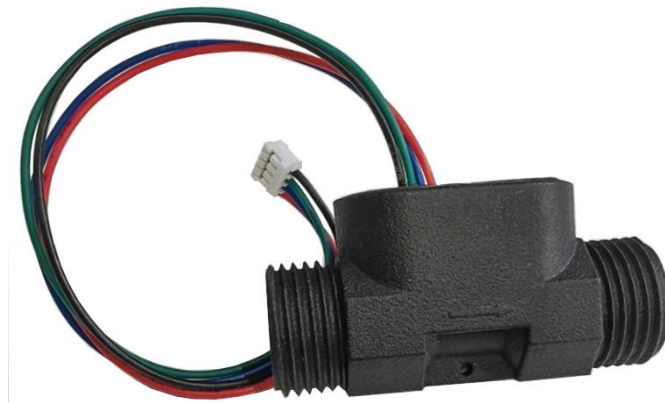Technical Datasheet

MUS-01

Miro Flow Sensor Module

The MUS-01 module is a flow sensing module based on ultrasonic flow sensing technology which mainly targets at the home appliance market, to replace current, traditional Hall sensor flow solutions.

Key Features & Benefits

- **Long-time reliability**
  - o Solve the pain point, no movable parts, no risk of getting stuck

- **High accuracy**
  - o Up to 5% accuracy at wide range(can be even better with customization)

- **Wide sensing range**
  - o 0 to 2000 l/h

- **Low power**
  - o Less than 5 mA with single 5 V power supply

- **Standard interface**
  - o UART, 1-wire communication supported and industrial standard mechanical interface

- **Cost effective**
  - o Simplified system design and automatic production to optimize the overall cost

- **Food grade material**
  - o Can be used for drinking water directly

Applications

- **Boilers**
- **Water purifiers**
- **Coffee Machines**
- **Micro Flow**

Table of Contents

1 Block diagram

The internal block diagram of MUS-01 is shown in Figure 1.
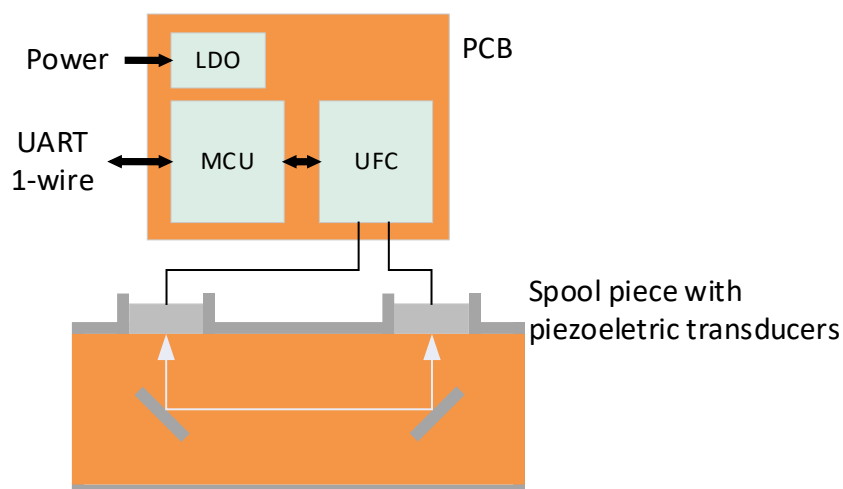

Figure 1: Functional blocks

2 Absolute maximum ratings

Stresses beyond those listed in this section may cause permanent damage to the device. These are - each at a time - stress ratings only. Functional operation of the device at these or any other conditions beyond those indicated under Electrical characteristics is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Table 1: MUS-01 absolute maximum ratings

Symbol	Parameter	Min	Max	Units	Comments
Electrical Parameters					
V_{DD}	Supply voltage	-0.30	6.0	V	
V_{IO}	IO voltage level	-0.30	5.5	V	UART_RX, UART_TX, 1-Wire
Electrostatic Discharge					
ESD_{HBM}	Human body model;all pins	±4000		V	JEDEC JS-001-2014
Water Pressure					
p_{Watr}	Maximum water pressure	4.0		MPa	
Operating and Storage Conditions					
T_{STRG}	Storage temperature	-25	100	°C	
T_A	Operating ambient temperature	-25	85	°C	

T_{Water}	Operating water temperature	0	60	°C	Not frozen
H_A	Operating ambient relative humidity	0	100	%RH	
p_{Water}	Operating water pressure		1.75	MPa	

3   Electrical characteristics

All limits are guaranteed. The parameters with min and max values are guaranteed with production tests or SQC (Statistical Quality Control) methods.

All values refer to T_A = 25 °C and at 1.80 V supply voltage, unless otherwise specified.

Table 2: Electrical characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{DD}	Supply voltage		4.5	5.0	5.5	V
I_{DD}	Supply current	Average working power consumption		2		mA
V_{IH}	High-level input voltage		$0.7 \times V_{DD}$		$V_{DD}+0.3$	V
V_{IL}	Low-level input voltage		-0.5		0.7	V

4   Sensor characteristics

Table 3: Electrical characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
F_{range}	Flow sensing range		0		2000	l/h
F_{acc}	Flow sensing accuracy	10 to 60 l/h			10	%
		60 to 2000 l/h		3	5	
T_{range}	Water temperature measurement range		1		60	°C
T_{acc}	Water temperature measurement accuracy			±1		°C

5 Interface Description

Table 4: Electrical characteristics

Pin Number	Pin Name	Description	
1	1-Wire	1-Wire output	
2	VCC	Power supply	
3	GND	Ground	
4	UART_RX	UART RX input	
5	UART_TX	UART TX output	
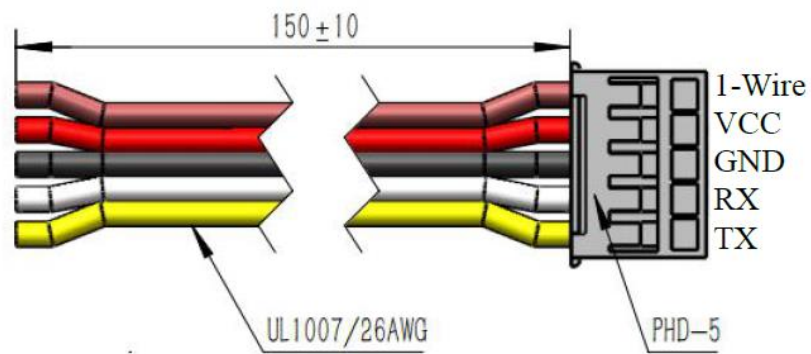
6   Mechanical Outline
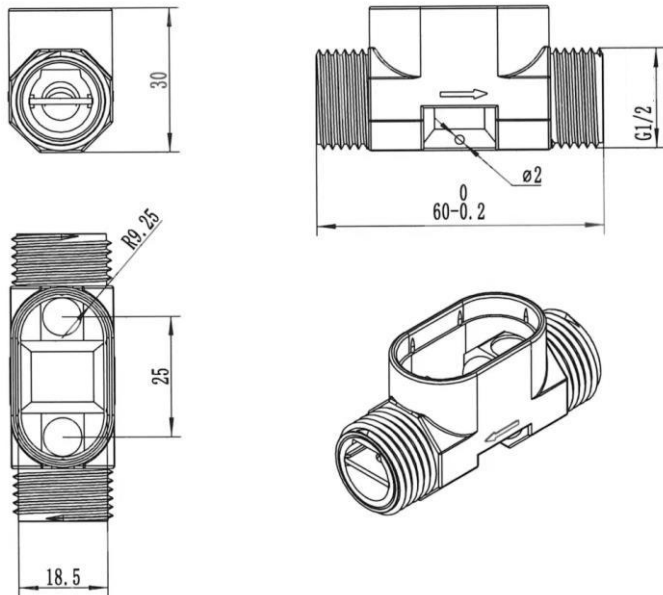

Figure 2: mechanical drawings

7   Application Information

7.1   UART
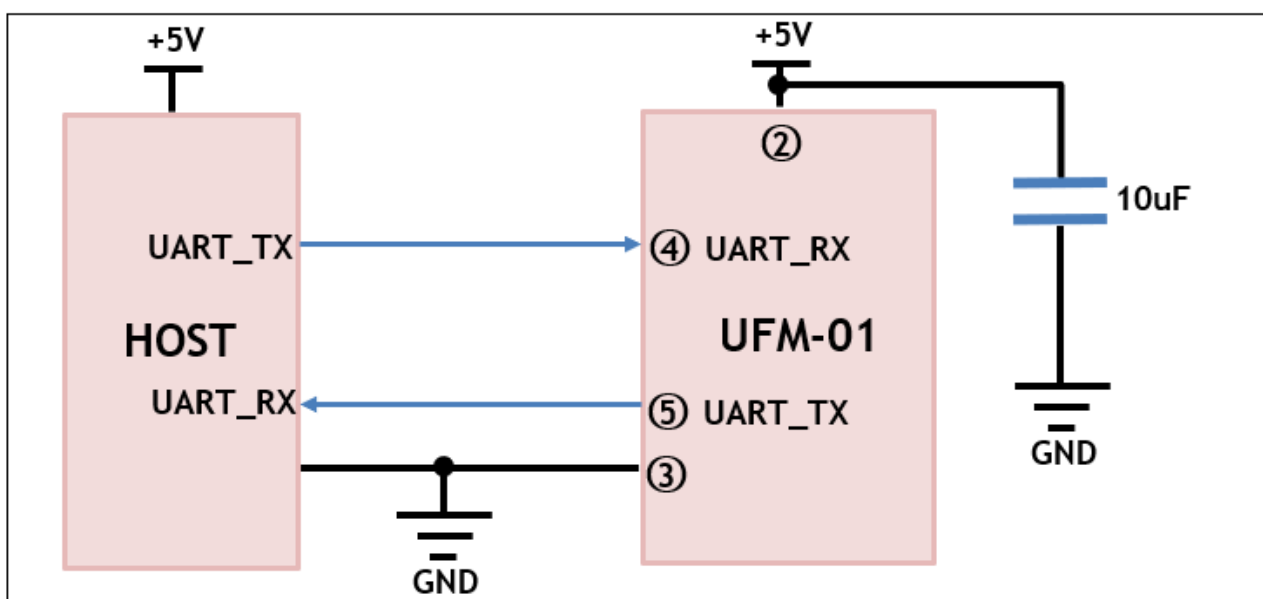
Figure 3: MUS-01 typical Application with UART connection

7.2   1-wire Connection
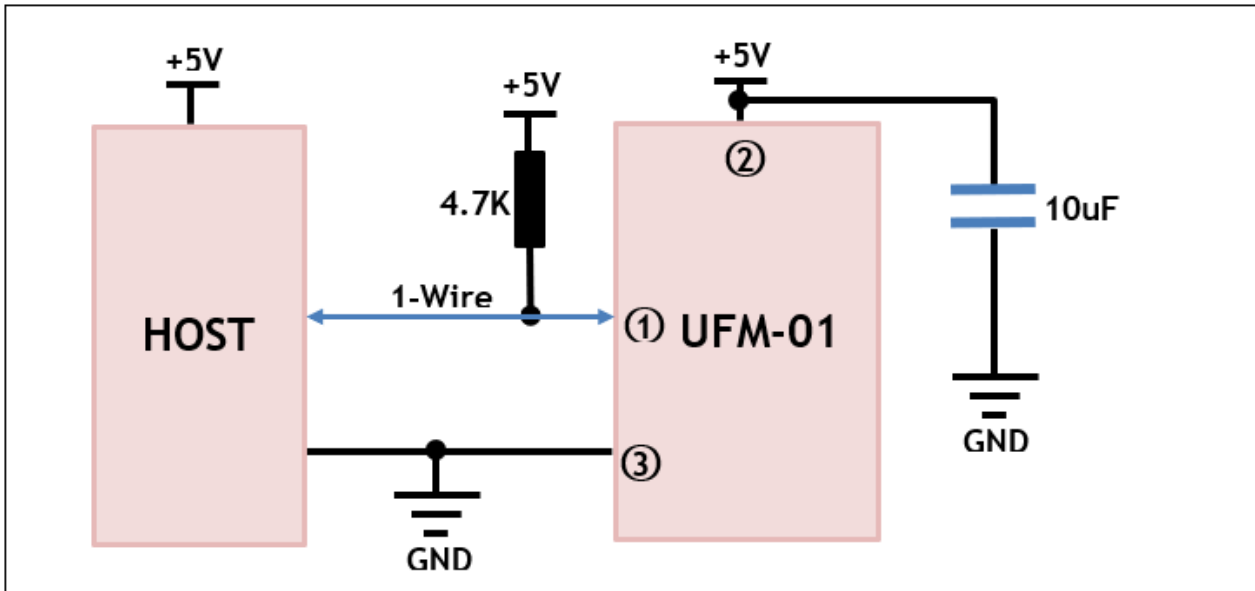
Figure 4: MUS-01 typical Application with 1-wire connection

8   UART Protocol

The UART protocol is based on

- Baude rate: 2400 bit/s
- Data bits: 8
- Parity: Even
- Stop bit: 1

8.1   Host Protocol

Table 5: Host protocol

Prefix Byte 1	Prefix Byte 2	Start Byte 1	Command Byte	Command para Byte	Checksum Byte	Stop Byte
0xFE	0xFE	0x11	CMD	DATA	CS	0x16

CS =(Command Byte +Command para byte n) & 0xFF

8.2 Command Definition

Table 6: Command definition

CMD	DATA1	Note
0x5A	0xFD	Clear accumulated flow
0x5C	00H- active 01H- passive	Change passive/active mode: Passive mode: device only send data when the host send a read command, data format according to the Table 22 and Table 23. Active mode: device send data automatically every second, data format according to the Table 21. Default: Active mode
0x5B	0xCB 0x0F	Read sensor data: 0xCB: Read all data including ID. 0x0F: Read data without ID. Data format defined in Table 22 and Table 23.
0x5D	0xCB	Reset the device

8.3 Answer

a)   Clear accumulated flow
       Host   0xFE 0xFE 0x11 0x5A 0xFD 0x57 0x16
       Device 0xE5

b)   Change passive/active mode
       Change passive mode:
       Host   0xFE 0xFE 0x11 0x5C 0x01 0x5D 0x16
       Device 0xE5

       Change active mode:
       Host   0xFE 0xFE 0x11 0x5C 0x00 0x5C 0x16
       Device 0xE5

c)   Read sensor data(WithOut ID):
       Host   0xFE 0xFE 0x11 0x5B 0x0F 0x6A 0x16
       Device Data out defined in 4. Data output format

d)   Read sensor data(With ID):
       Host   0xFE 0xFE 0x11 0x5B 0xCB 0x26 0x16
       Device Data out defined in 4. Data output format

e)   Reset the module:
      Host   0xFE 0xFE 0x11 0x5D 0xFD 0x5A 0x16
      Device 0xE5

8.4 Data Output Format

Table 7: Data output(Active Mode)

0	1	2	3	4	5	6	7
Start Byte1	Start Byte2	Device ID, fox example 2307140001 Data: 230714 SerialNum:0001					Reserved
0x3C	0x32	0x01	0x00	0x14	0x07	0x23	0x01

8	9	10	11	12	13	14	15
Acc Flow Flag	If Flag is 0x0A, then Acc Flow is 331023456.789l LSB:0.001L If Flag is 0x1A, then Acc Flow is 331023456.789m3 LSB:0.001m3						Instant Flow Flag
0x0A 0x1A	0x89	0x67	0x45	0x23	0x10	0x33	0x0B

16	17	18	19	20	21	22	23
Instant Flow is -234567.89 l/h, LSB:0.01l/h Bit20:0x80,Negative Value					Reserved		
0x89	0x67	0x45	0x23	0x80	0x0C		

24	25	26	27	28	29	30	31
Temp Flag	Measured water temperature in degree, for example 56.34 ˚C			ST1	ST2	Checksum	Stop Byte
0x0D	0x34	0x56	0x00			CS =(Byte 0 + Byte 1 + … +ST2) & 0xFF	0x16

Table 8: Data output(Passive Mode, Data report when read all data including ID)

0	1	2	3	4	5	6	7
Start Byte1	Start Byte2	Device ID, fox example 2307140001 Data: 230714 SerialNum:0001					Reserved
0x3C	0x96	0x01	0x00	0x14	0x07	0x23	

8	9	10	11	12	13	14	15
Acc Flow Flag	If Flag is 0x0A, then Acc Flow is 331023456.789l LSB:0.001L If Flag is 0x1A, then Acc Flow is 331023456.789m3 LSB:0.001m3						Reserved
0x0A/0x1A	0x89	0x67	0x45	0x23	0x10	0x33	

16	17	18	19	20	21	22	23
Reserved						Instant Flow Flag	
						0x0B	0x89

24	25	26	27	28	29	30	31
-234567.89 l/h,LSB:0.01l/h Bit20:0x80,Nagetive Value				Reserved			Temp Flag
0x67	0x45	0x23	0x80				0x0D

32	33	34	35	36	37	38
Measured water temperature in degree, for example 56.34 °C			ST1	ST2	Checksum	Stop Byte
0x34	0x56	0x00			CS =(Byte 0 + Byte 1 + … + ST2) & 0xFF	0x16

Table 9: Data output(Passive Mode, Data report when read data without ID)

0	1	2	3	4	5	6	7
Start Byte1	Start Byte2	Acc Flow Flag	If Flag is 0x0A, the Acc Flow is 331023456.789l LSB:0.001L If Flag is 0x1A, the Acc Flow is 331023456.789m3 LSB:0.001m3				
0x3C	0x64	0x0A/0x1A	0x89	0x67	0x45	0x23	0x10

8	9	10	11	12	13	14	15
	Instant Flow Flag	-234567.89 l/h, LSB:0.01l/h Bit20:80,Nagetive Value					Temp Flag
0x33	0x0B	0x89	0x67	0x45	0x23	0x80	0x0D

16	17	18	19	20	21	22
Measured water temperature in degree, for example 56.34 °C			ST1	ST2	Checksum	Stop Byte
0x34	0x56	0x00			CS =(Byte 0 + Byte 1 + … + ST2) & 0xFF	0x16

ST1 & ST2 are used for error code, ST1 is defined as below and ST2 is reserved:

ST2	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
			UFC chip error		Flow direction wrong	Flow rate out of range		

ST1	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
			Empty tube			-	-	

UFC chip error: UFC not detected or abnormal.
Flow direction wrong: Negative flow detected.

Empty tube: No water detected in the tube.

Flow rate out of range: Big flow rate out of range continuously detected for 5s.

9   1-wire Protocol

9.1   Protocol Description

The read and write operation of 1-wire protocol is low bit first and high bit last. The 1-wire interface of MUS-1 receives the reading time sequence and sends out measurement data. If the data is not ready, all the data will be zero. MUS-1 is a slave, which transmits data at a rate of 16.3k bit/s.

The sequence parameters in the figures in this section are from the general standard, and the brackets are the parameters implemented by the slave. In addition to standard function mode (NM), MUS-1 has added a simplified mode (SM) to reduce data flow.

As 1-wire interface is simulated via MCU's GPIO, it is not fully compatible with the hardware interface and some parameters are limited, pls refer to the following description for details.

9.1.1   BUS Initialization (1WRST)

The slave will pull the BUS down 60-240 us within 15-60 us after receiving the effective jump. During this period, the host will sample the bus to determine whether the slave is connected to the current BUS.
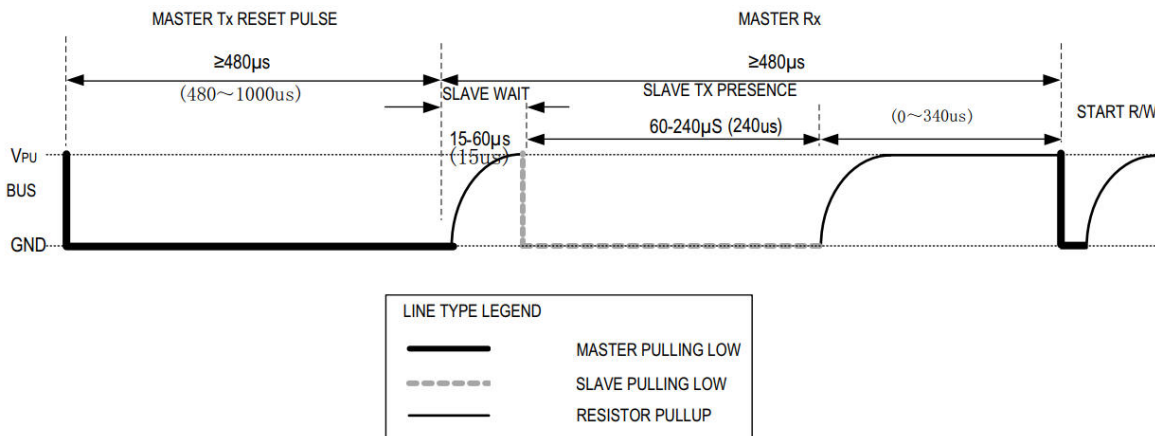
9.1.2   Master Write Operation

It needs at least 60 us for the master to write one bit to the bus, and there is more than 1 us interval for continuous write operations.

The operation steps of the master when writing data are as follows:

    1) The master pulls down the bus by 1 us.

    2) The master releases the bus within 15 us (routine is 3 us), and then puts the data immediately.

3) The master waits (routine is 50 us) for the end of this receiving cycle of 60 us, and then releases the bus.

4) If the data is not sent completely, wait for 1 us, repeat the above steps, and prepare to send the next bit.

The operation steps of the slave when writing data are as follows:

1) When there are 1-15 us low pulses on the slave detection bus, it is ready to receive data.

2) The slave reads the bus data in a time window of 15-60 us (20 us is recommended).
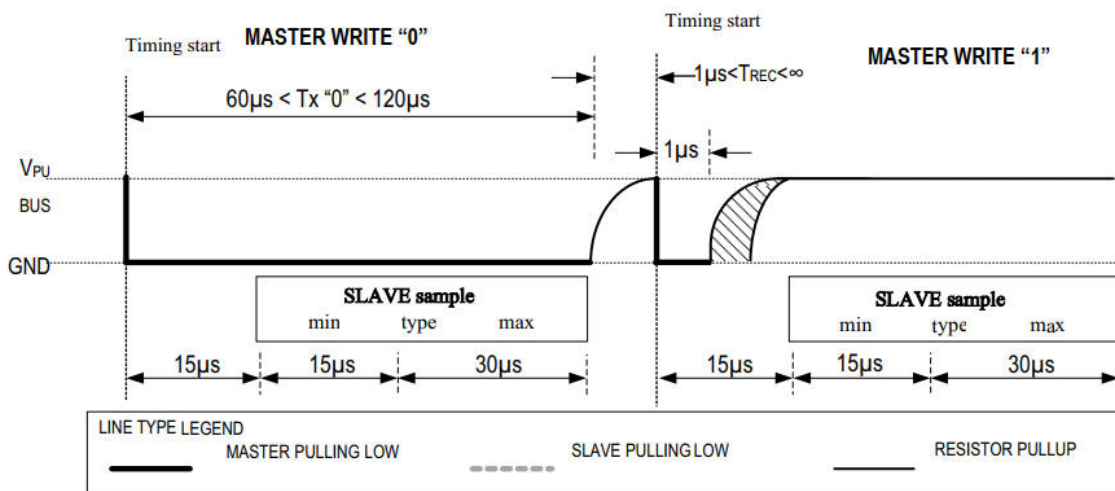
9.1.3   Master Read operation

The master needs at least 60 us to read one bit from the bus, and the interval between two consecutive read operations is more than 1 us.

When reading data, the master operation steps are as follows:

1) The master pulls down the bus by 1-15 us (routine is 4 us) and then releases it.

2) The host reads the bus value within 15 us, with a routine of 11 us.

3) The master waits (routine 40 us) for the end of this receiving cycle of 60 us, and then releases the bus.

4) If the data is not received completely, wait for 1 us or more (routine is 1 us), repeat the previous steps, and prepare to receive the next bit.

When reading data, the slave operation steps are as follows:

1) The slave detects the bus, data is immediately inserted when there are 1-15 us low pulses or at the falling edge.

Note: If the low pulse of the host is as low as 1 us, the slave may not be able to detect the accurate pulse width. A compromise method can be considered: after the slave detects the falling edge, it detects the high level arrival time t through interrupts or scans greater than 1 us

and less than 10 us. If t is less than 10 us, the slave will input data; If t is greater than 10 us, continue to detect and determine whether it is a 1WRST signal.

2) Hold the data to 60 us and then release the bus.

3) If the data is not sent completely, repeat the above steps to prepare to send the next bit.

9.2   1-wire Command

The command format is: command [parameters] [checksum], and the content of [] can be omitted, and the checksum is the 8-bit cumulative value of the parameter.

Table 10: 1-wire Command format

Command	Function
0x5a	Clear accumulated flow
0x5b, REG, data1,data2 ...	Continuously read data from address register (REG), with REG and read range from 0x30 to 0x3b
0x5d	Reset module

Notes:

1. [para] is the data read, with low bytes leading and can be omitted. After omission, the function of the command is the same as 0xaa.
2. The NM mode can be switched directly by command. When switching between SM mode and NM mode, or between SM modes, initialization (1WRST) must be executed first.
3. When already in SM mode, there is no need to issue a command to read data. Instead, initiate a read operation and return the last requested type data from the slave.

9.3   1-wire registers

Address	Symbol
0x30	InFl_L
0x31	InFl_M
0x32	InFl_H
0x33	InFl_CRC8
0x34	T_L
0x35	T_M
0x36	T_H
0x37	T_CRC8
0x38	CuFl_L
0x39	CuFl_M
0x3a	CuFl_H
0x3b	CuFl_CRC8

Example 1: 0x30 to 0x32 are sequentially 0x40, 0x0d, and 0x03, indicating an instantaneous flow of 200000 × 0.01=2000 l/h.

Example 2: 0x34 to 0x36 are sequentially 0x70, 0x17, and 0x00, indicating a temperature of 6000 × 0.01=60 ℃.

Example 3: 0x38 to 0x3a are sequentially 0xff, 0xff, and 0xff, indicating a cumulative flow of 16777215 × 1677721.5 l (1677.7 m3).1-wire parameters

9.4   CRC-8 calculation

CRC-8 calculation of array 'val' with a length of 'length'

```
uint8_t crc8( uint8_t *val, uint8_t length )
{
    uint8_t CRC=0xFF;
    uint8_t i,t;
    for(i=0;i<length;i++)
    {
        CRC^=val[i];
        for(t=8;t>0;--t)
        {
            if(CRC&0x80) { CRC=(CRC<<1)^0x31u;}
            Else { CRC=(CRC<<1); }
        }
    }
    return CRC;
}
```

9.5   Example of 1-wire read/write

10   Ordering information

Table 11: Ordering information

Ordering Code	Material ID	Package	Description	Delivery Quantity
MUS-01	-	-	Miro Sciosense Flow module	pcs

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