Analog Front-End IC

MM3609ARRE Datasheet

FUNCTION

This IC is an Analog Front-End IC which changes analog signal output from a sensor to a digital signal, processes the digital signal, and outputs it to a host such as a microcomputer in the subsequent stage through digital communication. This corresponds to wide variety of sensors.

FEATURES

- 24bit⊿ΣADC with a wide dynamic range is mounted.
- Able to store sensor-correcting sequence and corrective coefficient needed for correcting sensors in a non-volatile memory built in this IC. Correction is completed within this IC.
- Selectable communication interface: I2C Hs (max. 3.4Mbps) or SPI4-wire (max. 5Mbps)
- Able to behave with low voltage of 1.71V or above
- Temperature sensor is equipped. Able to correct temperature characteristics of external sensor
- Effective resolution or data-output-rate is selectable to suit users.
- Equipped with a built-in oscillator. No external oscillation circuit is needed.
- Corresponding to two modes of sensor driving method: constant current and constant voltage

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BLOCK DIAGRAM

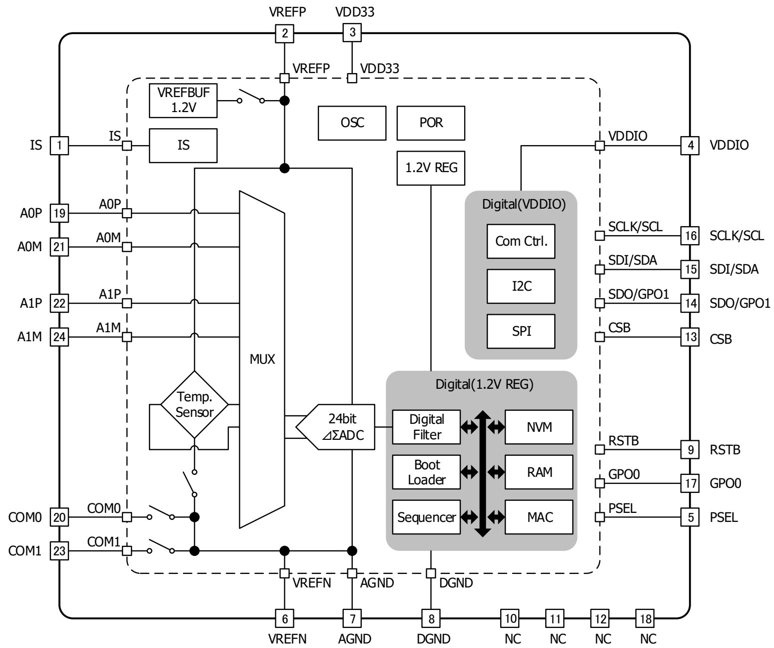


Fig. 4.1 Block diagram

PIN LAYOUT

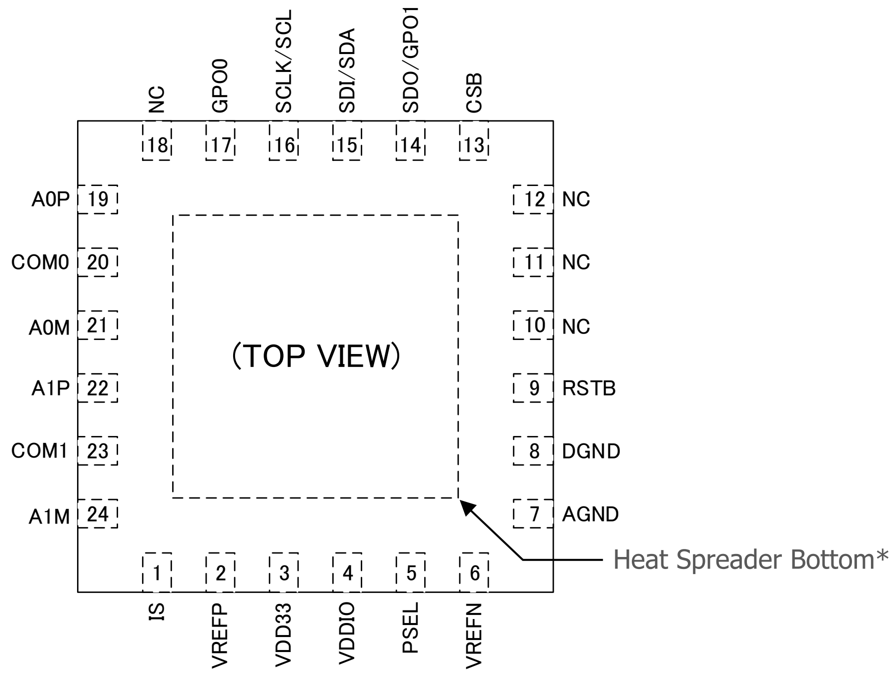


Fig. 5.1 Pin layout

*Heat Spreader Bottom with OPEN or GND

TERMINAL EXPLANATIONS

Pin function

Table 6.1 Pin list

No.	Name	TYPE	FUNCTION
1	IS	O	Output of constant current for driving external sensor
2	VREFP	I/O	Reference voltage plus *Internal VREF (=1.2V) is selectable by using sequence command.
3	VDD33	I	Power supply for analog circuit
4	VDDIO	I	Power supply for digital I/O
5	PSEL	I	Protocol select pin (High: SPI / Low: I2C)
6	VREFN	I	Reference voltage minus
7	AGND	-	Analog GND
8	DGND	-	Digital GND
9	RSTB	I	Negative logic reset
10	NC	I	*Inspection terminal: Do not connect
11	NC	I/O	*Inspection terminal: Do not connect
12	NC	I	*Inspection terminal: Do not connect
13	CSB	I	Chip select for SPI communication
14	SDO GPO1	O O	Serial Data Output for SPI communication (SDO=MISO) *When I2C is selected: General-use output port 1
15	SDI SDA	I I/O	Serial Data Input for SPI Communication (SDI=MOSI) Serial Data Input and Output for I2C Communication (SDA)
16	SCLK SCL	I I/O	Serial Clock for SPI communication (SCLK) Serial Clock for I2C communication (SCL)
17	GPO0	O	General Purpose Output Port 0
18	NC	-	No connection
19	A0P	I	External sensor input signal plus: Channel 0
20	COM0	I	Pin for controlling external sensor ground: Channel 0
21	A0M	I	External sensor input signal minus: Channel 0
22	A1P	I	External sensor input signal plus: Channel 1
23	COM1	I	Pin for controlling external sensor ground: Channel 1
24	A1M	I	External sensor input signal minus: channel 1

Equivalent circuit of pins

Table 6.2 Equivalent circuit of pins (1/4)

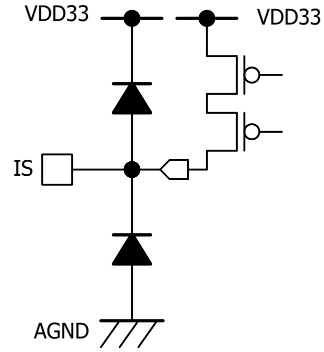
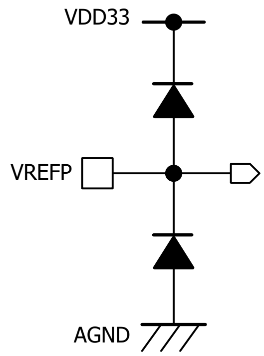
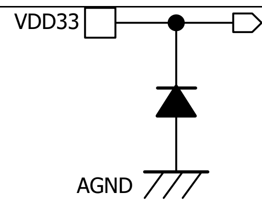
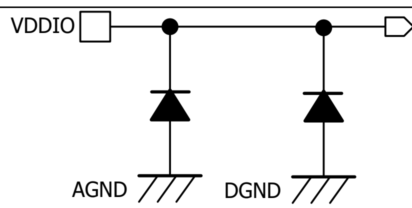
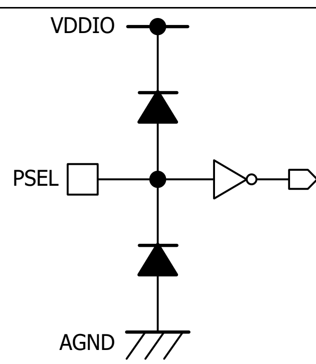
Pin name	Type	Equivalent circuit	
IS	O		
VREFP	I/O		*When internal VREF (=1.2V) is selected by sequence command, this IC functions as an output-pin. In this case, please do not impress voltage from outside.
VDD33	I		
VDDIO	I		
PSEL	I		

Table 6.3 Equivalent circuit of pins (2/4)

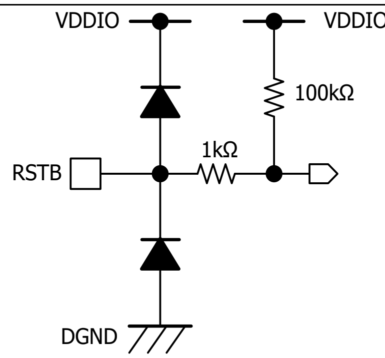
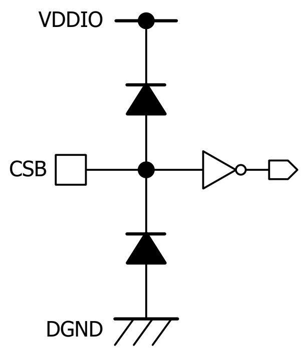
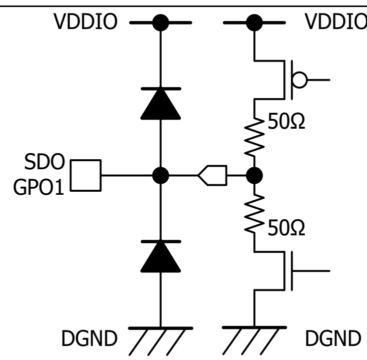
Pin name	Type	Equivalent circuit
AGND VREFN	- I	—
DGND	-	—
RSTB	I	
CSB	I	
SDO GPO1	O O	

Table 6.4 Equivalent circuit of pins (3/4)

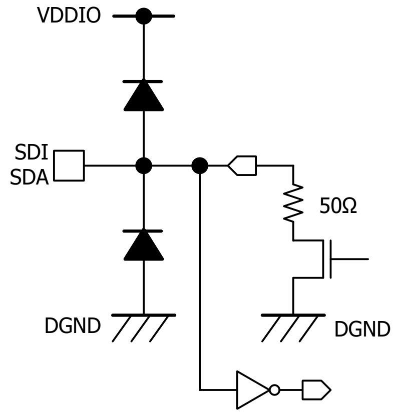
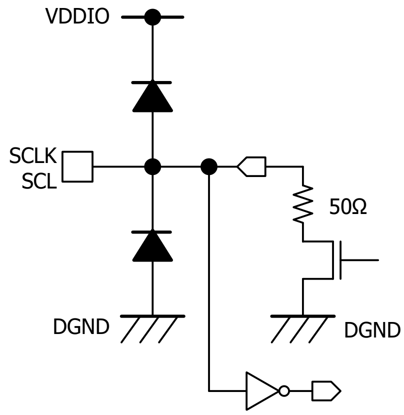
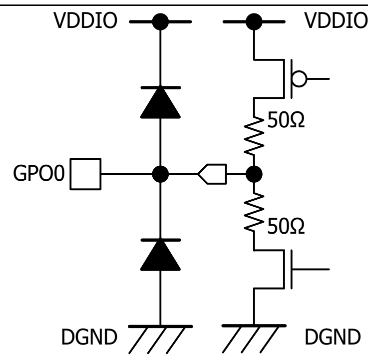
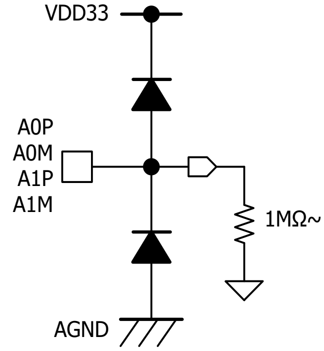
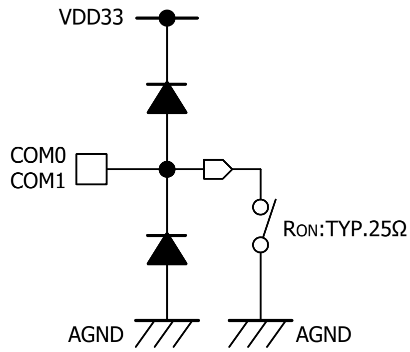
Pin name	Type	Equivalent circuit
SDI SDA	I I/O	
SCLK SCL	I I/O	
GPO0	O	

Table 6.5 Equivalent circuit of pins (4/4)

Pin name	Type	Equivalent circuit
A0P A0M A1P A1M	I	
COM0 COM1	I	

ABSOLUTE MAXIMUM RATINGS

(Unless otherwise specified, Ta=25deg.C)

Item	Symbol	Min.	Max.	Unit
Storage temperature range	T_{STG}	-55	+105	deg.C
Analog power supply voltage	$VDD33_{MAX}$	-0.3	+4.0 (note[1]) +6.1 (note[2])	V
Digital I/O power supply voltage	$VDDIO_{MAX}$	-0.3	+4.0 +1.32 (note[2], note[3])	V

RECOMMENDED OPERATING CONDITIONS

(Unless otherwise specified, Ta=25deg.C)

Item	Symbol	Min.	Max.	Unit
Operating temperature range	T_{OPR}	-40 +10 (note[2])	+85 +30 (note[2])	deg.C
Analog power supply voltage	$VDD33_{OPR}$	+1.71 +5.90 (note[2])	+3.60 +5.90 (note[2])	V
Digital I/O power supply voltage	$VDDIO_{OPR}$	+1.14 +1.14 (note[2])	+3.60 +1.32 (note[2])	V
Reference voltage	$VREFP_{OPR}$	+1.14	VDD33	V
Differential input voltage	VID_{OPR}	-VREFP	+VREFP	V
Common mode input voltage	VIC_{OPR}	0	VDD33	V

note[1]: Please do not exceed +4.0V during normal use (except NVM writing).
note[2]: During NVM writing
note[3]: Please do not exceed +1.32V during NVM writing.

· Power-on sequence

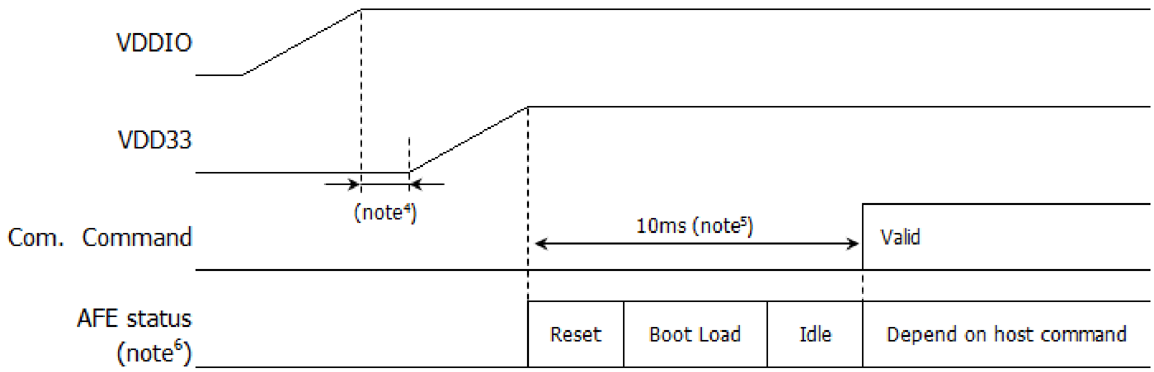


Fig. 8.2 Power-on sequence

note[4]: No time is specified from starting VDDIO to input VDD33.

note[5]: Communication shall not be started earlier than 10ms after starting both power sources of VDDIO and VDD33.
Communication shall not be started earlier than 10ms after sending reset command.
All commands ignore during Boot Load.

note[6]: The above is Power-on sequence under the condition without NVM programming in IC. For the case with NVM programming, AFE status after Boot Load differs.

ELECTRICAL CHARACTERISTICS

Current consumption

(Unless otherwise specified, Ta=25deg.C, VDD33=VDDIO=3.3V)

Item	Symbol	Condition	Min.	Typ.	Max.	Unit
Current consumption	IAD	at AD conversion	-	540	650	uA
	IADt	at AD conversion of temperature sensor inside IC	-	650	790	
Current consumption at shut down	Isd	at shut down	-	0.1	1.0	uA

Digital I/O

(Unless otherwise specified, Ta=25deg.C, VDD33=VDDIO=3.3V)

Item	Symbol	Condition	Min.	Typ.	Max.	Unit
H-level input voltage	V_{IH}		0.8 × VDDIO	-	VDDIO + 0.3	V
L-level input voltage	V_{IL}		-0.3	-	0.2 × VDDIO	V
Output voltage H-level	V_{OH1}	VDDIO ≧ 2.0V I_{OH}=-3mA	VDDIO – 0.4	-	-	V
	V_{OH2}	VDDIO ＜ 2.0V I_{OH}=-1mA	0.8 × VDDIO	-	-	V
Output voltage L-level	V_{OL1}	VDDIO ≧ 2.0V I_{OL}=3mA	-	-	0.4	V
	V_{OL2}	VDDIO ＜ 2.0V I_{OL}=1mA	-	-	0.2 × VDDIO	V
RSTB Low period (note[10])	t_{RSTBL}		10	-	-	us

note[10]: Design assurance items before correction

Current for sensor driving

(Unless otherwise specified, Ta=25deg.C, VDD33=VDDIO=3.3V)

Item	Symbol	Condition	Min.	Typ.	Max.	Unit
Setting range of the current for sensor driving	I_S		10	-	1270	uA
Setting Steps of the current for sensor driving	$I_{S step}$		-	10	-	uA
Allowable error of the current for sensor driving	$I_{S error}$		-7	-	+7	%

Reference voltage inside IC

(Unless otherwise specified, Ta=25deg.C, VDD33=VDDIO=3.3V)

Item	Symbol	Condition	Min.	Typ.	Max.	Unit
Reference voltage	V_{REF}	Load current = 1.2mA	1.176	1.2	1.224	V

Temperature sensor

*Design assurance items before correction
(Unless otherwise specified, VDD33=VDDIO=3.3V)

Item	Symbol	Condition	Min.	Typ.	Max.	Unit
Temperature sensitivity	T_{Sens}	VREFP = VDD33 = 3.3V Ta = -40 ~ +85deg.C	0.25	-	-	mV/ deg.C/VREF
Non-linearity	T_{NL}	VREFP = VDD33 = 3.3V Ta = -40 ~ +85deg.C	-6	-	6	%FS
		VREFP = VDD33 = 3.3V Ta = 0 ~ +50deg.C	-4	-	4	%FS

AD convert

*Design assurance items
(Unless otherwise specified, Ta=25deg.C, VDD33=VDDIO=3.3V)

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
Setting range of data output rate		High Power Mode (HPM)	20	-	2560	Hz
		Low Power Mode (LPM)	10	-	1280	Hz
Differential input impedance	Zdiff_in		1	-	-	MΩ
Differential full scale range	VID,FSR		-VREFP	-	VREFP	V
Input conversion noise voltage	V_{noise1}	Data output rate = 2560Hz(HPM)/1280Hz(LPM) VREFP = VDD33 = 3.3V	-	17.61	52.11	uVrms
	V_{noise2}	Data output rate = 1280Hz(HPM)/640Hz(LPM) VREFP = VDD33 = 3.3V	-	7.47	13.56	
	V_{noise3}	Data output rate = 640Hz(HPM)/320Hz(LPM) VREFP = VDD33 = 3.3V	-	4.71	7.37	
	V_{noise4}	Data output rate = 320Hz(HPM)/160Hz(LPM) VREFP = VDD33 = 3.3V	-	3.19	5.10	
	V_{noise5}	Data output rate = 160Hz(HPM)/80Hz(LPM) VREFP = VDD33 = 3.3V	-	2.34	3.60	
	V_{noise6}	Data output rate = 80Hz(HPM)/40Hz(LPM) VREFP = VDD33 = 3.3V	-	1.74	2.67	
	V_{noise7}	Data output rate = 40Hz(HPM)/20Hz(LPM) VREFP = VDD33 = 3.3V	-	1.29	2.16	
	V_{noise8}	Data output rate = 20Hz(HPM)/10Hz(LPM) VREFP = VDD33 = 3.3V	-	1.05	2.16	
Integral non-linearity	INL	VREFP = VDD33 = 3.3V Ta = +25 deg.C Common mode voltage = VDD33/2	-30	-	30	ppm Of FSR
		VREFP = VDD33 = 3.3V Ta = -40 ~ +85 deg.C Common mode voltage = VDD33/2	-150	-	150	ppm Of FSR

SERIAL INTERFACE

SPI and I2C of serial communication interface are supported. You can choose SPI (max.: 5Mbps) or I2C (max.: 3.4Mbps) by PSEL-pin. When PSEL-pin is set to High, SPI is selected; when it is Low, I2C. Set the High voltage of PSEL-pin to the same electric potential as that of VDDIO-pin.

Communication speed

*Design assurance items
(Unless otherwise specified, Ta=25deg.C, VDD33=VDDIO=3.3V)

Item	Symbol	Condition	Min.	Typ.	Max.	Unit
I2C communication speed (Hs mode)	BR_{I2CHs1}	VDDIO ≥ 2.0V Cb ≤ 100pF	-	-	3.4M	bps
	BR_{I2CHs2}	VDDIO ≥ 2.0V Cb ≤ 400pF	-	-	1.7M	
I2C communication speed (Fast mode)	BR_{I2CFm}	VDDIO < 2.0V	-	-	400k	
SPI communication speed	BR_{SPI1}	VDDIO ≥ 2.0V Cb ≤ 100pF	-	-	5.0M	
	BR_{SPI2}	VDDIO ≥ 2.0V Cb ≤ 400pF	-	-	2.5M	
	BR_{SPI3}	VDDIO < 2.0V	-	-	1.0M	

SPI format

SPI command format is shown below. Data transmission is started when CSB becomes low from the status in which SCLK is high. Input data is sampled on rising edges of the SCLK. (SPI MODE 3) For the detailed timing, please refer to each command format.

SPI operation command format

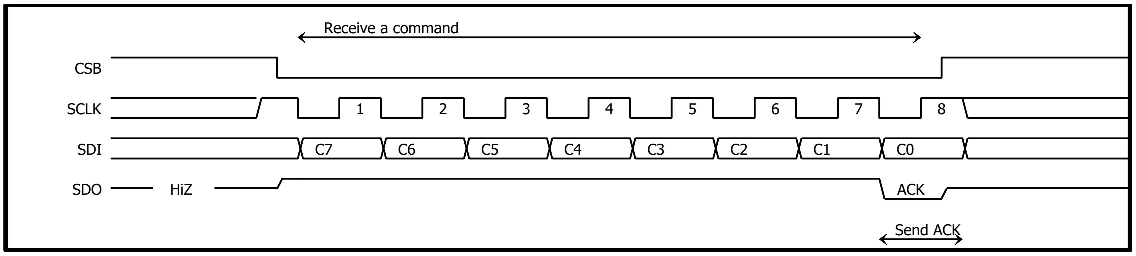


Fig. 10.1 SPI operation command format

SPI result command format

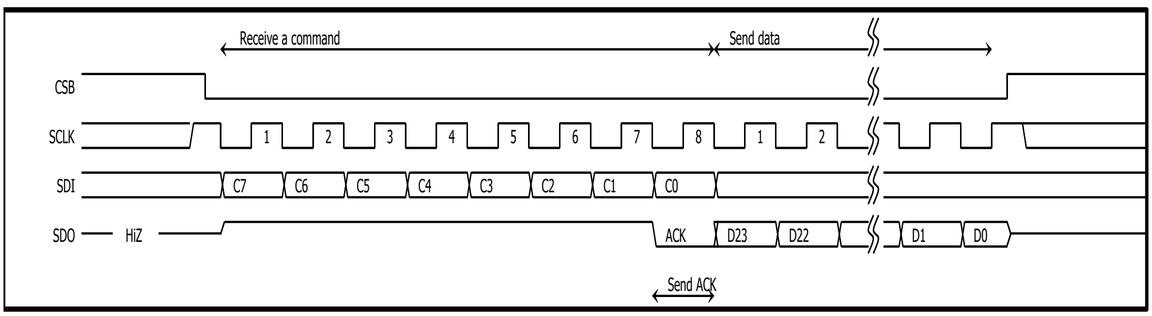


Fig. 10.2 SPI result command format

*The above are the command formats during 24-bit data output. During 8-bit output, it is immediately output from D7 to D0 after ACK transmission.

SPI write (RAM, NVM) command format

Following the command, send 8-bit memory address and writing data. The writing data should be 8 bits for sequencer RAM / NVM and 32 bits for MAC RAM. After receiving a write command, the internal area becomes busy for 50msec at the maximum to write memory. During busy, SDO becomes Low. Please note that all commands are ignored during busy.

How to discern busy:

After sending the writing data, continue to input clock with maintaining communicating mode. Then, 00h indicating busy status is output. When the writing is completed, 01h will be output. *The "00h" indicating busy may sometimes be output or not depending on the clock frequency.

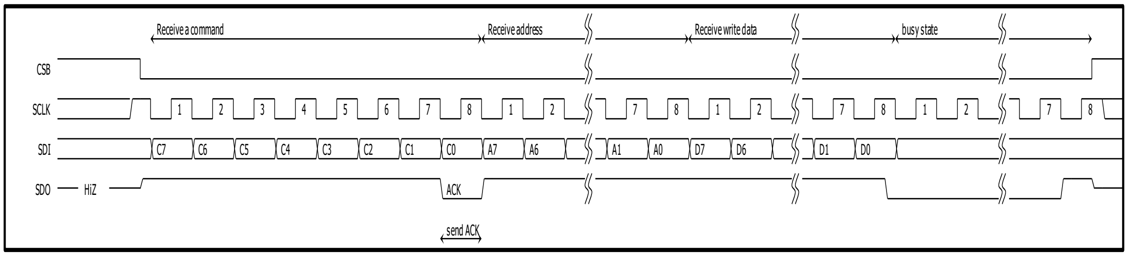


Fig. 10.3 SPI write (RAM, NVM) command format

SPI write (Register) command format

Following the command, send 8-bit memory address and 8-bit write data.

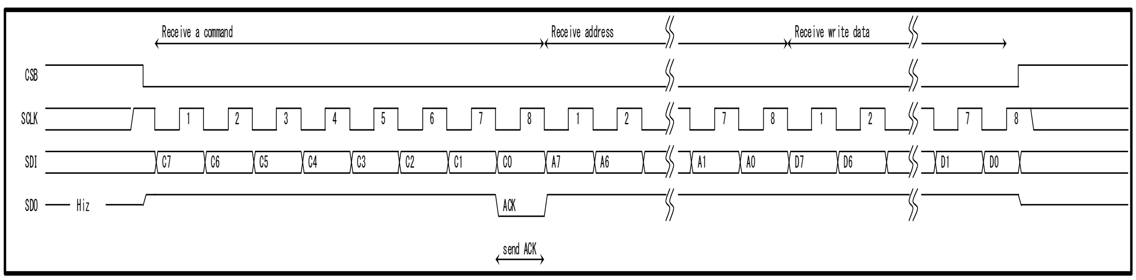


Fig. 10.4 SPI write (Register) command format

SPI read (RAM, NVM) command format

Following the command, send 8-bit memory address. After receiving memory address, the internal area becomes busy for 25usec at the maximum to prepare for data sending. During this time, 00h indicating busy status is output. When data preparation is completed, 01h is output. Continuously, 8-bit data is output for sequencer RAM and NVM, and 32-bit data for MAC RAM.

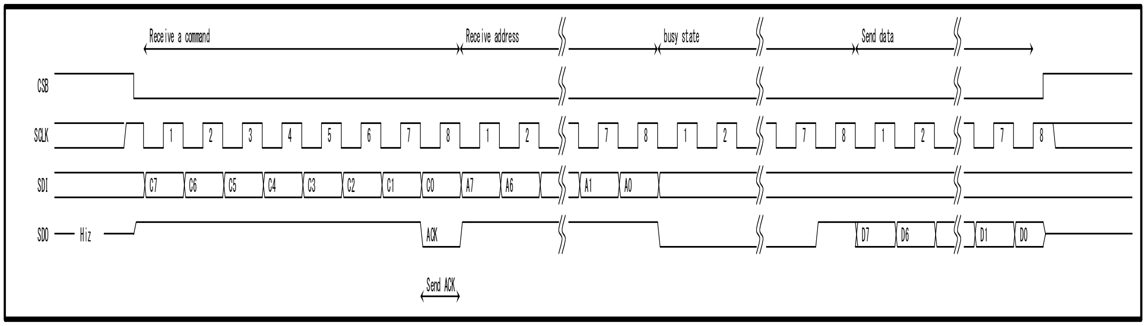


Fig. 10.5 SPI read (RAM, NVM) command format

SPI read (Register) command format

Following the command, send 8-bit memory address. After receiving the memory address, 8-bit data is output.

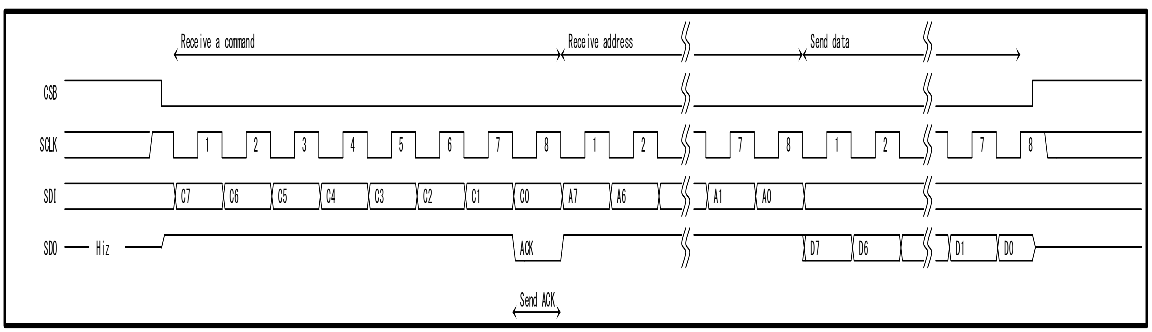


Fig. 10.6 SPI read (Register) command format

SPI AC characteristics

*Design assurance item

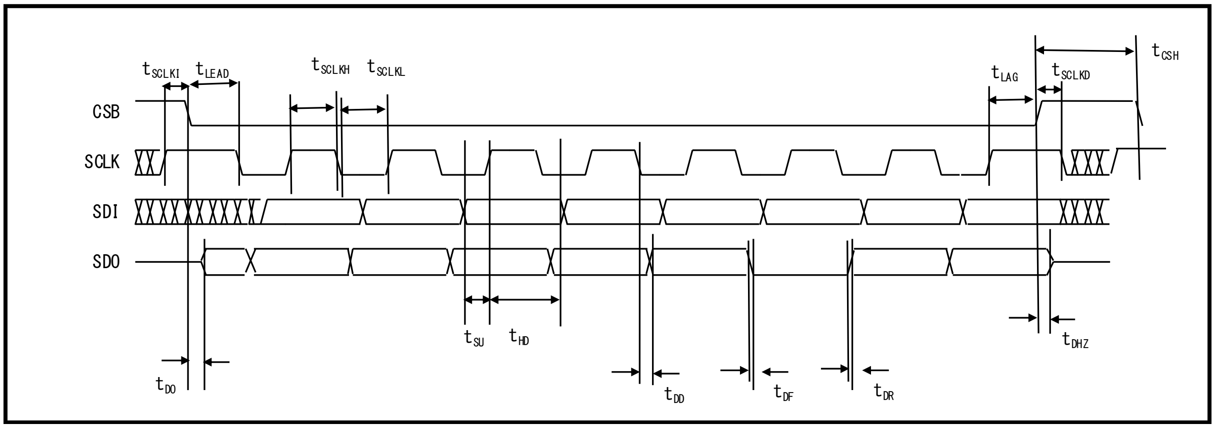


Fig. 10.91 SPI AC timing chart

(Unless otherwise specified, Ta=25deg.C, VDD33=3.3V)

Table 10.1 SPI AC characteristics

Item	Symbol	VDDIO<2V		VDDIO ≥ 2V		Unit
		min.	max.	min.	max.	
SCLK frequency (Duty 50±10%)	f_{SCLK}	-	1	-	5	MHz
SCLK High period (90%~90%)	t_{SCLKH}	400	-	80	-	ns
SCLK Low period (10%~10%)	t_{SCLKL}	400	-	80	-	ns
SCLK standby time	t_{SCLKI}	500	-	100	-	ns
SCLK delay time	t_{SCLKD}	0	-	0	-	ns
CSB High period (90%~90%)	t_{CSH}	1000	-	200	-	ns
Time from CSB falling edge to SCLK falling edge	t_{LEAD}	0	-	0	-	ns
Time from SCLK rising edge to CSB rising edge	t_{LAG}	500	-	100	-	ns
SDI setup time	t_{SU}	100	-	10	-	ns
SDI hold time	t_{HD}	10	-	10	-	ns
SDO rise time (Load: 100pF) (10%~90%)	t_{DR}	-	50	-	50	ns
SDO fall time (Load: 100pF) (10%~90%)	t_{DF}	-	50	-	50	ns
SDO output delay time (Load: 100pF)	t_{DD}	-	120	-	60	ns
SDO output delay time (Load: 100pF) from CSB became Low	t_{DO}	-	120	-	60	ns
Time from CSB reaches High to SDO reaches HiZ (Load: 100pF)	t_{DHZ}	-	170	-	170	ns

I2C format

I2C address is composed of total 8 bits: 7 bits of slave-address in the head and the rest 1 bit of R/W bit. Users can set the slave-address (7 bits) of MM3609 optionally by writing to NVM (default 1001111). However, 0000xxx and 1111xxx cannot be used because they are reserved addresses. *Please use this product after confirming I2C specification and understanding the details.

I2C operation command format

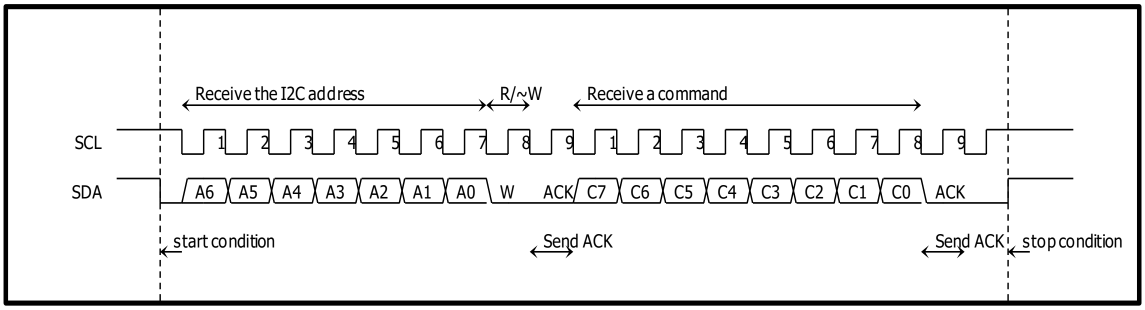


Fig. 10.102 I2C operation command format

I2C result command format

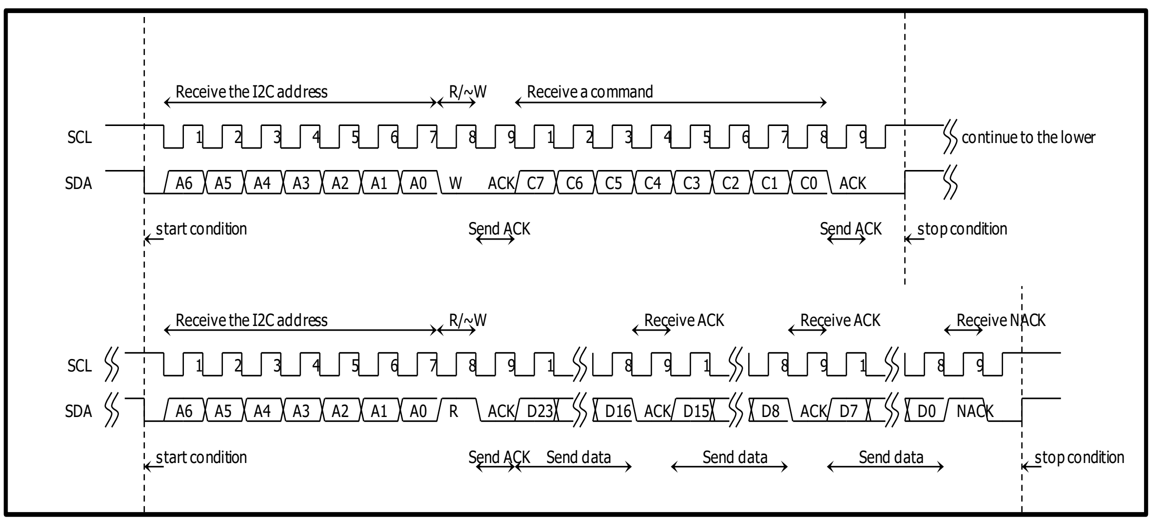


Fig. 10.113 I2C result command format

I2C write (RAM, NVM) command format

Following the command, send 8-bit memory address and writing data. The writing data should be 8 bits for sequencer RAM / NVM and 32 bits for MAC RAM. After receiving a write command, the internal area becomes busy for 50msec at the maximum to write memory. During busy, SCL becomes Low.

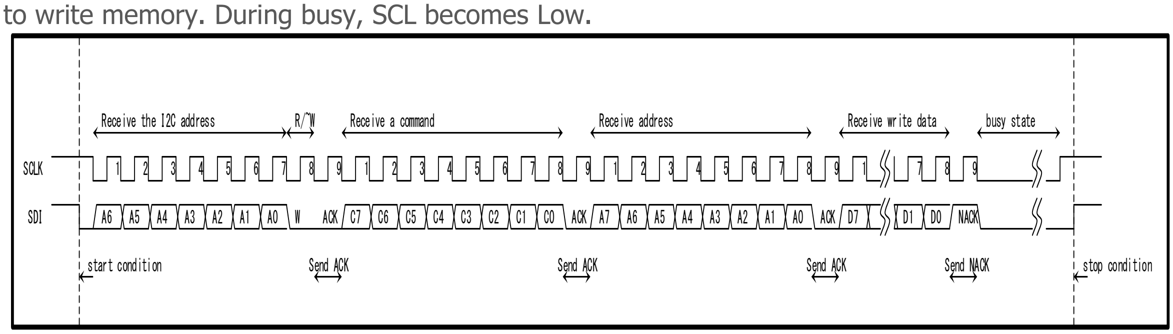


Fig. 10.124 I2C write (RAM, NVM) command format

I2C write (Register) command format

Following the command, send 8-bit memory address and 8-bit writing data.

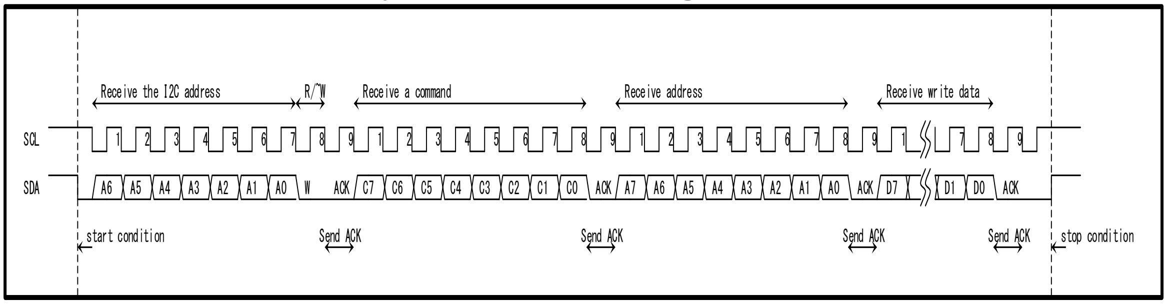


Fig. 10.135 I2C write (Register) command format

I2C read (RAM, NVM) command format

Following the command, send 8-bit memory address. After receiving memory address, it becomes busy during preparation for sending data. During this time, SCL becomes Low. SCL is released when data preparation is completed. Subsequently, when it is accessed (read command is sent) in the read mode, 8-bit data is output for sequencer RAM / NVM and 32-bit data for MAC RAM.

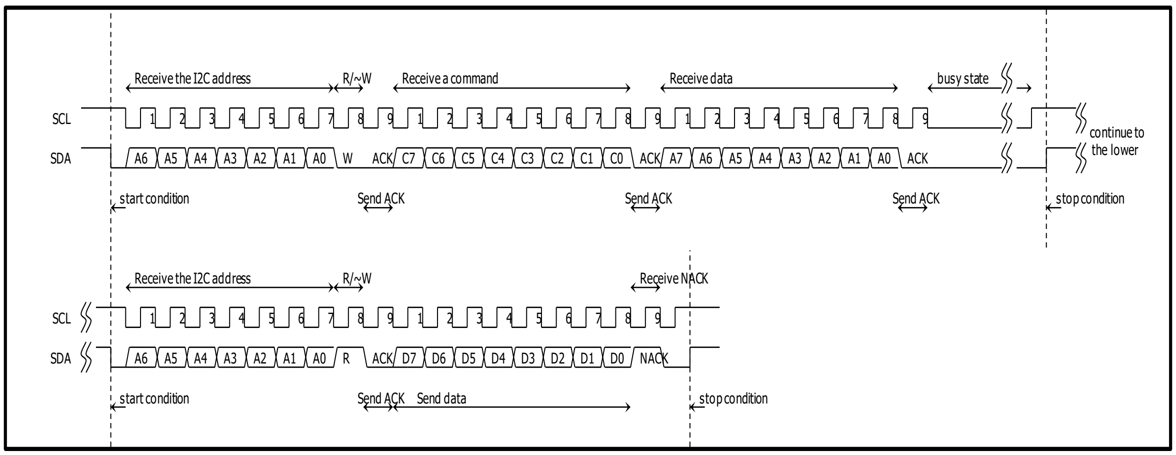


Fig. 10.146 I2C read (RAM, NVM) command format

I2C read (Register) command format

Following the command, send 8-bit memory address. Subsequently, when it is accessed (read command is sent) in the read mode, 8-bit data is output.

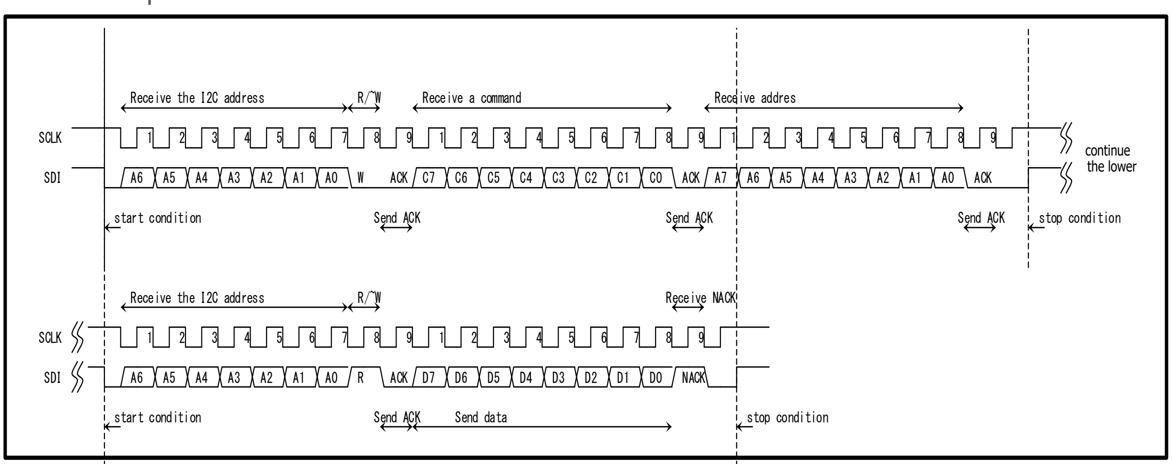


Fig. 10.157 I2C read (Register) command format

I2C AC characteristics

*Design assurance item

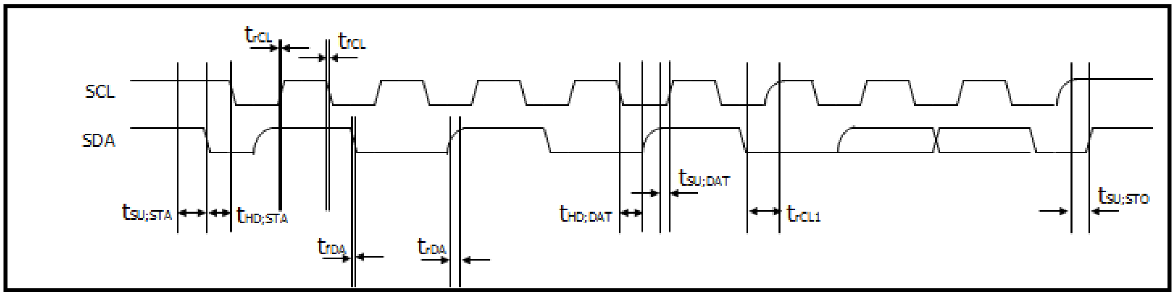


Fig. 10.178 I2C AC timing chart

(Unless otherwise specified: Ta=25deg.C, VDD33=3.3V)

Table 10.2 I2C AC characteristics

Item	Symbol	VDDIO < 2.0V		VDDIO ≥ 2.0V				Unit
		Fast mode		Hs mode				
				Cb ≤ 100pF		Cb ≤ 400pF		
		min.	max.	min.	max.	min.	max.	
SCL frequency	f_{SCL}	0	400kHz	0	3.4	0	1.7	MHz
Start condition setup time	$t_{SU;STA}$	600	-	160	-	160	-	ns
Start condition hold time	$t_{HD;STA}$	600	-	160	-	160	-	ns
Stop condition setup time	$t_{SU;STO}$	600	-	160	-	160	-	ns
Data setup time	$t_{SU;DAT}$	100	-	20	-	20	-	ns
Data hold time (note[7])	$t_{HD;DAT}$	20	-	20	70	20	150	ns
SCL rise time	t_{rCL}	-	300	10	40	20	80	ns
Rise time of SCL after ACK (When clock stretch is released.)	t_{rCL1}	-	300	10	80	20	160	ns
SCL fall time	t_{fCL}	10	300	10	-	20	80	ns
SDA rise time	t_{rDA}	-	300	10	80	20	160	ns
SDA fall time	t_{fDA}	10	300	10	80	20	160	ns

note[7]: This product does not have the function to retain data in SDA. Please ensure SDA is held for 20nsec in the area where SCL falling edge is not defined.

Command list

Table 10.3 Operation command list (1/2)

Command Name	Command Code									Action
	HEX.	BIN.								
		C7	C6	C5	C4	C3	C2	C1	C0	
Reset	0x72	0	1	1	1	0	0	1	0	Reset the IC. After the reset, boot loader behaves automatically.
Shutdown	0x90	1	0	0	1	0	0	0	0	Shift to shutdown state
Standby	0x92	1	0	0	1	0	0	1	0	Shift to standby state
Idle	0x94	1	0	0	1	0	1	0	0	Shift to idle state
Active	0xA0 0xA2 0xA4 0xA6	1	0	1	0	0	CM1	CM0	0	Shift to Active state. If this command is output during Shutdown state, Standby state or Idle state, this IC starts sequence automatically. Even if input of active command is continued, this IC does not re-start. To re-start, output the active command after shifting the IC to shutdown state.
	C2 and C1 assign AD conversion mode. The values written in 7Ah to 7Dh of NVM are referred for the advanced setting of each mode.									

CM1	CM0	Conversion mode	Description
0	0	Mode 0	AD conversion mode 0
0	1	Mode 1	AD conversion mode 1
1	0	Mode 2	AD conversion mode 2
1	1	Mode 3	AD conversion mode 3

Table 10.4 Operation command list (2/2)

<table>
<tr><th rowspan="3">Command Name</th><th colspan="9">Command Code</th><th rowspan="3">Action</th></tr>
<tr><th rowspan="2">HEX.</th><th colspan="8">BIN.</th></tr>
<tr><th>C7</th><th>C6</th><th>C5</th><th>C4</th><th>C3</th><th>C2</th><th>C1</th><th>C0</th></tr>
<tr><td rowspan="2">BankSW</td><td>0xB0
0xB2
0xB4
0xB6</td><td>1</td><td>0</td><td>1</td><td>1</td><td>0</td><td>BA1</td><td>BA0</td><td>0</td><td>Convert the banks of NVM. If the command is output during standby or idle state, this IC becomes reset state until boot loader starts automatically.</td></tr>
<tr><td colspan="10">C2 and C1 assign the bank of NVM.
<table><tr><th>BA1</th><th>BA0</th><th>Bank Type</th><th>Description</th></tr><tr><td>0</td><td>0</td><td>Bank 0</td><td>Use only bank 0</td></tr><tr><td>0</td><td>1</td><td>Bank 1</td><td>Use only bank 1</td></tr><tr><td>1</td><td>0</td><td>Bank 2</td><td>Use only bank 2</td></tr><tr><td>1</td><td>1</td><td>Bank wrapper</td><td>Use the latest data of bank 0 to 3</td></tr></table></td></tr>
</table>

Table 10.51 Result command list

<table>
<tr><th rowspan="3">Command Name</th><th colspan="9">Command Code</th><th rowspan="3">Action</th></tr>
<tr><th rowspan="2">HEX.</th><th colspan="8">BIN.</th></tr>
<tr><th>C7</th><th>C6</th><th>C5</th><th>C4</th><th>C3</th><th>C2</th><th>C1</th><th>C0</th></tr>
<tr><td rowspan="2">Result</td><td>0xC0
0xC2
0xC4
0xC6</td><td>1</td><td>1</td><td>0</td><td>0</td><td>0</td><td>D1</td><td>D0</td><td>0</td><td>Read the result of sequencer calculation.</td></tr>
<tr><td colspan="10">C2 and C1 assign the result of AD-conversion.
The data is output in the forms of 24 bits and MSB 1st. This IC uses two's complement to express negative number. If you want to obtain Result0 as a relative value, input reference value to result2 and convert AD. The reference value is the copied value of Result 0 which is a standard by using Sequencer Command Cal Copy.
Default value of Result2 is 0.
<table>
<tr><th>D1</th><th>D0</th><th>AD convert result</th><th>Description</th></tr>
<tr><td>0</td><td>0</td><td>Result 0</td><td>Output physical sensor value.</td></tr>
<tr><td>0</td><td>1</td><td>Result 1</td><td>Output temperature sensor value.</td></tr>
<tr><td>1</td><td>0</td><td>Result 2</td><td>Output reference value.</td></tr>
<tr><td>1</td><td>1</td><td>Result 3</td><td>Reserve</td></tr>
</table></td></tr>
<tr><td rowspan="2">Status</td><td>0x80</td><td>1</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>Output status signals that can indicate the IC status.</td></tr>
<tr><td colspan="10">Output 8-bit data depending on the conditions
<table>
<tr><th>D7</th><th>D6</th><th>D5</th><th>D4</th><th>D3</th><th>D2</th><th>D1</th><th>D0</th><th>State</th></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>Shutdown</td></tr>
<tr><td>1</td><td>1</td><td>0</td><td>0</td><td>0</td><td>1</td><td>0</td><td>1</td><td>Standby</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>0</td><td>0</td><td>1</td><td>0</td><td>1</td><td>Idle</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>0</td><td>1</td><td>1</td><td>0</td><td>1</td><td>Active</td></tr>
</table></td></tr>
</table>

Table 10.62 Read / write command list

<table>
<tr><th rowspan="3">Command Name</th><th colspan="9">Command Code</th><th rowspan="3">Action</th></tr>
<tr><th rowspan="2">HEX.</th><th colspan="8">BIN.</th></tr>
<tr><th>C7</th><th>C6</th><th>C5</th><th>C4</th><th>C3</th><th>C2</th><th>C1</th><th>C0</th></tr>
<tr><td>Read</td><td>0xD0
0xD2
0xD4
0xD6</td><td>1</td><td>1</td><td>0</td><td>1</td><td>0</td><td>M1</td><td>M0</td><td>0</td><td>Read data from NVM, register and RAM.</td></tr>
<tr><td>Write</td><td>0xE0
0xE2
0xE4
0xE6</td><td>1</td><td>1</td><td>1</td><td>0</td><td>0</td><td>M1</td><td>M0</td><td>0</td><td>Write data to NVM, register and RAM.</td></tr>
<tr><td>Read/Write</td><td colspan="10">Assign the type of memory with M1 and M0.
<table>
<tr><th>M1</th><th>M0</th><th>Type of Memory</th><th>Width of data sending and receiving</th></tr>
<tr><td>0</td><td>0</td><td>Register</td><td>8 bit</td></tr>
<tr><td>0</td><td>1</td><td>Sequencer RAM</td><td>8 bit</td></tr>
<tr><td>1</td><td>0</td><td>MAC RAM</td><td>32 bit (Low 28 bit)</td></tr>
<tr><td>1</td><td>1</td><td>NVM</td><td>8 bit</td></tr>
</table></td></tr>
</table>

State

Table 10.7 State definition list

Block	State			
	Shutdown	Standby	Idle Boot Load	Active
Digital Block(VDDIO)	ON	ON	ON	ON
Digital Block(1.2VREG)	OFF	ON	ON	ON
Oscillator	OFF	OFF	ON	ON
Sequencer	OFF	OFF	OFF	ON
NVM	OFF	OFF	ON	ON (note[8])

State transition

Table 10.8 State transition list

Receiving command	State			
	Shutdown	Standby	Idle	Active
Reset	○ Shift to Shutdown after Reset and BootLoad	○ Shift to Shutdown after Reset and BootLoad	○ Shift to Shutdown after Reset and BootLoad	○ Shift to Shutdown after Reset and BootLoad
Status	○ Keep Shutdown	○ Keep Standby	○ Keep Idle	○ Keep Active
Shutdown	×	○ Shift to Shutdown	○ Shift to Shutdown	○ Shift to Shutdown
Standby	○ Shift to Standby after Reset and BootLoad	×	○ Shift to Standby	Not supported (note[91])
Idle	○ Shift to Idle after Reset and BootLoad	○ Shift to Idle	×	○ Shift to Idle
Active	○ Shift to active after Reset and BootLoad Implement sequence *The destination to shift depends on sequence.	○ Shift to Active Implement sequence *The destination to shift depends on sequence.	○ Shift to Active Implement sequence *The destination to shift depends on sequence.	×
Bank SW	○ Keep Shutdown	○ Back to Standby after Reset and BootLoad	○ Back to Idle after Reset and BootLoad	○ Keep Active *The destination to shift depends on sequence.
Result	×	○	○	○
Read	×	△ Only register is acceptable.	○	Not supported (note[8])
Write	×	△ Only register is acceptable.	○	Not supported (note[8])

○ : Accept × : Ignore

note[8]: Although command is acceptable, it goes unintended behavior since sequence is running.
note[9]: If you want to shift the state from active to standby, please issue standby command after issuing idle command.

After turning on the power, POR circuit built in this IC resets digital circuit. After resetting, it conducts boot load and reads the contents of NVM to a register and RAM. There are Boot Load 0 that reads I2C address etc. and Boot Load 1 that reads sequence program, correction value, etc. After Boot Load0, this IC shifts to the Shutdown state. When receiving a command from host, after shifting to Boot Load1, the IC shifts to the Standby state, Idle state, and active state following to the command. By writing to the auto-start acceptance setting to NVM, after turning on the power, this IC can be shifted to Boot Load0, Boot Load1, and active state.

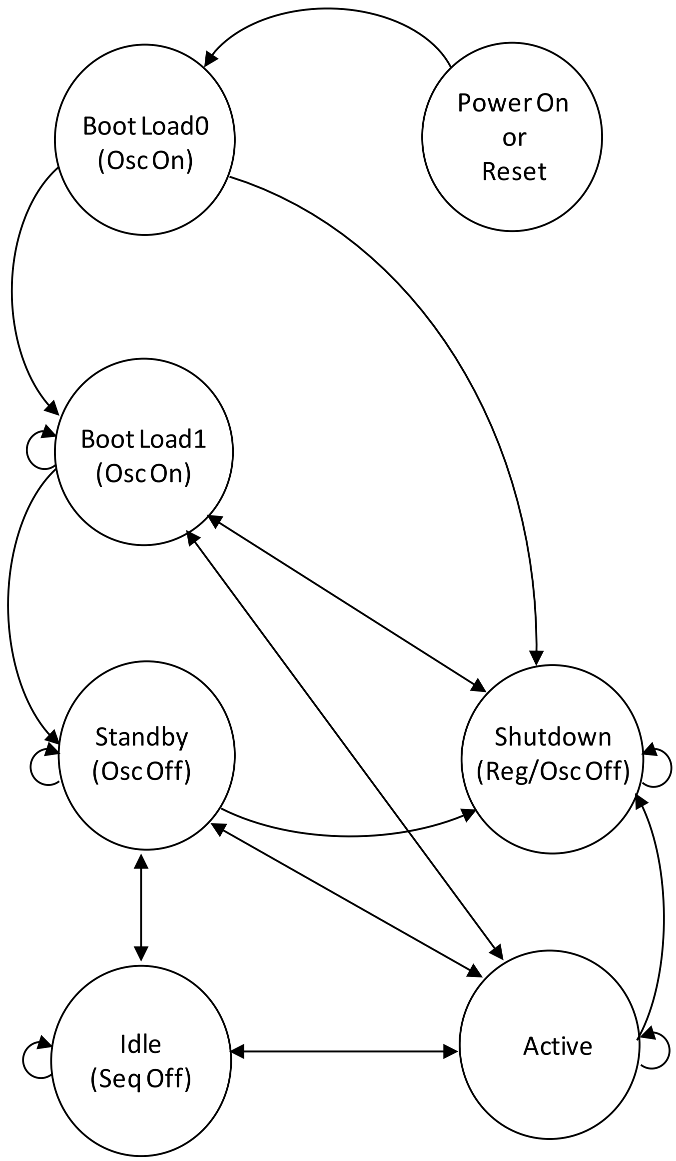


Fig. 10.18 State transition diagram

NVM (Non-volatile memory)

MM3609 contains NVM (Non-volatile memory) in order to store sensor correction value and sequence program. NVM is OTP (One-Time Programmable) where data cannot be erased once it is written in. The 4k bits are divided into four banks. This configuration allows you to write to each area of 1k bit, this can be used as a FTP(Few-Times Programmable) on which can be written for four times, although it is OTP.
If you want to use multiple sequence programs, this product can apply to multiple applications by writing different sequence programs on each bank and selecting the bank to use for BsnkSW command. The newest I2C address shold be used at all times.

NVM Address Map

Table 11.1 NVM Address Map

Addr	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
00h	Reserve	Assign shift state after Boot Load	Reserve					
01h	Reserve	I2C Address[6:0]						
02h ~ 06h	Reserve							
07h	Reserve							
08h ~ 47h	Sequence program 00h to 3Fh							
48h ~ 50h	External sensor offset temperature characteristics zero-order coefficient, primary coefficient, secondary coefficient							
51h ~ 59h	External sensor primary change temperature characteristics zero-order coefficient, primary coefficient, secondary coefficient							
5Ah ~ 62h	External sensor secondary change temperature characteristics zero-order coefficient, primary coefficient, secondary coefficient							
63h ~ 6Eh	Correction coefficient for temperature sensor offset, primary change correction coefficient, secondary correction coefficient, tertiary change correction coefficient							
6Fh ~ 77h	reserve coefficient1, reserve coefficient2, reserve coefficient3							
78h	Reserve				A1 sensor type [1:0]		A0 sensor type [1:0]	
	Kind of sensor: 0, not connected; 1, physical sensor; 2, temperature sensor							
79h	Reserve	Temp Result Bit Shift[2:0]			Reserve	Phy Result Bit Shift[2:0]		
		Assign the quantity of bit shift of the final output of temperature sensor value				Assign the quantity of the bit shift of the final output of physical sensor value		
7Ah ~ 7Dh	Mode 0 temperature sensor CIC decimation ratio Mode 1 temperature sensor CIC decimation ratio Mode 2 temperature sensor CIC decimation ratio Mode 3 temperature sensor CIC decimation ratio				Mode 0 Physical sensor CIC decimation ratio Mode 1 Physical sensor CIC decimation ratio Mode 2 Physical sensor CIC decimation ratio Mode 3 Physical sensor CIC decimation ratio			
7Eh ~ 7Fh	Check some area: CRC16CCITT [15:0]							

80h	Reserve
81h ~ FFh	Bank1 address 01h to 7Fh

100h	Reserve
101h ~ 17Fh	Bank2 address 01h to 7Fh

180h	Reserve
181h ~ 1FFh	Bank3 address 01h to 7Fh

REGISTER

The resisters of this product are a result resister where the result of correction calculation is stored, and register where control register to control IC is aligned. This has 8-bit width.

Register address map

Table 12.1 Register address map

Address	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
[Result Register]								
00h ～02h	Calculated result of physical quantity of corrected and proofed external sensor 0 (24bit) The bit shifted value is that stored in the 75h address of MACRAM. Result 0 command reads this data. *The bit shift quantity is assigned by the address 79h of NVM. Default 0 = Right 4 bit shift First, please read 00h address. Next, please read until 02h address.							
03h ～05h	Calculated result of corrected temperature value (24bit) The bit shifted value is that stored in the 74h address of MACRAM Result 1 command reads this data. *The bit shift quantity is assigned by the address 79h of NVM. Default 0= Right 4 bit shift First, please read 03h address. Next, please read until 05h address.							
06h ～08h	Corrected External sensor0 physical quantity standard value (24bit) The bit shifted value is that stored 76h address of MACRAM. Result 2 command reads this data. ※The bit shift quantity is assigned by the address 79h of NVM. Default 0 = Right 4 bit shift First, please read 06h address. Next, please read until 08h address.							
09h ～0Bh	Reserve for calculation 15(24bit) The bit shifted value is that stored in 7Ah address of MACRAM. Result 3 command reads this data. *The bit shift quantity is assigned by the address 79h of NVM. Default 0 = right 4 bit shift First, please read 09h address. Next, please read until 0Bh address.							
0Ch ～0Fh	ADC (CIC filter, FIR filter) output value First, please read 0Ch address. Next, please read until 0Fh address.							
10h ～20h	Reserve							
[Control Register]								
21h ～3Eh	Reserve							
3Fh	Reserve						CMD1	CMD0
	CMD1,CMD0: This bit is referred in Wait Until Ctrl Reg 3Fh [1, 0] in sequence command and Jump If Ctrl Reg 3Fh [1, 0].							
40h ～53h	Reserve							

MAC RAM (Multiply and ACcumulation RAM)

This RAM is for MAC (Multiply and ACcumulation). This RAM is used for calculations of sequence command. This has 28-bit width.

MAC RAM address map

Table 13.1 MAC RAM address map

Address	Description
[FIR Filter Setting]	
00h ~ 3Eh	FIR tap 00~62
3Fh	Reserve
40h ~ 5Fh	Reserve
[Compensation Coefficient]	
60h	External sensor offset correction coefficient temperature zero-order coefficient
61h	External sensor offset correction coefficient temperature primary coefficient
62h	External sensor offset correction coefficient temperature secondary coefficient
63h	External sensor primary correction coefficient temperature zero-order correction coefficient
64h	External sensor primary correction coefficient temperature primary correction coefficient
65h	External sensor primary correction coefficient temperature secondary correction coefficient
66h	External sensor secondary correction coefficient temperature zero-order correction coefficient
67h	External sensor secondary correction coefficient temperature primary correction coefficient
68h	External sensor secondary correction coefficient temperature secondary correction coefficient
69h	Temperature sensor temperature zero-order coefficient
6Ah	Temperature sensor temperature primary coefficient
6Bh	Temperature sensor temperature secondary coefficient
6Ch	Temperature sensor temperature tertiary coefficient or preparatory coefficient 0
6Dh	Reserve coefficient 1
6Eh	Reserve coefficient 2
6Fh	Reserve coefficient 3
[Result of ADC, compensation, arithmetic]	
70h	ADC (CIC filter, FIR filter) output value
71h	Computed result of offset correction coefficient of external sensor of the current temperature
72h	Computed result of primary sensitivity correction coefficient of external sensor under current temperature
73h	Computed result of secondary sensitivity correction coefficient of external sensor under current temperature
74h	Computed result of Corrected temperature value
75h	Computed result of physical quantity of corrected and proofed external sensor0
76h	Standard value of physical quantity of corrected external sensor0
77h	Reserve for calculation 12
78h	Reserve for calculation 13
79h	Reserve for calculation 14
7Ah	Reserve for calculation 15
7Bh	Reserve
7Ch	Reserve
7Dh	Reserve
7Eh	Reserve
7Fh	Reserve

SEQUENCER RAM

The maximum quantity of sequence program is 64 bytes. This IC copies the sequence program written on NVM to this area during Boot Load. This has 8-bit width.

Sequencer RAM address map

Table 14.1 Sequencer RAM address map

Address	Description
00h ~ 3Fh	Sequence program

SEQUENCER

Sequencer is a function that can implement sequence program stored in NVM in order. This can control behaviors of sensor, ADC, digital filter, correction calculation, and output-interrupt signals. This is also able to program the loop structure include finish judgment. For a judgment of finish, you can choose one from interruption by host, interruption from internal IC or designation of loop frequency up to 15 times.
The maximum capacity of sequence program is 64 bytes. The command code is one byte. Parameter of one to two bytes is required depending on the command.

Sequence command group list

Table 15.1 Sequence command group list (Basic)

Group name *Linked to the detailed command list	Group Description
Init/Copy	Initialization, copy
Power Mode	Power Mode setting
Set Ref Current	Output current setting of IS pin
Block Enable	Enable the settings of each circuit block
Block Disable	Disable the settings of circuit block
Compensation	Compensation calculation
Bit Shift	Zero to 15bit shift from side to side
[GPO Output(SDO,GPO0)]	Output setting of GPO
Wait	Wait control
Loop/Jump	Sequence flow control
End	Completed

Table 15.2 Sequence command group list (Advanced)

Group name *Linked to detailed command list	Group Description
DSM WarmUp Setting	Setting of start wait of ⊿Σmodulator
FIR Filter	FIR filter ON/OFF, settings of decimation ratio
Arithmetic	Calculation for general purpose

Details of sequence command

Table 15.3 Details of sequence command (Basic)

Code	Command	Description
[Init/Copy]		
01h	Clear Temp Data	Clear the address of MAC RAM 0x71 to 0x74
02h	Clear FIR Result	Clear the address of MAC RAM 0x00 to 0x5F
03h	Clear MAC Result	Clear the address of MAC RAM 0x70 to 0x7F
04h	Clear MAC RAM	Clear the address of MAC RAM 0x00~0x7F
05h	Set PhyVal to PhyCal	Copy MAC RAM 0x75 to 0x76
06h	Copy MAC RAM Data AtoB ***Parameter 1：srcA_addr[7:0]*** ***Parameter 2：dstB_addr[7:0]***	Copy MAC RAM data from the designated address to the designated address. ***Source address (8bit)*** Designate MACRAM Address from 0x00 to 0x7F ***Destination address (8bit)*** Designate MACRAM Address from 0x00 to 0x7F
2Ch	Save Temporary	Save MAC RAM 0x74~0x76 and 0x7E~0x7F to the area where values can be maintained even though they are in Shutdown State.
2Dh	Load Temporary	Load MAC RAM 0x74~0x76 and 0x7E~0x7F from the saved area
[Power Mode]		
08h	High Power Mode	Set DSM to HPM (High Power Mode)
09h	Low Power Mode	Set DSM to LPM(Low Power Mode) (Default)
[Set Ref Current]		
11h	IS Output Current ***Parameter 1：RefCurrent[7:0]***	Set current value of IS-pin ***Reference current (8bit)*** 00h:OFF 01h:10uA ～ 7Fh:1270uA ※10uA step
31h	IS Output Current 0	Set the current value of IS-pin to zero
[Block Enable]		
10h	EN IS	Enable IS-pin Output the current set by Is Output Current (11h) command to IS-pin
12h	EN A0 Sensor (COM0, MUX Ch0 ON)	Enable COM0 and MUX Ch0
13h	EN A1 Sensor (COM1, MUX Ch1 ON)	Enable COM1 and MUX Ch1
14h	EN Temp Sensor (Int Temp Sensor, MUX Ch2 ON)	Enable Internal Temperature Sensor and MUX Ch2.
18h	EN DSM & Wait for Conversion	Enable DSM, CIC Filter and FIR Filter. Start AD conversion. Wait until the conversion completed.
28h	EN VREFBUF	Enable VREFBUF Output VREFBUF 1.2V to VREFP-pin
[Block Disable]		
30h	DIS IS	Disable IS-pin
32h	DIS COM0,MUX HiZ	Disable COM0 and MUX (HiZ)
33h	DIS COM1,MUX HiZ	Disable COM1 and MUX (HiZ)
34h	DIS Int Temp Sensor,MUX HiZ	Disable Internal Temp Sensor and MUX (HiZ)
38h	DIS DSM	Disable DSM, CIC Filter, and FIR Filter
39h	DIS VREFBUF	Disable VREFBUF

[Compensation]		
19h	Compensation 2D Internal Temp Sensor	Compensation 2D Internal Temperature Sensor (Bit shift enable)
1Ah	Compensation 3D Internal Temp Sensor	Compensation 3D Internal Temperature Sensor (Bit shift enable)
1Bh	Compensation Phy Sensor 2D Sensitivity	Compensation Physical Sensor 2D Sensitivity (Bit shift enable)
1Ch	Compensation Phy Sensor 1D Sensitivity	Compensation Physical Sensor 1D Sensitivity (Bit shift enable)
1Dh	Compensation Phy Sensor Offset	Compensation Physical Sensor Offset (Bit shift enable)
1Eh	Compensation External Sensor	Compensation External Sensor (Bit shift enable)
[Bit Shift] This command is to set the bit shift quantity of calculated result preliminary. A bit shift which is set after conducting calculation command for bit shift enable is conducted.		
90h	Bit Shift Cancel	Bit Shift Cancel (Default)
91h	Right 1bit Shift	Right 1bit Shift
92h	Right 2bit Shift	Right 2bit Shift
93h	Right 3bit Shift	Right 3bit Shift
94h	Right 4bit Shift	Right 4bit Shift
95h	Right 5bit Shift	Right 5bit Shift
96h	Right 6bit Shift	Right 6bit Shift
97h	Right 7bit Shift	Right 7bit Shift
98h	Right 8bit Shift	Right 8bit Shift
99h	Right 9bit Shift	Right 9bit Shift
9Ah	Right 10bit Shift	Right 10bit Shift
9Bh	Right 11bit Shift	Right 11bit Shift
9Ch	Right 12bit Shift	Right 12bit Shift
9Dh	Right 13bit Shift	Right 13bit Shift
9Eh	Right 14bit Shift	Right 14bit Shift
9Fh	Right 15bit Shift	Right 15bit Shift
A0h	Bit Shift Cancel	Bit Shift Cancel
A1h	Left 1bit Shift	Left 1bit Shift
A2h	Left 2bit Shift	Left 2bit Shift
A3h	Left 3bit Shift	Left 3bit Shift
A4h	Left 4bit Shift	Left 4bit Shift
A5h	Left 5bit Shift	Left 5bit Shift
A6h	Left 6bit Shift	Left 6bit Shift
A7h	Left 7bit Shift	Left 7bit Shift
A8h	Left 8bit Shift	Left 8bit Shift
A9h	Left 9bit Shift	Left 9bit Shift
AAh	Left 10bit Shift	Left 10bit Shift
ABh	Left 11bit Shift	Left 11bit Shift
ACh	Left 12bit Shift	Left 12bit Shift
ADh	Left 13bit Shift	Left 13bit Shift
AEh	Left 14bit Shift	Left 14bit Shift
AFh	Left 15bit Shift	Left 15bit Shift
[GPO Output(SDO,GPO0)] During SPI communication, the settings of SDO-pins are disabled.		
C0h	GPO 0,0	Set SDO-pin, Low; GPO0-pin, Low
C1h	GPO 0,1	Set SDO-pin, Low; GPO0-pin, High (Default)
C4h	GPO 1,0	Set SDO-pin, High; GPO0-pin, Low
C5h	GPO 1,1	Set SDO-pin, High; GPO0-pin, High

[Wait]		
40h	Wait 100usec	Wait 100usec
41h	Wait 500usec	Wait 500usec
42h	Wait 1msec	Wait 1msec
43h	Wait 5msec	Wait 5msec
44h	Wait 10msec	Wait 10msec
45h	Wait 50msec	Wait 50msec
46h	Wait 100msec	Wait 100msec
47h	Wait 500msec	Wait 500msec
4Bh	Wait Until FIR/CIC Finished	Wait Until FIR/CIC filter Finished
4Dh	Wait Until Result Command	Wait until receiving result command *This command is available for only once combined with Jump Detect Result Command within a same sequence.
4Eh	Wait Until Ctrl Reg 3Fh[1]=1	Wait until 3Fh[1] of control register to be High
4Fh	Wait Until Ctrl Reg 3Fh[0]=1	Wait until 3Fh[0] of control register to be High
[Loop/Jump]		
	Common parameter ***Parameter 1:JumpAddr[7:0]***	***Jump address (8bit)*** Designate the sequence address from 00h to 3Fh
54h	Jump Until MAC Compare TRUE	Jump Until the result of comparing calculation is true.
55h	Jump Until Detect Result Command	Jump Until Result command is received. *This command is available for only once combined with Wait Until Result Command within a same sequence
56h	Jump Until Ctrl Reg 3Fh[1]=1	Jump Until control register 3Fh [1] is High
57h	Jump Until Ctrl Reg 3Fh[0]=1	Jump Until control register 3Fh [0] is High.
58h	Infinite Loop	Unconditional Jump (Effective number: Unlimited)
59h	1-time Loop	Unconditional Jump (Effective number: Once)
5Ah	2-time Loop	Unconditional Jump (Effective number: Twice)
5Bh	3-time Loop	Unconditional Jump (Effective number: Three times)
5Ch	4-time Loop	Unconditional Jump (Effective number: Four times)
5Dh	5-time Loop	Unconditional Jump (Effective number: Five times)
5Eh	6-time Loop	Unconditional Jump (Effective number: Six times)
5Fh	7-time Loop	Unconditional Jump (Effective number: Seven times)
60h	8-time Loop	Unconditional Jump (Effective number: Eight times)
61h	9-time Loop	Unconditional Jump (Effective number: Nine times)
62h	10-time Loop	Unconditional Jump (Effective number: Ten times)
63h	11-time Loop	Unconditional Jump (Effective number: 11 times)
64h	12-time Loop	Unconditional Jump (Effective number: 12 times)
65h	13-time Loop	Unconditional Jump (Effective number: 13 times)
66h	14-time Loop	Unconditional Jump (Effective number: 14 times)
67h	15-time Loop	Unconditional Jump (Effective number: 15 times)
[End]		
00h	End (transition to idle)	Sequence completed *After sequence is completed, shift to idle state
36h	End (transition to standby)	Sequence completed *After sequence is completed, shift to standby state
37h	End (transition to shutdown)	Sequence completed *After sequence is completed, shift to shutdown state

Table 15.4 Details of sequence command (Advanced)

Code	Command	Description	
[DSM WarmUp Setting]			
0Ah	DSM Start Wait Setting	Set the default no-output period and wait time of modulator	
	***Parameter 1(higher 2bit)*:**	***Initial no-output period (2bit)***	
	non-OutputCount[7:6]	00:1 decimation	
		01:2 decimation	
		10:3 decimation (default)	
		11:4 decimation	
	***Parameter 1(lower 6bit)*:**	***Wait time (6bit)***	
	WarmUpCount[5:0]	00_0000:0 modulation clock	10_0000:128 modulation clock
		00_0001:1 modulation clock	10_0001:256 modulation clock
		00_0010:2 modulation clock	10_0010:384 modulation clock
		00_0011:3 modulation clock	10_0011:512 modulation clock
		00_0100:4 modulation clock	10_0100:640 modulation clock
		00_0101:5 modulation clock	10_0101:768 modulation clock
		00_0110:6 modulation clock	10_0110:896 modulation clock
		00_0111:7 modulation clock	10_0111:1024 modulation clock
		00_1000:8 modulation clock	10_1000:1152 modulation clock
		00_1001:9 modulation clock	10_1001:1280 modulation clock
		00_1010:10 modulation clock (Default)	10_1010:1408 modulation clock
		00_1011:11 modulation clock	10_1011:1536 modulation clock
		00_1100:12 modulation clock	10_1100:1664 modulation clock
		00_1101:13 modulation clock	10_1101:1792 modulation clock
		00_1110:14 modulation clock	10_1110:1920 modulation clock
		00_1111:15 modulation clock	10_1111:2048 modulation clock
		01_0000:16 modulation clock	11_0000:2176 modulation clock
		01_0001:17 modulation clock	11_0001:2304 modulation clock
		01_0010:18 modulation clock	11_0010:2432 modulation clock
		01_0011:19 modulation clock	11_0011:2560 modulation clock
		01_0100:20 modulation clock	11_0100:2688 modulation clock
		01_0101:21 modulation clock	11_0101:2816 modulation clock
		01_0110:22 modulation clock	11_0110:2944 modulation clock
		01_0111:23 modulation clock	11_0111:3072 modulation clock
		01_1000:24 modulation clock	11_1000:3200 modulation clock
		01_1001:25 modulation clock	11_1001:3328 modulation clock
		01_1010:26 modulation clock	11_1010:3456 modulation clock
		01_1011:27 modulation clock	11_1011:3584 modulation clock
		01_1100:28 modulation clock	11_1100:3712 modulation clock
		01_1101:29 modulation clock	11_1101:3840 modulation clock
		01_1110:30 modulation clock	11_1110:3968 modulation clock
		01_1111:31 modulation clock	11_1111:4096 modulation clock
[FIR Filter]			
78h	FIR Off	Set FIR filter off (Default)	
79h	FIR Decimation Ratio 2	Set decimation ratio of FIR filter "2"	
7Ah	FIR Decimation Ratio 4	Set decimation ratio of FIR filter "4"	
7Bh	FIR Decimation Ratio 8	Set decimation ratio of FIR filter "8"	

Code	Command	Description

[Arithmetic]

These are general-purpose calculation commands. One byte is needed for command code and two bytes for parameter. Total three bytes are needed. Set Variable Number A which is subject to command code, next, Variable Number B and C, and designate the save destination D and the calculation method before conducting the calculation.

Example) Add the offset of reserve coefficient 1 to compensated change-value of external sensor.

Code	Parameter	Details
8Ah	A: Calculation target	Corrected external sensor conversion result
02h	B: Variable 1	Fixed value 1
	C: Variable 2	reserve coefficient1
A1h	D: Destination to save	Corrected external sensor conversion result
	Calculation method	D=A*B+C

Common parameter		
Parameter 1(higher 4bit): MultiplyB[7:4]	***Variable B for multiplication, division and comparison (4bit)***	
	0000:Fixed value 1	1000:MACRAM Addr=73h
	0001:MACRAM Addr=6Ch	1001:MACRAM Addr=74h
	0010:MACRAM Addr=6Dh	1010:MACRAM Addr=75h
	0011:MACRAM Addr=6Eh	1011:MACRAM Addr=76h
	0100:MACRAM Addr=6Fh	1100:MACRAM Addr=77h
	0101:MACRAM Addr=70h	1101:MACRAM Addr=78h
	0110:MACRAM Addr=71h	1110:MACRAM Addr=79h
	0111:MACRAM Addr=72h	1111:MACRAM Addr=7Ah
Parameter 1(lower 4bit): AddC[3:0]	***Variable C for addition and comparison (4bit)***	
	0000:Fixed value 0	1000:MACRAM Addr=73h
	0001:MACRAM Addr=6Ch	1001:MACRAM Addr=74h
	0010:MACRAM Addr=6Dh	1010:MACRAM Addr=75h
	0011:MACRAM Addr=6Eh	1011:MACRAM Addr=76h
	0100:MACRAM Addr=6Fh	1100:MACRAM Addr=77h
	0101:MACRAM Addr=70h	1101:MACRAM Addr=78h
	0110:MACRAM Addr=71h	1110:MACRAM Addr=79h
	0111:MACRAM Addr=72h	1111:MACRAM Addr=7Ah
Parameter 2(higher 4bit): StoreD[7:4]	***Destination D to save calculation results (4bit)***	
	0000:Prohibited setting	1000:MACRAM Addr=73h
	0001:MACRAM Addr=6Ch	1001:MACRAM Addr=74h
	0010:MACRAM Addr=6Dh	1010:MACRAM Addr=75h
	0011:MACRAM Addr=6Eh	1011:MACRAM Addr=76h
	0100:MACRAM Addr=6Fh	1100:MACRAM Addr=77h
	0101:MACRAM Addr=70h	1101:MACRAM Addr=78h
	0110:MACRAM Addr=71h	1110:MACRAM Addr=79h
	0111:MACRAM Addr=72h	1111:MACRAM Addr=7Ah
Parameter 2(lower 4bit): ArithmeticType[3:0]	***Calculation method (4bit)***	
	0000: Multiplication and Addition D=A*B+C	0110: Comparison operation for Jump command C<=A<=B *Disregard D
	0001: Multiplication and Addition D=A*B-C	0111: Saturate calculation If C<=A<=B, D=A If A<C, D=C If B<A, D=B
	0010: Multiplication and Addition D=-A*B+C	1000~1111: Prohibited settings
	0011: Multiplication and Addition D=-A*B-C	
	0100: Division D=A/B *Disregard C	
	0101: Comparison operation for Jump command A<=B *Disregard C and D	

80h	A=1(Const Value)	Set fixed value 1 to Variable A (Bit shift enable)
81h	A=Variable 0 (MACRAM Addr=6Ch)	Set MACRAM Addr=6Ch to Variable A (Bit shift enable)
82h	A=Variable 1 (MACRAM Addr=6Dh)	Set MACRAM Addr=6Dh to Variable A (Bit shift enable)
83h	A=Variable 2 (MACRAM Addr=6Eh)	Set MACRAM Addr=6Eh to Variable A (Bit shift enable)
84h	A=Variable 3 (MACRAM Addr=6Fh)	Set MACRAM Addr=6Fh to Variable A (Bit shift enable)
85h	A=FIR Filter Value (MACRAM Addr=70h)	Set MACRAM Addr=70h to Variable A (Bit shift enable)
86h	A=Phy Sensor Offset Coeff (MACRAM Addr=71h)	Set MACRAM Addr=71h to Variable A (Bit shift enable)
87h	A=Phy Sensor 1st Order Coeff (MACRAM Addr=72h)	Set MACRAM Addr=72h to Variable A (Bit shift enable)
88h	A=Phy Sensor 2nd Order Coeff (MACRAM Addr=73h)	Set MACRAM Addr=73h to Variable A (Bit shift enable)
89h	A=Corrected Temp Value (MACRAM Addr=74h)	Set MACRAM Addr=74h to Variable A (Bit shift enable)
8Ah	A=Corrected Phy Value (MACRAM Addr=75h)	Set MACRAM Addr=75h to Variable A (Bit shift enable)
8Bh	A=Corrected & Cal Phy Value (MACRAM Addr=76h)	Set MACRAM Addr=76h to Variable A (Bit shift enable)
8Ch	A=Variable12 (MACRAM Addr=77h)	Set MACRAM Addr=77h to Variable A (Bit shift enable)
8Dh	A=Variable13 (MACRAM Addr=78h)	Set MACRAM Addr=78h to Variable A (Bit shift enable)
8Eh	A=Variable14 (MACRAM Addr=79h)	Set MACRAM Addr=79h to Variable A (Bit shift enable)
8Fh	A=Variable15 (MACRAM Addr=7Ah)	Set MACRAM Addr=7Ah to Variable A (Bit shift enable)

Example of application circuit

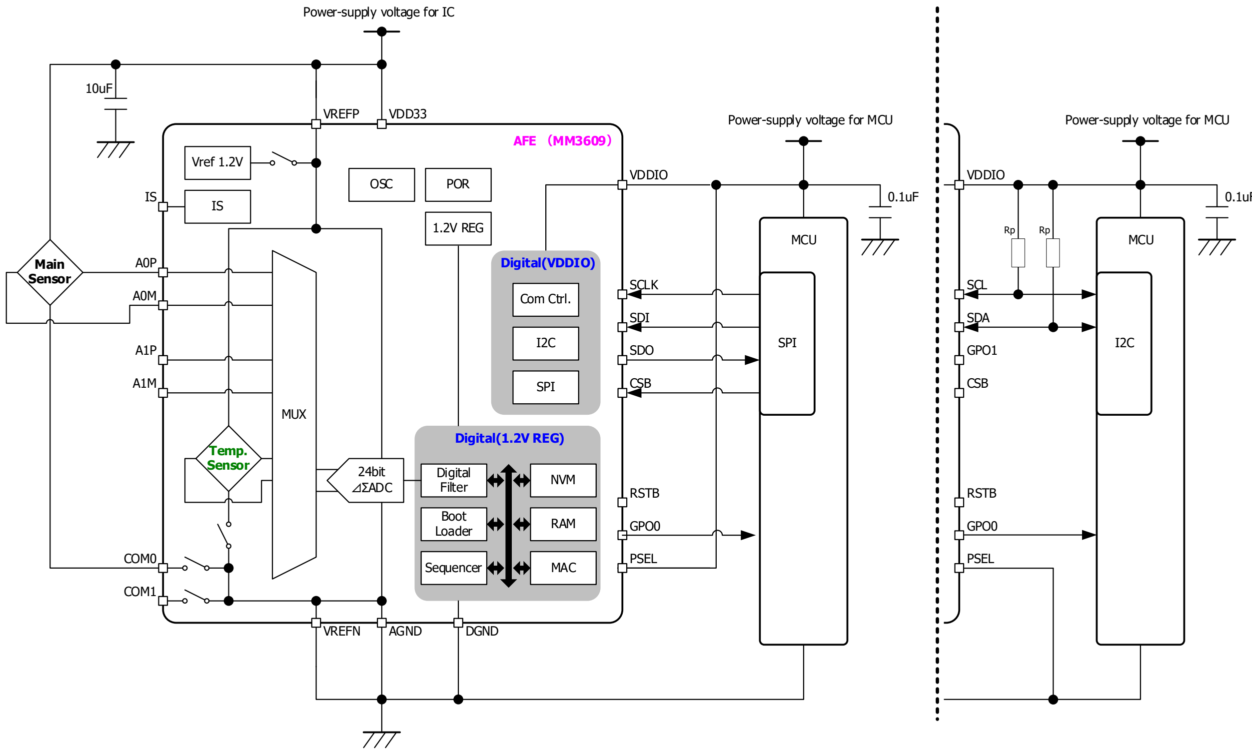
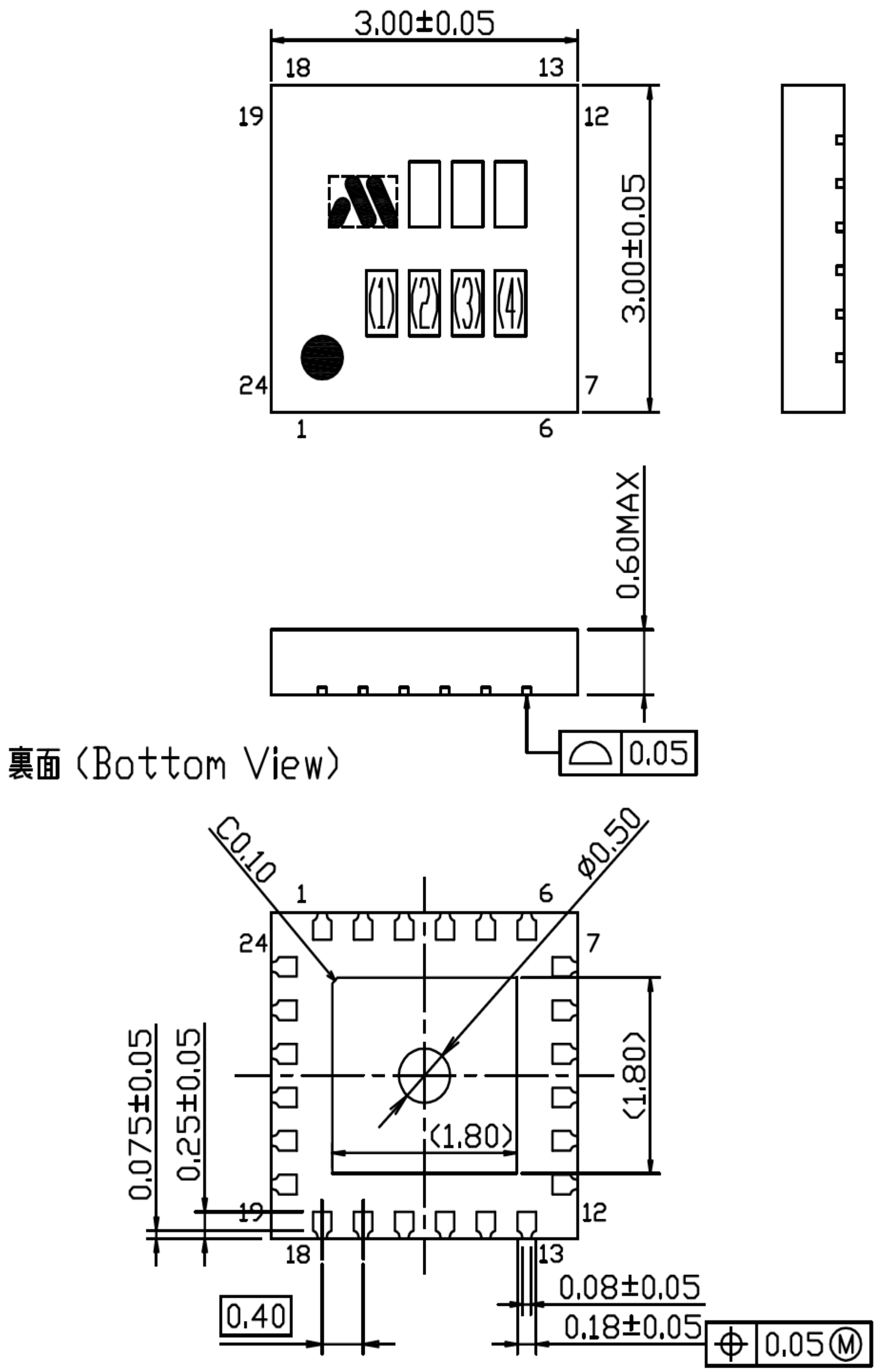


Fig. 16.1 Example of application circuit

OUTLINE DRAWING

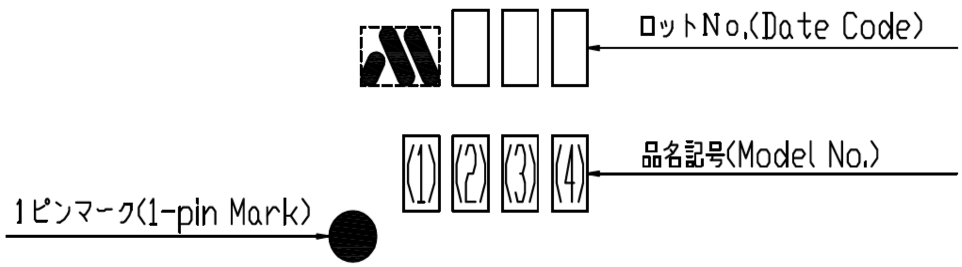
PACKAGE：PLP-24A

UNIT	mm



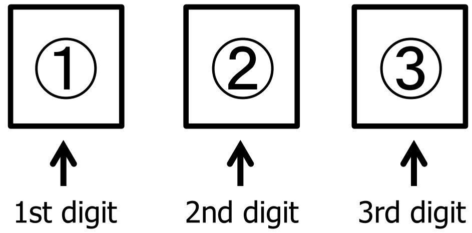
No. R24-PLP24A-0001

MARKING



Model name	Model No.			
	(1)	(2)	(3)	(4)
MM3609ARRE	6	0	9	A

How to identify 3-digit lot numbers



1. The 1st digit (①) shows the last digit of a production year (western calendar).
2. The 2nd (②) and 3rd (③) digits show a production week of mass production.

【How to indicate a production year】

The 1st digit (①)	
the last digit of a production year	mark
xxx1	1
xxx2	2
xxx3	3
xxx4	4
xxx5	5
xxx6	6
xxx7	7
xxx8	8
xxx9	9
xxx0	0

The 2nd and 3rd digit (②③)			
production week	mark	production week	mark
1	01	27	27
2	02	28	28
3	03	29	29
4	04	30	30
5	05	31	31
6	06	32	32
7	07	33	33
8	08	34	34
9	09	35	35
10	10	36	36
11	11	37	37
12	12	38	38
13	13	39	39
14	14	40	40
15	15	41	41
16	16	42	42
17	17	43	43
18	18	44	44
19	19	45	45
20	20	46	46
21	21	47	47
22	22	48	48
23	23	49	49
24	24	50	50
25	25	51	51
26	26	52	52
		53	53

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