



Integrated Reflective Encoder SAA Series Operation Manual

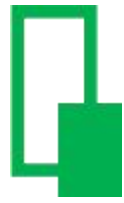


Changchun Rongde Optics Co.,Ltd.
www.roundss.cc



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1. Security Considerations:

When using this product, please strictly follow the following important precautions to prevent malfunctions or unintended operations. Use this product only after fully understanding the following instructions.

1.1 Precautions During Storage, Transportation, and Installation:

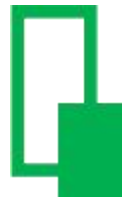
1.1.1 Do Not Store or Configure in the Following Environments:

- Where sunlight is directly shining;
- Environments where the surrounding temperature exceeds the specified storage and setting temperature conditions;
- The relative humidity exceeds the specified levels for storage and designated environmental conditions.
- Environments with sudden temperature fluctuations and a high tendency for condensation;
- Areas near corrosive gases*1 (hydrogen sulfide, sulfurous acid, chlorine, ammonia, etc.) or flammable gases;**when installed in environments with other special gases, customers must conduct independent testing before use. This product does not guarantee proper performance under special gas conditions.)**
- Radiation-environmented areas or locations exposed to radiation;
- Environments with high concentrations of dust, particulate matter, salt, and metal particles;
- Locations prone to contact with water, oil, chemicals, etc.;
- Excessive vibration and impact may propagate to the main structure.
- **※Please note that, in addition to the surrounding environment, corrosive gases may be generated due to the volatilization of components such as grease around the encoder.**

1.2 Installation Notes:

1.2.1 During Installation, Follow the Operating Manual for Assembly and Adjustment:

- Pay close attention to the installation environment to prevent oil, foreign objects, or other contaminants from entering the encoder.
- When securing the screws and bolts used for the fixed encoder, please loosen them slightly before installation.
- It is essential to implement electrostatic countermeasures during environmental setup to prevent electrical components from being subjected to overvoltages or similar hazards.
- If the encoder is subjected to vibration or impact, it may malfunction or operate incorrectly. Please carefully verify the installation environment.
- Do not apply external forces such as striking to the encoder;
- For the encoder cables and their connections to the outer cover, ensure they are not subjected to pulling, bending, or other stresses during installation. Otherwise, the cables may detach or become disconnected.



1.2.2 Interference to the Encoder May Cause Malfunctions; Please Pay Close Attention to the Installation Environment, Including the Mounting Method of the Encoder Housing and the Connection Method of Motor Wires:

- **※Use a metal housing for the encoder that can shield electromagnetic interference and maintain stable potential. Ensure sufficient clearance from internal circuit board components. If the encoder is exposed to magnetic fields from nearby motors or welding currents, use a soft magnetic material (e.g., soft iron) for the housing.**
- **※Do not place the motor power cable near the encoder;**
- **※The FG lines of the motor and the FG components of the mechanical device must be properly grounded.**
- After installing the encoder, users should conduct a thorough system assessment beforehand.
- Do not perform voltage withstand tests or insulation impedance tests on the encoder.

1.3 Wiring Notes:

1.3.1 Perform Wiring Correctly and Accurately:

- Perform wiring when the power is off.
- Use the specified power voltage. Also, consider potential voltage drops due to wiring length.
- Do not route encoder cables through the same conduit as other power lines, nor bundle them in parallel.
- Use twisted-pair cables for both signal and power lines in encoder wiring.
- For encoder wiring, use bundled shielded cables, and ensure both the encoder and the controller are properly grounded.

1.4 Operating Notes:

- Thoroughly study and confirm the safety design of the device for encoder failures and malfunctions before use. When an alarm occurs, identify the cause, ensure safety, reset the alarm, and resume operation. Do not subject cables to excessive stress, as this may lead to wire breakage.
- Do not apply overvoltages or reverse voltages exceeding the absolute maximum rated values, as this may damage components or even cause fires.



2. General Precautions:

- These specifications may be changed without prior notice due to product improvements or technical upgrades. Please consult the latest specifications and confirm the intended use before actual application.
- Please note that this product is intended for integration into standard electronic components (e.g., OA devices, communication systems, household appliances, entertainment systems, measurement instruments, and general industrial equipment) rather than for applications requiring exceptionally high reliability and safety (such as transportation systems, aerospace equipment, nuclear power control systems, or medical devices for life support).
- Our company is committed to enhancing quality and reliability; however, under normal circumstances, malfunctions and failures in semiconductor products cannot be entirely avoided. Therefore, when using this product, please consider potential impacts such as improper operation and implement safety measures to prevent accidents. Our company shall not be liable for any damage to life or property or adverse effects resulting from malfunctions, failures, or service life issues related to this product, nor for any malfunction of equipment, facilities, or machinery caused by its installation or use, regardless of severity. Users are solely responsible for ensuring proper system safety design.



3. Encoder Classification:

3.1 Integrated Reflective Encoder SAA37P8:

Basic Specifications:

Resolution: Up to 22 bits

Best achievable accuracy: ± 40 arcsec

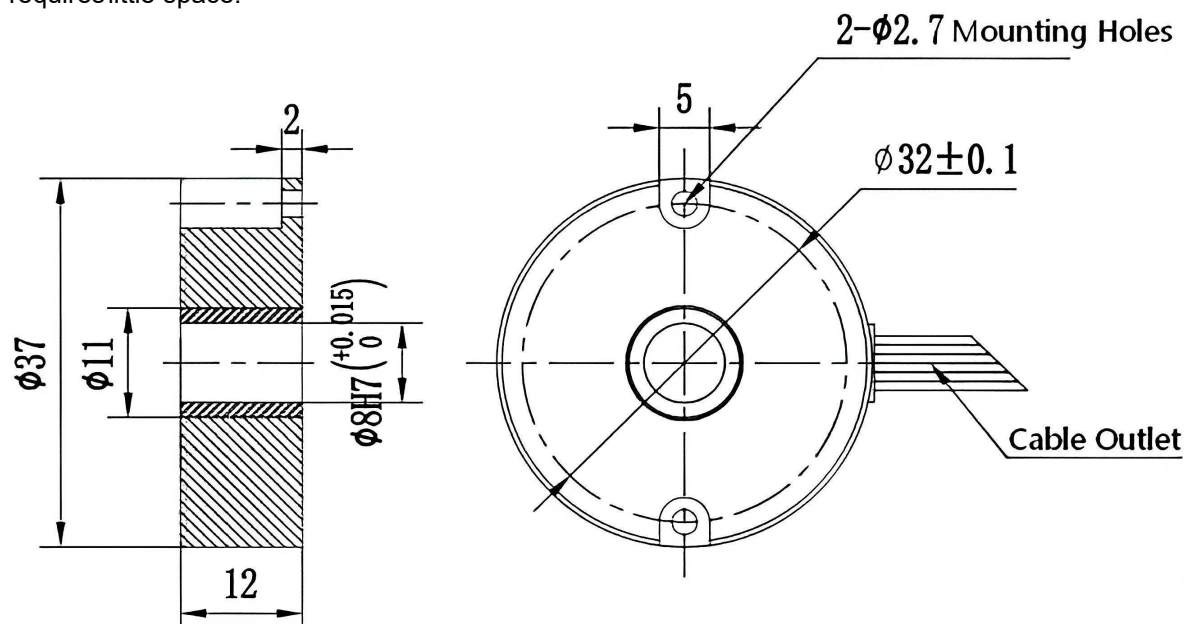
Repeatability: ± 2 arcsec

Application:

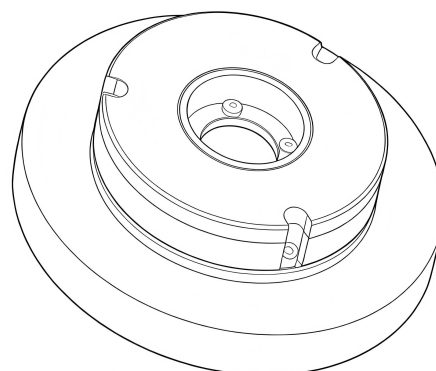
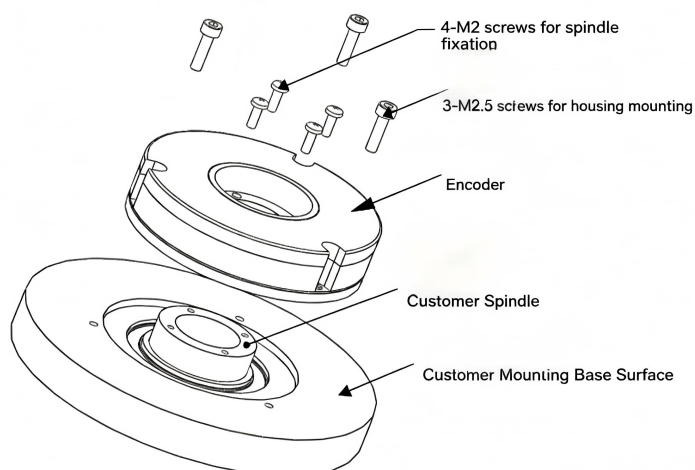
Robots, DD motors, industrial automation; Radar, non-standard;
Drone turntable, rotating platform, pod.

Product Features:

Based on optical reflection principle; equipped with ultra-thin bearings and absolute encoders;
requires little space.



3.1.1 Product Assembly Diagram:





3.2 Integrated Reflective Encoder SAA58P24

Basic Specifications:

Resolution: Up to 24 bits

Best achievable accuracy: ± 40 arcsec

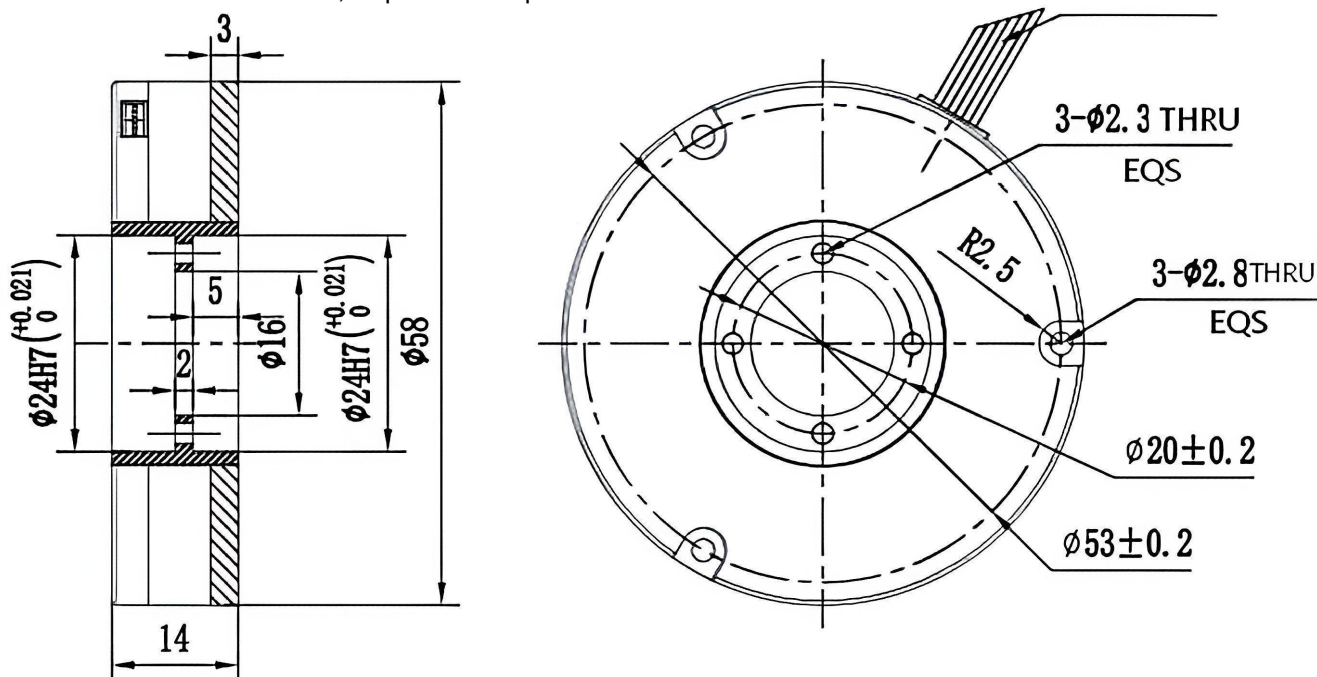
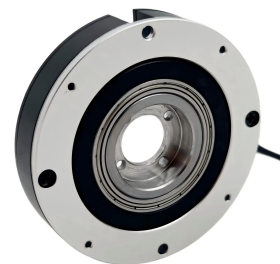
Repeatability: ± 1 arcsec

Application:

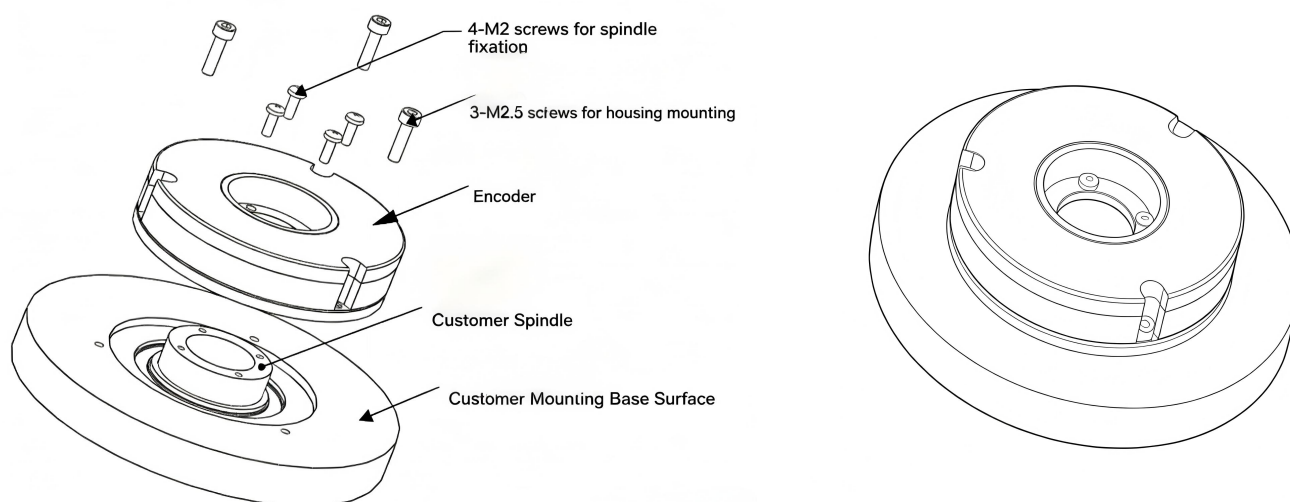
Robots, DD motors, industrial automation; Radar, non-standard;
Drone turntable, rotating platform, pod.

Product Features:

Based on optical reflection principle; equipped with ultra-thin bearings and absolute encoders; requires little space.



3.2.1 Product Assembly Diagram:





3.3 Integrated Reflective Encoder SAA70P30:

Basic Specifications:

Resolution: Up to 24 bits

Best achievable accuracy: ± 40 arcsec

Repeatability: ± 2 arcsec

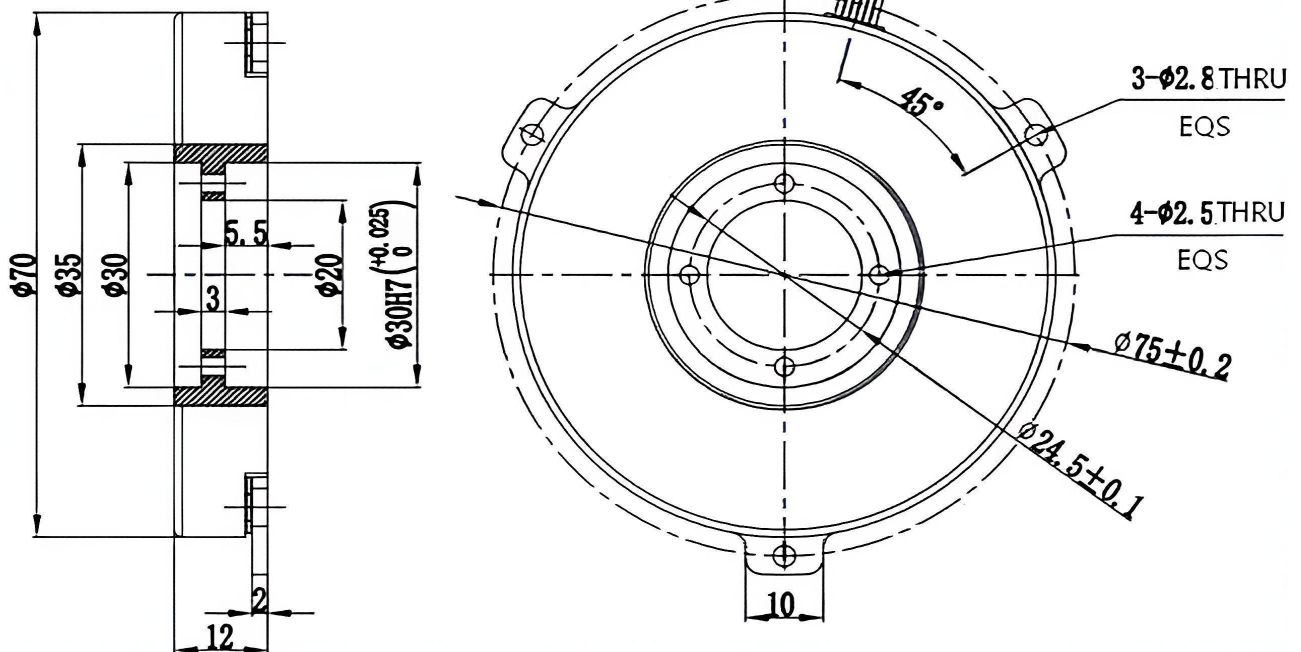


Application:

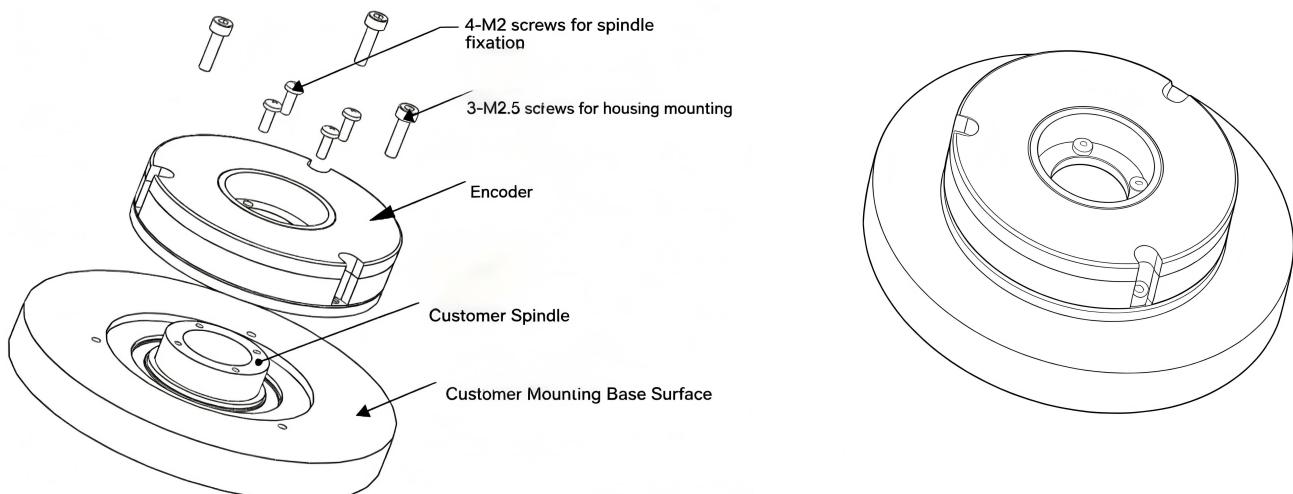
Robots, DD motors, industrial automation; Radar, non-standard;
Drone turntable, rotating platform, pod.

Product Features:

Based on optical reflection principle; equipped with ultra-thin bearings
and absolute encoders; requires little space.



3.3.1 Product Assembly Diagram:





3.4 Integrated Reflective Encoder SAA90P50

Basic Specifications:

Resolution: Up to 24 bits

Best achievable accuracy: $\pm 25 \text{ arcsec}$

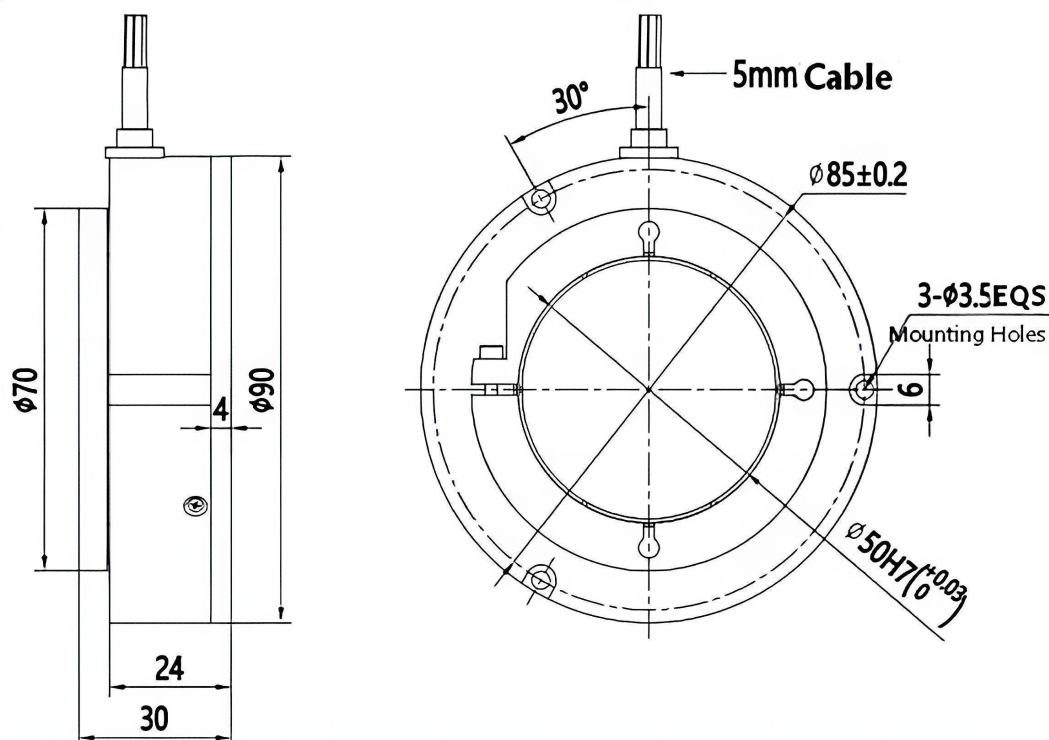
Repeatability: $\pm 1 \text{ arcsec}$

Application:

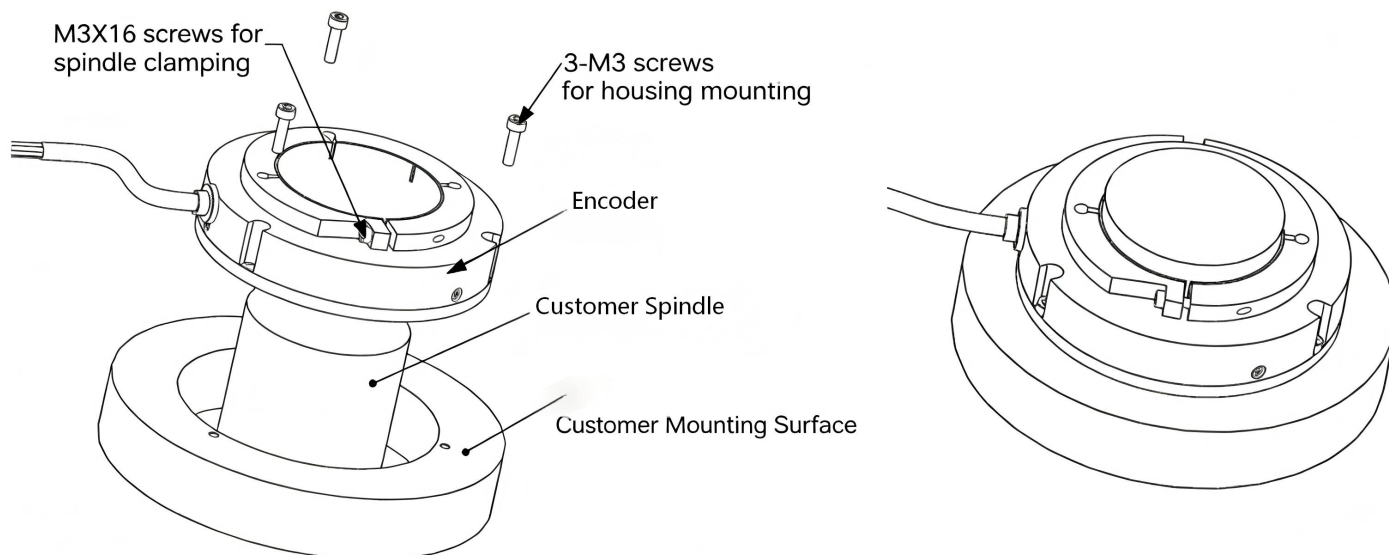
Robots, DD motors, industrial automation; Radar, non-standard;
Drone turntable, rotating platform, pod.

Product Features:

Based on optical reflection principle; equipped with ultra-thin bearings and absolute encoders; requires little space.



3.4.1 Product Assembly Diagram:





3.5 Integrated Reflective Encoder SAA130P90:

Basic Specifications:

Resolution: Up to 24 bits

Best achievable accuracy: ± 15 arcsec

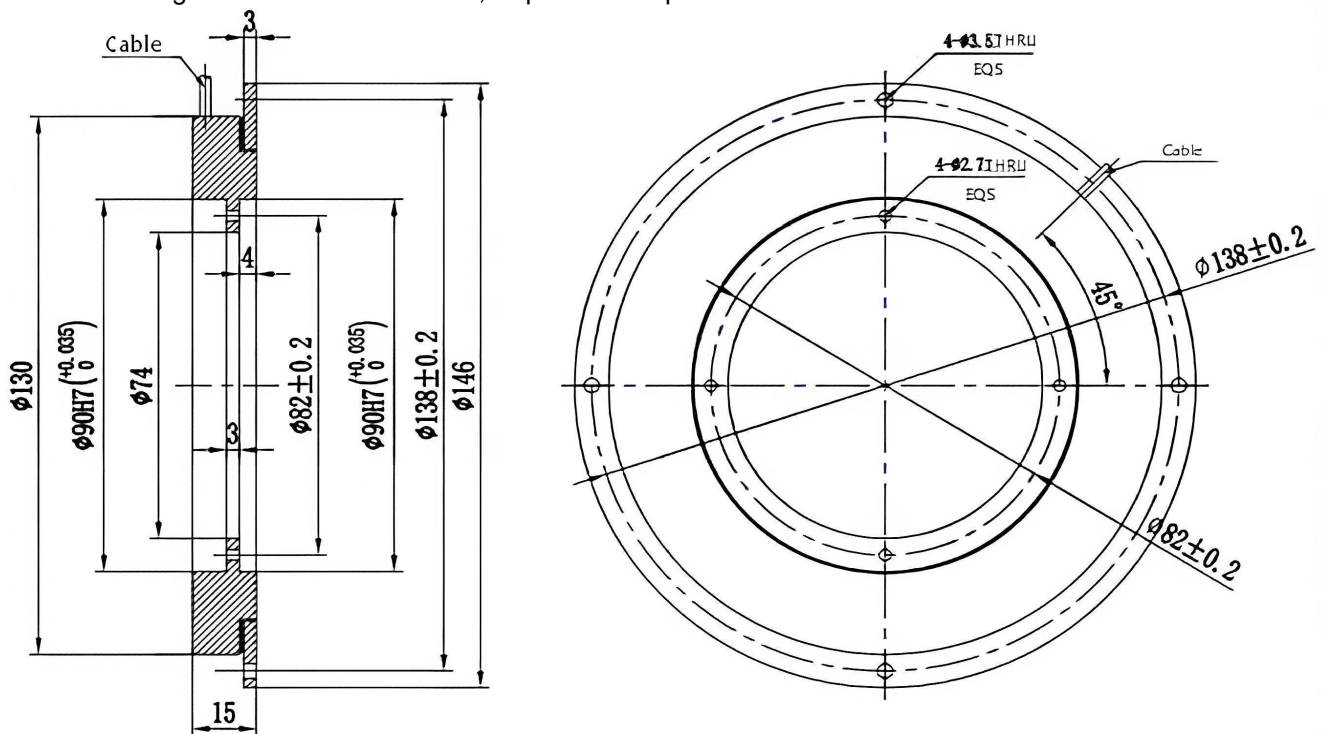
Repeatability: ± 1 arcsec

Application:

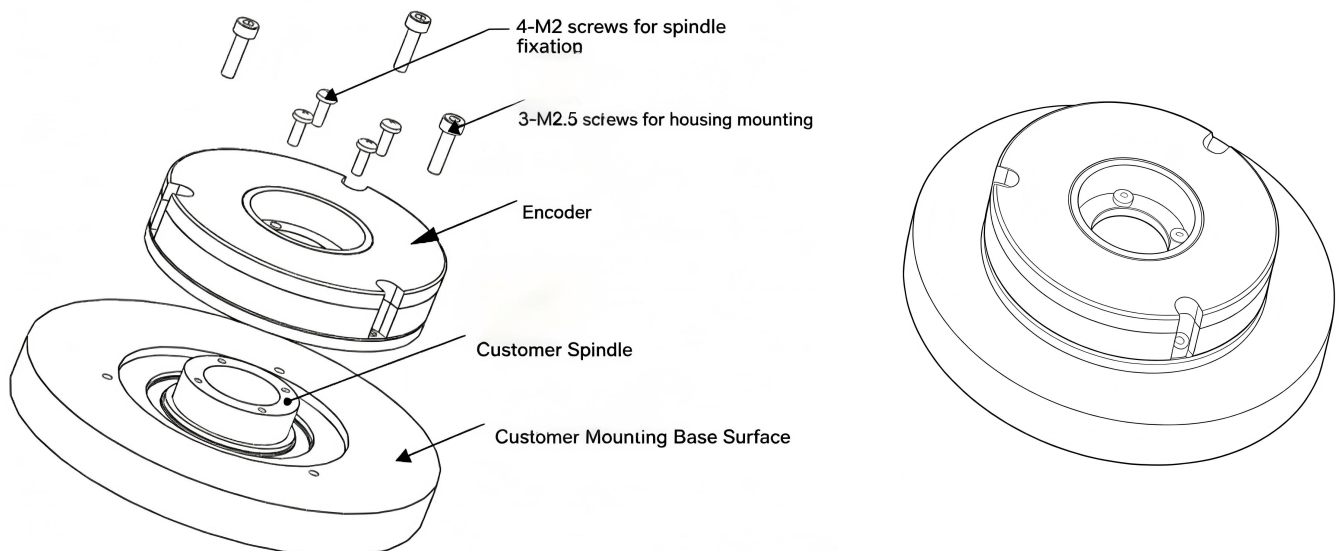
Robots, DD motors, industrial automation; Radar, non-standard;
Drone turntable, rotating platform, pod.

Product Features:

Based on optical reflection principle; equipped with ultra-thin bearings and absolute encoders; requires little space.



3.5.1 Product Assembly Diagram:





3.6 Integrated Reflective Encoder SAA290P184:

Basic Specifications:

Resolution: Up to 25 bits

Best achievable accuracy: ± 5 arcsec

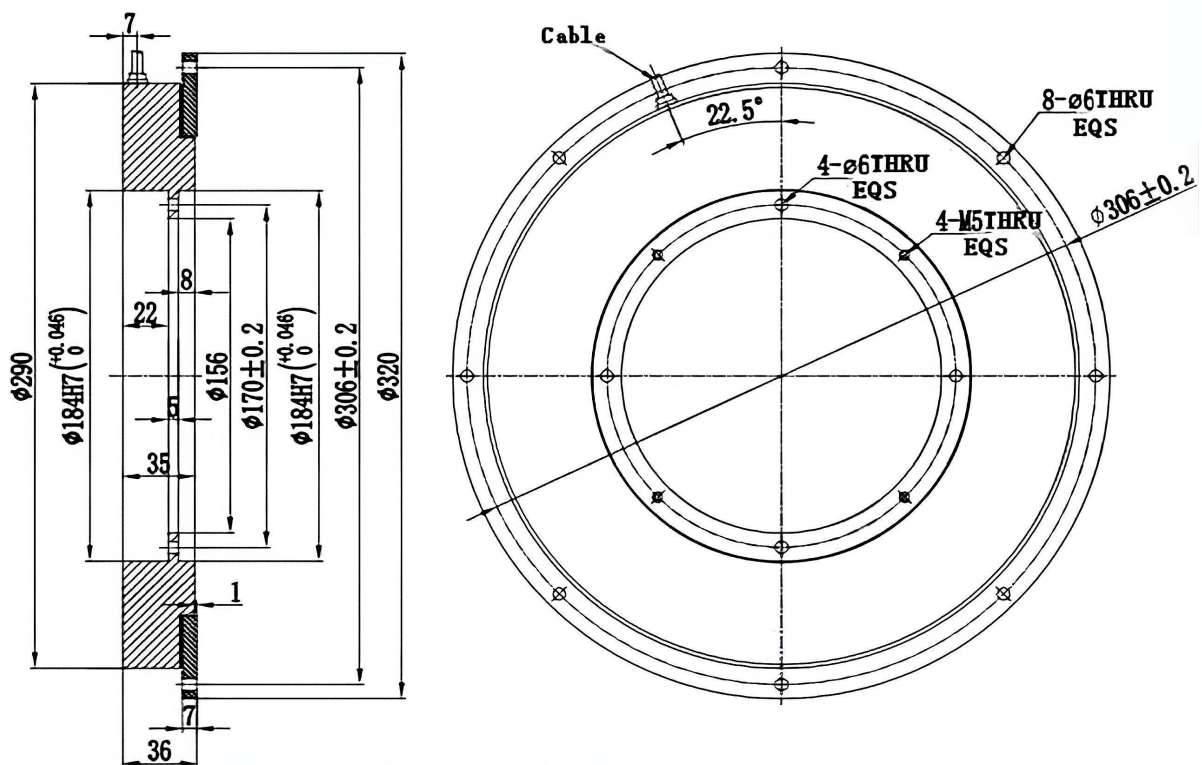
Repeatability: ± 1 arcsec

Application:

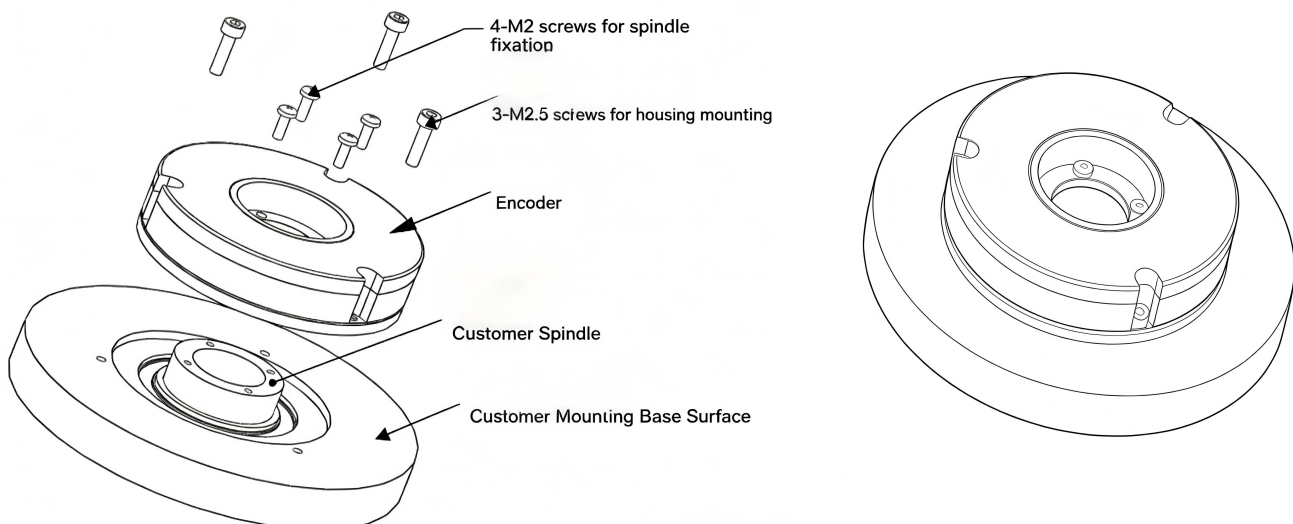
Robots, DD motors, industrial automation; Radar, non-standard;
Drone turntable, rotating platform, pod.

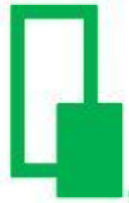
Product Features:

Based on optical reflection principle; equipped with ultra-thin bearings
and absolute encoders; requires little space.



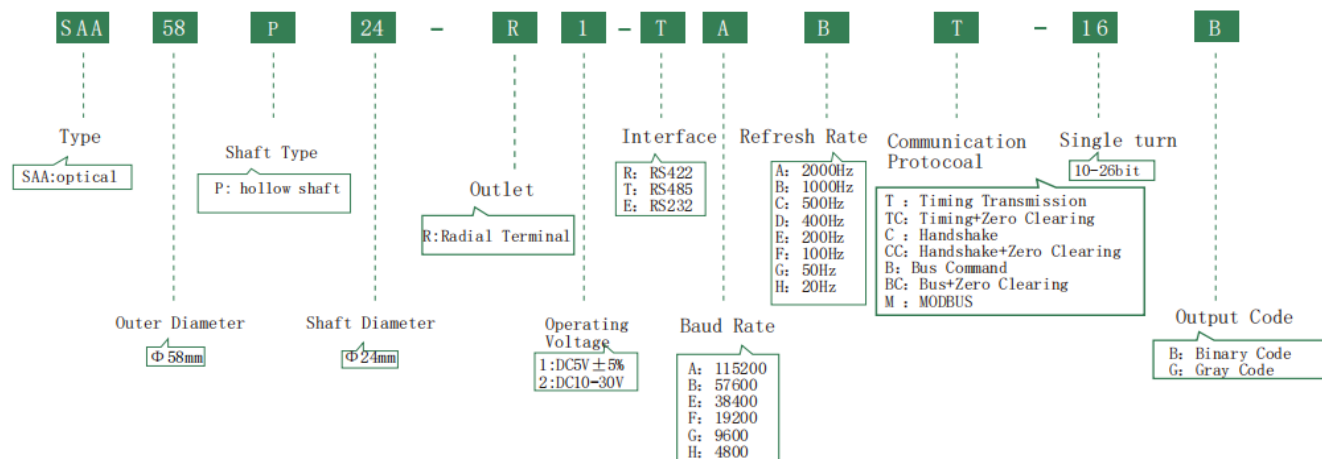
3.6.1 Product Assembly Diagram:



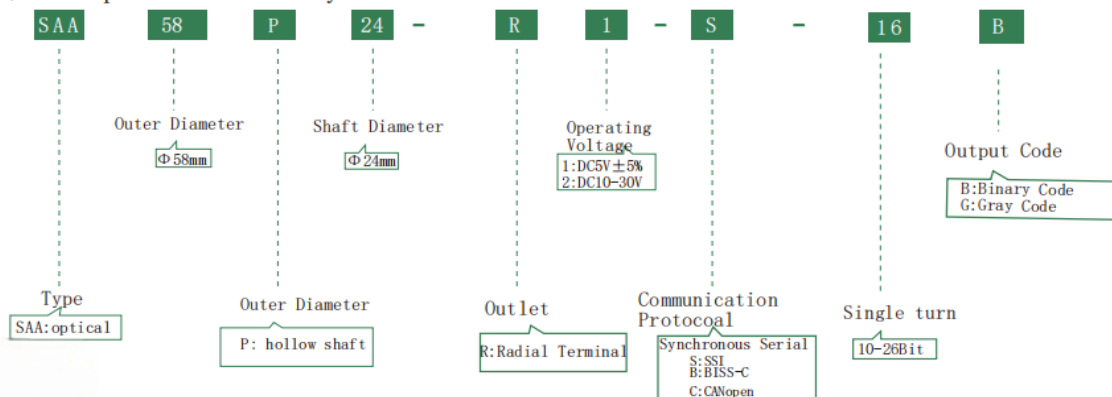


4. Model Definition:

(1) Asynchronous Serial Communication



(2) CANopen, SSI, BISS-C Synchronous Serial Communication



4.1 Mechanical and Environmental Parameters:

Operating Temperature	-40℃ ~ +65℃	Operating Humidity	≤90% RH (No Condensation)
Storage Temperature	-50℃ ~ +70℃	Protection Class	None / IP54 / IP65
Vibration Resistance	2.5 g	Radial Shaft Load	≤20 N
Shock Resistance	20 g	Axial Shaft Load	≤10 N
Max. Rotational Speed	5000 r/min	Starting Torque	< 0.01 Nm at 20℃

5.Communication Protocol

Asynchronous serial: Number of data bits per character :10 Bits start bits - 1 data bits - 8 parity bits - 0 stop bits - 1 Bit transfer order:LSB first (Odd Parity Check and even parity check are optional for customer requirements)

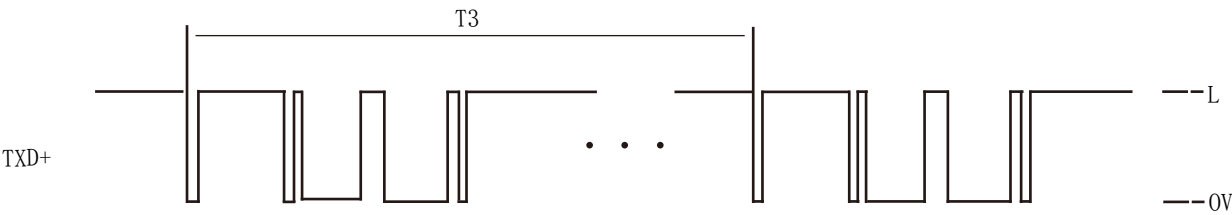
5.1 RS485

RS485 interface chip——MAX485 ESA (250kbps) or MAX13443EASA (10Mbps)

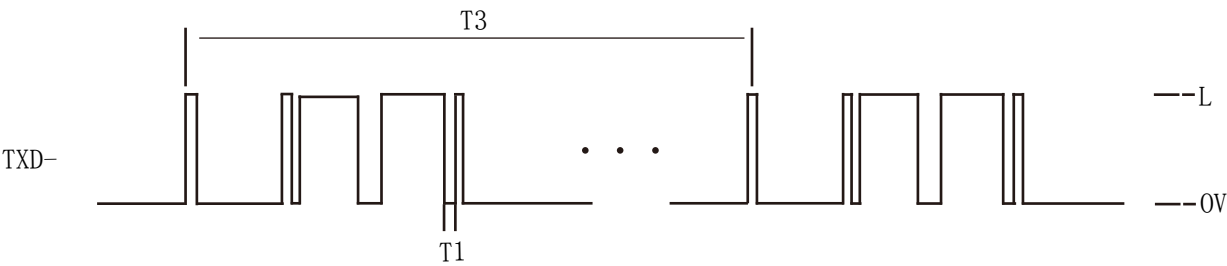
5.1.1 Timing Transmission

(1) Output data waveform
For Example, 0xff 0x81 0xd0 ...

■ TXD+ Bit Transmission: 0 1111 1111 1 0 1000 0001 1 0 0000 1011 1 ...
3.3V≤L≤5V



■ TXD- Bit Transmission: 1 0000 0000 0 1 0111 1110 0 1 1111 0100 0 ...
3.3V≤L≤5V



T1: Baud Rate T3: Refresh Rate

(2) Data Frame Format

	1 st Byte	2 nd Byte	3 rd Byte	4 th Byte	5 th Byte	6 th Byte	7 th Byte
≤16bit	FFH	81H	The Top Eight Bits	The Bottom Eight Bits	Checksum		
17~24bit	FFH	81H	The Top Eight Bits	The Middle Eight Bits	The Bottom Eight Bits	Checksum	
>24bit	FFH	81H	The Top Eight Bits	The Sub-top Bits	The Middle Eight Bits	The Bottom Eight Bits	Checksum

(Checksum is the sum of first n bytes data and rounded up to the bottom eight bits. n=4(≤16bit); n=5(17~24bit);n=6(>24bit))

(3) Connection

Color	RED	BLACK	YELLOW	GREEN	WHITE	SHIELD
Signal	VCC	0V	TXD+	TXD-	NC	G

(4) Angle Conversion Formula

$\theta = (360^\circ \times a) / 2^n$ [a: data (decimal) , n: encoder bits]

Take an example of 14 bit absolute encoder, returned data FFH 81H 01H 7FH 00H, data bit 01H 7FH (decimal) 383, Checksum 00H.

$a=383, n=14, \theta = (360^\circ \times 383) / 2^{14}, \theta = (360^\circ \times 383) / 16384, \theta = 8.4155^\circ$.

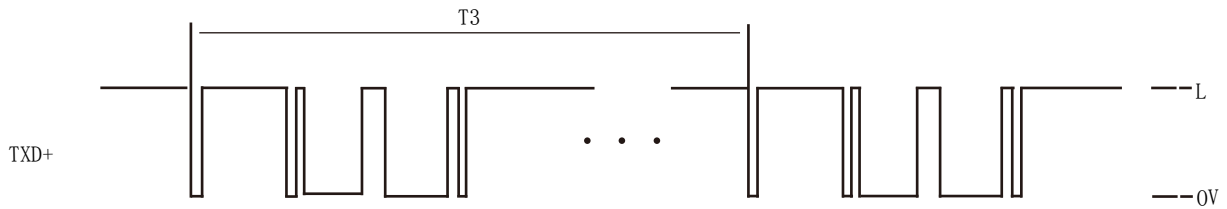
5.1.2 Timing Transmission + Zero Clearing

(1) Output data waveform

For Example 0xff 0x81 0xd0 ...

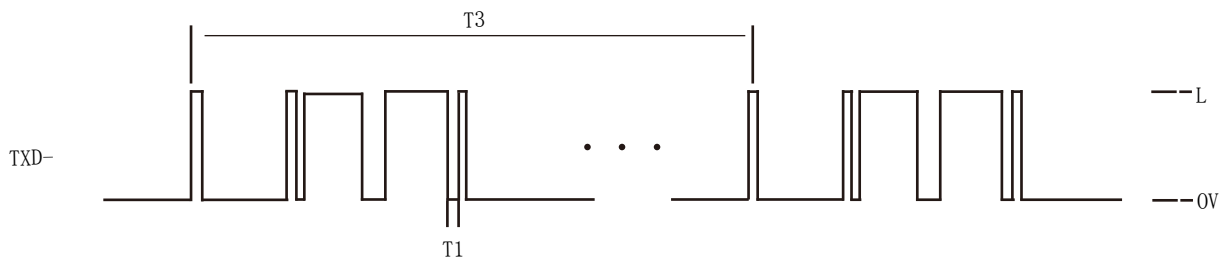
■ TXD+ Bit Transmission: 0 1111 1111 1 0 1000 0001 1 0 0000 1011 1 ...

$3.3V \leq L \leq 5V$



■ TXD- Bit Transmission: 1 0000 0000 0 1 0111 1110 0 1 1111 0100 0 ...

$3.3V \leq L \leq 5V$



T1: Baud Rate T3: Refresh Rate

(2) Data Frame Format

	1 st Byte	2 nd Byte	3 rd Byte	4 th Byte	5 th Byte	6 th Byte	7 th Byte
≤16bit	FFH	81H	The Top Eight Bits	The Bottom Eight Bits	Checksum		
17~24bit	FFH	81H	The Top Eight Bits	The Middle Eight Bits	The Bottom Eight Bits	Checksum	
>24bit	FFH	81H	The Top Eight Bits	The Sub-top Bits	The Middle Eight Bits	The Bottom Eight Bits	Checksum

(Checksum is the sum of first n bytes data and rounded up to the bottom eight bits. n=4(≤16bit); n=5(17~24bit); n=6(>24bit))

(3) Connection

Color	Red	Black	Yellow	Green	White	Shield
Signal	VCC	0V	TXD+	TXD-	CLR	G

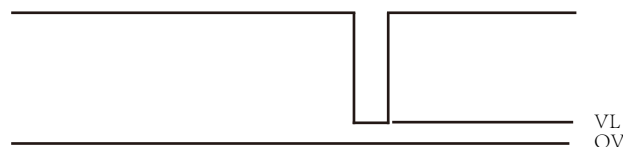
(4) Angle Conversion Formula

$$\theta = (360^\circ \times a) / 2^n \quad [a: \text{data (decimal)}, \quad n: \text{encoder bits}]$$

Take an example of 14 bit absolute encoder, returned data FFH 81H 01H 7FH 00H, data bit 01H 7FH (decimal) 383, Checksum 00H.

$$a=383, n=14, \theta = (360^\circ \times 383) / 2^{14}, \theta = (360^\circ \times 383) / 16384, \theta = 8.4155^\circ.$$

(5) Zero Clearing Signal:



Normally the voltage of CLR pin is 3.3V; When customer input a falling edge pulse and $V_L < 0.5V$, zero cleared.

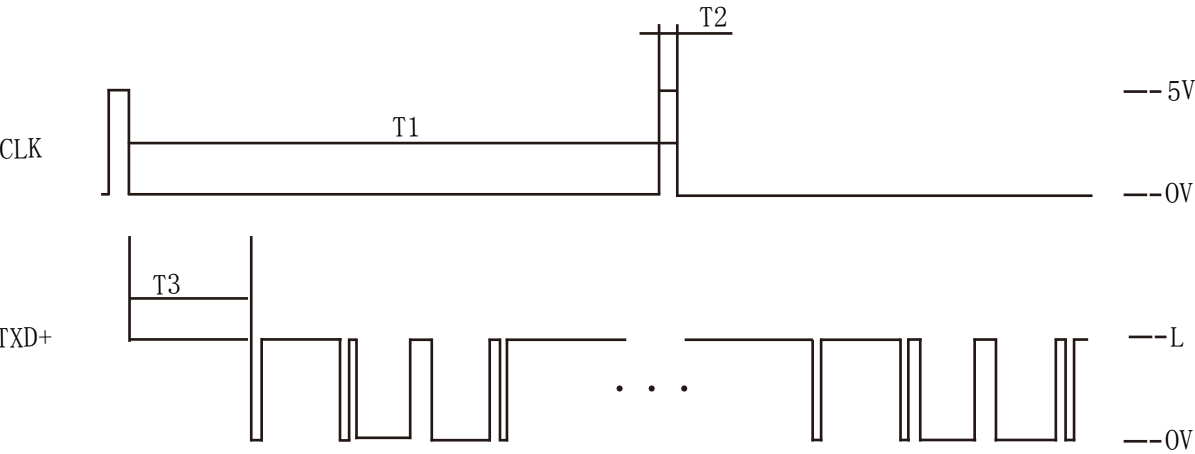
5. 1. 3 Handshake

(1) Output Data Wave Form

For example 0xff 0x81 0xd0 ...

TXD+ Bit Transmission: 0 1111 1111 1 0 1000 0001 1 0 0000 1011 1 ...

3. 3V≤L≤5V



The falling edge of outer pules signal triggers encoder working
T2≥10us
T3: Signal acquisition and processing time after receiving the falling edge outer pulse.
T1-T3: Data transmission time
T1、 T3 will be different according to customer’ s requirements.

(2) Data Frame Format

	1 st Byte	2 nd Byte	3 rd Byte	4 th Byte	5 th Byte	6 th Byte	7 th Byte
≤16bit	FFH	81H	The Top Eight Bits	The Bottom Eight Bits	Checksum		
17~24bit	FFH	81H	The Top Eight Bits	The Middle Eight Bits	The Bottom Eight Bits	Checksum	
>24bit	FFH	81H	The Top Eight Bits	The Sub-top Bits	The Middle Eight Bits	The Bottom Eight Bits	Checksum

(Checksum is the sum of first n bytes data and rounded up to the bottom eight bits. n=4(≤16bit); n=5(17~24bit);n=6(>24bit)

(3) Connections

Color	Red	Black	Yellow	Green	White	Shield
Signal	VCC	0V	TXD+	TXD-	CLK	G

(4) Angle Conversion Formula

$\theta = (360^{\circ} \times a) / 2n$ [a: data (decimal) , n: encoder bits]
Take an example of 14 bit absolute encoder, returned data FFH 81H 01H 7FH 00H, data bit 01H 7FH (decimal) 383, Checksum 00H.
a=383,n=14, $\theta = (360^{\circ} \times 383) / 2^{14}$, $\theta = (360^{\circ} \times 383) / 16384$, $\theta = 8.4155^{\circ}$.

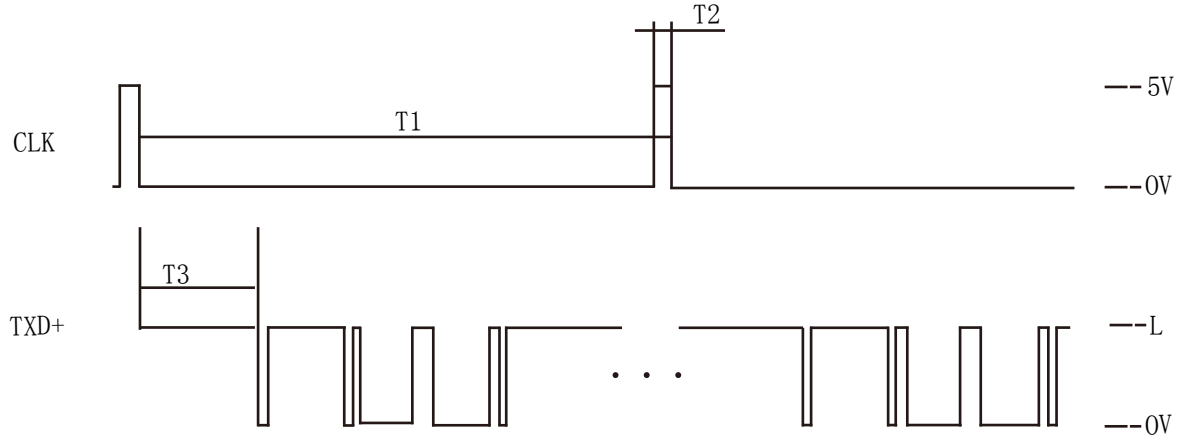
5.1.4 Handshake+Zero Clearing

(1) Output Data Wave Form

For example 0xff 0x81 0xd0 ...

TXD+ Bit Transmission: 0 1111 1111 1 0 1000 0001 1 0 0000 1011 1 ...

$3.3V \leq L \leq 5V$



The falling edge of outer pules signal triggers encoder working

$T2 \geq 10\mu s$

T3: Signal acquisition and processing time after receiving the falling edge outer pulse.

T1-T3: Data transmission time

T1、T3 will be different according to customer' s requirements.

(2) Data Frame Format

	1 st Byte	2 nd Byte	3 rd Byte	4 th Byte	5 th Byte	6 th Byte	7 th Byte
$\leq 16\text{bit}$	FFH	81H	The Top Eight Bits	The Bottom Eight Bits	Checksum		
17~24bit	FFH	81H	The Top Eight Bits	The Middle Eight Bits	The Bottom Eight Bits	Checksum	
$> 24\text{bit}$	FFH	81H	The Top Eight Bits	The Sub-top Bits	The Middle Eight Bits	The Bottom Eight Bits	Checksum

(Checksum is the sum of first n bytes data and rounded up to the bottom eight bits. $n=4(\leq 16\text{bit})$; $n=5(17\sim 24\text{bit})$; $n=6(> 24\text{bit})$)

(3) Connections (8 core cable)

Color	Red	Black	Yellow	Green	Gray	White	Orange	Brown	Shield
Signal	VCC	0V	TXD+	TXD-	CLK	CLR	NC	NC	G

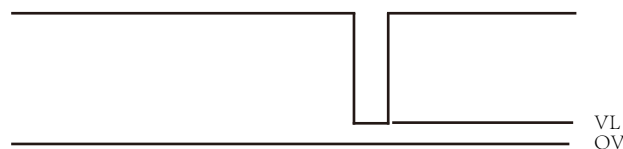
(4) Angle Conversion Formula

$\theta = (360^\circ \times a) / 2^n$ [a: data (decimal) , n: encoder bits]

Take an example of 14 bit absolute encoder, returned data FFH 81H 01H 7FH 00H, data bit 01H 7FH (decimal) 383, Checksum 00H.

$a=383, n=14, \theta = (360^\circ \times 383) / 2^{14}, \theta = (360^\circ \times 383) / 16384, \theta \approx 8.4155^\circ$.

(5) Zero Clearing Signal:



Normally the voltage of CLR pin is 3.3V; When customer input a falling edge pulse and $VL < 0.5V$, zero cleared.

5.1.5 Bus Command

(1) Control command:

BC AA BX (BX: Command Number. If customers don't have special requirements, each encoder within same batch has sole command number. This number will be also used as encoder address number.)

For example, 3 encoders in same batch. control command: BC AA B1、BC AA B2、BC AA B3; Corresponding returned data: FF B1....., FF B2, FF B3; The second byte of returned data is product address number.

(2) Data Frame Format

	1 st Byte	2 nd Byte	3 rd Byte	4 th Byte	5 th Byte	6 th Byte	7 th Byte
Control command	BCH	AAH	BXH				
≤16bit	FFH	81H	The Top Eight Bits	The Bottom Eight Bits	Checksum		
17~24bit	FFH	81H	The Top Eight Bits	The Middle Eight Bits	The Bottom Eight Bits	Checksum	
>24bit	FFH	81H	The Top Eight Bits	The Sub-top Bits	The Middle Eight Bits	The Bottom Eight Bits	Checksum

(Checksum is the sum of first n bytes data and rounded up to the bottom eight bits. n=4(≤16bit); n=5(17~24bit); n=6(>24bit)

(3) Connection

Color	RED	BLACK	YELLOW	GREEN	WHITE	SHIELD
Signal	VCC	0V	TXD+	TXD-	NC	G

(4) Angle Conversion Formula

$$\theta = (360^\circ \times a) / 2^n \quad [a: \text{data (decimal)}, \quad n: \text{encoder bits}]$$

Take an example of 14 bit absolute encoder, returned data FFH 81H 01H 7FH 00H, data bit 01H 7FH (decimal) 383, Checksum 00H.

$$a=383, n=14, \theta = (360^\circ \times 383) / 2^{14}, \theta = (360^\circ \times 383) / 16384, \theta = 8.4155^\circ.$$

5.1.6 Bus + Zero Clearing

(1) Control command:

BC AA BX (BX: Command Number. If customers don't have special requirements, each encoder within same batch has sole command number. This number will be also used as encoder address number.)

For example, 3 encoders in same batch. control command: BC AA B1、BC AA B2、BC AA B3; Corresponding returned data: FF B1....., FF B2, FF B3; The second byte of returned data is product address number.

Zero clearing command:

BC AA CX. (CX: zero clearing command. If customers don't have special requirements, each product in same batch has sole zero clearing command. Generally, the X in zero clearing command is corresponding with the X in control command.)

For example, when control command is BC AA B1, its zero clearing command is BC AA C1.

(2) Data Frame Format

	1 st Byte	2 nd Byte	3 rd Byte	4 th Byte	5 th Byte	6 th Byte	7 th Byte
Control Command	BCH	AAH	BXH				
Zero Clearing Command	BCH	AAH	CXH				
≤16bit	FFH	81H	The Top Eight Bits	The Bottom Eight Bits	Checksum		
17~24bit	FFH	81H	The Top Eight Bits	The Middle Eight Bits	The Bottom Eight Bits	Checksum	
>24bit	FFH	81H	The Top Eight Bits	The Sub-top Bits	The Middle Eight Bits	The Bottom Eight Bits	Checksum

(Checksum is the sum of first n bytes data and rounded up to the bottom eight bits. n=4(≤16bit); n=5(17~24bit); n=6(>24bit)

(3) Connection

Color	RED	BLACK	YELLOW	GREEN	WHITE	SHIELD
Signal	VCC	0V	TXD+	TXD-	NC	G

(4) Angle Conversion Formula

$$\theta = (360^\circ \times a) / 2^n \quad [a: \text{data (decimal)}, \quad n: \text{encoder bits}]$$

Take an example of 14 bit absolute encoder, returned data FFH 81H 01H 7FH 00H, data bit 01H 7FH (decimal) 383, Checksum 00H.

$$a=383, n=14, \theta = (360^\circ \times 383) / 2^{14}, \theta = (360^\circ \times 383) / 16384, \theta = 8.4155^\circ.$$

5.1.7 MODBUS Protocol

- (1) Modbus Communication Protocol (RTU mode)。
 (2) Baud Rate: 2400bps 4800bps 9600bps 19200bps 57600bps
 (3) Factory Default Settings:①no odd-even parity ②Baud rate 19200bps③ address 0x01④ starting address 0x00 0x00
 Note: When changing parameters, do not regularly send in case the internal structure of the device would be damaged.

Sending a return match on behalf of the data was set successfully.

(4) Function Code 03:

The 03 code function of Modbus communication protocol could help reading the encoder values.

The slave address, function code, starting address, number of bytes and CRC code are all included in command format of the master.

The format of slave response data is made up with the slave address, function code, data areas and CRC code. The data area is a binary code, two bytes (or three bytes), MSB first. CRC code is two bytes, LSB first.

(5) Data Frame Format:

- ① The reading real-time data of encoder is below - 16bit when the master is calling, the slave address is 01

01	03	00	00	00	01	84	0A
Slave address	Function code	Starting address	Reading points		CRC checksum(LSB first)		

Encoder Answering:

01	03	02	XX	XX	XX	XX
Slave address	Function code	Starting address	data (MSB first)		CRC checksum(LSB first)	

- ② The reading real-time data of encoder is between - 16bit and - 32bit when the master is calling, the slave address is 01

01	03	00	00	00	02	C4	0B
Slave address	Function code	Starting address	Reading points		CRC checksum(LSB first)		

Encoder Answering:

01	03	04	XX	XX	XX	XX	XX
Slave address	Function code	Single unit byte	data (MSB first)		CRC checksum(LSB first)		

01, 03, 02, XX, etc. above are all a byte. The data is two bytes, the higher byte ahead.

The interval time between the beginning and the end of each frame is at least 3.5 bytes.

When users programming for the master, in addition to the station number (address) and the CRC checksum code, all other byte characters used in the above remains unchanged. The reading points in the master format could be 01 or 02 (02 is for compatible with certain protocols). The function code 03 in the slave remains unchanged.

③ Check Device Address

Master calling	FF	A0	40	38
Encoder answering	FF	A0	01 (Slave address)	XX XX (CRC checksum code, MSB first)

④ Check Device Address

Mastering calling	01	A1	02 (new address)	XX XX (CRC checksum code, LSB first)
Encoder answering	02 (new address)	A1	XX:XX (CRC checksum code, LSB first)	

⑤ Change the baud , zero position and direction of device

Master calling	01	CC	02 (parameter)	XX XX (CRC checksum code, LSB first)
Encoder answering	01 (address)	CC	02 (parameter)	XX XX (CRC checksum code, LSB first)

Definition of Setting:

I、0x00 Set the current position to zero; II、0x01 positive bit; III、0x02 negative bit;

IV、0x24 Baud Rate 2400bps; V、0x48 Baud Rate 4800bps;VI、0x96 Baud Rate 9600bps;

VII、0x19 Baud Rate 19200bps; VIII、0x57 Baud Rate 57600bps;

The steps of calculating the CRC code is:

- ① Preset 16 bits slave is hexadecimal coding FFFF (that is 1 for all) .We call this kind of slave as CRC slave;
- ② Exclusive OR the first 8-bit data with 16-bit CRC slave low-XOR, put the result into CRC slave;
- ③ Move one bit of the slave into right direction(towards low), filling the highest position with 0, checking the lowest position;
- ④ If the lowest bit (the moved out one) is 0: then repeat Step 3 (shifted again)
 If the lowest bit (the moved out one) is 1: Exclusive OR CRC slave with polynomial A001 (1010 0000 0000 0001) ;
- ⑤ Repeat step 3 for and 4 until the right eight times, so that the whole 8-bit data are fully processed;
- ⑥ Repeat from the steps 2 to step 5, and carrying next 8-bit data processing;
- ⑦ The resulting of CRC slave is the CRC code.
- ⑧ Put CRC results into information frames, exchange the low bit with high bit, LSB first.

(6) Connection

Color	RED	BLACK	YELLOW	GREEN	WHITE	SHIELD
Signal	VCC	0V	TXD+	TXD-	NC	G

(7) Angle Conversion Formula

$$\theta = (360^\circ \times a) / 2^n \quad [a: \text{data (decimal)}, n: \text{encoder bits}]$$

Take an example of 14 bit absolute encoder, returned data FFH 81H 01H 7FH 00H, data bit 01H 7FH (decimal) 383, Checksum 00H.

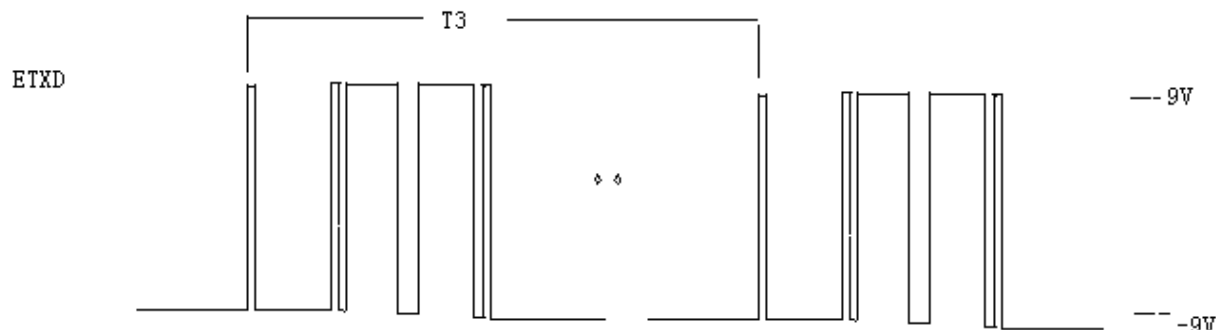
$$a=383, n=14, \theta = (360^\circ \times 383) / 2^{14}, \theta = (360^\circ \times 383) / 16384, \theta = 8.4155^\circ$$

5.2.1 Timing Transmission

(1) Output Data Waveform

For instance: 0xff 0x81 0xd0 ...

TXD + Bit transfer: 0 1111 1111 1 0 1000 0001 1 0 0000 1011 1 ...



T3: Refresh Rate

(2) Data Frame Format

	1 st Byte	2 nd Byte	3 rd Byte	4 th Byte	5 th Byte	6 th Byte	7 th Byte
≤16bit	FFH	81H	The Top Eight Bits	The Bottom Eight Bits	Checksum		
17~24bit	FFH	81H	The Top Eight Bits	The Middle Eight Bits	The Bottom Eight Bits	Checksum	
>24bit	FFH	81H	The Top Eight Bits	The Sub-top Bits	The Middle Eight Bits	The Bottom Eight Bits	Checksum

(Checksum is the sum of first n bytes data and rounded up to the bottom eight bits. n=4(≤16bit); n=5(17~24bit); n=6(>24bit))

(3) Connections

Color	Red	Black	Yellow	Green	White	Shield
Signal	VCC	0V	ETXD	NC	CLR	G

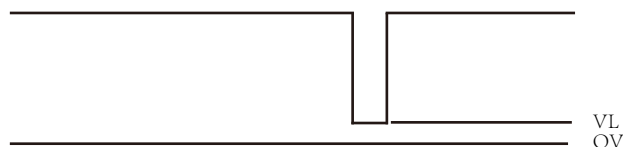
(4) Angle Conversion Formula

$$\theta = (360^\circ \times a) / 2^n \quad [a: \text{data (decimal)}, n: \text{encoder bits}]$$

Take an example of 14 bit absolute encoder, returned data FFH 81H 01H 7FH 00H, data bit 01H 7FH (decimal) 383, Checksum 00H.

$$a=383, n=14, \theta = (360^\circ \times 383) / 2^{14}, \theta = (360^\circ \times 383) / 16384, \theta = 8.4155^\circ.$$

(5) Zero Clearing Signal:



Normally the voltage of CLR pin is 3.3V; When customer input a falling edge pulse and VL<0.5V, zero cleared.

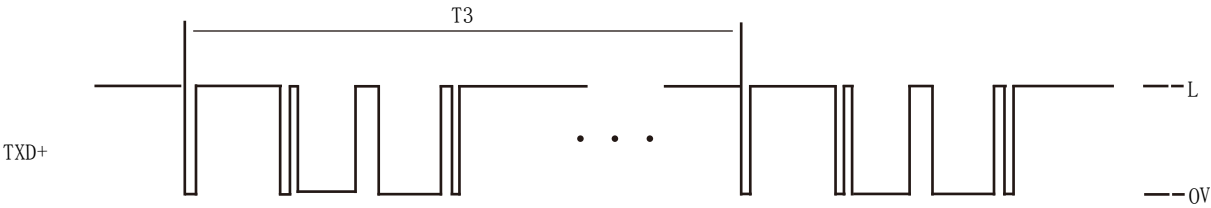
5.2.2 Timing Transmission + Zero Clearing

(1) Output Data Waveform

For Example 0xff 0x81 0xd0 ...

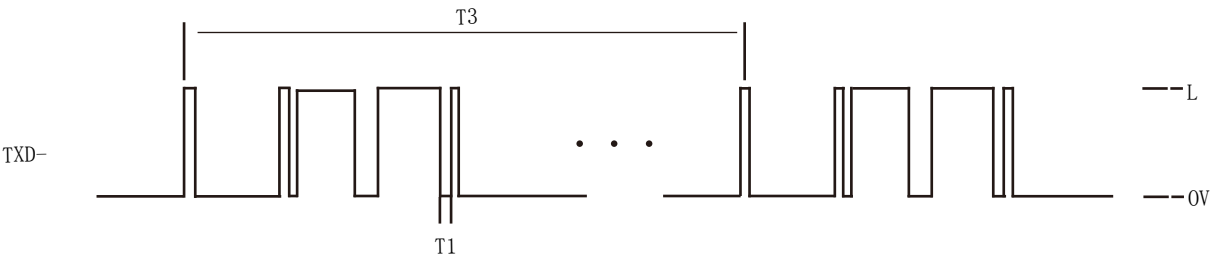
■ TXD+ Bit Transmission: 0 1111 1111 1 0 1000 0001 1 0 0000 1011 1 ...

$3.3V \leq L \leq 5V$



■ TXD- Bit Transmission: 1 0000 0000 0 1 0111 1110 0 1 1111 0100 0 ...

$3.3V \leq L \leq 5V$



T1: Baud Rate T3: Refresh Rate

(2) Data Frame Format

	1 st Byte	2 nd Byte	3 rd Byte	4 th Byte	5 th Byte	6 th Byte	7 th Byte
≤16bit	FFH	81H	The Top Eight Bits	The Bottom Eight Bits	Checksum		
17~24bit	FFH	81H	The Top Eight Bits	The Middle Eight Bits	The Bottom Eight Bits	Checksum	
>24bit	FFH	81H	The Top Eight Bits	The Sub-top Bits	The Middle Eight Bits	The Bottom Eight Bits	Checksum

(Checksum is the sum of first n bytes data and rounded up to the bottom eight bits. n=4(≤16bit); n=5(17~24bit);n=6(>24bit)

(3) Connections

Color	Red	Black	Yellow	Green	White	Shield
Signal	VCC	0V	ETXD	NC	CLR	G

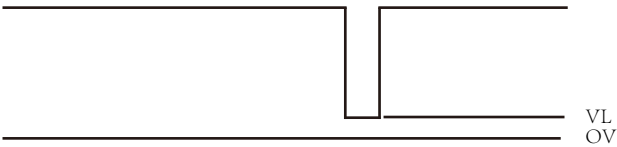
(4) Angle Conversion Formula

$\theta = (360^\circ \times a) / 2^n$ [a: data (decimal) , n: encoder bits]

Take an example of 14 bit absolute encoder, returned data FFH 81H 01H 7FH 00H, data bit 01H 7FH (decimal) 383, Checksum 00H.

$a=383, n=14, \theta = (360^\circ \times 383) / 2^{14}, \theta = (360^\circ \times 383) / 16384, \theta = 8.4155^\circ$.

(5) Zero Clearing Signal:



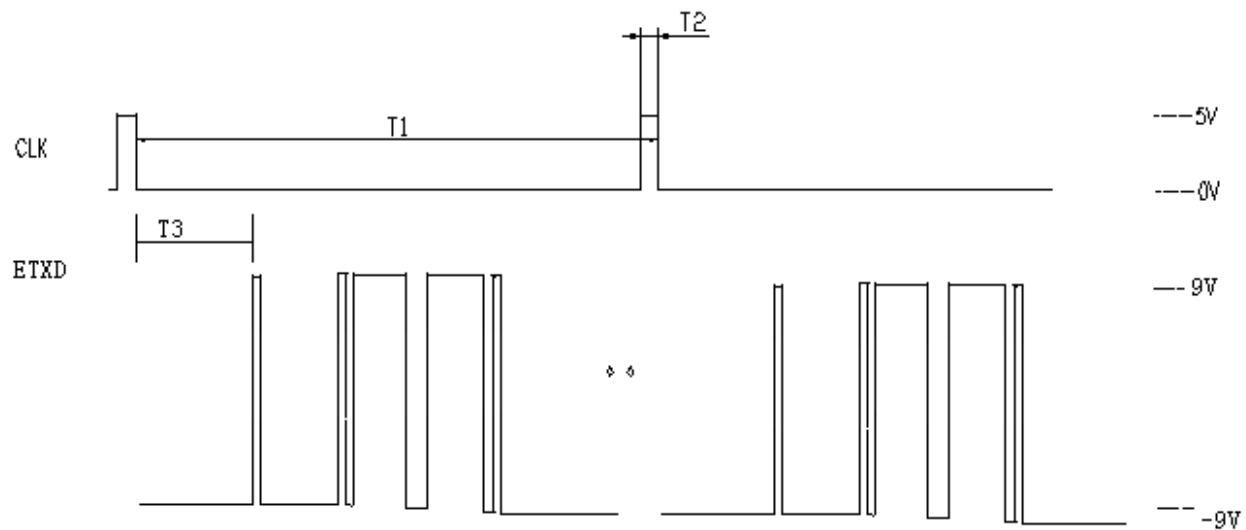
Normally the voltage of CLR pin is 3.3V; When customer input a falling edge pulse and VL<0.5V, zero cleared.

5.2.3 Pulse Handshake

(1) Output Data Waveform

For instance: 0xff 0x81 0xd0 ...

TXD + Bit Transfer: 0 1111 1111 1 0 1000 0001 1 0 0000 1011 1 ...



Pulse Handshake: external falling edge pulse signal triggers encoder working

$T2 \geq 10\mu s$

T3: Signal acquisition and processing time after receiving the falling edge outer pulse.

T1-T3: Data Transmission Time

T1, T3 vary according to the actual requirements or customer's needs.

(2) Data Frame Format

	1 st Byte	2 nd Byte	3 rd Byte	4 th Byte	5 th Byte	6 th Byte	7 th Byte
$\leq 16\text{bit}$	FFH	81H	The Top Eight Bits	The Bottom Eight Bits	Checksum		
17~24bit	FFH	81H	The Top Eight Bits	The Middle Eight Bits	The Bottom Eight Bits	Checksum	
$> 24\text{bit}$	FFH	81H	The Top Eight Bits	The Sub-top Bits	The Middle Eight Bits	The Bottom Eight Bits	Checksum

(Checksum is the sum of first n bytes data and rounded up to the bottom eight bits. $n=4(\leq 16\text{bit})$; $n=5(17\sim 24\text{bit})$; $n=6(> 24\text{bit})$)

(3) Connections

Color	Red	Black	Yellow	Green	White	Shield
Signal	VCC	0V	ETXD	NC	CLK	G

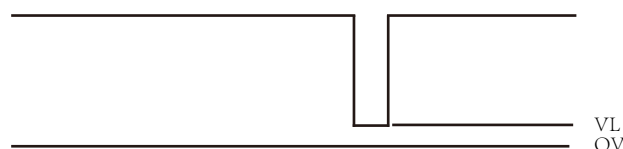
(4) Angle Conversion Formula

$$\theta = (360^\circ \times a) / 2^n \quad [a: \text{data (decimal)}, n: \text{encoder bits}]$$

Take an example of 14 bit absolute encoder, returned data FFH 81H 01H 7FH 00H, data bit 01H 7FH (decimal) 383, Checksum 00H.

$$a=383, n=14, \theta = (360^\circ \times 383) / 2^{14}, \theta = (360^\circ \times 383) / 16384, \theta \approx 8.4155^\circ$$

(5) Zero Clearing Signal:



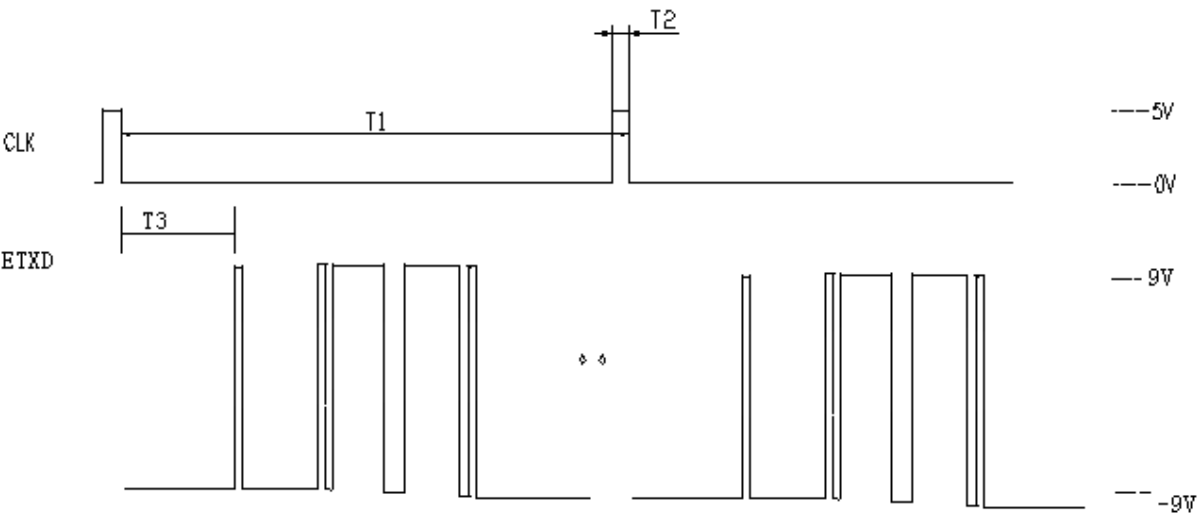
Normally the voltage of CLR pin is 3.3V; When customer input a falling edge pulse and $V_L < 0.5V$, zero cleared.

5.2.4 Handshake + Zero Clearing

(1) Output Data Waveform

For instance:0xff 0x81 0xd0 ...

TXD + Bit Transfer: 0 1111 1111 1 0 1000 0001 1 0 0000 1011 1 ...



Pulse Handshake: external falling edge pulse signal triggers encoder working
T2>=10us
T3: Signal acquisition and processing time after receiving the falling edge outer pulse.
T1-T3: Data Transmission Time
T1、T3 vary according to the actual requirements or customer’ s needs.

(2) Data Frame Format

	1 st Byte	2 nd Byte	3 rd Byte	4 th Byte	5 th Byte	6 th Byte	7 th Byte
≤16bit	FFH	81H	The Top Eight Bits	The Bottom Eight Bits	Checksum		
17~24bit	FFH	81H	The Top Eight Bits	The Middle Eight Bits	The Bottom Eight Bits	Checksum	
>24bit	FFH	81H	The Top Eight Bits	The Sub-top Bits	The Middle Eight Bits	The Bottom Eight Bits	Checksum

(Checksum is the sum of first n bytes data and rounded up to the bottom eight bits. n=4(≤16bit); n=5(17~24bit);n=6(>24bit)

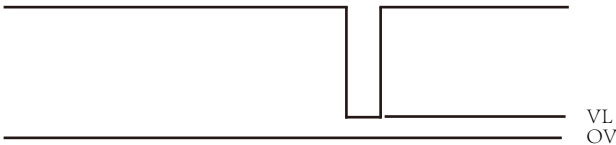
(3) Connections

Color	Red	Black	Yellow	Green	Grey	White	Orange	Brown	Shield
Signal	VCC	0V	ETXD	NC	CLK	CLR	NC	NC	G

(4) Angle Conversion Formula

$\theta = (360^{\circ} \times a) / 2^n$ [a: data (decimal) , n: encoder bits]
Take an example of 14 bit absolute encoder, returned data FFH 81H 01H 7FH 00H, data bit 01H 7FH (decimal) 383, Checksum 00H.
 $a=383, n=14, \theta = (360^{\circ} \times 383) / 2^{14}, \theta = (360^{\circ} \times 383) / 16384, \theta \approx 8.4155^{\circ}$.

(5) Zero Clearing Signal:



Normally the voltage of CLR pin is 3.3V; When customer input a falling edge pulse and VL<0.5V, zero cleared.

5.2.5 Bus Command

(1) Control Command:

BC AA BX (BX: Command Number. If customers don't have special requirements, each encoder within same batch has sole command number. This number will be also used as encoder address number.)
For example, 3 encoders in same batch. control command: BC AA B1、BC AA B2、BC AA B3; Corresponding returned data: FF B1....., FF B2, FF B3; The second byte of returned data is product address number.

(2) Data Frame Format

	1 st Byte	2 nd Byte	3 rd Byte	4 th Byte	5 th Byte	6 th Byte	7 th Byte
Control command	BCH	AAH	BXH				
≤16bit	FFH	81H	The Top Eight Bits	The Bottom Eight Bits	Checksum		
17~24bit	FFH	81H	The Top Eight Bits	The Middle Eight Bits	The Bottom Eight Bits	Checksum	
>24bit	FFH	81H	The Top Eight Bits	The Sub-top Bits	The Middle Eight Bits	The Bottom Eight Bits	Checksum

(Checksum is the sum of first n bytes data and rounded up to the bottom eight bits. n=4(≤16bit); n=5(17~24bit); n=6(>24bit))

(3) Connections

Color	Red	Black	Yellow	Green	White	Shield
Signal	VCC	0V	ETXD	NC	CLK	G

(4) Angle Conversion Formula

$\theta = (360^\circ \times a) / 2^n$ [a: data (decimal), n: encoder bits]

Take an example of 14 bit absolute encoder, returned data FFH 81H 01H 7FH 00H, data bit 01H 7FH (decimal) 383, Checksum 00H.

a=383, n=14, $\theta = (360^\circ \times 383) / 2^{14}$, $\theta = (360^\circ \times 383) / 16384$, $\theta = 8.4155^\circ$.

5.2.6 Bus +Zero Clearing

(1) Control Command:

BC AA BX (BX: Command Number. If customers don't have special requirements, each encoder within same batch has sole command number. This number will be also used as encoder address number.)
For example, 3 encoders in same batch. control command: BC AA B1、BC AA B2、BC AA B3; Corresponding returned data: FF B1....., FF B2, FF B3; The second byte of returned data is product address number.

Zero Clearing Command:

BC AA CX. (CX: zero clearing command. If customers don't have special requirements, each product in same batch has sole zero clearing command. Generally, the X in zero clearing command is corresponding with the X in control command.)

For example, when control command is BC AA B1, its zero clearing command is BC AA C1.

(2) Data Frame Format

	1 st Byte	2 nd Byte	3 rd Byte	4 th Byte	5 th Byte	6 th Byte	7 th Byte
Control Command	BCH	AAH	BXH				
Zero Clearing Command	BCH	AAH	CXH				
≤16bit	FFH	81H	The Top Eight Bits	The Bottom Eight Bits	Checksum		
17~24bit	FFH	81H	The Top Eight Bits	The Middle Eight Bits	The Bottom Eight Bits	Checksum	
>24bit	FFH	81H	The Top Eight Bits	The Sub-top Bits	The Middle Eight Bits	The Bottom Eight Bits	Checksum

(Checksum is the sum of first n bytes data and rounded up to the bottom eight bits. n=4(≤16bit); n=5(17~24bit); n=6(>24bit))

(3) Connections

Color	Red	Black	Yellow	Green	White	Shield
Signal	VCC	0V	ETXD	RTXD	NC	G

(4) Angle Conversion Formula

$\theta = (360^\circ \times a) / 2^n$ [a: data (decimal), n: encoder bits]

Take an example of 14 bit absolute encoder, returned data FFH 81H 01H 7FH 00H, data bit 01H 7FH (decimal) 383, Checksum 00H.

a=383, n=14, $\theta = (360^\circ \times 383) / 2^{14}$, $\theta = (360^\circ \times 383) / 16384$, $\theta = 8.4155^\circ$.

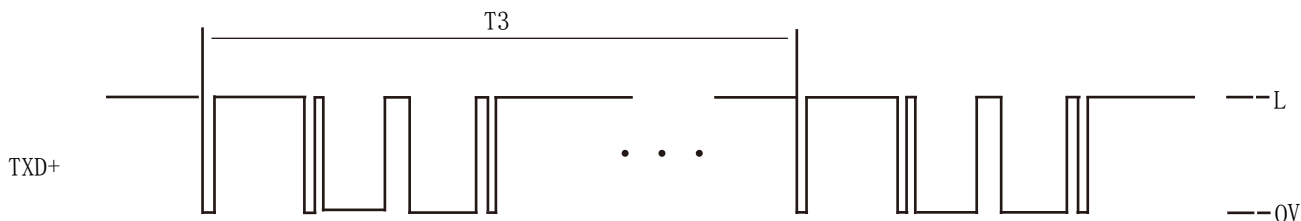
5.3.1 Timing Transmission

(1) Output Data Waveform

For Example, 0xff 0x81 0xd0 ...

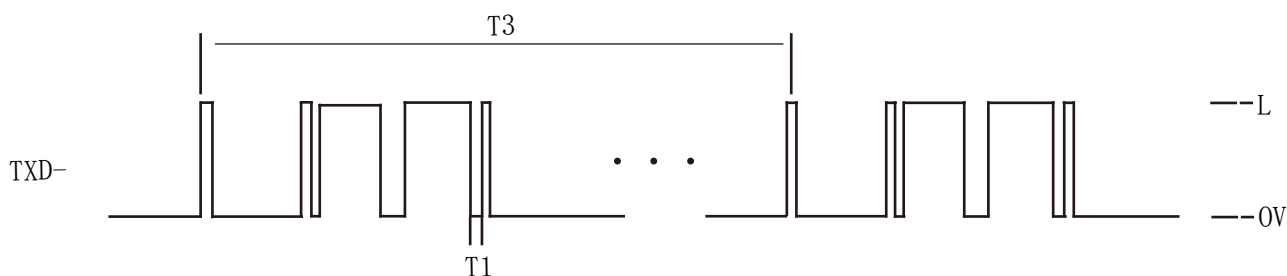
■ TXD+ Bit Transmission: 0 1111 1111 1 0 1000 0001 1 0 0000 1011 1 ...

$3.3V \leq L \leq 5V$



■ TXD- Bit Transmission: 1 0000 0000 0 1 0111 1110 0 1 1111 0100 0 ...

$3.3V \leq L \leq 5V$



T1: Baud Rate T3: Refresh Rate

(2) Data Frame Format

	1 st Byte	2 nd Byte	3 rd Byte	4 th Byte	5 th Byte	6 th Byte	7 th Byte
≤16bit	FFH	81H	The Top Eight Bits	The Bottom Eight Bits	Checksum		
17~24bit	FFH	81H	The Top Eight Bits	The Middle Eight Bits	The Bottom Eight Bits	Checksum	
>24bit	FFH	81H	The Top Eight Bits	The Sub-top Bits	The Middle Eight Bits	The Bottom Eight Bits	Checksum

(Checksum is the sum of first n bytes data and rounded up to the bottom eight bits. n=4(≤16bit); n=5(17~24bit); n=6(>24bit))

(3) Connection

Color	RED	BLACK	YELLOW	GREEN	WHITE	SHIELD
Signal	VCC	0V	TXD+	TXD-	NC	G

(4) Angle Conversion Formula

$$\theta = (360^\circ \times a) / 2^n \quad [a: \text{data (decimal)}, \quad n: \text{encoder bits}]$$

Take an example of 14 bit absolute encoder, returned data FFH 81H 01H 7FH 00H, data bit 01H 7FH (decimal) 383, Checksum 00H.

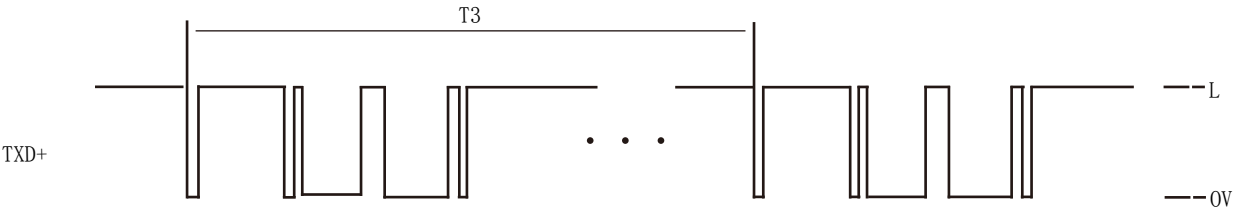
$$a=383, n=14, \theta = (360^\circ \times 383) / 2^{14}, \theta = (360^\circ \times 383) / 16384, \theta = 8.4155^\circ$$

5.3.2 Timing Transmission+Zero Clearing

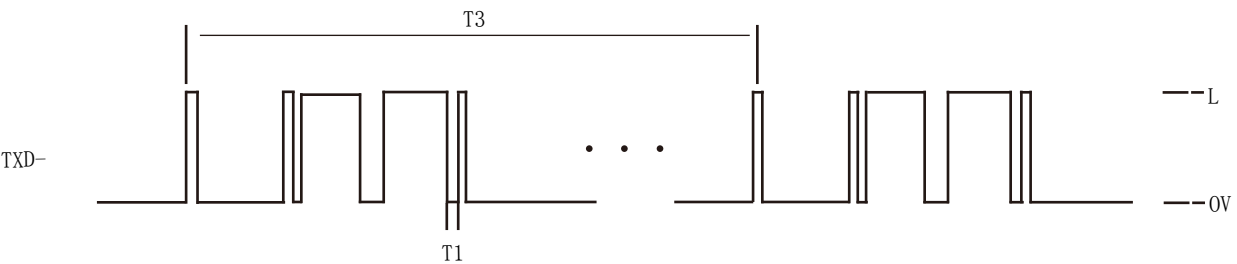
(1) Output Data Waveform

For Example 0xff 0x81 0xd0 ...

- TXD+ Bit Transmission: 0 1111 1111 1 0 1000 0001 1 0 0000 1011 1 ...
3.3V≤L≤5V



- TXD- Bit Transmission: 1 0000 0000 0 1 0111 1110 0 1 1111 0100 0 ...
3.3V≤L≤5V



T1: Baud Rate T3: Refresh Rate

(2) Data Frame Format

	1 st Byte	2 nd Byte	3 rd Byte	4 th Byte	5 th Byte	6 th Byte	7 th Byte
≤16bit	FFH	81H	The Top Eight Bits	The Bottom Eight Bits	Checksum		
17~24bit	FFH	81H	The Top Eight Bits	The Middle Eight Bits	The Bottom Eight Bits	Checksum	
>24bit	FFH	81H	The Top Eight Bits	The Sub-top Bits	The Middle Eight Bits	The Bottom Eight Bits	Checksum

(Checksum is the sum of first n bytes data and rounded up to the bottom eight bits. n=4(≤16bit); n=5(17~24bit);n=6(>24bit)

(3) Connection

Color	Red	Black	Yellow	Green	White	Shield
Signal	VCC	0V	TXD+	TXD-	CLR	G

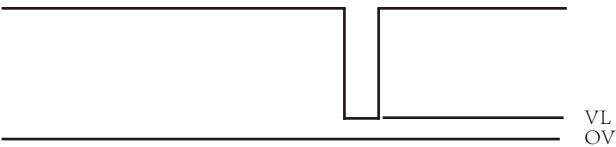
(4) Angle Conversion Formula

$\theta = (360^\circ \times a) / 2n$ [a: data (decimal) , n: encoder bits]

Take an example of 14 bit absolute encoder, returned data FFH 81H 01H 7FH 00H, data bit 01H 7FH (decimal) 383, Checksum 00H.

a=383,n=14, $\theta = (360^\circ \times 383) / 2^{14}$, $\theta = (360^\circ \times 383) / 16384$, $\theta = 8.4155^\circ$.

(5) Zero Clearing Signal:



Normally the voltage of CLR pin is 3.3V; When customer input a falling edge pulse and VL<0.5V, zero cleared.

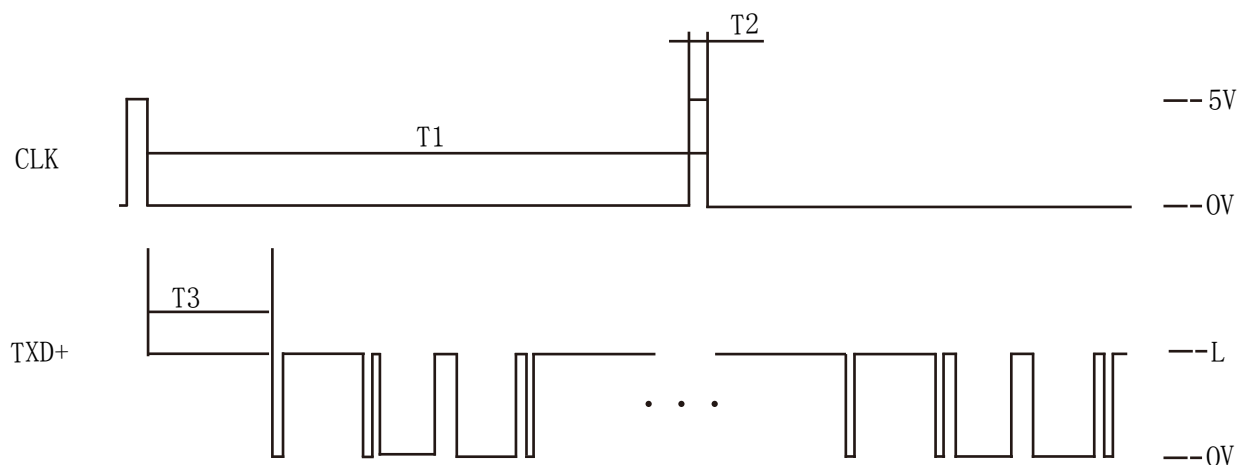
5.3.3 Bus Command

(1) Output Data Wave Form

For example 0xff 0x81 0xd0 ...

TXD+ Bit Transmission: 0 1111 1111 1 0 1000 0001 1 0 0000 1011 1 ...

$3.3V \leq L \leq 5V$



The falling edge of outer pules signal triggers encoder working

$T2 \geq 10\mu s$

T3: Signal acquisition and processing time after receiving the falling edge outer pulse.

T1-T3: Data transmission time

T1、T3 will be different according to customer' s requirements.

(2) Data Frame Format

	1 st Byte	2 nd Byte	3 rd Byte	4 th Byte	5 th Byte	6 th Byte	7 th Byte
$\leq 16\text{bit}$	FFH	81H	The Top Eight Bits	The Bottom Eight Bits	Checksum		
17~24bit	FFH	81H	The Top Eight Bits	The Middle Eight Bits	The Bottom Eight Bits	Checksum	
$> 24\text{bit}$	FFH	81H	The Top Eight Bits	The Sub-top Bits	The Middle Eight Bits	The Bottom Eight Bits	Checksum

(Checksum is the sum of first n bytes data and rounded up to the bottom eight bits. $n=4(\leq 16\text{bit})$; $n=5(17\sim 24\text{bit})$; $n=6(> 24\text{bit})$)

(3) Connections

Color	Red	Black	Yellow	Green	Grey	White	Orange	Brown	Shield
Signal	VCC	0V	TXD+	TXD-	CLK+	CLK-	NC	NC	G

(4) Angle Conversion Formula

$$\theta = (360^\circ \times a) / 2^n \quad [a: \text{data (decimal)}, \quad n: \text{encoder bits}]$$

Take an example of 14 bit absolute encoder, returned data FFH 81H 01H 7FH 00H, data bit 01H 7FH (decimal) 383, Checksum 00H.

$$a=383, n=14, \theta = (360^\circ \times 383) / 2^{14}, \theta = (360^\circ \times 383) / 16384, \theta = 8.4155^\circ.$$

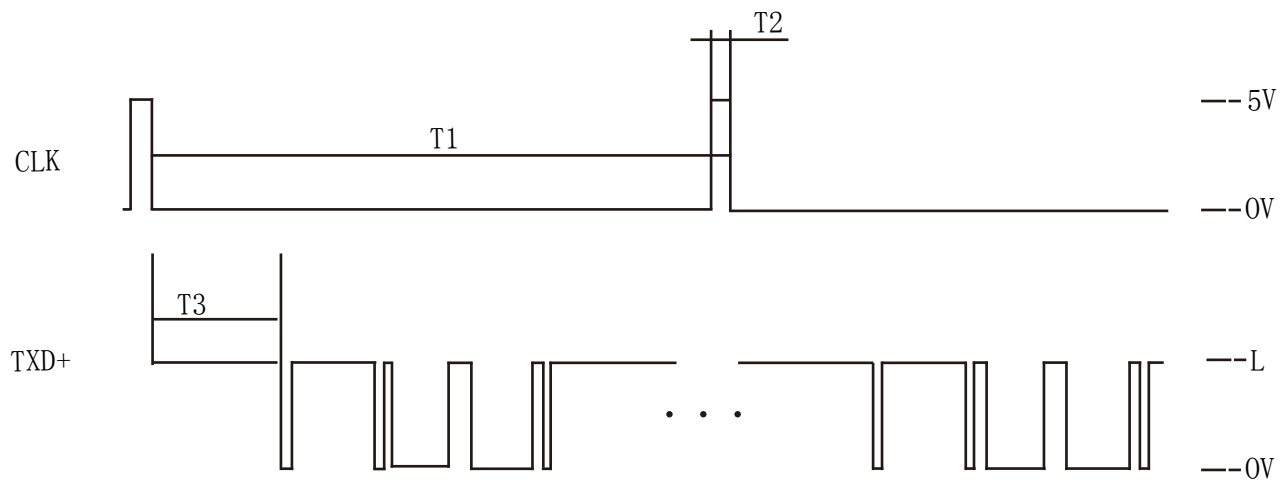
5.3.4 Bus + Zero Clearing

(1) Output Data Wave Form

For example 0xff 0x81 0xd0 ...

TXD+ Bit Transmission: 0 1111 1111 1 0 1000 0001 1 0 0000 1011 1 ...

3.3V≤L≤5V



The falling edge of outer pules signal triggers encoder working

T2≥10us

T3: Signal acquisition and processing time after receiving the falling edge outer pulse.

T1-T3: Data transmission time

T1、T3 will be different according to customer' s requirements.

(2) Data Frame Format

	1 st Byte	2 nd Byte	3 rd Byte	4 th Byte	5 th Byte	6 th Byte	7 th Byte
≤16bit	FFH	81H	The Top Eight Bits	The Bottom Eight Bits	Checksum		
17~24bit	FFH	81H	The Top Eight Bits	The Middle Eight Bits	The Bottom Eight Bits	Checksum	
>24bit	FFH	81H	The Top Eight Bits	The Sub-top Bits	The Middle Eight Bits	The Bottom Eight Bits	Checksum

(Checksum is the sum of first n bytes data and rounded up to the bottom eight bits. n=4(≤16bit); n=5(17~24bit);n=6(>24bit)

(3) Connection

Color	Red	Black	Yellow	Green	White	Shield
Signal	VCC	0V	TXD+	TXD-	CLR	G

(4) Angle Conversion Formula

$$\theta = (360^{\circ} \times a) / 2^n$$
 [a: data (decimal) , n: encoder bits]

Take an example of 14 bit absolute encoder, returned data FFH 81H 01H 7FH 00H, data bit 01H 7FH (decimal) 383, Checksum 00H.

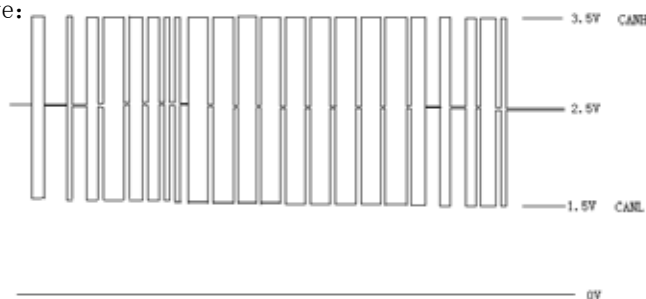
$$a=383, n=14, \theta = (360^{\circ} \times 383) / 2^{14}, \theta = (360^{\circ} \times 383) / 16384, \theta = 8.4155^{\circ}$$

5.4.1 CANopen ——— CAN interface chip-----SN65HVD230 CANopen protocol

(1) The Data Received As Shown Below:

序列	通道号	时间标识 (ms)	传输方向	帧ID (Hex)	帧类型	帧格式	数据长度	数据 (Hex)
002365	0	000936990.5	接收	000001FF	标准帧	数据帧	08	02 2B 00 00 00 00 00 00
002366	0	000937096.9	接收	000001FF	标准帧	数据帧	08	02 2B 00 00 00 00 00 00
002367	0	000937203.3	接收	000001FF	标准帧	数据帧	08	02 2B 00 00 00 00 00 00
002368	0	000937309.7	接收	000001FF	标准帧	数据帧	08	02 2B 00 00 00 00 00 00
002369	0	000937416.1	接收	000001FF	标准帧	数据帧	08	02 2B 00 00 00 00 00 00
002370	0	000937522.5	接收	000001FF	标准帧	数据帧	08	02 2B 00 00 00 00 00 00

Correspondence Signal Wave:



(2) Parameter Settings

The encoder with factory baud rate 250K, the node number 20H, the programming cycle time 100ms.
CANopen Data Format Description:

COB-ID	Command	Index		Subindex		Data		
11bit	Byte 0	Byte1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
		low	High		Low	——	——	High

COB-ID Composition Description:

10	9	8	7	6	5	4	3	2	1	0
Function Code				Device Address						
X	X	X	X	X	X	X	X	X	X	X

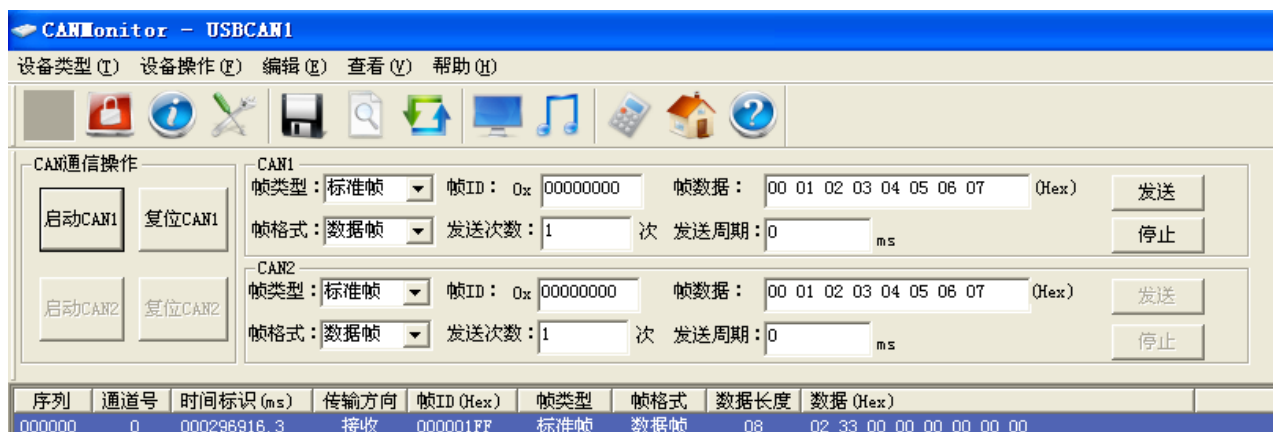
Function code can be used:

Function	Code (bit)	COB-ID
NMT	0000	0
SYNC	0001	128 (70H)
Emergency	0001	129-255 (71H-FFH)
PDO (RX)	0011	385-511 (181H-1FFH)
PDO (TX)	0100	513-639 (201H-27F)
SDO (RX)	1011	1409-1535 (581H-5FFH)
SDO (TX)	1100	1537-1663 (601H-67FH)

RX/TX was output by the PC , , RX encoder data issue, TX encoder data reception.

Under CAN open protocol product properly grounded electrical wiring, select the correct baud rate, the boot device, open electricity, the software will automatically receive a data, you can see the current frame ID, such as the following figure frame ID 000001FF. At this point the encoder node number is FF, send 2FF, 01, FF, 0, 0, 0, 0, 0 start No. FF encoder.

Note: Frame enter configuration mode ID input is 7E5



(3) Absolute encoders CANopen protocol setup instructions:

The following relates to the CAN bus data format are frame ID, D0, D1, D2, D3, D4, D5, D6, D7 all data is hexadecimal, assuming the encoder node number is NN, DLC are 8.

①

	FrameID	D0	D1	D2	D3	D4	D5	D6	D7	
Send:	2NN	01	NN	0	0	0	0	0	0	Start NN node
Or send:	2NN	80	NN	0	0	0	0	0	0	Jog No.NN encoder
Reply:	1NN	The Bottom Eight Bits	The Top Eight Bits	0	0	0	0	0	0	Resend data

②

	FrameID	D0	D1	D2	D3	D4	D5	D6	D7	
Send:	7E5	04	01	0	0	0	0	0	0	Enter configuration mode
Or send:	7E5	11	20	0	0	0	0	0	0	Set a new node address as 0x20
Reply:	7E5	11	00	0	0	0	0	0	0	Success

③

	FrameID	D0	D1	D2	D3	D4	D5	D6	D7	(00:1M, 02:500K, 03:250K)
Send:	7E5	04	01	0	0	0	0	0	0	Enter configuration mode
Or send:	7E5	13	00	02	0	0	0	0	0	Set new baud rate to 500K
Reply:	7E5	13	00	0	0	0	0	0	0	Success

④

	Frame ID	D0	D1	D2	D3	D4	D5	D6	D7	
Send:	2NN	22	NN	0	0	0	0	0	0	NN Node positive carry
Reply:	1NN	22	00	0	0	0	0	0	0	

⑤

	FramID	D0	D1	D2	D3	D4	D5	D6	D7	
Send:	2NN	22	NN	0	0	0	0	0	0	NN inverse carry Node
Reply:	1NN	22	00	0	0	0	0	0	0	

⑥

	framID	D0	D1	D2	D3	D4	D5	D6	D7	
Send:	2NN	20	NN	0	0	0	0	0	0	Setting NN Node
Reply:	1NN	20	00	0	0	0	0	0	0	

⑦

	FramID	D0	D1	D2	D3	D4	D5	D6	D7	
Send:	2NN	31	NN	TT	0	0	0	0	0	NN node to transmit data timing TT times / S
Rpely:	1NN	31	00	0	0	0	0	0	0	

⑧

	FramID	D0	D1	D2	D3	D4	D5	D6	D7	
Send:	2NN	31	NN	TT	0	0	0	0	0	Stop NN Node timed transmission mode
Reply:	1NN	31	00	0	0	0	0	0	0	

(4) Connection

Color	Red	Black	Yellow	Green	White	Shield
Signal	VCC	0V	NC	CANL	CANH	G

(5) Angle Conversion Formula

$$\theta = (360^\circ \times a) / 2^n \text{ 。 (a: data (Decimal, n: Encoder Resolution in Bits)}$$

For example: 14 bit absolute encoder, return frame ID 0120H data frame 47H 26H 00H 00H 00H 00H 00H, data bits 47H 26H (decimal 9799).

$$a=9799, n=14, \theta = (360^\circ \times 9799) / 2^{14}, \theta = (360^\circ \times 9799) / 16384,$$

$$\theta = 215.3100^\circ$$

Synchronous Serial: communication rate in the contract, the sender and the receiver clock signal frequency and phase are always consistent (synchronous).

5.5 SSI

SSI Interface Chip---MAX3087 ESA

Two-wire system: single-ended clock input, single-ended data output.

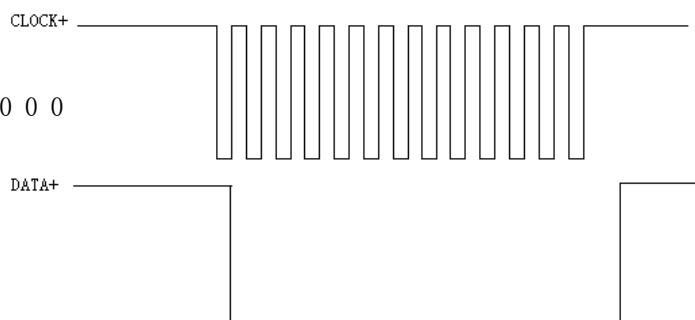
Absolute position value triggered by the clock signal, the output of the clock signal synchronized with the serial signal from the upper (MSB), when not transmitting a signal, a clock and data are high, in the first falling edge of the clock signal, the current start value stored on the rising edge of the clock signal starts transmitting data. Signal high between 3.3V-5V.

If the clock appears excessive abnormal angle, for example: 12 bits SSI encoder sends 14 bits clock reads the data, the maximum angle values of thousands of degrees, and no full-1 status, if the timing happens to fit, the extra clock will read out repeat the high-order data. If the clock is less than the normal requirements, send eight clock read 12 encoder data, and with eight of the angle conversion mode, the data may not be wrong; with 12 angle conversion method, the maximum angle of 22.4121 degrees.

(1) Data Output Waveform

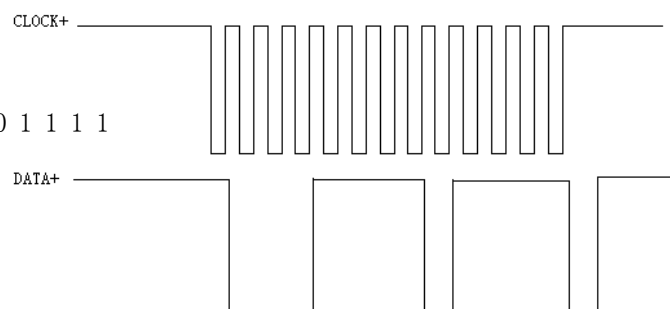
For example 1: 12 bits SSI Clock

DATA+ Transmission: 0 0 0 0 0 0 0 0 0 0 0 0

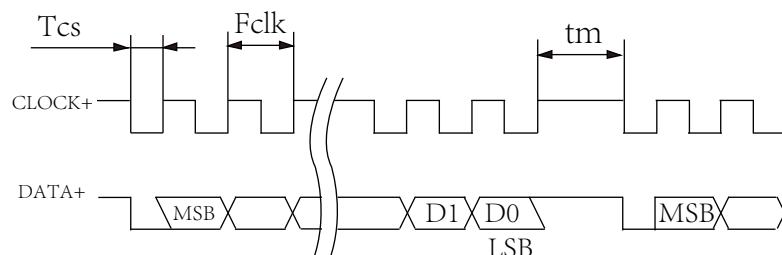


For example 2: 12 bits SSI Clock

DATA+ Bit Transmission: 0 0 0 1 1 1 1 0 1 1 1 1



(2) Interface Timing



Absolute position values are triggered clock signal, the output of the clock signal synchronized with the serial signal from the upper (MSB), when not transmitting a signal, a clock and data are high, in the first falling edge of the clock signal, the present value storage, transfer clock rising edge of the start signal for starting data.

Note: $T_{cs} > 4\mu s$; $100kHz < f_{clk} < 250kHz$; $T_m > 500\mu s$;

Note: T_{cs} f_{clk} T_m Products vary according to the actual situation.

(3) Connection

8 Pin Cable

Color	Red	Black	Yellow	Green	Gray	White	Yellow	Brown	Shield
Signal	VCC	0V	NC	D+	C+	C-	NC	D-	G

6 Pin Cable

Color	Red	Black	Green	Brown	Gray	White	Shield
Signal	VCC	0V	D+	D-	C+	C-	G

(4) Angle Conversion Formula

$\theta = (360^\circ \times a) / 2^n$. (a: Data (Decimal) , n: Resolution in bits of Encoder)

For example: 12 bits absolute encoder SSI protocol returns data DATA + Bit Transfer: 000111101111 (decimal 495)

$a=495$, $n=12$, $\theta = (360^\circ \times 495) / 2^{14}$, $\theta = (360^\circ \times 495) / 4096$, $\theta = 43.5058^\circ$

5.6 BISS

The BISS protocol uses 4 differential wires with point-to-point topology and only binary encoded data. It is hardware-compatible with the SSI interface.

The first rising edge of MA+ latches the sensor status; the second rising edge makes the encoder pull SLO+ low to acknowledge the master request. When SLO+ start bit St2 is high, data is ready, followed by a fixed logic 0 bit. Absolute position data is output synchronously from MSB at each clock rising edge.

The frame includes position data, error bit, warning bit, and 6-bit negative-logic CRC. CRC covers position data, error bit and warning bit. CRC polynomial: $(g(x)=x^6+x+1)$. Idle state: clock and data lines stay high.

Example of 16-bit BISS-C transmission:

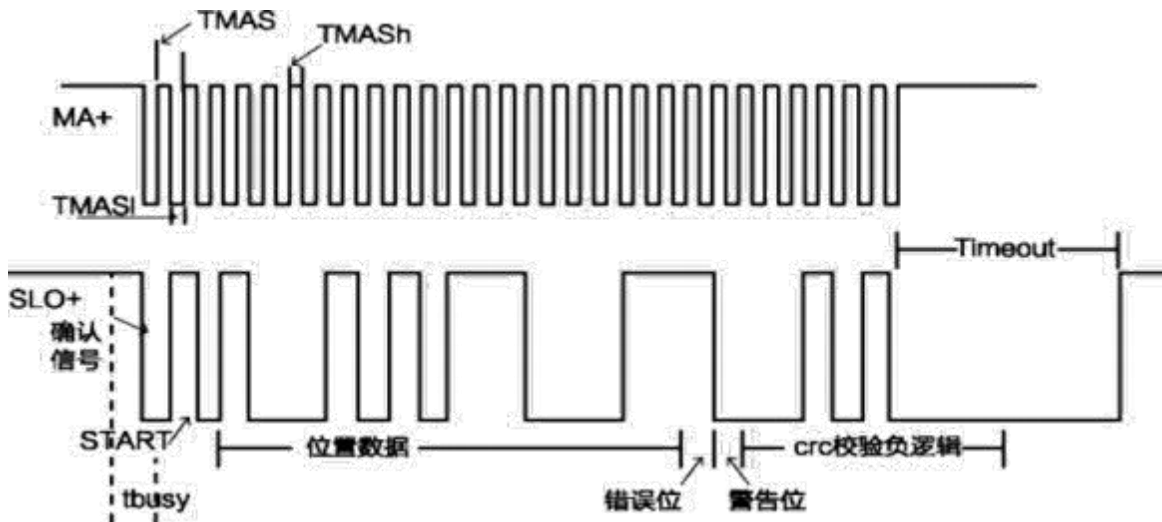
Raw data: 1000101011100011

With no error but warning: error bit=1, warning bit=0

Full frame: 100010101110001110

CRC code: 110101; negative logic: 001010

Communication Timing Diagram



Maximum Output Timing Parameters

TMAS: Minimum allowable clock cycle $> 100\text{ ns}$ TMASH: High-level duration $> 25\text{ ns}$ TMASL: Low-level duration $> 25\text{ ns}$ Tbusy: Minimum data output delay $= 2 \times \text{TMAS}$ Timeout: BISS timeout time $= 16\text{ }\mu\text{s}$

Driver Configuration

Digital driver maximum slew rate: 10 ns Default digital driver output mode: Push-pull output Maximum driver output short-circuit current: 50 mA

Angle Conversion Formula

$$\theta = (360^\circ \times a) / 2^n$$

Where: a — Decimal output data n — Encoder resolution bits

Example

For a 16-bit absolute encoder, the SLO+ transmission data: 1000101011100011 (decimal value = 35555)

$$a=35555, n=16, \theta = (360^\circ \times 35555) / 2^{16}, \theta = (360^\circ \times 35555) / 65536, \theta = 195.3094^\circ$$

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