Soil and Water environment sensor Specification Sheet

Model :LT5006

Murata Manufacturing Co., Ltd.

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[1]Abstract

Murata soil and water environment sensor has developed as a sensor which monitors the conditions continuously at several environments.
Three sensors are installed in one package, they can measure EC(Electrical conductivity),Moisture(Volumetric water content; VWC) and Temperature in the soil and water at same time.
As an option, Murata can provide own wireless module(transmitter, receiver and gateway). It substantializes to monitor at wide area and at fixed-point with real time.

[2]Feature

・ Simple user interface with three sensors in one package.
・ High accuracy VWC measurement without the effect of saline.
・ No calibration for mineral soil and organic soil. Customized calibration available for several soils.
・ Small EC, Temperature sensor for spot area. Gathering 3D information with multi placement.
・ Rugged and water proof structure for in-soil and in-water use.
・ Low voltage and Low power consumption for wireless system.
・ As an option, Murata original protocol 2.4GHz transmitter and receiver and gateway.

[3]Sensing target

①EC sensor
  Electrical conductivity depends on contained anion/ cation amount.
  (NO_3,NH_4,H_2PO_4,K,Ca,Mg,Nacl etc..)
②Moisture sensor
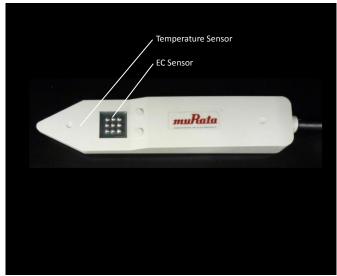 Measure the electric permittivity, translate to VWC.
③Temperature sensor
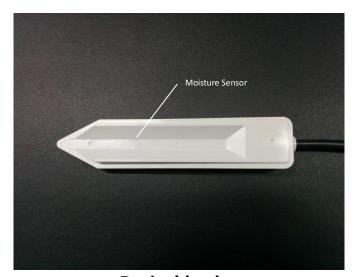 Temperature in the soil and water environment.

[4]Application

・Long term soil condition monitoring
・Agriculture irrigation system control
・Land slip disaster monitoring
・Long term river and pond water condition monitoring
・Aquaculture pond water condition control
・Powder dry monitoring and control
・Soil and water environment research

[5]Sensor Figure

Sensor size: 132.5 x 27 x 16.2 mm

Temperature Sensor

EC Sensor

Top side view

Moisture Sensor

Back side view

[6]Specification

EC		Comments
Range[dS/m]	0－2	
Resolution[dS/m]	0.001	
Accuracy[dS/m]	±0.01 ±1digit	r.d.g
Temperature		
Range[°C]	-20 – 70	
Resolution[°C]	0.0625	
Accuracy[°C]	±1.0 ±1digit	r.d.g
Moisture		
Range[%]	0－60	
Resolution[%]	0.1	
Accuracy[%]	±3	r.d.g

Items	minimum	typical	maximum	Remark
Operation Power Supply[V]	3.0	-	6.0	
Active Current[mA]	25	30	50	@Read/Write cycle
Operation Temperature[°C]	-20	-	70	
Measurement Cycle [ms]	Free			
Enclosure Class	IP68			
Interface	Digital UART			
Cable length[m]	3m@UART			

[7]Warranty
 The soil and water environment sensor has a one-year warranty.

[8]Sensor operation

①EC sensor
 EC sensor can measure electrical conductivity of surrounding environments. The basic method is the resistance measurement between two electrodes using alternating voltage. The electrodes need to be protected from corrosion. Therefore, it is important to use the low voltage and the high corrosive-resistant materials.
  Normally EC sensor measures the bulk EC, but to know the Pore EC is also important as an indicator of the solute concentration. This is calculated by some parameters which is measured by moisture sensor.
   All sensors have the high accuracy by calibration compensated the temperature dependence also before shipment.
   On the other hand, EC sensor outputs the raw A-D converter values also, the customer can examine the essential quality for the environments.

②Moisture sensor
 Moisture sensor can measure VWC(volumetric water content) of surrounding environments. The basic method is the electric permittivity measurement between two electrodes using alternating voltage with 200MHz. The electric permittivity bears a proportionate to VWC. The electric permittivity at air(no water) becomes close to 0. On the other hand, the electric permittivity at water(100%) becomes close to 80.
 High frequency of 200MHz can eliminate the error effect by the content of ions.
 All sensors have the high accuracy for the temperature compensation.

③Temperature sensor
 Temperature sensor utilizes application of diode K factor. It realizes to measure with a high speed and a high accuracy.

[9]Communication specification

Applicable Model

LT5006

Interface

Connection Type	UART
Signal	TxD, RxD
Baud rate	9600
Data	8 bit
Parity	None
Stop	1 bit
Flow Control	None
Data Format	Binary
Note:	If you want to connect your PC and a soil sensor with a USB port, you may use a USB-Serial Converter cable(TTL-232RG-VIP-WE from FTDI(for UART) etc.)

Cable

No.	Color	Input/output						Remark
		Name	Symbol	IO		Min	Max	
1	RED	Supply Voltage	VDD	-		3.0	6.0	
2	BLACK	Ground	VSS	-		0.0	0.0	
3	WHITE	Enable the device	EN	IN	VIH	0.8 x VDD	VDD	
					VIL	VSS	0.2 x VDD	
4	BLUE	Transmitted Data	TxD	OUT	VOH	VINT - 0.45	-	+2mA
					VOL	-	0.45	
5	YELLOW	Received Data	RxD	IN	VIH	0.7 x VINT	VINT + 0.3	
					VIL	VSS - 0.3	0.3 x VINT	
6	GREEN	No connected	NC	-		-		
7	ORANGE	No connected	NC	-		-		
8	GRAY	No connected	NC	-		-		
-	-	Internal Voltage	VINT	-		3.3		

Communication Format

Name	Size	Description
Function Code	1 byte	Specify "read" or "write"
Start Address	1 byte	Indicate the start address of data for read or write
Byte Size	1 byte	Specify the Byte size of data for read or write
Data	Up to 26 bytes	Read data or write data
Error Check	2 bytes	Error Check field based on CRC-16.

Function Code

Function Code	Action
0x01	Read
0x02	Write

Operation Method

①Firstly Measuring operation starts by write operation of "0x01" to SNSR_CTRL register.
②Next, Host device needs a monitoring of sensor status in SNSR_STATE register.
③After the measurement finished, host device can read the measurement data.

Read (0x01)

A message from a host device specifies an address and size of data.

A response from the soil sensor includes an address, size and read data.

Message

Host device -> Soil Sensor

No.	Format	Example
1	Function Code	0x01
2	Start Address	0x09
3	Byte Size	0x04
4	CRC-16(Upper)	0x93
5	CRC-16(Lower)	0x27

Response

Soil Sensor -> Host device

No.	Format	Example
1	Function Code	0x01
2	Start Address	0x09
3	Byte Size	0x04
4	Data1(Lower)	0x19
5	Data1(Upper)	0x0B
6	Data2(Lower)	0xFA
7	Data2(Upper)	0x0A
8	CRC-16(Upper)	0xA0
9	CRC-16(Lower)	0x4E

Write(0x02)

A message from a host device specifies a address, size and data.

When the data are written successfully, the soil sensor echoes back the message.

To start measurement, firstly it is needed to write "0x01" to SNSR_CTRL(0x07).

Message

Host device -> Soil Sensor

No.	Format	Example
1	Function Code	0x02
2	Start Address	0x23
3	Byte Size	0x04
4	Data (1/4)	0x40
5	Data (2/4)	0x4B
6	Data (3/4)	0x4C
7	Data (4/4)	0xBB
8	CRC-16(Upper)	0x36
9	CRC-16(Lower)	0xDF

Response

Soil Sensor -> Host device

No.	Format	Example
1	Function Code	0x02
2	Start Address	0x23
3	Byte Size	0x04
4	Data (1/4)	0x40
5	Data (2/4)	0x4B
6	Data (3/4)	0x4C
7	Data (4/4)	0xBB
8	CRC-16(Upper)	0x36
9	CRC-16(Lower)	0xDF

Error Message

If a host device sends an inappropriate message, it will receive an error message.

If a communication error or CRC error occurs, the soil sensor does not return a response.

Format	Size
Function Code | 0x80 [1]	1 byte
Error Code	1 byte
Error Check (CRC-16)	2 bytes

[1] MSB of a received function code is set to 1.

Error Code	Description
0x01	Illegal Function Code
0x02	Illegal Start Address
0x03	Illegal Byte Size
0x04	Receive buffer overflow
0x05	CRC-16 error
0x06	Sensor is measuring
0x10	Failed to write register
0x20	Internal I2C communication error

Register Map
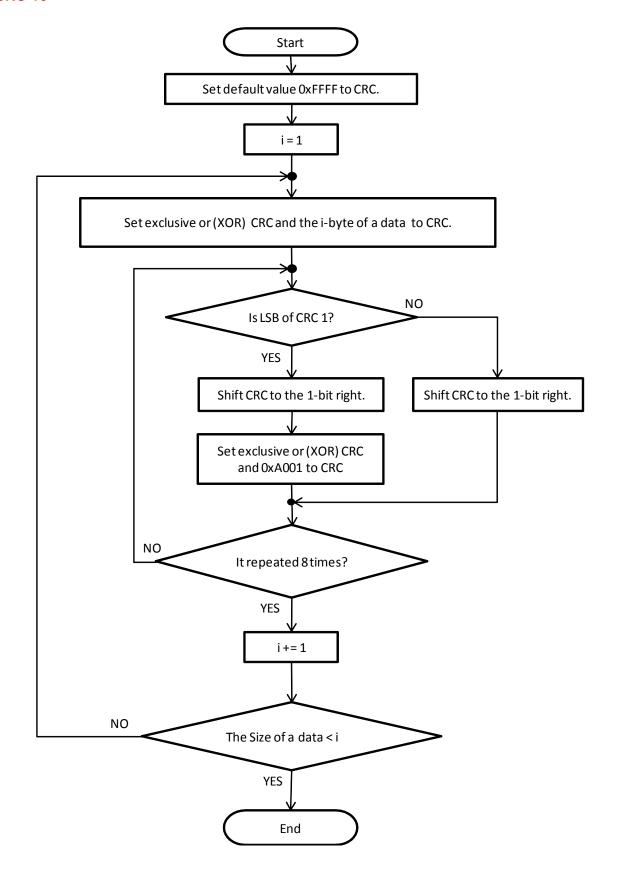
R/W	Address	Register	7	6	5	4	3	2	1	0
Read	0x00	FW Version	MAJOR[7:0]							
	0x01		MINOR[7:0]							
	0x02		REVISION[7:0]							
	0x03	SERIAL_NO	UID[7:0]							
	0x04		UID[15:8]							
	0x05		UID[23:16]							
	0x06		UID[31:24]							
Write	0x07	SNSR_CTRL	0	0	0	0	0	0	0	MEASRUN
Read	0x08	SNSR_STATE	0	0	0	0	0	0	0	MEASDONE
	0x09	DDS	DDS[7:0]							
	0x0A		0	0	0	0	DDS[11:8]			
	0x0B	ADC_EC	ADC_EC[7:0]							
	0x0C		0	0	0	0	ADC_EC[11:8]			
	0x0D	Reserved	Reserved							
	0x0E	Reserved	Reserved							
	0x0F	ADC_PERMITTIVITY	ADC_PERMITTIVITY[7:0]							
	0x10		0	0	0	0	ADC_PERMITTIVITY [11:8]			
	0x11	ADC_BATTERY	ADC_BATTERY[7:0]							
	0x12		0	0	0	0	ADC_BATTERY[11:8]			
	0x13	TEMP	TEMP[7:0]							
	0x14		0	0	0	0	SIGN	TEMP[10:8]		
	0x15	EC_BULK	EC_BULK[7:0]							
	0x16		EC_BULK[15:8]							
	0x17	Reserved	Reserved							
	0x18	Reserved	Reserved							
	0x19	VWC	VWC[7:0]							
	0x1A		0	0	0	0	0	0	VWC [9:8]	
	0x1B	Reserved	Reserved							
	0x1C	Reserved	Reserved							
	0x1D	Reserved	Reserved							
	0x1E	Reserved	Reserved							
	0x1F	EC_PORE	EC_PORE[7:0]							
	0x20		EC_PORE[15:8]							
	0x21	Reserved	Reserved							
	0x22	Reserved	Reserved							
-	0x23 ~ 0x3C		Access inhibit							

Parameter description

Name	Description	Range
FW Version	Firmware version. Firmware version consists of major version, minor version and revision.	-
UID	Unique ID.	-
SNSR_CTRL	A start bit of a measurement. Writing 0x01 starts the measurement.	-
SNSR_STATE	Status of the measurement. 0x00: In measuring or not started measurement. 0x01: Measurements are finished.	-
DDS	Output of 12-bit Analog-to-Digital (AD) converter which represent EC reference value for calibration.	0 ～ 4095
ADC_EC	Output of 12-bit Analog-to-Digital converter which represent EC sensor output.	0 ～ 4095
ADC_BATTERY	Output of 12-bit Analog-to-Digital converter which represent half of power-supply voltage.	0 ～ 4095
ADC_PERMITTIVITY	Output of 12-bit Analog-to-Digital converter which represent moisture sensor output.	0 ～ 4095
TEMP	Calibrated temperature in ℃ (0.0625x).Data is represented in 2's complement. Temperature table Temperature table below	-2048 ～ 2047 (-128 ～ 127.9375℃)
EC_BULK	Calibrated Electrical Conductivity (Bulk).	0 ～ 65535 (0 ～ 65.535 dS/m)
VWC	Calibrated Volumetric Water Content.	0 ～ 1000 (0 ～ 100.0 %)
EC_PORE	Calibrated Electrical Conductivity (Pore water).	0 ～ 65535 (0 ～ 65.535 dS/m)

Temperature table

TEMP[11:0] Binary	Hex	Temperature [℃]
0100_0110_0000	460	70
0100_0101_1111	45F	69.9375
:	:	:
0000_0000_0001	001	0.0625
0000_0000_0000	000	0
1111_1111_1111	FFF	-0.0625
:	:	:
1110_1100_0001	EC1	-19.9475
1110_1100_0000	EC0	-20

CRC-16

```
                    ┌─────────────────────┐
                    │        Start        │
                    └─────────────────────┘
                               │
                    ┌─────────────────────┐
                    │ Set default value   │
                    │ 0xFFFF to CRC.      │
                    └─────────────────────┘
                               │
                         ┌───────────┐
                         │   i = 1   │
                         └───────────┘
                               │
                               ▼
        ┌──────────────────────────────────────────────┐
        │ Set exclusive or (XOR) CRC and the i-byte     │
        │ of a data to CRC.                             │
        └──────────────────────────────────────────────┘
                               │
                               ▼
                        ◇ Is LSB of CRC 1? ◇ ── NO ──┐
                         │                            │
                        YES                           │
                         │                            │
              ┌───────────────────────┐   ┌───────────────────────┐
              │ Shift CRC to the      │   │ Shift CRC to the      │
              │ 1-bit right.          │   │ 1-bit right.          │
              └───────────────────────┘   └───────────────────────┘
                         │                            │
              ┌───────────────────────┐               │
              │ Set exclusive or (XOR)│               │
              │ CRC and 0xA001 to CRC │               │
              └───────────────────────┘               │
                         │◄───────────────────────────┘
                         ▼
          NO ── ◇ It repeated 8 times? ◇
                         │
                        YES
                         │
                   ┌───────────┐
                   │  i += 1   │
                   └───────────┘
                         │
     NO ── ◇ The Size of a data < i ◇
                         │
                        YES
                         │
                  ┌─────────────┐
                  │     End     │
                  └─────────────┘
```

Is LSB of CRC 1?

It repeated 8 times?

The Size of a data < i
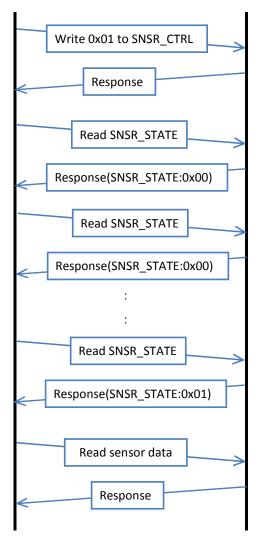
CRC-16 (Program)

```
USHORT CRC16(int size, BYTE* data)
{
    USHORT cr = 0xFFFF;

    for(int i = 0; i < size; i++)
    {
        cr = cr ^ data[i];

        for(int j = 0; j < 8; j++)
        {
            if((cr & 0x0001) == 0x0001)
            {
                cr >>= 1;
                cr ^= 0xA001;
            }
            else
            {
                cr >>= 1;
            }
        }
    }

    return cr;

}
```
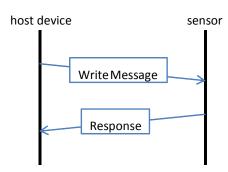
Time Chart

Measurement and read sensor data

Measuring Operation starts by writing "0x01" to SNSR_CTRL register.
Host device needs a monitoring of sensor status in SNSR_STATE register.
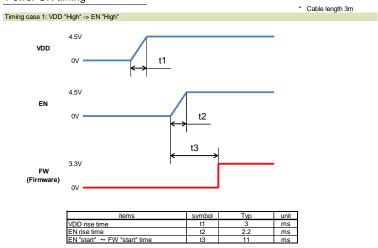After the measurement finished, host device can read the measurement data.

Write 0x01 to SNSR_CTRL

* If the sensor receives a measurement request from host device,
 it measures all values and subsequently calculates the
 calibrated data.

Response

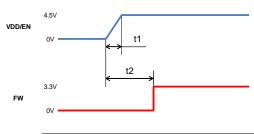Read SNSR_STATE

Response(SNSR_STATE:0x00)

Read SNSR_STATE

Response(SNSR_STATE:0x00)

:

:

Read SNSR_STATE

Response(SNSR_STATE:0x01)

Read sensor data

Response

Write data for COEFFICIENT

host device   sensor

Write Message

Response

Power ON timing

* Cable length 3m

Timing case 1: VDD "High" -> EN "High"

items	symbol	Typ	unit
VDD rise time	t1	3	ms
EN rise time	t2	2.2	ms
EN "start" ～ FW "start" time	t3	11	ms
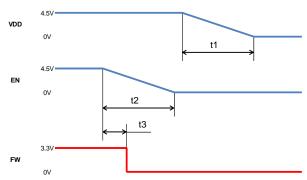
Timing case 2: VDD and EN "High" at same time

items	symbol	Typ	unit
VDD/EN rise time at same time	t1	3	ms
VDD/EN "start" ～ FW "start" time	t2	11	ms

Power off timing

Timing case 1: EN "Low" -> VDD "Low"
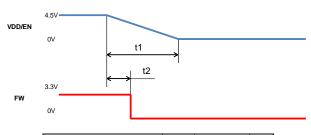
items	symbol	Typ	unit
VDD fall time	t1	110	ms
EN fall time	t2	103	ms
EN "fall start" ～FW "stop" time	t3	69	ms

Timing case 2: VDD and EN "Low" at same time
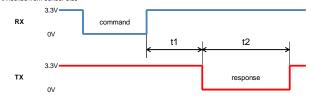
items	symbol	Typ	unit
VDD/EN fall time at same time	t1	70	ms
VDD/EN "fall start" ～ FW "stop" time	t2	52	ms

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UART communication

UART communication specification	Baud rate	9600bps
	Data size	8bit
	Parity	none
	Stop bit	1bit
	Flow control	none
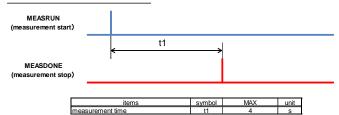
TX/RX looked from sensor side

items	symbol	MAX	unit
response wait time	t1	5	ms
response time	t2	33	ms ※

※Response as 26 data were read from DDS to PORE_EC_C

Measurement time

items	symbol	MAX	unit
measurement time	t1	4	s

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Revision history

Date	Revision	Changes
08-feb-2016	1.0.0	Newly create.
29-Mar-2016	1.1.0	[6]Specification Moisture Range[%]0-100 →0-60
16-Jan-2017	1.2.0	P.4 [6]Specification: Operation supply voltage min 3.3→3.0 P.4 Cable length 2m@UART→3m@UART P.6 Cable: VDD 3.3-6.0V → 3.0-6.0V 　　　　　EN 3.3-6.0V → 3.0-6.0V, add VIH,VIL 　　　　　TxD add VOH,VOL 　　　　　RxD add VIH,VIL P.16,P17　add timing chart
7-Feb-2017	1.3.0	P.4 [6]Specification: EC resolution 0.01→0.001 P.9 RegisterMap: 　EC_BULK,EC_PORE_M,EC_PORE_O,EC_PORE_C 　　14bit→16bit P11 Parameter description: 　EC_BULK,EC_PORE_M,EC_PORE_O,EC_PORE_C 　　0～99.99dS/m → 0～65.535dS/m
20-Nov-2017	1.4.0	P.4[6]Specification: Temperature resolution 0.1→0.0625 P.10, P.11 Change the following registers. ADC_TEMP → × （Deleted） VWC_MINERAL → × （Deleted） VWC_ORGANIC → VWC （Changed） VWC_CUSTOM → × （Deleted） EC_PORE_M → × （Deleted） EC_PORE_O → EC_PORE （Changed） EC_PORE_C → × （Deleted） COEFFICIENT → × （Deleted）

⚠️CAUTION

1. Limitation of Applications

   Please contact us before using our products for the applications listed below which require especially high reliability for the prevention of defects which might directly cause damage to the third party's life, body or property.
   ①Aircraft equipment
   ②Aerospace equipment
   ③Undersea equipment
   ④Power plant control equipment
   ⑤Medical equipment
   ⑥Transportation equipment(vehicles, trains, ships, etc.)
   ⑦Traffic signal equipment
   ⑧Disaster prevention / crime prevention equipment
   ⑨Data-processing equipment
   ⑩Application of similar complexity and/or reliability requirements to the applications listed in the above.

2. Model No.LT5006 is the products for the market research.
   Product specifications in this sheet are as of Nov.2017, and are subject to change or obsolescence without notice.