Briterencoder Absolute Rotary Encoder

RS422 Single-turn Interface Modbus RTU Communication Protocol

1. Product Model Description

BRT=BriterEncoder:
BRT25=OD.25mm,4mm shaft
BRT27=27*27mm,6mm shaft
BRT38=OD.39mm, 6mm shaft
BRT38B=OD.39mm, 8mm hoop blind hole
BRT38M=OD.39mm,8mm blind hole
BRT42=OD.42mm, 6mm shaft
BRT50=OD.50mm, 8mm shaft
BRT58=OD.58mm, 10mm shaft

Resolution:
1024=10bit
4096=12bit
16384=14bit
32768=15bit
16bit =65536
17bit =131072
.....
21bit=2097152

RT1=Side Outlet
AT1=Tail Outlet
(Default Cable Length 1~1.2M)

IP54:Normal
IP65:Waterproof
IP68:Waterproof and dustproof
(Usable 1m underwater)
EX:Explosion-proof

BRT38 — R0M — 1024 — D24 — RT1 — IP68 — X3

Communication Protocal:

R0M=RS485 (Modbus RTU)	A0M=4~20mA
R2M=RS232(Modbus RTU)	V5M=0~5V
R4M=RS422(Modbus RTU)	V10M=0~10V
T0M=TTL(Modbus RTU)	R0&A0M=RS485&4~20mA
C0M=CANbus	R0&V5M=RS48580~5V
C2M=CANopen	R0&V10M=RS485&0~10V
S0M=SPI	
S1M=SSI	
S2M=BISS-C	

Turns:
1, 16, 24, 32, 50, 64, 99, 100, 200, 400, 600, 800, 1800, 5400, 10800, 21600, 34891, 69782 turns (Customizable)
D1 = Single turn
D16 = 16 turns

Internal Identification Code

Note 1: For photoelectric types, add P before the communication interface, e.g., photoelectric RS485 = PROM.

Note 2: For high-speed RS485 communication interfaces compatible with Tamagawa models, add HS before the communication interface, e.g., high-speed RS485 = HSR0M.

Note 3: For analog speed models, note the maximum speed RPM after the model, e.g., BRT38 - A0M1024 - RT1 - IP68(1000RPM).

Model Description:
1.Model:e.g., BRT25 indicates an outer diameter of 25mm and an output shaft of 4mm.
2.Communication interface: e.g., R0M means the electrical interface is RS485 and the communication protocol is Modbus RTU.
3.Resolution: It refers to the single - turn resolution, which has nothing to do with the subsequent number of turns. e.g., with a 10 - bit resolution, 2 to the power of 10 equals 1024. That is, the 360° full circle is divided into 1024 parts, and the minimum angular resolution is 360°/1024 = 0.38°.
4.Turns:It represents the power-off memory range, rather than the mechanical rotation turns of the encoder. The power-off memory of a single-turn encoder is limited to one turn, while a multi-turn encoder can record and restore multi-turn position information. Both types of encoders can perform infinite mechanical rotations.
5.Blind holes are mainly used to provide space for fixed threaded connections, while hoop blind hole are mainly used to fix and connect components. In practical applications, it is more recommended to use hoop blind hole for encoders.
6.Inventory: Some randomly combined models may be out of stock. Please consult in advance to ensure that the selected model is available.

2. Wiring Definition and connection

Red wire	Power Supply	DC 5V~24V
Black wire	0V (GND)	-
Green wire	RX+	-
Brown wire	RX-	-
White	TX+	-
Gray	TX-	-
Yellow wire	Function line	1. It serves for encoder zero position setting and factory settings restoration. 2. During normal encoder operation, keep the yellow wire suspended and disconnected.
Orange wire	Empty (or NC)	Generally, keep the yellow wire insulated with tape.

3. Product Parameters

Resolution	10bit、12bit、13bit、14bit、15bit、16bit		
Supply Voltage	5~24V	Linearity	0.1%
Kernel Refresh Period	50uS	Electrical lifespan	> 100000 h
Working Current	100mA	Baud Rate	9600~115200(default 9600)
Shell/ Flange Material	Galvanized steel / Aluminum alloy IP68/EX Stainless Steel	Address	1-255(default 1)
Shaft Material	Stainless Steel(Customizable)	Maximum mechanical speed	8000PRM
Bearing material	Bearing Steel	Starting Torque	0.006Nm
Maximum load on the shaft	Axial 20 N, Radial 80 N	Weight	120 g-and-above
Working temperature	-40 ~ + 85 ℃	Humidity	98 % (No condensation)
Storage temperature	-40 ~ +85℃	Protection Level	IP54、IP68、EX

Three simple ways to set absolute encoder to zero position?

- Method 1. Connect yellow wire to ground (black wire) more than 100mS. After set zero, please separate the yellow and black wire.
- Method 2. After right connected the wires according to the wiring definition. send set zero position command according to the user manual.
- Method 3. Use the upper computer provided by our company (BriterEncoder).

How to restore the absolute encoder to factory settings?

- Step 1, After power off, connect the yellow wire to the black wire.
- Step 2, power on, and hold for two minutes.
- Step 3, power off, then separate the yellow wire from the black wire. now the rotary encoder had been restored to factory settings.

4. RS422 with Modbus-RTU communication protocol

This encoder uses the MODBUS-RTU (national standard GB/T19582-2008) communication protocol for communication, supporting one master station to control multiple slave stations. Through the built-in upper computer, 127 slave station addresses can be configured, and the master station can be a microcontroller unit, PLC, or PC, etc.

Communication parameters

The default configuration of the serial port at the factory is 9600bps, with a data bit of 8, no verification, and a stop bit of 1; The baud rate can be configured in the range of 9600~115200bps, and the default communication address (station number) of the encoder is 1.

MODBUS-RTU Frame format

This encoder supports MODBUS's 0x03 (read hold register), 0x06 (write single register)

1) 0x03 Read the holding register

Main Station Sending

Byte	1	2	3	4	5	6	7	8
Content	ADR	0x03	Start register high byte	Start register low byte	High byte of register number	Low byte of register number	CRC High byte	CRC low byte

The 1st byte ADR: Slave address code(1 ~ 127)

The 2nd byte 0x03 : Read register value function code

The 3rd.、4th. byte: Starting address of the register to be read

The 5th.、6th. byte: Number of registers to be read

The 7th.、8th. byte: CRC16 checksum from bytes 1 to 6

Slave Station Response:

Byte	1	2	3	4、5	6、7		M-1、M	M+1	M+2
Content	ADR	0x03	Total byte	Register data 1	Register data 2	…..	Register data M	CRC High byte	CRC Low byte

The 1st byte ADR: Slave address code(2 ~ 127)

The 2nd byte 0x03 : Return to read function code

The 3rd byte: The total number of bytes from 4 to M (including 4 and M)

The 4th. ~ M byte: Register data

The M + 1、 M+2byte: CRC16 checksum from bytes 1 to M

2) 0x06 Write a single register

Main Station Sending

Byte	1	2	3	4	5	6	7	8
content	ADR	0x06	Start register high byte	Start register low byte	High byte of register number	Low byte of register number	CRC High Byte	CRC Low byte

When the slave station receives correctly, the slave station sends back:

Byte	1	2	3	4	5	6	7	8
Content	ADR	0x06	Register high byte	Register low byte	High byte of register number	Low byte of register number	CRC high byte	CRC low byte

3) Register definition

List of encoder register

Register address	Description	Value ranges	Function code	Remarks

0x0000	Encoder single turn value	0~0xFFFFFFFF(0~4294967295)	0x03	Power off memory
0x0000~0x0001	Encoder virtual multi turn value	0~0xFFFFFFFF (0~4294967295)	0x03	The value returns to Zero after power failure
0x0002	Encoder virtual number of turns	0~0xFFFF (0~65535)	0x03	The value returns to Zero after power failure
0x0003	Encoder angular velocity value	0~0xFFFF (0~65535) Unsigned integer	0x03	/
0x0004	Encoder address	1~255	0x06	Communication address (default 1)
0x0005	Baud rate	0x0000~0x0004	0x06	Default 9600, 0x00: 9600 0x01: 19200 0x02: 38400 0x03: 57600 0x04: 115200
0x0006	Encoder mode	0x0000 0x0001 0x0004 0x0005	0x06	0x00: Query mode 0x01: Automatic return encoder single turn value 0x04: Automatic return encoder virtual multi turn value 0x05: Automatic return of encoder angular velocity value
0x0007	Encoder automatic return time	0~65535(ms)	0x06	default: 20mS
Note: once the automatic transmission time is set to less than 20 milliseconds, the encoder will set other parameters that may fail. Use with caution.				
0x0008	Encoder reset zero position	0x0001	0x06	Write 0x0001, the encoder takes the current position as the zero point
0x0009	Encoder value increasing direction	0x0000~0x0001	0x06	0x00: clockwise 0x01: counterclockwise
0x000A	Encoder angular velocity Sampling time	0~65535(ms)	0x06	Default: 100mS
0x000B	Set the current value of the encoder	0~65535	0x06	Power off memory
0x000E	Set the encoder's midpoint	0x0001	0x06	Write 0x0001, the encoder takes the current position as the mid-point
0x0020~0x0021	Encoder angular velocity value 2	0~0xFFFFFFFF (-2147483648~2147483647)	0x03	
0x0025 ~0x0026	Encoder single turn value 2 (support the encoder with a resolution of 17bits and above)	0~0xFFFFFFFF (0~4294967295)	0x03	Power off memory

4) Example of Encoder communication

Read encoder single turn value

Register Address	0x0000	Siemens PLC address	40001

Data Range	0~N (N is single turn resolution-1)	Unit	-
Default value	-	Read/Write	Read only (supports function codes 0x03)
Effective method	-	Memory	Data can be memorized after power failure
data type	Unsigned integer	Applicable scope	Encoders with a resolution of 16bit and below

Encoder current angle=Encoder single turn value*360/ single turn resolution.
e.g. reading the encoder single turn value is 1000, the single turn resolution is 1024 (10bit). then the encoder current angle= 1000*360/1024=351.5625°

Communication examples:

Tx:01 03 00 00 00 01 (84 0A)
Rx:01 03 02 01 42 (39 E5)

Note: The CRC check bits are shown in parentheses，the return data of the encoder single turn value is 01 42 (Decimal: 322)

Read encoder virtual number of turns (virtual multi-turns)

Register Address	0x0000~0x0001	Siemens PLC address	40001~40002
Data Range	0~2147483647	Unit	-
Default value	-	Read/Write	Read only (supports function codes 0x03)
Effective method	-	Memory	The value returns to Zero after power failure
data type	Unsigned integer	Applicable scope	All the single-turn encoders

Multi turn angle encoding value (software implementation)
Encoder's current virtual multi turn angle=Encoder virtual multi turn value*360/single turn resolution.

E.g. reading the virtual multi turn value of the encoder is 100000, the single turn resolution is 10bit (1024ppr), then the Encoder current angle=100000*360/1024=35156.25°

Communication examples:

Tx:01 03 00 00 00 02 (C4 0B)
Rx:01 03 04 00 01 76 3B (CC 40)

Note: The CRC check bits are shown in parentheses，The return data of encoder virtual multi-turn value is 00 01 76 3B (Decimal：95803)

Encoder angular velocity value

Register Address	0x0003	Siemens PLC address	40004
Data Range	-32768~32767	Unit	-
Default value	-	Read/Write	Read only (Support function codes 0x03)
Effective method	-	Memory	-
data type	Signed integer	Applicable scope	All the single-turn encoders

Encoder angular velocity encoding value (the change in encoder single turn value during encoder angular velocity sampling time)
Encoder rotation speed=encoder angular velocity value/single turn resolution/speed calculation time (unit:rpm)
E.g. the encoder angular velocity value is transmitted back to 1000, the single turn resolution is 32768, and the speed sampling time is 100ms (0.1/60min)
Encoder rotation speed=1000/32768/(0.1/60)=1000 * 0.0183=18.31 rpm

Communication examples:

Tx:01 03 00 03 00 01 (74 0A)

Rx:01 03 02 02 7A (D8 C6)

Note: The CRC check bits are shown in parentheses，The return data of the encoder angular velocity value is 02 7A (Decimal: 634)

Set the encoder address (ID/ Station Number)

Register Address	0x0004	Siemens PLC address	40005
Data Range	1~255	Unit	-
Default value	1	Read/Write	Write Only (Support function codes 0x06)
Effective method	Effective immediately	Memory	Data can be memorized after power failure
data type	Unsigned integer	Applicable scope	All the single-turn encoders

Communication examples:

Tx:01 06 00 04 00 02 (49 CA)
Rx:01 06 00 04 00 02 (49 CA)

Note: The CRC check bits are shown in parentheses，Set the address as 02 (HEX:0x0002)

Set the encoder baud rate

Register Address	0x0005	Siemens PLC address	40006
Data Range	0~4 (0: 9600bps 1: 19200bps 2: 38400bps 3: 57600bps 4: 115200bps)	Unit	-
Default value	0 (9600bps)	Read/Write	Write Only (Support function codes 0x06)
Effective method	Effective immediately	Memory	Data can be memorized after power failure
data type	Unsigned integer	Applicable scope	All the encoders

Communication examples:

Tx:01 06 00 05 00 02 (18 0A)
Rx:01 06 00 05 00 02 (18 0A)

Note: The CRC check bits are shown in parentheses，Set the baud rate as 38400bps (0x02)

Set encoder data mode.(Encoder working mode)

Register Address	0x0006	Siemens PLC address	40007
Data Range	0~5 (0x00: Query mode 0x01: Automatic return encoder single turn value 0x04: Automatic return encoder virtual multi turn value 0x05: Automatic return encoder angular velocity value)	Unit	-
Default value	0 (Query mode)	Read/Write	Write Only (Support function codes 0x06)

Effective method	Effective immediately	Memory	Data can be memorized after power failure
data type	Unsigned integer	Applicable scope	All the encoders

Communication examples:

Tx: 01 06 00 06 00 01 (A8 0B)
Rx: 01 06 00 06 00 01 (A8 0B)

Note: The CRC check bits are shown in parentheses, Set the current encoder data mode to automatically return encoder values.

Set encoder automatic return time (milliseconds).

Register Address	0x0007	Siemens PLC address	40008
Data Range	0~65535	Unit	Milliseconds (mS)
Default value	50 (mS)	Read/Write	Write Only (Support function codes 0x06)
Effective method	Effective immediately	Memory	Data can be memorized after power failure
data type	Unsigned integer	Applicable scope	All the single-turn encoders

Explanation: The time period for the encoder to automatically return data (to be used in conjunction with the encoder's automatic data return mode)

Communication examples:

Tx: 01 06 00 07 00 64 (39 E0)
Rx: 01 06 00 07 00 64 (39 E0)

Note: The CRC check bits are shown in parentheses， Set the automatic return time to 100 milliseconds (HEX:0x0064)

Note: Once the automatic transmission time is set to less than 20 milliseconds, setting other parameters on the encoder can easily fail. Use with caution.

Set Encoder zero position

Register Address	0x0008	Siemens PLC address	40009
Data Range	0~1	Unit	-
Default value	-	Read/Write	Write Only (Support function codes 0x06)
Effective method	Effective immediately	Memory	-
data type	Unsigned integer	Applicable scope	All the single-turn encoders

Communication examples:

Tx:01 06 00 08 00 01 (C9 C8)
Rx:01 06 00 08 00 01 (C9 C8)
Note: The CRC check bits are shown in parentheses, set the current position of the encoder to 0.

Set the encoder value increment direction.

Register Address	0x0009	Siemens PLC address	40010
Data Range	0~1 (0: CW Clockwise increment) (1: CCW Counterclockwise increment)	Unit	-
Default value	1 (CCW Counterclockwise	Read/Write	Write Only (Support function codes

	increment)		0x06)
Effective method	Effective immediately	Memory	Data can be memorized after power failure
data type	Unsigned integer	Applicable scope	All the encoders

Explanation: Encoder value increasing direction (Encoder output shaft facing observer)

Communication examples:

Tx:01 06 00 09 00 00 (59 C8)
Rx:01 06 00 09 00 00 (59 C8)

Note: The CRC check bits are shown in parentheses，Set the current encoder value to increase clockwise value

Encoder angular velocity sampling time

Register Address	0x000A	Siemens PLC address	40011
Data Range	0~65535	Unit	Milliseconds (mS)
Default value	100 (mS)	Read/Write	Write Only (Support function codes 0x06)
Effective method	Effective immediately	Memory	Data can be memorized after power failure
data type	Unsigned integer	Applicable scope	All the single-turn encoders

Communication examples:

Tx: 01 06 00 0A 03 E8 (A9 76)
Rx: 01 06 00 0A 03 E8 (A9 76)

Note: The CRC check bits are shown in parentheses，Set the automatic return time to 1000 mS (HEX:0x3E8)

Set encoder current value

Register Address	0x000B	Siemens PLC address	40012
Data Range	0~N (N is the single turn resolution-1)	Unit	-
Default value	-	Read/Write	Write Only (Support function codes 0x06)
Effective method	Effective immediately	Memory	-
data type	Unsigned integer	Applicable scope	All the single-turn encoders

Communication examples:

Tx 01 06 00 0B 03 E8 (F8 B6)
Rx: 01 06 00 0B 03 E8 (F8 B6)

Note: The CRC check bits are shown in parentheses，Set the current position to 1000 (HEX:0x3E8)

Set the midpoint of the encoder

Register Address	0x000E	Siemens PLC address	40015
Data Range	0~1	Unit	-
Default value	-	Read/Write	Write Only (Support function codes 0x06)
Effective method	Effective immediately	Memory	-
data type	Unsigned integer	Applicable scope	All the single-turn encoders

Explanation: Set the current encoder value to M (M is the single-turn resolution/2), After setting, calculate the current angle as 180 °

Communication examples:

Tx:01 06 00 0E 00 01 (29 C9)
Rx:01 06 00 0E 00 01 (29 C9)

Note: The CRC check bits are shown in parentheses， Set the current position of the encoder to the midpoint of the range.

Encoder angular velocity value 2

Register Address	0x0020~0x0021	Siemens PLC address	40033~40034
Data Range	-2147483648~2147483647	Unit	-
Default value	-	Read/Write	Read only (Support function codes 0x03)
Effective method	Effective immediately	Memory	-
data type	Signed integer	Applicable scope	All the single turn encoders

Encoder rotation speed= Encoder angular velocity value/ single turn resolution/ Speed calculation time (Unit: rpm)

e.g. The encoder angular velocity value is returned as 1000， single turn resolution is 32768 (15bit), Speed calculation time is 100ms (0.1/60min).

Encoder rotation speed= 1000/32768/(0.1/60) = 1000*0.0183 = 18.31rpm.

Communication examples:

Tx:01 03 00 20 00 02 (C5 C1)
Rx:01 03 04 00 01 B3 FC (DE 82)

Note: CRC check bits are shown in parentheses, and the return data of encoder angular velocity value 2 is 00 01 B3 FC (Decimal: 111612)

Encoder single turn value 2

Register Address	0x0025~0x0026	Siemens PLC address	40038~40039
Data Range	0~N (N is single turn resolution-1)	Unit	-
Default value	-	Read/Write	Write Only (Support function codes 0x03)
Effective method	Effective immediately	Memory	Data can be memorized after power failure
data type	Unsigned integer	Applicable scope	Encoders with a resolution of 17bit and above

Encoder current angle=Encoder single turn value*360/ single turn resolution.

e.g. reading the encoder single turn value is 1000, the single turn resolution is 1024 (10bit). then the encoder current angle= 1000*360/1024=351.5625°

Communication examples:

Tx:01 03 00 25 00 02 (D5 C0)

Rx:01 03 04 00 01 76 3B (CC 40)

Note: CRC check bits are shown in parentheses, and the returned data for encoder single turn value 2 is 00 01 76 3B (Decimal: 95803)

5) CRC Check Function Code Reference

```
unsigned int Crc_Count(unsigned char pbuf[],unsigned char num)
{
    int i,j; unsigned int wcrc=0xffff;
```

```
    for(i=0;i<num;i++)
    {
     wcrc^=(unsigned int)(pbuf[i]);
     for (j=0;j<8;j++)
    {
          if(wcrc&0x0001)
          {
            wcrc>>=1; wcrc^=0xa001;
          }
           else
              wcrc>>=1;
    }
    }
    return wcrc;
}
```

5. Precautions and warranty

● Encoders belong to precision instruments. Please handle them with care and use them with care, especially do not knock, hit, or forcefully pull the encoder shaft.
● The encoder and mechanical connection should use flexible connectors or elastic brackets to avoid hard damage caused by non concentric rigid connections.
● Although the encoder itself does not lose the number of turns in interference environments, it can cause interference to the data during transmission. Therefore, when there is a motor or strong electromagnetic interference environment in the system, an isolated power supply should be used to power the encoder. And when there's external extended communication lines, it is best to use double shielded cables.
● The encoder casing and shielding wire should be well grounded to prevent damage to the encoder circuit caused by lightning strikes or high-voltage static electricity
● The product is guaranteed for one year free of charge when used correctly.
● When exceed the warranty period, or the product is damaged due to improper use, the product can be sent back to the original factory for repair (only raw material cost is required when repair).

6. Encoder Indicator Lights Description

1. The status lights display as follows.
1) The default state consists of 5 flashing statuses in the following sequence: "Blue -> Blue -> Blue -> Cyan -> Blue" with a slow flash every 1 second, indicating normal power supply to the encoder.

2) Other operational status indications
a. Query encoder data status: Green light flashing quickly every 0.5 seconds.
b. Setting the zero point for the yellow line: Orange light flashing quickly every 0.5 seconds.
c. Power-on reset status for the yellow line: Purple light flashing quickly every 0.5 seconds.
d. Encoder data automatic return status: Pause for 1 second, slow flash, interval of 0.5 seconds fast flash, blinking 5 times, defined with reference to the first item.
e. The red light indicates encoder malfunction.

3) When the encoder's ID and baud rate are changed, the colors of the flashing lights will correspondingly change. Here is the color reference table for the status lights and their meanings:

Table 1 Color and Numerical Definition Relationship

Color	Blue	Cyan	Orange	Purple	Green	Red
Numerical Value	0	1	2	3	4	5

Table 2 RS422 Baud Rate and Numerical Definition Relationship

Baud Rate	9600	19200	38400	57600	115200
Numerical Value	0	1	2	3	4

(1) Upon power-on in normal operation:
a. There is a 4-second pause followed by 5 slow flashes with a 1-second interval.
b. The colors of the first 4 flashes form a quaternary (base-4) data that corresponds to the encoder ID number.
c. The color of the last flash defines the baud rate.

(2) For example: Orange -> Cyan -> Purple -> Orange -> Blue. Referring to Table 1 and Table 2, we can determine the corresponding numbers: 21320. The last digit is 0, according to Table 2, which corresponds to a baud rate of 9600. The first four digits form the quaternary number 2132, which converts to decimal ID: 2 * 4^3 + 1 * 4^2 + 3 * 4^1 + 2 * 4^0 = 158 (Encoder ID).

Table 4: Status LED Blinking Definitions and Examples

		Section 1 Encoder ID				Section 2 Baud Rate	
LED Status	OFF	ON	ON	ON	ON	ON	OFF
Hold Time	4s	1s	1s	1s	1s	1s	4s
Status Color	-	orange	Cyan	purple	orange	blue	-
Number	-	2	1	3	2	0	-
Status Analysis	-	2*4^3+ 1*4^2 + 3*4^1 + 2*4^0 ＝ 158				Baud rate is 9600	-
Status Meaning	-	Encoder ID				Baud Rate	-

7. Contact us and technology support

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Technical documentation

Detailed version of the instruction manual;
PC software;
2D drawings and 3D model files;
Additional Video Tutorials;

For more details, please visit our website:
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