Product Specification

Temperature・Humidity Sensor：HSU-CHU-41A

HOKURIKU ELECTRIC INDUSTRY CO., LTD.

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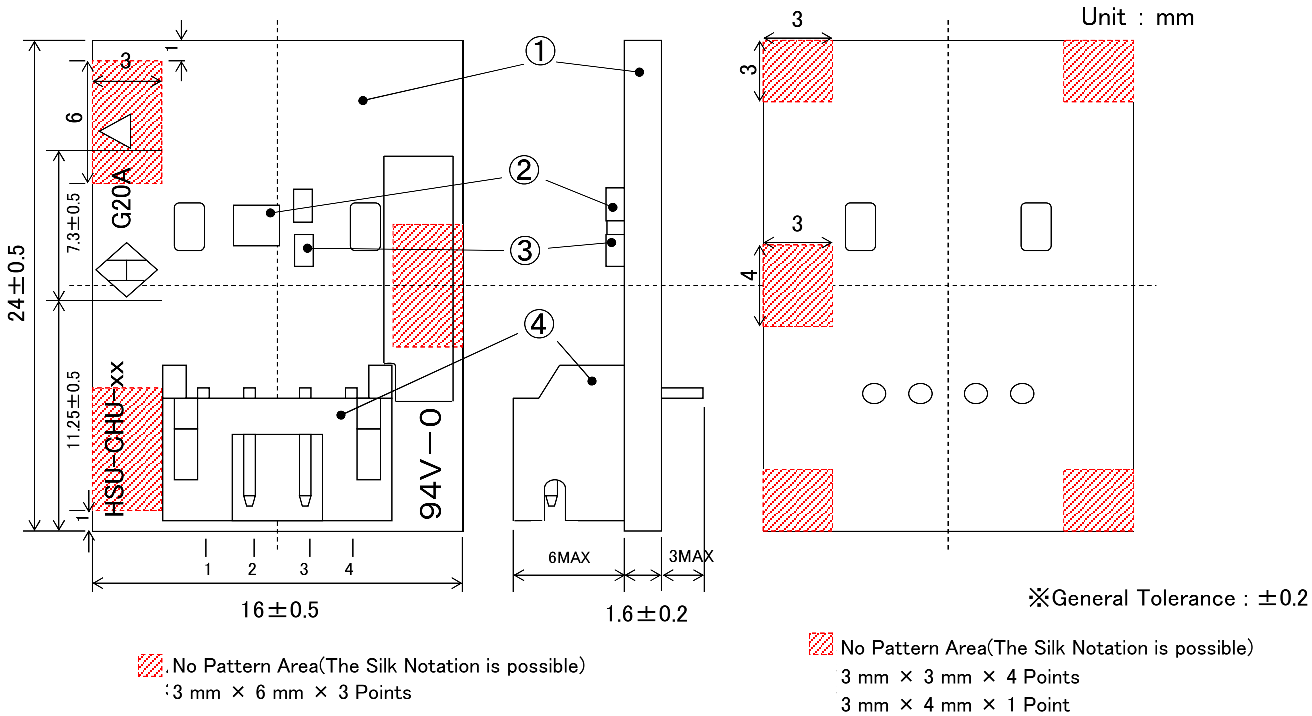
1. Application

This specifications shall be applied to the temperature・humidity sensor "HSU-CHU-41A".

2. Outside Dimensions and Terminal Layout



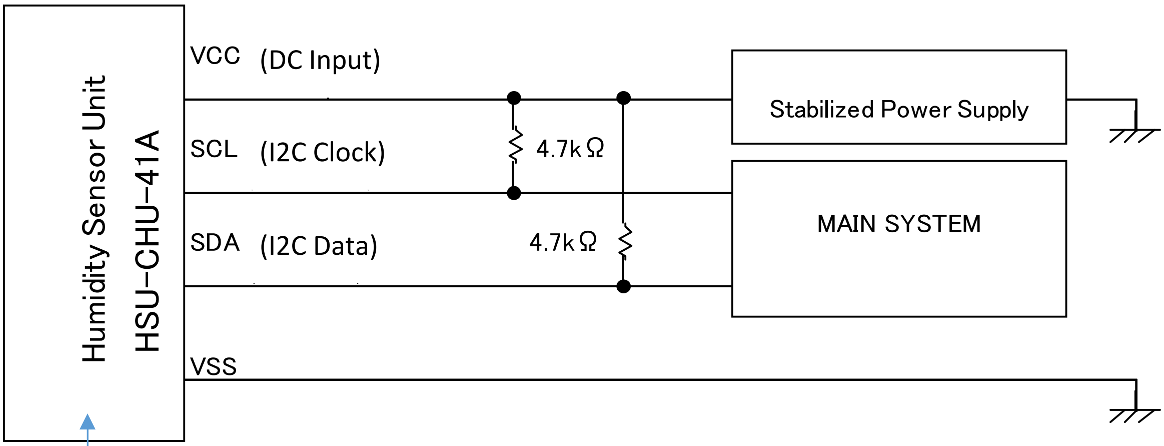
※General Tolerance : ±0.2

Terminal Layout

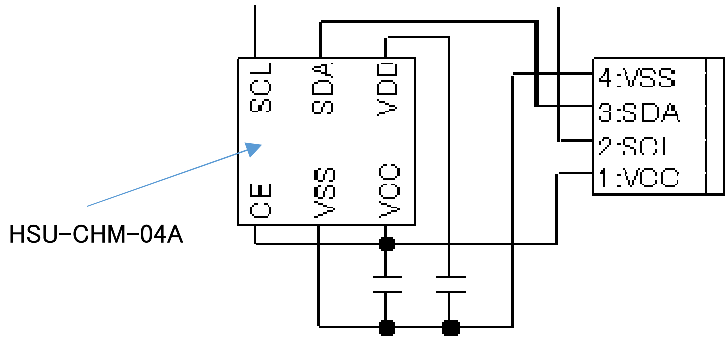
No.	Symbol	Name
1	VCC	Power Supply Terminal
2	SCL	I2C Clock
3	SDA	I2C Data
4	VSS	Ground Terminal

Parts No.	Name	Material and Specification
①	Printed Circuit	CEM-3 / 1.6±0.2mmt
②	Sensor	Capacitance Humidity Sensor (HSU-CHM-04A)
③	Mounted Parts	Chip Capacitor
④	Connector	Manufactured by JST S4B-PH-K-S (White / 4pins / 2mm pitch) Pb free

3. Basic Outside Connection Diagram



<HSU-CHU-41A Internal Connection Diagram>



Since the CE Terminal is connected to the VCC Terminal, it is always waiting for communication.

Pull-up Resistance 4.7kΩ is a reference level. Please select a resistance value that satisfies the AC Characteristics described in Section 9.3.

4. Absolute Maximum Ratings

Item	Symbol	Conditions	Rated Value	Unit
Power Supply Voltage	VCC		−0.3～7.0	V
Input Voltage	VI	SCL・SDA	−0.3～7.0	V
High Level Output Current	IOH	1 Terminal	−5	mA
		All Terminals Total	−20	mA
Low Level Output Current	IOL	1 Terminal	5	mA
		All Terminals Total	20	mA
Operating Temperature	Ta		−20～100	℃
Storage Temperature	Tstg		−25～105	℃

5. Recommended Operating Condition

Item	Symbol	Min	Typ	Max	Unit
Power Supply Voltage	VCC	1.62		5.5	V

6. Electrical Characteristics

6-1. Humidity Detection Characteristics

Unless Otherwise Specified : VCC = 1.62～5.5V , VSS = 0V , Ta = -20～100℃ , No Condensation

Item	Conditions	Value	Unit
Measurement Range	-	0～100	%RH
Measurement Accuracy (Tolerance) ※1	Standard	±3	%RH
	Max	Cf. Fig5-1	%RH
Resolution	10 Bit Data	0.1	%RH
Hysteresis	5～45℃/0～100%RH	±1.0	%RH
Response Time ※2	Reach τ 63%	1	s

6-2. Temperature Detection Characteristics

Unless Otherwise Specified : VCC = 1.62～5.5V , VSS = 0V , Ta = -20～100℃ , No Condensation

Item	Conditions	Value	Unit
Measurement Range	-	-20～100	℃
Measurement Accuracy (Tolerance) ※1	5～60℃ Standard	±0.5	℃
Resolution	11 Bit Data	0.1	℃

※1 It is specified by the standard deviation σ from the normal distribution. Regarding the standard accuracy tolerance at a certain measurement point, 95% of all products within the maximum accuracy are considered to be within $\pm 2\sigma$ (σ: standard deviation).

※2 It is defined as the time (25℃ & Airflow 1.0m/s) until 63% change with step change.

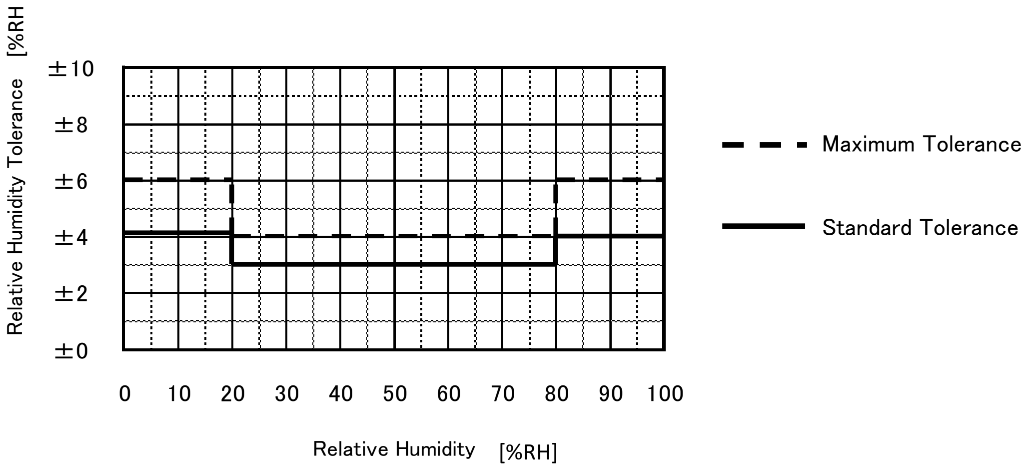


Figure 6-1. Relative Humidity Measurement Accuracy Tolerance (25℃)

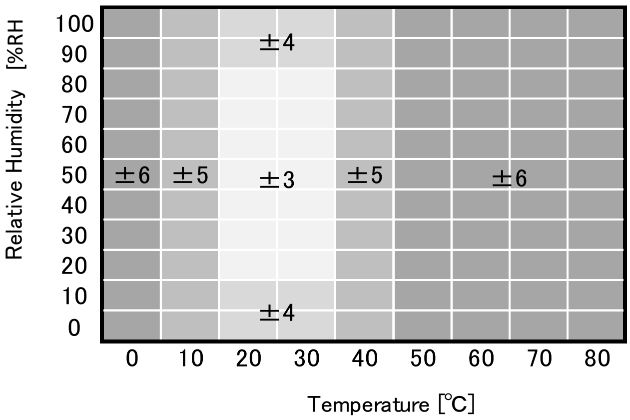


Figure 6-2. Measurement Accuracy of Relative Humidity in the Temperature Range (0～80℃)

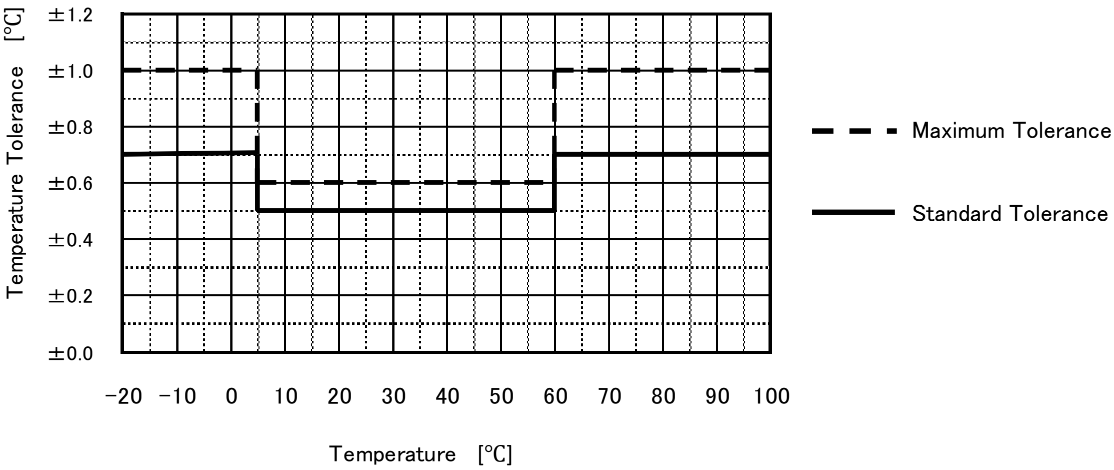


Figure 6-3. Temperature measurement tolerance

6-3. Current Consumption

Unless Otherwise Specified : VCC = 1.62～5.5V , VSS = 0V , Ta = 0～60℃ , No Condensation

Item	Conditions	Min	Typ	Max	Unit
Average Operating Current	Hum Detection : 1 Time / s Temp Detection : 1 Time / s	–	150	300	μA

6-4. Input Output Terminal Characteristic

Unless Otherwise Specified : VCC = 1.62～5.5V , VSS = 0V , Ta = -20～100℃ , No Condensation

Item	Sign	Conditions	Min	Typ	Max	Unit
High Level Input Voltage	VIH	Target Terminal : SCL , SDA	0.7VCC	–	VCC	V
Low Level Input Voltage	VIL	Target Terminal : SCL , SDA	VSS	–	0.3VCC	V
Low Level Output Current	IOL	VOL = 0.1VCC Target Terminal : SCL , SDA	0.5	–	–	mA
Terminal Leek Current 1	IL1	Terminal Voltage = VCC Target Terminal : SCL , SDA	-1	–	1	μA
Terminal Leek Current 2	IL2	Terminal Voltage = 0V Target Terminal : SCL , SDA	-1	–	1	μA

7. Reliability Test Specification

Item	Conditions	Test Time
High Temperature	105℃	1,000hr
Low Temperature	−25℃	1,000hr
High Temperature, High Humidity	60±5℃ / 90±5%RH	1,000hr
Heat Shock	−25⇔105℃　各30min −25⇔105℃ Each 30 min	200 Cycles
ESD Resistance	HBM Method : ±1,000 V　MM Method : ±200 V	2 Times

* Evaluation item and criteria shall be specified separately.

8. Functional Description

8-1. Serial Communication Interface

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

8-1-1. Basic Specification of I2C Communication Interface

This product is based on [Philips I2C specification ver2.1].

Address

7 Bit Length

Slave Address

I2C slave address (SADR) is defined as "111 1111" (7Fh).

8-2. Operation Mode

Table 8-1 shows operation mode of this IC. After power is on and reset is released, regulator and oscillation circuit starts operation, and the IC shifts to standby mode, under which is ready to receive command by I2C-BUS. By receiving I2C-BUS command, it performs temperature detection/humidity detection/compensation operation/humidity output, etc.

Table 8-1. Operation Mode

Operation Mode	Terminal Setup	Operation State of Each Functional Block					
	CE	Power Supply	Oscilla-tion	Tempera-ture Detection	Humidity Detection	OTP Memory	I2C-BUS
Standby	1	Operation	Operation	Stop	Stop	Read-out Possible	Operation

Table 8-2. shows control register used at standby.

Table 8-2. Control Register

Address	Bit	Bit Name	Functions	Value	Read-out	Write-in	R/W	Init.
00h	D7-1	-	Reserved	-			R	0
	D0	RESET	Reset	0	Normal Operation	None	R/W	0
				1	-	Reset Action		
01h	D7-6	MANMODE	Temperature and Humidity Detection Mode	00	Normal Operation Mode		R/W	0
	D5-3	HAVE[2:0]	Humidity Detection Value Average Mode	000	No Averaging Process		R/W	0
				001	2 Times Average Mode			
				01x	4 Times Average Mode			
				1xx	8 Times Average Mode			
	D2	TAVE	Temperature Detection Value Average Mode	0	No Averaging Process		R/W	0
				1	8 Times Average Mode			
	D1	-	Reserved	-			R	0
	D0	MAN	Temperature and Humidity Detection	0	Standby State	Detection Operation Stop	R/W	0
				1	Under Detection Operation	Detection Operation Start		
03h	D7-1	-	Reserved	-			R	0
	D0	ERR	Temperature and Humidity Detection Error Flag	0	No Error	None	R/W	0
				1	Error Occurred	Error Flag Reset		

●RESET : Reset Action (Address : 00h Bit : D0)

This performs reset of IC.

"1" Write-in : Reset
"0" Write-in : Invalid
Read-out : Possible

By writing "1" in RESET Register, internal circuit of IC will be in reset state.

●MAN : Temperature and Humidity Detection Operation (Address : 01h Bit : D0)

Detection of temperature and humidity is performed.

"1" Write-in : Detection Operation Start
Read-out : Under Detection Operation
"0" Write-in : Detection Operation Stop
Read-out : Standby State

By writing in "1" in MAN Register, detection operation (operation specified in MANMODE Register) will be performed. Under detection operation, MAN Register keeps holding "1" and it will be cleared to "0" after detection operation finishes.
If "0" is written in MAN Register during detection operation detection operation will stop.

●TAVE : Temperature Detection Value Average Mode (Address : 01h Bit : D2)

●HAVE : Humidity Detection Value Average Mode (Address : 01h Bit : D5-3)

They select number of temperature detection and humidity selection. (Table 8-3. , Table 8-4.)
Designated number of detection operation will be performed. Detection values of temperature and humidity acquired by every detection will be averaged and stored them in detection result register as detection value of temperature and himidity.

Table 8-3. Setting of Averaging Number for Temperature Detection Value

TAVE	Number of Operation
0	1 Time
1	8 Times

Table 8-4. Setting of Averaging for Humidity Detection Value

HAVE[2:0]	Number of Operation
0 0 0	1 Time
0 0 1	2 Times
0 1 X	4 Times
1 X X	8 Times

For both temperature and humidity, averaging process will be performed before compensation operation.

● MANMODE : Temperature and Humidity Detection Operation Mode (Address : 01h Bit : D7-6)

This selects detection operation to be performed at the time of write "1" in MAN Register. (Table 8-5.).

Table 8-5. Mode Setup of Temperature and Humidity Detection Operation

MANMODE	Mode of Operation	Detail
0 0	Normal Operation Mode	Perform in order of temperature detection → humidity detection → compensation processing, Upon completion, return to standby.

●ERR : Temperature and Humidity Detection Error Flag (Address : 03h Bit : D0)

This notifies that error occurred during manual detection operation.

"1" Write-in : Error Flag Reset
Read-out : Error Occurred
"0" Write-in : Invalid
Read-out : No Error

If overflow occurs in internal counter (Time Base Counter and Measurement Counter) due to abnormal oscillation during humidity detection, error flag becomes "1" in this IC.

* This register will not be cleared automatically.
Please write "1" in this register to clear when error occurred.

8-3. Start-up / Shut-down Sequence

The Start-up/Shut-down sequence of this IC is as follows.

Power control : By pull-up of CE terminal, ON/OFF of power supply (VCC) controls halt/operation of circuit.

Sequence by Power Control

Figure 8-1. shows Start-up/Shut-down sequence by Power Control.

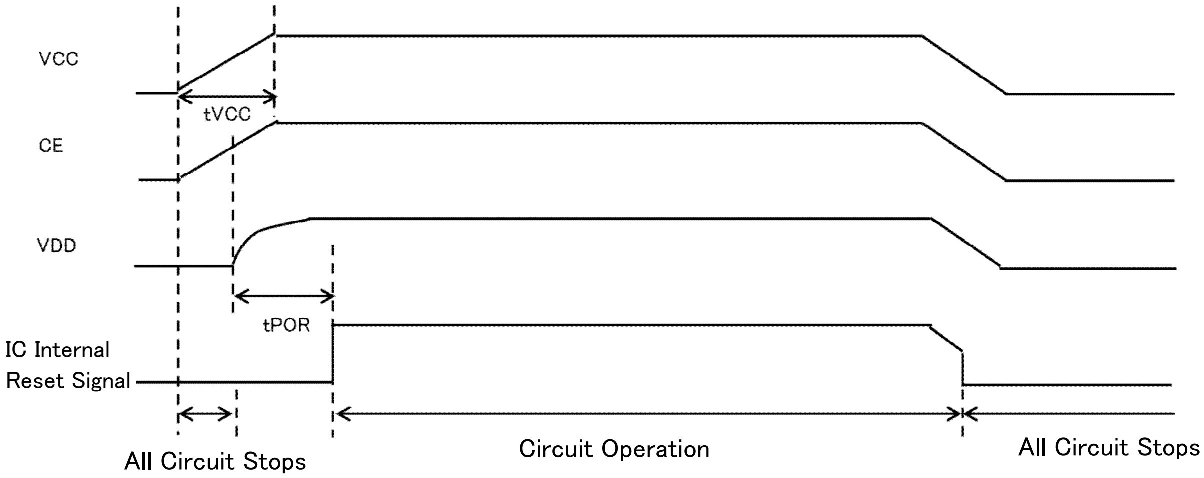


Figure 8-1. Start-up/Shut-down Sequence (Power Control)

8-4. Temperature / Humidity Detection Sequence

Figure 8-2. shows operation timing during detection of temperature and humidity in this IC.

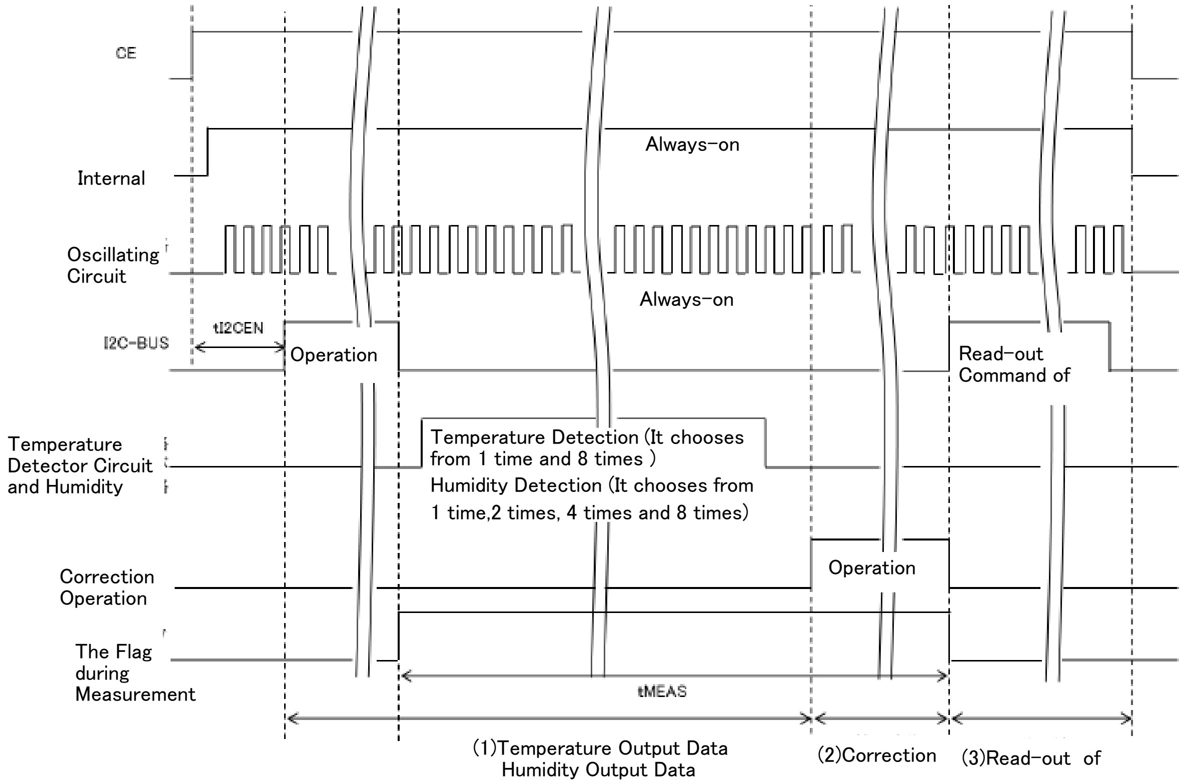


Figure 8-2. Temperature / Humidity Detection Sequence

After I2C-BUS Command waiting state, there are 3 steps of temperature detection/ humidity detection/compensation operation/read-out of detection result.

(1) Temperature Detection / Humidity Detection

Temperature detection/Humidity detection is performed according to contents of I2C-BUS Command.

Moreover, I2C Register can set up number of detecting temperature and humidity. Temperature detection can select from 1/8 times. Humidity detection can select from 1/2/4/8 times.

(2) Compensation Operation

Compensation of temperature and humidity values will be performed using detection result of temperature and humidity and compensation parameter recorded in OTP Memory.

Upon completion of performing detection/operation, detecting flag will be cleared.

* When 8 times are selected for temperature detection, compensation operation will be performed by using average value of temperature detection result.
* When 2/4/8 times are selected for humidity detection, compensation operation will be performed by using average value of himidity detection result.

(3) Read-out of Detection Result

I2C-BUS Master will check detection operation flag, and wait for completion of detection operation. Upon completion of detection operation, detection result of temperature and humidity before compensation or temperature and humidity after compensation can be read.

8-5. Humidity・Temperature Arithmetic Expression

Humidity Arithmetic Expression

$$RH = \frac{100}{2^{10} - 1} \times RH_{IC} \quad (0〜100\%RH)$$

RH_{IC} : IC Humidity Output Data (10 Bit Output)

＊Refer to Attached Chart 1. Register Map RH_{IC} = Data of the addresses 04H and 05H (000h〜3FFh) it changes into a decimal and is operation.

Temperature Arithmetic Expression

$$T = [T_{IC} - \left(2^{10} - \frac{25}{0.1}\right)] \times 0.1 \quad (-20〜100℃)$$

T_{IC} : IC Temperature Output Data (11 Bit Output)

＊Refer to Attached Chart 1. Register Map. T_{IC} = Data of the addresses 06H and 07H (000h〜7FFh) it changes into a decimal and is operation.

Table 8-6. Example of Humidity Output

RH_{IC}	RH [%RH]	Resolution [%RH]
0	0.0	0.1
512	50.0	
1023	100.0	

Table 8-7. Example of Temperature Output

T_{IC}	T [℃]	Resolution [℃]
574	-20.0	0.1
1024	25.0	
1774	100.0	

<Measurement Example>

1. Slave address is set to "7F".
2. The address 01h "01h" Write (Start Detection Operation)
3. It reads until address 01h D0 turns into 0 (waiting for Detection Completion).
4. Address 03h D0 is Read and it checks that it is D0=0. (*1)
5. Data of the addresses 04h and 05h is read (Humidity Data reading)
6. Data of the addresses 06h and 07h is read (Temperature Data reading)

(*1) In the case of D0=1, it is an error.
Please write 1 in D0 of address 03h (Error Clearance), and redo work from No. 2.

Attached Chart 1-1. Register Map

System Control Register

Address	Bit	Bit Name	Functions	Value	Read-out	Write-in	R/W	Init.
00h	D7-1	-	Reserved	-			R	0
	D0	RESET	Reset	0	Normal Operation	None	R/W	0
				1	-	Reset Action		
01h	D7-6	MANMODE	Temperature and Humidity Detection Mode	00	Normal Operation Mode		R/W	0
	D5-3	HAVE[2:0]	Humidity Detection Value Average Mode	000	No Averaging Process		R/W	0
				001	2 Times Average Mode			
				01x	4 Times Average Mode			
				1xx	8 Times Average Mode			
	D2	TAVE	Temperature Detection Value Average Mode	0	No Averaging Process		R/W	0
				1	8 Times Average Mode			
	D1	-	Reserved	-			R	0
	D0	MAN	Temperature and Humidity Detection	0	Standby State	Detection Operation Stop	R/W	0
				1	Under Detection Operation	Detection Operation Start		
03h	D7-1	-	Reserved	-			R	0
	D0	ERR	Temperature and Humidity Detection Error Flag	0	No Error	None	R/W	0
				1	Error Occurred	Error Flag Reset		

Attached Chart 1-2. Register Map

System Control Register

Address	Bit	Bit Name	Functions	Value	Read-out	Write-in	R/W	Init.
04h	D7-0	HC[7:0]	Humidity Detection Result (After Correction Operation)	000h-3FFh			R	X
05h	D7	-	Reserved	-			R	X
	D1-0	HC[9:8]	Humidity Detection Result (After Correction Operation)				R	X
06h	D7-0	TC[7:0]	Temperature Detection Result (After Correction Operation)	000h-7FFh			R	X
07h	D7-3	-	Reserved	-			R	0
	D2-0	TC[10:8]	Temperature Detection Result (After Correction Operation)				R	X

9. Communication Timing Chart

9-1. At Data Write-in

Data write-in from the register of this IC is done by the procedure shown in 9-1.

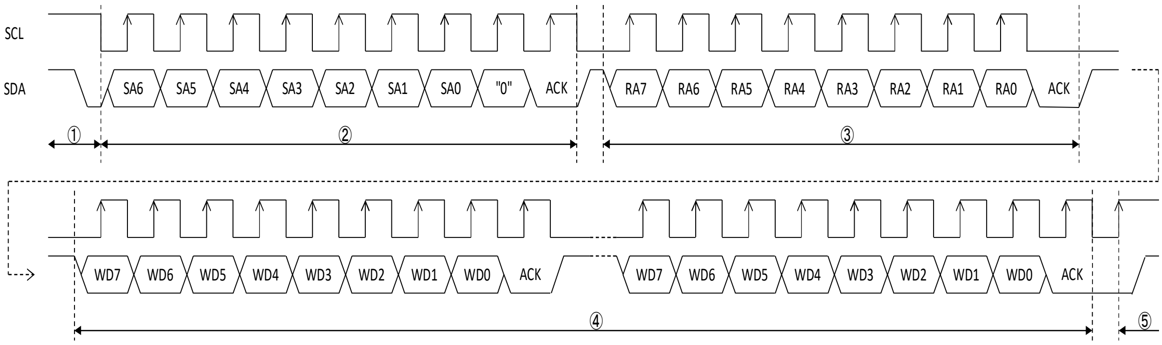


Figure 9-1. I2C-BUS Data Write-in Procedure

① I2C Master Device releases Start Condition.
(Start Condition can be released by changing SDA from ″H″ to ″L″ while SCL is in ″H″ state.)

② I2C Master Device transmits Slave Address and Write Mode Selection.
(Write Mode can be selected by transmitting ″0″ in 8th bit while 1～7th bits are Slave Address.)

③ I2C Master Device transmits Register Address of this IC.

④ I2C Master Device transmits Write-in Data.
It is possible to Write-in Data while Register Address increments one,
by transmitting multiple Write-in Data continuously.

⑤ After the completion of transmitting all Write-in Data, I2C Master Device releases Stop Condition.
(Stop Condition can be released by changing SDA from ″L″ to ″H″ while SCL is in ″H″ state.)

9-2. At Data Read-out

Data read-out from the register of this IC is done by the procedure shown in 9-2.

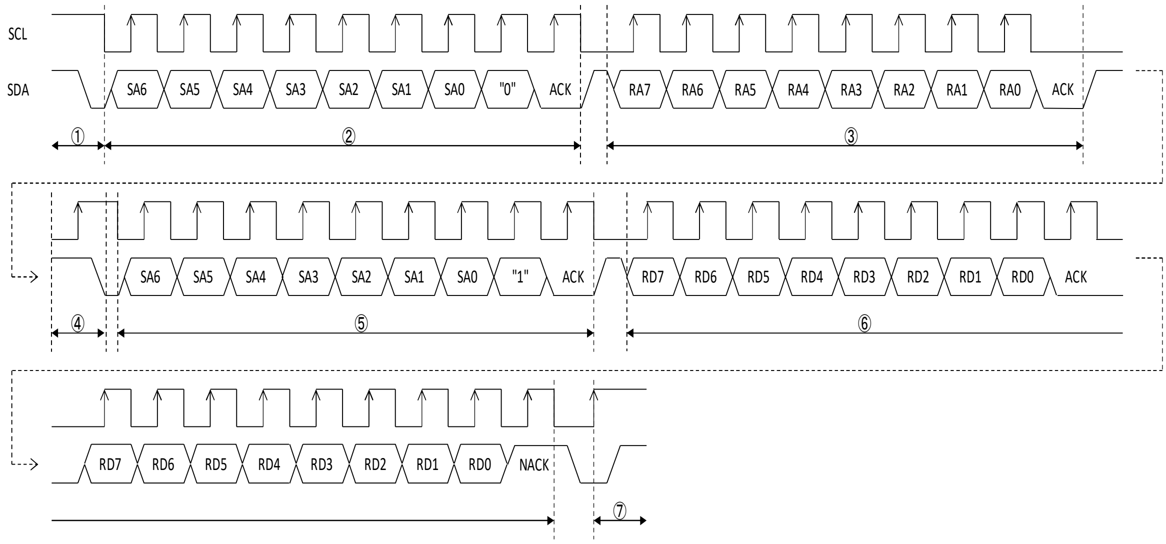


Figure 9-2. I2C-BUS Data Read-out Procedure

① I2C Master Device releases Start Condition.

② I2C Master Device transmits Slave Address and Write Mode Selection.

③ I2C Master Device transmits Register Address of this IC.

④ I2C Master Device releases Repeated Start Condition.
(Release method is same as Start Condition.)

⑤ I2C Master Device again transmits Slave Address Read Mode Selection.
(Read Mode can be selected by transmitting ″1″ in 8th bit.)

⑥ I2C Master Device reads out data from Register Address designated at ③.
It is possible to Read-out Data while Register Address increments one, by reading out multiple data continuously. But, during continuous Read-out, please return ACK to this IC as a reply of Master. Only for last data Read-out, please return NACK to this IC as a reply.

⑦ After the completion of all Read-out, I2C Master Device releases Stop Condition.

9-3. AC Characteristic

Unless otherwise specified : VCC = 1.62～5.5V , VSS = 0V , Ta = -20～100℃ , No Condensation

Item	Symbol	Conditions	Min	Typ	Max	Unit
VCC Fluction	tsl	tsl=tVCC/VCC Cf. Figure 8-1	10	-	2000	μs/V
Power-on Reset Release Time	tPOR	Cf. Figure 8-1	-	1	5	ms
I2C Command Wait Time	tI2CEN	Cf. Figure 8-2	-	-	20	ms
Temperature / Humidity Detection Time	tMEAS	Temp Detection : 1 Time Hum Detection: 1 Time	-	-	14	ms
SCL Cycle Time	t_{SCL}		2.5	-	-	μs
SCL Low Pulse Width	t_{LOW}		1.3	-	-	μs
SCL High Pulse Width	t_{HIGH}		0.6	-	-	μs
SDA , SCL Rise Time	t_r		-	-	1000※	ns
SDA , SCL Fall Time	t_f		-	-	300	ns
Start Condition Hold Time	$t_{HD:STA}$		0.6	-	-	μs
Repeated Start Condition Setup Time	$t_{SU:STA}$		0.6	-	-	μs
Stop Condition Setup Time	$t_{SU:STO}$		0.6	-	-	μs
Data Hold Time	$t_{HD:DAT}$		0	-	-	ns
Data Setup Time	$t_{SU:DAT}$		100	-	-	ns
Bus Free Time	t_{BUF}		1.3	-	-	μs

※When using the product, please check the noise immunity at customer side.

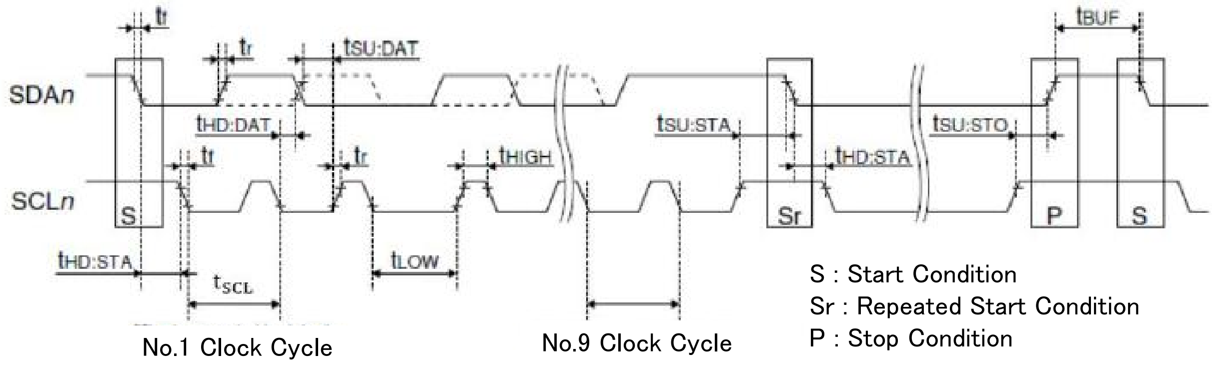


Figure 9-3. AC Characteristic Timing Chart

10. About I2C Communication

10-1. How to Check Data Integrity

This product does not have a checksum function.
Follow the steps below to check the consistency of the data.
Since the temperature/humidity data is not updated unless "01h" is written to register address 01h,
it is possible to check the consistency of the data by reading register addresses 04h to 07h multiple times.

10-2. How to Recover from Communication Failure

Symptom : SDA Line Fixed at Low

①Recovery Method by Pseudo Clock

Switch the SCL / SDA pin on the master side to a general-purpose port,
output a pseudo clock from the SCL pin (pseudo clock output with Hi-z and Low output),
and check that SDA is released on the slave side. (Confirm that SDA becomes "Hi")
At this time, if the slave side does not release SDA after a single pseudo clock output,
output the pseudo clock repeatedly until the slave side releases SDA.
When the slave side releases SDA (SDA = "Hi"), return the setting on the master side to
the I2C bus, issue a start condition (start condition) and a stop condition (stop condition),
and terminate communication once. After that, execute the reset command (Address: 00h Bit: D0).

②Recovery Method by Hard Reset

It can be reset by turning off the power supply (VCC).

11. Notes

・This product is a very precise environment measurement part. Unlike ordinary electronic parts, there are openings for exposing the moisture-sensitive membrane to the outside atmosphere, so it is easy to be affected by chemical contamination.
In order to operate the humidity sensor function stably, please note that adhesion of solvent, foreign matter, etc. (see below) or scratches on the opening of this sensor may cause defects.

Organic Solvent
Do not allow it to adhere to liquids or vapors such as acetone, ethanol, isopropyl alcohol, and toluene.

Damp proofing agent
Moisture proofing agents also generally contain organic solvents.
When applying a damp proofing agent, make sure that the opening is sufficiently ventilated so that the damp proofing agent does not adhere to the opening.

Flux
Use non-cleaning type solder, and be careful not to adhere due to flux smoke or scattering.

Foreign Matter
Make sure that sebum, oil, conductive substances, dielectric substances, etc. do not adhere.

Acid (Hydrochloric Acid, Sulfuric Acid, Nitric Acid, etc.), Alkali
Please note that the ammonia atmosphere in particular has a significant effect.

・If this product comes into contact with high-concentration ozone, corrosive gases (organic solvents, sulfurous acid gas, hydrogen sulfide gas, etc.), or a large amount of dust, the performance may be adversely affected. Please be sure to check it thoroughly before using it.

・Avoid exposure to volatile organic compounds (whether liquid or vapor).

・Make sure that this sensor is not exposed to high concentrations of chemical solvents.
Also, avoid contact with gas released from adhesives and tapes, and packaging materials that may release gas.

・When performing soldering work around this product, make sure that flux does not adhere to the sensor opening of this product. Performance may be adversely affected.

・Please don't wash the sensor, there is a case that it affects to its performance.

・Do not apply mechanical stress to any part of this sensor.
Performance may be adversely affected.

・Electrostatic may fear destroying this sensor. When handling,
please give extra care to take measure against ESD.

<Countermeasure Example>
・Work with a grounded wrist strap.
・Use a conductive material for the floor of the work area and ground it.

・Please protect our sensors with ESD protective packaging outside the ESD protected area.

・This sensor is not designed as radiation-proof.
If the product is exposed to excessive radiation, it may adversely affect performance.

・Use and storage in an environment where splashes of water or salt water may adversely affect performance, so be sure to check thoroughly before use.

・Do not apply excessive mechanical shock to this product. Performance may be adversely affected.

・Do not block the opening of this product or use it while physical contact is occurring.
It may adversely affect the characteristics or lead to product destruction.

・These contents are applied not only at the time of storage and manufacturing, but also during the entire period such as transportation and usage environment in the market.

・Please store this product under the following conditions.

Unopened Packaging	: Within 1 Year at 5～35℃ / ≦60%RH
After Opening the Package	: MSL2

・Do not use a desiccant such as silica gel for storage.

・For long-term storage of one year or more, storage in a nitrogen atmosphere is recommended.

・This sensor is intended to be used for general electrical equipment.
For any other uses falling into the following category, please contact to our company in advance.
Any uses in applications demanding extremely-high reliability such that failure or malfunction of medical equipment, safety device, aviation and space instrument, nuclear control equipment, combustion control apparatus, etc. is normally feared to cause serious damage to human life, body, property, etc., regardless direct or indirect.

・For use in equipment that requires a high degree of safety and reliability other than the prohibited uses above, please contact our sales representative in advance. Alternatively, please design safety measures after sufficiently confirming compatibility by yourself.

・Do not use this product for military purposes or anti-social activities such as terrorism. Also, please do not supply this product to corporations, organizations, individuals, etc. who may end up using it for such purposes.

・When exporting products that are regulated by domestic and foreign export-related laws and regulations, please comply with the laws and regulations and take necessary permission and procedures by yourself.

*Please also refer to the attached application manual.

12. Others

・Environment
This product is complying with EU RoHS.
In addition, it is based on "Hokuriku Electric Industry Co., Ltd. Green Procurement Guideline".

・When using this product, regardless of whether it is accidental or consequential, we will not be responsible for any problems caused by the product or circuit. Customers are responsible for demonstrating compliance with customer application design, verification, testing, various standards, safety, security, regulations, and other matters. In addition, the customer shall bear the same responsibility.

・We are not responsible for any damage caused by use beyond the specified range and conditions of this specification.

・If any doubt arise on this specification, both parties shall make efforts to solve it upon mutual discussion.