ALPS

Digtal Humidity Sensor
HSHCAL001A (DHC-2.0)
Data Sheet Rev.D1

1. ALPS product No. HSHCAL001A

2. Application This specifications applies to digtal humidity and temperature sensor.

3. General description
・HSHCAL001A is small size package, surface mouting possible, digtal output relative humidity and temperature sensor .
・HSHCAL001A has I2C (Inter-Integrated Circuit) as a communication interface.
・Humidity sensing element is capacitance type.
・Temperature compensation is automatically carried out.

4. Content of specifications

ALPS Confidential

SYMB.	CHANGE RECORD	DATE	APPD.	CHKD.	DSGD.		
						DSGD.	Oct. 26, 2012 S. Yanagi
						CHKD.	Oct. 26, 2012 A. Tondokoro
						APPD.	Oct. 26, 2012 Y. Shimizu

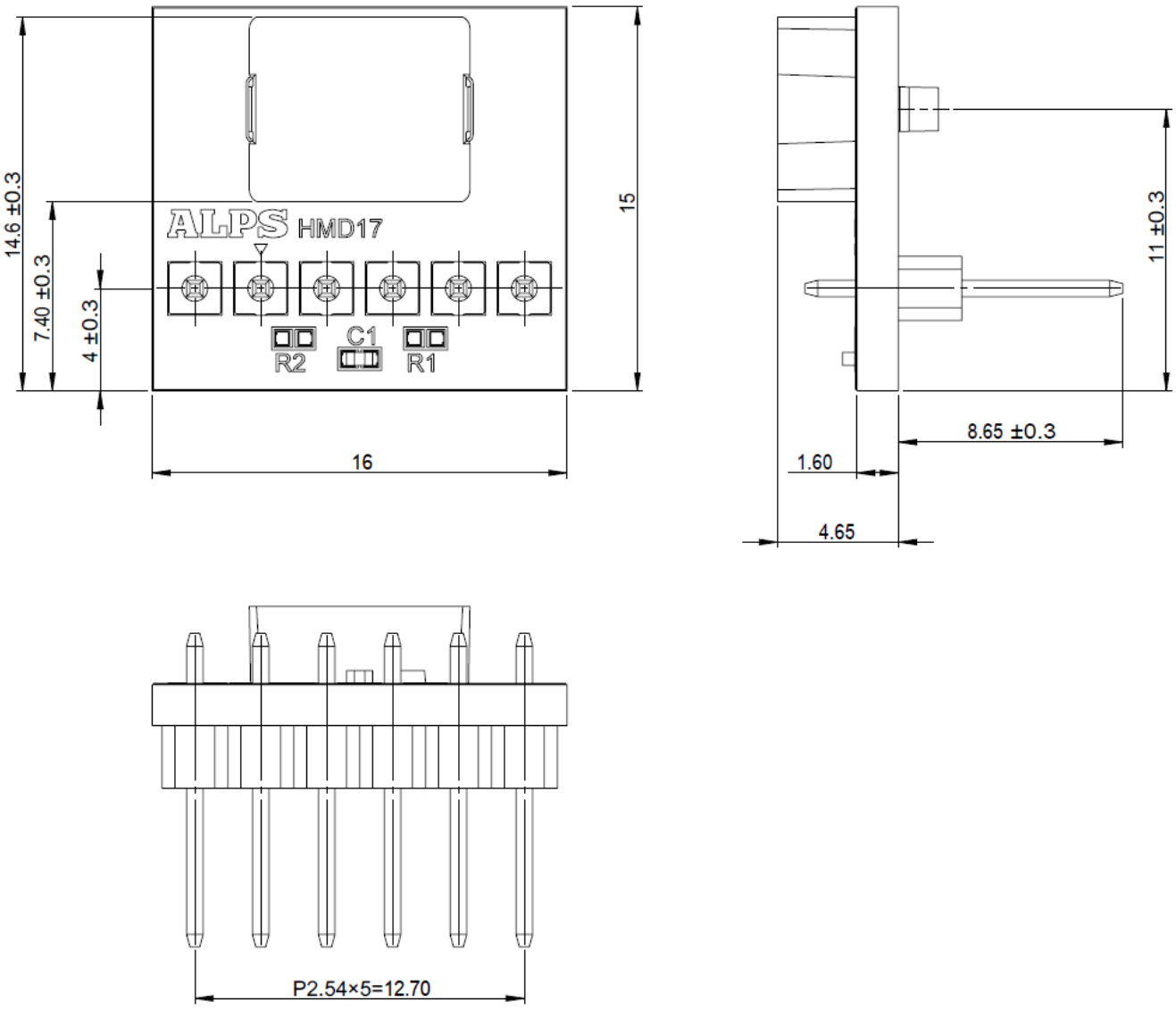
4-1. Electrical specifications

Table 1. Electrical specifications

Item	Symbol	Unit.	Specification			Notes
			min.	Typ.	max.	
Environmental conditions						
Absolute limits supply voltage	Vlim	[V]	-0.3	-	2	
Storage Humidity	Hstr	[%RH]	0		+95	No condensation
Storage temperature	Tstr	[degC]	-40	-	+125	
ESD	Vh	[V]	-	-	±2000	HBM
Operating conditions (Vdd=1.8V , 50degC)						
Humidity range	Hrng	[%RH]	0	-	+100	
Operating temperature	Topr	[degC]	-20	-	+85	
Supply voltage	VDD	[V]	1.71	1.8	1.89	
Current consumption	idd1	[µA]	-	65	-	Normal state 1Hz
	idd10	[µA]	-	140	-	Normal state 10Hz
	Iddm	[µA]	-	15	-	Force state 1Hz
	Idds	[µA]	-	1	-	Force state Sleep state
A/D change time	Tad	[ms]	-	6.7	-	
I2C Communication rate	Crat	[MHz]	-	-	3.4	SS, FS, FS+, HS supported
Relative Humidity						
Offset tolerance	Hoff	[%RH]	-1.5	0	1.5	50%RH 25deg C
Gain tolerance	Hgain	[%]	-5	0	5	
Temperature						
Offset tolerance	Toff	[deg C]	-0.5	0	0.5	25deg C

4-2. Dimensions

Figure 1. Dimensions of the product



4-3. Structure of evaluation Board

Figure 2. Outside structure

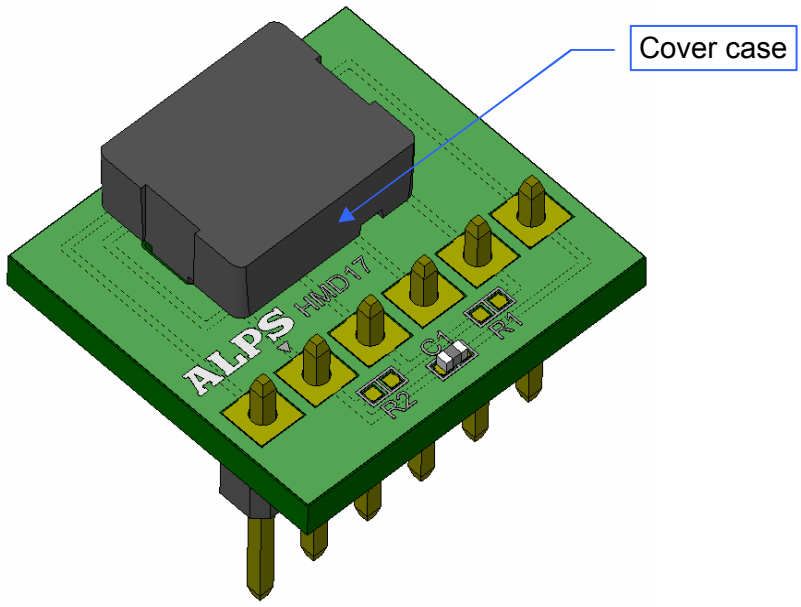
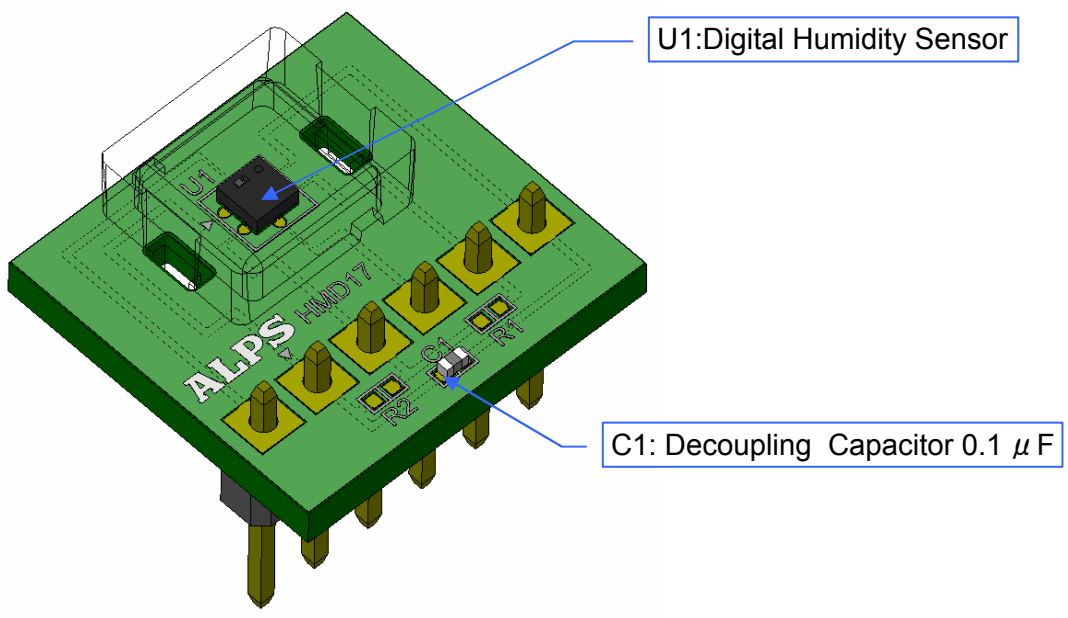


Figure 3. Internal structure

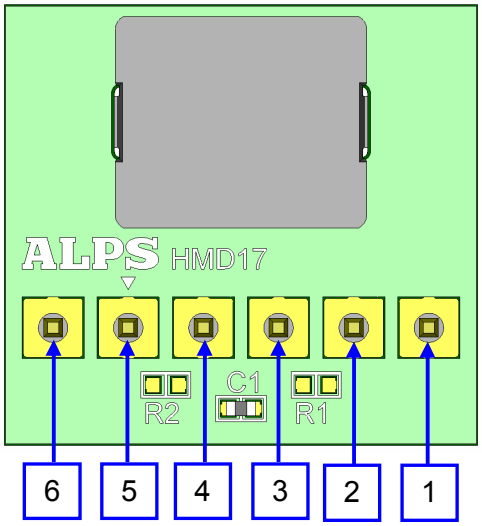


4-4. Schematic layout of the terminal

Table 2. Terminal descriptions

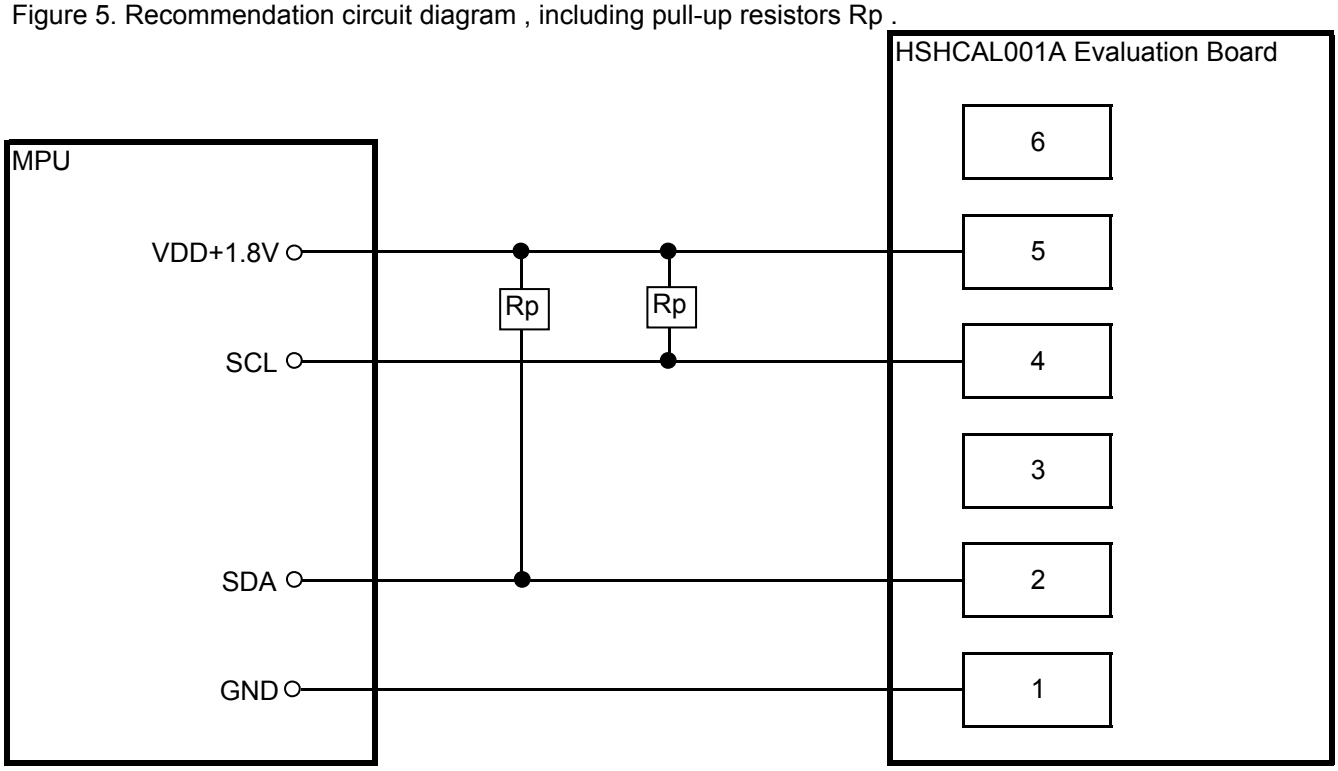
No	Name	Comment
1	GND	Ground
2	SDA	Serial data
3	NC	Not connect
4	SCL	Serial clock
5	VDD	Supply voltage
6	NC	Not connect

Figure 4. Terminal information



4-5. Recommendation circuit diagram

Figure 5. Recommendation circuit diagram , including pull-up resistors Rp .



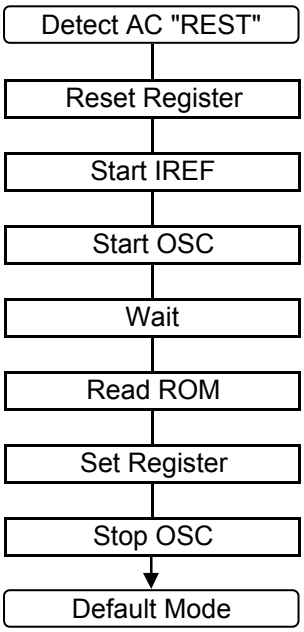
Rp is a recommendation 3.3k ohm pull-up resistor.

4-6. Power-on sequence

4-6-1. Power-on sequence

Internal operation after applying power supply is as follows

Figure 6. Power-on sequence



4-6-2. Power up sequence

Power up sequence is subscribed as follows

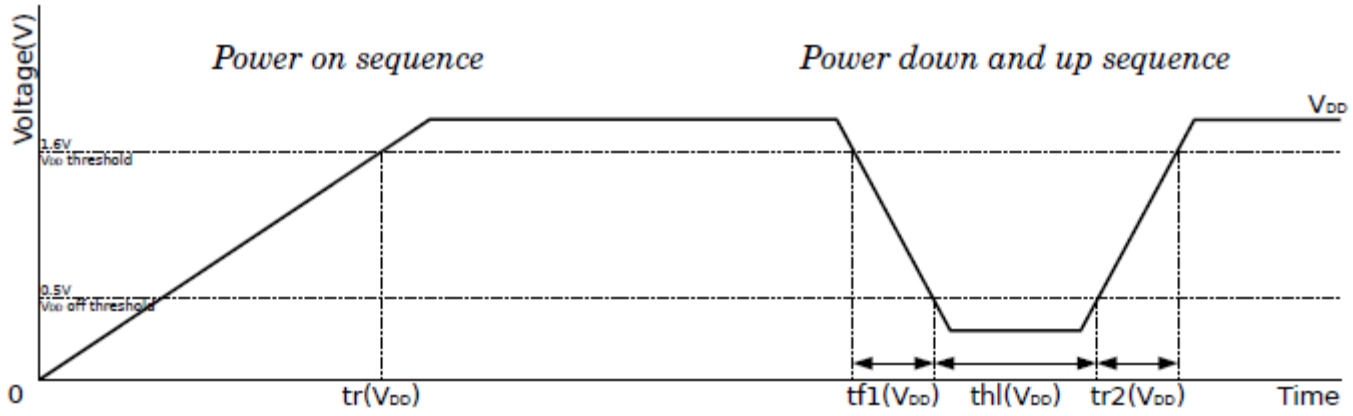
- After applying the power supply, VDD must become 1.6V or more within tr(VDD) = 30us~50ms .

4-6-2. Power down and up sequence

Power down and up sequence is subscribed as follows

- Fall time (tf1(VDD)) of the power supply voltage VDD must be 0.5V or less within the range of 30us~50ms.
- After power supply is turned off, keep its state (thl(VDD)) for 100ms or more.
- To reboot the device, VDD must be 1.6V or more within tr2(VDD) = 30us~50ms .

Figure 7. Power down and up sequence



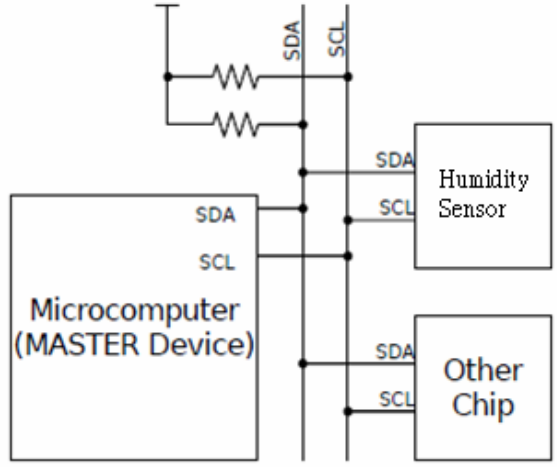
4-7. Srial communication interface

This product has I2C (Inter-Integrated Circuit) as a communication interface.

4-7-1. I2C communication interface

- This product is based on [Philips I2C specification ver 2.1] and [NXP UM10204 I2C-bus specification and user manual Rev.03-19 Jun 2007].
- Standard mode (SS, 100kHz), Fast mode (FS, 400kHz), Fast mode plus (FS+, 1MHz) and High speed mode (HS, 3.4MHz) are supported.
- Clock frequencies above are maximum values and device can communicate with host with lower frequency.
- 7bit address is used.
- This device supports multiple byte read and write. Resister address is automatically incremented every read/write.
- When Master code is detected, the ASIC return NAK then switch to HS mode. After that, Master device must start the communication from sending Slave address.
- I2C slave address (SADR) is defined as "0011000"(18h).

Figure 8. I2C communications



4-7-2. I2C pin specifications

SCL : I2C Serial Clock
Driven by master device.

SDA : I2C Serial data input and output
Communication data and ACK/NAK bit data are sent and received.

4-7-3. Read and Write Resisters

- There are two kinds of communication sequences when the Register is read. (Refer to Sequence 1 and 2) There are three kinds of communication sequences when the Register is written or sending acction comands (Refer to Sequence 3 to 5)

- This product has a Multi-Read/Write function, in order to perform Read/Write for two or more data of continuous registers in one time communication. This function makes an internal register address increment automatically for every communication process.
MSB1 of a register address must be Low (0).

- If a master command is received instead of a slave address at the time of communication, the device will reply NAK and will change it to HS communication. Then, detection of [Stop Condition] will end HS communication. Therefore, when performing continous communication of Read/multiple byte Read of a register and etc, it is necessary to use [Repeated Start Condition] for a pause of communication from master device.
(Refer to Sequence 6)

Table 3. List of items

Item	Description
START	Start Condition
P&S|REST	Stop Condition -> Start Condition or Repeated Start Condition
RESTART	Repeated Start Condition
SADR	Slave Address
MCODE	Master Code
R	Read Bit
W	Write Bit
ACK	Acknowledge
NAK	Not Acknowledge
RADR	Embedded Register Address
DATA	Read / Write Data
STOP	Stop Condition
AC	Action Command

Sequence 1. register Read (single byte)

Master	START	SADR,W		RADR		P&S|REST	SADR,R			ACK|NAK	STOP
Slave			ACK		ACK			ACK	DATA		

Sequence 2. register Read (multiple byte)

Master	START	SADR,W		RADR		P&S|REST	SADR,R			ACK	….		ACK|NAK	STOP
Slave			ACK		ACK			ACK	DATA(1)		….	DATA(N)		

Sequence 3. register Write (single byte)

Master	START	SADR,W		RADR		DATA		STOP
Slave			ACK		ACK		ACK	

Sequence 4. register Write (multiple byte)

Master	START	SADR,W		RADR		DATA(1)		….	DATA(N)		STOP
Slave			ACK		ACK		ACK	….		ACK	

Sequence 5. ACion Command

Master	START	SADR,W		AC		STOP
Slave			ACK		ACK	

Sequence 6. Higt Speed Mode

Master	START	MCODE		RESTART	SADR,R|W		….	ACK|NAK	STOP	START	….
Slave			NAK			ACK	….	ACK|NAK			
Mode	FS			HS						FS	

4-8. Detection State

- There are two states to detect Humidity and Temperature.
- According to the status of register CTL1.FS , the device will switch Nomarl State or Force State after Power on Reset.

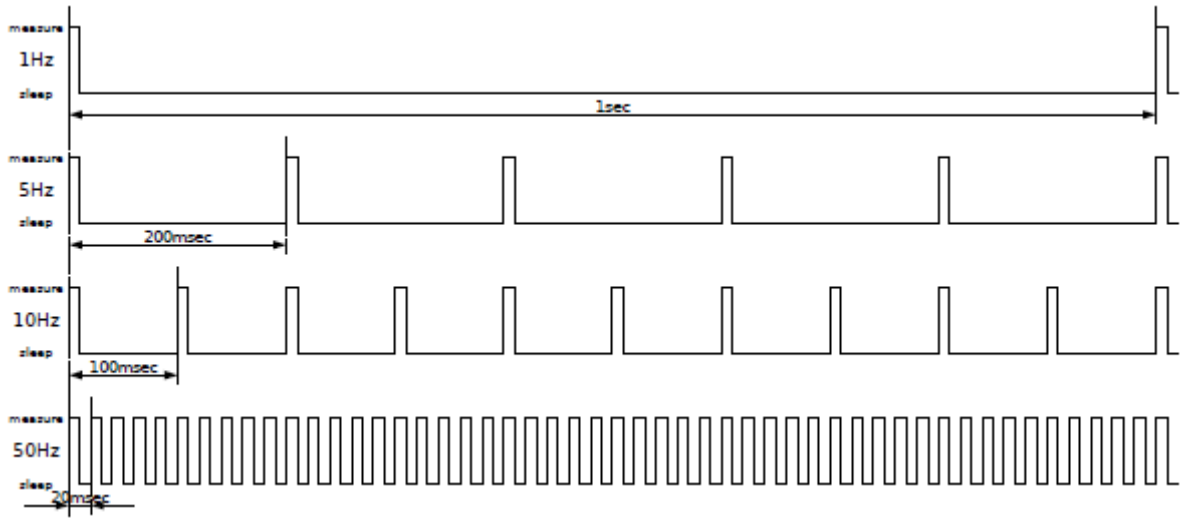
4-8-1. Normal State

- In Normal State, the device will measure Humidity and Temperature with the sampling rate which is specified in the register CTRL1.ODR.
- the device will be sleep state out of measurement time.
- Humidity and a temperature detection cycle can be chosen from 1,5,10 and 50Hz by the register CTR1.ODR [1:0].

Table 4. Measurement processing timing in Normal State.

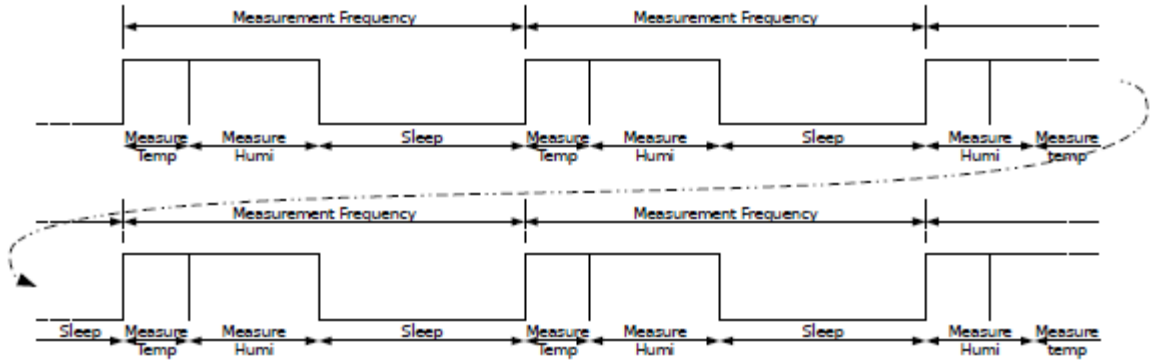
Output cycle setup (CTR1.ODR)	Hygrometry cycle	Time of one cycle in hygrometry	Temperature survey timing	Time of one cycle in temperature survey
00b	1 Hz	1 sec	1/1 sample	1 sec
01b	5 Hz	200 msec	1/1 sample	200 msec
10b	10 Hz	100 msec	1/1 sample	100 msec
11b	50 Hz	20 msec	1/1 sample	20 msec

Figure 9. The image of the measurement timing of Normal State



The specified cycle is united with the measurement start of a temperature sensor in Normal State.

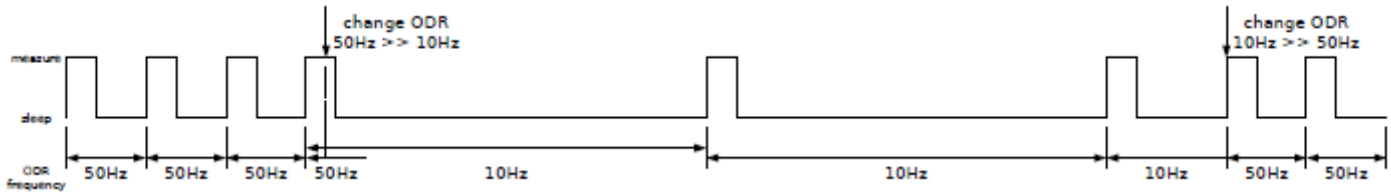
Figure 10. The image of measurement of Normal State



Device reaction when the sampling rate is changed is as follows.

- When ODR register is changed and settled during measurement period, change the sampling rate right away.
- When ODR register is changed and settled during Sleep State, start measurement with the sampling rate right away.

Figure 11. Normal State, change output data rate



4-8-2. Force State

In Force State, measurement trigger is generated by the action command DET.
Action Command DET is sent during measurement period, it will be ignored.

Figure 12. Force State, Detect trigger

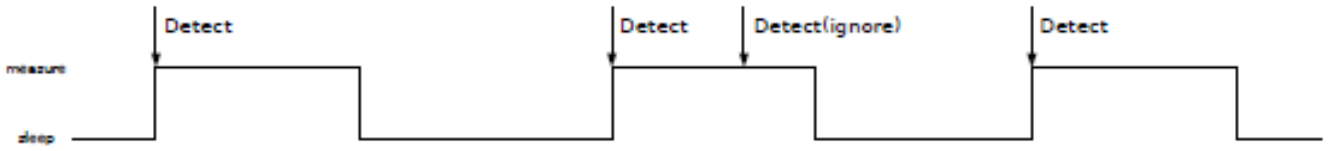
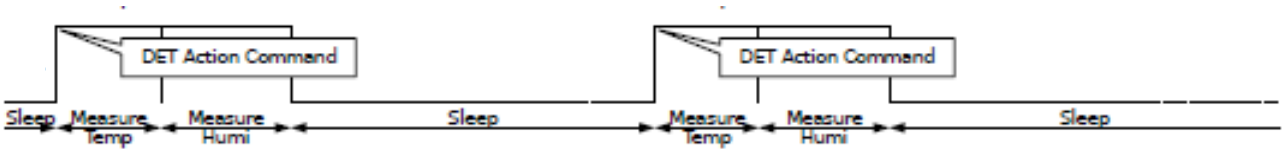


Figure 13. The image of measurement of Force State



4-9. Built-in Register and Action command

4-9-1.The feature of the register

To this product, master devices are accessing a Register or carrying out action command issue, and become acquirable about the data of humidity and temperature.
Access for every byte to the register from a master device is answered at MSB first.
Multiple Read/Write is answered with a little endian.
The value of a ROM register is as follows.

- An initial value is substituted for it at the time of a power supply injection.
- The data read from ROM is substituted for it at the time of power on reset.
- At the time of ROM writing, the value of a ROM register is written in the appointed domain of ROM.

Table 5. Register Address Bit Map

Bit	Description
0(LSB)	register address / Action command
1	
2	
3	
4	00,01,10:register, 11:Action comannd,
5	
6	0:register/command, 1:ROM
7(MSB)	N/A

4-9-2. Register MAP

Reg Adr	ROM Adr	Default R/W/A	NAME	Abbr.	Bitmap								Initial value
0C		R	Self test response	STR	STB[7:0]								00
0D		R	More info Version	INF1	0	0	0	1	0	0	0	1	11
0E		R	More info ALPS	INF2	0	0	1	0	0	0	1	1	23
0F		R	Who I am	WIA	0	1	0	0	1	0	0	1	49
10		R	Humidity output1	HUMI1	HUMI[7:0]								00
11		R	Humidity output2	HUMI2	HUMI[15:8]								00
12		R	temperature output1	TEMP1	TEMP[7:0]								00
13		R	temperature output2	TEMP2	TEMP[15:8]								00
18		R	Status	STAT	SRDY	DRDY	DOR	MEAS	-	-	TRDY	-	00
1B	55	RW	Control1	CTL1	-	MMD[1:0]		ODR[1:0]		LP	FS	-	ROM
20	4F	R	Reserved data1	RDAT1	DAT[7:0]								ROM
21	50	R	Reserved data2	RDAT2	DAT[15:8]								ROM
22	51	R	Reserved data3	RDAT3	DAT[23:16]								ROM
23	52	R	Reserved data4	RDAT4	DAT[31:24]								ROM
30		AC	Reset command	REST	-	-	-	-	-	-	-	-	00
31		AC	Sensor detect command	DET	-	-	-	-	-	-	-	-	00
32		AC	Self test command	STST	-	-	-	-	-	-	-	-	00

"-" = Non assign, register read data = 00
"R" = Read only
"W" = Write only
"RW" = Read and Write
"AC" = Action command (, register read data = 00)
Bitmap : "-" = Non assign
The execution data of humidity output is 14 bit.
The execution data of temperature is 13 bit.

4-9-3. Register

The register of this product has the following five kinds of domains.

1) R: Read only

This area do not accept write process. If master device tries to write values into this area, the device reply ACK but does not revice the resister values.

2) W: Write only

This area do not accept read process. If master device tries to read values from this area, the device reply ACK and return 0.

3) RW: Read/Write

This area accept read read and write process.

4) AC: Action Command

This area is for Action Command and register does not exist physically.

When the register is read and write, the device reacts as "Read only" and "Write only" respectively.

5) - : Undefined area

No register exist.

When write process is performed to this area, ACK is answered.

When read process is performed, ACK is answered and 0 is returned.

4-9-4. Test control register

The register for performing communication of this product, and the check of a register of operation.

Register Address	Access	NAME	Abbr.	Function
0Ch	R	Self test response	STR	The response register for a self test

Self Test Response (STR)

BIT	NAME	Access	Default	Description
7:0	STB	R	55h	Issue of Self test command (STST) will set AA (bit inversion of an initial value). After this register is read, it returns to an initial value again.

4-9-5. The register which stored inside information

The register which stored the variety of information of this product

Register Address	Access	NAME	Abbr.	Function
0Dh	R	More info Version	INF1	The version of IC and customer code
0Eh	R	More info ALPS	INF2	A sensor category and a product version
0Fh	R	Who I am	WIA	ID of a supplier

More info Version1,2. Who Iam (INF1,INF2 WIA)

BIT	NAME	Access	Default	Description
7:0	INF1	R	11h	IC version(4bit), Customer code(4bit) : 0001 0001b
7:0	INF2	R	23h	Sensor category(4bit), Generation(4bit) : 0010 0011b
7:0	INF3	R	49h	Supplier ID(8bit) : 0100 1001b

4-9-6. The register which stored inside information

The register for storing the sensor detection information on this product.

Register Address	Access	NAME	Abbr.	Function
10h	R	Humidity output 1	HUMI1	Humidity output register, a low byte
11h	R	Humidity output 2	HUMI2	Humidity output register, a high byte
12h	R	Temperature output1	TEMP1	Temperature output register, a low byte
13h	R	Temperature output2	TEMP2	Temperature output register, a high byte
18h	R	Status	STAT	Various status registers

Humidity output 1,2, Temperature output 1,2 (HUMI1,HUMI2,TEMP1,TEMP2)

BIT	NAME	Access	Default	Description
HUMI1. 7:0	HUMI[7:0]	R	00h	Humidity output register, a low byte
HUMI2. 7:0	HUMI[15:8]	R	00h	Humidity output register, a high byte
TEMP1. 7:0	TEMP[7:0]	R	00h	Temperature output register, a low byte
TEMP2. 7:0	TEMP[15:8]	R	00h	Temperature output register, a high byte

Sensor measurement data is stored at a little endian and MSB first.
Sensor data is stored without unsigned binary.
DRDY and DOR will be canceled if HUMI is read.
TRDY will be canceled if TEMP is read.
The execution data of humidity output is 14 bit.
The execution data of temperature is 13 bit.

Status (STAT)

BIT	NAME	Access	Default	Description
7	SRDY	R	0b	The flag under starting 0 : Inactive , 1 : Active
6	DRDY	R	0b	The flag of the end of humidity sensor measurement 0 : Inactive , 1 : Active
5	DOR	R	0b	Detection of data overrun 0 : No overrun , 1 : Detect overrun
4	MEAS	R	0b	The flag of measurement execution 0 : Sleep , 1 : Execute Measurement
3:2	-	-	-	-
2	TRDY	R	0b	The flag of the end of temperature sensor measurement 0 : Inactive , 1 : Active
0	-	-	-	-

4-9-7. IC control register

The register for controlling the internal state of this product

Register Address	Access	NAME	Abbr.	Function
1Bh	RW	Control 1	CTL1	The register which controls state transition

Control 1 (CTL1)

BIT	NAME	Access	Default	Description
7	-	-	-	-
6:5	MMD	RW	ROM	Change of A/D translation filter 00 : Ultra low power 01 : Low power 10 : Middle power / middle accuracy 11 : High accuracy
4:3	ODR	RW	ROM	Control of Output data rate 00 : 1Hz (1sec) 01 : 5Hz (200msec) 10 : 10Hz (100msec) 11 : 50Hz (20msec)
2	LP	RW	ROM	Control in power-saving mode 0 : invalid , 1 : valid
1	FS	RW	ROM	Control of State 0 : Normal state , 1 : Force state
0	-	-	-	-

4-9-8. Reserved Resistor

The register to store various data

Register Address	Access	NAME	Abbr.	Function
20h	R	Reserved Data 1	RDAT1	–
21h	R	Reserved Data 2	RDAT2	–
22h	R	Reserved Data 3	RDAT3	–
23h	R	Reserved Data 4	RDAT4	–

4-9-9. Action command

The command for making special operation perform

In write-in mode, the writing of register data is not performed, but it is only the communication which specifies a register address and performs various functions.

Register Address	Access	NAME	Abbr.	Function
30h	AC	Reset command	REST	Software reset Power on reset is performed.
31h	AC	Sensor detect command	DET	Sensor measurement is started in Force state. Mesurement of temperature and humidity.
32h	AC	Self test command	STST	Control of a self test The data of STR.STB [7:0] is changed into AAh.

4-10. Relative Humidity Conversion

Humi[0:13] is Relative Humidity Output. This is divided and stored in the resist area HUMI1 and HUMI2 to A/D value of Humidity Sensor.
This register is only reading.

HUMI1 ;Low 8 bits is stored in this area.

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Humi[7]	Humi[6]	Humi[5]	Humi[4]	Humi[3]	Humi[2]	Humi[1]	Humi[0]

Register Address ; 10h

HUMI2 ;Top 6 bits is stored in this area.

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
-	-	Humi[13]	Humi[12]	Humi[11]	Humi[10]	Humi[9]	Humi[8]

Register Address ; 11h

The formula made the relative humidity notation from the digital output count of Humi is as follows.

$$RH = 0.015625 \times HUMI - 14$$

Formule 1. Relative humidity conversion

RH is value of Relative Humidity. Unit is %RH.
HUMI is value of Digtal output count. Unit is LSB.

4-11. Temperature Conversion

Temp[0:12] is Temperature Output. This is divided and stored in the resist area TEMP1 and TEMP2 to A/D value of Temperature Sensor.
This register is only reading.

TEMP1 ;Low 8 bits is stored in this area.

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Temp[7]	Temp[6]	Temp[5]	Temp[4]	Temp[3]	Temp[2]	Temp[1]	Temp[0]

Register Address ; 12h

TEMP2 ;Top 5 bits is stored in this area.

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
-	-	-	Temp[12]	Temp[11]	Temp[10]	Temp[9]	Temp[8]

Register Address ; 13h

The formula made the temperature notation from a digital output count is as follows.

$$T = 0.02 \times TEMP - 41.92$$

Formula 2. Temperature conversion

T is value of Temperature. Unit is deg C
HUMI is value of Digtal output count. Unit is LSB.

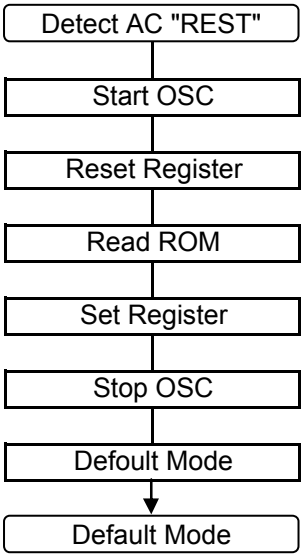
4-12. Other functions

4-12-1. Software reset

This product has a Software reset function.

Software reset performs the following operations, when action command "REST" is received.

Figure 14. Software reset

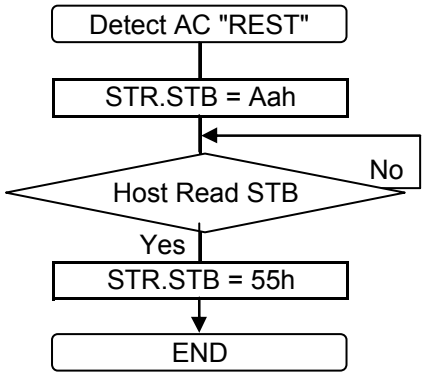


4-12-2. Self test

This product has a Self test function.

As for this self test, a master device checks communication of this product, and normal operation of a digital portion.

Figure 15. Self test



A master device is checking the following and can check that the digital portion of this product is operating correctly.

1. "STR.STB" should be 55h before transmitting "STST".
2. "STR.STB" should be AAh after transmitting "STST".
3. "STR.STB" should be 55h after reading "STR.STB."