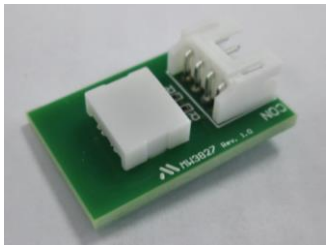
Temperature and Humidity sensor MMS201AA Data Sheet

Description



The MMS201 is a combined relative humidity and temperature sensor module. The dual sensor is also combined with our custom analog front end to provide a fully calibrated and temperature compensated digitized I^2C output. The MMS201 proprietary polymer and parallel plate capacitive structure provides excellent robustness and reliability. No complicated sensor drive or control circuit is required, and high performance sensing is achievable only with the MMS201 and an external microcontroller which works as a host.

Features

- Small module: 24mm(W) × 16mm(D)
- Operating temperature ranges -25~+85℃
- Operating Humidity ranges 0~100%RH
- Supply voltage 2.2~5.5V
- Current consumption 8.97μA Typ. （@1sample/sec.）
- Current consumption at sleep 0.85μA Typ.
- Output corrected humidity value with repeatability of 0.015%RH (I^2C)
- Equipped with a heater for checking operation
- 8-bit I^2C address 50h(Write), 51h(Read)

Contents

BLOCK DIAGRAM

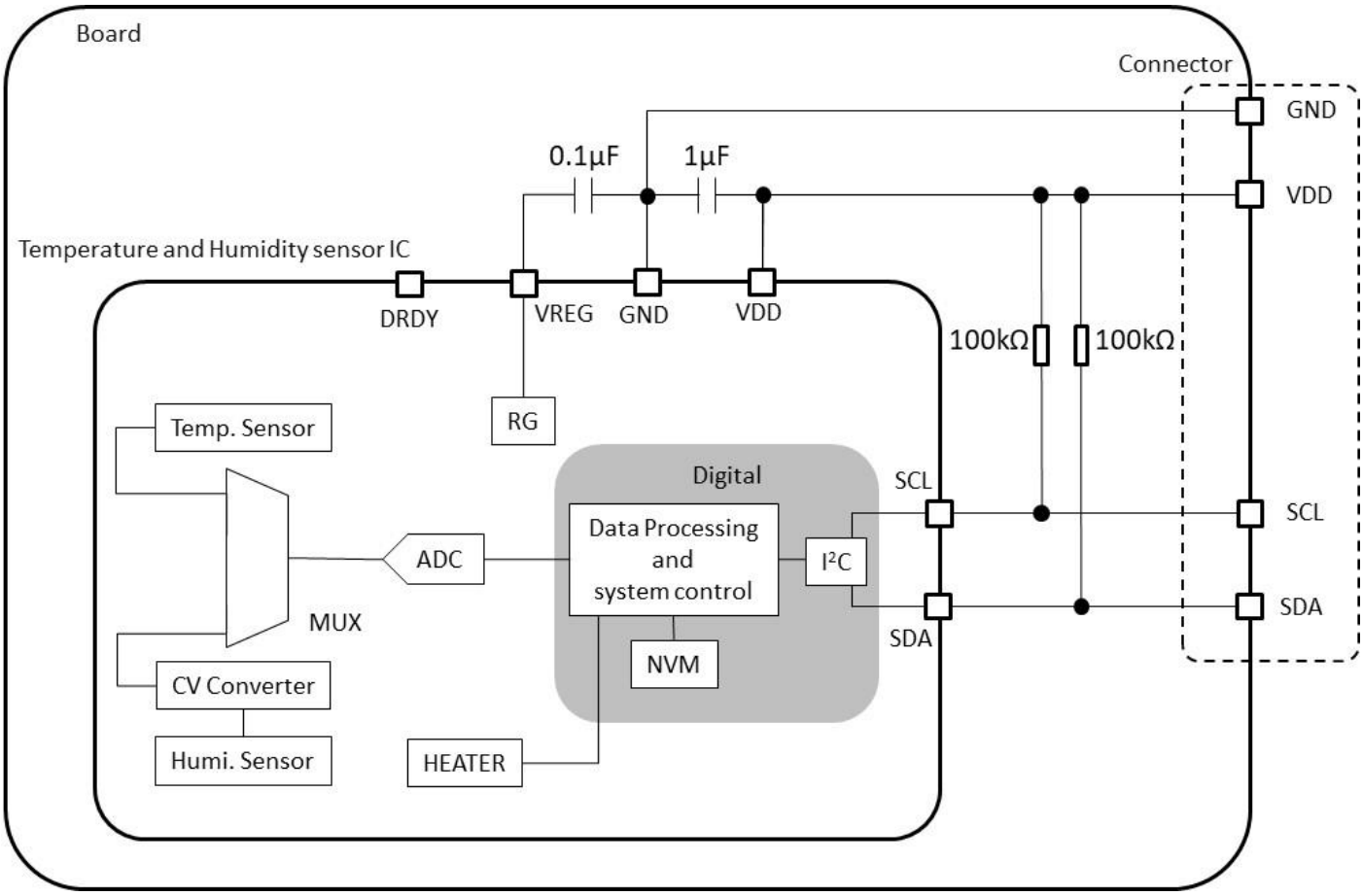


Fig.1 Block diagram

Internal structure

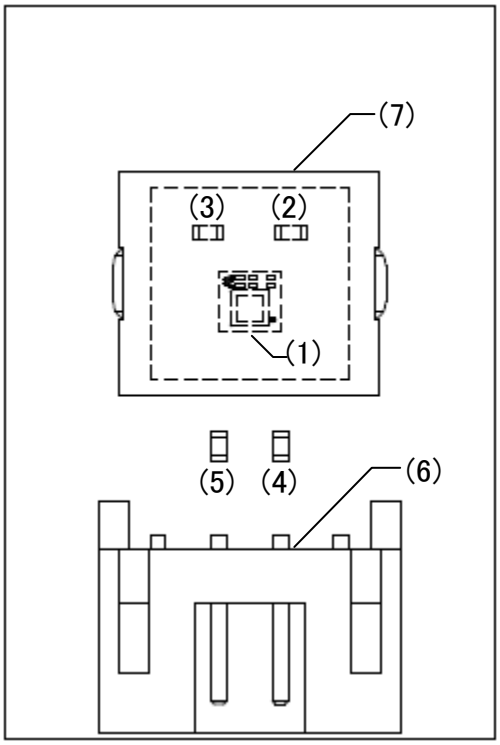


Fig.2 Internal structure

Table.1 arts on board

No.	Symbol	Name
(1)	U1	Temperature and Humidity sensor
(2)	C0	Capacitor 1μF
(3)	C1	Capacitor 0.1μF
(4)	R0	Pull-up resistor (100kΩ)
(5)	R1	Pull-up resistor (100kΩ)
(6)	CON	Connector (JST S4B-PH-K-S)
(7)	-	Cover case

PIN CONFIGURATION

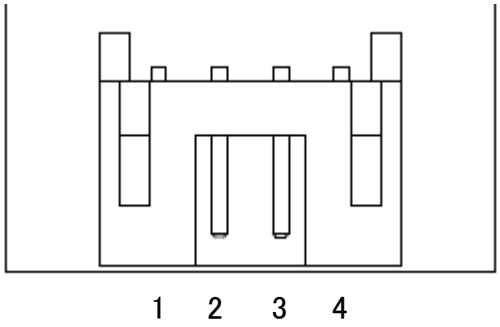


Fig.3 Pin configuration (Top view)

Table.2 Pin table

No.	Pin Name	Function
1	VDD	Supply voltage
2	SCL	Serial clock
3	SDA	Serial data
4	GND	Ground

TERMINAL EXPLANATIONS

Table.3 Pin table

No.	Pin Name	Type	Function
1	VDD	I	Power supply
2	SCL	I/O	Serial clock for I^2C communication(SCL)
3	SDA	I/O	Serial Data (Input and output) for I^2C communication(SDA)
4	GND	-	GND

ABSOLUTE MAXIMUM RATINGS

(unless otherwise specified, Ta=25°C, VDD=3.3V)

Item	Symbol	Min.	Max.	Unit
Storage temperature range	T_{STG}	-25	+85	°C
Analog supply voltage	VDD_{MAX}	-0.3	+6.0	V
Digital input voltage	$VDIN_{MAX}$	-0.3	VDD+0.3	V

RECOMMENDED OPERATING CONDITIONS

(unless otherwise specified, Ta=25°C, VDD=3.3V)

Item	Symbol	Min.	Max.	Unit
Operating temperature range	T_{OPR}	-25	+85	°C
Operating humidity range	H_{OPR}	0	100	%RH
Analog supply voltage	VDD_{OPR}	+2.2	+5.5	V
Digital input voltage	$VDIN_{OPR}$	0	VDD	V

Power-on sequence

When the power is turned on, access the device at least 15msec. after reaching 90% of the applied voltage. (note[1])

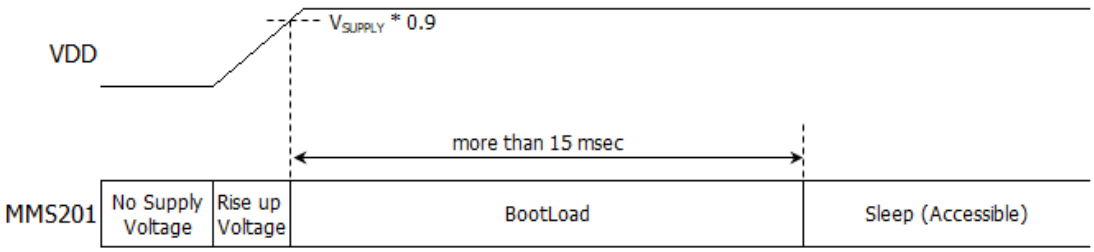


Fig.4 Power-on sequence

Reapply voltage sequence

When turning on the power again, wait until VDD drops below 0.1V, and then turn on the power again after at least 6msec has elapsed.

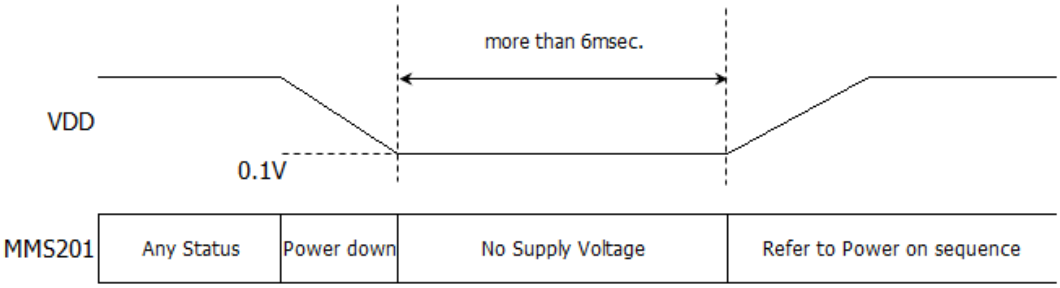


Fig.5 Reapply voltage Sequence

note[1]: The above power-on sequence operation may fail when the power is turned on, for example, if the power waveform is not appropriate. If the power-on sequence fails, MMS201 transitions to a setting that rejects I^2C communication, reflecting the error state in the ERR_BL bit of the status register, in order to prevent the error from continuing to operate in the abnormal state. Refer to the Status register for details on how to check and return.

ELECTRICAL CHARACTERISTICS

Analog characteristics
(unless otherwise specified, Ta=25°C, VDD=3.3V)

Item	Symbol	Condition	Min.	Typ.	Max.	Unit.
Current consumption	I_{DD}	One Shot Operation 1sample/sec. (note[2])	-	8.97	14.2	μA
Current consumption at Sleep	I_{DDSL}	At Sleep state (note[3])	-	0.85	1.6	μA
Current consumption at Standby	I_{DDSB}	At Standby state (note[3])	-	0.95	1.8	μA
Current consumption at Measurement	I_{DDM}	At Measurement state (note[3])	-	1120	1420	μA
Current at Heater-ON (note[4])	I_{HEAT}		-	10	-	mA
VREG voltage	V_{RGSL}	At Sleep state (note[3])	1.71	1.8	1.89	V
	V_{RGACT}	At Active	1.71	1.8	1.89	V

note[2]: The average of one sample per second by One Shot Operation.
note[3]: For details of each state, refer to Description of the state or State transition diagram.
note[4]: About setting heater, please see Heater function.

Humidity sensor characteristics
(unless otherwise specified, Ta=25℃, VDD=3.3V)

Item	Symbol	Condition	Min.	Typ.	Max.	Unit
Humidity accuracy	H_{acc}	25℃, 50%RH	-	(±2) TBD	-	%RH
Humidity repeatability	H_{rep}		-	0.015	-	%RH RMS
Humidity hysteresis	H_{hys}	Ta=25℃	-1	-	+1	%RH
Humidity response time	t_{HRESP}	10⇔90%RH @Ta=25℃, τ=63%	-	TBD	-	sec.

Temperature sensor characteristics
(unless otherwise specified, Ta=25℃, VDD=3.3V)

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
Temperature accuracy	T_{acc}	Ta = 25℃	-0.6	-	+0.6	℃

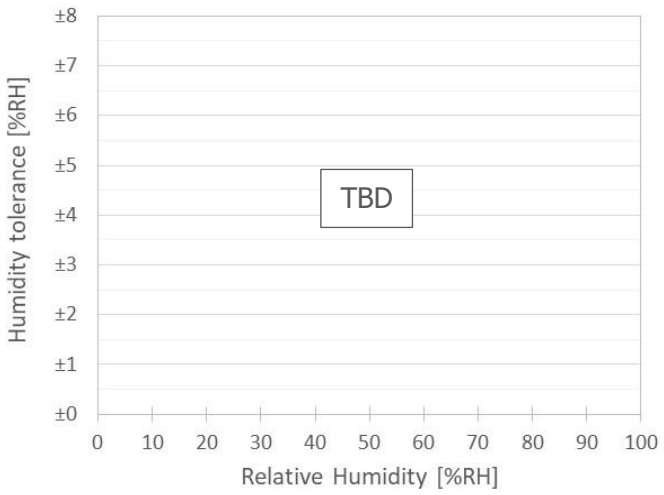


Fig.6 Humidity tolerance at 25℃

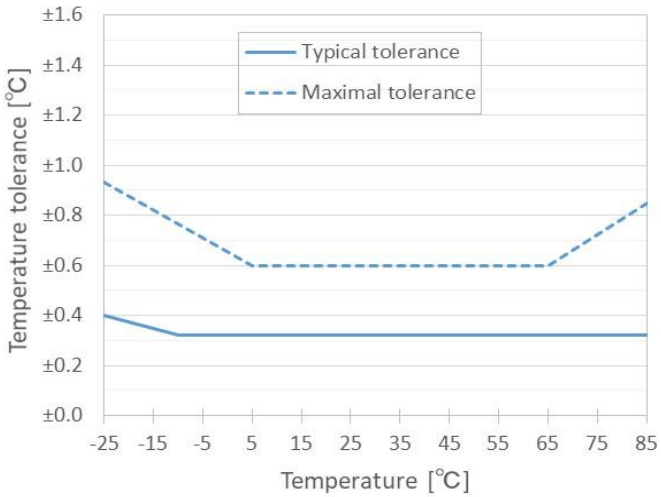


Fig.7 Temperature tolerance

Digital I/O

(unless otherwise specified, Ta=25℃, VDD=3.3V)

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
High level input voltage	V_{IH}	SCL、SDA	0.7 × VDD	-	VDD +0.3	V
Low level input voltage	V_{IL}	SCL、SDA	-0.3	-	0.3 × VDD	V
Output voltage High level	V_{OH}	I_{OH}=-3mA	0.8 × VDD	-	-	V
Output voltage Low level	V_{OL}	SCL、SDA I_{OL}=3mA	-	-	0.4	V

DEFINITION OF CHARACTERISTICS

To be released

FUNCTION

Description of operation method

MMS201 operates on the I^2C interface and the slave address (7-bit) is 28h. The operation is controlled by specifying the control register in the write format. When accessed in the read format, the measurement result can be read as a digital value. For the method of calculating the digital value to temperature and humidity, refer to Method of calculation to temperature and humidity values. The status register reflects the operating state and reads the register value by specifying the register address in the combination format

Description of state（Sleep State / Measurement State）

MMS201 transitions to the state according to the control register settings. There are two types of state: Sleep state and Measurement state. Additionally, there are two types of Measurement state: One Shot Operation and Repeat Operation. The outline is shown below

■Sleep state ･･･Waiting state.

■Measurement state

1) Repeat Operation ･･･ Repeat measurement for each set $T_{Standby}$.

2) One Shot Operation ･･･ Only one time measurement.

For details of each state, refer to State transition table and State transition diagram.

About system design

1) Repeat Operation

Measured continuously at each set $T_{standby}$. Read the result after confirming that RDY_DATA in the status register is "1".

2) One Shot Operation

This operation is based on the assumption that the timing should be controlled under the initiative of the MCU. Measurement is instructed by the MCU each time. After measuring is complete, MMS201 transitions to Sleep and waits with minimal current savings.

Detailed description of Measurement state

Repeat Operation

Repeat Operation is measured continuously according to $T_{Standby}$ setting. Set the operation state setting bit SET_STATE [2:0] of the control register to 001b. Set the standby time $T_{Standby}$ for repeat measurements with the Standby time setting bit TSTBY[2:0]. After the measurement is completed, the previous measurement results are discarded and the new measurement results are retained.

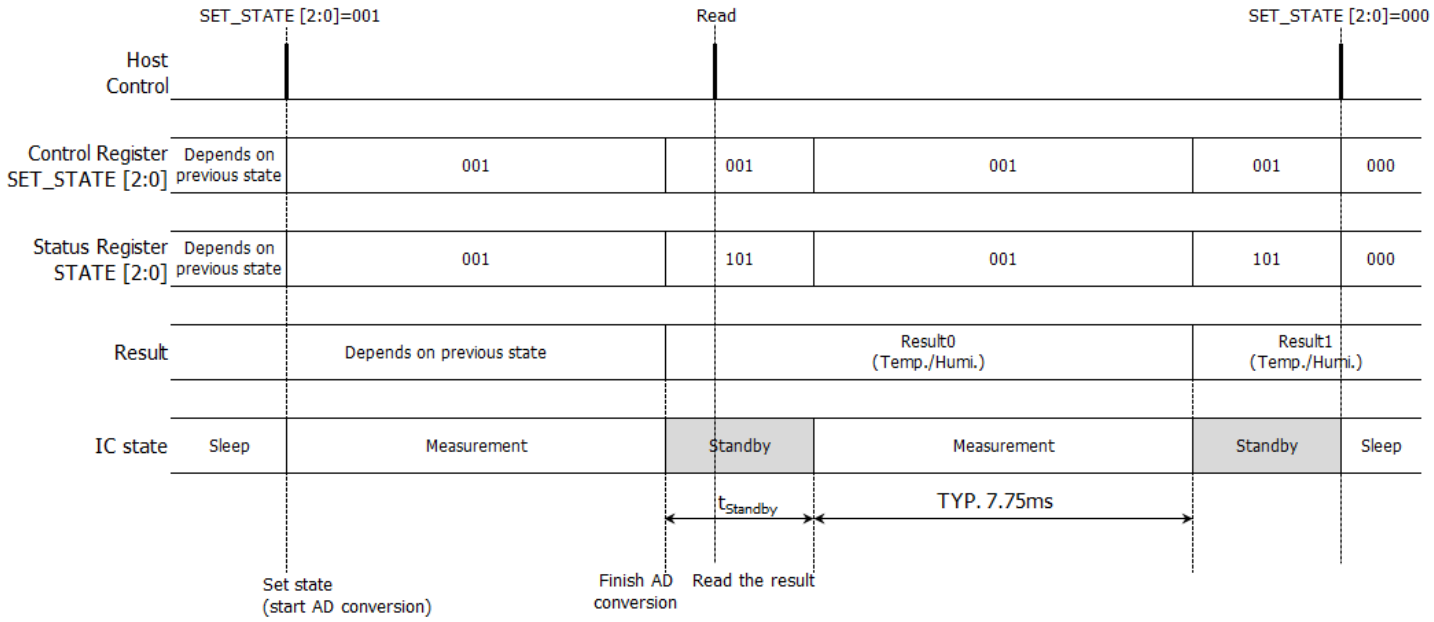


Fig.8 Timing chart for Repeat Operation

One Shot Operation

One Shot Operation is a single measure that automatically returns to sleep without transitioning to Standby state. Set the operation state setting bit SET_STATE [2:0] of the control register to 001b and Standby time setting bit TSTBY [2:0] to 111b. After the measurement is completed, the previous measurement results are discarded and the new measurement results are retained.

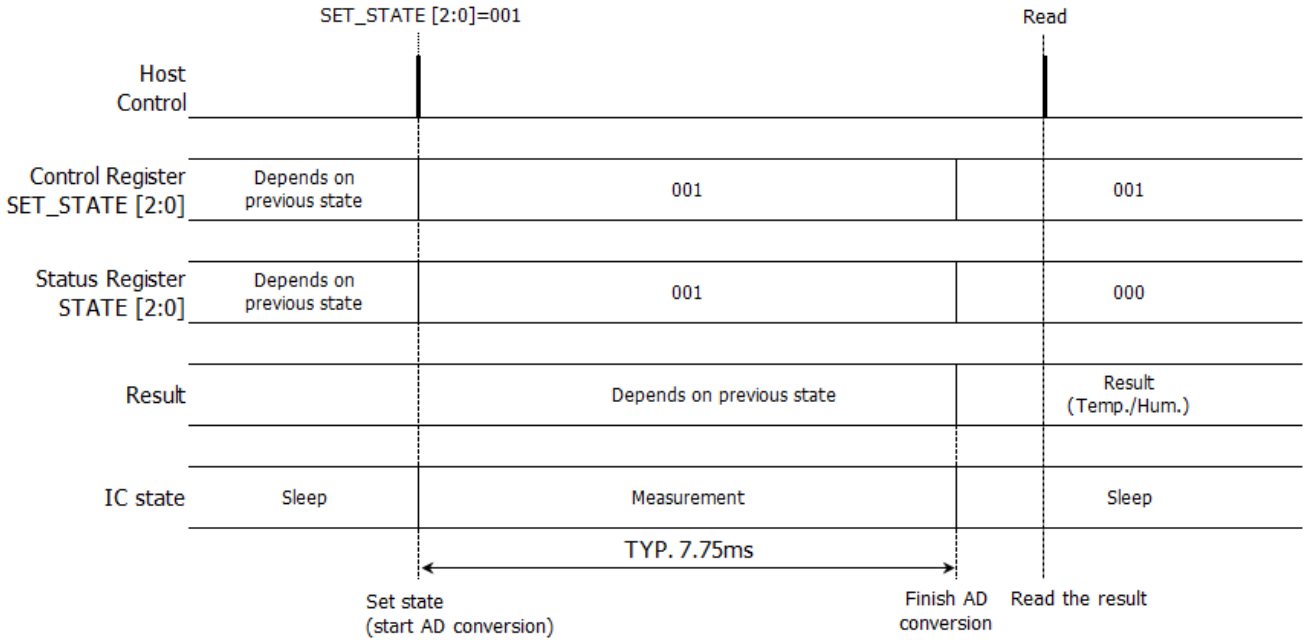


Fig.9 Timing chart for One Shot Operation

Heater function

MMS201 is equipped with a heater for functional verification. When the heater is enabled (EN_HEATER bit in the control register is 1b), it can be checked to see if it is functioning as a sensor by checking that the temperature is rising and the humidity is falling. Please wait about 20 seconds after activating the heater. Be careful not to forget to return the heater to OFF (EN_HEATER bit in the control register to 0b) after the operation check is finished. The initial value of EN_HEATER bit in the control register is 0b (Heater Off).

MMS201 is equipped with a function to detect abnormal heater current to prevent excessive heat generation.The ERR_HEAT bit in the status register indicates the monitoring result of the abnormal current of the heater.

State transition table

Table.4 State transition table

SET_STATE [2:0]	State		
	Sleep	Standby	Measurement
Sleep (000b)	Keep state	Transit to Sleep	After AD conversion, transit to Sleep
Measurement (001b) Repeat Operation	Transit to Measurement	Transit to Measurement	Keep state
Measurement (001b) One Shot Operation	Transits to Measurement, transits to Sleep after AD conversion	Transits to Measurement, transits to Sleep after AD conversion	Transits to Sleep after AD conversion
Reset & Sleep (100b)	After all register reset and Boot Load, transit to Sleep	After all register reset and Boot Load, transit to Sleep	After all register reset and Boot Load, transit to Sleep

When there is error in Boot Load, the MMS201 will be waiting in the sleep state, set ERR_BL "1". Please see Status register for details

State transition diagram

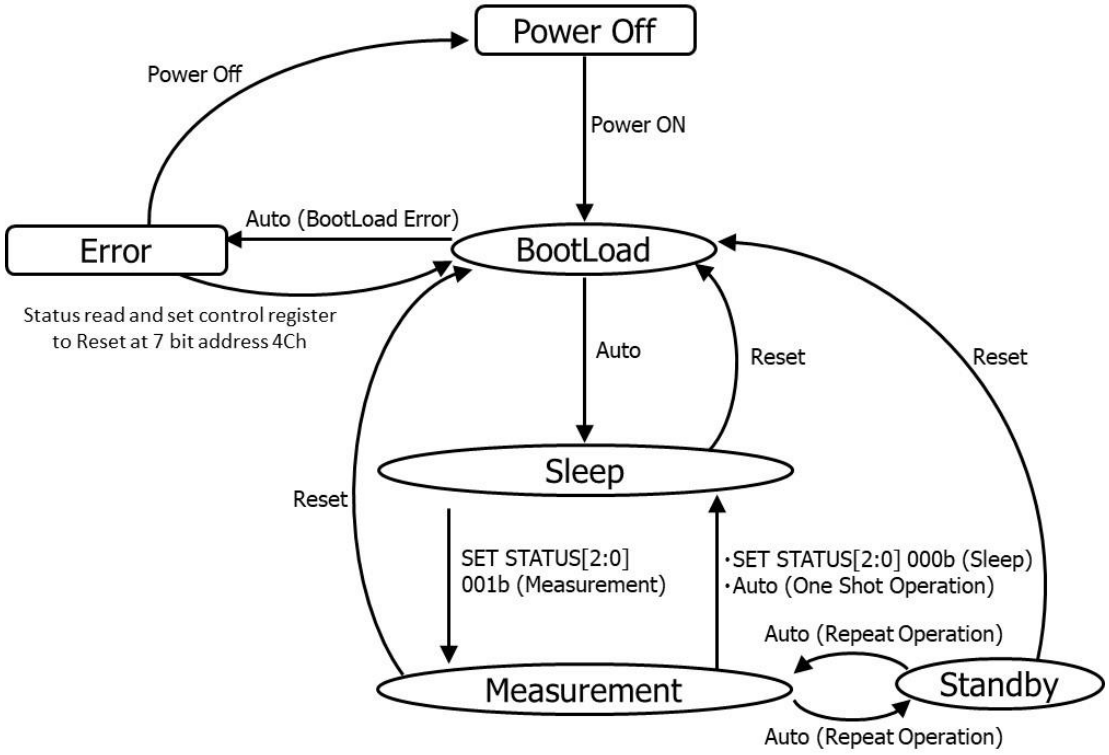


Fig.10 State transition diagram

Notes on transitioning from a Repeat Operation to another

When MMS201 is in Repeat operation and the device is accessed during the transition from Standby to Measurement, it returns an NACK as a communication error. If this happens, wait at least 3msec after a communication error occurs before accessing the device again.

Control register

Table.5 Detail of control register

Addr	Initial	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	R/W
0Ch	00h	Reserved	TSTBY[2:0]			EN_HEATER	SET_STATE[2:0]			R/W

●TSTBY[2:0] :
Either 000b~110b is set $T_{Standby}$ (Standby time) When SET_STATE [2:0] is set other than 001b, this setting is ignored.
000b : For manufacturer (note[5])
001b : For manufacturer (note[5])
010b : $T_{Standby}$ 100ms
011b : $T_{Standby}$ 400ms
100b : $T_{Standby}$ 1000ms
101b : For manufacturer (note[5])
110b : For manufacturer (note[5])
111b : One Shot (Returns to Sleep without transit to Standby)

●EN_HEATER :
Set Heater On or Off. "0" is Heater-OFF. "1" is Heater-ON.
●SET_STATE[2:0] :
Set operation state.
000b : Transit to "Sleep".
001b : Transit to "Measurement".
010b : Prohibited settings
011b : For manufacturer (Test state) (note[5])
100b : Reset & Sleep Reset to initialize all registers, and then transit to Sleep.
101b : For manufacturer (Test state) (note[5])
110b : For manufacturer (Test state) (note[5])
111b : Prohibited settings

Important : Don't send data the other register in this specification sheet.
It could lead to operate out of specification

note[5]: Setting for inspection. Be care not to set it. If it is set incorrectly, perform Reset & Sleep.
note[6]: After Reset & Sleep, wait for at least 3msec before accessing the device.

Status register

Table.6 Detail of status register

Addr	Initial	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	R/W
09h	00h	Reserved	ERR_HEAT	ERR_BL	ERR_INFO	RDY_DATA	STATE[2:0]			R/-

●ERR_HEAT :
Overcurrent detection signal for heater current. 0: Normal, 1: Abnormal
If an overcurrent flows when the heater is used (EN_HEATER=1), the heater operation is stopped and this bit is set to "1". (Overcurrent threshold is 140mA; design value.)
Clear condition: Reset & Sleep (SET_STATE[2:0]を 001b) or EN_HEATER=0

●ERR_BL :
NVM BootLoad error detection signal. 0: Normal, 1: Abnormal
When this signal becomes "1" (Abnormal), slave address (7-bit) is changed to "4Ch" and transit to error state.
Clear condition: Reset & Sleep (SET_STATE[2:0]001b) or being turned on again after power supply is cut off.

●ERR_INFO :
Signal informing prohibition setting of control register. 0: Normal, 1: Abnormal
If it is set to prohibit, it transits to sleep state without starting operation. At this time, the ERR_INFO bit of the status register becomes "1".
Clear condition: Writing the correct settings starts normal operation. At that time, ERR_INFO is set to "0".

●RDY_DATA :
Signal determining acquisition of conversion result.
This bit becomes "0" at the time of conversion setting and "1" after conversion completion. This bit is cleared to "0" by reading the result or Reset & Sleep when this bit is "1".

●STATE[2:0] :
Represents MMS201 state.
000b : Sleep
001b : Measurement (Repeat Operation or One Shot Operation)
010b, 011b : For manufacturer
In normal operation, this state is not entered. If this condition stops, Reset & Sleep MMS201 or being turned on again after power supply is cut off.
100b : None
101b : Standby（Temporary state）
110b : For manufacturer
111b : None

Method of calculation to temperature and humidity values

The read digital value is the corrected value that is automatically performed for each AD conversion. Therefore, the user can obtain the temperature and humidity using the formula shown below.

Temperature = (16-bit digital value -2^{15}) / 50 + 25 [°C]

Humidity = 1000 * (16-bit digital value -2^{15}) / 2^{18} − 20 [%RH]

■Example for temperature calculation

temperature = (34003 – 2^{15}) / 50 + 25
= (+1235) / 50 + 25
= (24.7) +25
= 49.70 [°C]

■Example for humidity calculation

humidity = 1000 * (51118 – 2^{15}) / 2^{18} – 20
= 1000 * (+18350) / 2^{18} – 20
= (69.9997) – 20
= 49.9997 [%RH]

Table.7 16 Correspondence table between 16-bit digital value and temperature

16-bit digital value	16-bit digital value – 2^{15}	Temperature [°C]
65535 (FFFFh)	32767 (7FFFh)	680.34
32769 (8001h)	1 (0001h)	25.02
32768 (8000h)	0 (0000h)	25.00
32767 (7FFFh)	-1 (FFFFh)	24.98
0 (0000h)	-32768 (8000h)	-630.36

Table.8 16 Correspondence table between 16-bit digital value and humidity

16-bit digital value	16-bit digital value – 2^{15}	Humidity [%RH]
65535 (FFFFh)	32767 (7FFFh)	104.9962
64225 (FAE1h)	31452 (7AE1h)	99.9989
51118 (C7AEh)	18350 (47AEh)	49.9997
38011 (947Bh)	5243 (147Bh)	0.0005
32769 (8001h)	1 (0001h)	-19.9962
32768 (8000h)	0 (0000h)	-20.0000
32767 (7FFFh)	-1 (FFFFh)	-20.0038
0 (0000h)	-32768 (8000h)	-145.0000

SERIAL INTERFACE

The MMS201 supports I²C of Fast mode (fmax = 400kHz) as an interface for serial communication.

I²C format

The I²C address is 8-bit, including the slave address of the first 7-bits and R/W bit of the remaining 1-bit. Slave address for the MMS201 (7-bit) is 28h. I²C address (8-bit) will be 50h (Write) and 51h (Read) by combining with R/W bit.

Table.9 I²C address

	I²C Address (8-bit)							
	Slave address (7-bit)							R/W bit
HEX.	A6	A5	A4	A3	A2	A1	A0	
50h	0	1	0	1	0	0	0	0
51h	0	1	0	1	0	0	0	1

Write format

This format is used to set the control register (0Ch). Start by sending 8-bit I²C address 50h (Write). After the address is received, ACK is returned to the 9th bit. After that, send 8-bit control register address (0Ch). After the register address is received, ACK is returned to the 9th bit. Then, send 8-bit data according to the control register details.

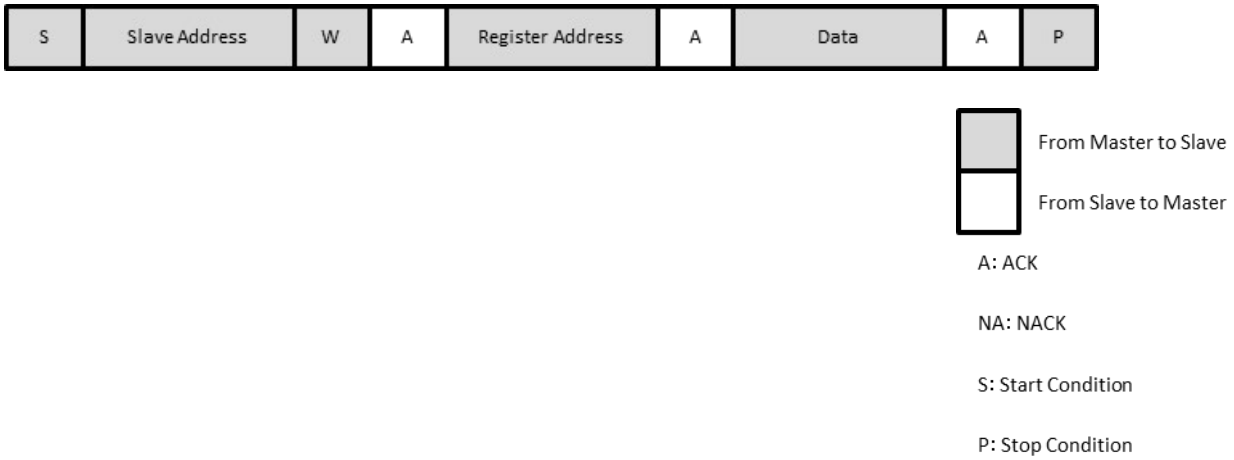


Fig.11 Write format

Important : Don't send data the other register in this specification sheet.
It could lead to operate out of specification

Read format

This format is used to read measurement results of temperature and humidity. Start by sending 8-bit I^2C address 51h (Read). After the address is received, ACK is returned to the 9th bit. After that, 32-bit data is output in 8-bit units in MSB first. Then, send ACK every 8-bit. As shown, Humi.Data is 16-bit of [15:0] and Temp.Data is 16-bit of [15:0]. It is unnecessary to send register address.

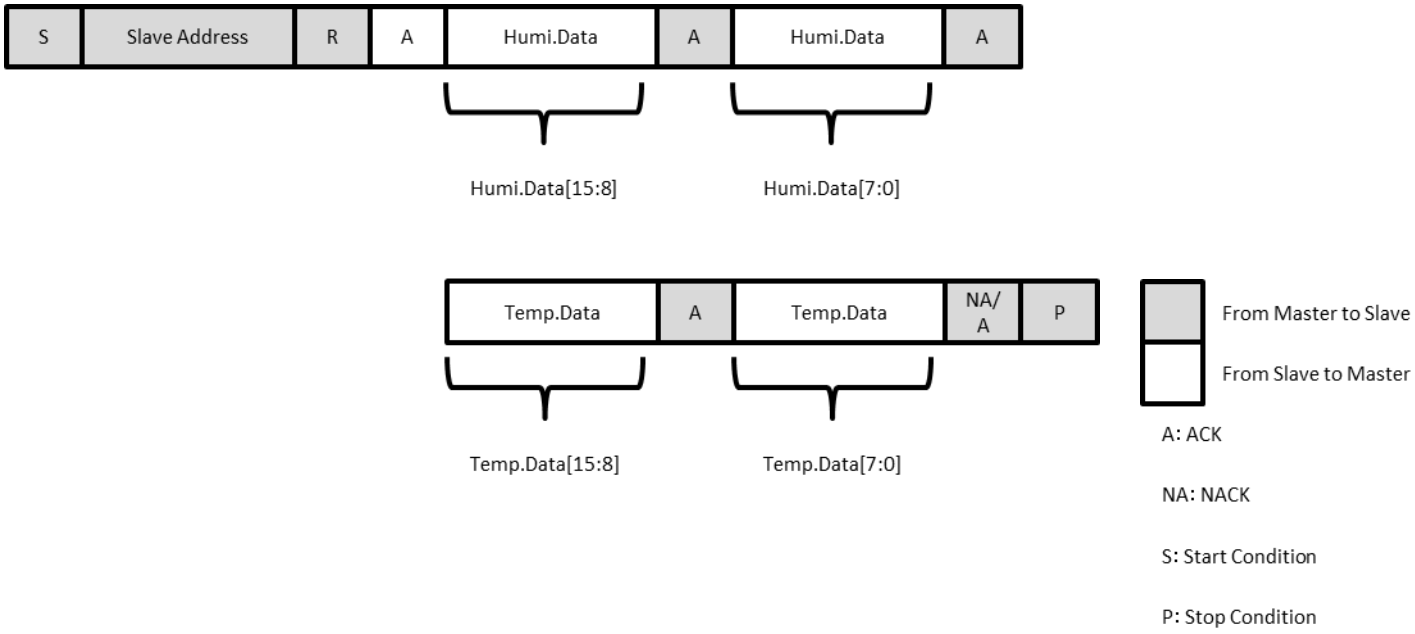


Fig.12 Read format

Combined format

This format is used to read register value. Start by sending 8-bit I²C address 50h (Write). After the address is received, ACK is returned to the 9th bit. After that, send an 8-bit control register address (0Ch) or status resister address (09h). The MMS201 will respond with ACK with 9th bit. Then, send 8-bit I²C address 51h (Read). After the address is received, ACK is returned to the 9th bit and 8-bit data is output. For details of register, refer to Control register or Status register.

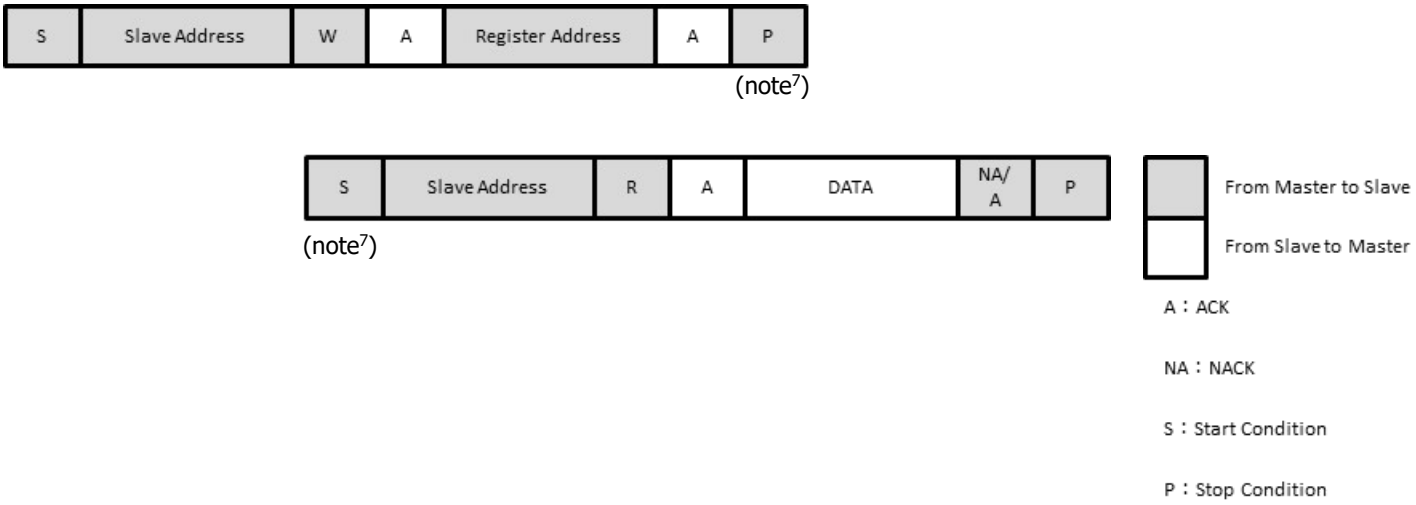


Fig.13 Combined format

note7: It also supports Repeat start condition.

I^2C AC characteristics

※Design assurance items

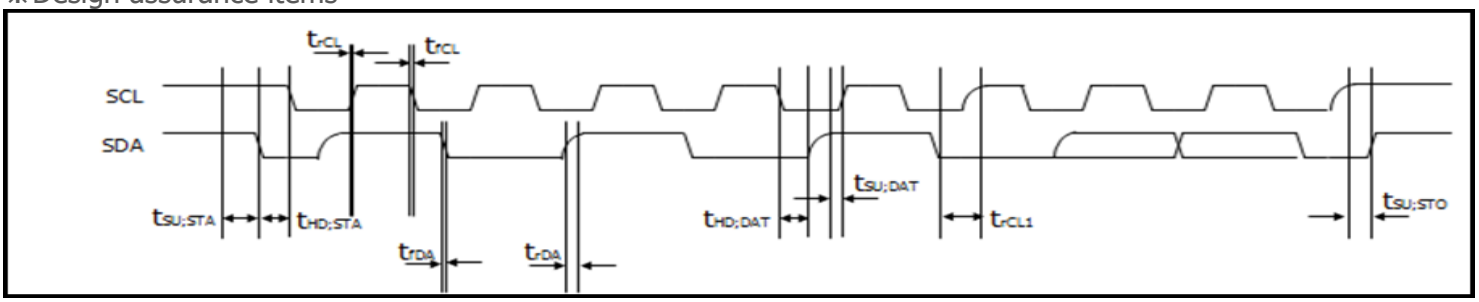


Fig.14 I^2C AC timing chart

Table.10 I^2C AC Characteristics (note[8])
(unless otherwise specified, Ta=25℃, VDD=3.3V, C_{OL}≦400pF)

Items	Symbol	Fast mode			Unit
		min	typ	max	
SCL clock frequency	f_{SCL}	0	-	400	kHz
Start condition setup time relative to SCL edge	t_{SUSTA}	600	-	-	ns
Start condition hold time relative to SCL edge	t_{HDSTA}	600	-	-	ns
Stop condition setup time on SCL	t_{SUSTO}	600	-	-	ns
Data setup time on SDA relative to SCL edge	t_{SUDAT}	100	-	-	ns
Data hold time on SDA relative to SCL edge	t_{HDDAT}	20	-	-	ns
SCL rise time	t_{rCL}	-	-	300	ns
SCL fall time	t_{fCL}	10	-	300	ns
SDA rise time	t_{rDA}	-	-	300	ns
SDA fall time	t_{fDA}	10	-	300	ns

note[8]: This product does not have the function to retain data in SDA. Please ensure the hold of SDA with 20nsec for the area where SCL falling edge is not defined.

TYPICAL APPLICATION CIRCUIT

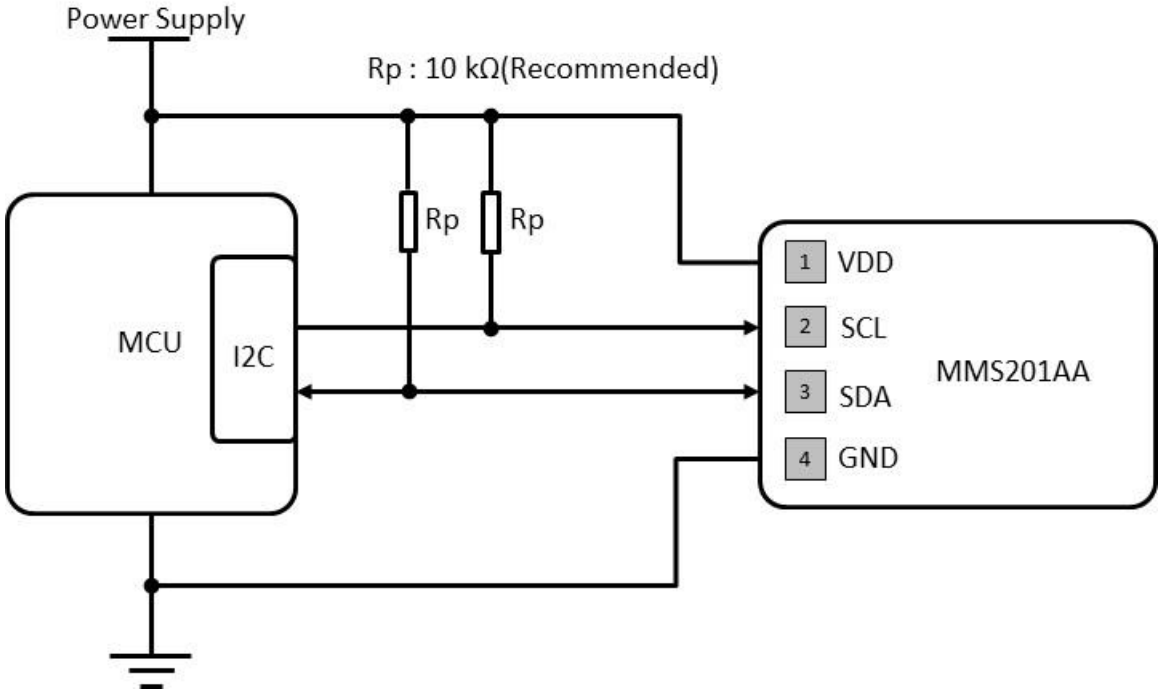


Fig.15 Typical electrical connection

TYPICAL PERFORMANCE CHARACTERISTICS

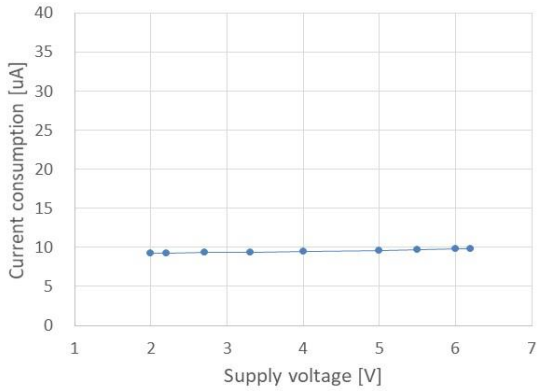


Fig.16 Current consumption I_{DD}
Supply voltage characteristics

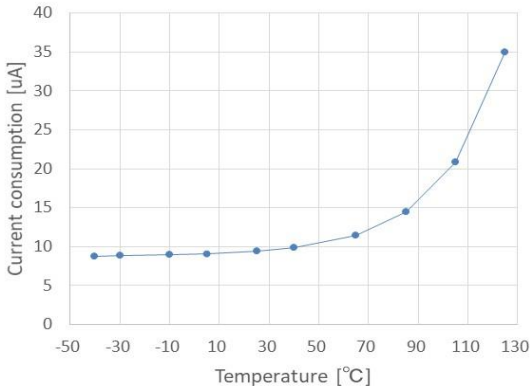


Fig.17 Current consumption I_{DD}
Temperature characteristics

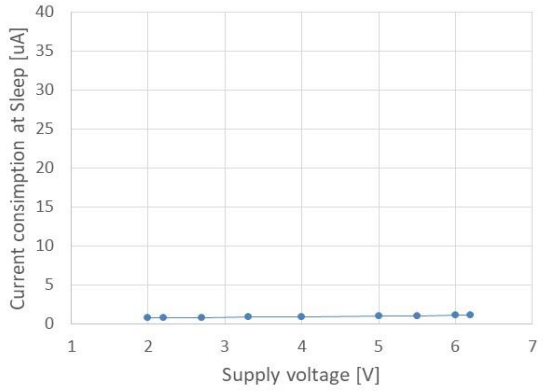


Fig.18 Current consumption at Sleep I_{DDSL}
Supply voltage characteristics

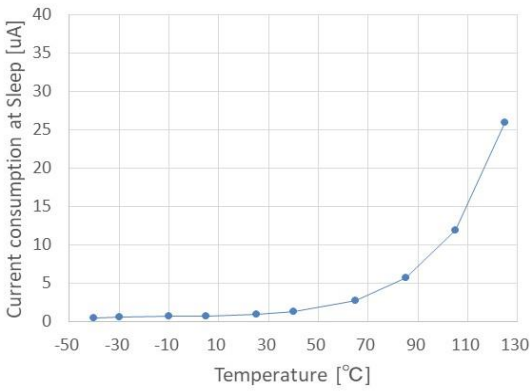


Fig.19 Current consumption at Sleep I_{DDSL}
Temperature characteristics

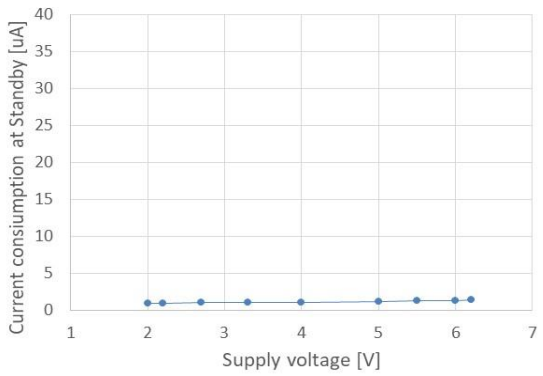


Fig.20 Current consumption at Standby I_{DDSB}
Supply voltage characteristics

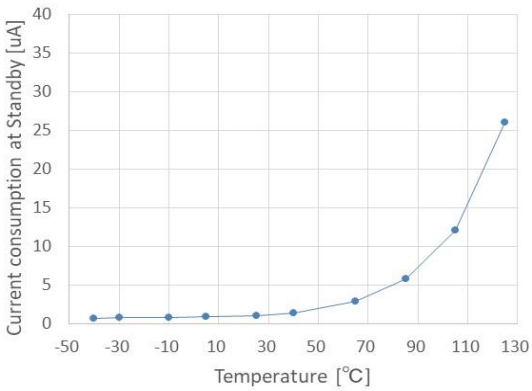


Fig.21 Current consumption at Standby I_{DDSB}
Temperature characteristics

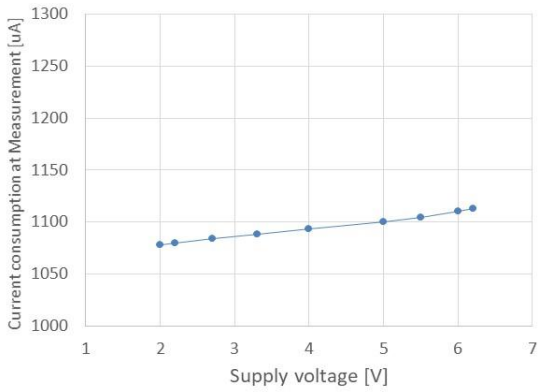


Fig.22 Current consumption at Measurement I_{DDM}
Supply voltage characteristics

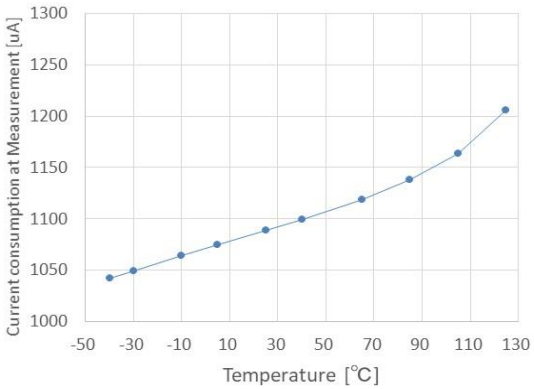


Fig.23 Current consumption at Measurement I_{DDM}
Temperature characteristics

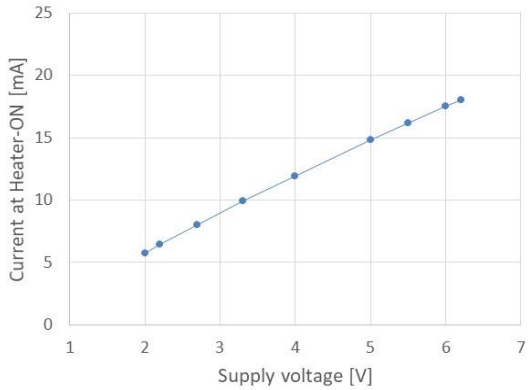


Fig.24 Current at Heater-ON I_{HEAT}
Supply voltage characteristics

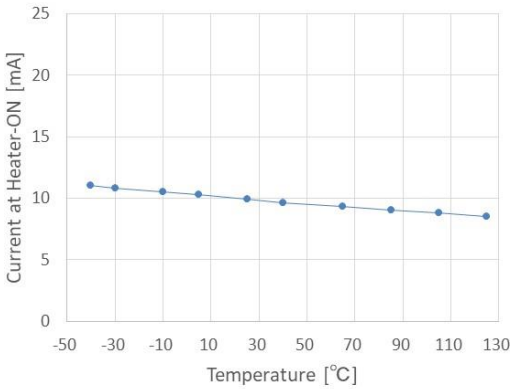


Fig.25 Current at Heater-ON I_{HEAT}
Temperature characteristics

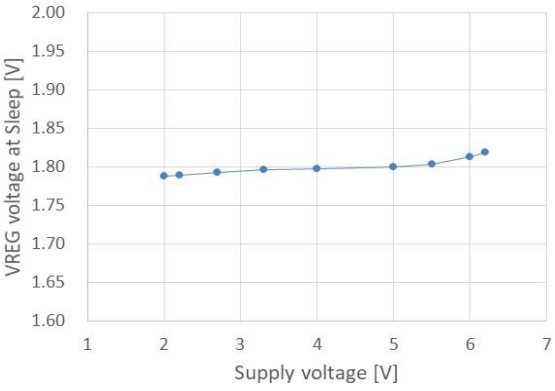


Fig.26 VREG voltage at Sleep V_{RGSL}
Supply voltage characteristics

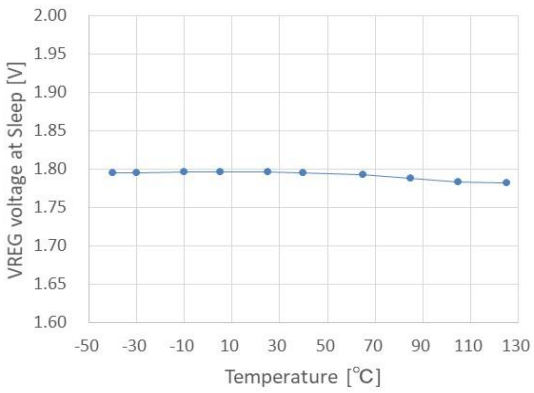


Fig.27 VREG voltage V_{RGSL}
Temperature characteristics

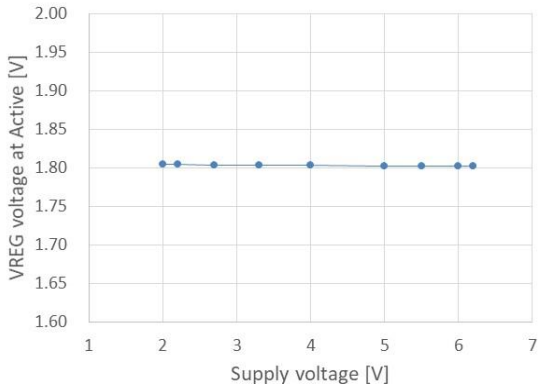


Fig.28 VREG voltage V_{RGACT}
Supply voltage characteristics

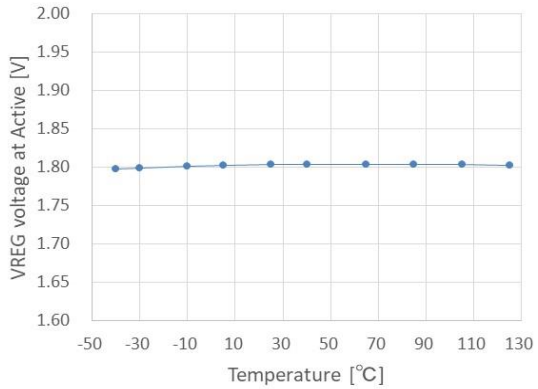
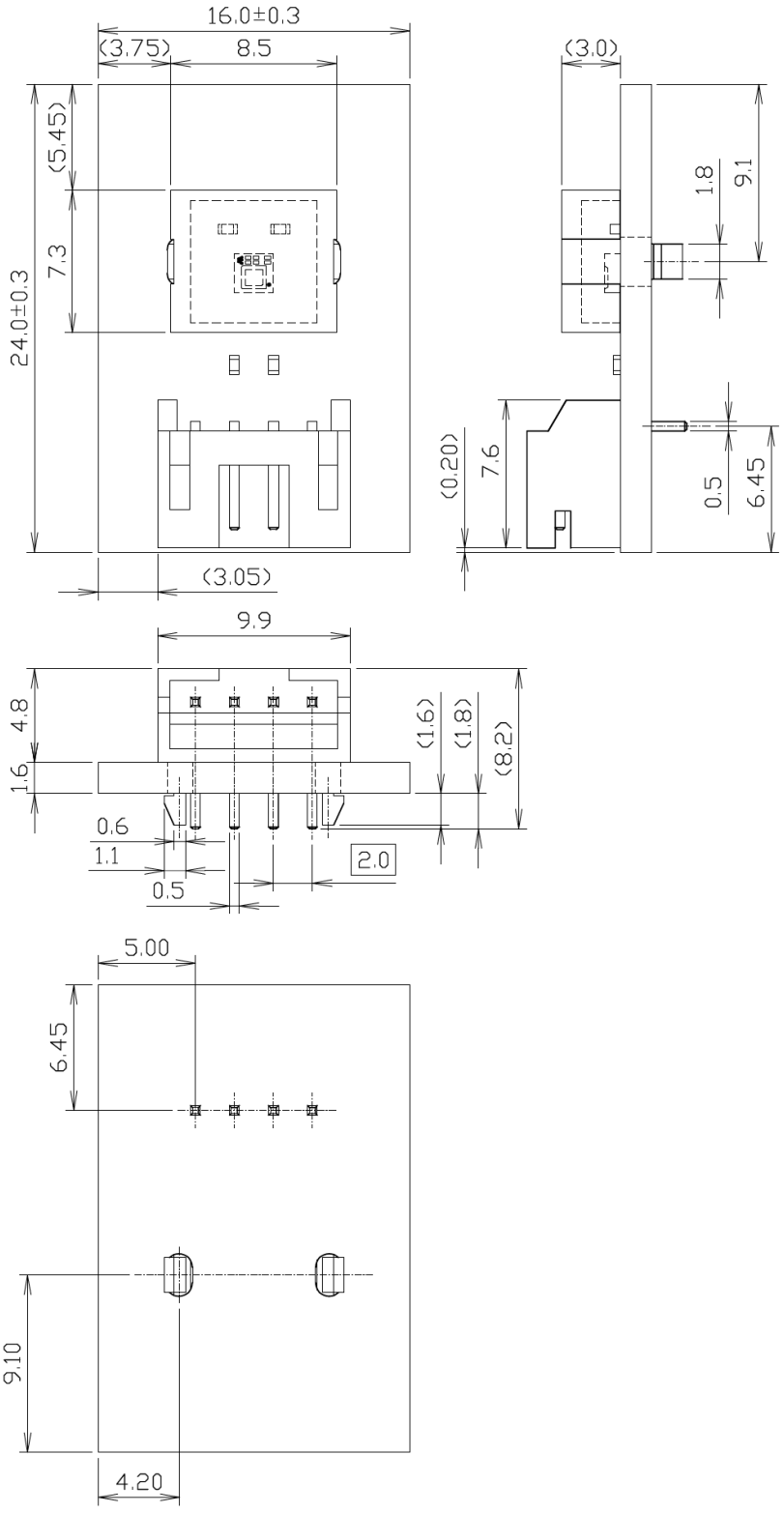


Fig.29 VREG voltage V_{RGACT}
Temperature characteristics

DIMENSIONS

UNIT	mm



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