidirectional; 0x01: only UART/SPI to CAN；； 0x02: only CAN to UART/SPI.
44	UART frame interval	x02~0x0A	--
45	CAN frame information is forwarded to serial frame.	0x00 / 0x01	0x00: Disabled; 0x01: Enabled. This item is only used for transparent conversion.
46	CAN frame ID is forwarded to serial frame	0x00 / 0x01	0x00: Disabled; 0x01: Enabled. This item is only used for transparent conversion.
47	Send frame type	0x08 / 0x00	0x08: Extended frame; 0x00: Standard frame. This item is used for transparent conversion and transparent conversion with identification change.
48~51	Send identifier	00 00 00 00 ~ FF FF FF FF	This item is only used for transparent conversion and identification ID3~ID0. Standard frame: 000~7FF valid; Extended frame: 00000000 ~1FFFFFFF is valid.

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52	The length of CAN identification in serial frame	0x01~0x04	In bytes, this item is only used for transparent conversion with identification.
53	CAN identifies the starting address in the serial frame	0x00~0x07	In bytes, this item is only used for transparent conversion with identification.
54	frame header	0x00~0xFF	One byte, user-defined.
55	Frame tail	0x00~0xFF	One byte, user-defined.
56	Feedback trigger frame number	0x08~0xFF	With one CAN frame as a unit, this item is only used in SPI- to-CAN mode.
57	Feedback trigger time	0x01~0xFF	With 100ms as a time unit, this item is only used in SPI- to- CAN mode.
58	CPOL	0x00~0x01	Only 0x01 is temporarily supported.
59	CPHA	0x00~0x01	Only 0x01 is temporarily supported.

Table 4.6 Code table of serial port and CAN baud rate

Code	Corresponding hexadecimal	Serial baud rate （bps）	CAN baud rate （bps）
0	0x00	--	--
1	0x01	115200	5K
2	0x02	57600	10K
3	0x03	38400	20K
4	0x04	19200	40K
5	0x05	14400	50K
6	0x06	9600	80K

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7	0x07	4800	100K
8	0x08	2400	125K
9	0x09	1200	200K
10	0x0A	600	250K
11	0x0B	300	400K
12	0x0C	128000	500K
13	0x0D	230400	666K
14	0x0E	256000	800K
15	0x0F	460800	1M
16	0x10	921600	--

2. Write configuration response frame

After receiving the command frame for writing configuration parameters, TD5(3)USPCAN will update the current configuration according to the received data. After the operation is completed, no matter whether the configuration update is successful or not, it will send a response frame to the main control terminal to respond. The format of the configuration response frame is shown in Table 4.7.

Table 4.7 Format of command frame for writing configuration parameters

Frame start	Command word	Status word	Check word
2 byte	1 byte	1 byte	1 byte
0xF7, 0xF8	0x01	0x13 or 0x07	XOR of all previous bytes

Description:

Frame start: 2 bytes, followed by 0xF7 and 0xF8.

Command word: the command word in the response frame is the same as that in the command frame, namely 0x01.

Status word: 1 byte, 0x13 indicates successful command execution, 0x07 indicates failed command execution.

Check word: 1 byte, which is exclusive OR of all previous bytes.

4.3.2 Verify product hardware identification

1.Verify product hardware identification command frame

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Verify the product hardware identification, which is used to confirm whether the specific hardware information of the configured product is correct before configuring the product. The format of the product hardware identification command frame is shown in Table 4.8.

Table 4.8 Verify the Frame Format of Product Hardware Identification Command

Frame start	Command word	Data length	Data field	Check word
2 byte	1 byte	4 byte	1 byte	1 byte
0xF7, 0xF8	0x02	0x04	0x0A, 0x15, 0x12, 0x03	0x07

Description:

Frame start: 2 bytes, followed by 0xF7 and 0xF8.

Command word: the command word in the response frame is the same as that in the command frame, namely 0x02.

Data length: 1 byte, the number of data bytes in the data field within the frame, which is fixed at 4 (i.e. 0x04).

Data field: 4 bytes, product hardware identification information.

Check word: 1 byte, which is exclusive OR of all previous bytes.

2. Verify product hardware identification response frame

After receiving the command frame for verifying product hardware identification, TD5(3)USPCAN will identify the hardware identification in the command frame with its own hardware identification.

Match the knowledge, and return the comparison result to the main control terminal through the response frame. The format of the response frame for verifying product hardware identification is shown in Table 4.9.

Table 4.9 Format of response frame for verifying product hardware identification

Frame start	Command word	Status word	Check word
2 byte	1 byte	1 byte	1 byte
0xF7, 0xF8	0x02	0x13 or 0x07	XOR of all previous bytes

Description:

Frame start: 2 bytes, followed by 0xF7 and 0xF8.

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Command word: the command word in the response frame is the same as that in the command frame, that is, 0x02.

Status word: 1 byte, 0x13 indicates successful identification matching, 0x07 indicates failed identification matching. Check word: 1 byte, which is exclusive OR of all previous bytes.

4.3.3 Read configuration parameters

1. Read configuration parameter command frame

Read the configuration parameter command frame, which can be used to obtain the current configuration parameters of TD5(3)USPCAN. The format of the read parameter command frame is shown in Table 4.10.

Table 4.10 read configuration parameter command frame format

Frame start	Command word	Data length	Data field	Check word
2 byte	1 byte	1 byte	0 byte	1 byte
0xF7, 0xF8	0x03	0x00	None	0x0C

Description:

Frame start: 2 bytes, followed by 0xF7 and 0xF8.

Command word: 1 byte. Fixed at 0x03.

Data length: 1 byte, this command frame has no data and is fixed at 0x00.

Data: 0 bytes, no data.

Check word: 1 byte, which is the exclusive OR of all previous bytes, namely 0x0C.

2.Read configuration parameter response frame

After receiving the command frame of reading configuration parameters, TD5(3)USPCAN will acquire its current configuration parameter information and return it to the main control terminal through the response frame. The format of the read parameter response frame is shown in Table 4.11.

Table 4.11 read configuration parameter response frame format

Frame start	Command word	Data length	Data field	Check word
2 bytes	1 byte	1 byte	60 bytes	1 byte
0xF7, 0xF8	0x03	0x3C	As defined in Table 4.5.	XOR of all previous bytes

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Description:

Frame start: 2 bytes, followed by 0xF7 and 0xF8.

Command word: the command word in the response frame is the same as that in the command frame, namely 0x03.

Data length: 1 byte, the number of data bytes in the data field in the frame, fixed at 60 (i.e. 0x3C).

Data field: 60 bytes, when the parameter information is configured.

Check word: 1 byte, which is exclusive OR of all previous bytes.

4.4 Collocation method

4.4.1 MCU configuration mode

1. With UART configuration

When the user uses the UART interface of MCU to connect with TD5(3)USPCAN, the product parameters can be configured through the UART interface. Refer to Figure 2.5 and Figure 2.6 for the hardware connection diagram. Among them, the baud rate of serial port during configuration is fixed at 9600bps and cannot be changed. If the baud rate used is incorrect, the configuration cannot be successful.

The configuration method is as follows:

(1) CFG is set low, MODE is set low, RST is reset, wait for at least 3ms, and the product enters UART configuration mode;

(2) Send MCU write configuration command frame (product RXD receives data);

(3) After receiving the configuration command frame, the product actively sends a write configuration response frame to MCU (product TXD sends data);

(4) Confirm the MCU write configuration response frame content, and judge whether the configuration is successful;

(5) After configuration, CFG pin is set high, RST is reset, wait for at least 3ms, and the product enters UART to CAN mode.

The timing diagram of writing configuration commands through UART is shown in Figure 4.1. This timing diagram is also suitable for reading configuration commands, verifying product identification and other operations, and only needs to change the command frame sent by MCU.

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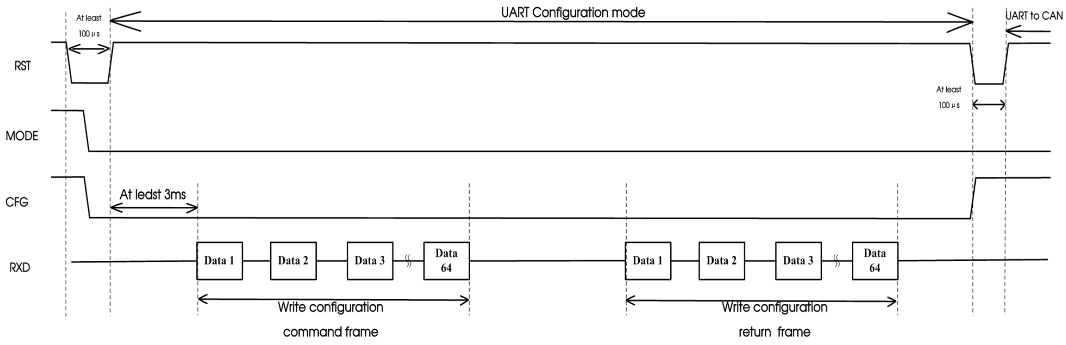

Figure 4.1 Timing diagram of configuration command written by UART

2.With SIP configuration

When the user uses the SPI interface of MCU to connect with TD5(3)USPCAN, the product parameters can be configured through the SPI interface. Refer to Figure 2.3 and Figure 2.4 for the hardware connection diagram.

The configuration method is as follows:

(1) CFG is set low, MODE is set high, RST is controlled to reset, wait for at least 3ms, and the product enters SPI configuration mode;

(2) The CTL0 and CTL1 pins are set high to control TD5(3)USPCAN to enter the SPI master write state and wait for at least 50us;

(3) Set SSEL low, MCU sends a write configuration command frame, then set SSEL high, wait for at least 150ms, or detect that the INT pin is low;

(4) CTL0 is set high, CTL1 is set low, and TD5(3)USPCAN is controlled to enter SPI master read state, waiting for at least 50us;

(5) Set SSEL low, the master sends 5 bytes of invalid data, receives the product write configuration response frame, and then sets SSEL high;

(6) Confirm the MCU write configuration response frame content, and judge whether the configuration is successful;

(7) After configuration, CFG pin is set high, RST is reset, wait for at least 3ms, and the product enters SPI-to- CAN mode. The timing diagram of writing configuration commands through SPI is shown in Figure 4.2. This timing diagram is also suitable for reading configuration commands, verifying product identification and other operations. It only needs to change the SPI reading and writing data and the waiting time after writing configuration commands.

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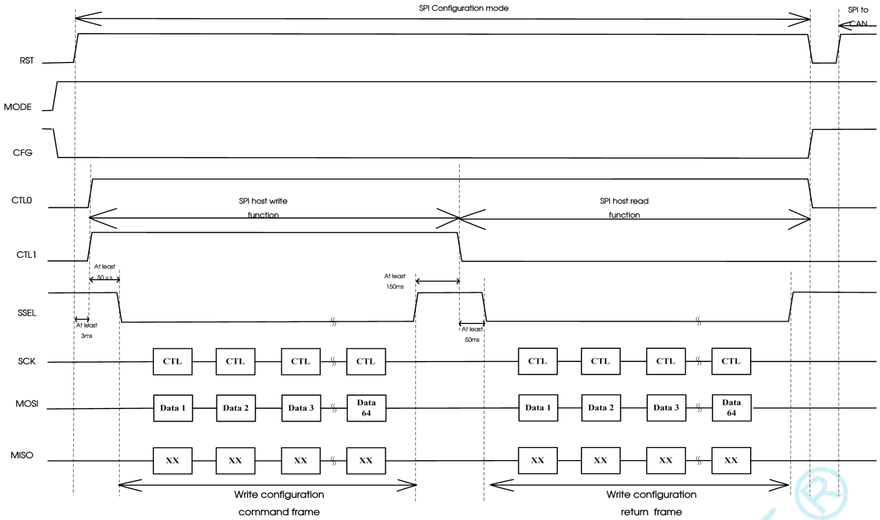

Figure 4.2 Timing diagram of configuration command written through SPI

4.4.2 Configuration mode of upper computer

If users don't want to configure TD5(3)USPCAN through MCU, they can use the upper computer configuration method to configure the product first, and then use it after the configuration is completed. For configuration through the upper computer, TD5(3)USPCAN configuration software and TD5(3)USPCAN evaluation board are needed. Please refer to Section 5 (Auxiliary Development Tools) for detailed configuration instructions.

5. Auxiliary development tools

5.1 TD5(3)USPCANCFG configuration software

TDxUSPCANCFG is an auxiliary development tool specially developed for TD5(3)USPCAN series products. Users can use this software to configure the product very conveniently. At the same time, the software provides the complete frame data of the write configuration command frame currently selected and configured by users, and users can directly copy it into the program for use, thus avoiding the tedious work of setting the command frame by users. The main interface of TD5 (3)USPCAN config is shown in figure 5.1.

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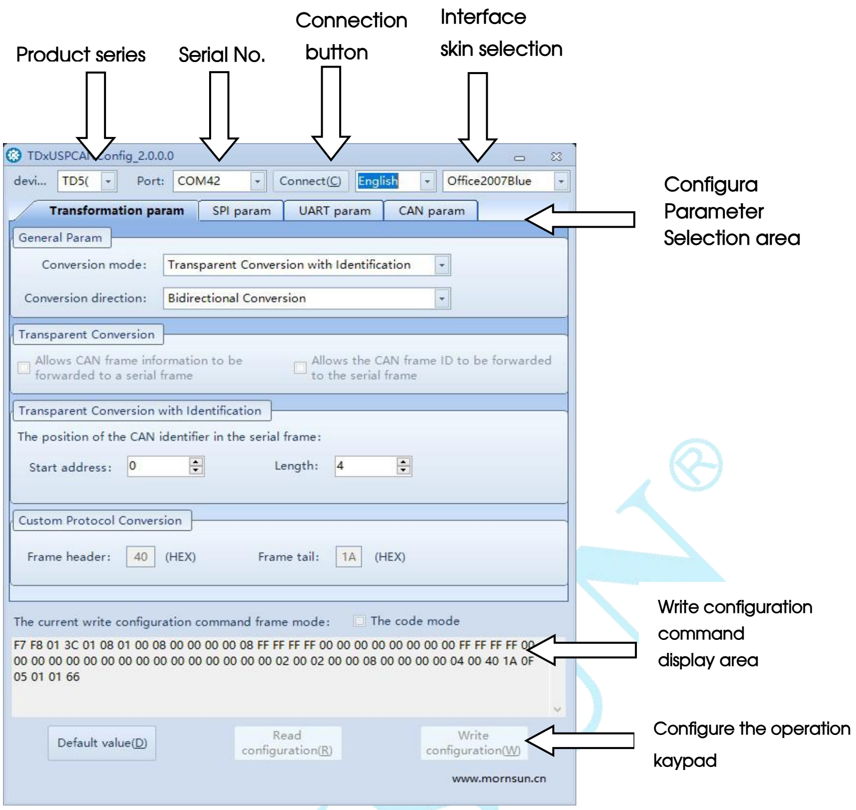

Figure 5.1 TDxUSPCANCFG software main page

Download link of PC: https://www.mornsun.cn/html/support/8/profiles.html

Note: After the official website is updated, the link of the upper computer may change, and the upper computer can also be obtained from Jinshengyang official website through "official website → application support → application materials → configuration file".

◆ Product model

The product model to be configured can be TD5(3)USPCAN, and other models are under development.

◆ Serial number

Only the available serial number of the current computer is displayed. If the serial port is occupied, please release the occupied serial port first, and then reconnect TDxUSPCANCFG software.

◆ Connect button

Connect or disconnect the product with this button.

◆ Configuration parameter setting interface

In this area, the user can set the configuration parameters of the functions that the product needs to realize. The configuration parameters are divided into four categories: conversion parameters, SPI parameters, UART parameters and CAN parameters, which correspond to the parameters in section 4.1 one by one, and users can set the parameters according to actual usage.

All parameters have a certain scope of application. Please pay attention to which scope the parameters are included when setting. If "Conversion Mode" is "General Parameter", it is valid in all cases;

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While "Allow CAN frame information to be converted into serial frames" is a "transparent conversion" parameter, which is only valid under "transparent conversion".

- Write configuration command display area

This area displays the complete frame data of the corresponding write configuration command frame under the current parameters of the Configuration Parameter Setting Interface. When "Code Mode" is not checked, the hexadecimal abbreviation value is displayed, which can be directly copied to other serial port software for use; When "Code Mode" is checked, it is displayed as code mode, which can be directly copied into user code for use.

- Operation button

The three buttons are Default, Read Configuration and Write Configuration.

Default button: used to set the parameters of Configuration Parameter Setting Interface as the default parameters of the software.

"Read Configuration" button: used to read the current configuration of the product and update the parameters of "Configuration Parameter Setting Interface" to the read values. This button is used when the user needs to know the current configuration of the product.

Write Configuration button: used to write the parameters set in Configuration Parameter Selection Interface into the product. This button enables when the user needs to change the product configuration use.

The "Read Configuration" button and "Write Configuration" button can only be used after successfully connecting the product.

5.2 TD5(3)USPCAN evaluation board

In order to improve the development efficiency of users, our company has equipped a special TD5(3)USPCAN evaluation board for TD5(3)USPCAN series products, which can be used for the configuration and testing of TD5(3)USPCAN products. Users can choose according to the actual situation. The physical object of TD5(3)USPCAN evaluation board is shown in Figure 5.2, and the interface description is shown in Table 5.1.

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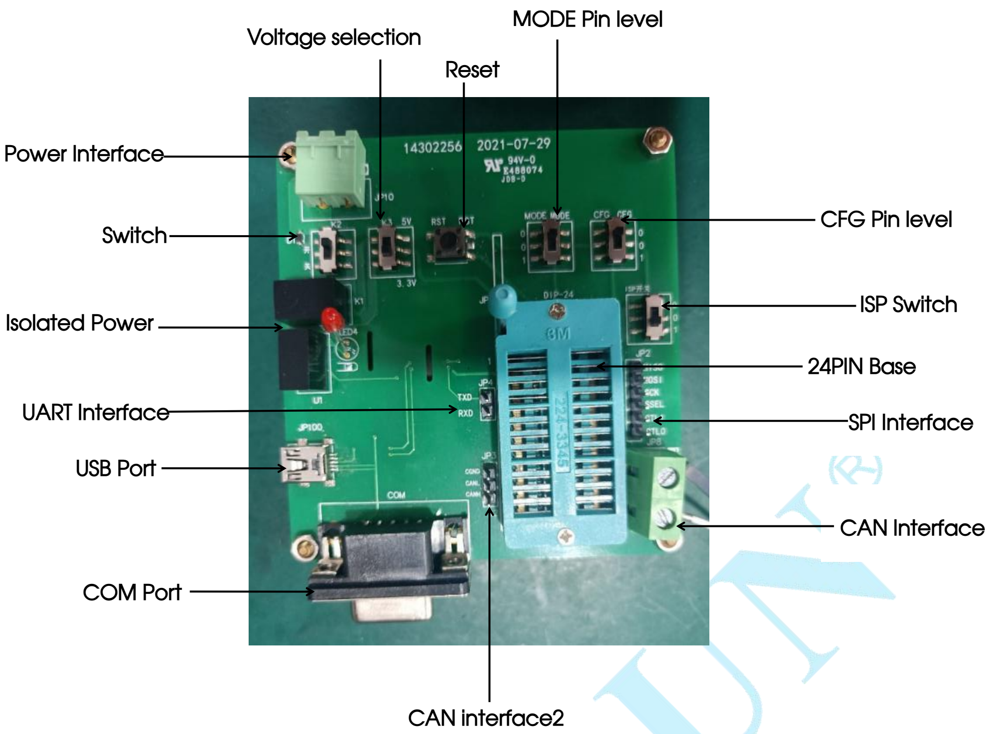

Figure 5.2 Physical drawing of TD5(3)USPCAN evaluation board

Table 5.1 Explanation of interface of TD5(3)USPCAN evaluation board

Location	Explain
power source	Evaluation board power interface, using 12VDC power supply
Power switch	Evaluation board switch
Isolated power supply	Evaluation board power supply
Voltage selection	Product power supply option, 3.3V and 5V can be selected.
Reset	Product reset key
MODE pin level	Product mode switch, 0 is UART mode and 1 is SPI mode.
CFG pin level	Product configuration switch, 0 is configuration mode and 1 is conversion mode.
24PIN base	TD5USPCAN test base
ISP switch	Please set to 1.
SPI interface	Test interface from SPI port of product

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CAN interface 1	CAN bus interface with CANL and CANH signals
CAN interface 2	Test interface from product CAN port
UART interface	Test interface from UART port of product
USB port	USB level, connected to computer com port
Cluster communication port	22 level, connected to the computer com port.

Matters needing attention:

(1) TD5(3)USPCAN evaluation board is only applicable to product configuration and product function evaluation, please do not apply TD5(3)USPCAN evaluation board to actual products.

(2) When using the computer COM port for testing, pay attention to the maximum baud rate limit supported by the computer COM port. If the test needs to exceed the computer COM port.

Baud rate is supported, please select USB serial port line that supports baud rate to be tested for testing.

5.3 Upper computer configuration example

Combined with TD5(3)USPCANCFG configuration software and TD5(3)USPCAN evaluation board, users can use computers to quickly configure the functions of products conveniently. Next, the product is configured with TD5(3)USPCANCFG and TD5(3)USPCAN evaluation boards through practical operation, and the process and steps are as follows:

(1) Connect the power adapter (8~24V, 12V recommended) to the power interface;

(2) Use serial cable (or USB-to-serial cable) to connect the COM port of TD5(3)USPCAN evaluation board and the computer com port (USB port);

(3) Select the correct working voltage of the product (TD5USPANA 5v, TD3USPCAN : 3.3v);

(4) Place the product;

(5) Select 0 for configuration switch (CFG) (enable configuration), 0 for MODE selection (UART mode) and 1 for ISP switch (disable);

(6) Turn on the power switch;

(7) Press the reset button to reset the product, and the product will enter UART configuration mode;

(8) Open the configuration software TDxUSPCANCFG on the computer, and select the product tD5 (3) USPANA ;

(9) Select the serial number of the COM port of the computer connected to TD5(3)USPCAN evaluation board;

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(10) Click the "Connect Equipment" button;

(11) After successful connection, set the parameters;

(12) Click the "Write Configuration" button after setting.

(13) After successful writing, the configuration switch (CFG) selects 1 (normal working mode);

(14) Press the reset button to reset the product, and the product will enter the UART to CAN working mode.

6. Notes of product using

- Does not support hot plug;
- Please leave unused pins in the air;
- For ESD sensitive devices, please take anti-static measures;
- The power supply voltage of the product should not exceed the allowable range, so as not to damage the product. TD5USPCAN standard 5V power supply, TD3USPCAN standard 3.3V power supply. TD5USPCAN and TD3USPCAN non-CAN bus signal interfaces are all 3.3V level standards.If you need to know more about the electrical parameters of TD5(3)USPCAN products, please refer to TD5(3)USPCAN Technical Manual.

7. Disclaimer

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