COMMUNICATION PROTOCOL

🕮 INTERFACE

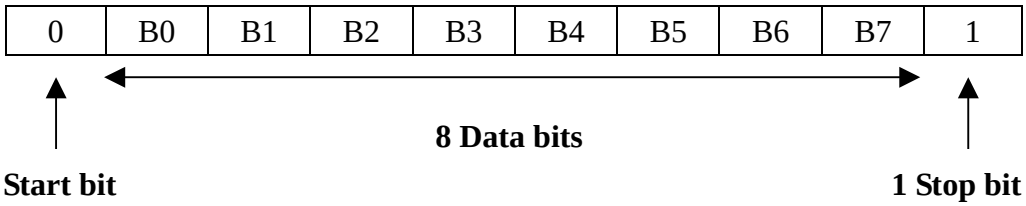
RS-485, RS-232

🕮 BAUD RATE

2400, 4800, 9600, 19200, 38400 bps

🕮 DATA FRAME

Data Bits = 8，Parity = None，Start bit = 1，Stop bit = 1



🕮 DATA FORMAT

ModBus Protocol RTU Mode

RTU Request：Read command

0	1	2	3	4	5	6	7
	0x03						
Station Number	**Func-tion**	**Address (MSB LSB)**		**Count (MSB LSB)**		**CRC16 (LSB MSB)**	

Station Number: 00H~1FH

Address: 0000H~0100H

Count: Number of Data

CRC16: Cyclical Redundancy Check

RTU Response：Read command

0	1	2	3	4	5	6	7	8
	0x03							
Station Number	**Func-tion**	**Byte Count**	**Data1 (MSB LSB)**		**Data2.. (MSB LSB)**		**CRC16 (LSB MSB)**	

Station Number: 00H~1FH

Address: 0000H~0100H

Byte Count: Number of Data Bytes

CRC16: Cyclical Redundancy Check

RTU Request：Write command

0	1	2	3	4	5	6	7
	0x06						
Station Number	**Func-tion**	**Address (MSB LSB)**		**Data (MSB LSB)**		**CRC16 (LSB MSB)**	

Station Number: 00H~1FH

Address: 0000H~00B6H

CRC16: Cyclical Redundancy Check

RTU Response：Write command

0	1	2	3	4	5	6	7
	0x06						
Station Number	**Func-tion**	**Address (MSB LSB)**		**Data (MSB LSB)**		**CRC16 (LSB MSB)**	

Station Number: 00H~1FH

Address: 0000H~00B6H

CRC16: Cyclical Redundancy Check

🕮 COMMUNICATION EXAMPLES

RTU Request：Read command

🗁 Read PV from station 1

- ☞ Station number: 01H
- ☞ Function: 03H
- ☞ Address MSB: 01H
- ☞ Address LSB: 00H
- ☞ Count MSB: 00H
- ☞ Count LSB: 01H
- ☞ CRC16 LSB: 85H
- ☞ CRC16 MSB: F6H

0	1	2	3	4	5	6	7
0x01	0x03	0x01	0x00	0x00	0x01	0x85	0xF6
Station Number	**Func-tion**	**Address (MSB LSB)**		**Count (MSB LSB)**		**CRC16 (LSB MSB)**	

RTU Response：Read command

🗁 Response PV 100.0℃ from D-Series station 1

- ☞ Station number: 01H
- ☞ Function: 03H
- ☞ Byte count: 02H
- ☞ Data MSB: 03H
- ☞ Data LSB: E8H
- ☞ CRC16 LSB: B8H
- ☞ CRC16 MSB: FAH

0	1	2	3	4	5	6
0x01	0x03	0x02	0x03	0xE8	0xB8	0xFA
Station Number	**Func-tion**	**Byte Count**	**Data1 (MSB LSB)**		**CRC16 (LSB MSB)**	

RTU Request: Write command

🗁 Write SV 100.0℃ to D-Series station 1

- ☞ Station number: 01H
- ☞ Function: 06H
- ☞ Address MSB: 00H
- ☞ Address LSB: 02H
- ☞ Data MSB: 03H
- ☞ Data LSB: E8H
- ☞ CRC16 LSB: 28H
- ☞ CRC16 MSB: B4H

0	1	2	3	4	5	6	7
0x01	0x06	0x00	0x02	0x03	0xE8	0x28	0xB4
Station Number	**Func-tion**	**Address (MSB LSB)**		**Data (MSB LSB)**		**CRC16 (LSB MSB)**	

RTU Response: Write command

- Response request command from D-Series station 1
  - Station number: 01H
  - Function: 06H
  - Address MSB: 00H
  - Address LSB: 02H
  - Data MSB: 03H
  - Data LSB: E8H
  - CRC16 LSB: 28H
  - CRC16 MSB: B4H

0	1	2	3	4	5	6	7
0x01	0x06	0x00	0x02	0x03	0xE8	0x28	0xB4
Station Number	**Func-tion**	**Address (MSB LSB)**		**Data (MSB LSB)**		**CRC16 (LSB MSB)**	

🕮 ADDRESS INDEX

PARA	ADDR	PARA	ADDR	PARA	ADDR
LEvL	00H	**P2**	20H	**AO**	40H
LoCK	01H	**i2**	21H	**O2LS**	41H
Sv	02H	**d2**	22H	**O2HS**	42H
OutL	03H	**Ct2**	23H	**t1SS**	43H
At	04H	**HSt2**	24H	**t1On**	44H
mAn	05H	**db**	25H	**t1ES**	45H
AL1S	06H	**SSv**	26H	**t1oF**	46H
AL1L	07H	**Sout**	27H	**t2SS**	47H
AL1U	08H	**StmE**	28H	**t2On**	48H
AL2S	09H	**rUCy**	29H	**t2ES**	49H
AL2L	0AH	**rPt**	2AH	**t2oF**	4AH
AL2U	0BH	**StAt**	2BH	**inP1**	4BH
AL3S	0CH	**PvSt**	2CH	**LoSP**	4CH
AL3L	0DH	**wAit**	2DH	**HiSP**	4DH
AL3U	0EH	**Pid**	2EH	**LoAn**	4EH
SOAK	0FH	**EndP**	2FH	**HiAn**	4FH
rAmP	10H	**AL1F**	30H	**A1LS**	50H
PvoF	11H	**AL1H**	31H	**A1HS**	51H
Pvrr	12H	**AL1t**	32H	**unit**	52H
SvoF	13H	**AL1m**	33H	**dP**	53H
Ct	14H	**AL2F**	34H	**FiLt**	54H
HbA	15H	**AL2H**	35H	**inP2**	55H
LbA	16H	**AL2t**	36H	**A2LS**	56H
Lbd	17H	**AL2m**	37H	**A2HS**	57H
rPtm	18H	**AL3F**	38H		
P1	19H	**AL3H**	39H	**bAud**	59H
i1	1AH	**AL3t**	3AH	**Addr**	5AH
d1	1BH	**AL3m**	3BH	**LEv1**	5BH
Ct1	1CH	**Act**	3CH	**LEv2**	5CH
HSt1	1DH	**Outm**	3DH	**LEv3**	5DH
AtoF	1EH	**O1LS**	3EH	**LvSL**	5EH
Ar	1FH	**O1HS**	3FH	**L1P1**	5FH

PARA	ADDR	PARA	ADDR	PARA	ADDR
L1i1	60H	**tS1**	80H	**1-12**	A0H
L1d1	61H	**Sv2**	81H	**1-13**	A1H
L1Ar	62H	**tP2**	82H	**1-14**	A2H
L1P2	63H	**tS2**	83H	**1-15**	A3H
L1i2	64H	**Sv3**	84H	**1-16**	A4H
L1d2	65H	**tP3**	85H	**1-17**	A5H
L2P1	66H	**tS3**	86H	**1-18**	A6H
L2i1	67H	**Sv4**	87H	**1-19**	A7H
L2d1	68H	**tP4**	88H	**1-20**	A8H
L2Ar	69H	**tS4**	89H	**1-21**	A9H
L2P2	6AH	**Sv5**	8AH	**1-22**	AAH
L2i2	6BH	**tP5**	8BH	**2-14**	ABH
L2d2	6CH	**tS5**	8CH	**2-15**	ACH
L3P1	6DH	**Sv6**	8DH	**2-16**	ADH
L3i1	6EH	**tP6**	8EH	**2-17**	AEH
L3d1	6FH	**tS6**	8FH	**3-20**	AFH
L3Ar	70H	**Sv7**	90H	**3-21**	B0H
L3P2	71H	**tP7**	91H	**3-22**	B1H
L3i2	72H	**tS7**	92H	**3-23**	B2H
L3d2	73H	**Sv8**	93H	**3-24**	B3H
L4P1	74H	**tP8**	94H	**3-25**	B4H
L4i1	75H	**tS8**	95H	**3-26**	B5H
L4d1	76H	**1-2**	96H	**3-27**	B6H
L4Ar	77H	**1-3**	97H		
L4P2	78H	**1-4**	98H		
L4i2	79H	**1-5**	99H		
L4d2	7AH	**1-6**	9AH		
SEG	7BH	**1-7**	9BH		
TimE	7CH	**1-8**	9CH		
EndS	7DH	**1-9**	9DH		
Sv1	7EH	**1-10**	9EH		
tP1	7FH	**1-11**	9FH	**Pv**	100H

6.2.2 CRC Generation

The Cyclical Redundancy Checking (CRC) field is two bytes, containing a 16–bit binary value. The CRC value is calculated by the transmitting device, which appends the CRC to the message. The device that receives recalculates a CRC during receipt of the message, and compares the calculated value to the actual value it received in the CRC field. If the two values are not equal, an error results.

The CRC is started by first preloading a 16–bit register to all 1's. Then a process begins of applying successive 8–bit bytes of the message to the current contents of the register. Only the eight bits of data in each character are used for generating the CRC. Start and stop bits and the parity bit, do not apply to the CRC.

During generation of the CRC, each 8–bit character is exclusive ORed with the register contents. Then the result is shifted in the direction of the least significant bit (LSB), with a zero filled into the most significant bit (MSB) position. The LSB is extracted and examined. If the LSB was a 1, the register is then exclusive ORed with a preset, fixed value. If the LSB was a 0, no exclusive OR takes place.

This process is repeated until eight shifts have been performed. After the last (eighth) shift, the next 8–bit character is exclusive ORed with the register's current value, and the process repeats for eight more shifts as described above. The final content of the register, after all the characters of the message have been applied, is the CRC value.

A procedure for generating a CRC is:

1. Load a 16–bit register with FFFF hex (all 1's). Call this the CRC register.
2. Exclusive OR the first 8–bit byte of the message with the low–order byte of the 16–bit CRC register, putting the result in the CRC register.
3. Shift the CRC register one bit to the right (toward the LSB), zero–filling the MSB. Extract and examine the LSB.
4. (If the LSB was 0): Repeat Step 3 (another shift).

   (If the LSB was 1): Exclusive OR the CRC register with the polynomial value 0xA001 (1010 0000 0000 0001).
5. Repeat Steps 3 and 4 until 8 shifts have been performed. When this is done, a complete 8–bit byte will have been processed.
6. Repeat Steps 2 through 5 for the next 8–bit byte of the message. Continue doing this until all bytes have been processed.
7. The final content of the CRC register is the CRC value.
8. When the CRC is placed into the message, its upper and lower bytes must be swapped as described below.

Placing the CRC into the Message

When the 16–bit CRC (two 8–bit bytes) is transmitted in the message, the low-order byte will be transmitted first, followed by the high-order byte.

For example, if the CRC value is 1241 hex (0001 0010 0100 0001):

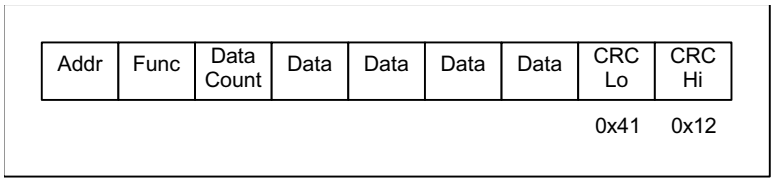
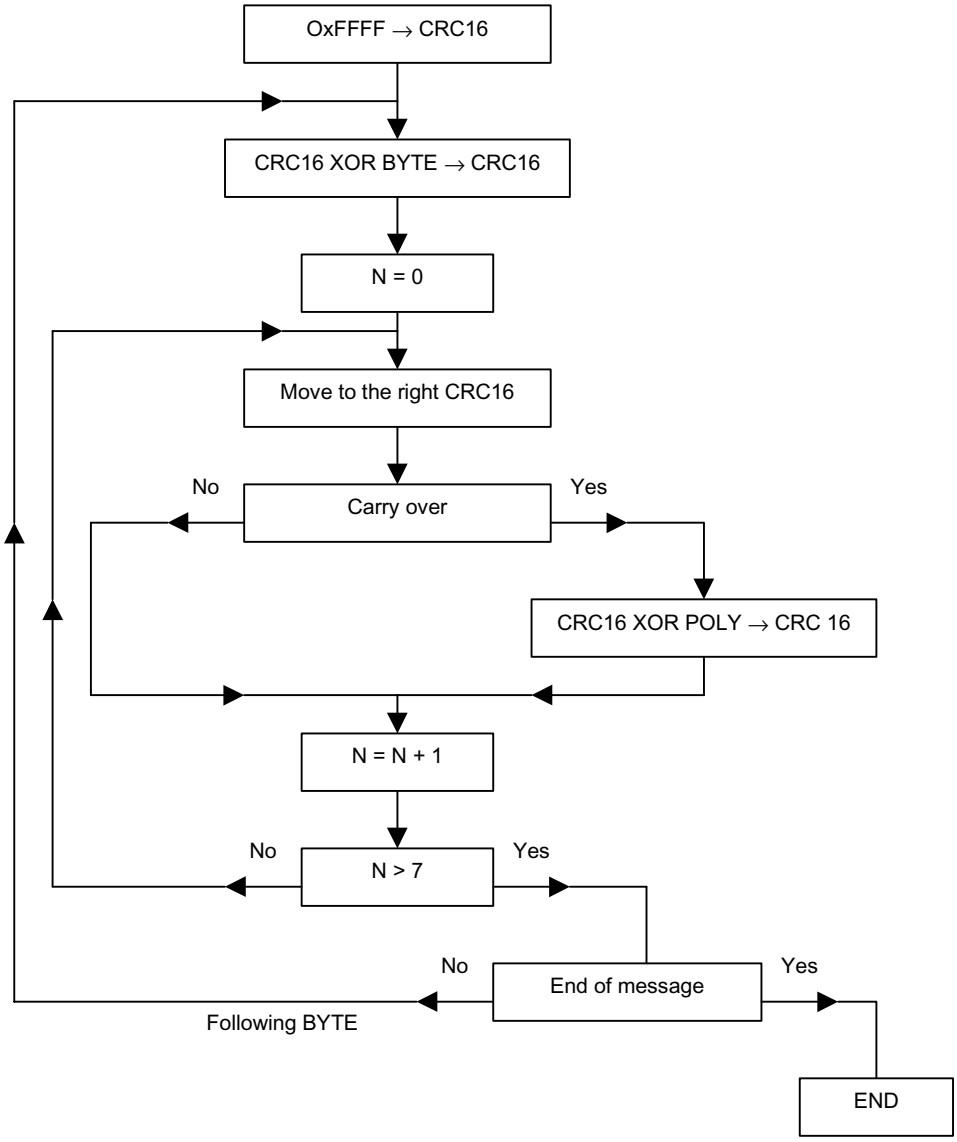


Figure 30: CRC Byte Sequence

Calculation algorithm of the CRC 16



XOR = exclusive or

N = number of information bits

POLY = calculation polynomial of the CRC 16 = 1010 0000 0000 0001

(Generating polynomial = $1 + x_2 + x_{15} + x_{16}$)

In the CRC 16, the 1st byte transmitted is the least significant one.

Example of CRC calculation (frame 02 07)

CRC register initialization		1111	1111	1111	1111
XOR 1st character		0000	0000	0000	0000
		1111	1111	1111	1101
	Move 1	0111	1111	1111	1110|1
		1010	0000	0000	0001
Flag to 1, XOR polynomial		1101	1111	1111	1111
	Move 2	0110	1111	1111	1111|1
Flag to 1, XOR polynomial		1010	0000	0000	0001
		1100	1111	1111	1110
	Move 3	0110	0111	1111	1110 | 0
	Move 4	0011	0011	1111	1111 | 1
		1010	0000	0000	0001
		1001	0011	1111	1110
	Move 5	0100	1001	1111	1111 | 0
	Move 6	0010	0100	1111	1111 | 1
		1010	0000	0000	0001
		1000	0100	1111	1110
	Move 7	0100	0010	0111	1111 | 0
	Move 8	0010	0001	0011	1111 | 0
		1010	0000	0000	0001
		1000	0001	0011	1110
		0000	0000	0000	0111
XOR 2nd character		1000	0001	0011	1001
	Move 1	0100	0000	1001	1100 | 1
		1010	0000	0000	0001
		1110	0000	1001	1101
	Move 2	0111	0000	0100	1110 | 1
		1010	0000	0000	0001
		1101	0000	0100	1111
	Move 3	0110	1000	0010	0111 | 1
		1010	0000	0000	0001
		1100	1000	0010	0110
	Move 4	0110	0100	0001	0011 | 0
	Move 5	0011	0010	0000	1001 | 1
		1010	0000	0000	0001
		1001	0010	0000	1000
	Move 6	0100	1001	0000	0100 | 0
	Move 7	0010	0100	1000	0010 | 0
	Move 8	0001	0010	0100	0001 | 0
				Most significant	least significant

The CRC 16 of the frame is then: 4112

Example

An example of a C language function performing CRC generation is shown on the following pages. All of the possible CRC values are preloaded into two arrays, which are simply indexed as the function increments through the message buffer. One array contains all of the 256 possible CRC values for the high byte of the 16–bit CRC field, and the other array contains all of the values for the low byte.

Indexing the CRC in this way provides faster execution than would be achieved by calculating a new CRC value with each new character from the message buffer.

Note: This function performs the swapping of the high/low CRC bytes internally. The bytes are already swapped in the CRC value that is returned from the function.

Therefore the CRC value returned from the function can be directly placed into the message for transmission.

The function takes two arguments:

unsigned char *puchMsg;	A pointer to the message buffer containing binary data to be used for generating the CRC
unsigned short usDataLen;	The quantity of bytes in the message buffer.

CRC Generation Function

```
unsigned short CRC16 ( puchMsg, usDataLen )          /* The function returns the CRC as a unsigned short type  */
unsigned char *puchMsg ;                             /* message to calculate CRC upon                          */
unsigned short usDataLen ;                           /* quantity of bytes in message                           */
{
        unsigned char uchCRCHi = 0xFF ;              /* high byte of CRC initialized                           */
        unsigned char uchCRCLo = 0xFF ;              /* low byte of CRC initialized                            */
        unsigned uIndex ;                            /* will index into CRC lookup table                       */

        while (usDataLen--)                          /* pass through message buffer                            */
        {
                uIndex = uchCRCLo ^ *puchMsgg++ ;    /* calculate the CRC                                      */
                uchCRCLo = uchCRCHi ^ auchCRCHi[uIndex} ;
                uchCRCHi = auchCRCLo[uIndex] ;
        }
        return (uchCRCHi << 8 | uchCRCLo) ;
}
```

High-Order Byte Table

/* Table of CRC values for high–order byte */

```
static unsigned char auchCRCHi[] = {
   0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81,
   0x40, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0,
   0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01,
   0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41,
   0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81,
   0x40, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0,
   0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01,
   0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40,
   0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81,
   0x40, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0,
   0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01,
   0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41,
   0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81,
   0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0,
   0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01,
   0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41,
   0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81,
   0x40
} ;
```

Low-Order Byte Table

/* Table of CRC values for low–order byte */

```
static char auchCRCLo[] = {
   0x00, 0xC0, 0xC1, 0x01, 0xC3, 0x03, 0x02, 0xC2, 0xC6, 0x06, 0x07, 0xC7, 0x05, 0xC5, 0xC4,
   0x04, 0xCC, 0x0C, 0x0D, 0xCD, 0x0F, 0xCF, 0xCE, 0x0E, 0x0A, 0xCA, 0xCB, 0x0B, 0xC9, 0x09,
   0x08, 0xC8, 0xD8, 0x18, 0x19, 0xD9, 0x1B, 0xDB, 0xDA, 0x1A, 0x1E, 0xDE, 0xDF, 0x1F, 0xDD,
   0x1D, 0x1C, 0xDC, 0x14, 0xD4, 0xD5, 0x15, 0xD7, 0x17, 0x16, 0xD6, 0xD2, 0x12, 0x13, 0xD3,
   0x11, 0xD1, 0xD0, 0x10, 0xF0, 0x30, 0x31, 0xF1, 0x33, 0xF3, 0xF2, 0x32, 0x36, 0xF6, 0xF7,
   0x37, 0xF5, 0x35, 0x34, 0xF4, 0x3C, 0xFC, 0xFD, 0x3D, 0xFF, 0x3F, 0x3E, 0xFE, 0xFA, 0x3A,
   0x3B, 0xFB, 0x39, 0xF9, 0xF8, 0x38, 0x28, 0xE8, 0xE9, 0x29, 0xEB, 0x2B, 0x2A, 0xEA, 0xEE,
   0x2E, 0x2F, 0xEF, 0x2D, 0xED, 0xEC, 0x2C, 0xE4, 0x24, 0x25, 0xE5, 0x27, 0xE7, 0xE6, 0x26,
   0x22, 0xE2, 0xE3, 0x23, 0xE1, 0x21, 0x20, 0xE0, 0xA0, 0x60, 0x61, 0xA1, 0x63, 0xA3, 0xA2,
   0x62, 0x66, 0xA6, 0xA7, 0x67, 0xA5, 0x65, 0x64, 0xA4, 0x6C, 0xAC, 0xAD, 0x6D, 0xAF, 0x6F,
   0x6E, 0xAE, 0xAA, 0x6A, 0x6B, 0xAB, 0x69, 0xA9, 0xA8, 0x68, 0x78, 0xB8, 0xB9, 0x79, 0xBB,
   0x7B, 0x7A, 0xBA, 0xBE, 0x7E, 0x7F, 0xBF, 0x7D, 0xBD, 0xBC, 0x7C, 0xB4, 0x74, 0x75, 0xB5,
   0x77, 0xB7, 0xB6, 0x76, 0x72, 0xB2, 0xB3, 0x73, 0xB1, 0x71, 0x70, 0xB0, 0x50, 0x90, 0x91,
   0x51, 0x93, 0x53, 0x52, 0x92, 0x96, 0x56, 0x57, 0x97, 0x55, 0x95, 0x94, 0x54, 0x9C, 0x5C,
   0x5D, 0x9D, 0x5F, 0x9F, 0x9E, 0x5E, 0x5A, 0x9A, 0x9B, 0x5B, 0x99, 0x59, 0x58, 0x98, 0x88,
   0x48, 0x49, 0x89, 0x4B, 0x8B, 0x8A, 0x4A, 0x4E, 0x8E, 0x8F, 0x4F, 0x8D, 0x4D, 0x4C, 0x8C,
   0x44, 0x84, 0x85, 0x45, 0x87, 0x47, 0x46, 0x86, 0x82, 0x42, 0x43, 0x83, 0x41, 0x81, 0x80,
   0x40
};
```