Product Introduction

Summary

Ultrasonic Liquid Level Sensor (ULD_3) is designed for non-contact measurement of liquid level height in the closed container. The sensor can be installed directly under the measured container. It can accurately measure the liquid level of various toxic substances such as acids, alkalis and various pure liquids in high temperature and high pressure sealed containers. ULD may be deployed for various high-density container material such as steel, plastic, plastic, ceramics, and non-foaming plastics.

Product Highlights

- Non-contact liquid level measurement
- Full range real-time monitoring. Live filling during monitoring is allowed.
- IP67 compliant
- Operating temperature: -15˚C to +60˚C
- Storage temperature: -25˚C to +80˚C
- Electrostatic discharge: IEC61000-4-2 compliance

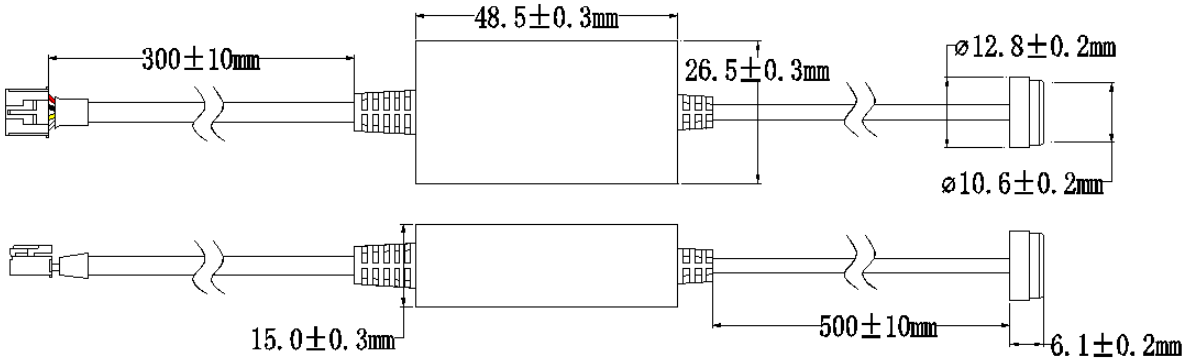
Device Characteristics

Description	Value	Unit
Input voltage	10~36	V_{DC}
Average current (1)	<30	mA
Detection Range (2)	40~2000	mm
Cycling Time	2	s
Output mode	UART/RS485	-
Resolution	1	mm
Room temperature accuracy (3)	±(5+H*1%)	mm

Notes:

1. Current consumption decreases with lower input voltage. The current consumption of 2s working cycle with 12V input voltage.
2. To emulate steel container, range obtained on water filled PVC container with Φ160mm placed on 2 mm thick steel plate at room temperature.
3. The data obtained under test environment as specified in note 2. “H”, denotes the current liquid level height.

Dimensions



Pin Definition

Color	Name	Description
Red	VCC	Power Input
Black	GND	Ground
Yellow	TX/D- (1)	UART Output/RS485 data -
White	RX/D+	Reserved/RS485 data +

Note:
1. Vout max is $5V_{DC}$.

Output Formats

Two output formats are available, UART and RS485, and must be selected with the matching model part name. UART mode actively outputs data without user input. RS485 mode will respond when instructed.

UART

Communication Description

Data bits	Stop bit	Parity check	Baud rate
8	1	NA	9600bps

Data packet description

Frame data	Description	Length
Header	0xFF	1byte
Data_H	High 8 bits of distance data	1byte
Data_L	Lower 8 bits of distance data	1byte
Checksum	Checksum	1byte

3. UART output example

Frame head	Data_H	Data_L	SUM
0XFF	0X07	0XA1	0XA7

Notes:

Only lower 8 bits of the accumulated value are kept;

Sum = (frame header + Data_H + Data_L) & 0x00ff

=(0XFF + 0X07 + 0XA1)&0x00FF

=0XA7;

Liquid level value = Data_H && Data_L = 0x07a1;

Conversion to decimal equals 1953mm;

RS485

Overview of Communication Protocol

Two communication protocols, Pro-Wave protocol and Modbus protocol, are supported. The sensor will determine the communication protocol based on the received data.

Communication Protocol Parameters

Default communication format: 9600, N, 8, 1 (baud rate: 9600, no check bit, 8-bit data bit, 1-bit stop bit).

Modbus protocol must support 0x03 an 0x06 function codes.

Application Scope of Communication Protocol

ULD_3 supports Modbus Protocol that includes 0x03 and 0x06 function code; or PRO-WAVE protocol.

Modbus Protocol Description

MODBUS Register Address

Protocol: MODBUS; mode: RTU; Slave address 0x01 (default)

Modbus read function address planning, function code: 0x03			
Op	Reg Addr	Reg Info	Description
R	0x00	Processed value[1]	Processed average value, unit: 1mm
R	0x01	Real time value	Real time measurement, 1mm
RSVD	0x02	RSVD	RSVD
Modbus write function address planning, function code: 0x06			
RSVD	0x03	RSVD	RSVD
RW	0x04	Slave address	Default: 0x01, Applicable range: 0x01 ~ 0xF7.
RW	0x05	Liquid Type	Default 0x01: water. 0x02: oil. All other values are invalid.
RW	0x06	Cycle time per seconds	Default: 0x02 Applicable range: 0x01~0x3C

Note:

1. The processed value is the value after the sensor samples the liquid level 5 times and discarding the first and last value while the real-time value is the live value.

Modbus Protocol Communication Example

1. Read the value (real-time value) of the register of address 0x01
   Master sends: 01 03 00 01 00 01 D5 CA
   01: Slave address
   03: Function Code
   00 01: Register address to read real time value
   00 01: Report back 1 register
   D5 CA: Checksum Big Endian CRC-16
   Slave Replies: 01 03 02 00 D2 38 19
   01: Slave address
   03: Function code
   02: Data length (2 bytes)
   00 D2: Liquid level 210mm
   38 19: Checksum Big Endian CRC-16

2. Read two data from address 0x00, processing value and real-time value.
   Master sends: 01 03 00 00 02 C4 0b
   01: Slave address
   03: Function Code
   00 00: Register address to read processed data value
   00 02: Report back 2 registers (0x00 and 0x01)
   C4 0B: Checksum Big Endian CRC-16

   Slave Replies: 01 03 04 00 DC 00 DD FB 90
   01: Slave address
   03: Function code
   04: Data length (4 bytes)
   00 DC: Register 0x00 (processed value) Liquid level 220mm

00 DD: Register 0x01 (real time value) Liquid level 221mm
FB 90: Checksum Big Endian CRC-16

3. Write data 0x02 to address 0x05, and set the liquid type to oil.
Master sends: 01 06 00 05 00 02 18 0A
01: Slave address
06: Function Code
00 05: Register address set liquid type
00 02: Set liquid type to 0x02 (oil)
18 0A: Checksum Big Endian CRC-16
Slave Replies: 01 06 00 05 00 02 18 0A
01: Slave address
06: Function code
00 05: Register address written is 0x05 (liquid type)
00 02: Register value written is 0x02
18 0A: Checksum Big Endian CRC-16

4. Write data 0x0a to address 0x06 and change cycle time to 10 seconds.
Master sends: 01 06 00 06 00 0A E9 CC
01: Slave address
06: Function Code
00 06: Register address set to cycle time
00 0A: Set cycle time to 10 seconds
E9 CC: Checksum Big Endian CRC-16

Reply from slave: 01 06 00 06 00 0A E9 CC
01: Slave address
06: Function Code
00 06: Register address written is 0x06 (cycle time)
00 0A: Register value written is 0x0A
E9 CC: Checksum Big Endian CRC-16

5. Write data 0x02 to address 0x04 and set Slave address to 0x02
Master sends: 01 06 00 04 00 02 49 CA
01: Slave address
06: Function Code
00 04: Register address set to Slave address
00 02: Set Slave address to 0x02
49 CA: Checksum Big Endian CRC-16

Slave Replies: 01 06 00 04 00 02 49 CA
01: Slave address
06: Function Code
00 04: Register address written to is 0x02 (Slave address)
00 02: Register value written is 0x02
49 CA: Checksum Big Endian CRC-16

6. Read the value (real-time value) of the register of address 0x01
Master sends: 02 03 00 01 00 01 D5 F9
02: Slave address (updated after last step)
03: Function Code
00 01: Register address to read real time value

00 01: Report back 1 register
D5 F9: Checksum Big Endian CRC-16

Slave Replies: 02 03 02 00 82 7C 25
02: Slave address
03: Function code
02: Data length (2 bytes)
00 82: Liquid level 130mm
7C 25: Checksum Big Endian CRC-16

Pro-Wave Protocol Description

Operation Instruction

Operation Description	Op code
Read processed value	0x01
Read real time value	0x02
Change slave address	0x03
Liquid medium setting[1]	0x04
Cycle time setting	0x05

Note:
1. Available options are 0x01: water (default) or 0x02: diesel

Data Frame Format

	Sync word		Slave addr	Op Code	Data		Checksum
Master	0x55	0xAA	0x01	0x01	None or data[1]		Checksum
Slave	0x55	0xAA	0x01	0x01	Data_H	Data_L	Checksum

Note:
1. Refer following examples in section in the following section

Checksum Calculation

Checksum value follows CheckSum8 Modulo 256.
Checksum = (frame header + address + instruction + data) & 0x00ff
Checksum failure will result in no operation and response.

Pro-Wave Protocol Communication Examples

1. Read the processed value
Master sends: 55 AA 01 01 01
55 AA: Sync Word
01: Slave address (default)
01: Op code to read processed value
01: Checksum. (0x55+0xaa+0x01+0x01) &0x00ff = 0x01
Slave Replies: 55 AA 01 01 02 33 36
55 AA: Sync Word
01: Slave address
01: Report received op code
02 33: Liquid level is 563mm
36: Checksum.

2. Modify slave address
Master sends: 55 AA 05 03 07

55 AA: Sync Word
05: Updated slave address to 0x05
03: Op code to change slave address
07: Checksum.
Slave Replies: 55 AA 05 03 07
55 AA: Sync Word
05: Slave address
03: Report received op code
07: Checksum.

3. Read processed value
Master sends: 55 AA 05 01 05
55 AA: Sync Word
05: Slave address
01: Op code to read processed value
05: Checksum.
Slave Replies: 55 AA 05 01 02 33 3A
55 AA: Sync Word
05: Slave address
01: Report received op code
02 33: Liquid level is 563mm
3A: Checksum.

4. Modify measured liquid medium
Master sends: 55 AA 05 04 00 02 0A
55 AA: Sync Word
05: Slave address
04: Op code to change liquid medium
00 02: Update liquid medium from 0x01(default) to 0x02 (diesel)
0A: Checksum.
Slave Replies: 55 AA 05 04 00 02 0A
55 AA: Sync Word
05: Slave address
04: Report received op code
00 02: Report received value
0A: Checksum

5. Modify cycle time
Master sends: 55 AA 05 05 00 0A 13
55 AA: Sync Word
05: Slave address
05: Op code to change cycle time
00 0A: Update to 10 seconds. Valid range 0x01~0x3C. Default is 0x02.
13: Checksum
Slave Replies: 55 AA 05 05 00 0A 13
55 AA: Sync Word
05: Slave address
05: Report received op code
00 0A: Report received value
13: Checksum.

6. Broadcast slave bus address

Master sends: 55 AA FF 01 03
55 AA: Sync Word
FF: Slave address set to FF will force sensor to broadcast value
01: Register to broadcast
-0x01: Processed value
-0x02: Real time value
-0x03: Slave address
-0x04: Liquid medium
-0x05: Cycle time
03: Checksum
Slave Replies: 55 AA 05 01 02 45 4C
55 AA: Sync Word
05: Slave address
01: Requested reporting register (processed value)
02 45: Report requested value
Register 0x01,0x02,0x05 will report 2 bytes of data.
Register 0x03,0x04 will report only 1 byte of data.
4C: Checksum.

External LED Indicator

Led on:
The sensor is powered but no liquid is detected.
Led slow flashing:
When the sensor detects a liquid, the LED indicator flashes at a frequency of 1 per second.

Model Selection

Part Name	Feature
ULD_3U	UART output with fixed cycle time
ULD_38	RS485 output with user input control

Design Consideration

1. Detection range will be different pending the conditions listed.
   - Container materials such as steel, glass, iron, ceramic, non-foaming plastics, and other high-density materials.
   - Container wall thickness.
2. UART output will fluctuate under the following conditions.
   - Liquid level exceeds the detection range.
   - Liquid level is tilted or changing.

Revision History

Date	Version	Description
12/01/2019	1.0	Initial Pro-Wave release.
01/09/2019	1.1	RS485 protocol updated with Pro-Wave variation
01/15/2020	1.2	Documentation format update