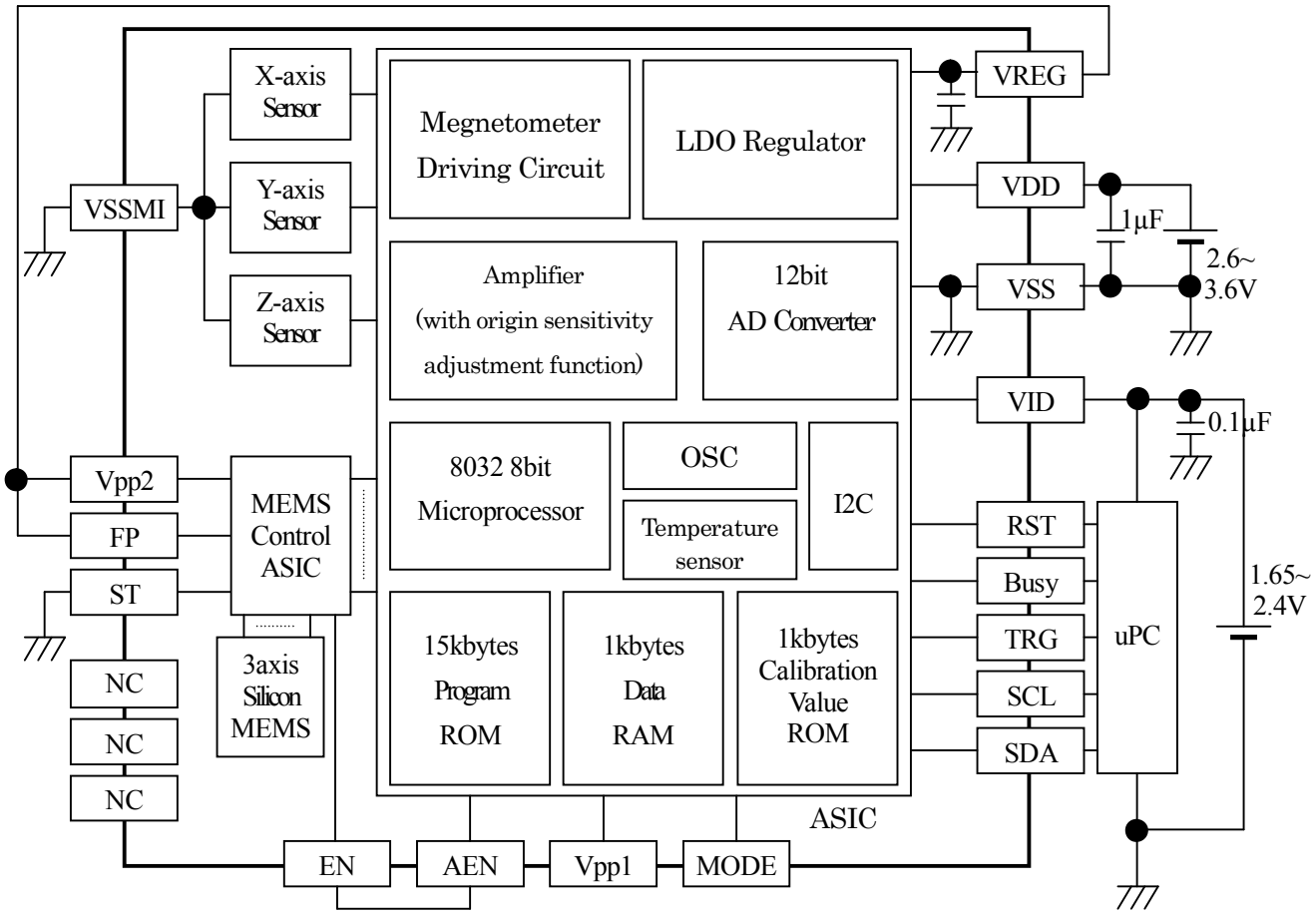
[1] Scope of Application

This specification applies to the 6-axis motion sensor AMI602 provided to ＊＊＊ by Aichi Steel Corporation.

[2] General Description

The AMI602 is a motion sensor that integrates a 3-axis MI (magnetoimpedance) sensor and a 3-axis silicon MEMS accelerometer with their controller IC in a single small package. The controller IC of the AMI602 consists of a circuit for detecting the magnetic signals from the 3 MI-sensor elements, an amplifier capable of compensating each sensors offset and setting appropriate sensitivity values, a temperature sensor for measuring the ambient temperature, a 12bitAD converter, an I2C serial output circuit, a constant voltage circuit for power control and a 8032 micro-processor controlling each circuit.

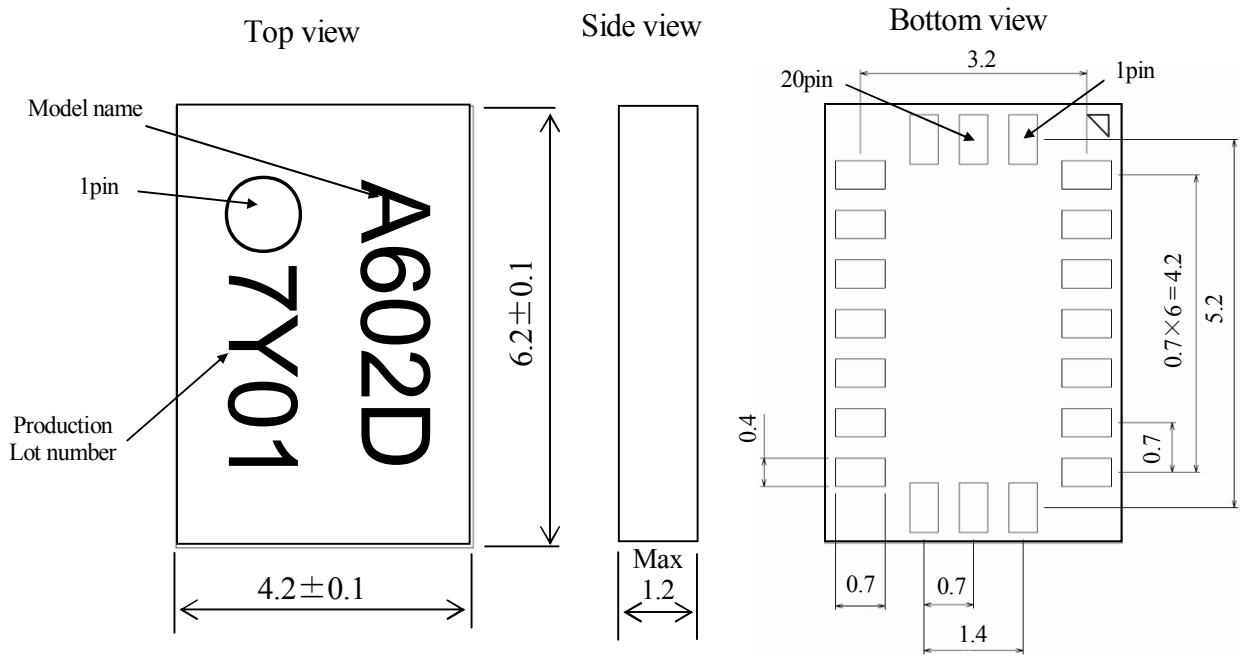
[3] Block Diagram



Note1) Each terminal of RST, TRG, SCL, and SDA is connected with VID with 100kohm.

Note2) When VID=1.8V and VDD=No connect, the output of Busy becomes high impedance.

[4] Dimensions and marking Layout



（単位：mm）

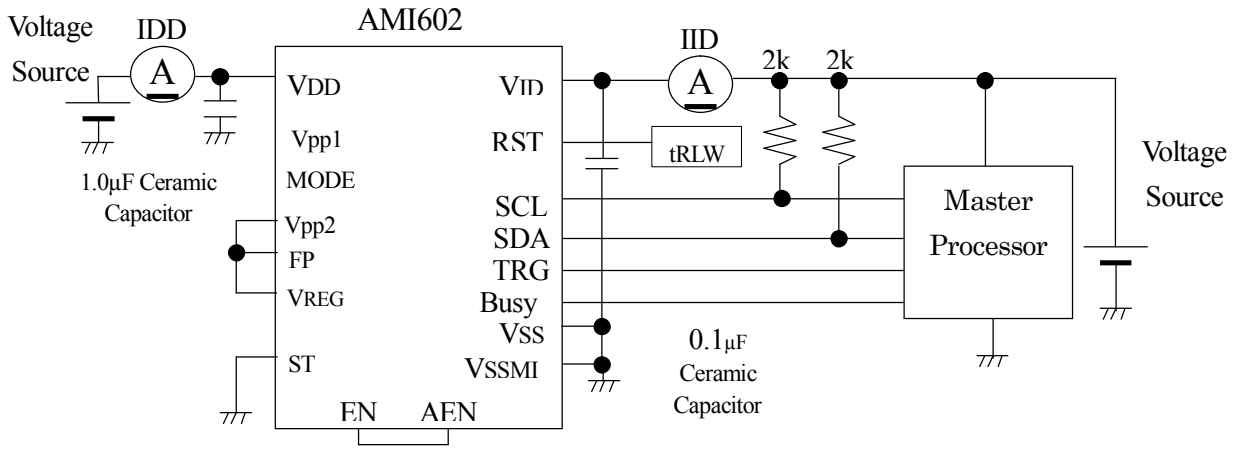
[5] Terminal Description

Pin No.	I/O	I/O	Description	Reference
1	VID	Power	Digital Circuit Power Input (1.65V～2.40V)	Please connect a 0.1μF bypass capacitor between VID and VSS
2	SDA	Input & Output	I2C communication Data I/O	—
3	RST	Input	Microcomputer Reset	Please input low level at power-on and keep high level while operating in order to ensure stable performance
4	MODE	—	Testing Terminal	Non-Connection (NC).
5	Busy	Output	Notify completion of Measurement	—
6	TRG	Input	Interrupt Input	Release from Power down mode or Suspend mode by falling edge input.
7	Vpp1	—	Testing Terminal	Non-Connection (NC).
8	EN	Input	Accelerometer control terminal	Please short-circuit with AEN
9	AEN	Output	Accelerometer control terminal	Please short-circuit with EN
10	VSS	Power	Ground。	—
11	VDD	Power	Analog Circuit Power Input (2.6V～3.6V)	Please connect a 1μF bypass capacitor between VDD and VSS. The capacitor should be mounted close to the terminals
12	Vpp2	Input	Accelerometer power supply	Please short-circuit with VREG
13	VREG	Output	Constant Voltage Output	—
14	VSSMI	Power	Ground	—
15	ST	Input	Testing Terminal	Please short-circuit with VSS
16	FP	Input	Testing Terminal	Please short-circuit with VREG
17	NC	—	Non-Connection	—
18	NC	—	Non-Connection	—
19	NC	—	Non-Connection	—
20	SCL	Input & Output	I2C Signal Clock Input	—

Note1) Each terminal of RST, TRG, SCL, and SDA is connected with VID with 100kohm.

Note2) When VID=1.8V and VDD=No connect, the output of Busy becomes high impedance.

[6] Test Circuit



Note1) [9] Electrical Characteristics and [10] Sensor Characteristics are measured with this circuit.

Note2) In order to obtain stable operation we recommend placing a ceramic capacitor (capacity more than 1.0 μF) between VDD and VSS and a ceramic capacitor (capacity more than 0.1μF) between VID and VSS.

[7] Absolute Maximum Ratings

Parameter	Symbol	Ratings	Unit
Supply Voltage	V_{DD}	-0.3 to +4.0	V
	V_{ID}	-0.3 to +4.0	V
Storage Temperature	T_{STG}	-40 to + 125	℃
Input Voltage	V_{IN}	-0.3 to V_{ID}+0.3	V

[8] Recommended Operating Conditions

Parameter	Symbol	Min.	Typ.	Max.	Unit
Supply Voltage	V_{DD}	2.60	3.00	3.60	V
	V_{ID}	1.65	1.80	V_{DD}	V
Operating Temperature	T_{OPR}	-20	—	+85	℃

[9] Electrical Characteristics

(Ta= +25 °C ,VDD= +3.00V, VID= +1.80V, 1.0µF ceramic capacitor between V_{DD} and V_{SS})

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Average Operating Current	IDD1	In Sensor Trigger Mode, with 20ms interval Measurement	—	1.0	2.0	mA
	IID1		—	0.1	2.0	µA
Power down mode Operating Current	IDD2	—	—	0.1	2.0	µA
	IID2	—	—	0.1	2.0	µA
Suspend mode Operating Current	IDD3	—	—	0.1	0.2	mA
Pedometer Operating Current	IDD4	at 40ms measurement	—	0.82	1.4	mA
	IDD5	at 2s measurement	—	0.15	—	mA
Constant Voltage Output	VREG	—	—	2.32	—	V
I2C Operating Frequency	fSCL	—	50	400	700	kHz
Cold Rest Time	tCR	—	60	—	—	µs
Warm Reset Time	tWR	Minimum pulse width for reset	5	—	—	µs
Internal Chip Reset Time	tIR	—	50	—	—	µs
Delay Time (From TRG Falling Edge until Micro-processor starts to operate)	tWU	—	—	32.8	—	ms
Start Condition Set-Time	tsta	—	0.6	—	—	µs
High Level Voltage Input	VIH	—	70% VID	—	—	V V
Low Level Voltage Input	VIL	—	—	—	30% VID	V V
Low Level Output Voltage	VOL	—	—	—	20% VID	V V
I2C Address	—	—	0110000			bit
I/O Terminal Bias Resistance	RL	Between each RST, TRG, SCL, SDA and VID, Ta= -20 °C～+85 °C	69	100	342	kohm
Necessary Delay Time betweenVID-on and VDD-on	tON	At Start of Supply Voltage	0	—	—	µs
Necessary Delay Time1 for Commands	tCMD1	Interval of Cmd1－Cmd2 in "11-1. Read Command"	200	—	—	µs
Necessary Delay Time2 for Commands	tCMD2	Interval of Cmd1－Cmd2 in "11-2. Write Command"	350	—	—	µs
Necessary Delay Time3 for Commands	tCMD3	Interval of Cmd1－Cmd2in "11-1. Read Command", only limited for GET_PED_TH	550	—	—	µs
Necessary Delay Time4 for Commands	tCMD4	Interval of Cmd1－Cmd2 in "11-2. Write Command", only limited for SET_PED_TH	500	—	—	µs
Necessary Delay Time5 for Commands	tCMD5	Interval of Cmd1－Cmd2in "11-1. Read Command", only limited for GET_MES_T	450	—	—	µs

[10] Sensor Characteristics

10-1. Magnetic Sensor

(VDD= +3.0 V, VID= +1.80V, 1μF ceramic capacitor between V_{DD} and V_{SS})

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Moving Range (*1)	Rm	Ta= +25 °C	—	Eoft±3	—	gauss
Measurable Range (*2)	Ra	Adjust operating point by SET_FINR to avoid output saturation	—	±6	—	gauss
Linearity	Lin	Rm=±3gauss、Ta= +25 °C	—	0.5	2	%FS
Output Offset Voltage at Zero Gauss	Vofs	Ta= +25 °C	—	2048	—	LSB
		Change rate by temperature（Ta=0～+60℃, as 25℃ standard）	-3	0	+3	mgauss /℃
Sensitivity	deltaV	Ta= +25 °C	—	600	—	LSB/ gauss
		Change rate by temperature（Ta=0～+60℃, as 25℃ standard）	-7	—	+5	%
Frequency Response	Fr	Ta= 0～+60 °C	—	200	—	Hz

*1: Moving range: preset operating range

*2: Measurable range: overall measurable range within which preset operating range can be fit in by adjusting appropriate offsets.

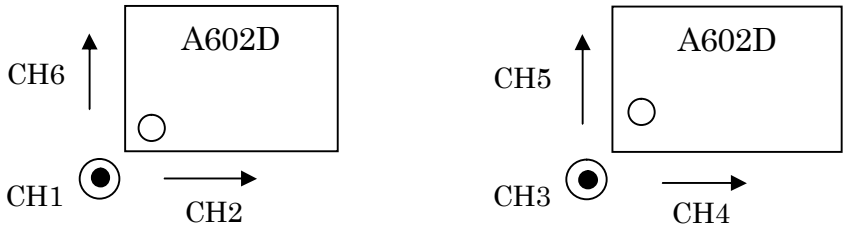
10-2. Acceleration sensor

(VDD= +3.0 V, VID= +1.80V, 1μF ceramic capacitor between V_{DD} and V_{SS})

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Dynamic Range	Rm	Ta= +25 °C	—	±2	—	g
Linearity	Lin	Ta= +25 °C	—	0.5	4	%FS
Output Offset Voltage at Zero g	Vofs	Ta= +25 °C	—	2048	—	LSB
		Change rate by temperature（Ta=0～+60℃, as 25℃ standard）	-100	0	+100	mg
Acceleration Sensitivity	deltaV	Ta= +25 °C	—	800	—	LSB /g
		Change rate by temperature（Ta=0～+60℃, as 25℃ standard）	-10	0	+10	%
Frequency Response	Fr	Ta= 0～+60 °C	—	100	—	Hz

Note1) The manufacturer assures above properties in condition of lead-free solder at +380±5℃、for 5±0.5sec by human operator.
Note2) The manufacturer assures above properties with N2 reflow or 2-time reflow with the condition of Fig. 1 in ［17］.

[11] Polarity



Magnetometer　　Accelerometer

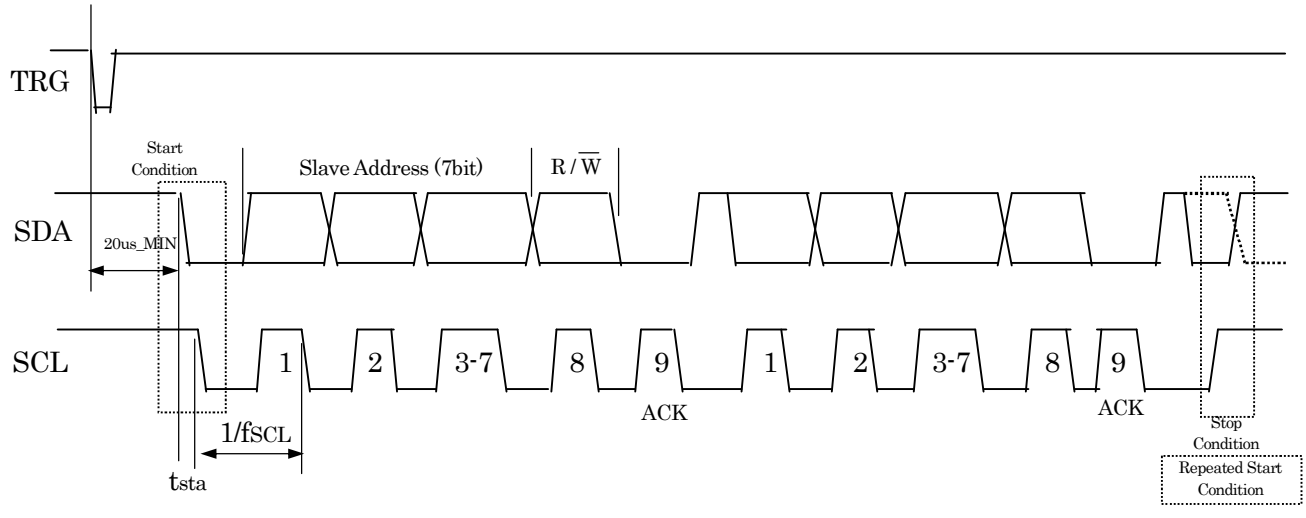
・When the arrow of the magnetic sensor is directing south output becomes "+".

・When the arrow of the acceleration sensor is directing vertically towards zenith output becomes "+".

[12] Timing Chart

12-1. I2C BUS Timing Chart

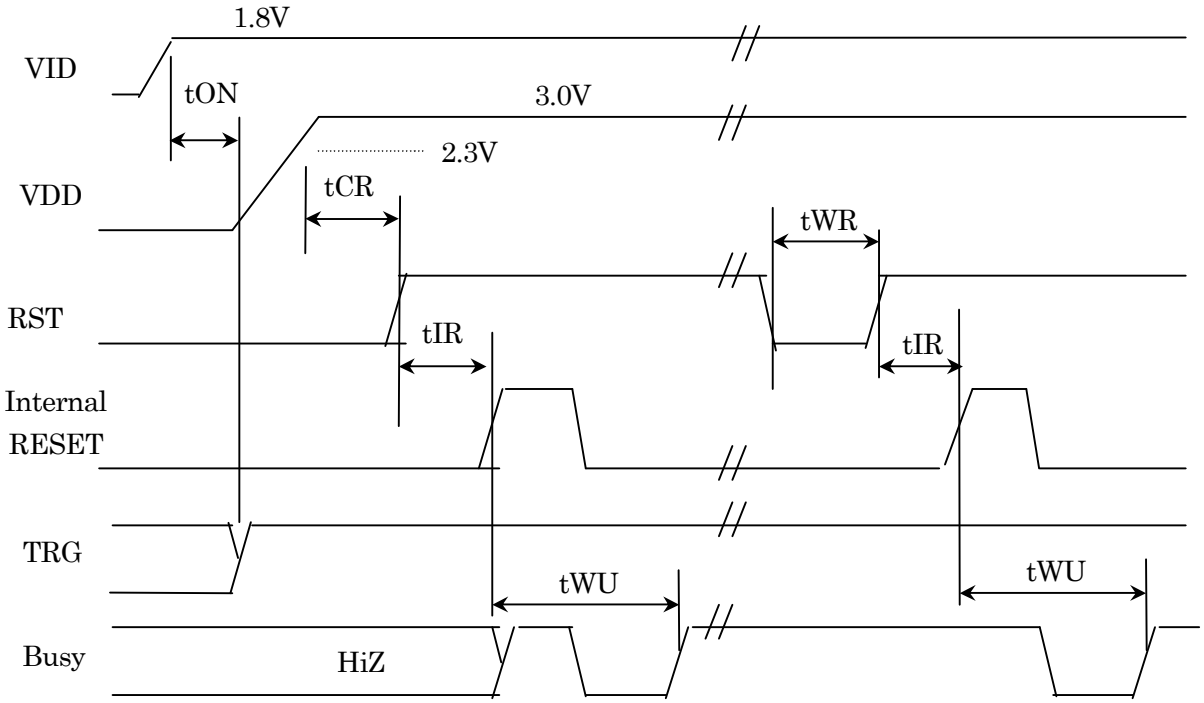
This timing chart shows behavior from Susuepnd mode.



Busy　　The high level is maintained.

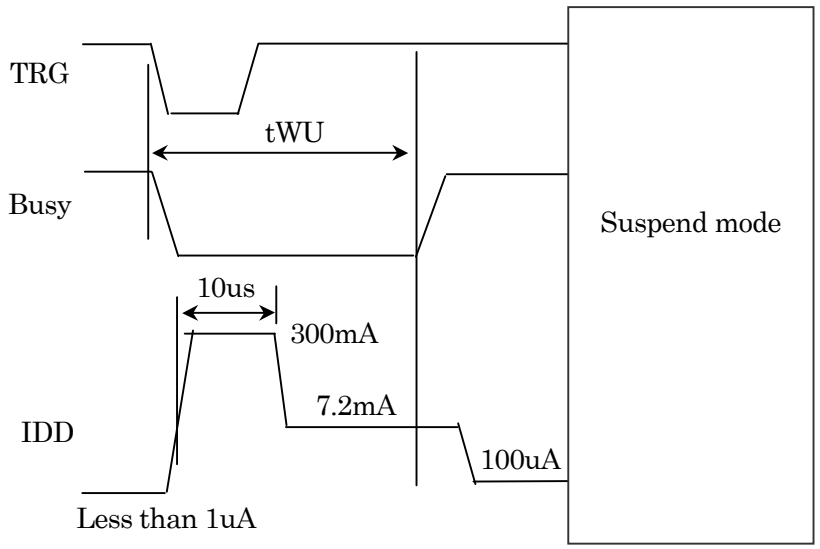
Note) The AMI602 transfers from Suspend mode to Active mode with the falling edge signal of TRG terminal.
Typical measuring time of one 6-axis measurement is 2.28 ms. After completion of measurement the Busy-terminal turns to HIGH.
Pedometer measurement time is 3.88ms TYP at walking check, 3.24ms TYP at stop.
Typical measuring time of pedometer + 6-axis measurement is 5.02ms.

12-2. Power on



Note) Please input low level at power-on and keep high level while operating in order to ensure stable performance

12-3. Started from Power down mode



Note) The shape of waves of IDD is figure where the size of the VDD power supply

[13] Standard Command Sequence

13-1. Read Command

cmd1: send command

Host	S	SAD+W		Command		P
AMI602			A		A	

cmd2: receive data

Read data

Host	S	SAD+R					A		A	・・・	N	P
AMI602			A	Err_no	A	RDA1		RDA2		・・		

S	Start Condition	SAD + W	slave address + write (01100000)
Sr	Restart Condition	SAD + R	slave address + read (01100001)
A	ACK（SDA_Low）	Command	Please refer to 15-1. Read Command
N	NACK（SDA_High）	RDA*	Read-in data*
P	Stop Condition	Err_no	0x00: success 0x01～0xF6: unused 0xF7: pedometer not operating 0xF8～0xF9: unused 0xFA: unusable command at Sensor Trigger Mode 0xFB～0xFD: unused 0xFE: wrong packet 0xFF: unused

13-2. Write Command

cmd1: send command & data

Write Data

Host	S	SAD+W		Command		WDA1		WDA2		・・・		P
AMI602			A		A		A		A		A	

cmd2: receive result

Host	S	SAD+R			N	P
AMI602			A	Result		

S	Start Condition	SAD + W	slave address + write (01100000)
Sr	Restart Condition	SAD + R	slave address + read (01100001)
A	ACK（SDA_Low）	Command	Please refer to 15-2. Write Command
N	NACK（SDA_High）	WDA *	Write-in data*
P	Stop Condition	Result	0x00: success 0x01～0xF6: unused 0xF7: pedometer not operating 0xF8～0xF9: unused 0xFA: unusable command at Sensor Trigger Mode 0xFB～0xFD: unused 0xFE: wrong packet 0xFF: unused

13-3. Format of GET_MES_SUSPEND / GET_MES

The size of the 1CH measurement data is 1.5 byte (12bit). According to the size, the measured result output format of GET_MES_SUSPEND / GET_MES is as follows.

Read Command

cmd2: receive data

Host	S	SAD+R			A		A		A	・・・	N	P
AMI602			A	Err_no		RDA1		RDA2		・・		

	Read data1		Read data2		Read data3	
CH	CH1	CH1	CH1	CH2	CH2	CH2
Bit	[11-8]	[7-4]	[3-0]	[11-8]	[7-4]	[3-0]

	Read data 4		Read data 5		Read data 6	
CH	CH3	CH3	CH3	CH4	CH4	CH4
Bit	[11-8]	[7-4]	[3-0]	[11-8]	[7-4]	[3-0]

	Read data 7		Read data 8		Read data 9	
CH	CH5	CH5	CH5	CH6	CH6	CH6
Bit	[11-8]	[7-4]	[3-0]	[11-8]	[7-4]	[3-0]

13-4. Wait times required for communications

Following wait times are needed.

command 1					*3.	command 2				
TRG Low / High	*1.	cmd1	*2.	cmd2	⟷	TRG Low / High	*1.	cmd1	*2.	cmd2

No	command	*1.	*2.	*3.
1	SET_MES_PED_AUTO_START	20us	350us	450us
2	SET_MES_PED_AUTO_STOP	20us	350us	450us
3	GET_MES_PED_AUTO_SUSPEND	20us	200us	30us
4	CLR_PED_SUSPEND	20us	350us	30us
5	SET_MES_6CH_START	20us	350us	450us
6	SET_MES_6CH_STOP	20us	350us	450us
7	GET_MES	20us	200us	30us
8	GET_MES_SUSPEND	20us	200us	30us
9	GET_COSR	20us	200us	30us
10	GET_FINR	20us	200us	30us
11	GET_DAT	20us	200us	30us
12	GET_FIRMWARE	20us	200us	30us
13	GET_MES_AVG	20us	200us	30us
14	GET_GAIN	20us	200us	30us
15	GET_PED_TH	20us	550us	30us
16	GET_MES_T	20us	450us	30us
17	REQ_MES	20us	350us	-
18	SET_PWR_DOWN	20us	350us	30us
19	SET_SUSPEND	20us	350us	30us
20	SET_COSR	20us	350us	30us
21	SET_FINR	20us	350us	30us
22	SET_INDEX_DAT	20us	350us	30us
23	SET_AEN	20us	350us	30us
24	CHG_MES_AVG	20us	350us	30us
25	SET_GAIN	20us	350us	30us
26	SET_PED_TH	20us	500us	30us

[14] Measurement Sequence

14-1. Measurement Mode

The measurement mode has following 3 patterns.

Measurement mode		Operation
Host Trigger mode		AMI602 carries out 6 CH measurement in response to the HOST's request
Sensor Trigger mode	6CH measurement (20ms) + Pedometer *1	AMI602 carries out 6 CH measurement at specified interval and pedometer simultaneously by receiving SET_MES_6CH_AUTO_START and SET_MES_PED_AUTO_START。 Rise-edge on Busy terminal activates data retrieve.
	6CH measurement (20ms,40ms 60ms,80ms 100ms) *1.	AMI602 carries out 6 CH measurement at specified interval by receiving SET_MES_6CH_AUTO_START Rise-edge on Busy terminal activates data retrieve.
	pedometer	AMI602 carries out pedometer by receiving SET_MES_PED_AUTO_START.

Note 1) When pedometer is operating solely, stop pedometer before transferring the measurement mode to 6CH measurement + pedometer.

Note 2) When you wish to operate 6 CH measurement + pedometer, first send the 6 CH measurement command beforehand.

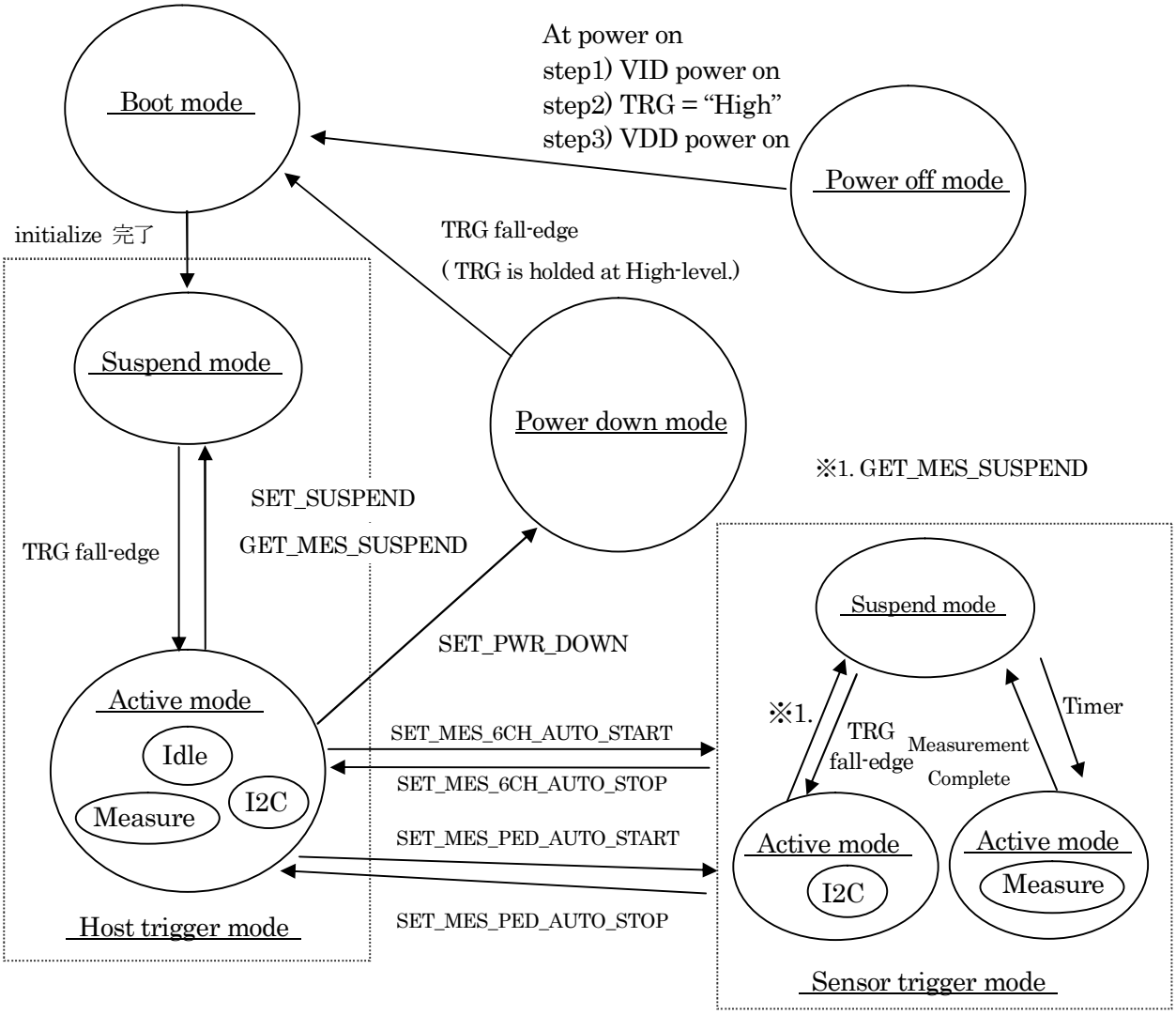
Note 3) When you wish to start I2C communication in Sensor Trigger mode, first turn TRG terminal from low to high, then send I2C commands.

Note 4) Carry out I2C communications when the Busy terminal is high. AMI602 will return NACK when you try I2C communications while the Busy terminal is low.

*1 For example, when you start pedometer(SET_MES_PED_AUTO_START) at 6 CH measurement (80ms), AMI602 carries out 6ch(20ms)+pedometer, after that when you stop the pedometer (SET_ MES_PED_AUTO_STOP, AMI602 carries out 6CH measurement (80ms).

14-2. Mode Transfer

The modes of AMI602 is shown in the figure below.



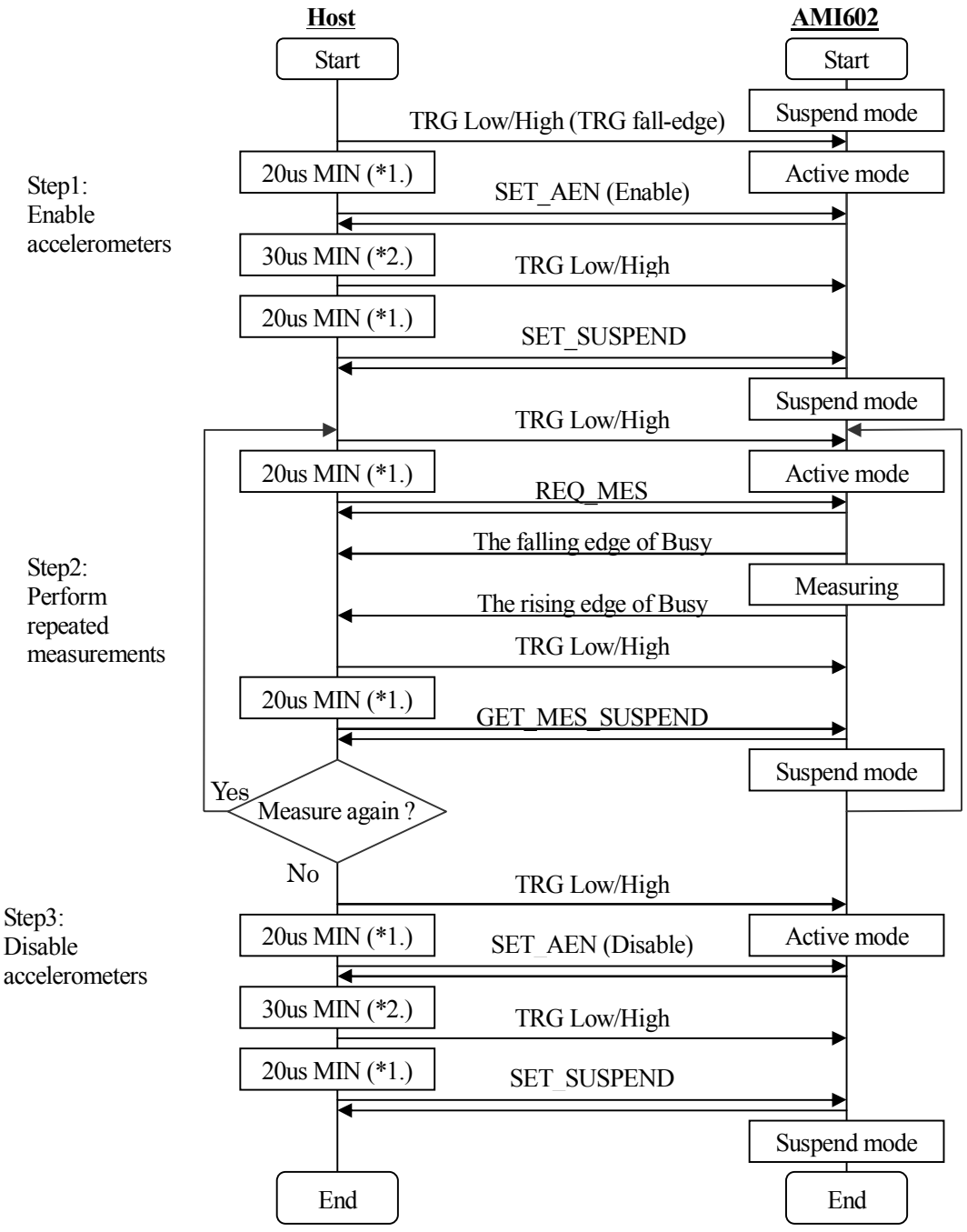
Additional Notes

1) After SET_MES_6CH(PED)_AUTO_START, AMI602 transfers from Active mode of Host_trigger_mode to Suspend mode of Sensor_trigger_mode.
2) After SET_MES_6CH (PED) _AUTO_START, further carrying out SET_MES_PED(6CH)_AUTO_START lets AMI602 transfer from Active mode of Sensor_trigger_mode to Suspend mode of Sensor_trigger_mode.
3) After carrying out both SET_MES_6CH_AUTO_START and SET_MES_PED_AUTO_START, SET_MES_6CH(PED)_AUTO_STOP lets AMI602 transfer from Active mode of Sensor_trigger_mode to Suspend mode of Sensor_trigger_mode.
4) After carrying out both SET_MES_6CH_AUTO_STOP and SET_MES_PED_AUTO_STOP, AMI602 transfers from Active mode of Sensor_trigger_mode to Active mode of Host_trigger_mode.

Mode	Status	Busy Terminal
Boot mode	To do initialization	Low-Level
Active mode	Measurement and I2C communication is possible. The Active mode has Idle, measure, and I2C.	High-Level (Low-Level during measurement)
Suspend mode	Keep the content of registers and RAM	High-Level
Power Down mode	Do no keep the content of registers and RAM	High-Level

14-3. Measurement Sequence in Host Trigger Mode

AMI602 performs the measurements upon the request from Host. A sample measurement sequence is shown below.

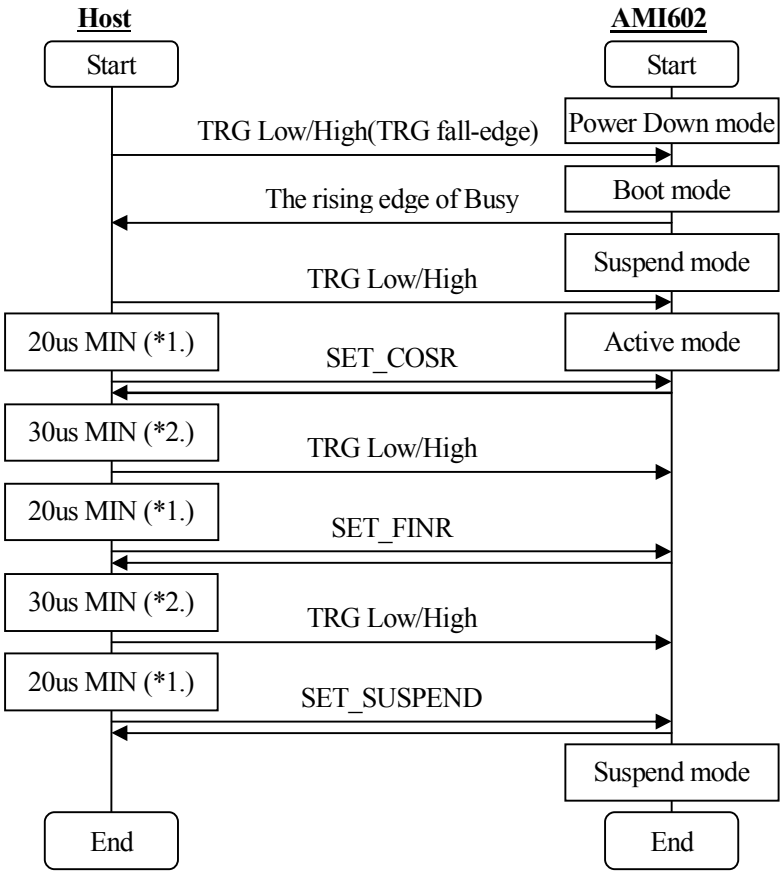


*1. Required time for AMI602 to detect the fall-edge of TRG and become able to communicate

*2. Required time for AMI602 to acknowledge next command

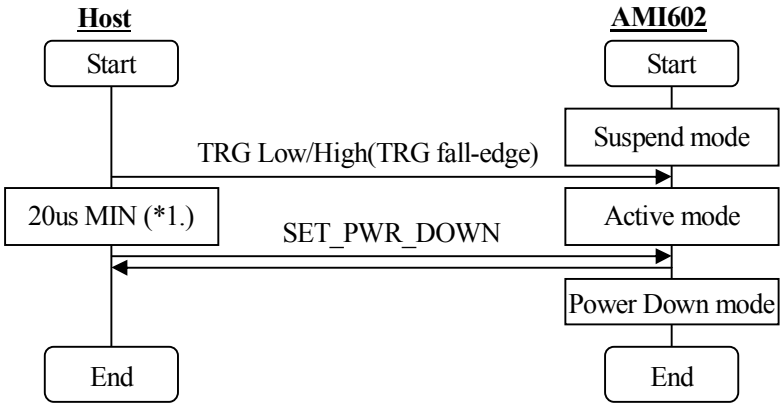
14-4. Start-up Sequence

Start-up sequence is as follows.



14-5. Power Down Sequence

Power down sequence is as follows

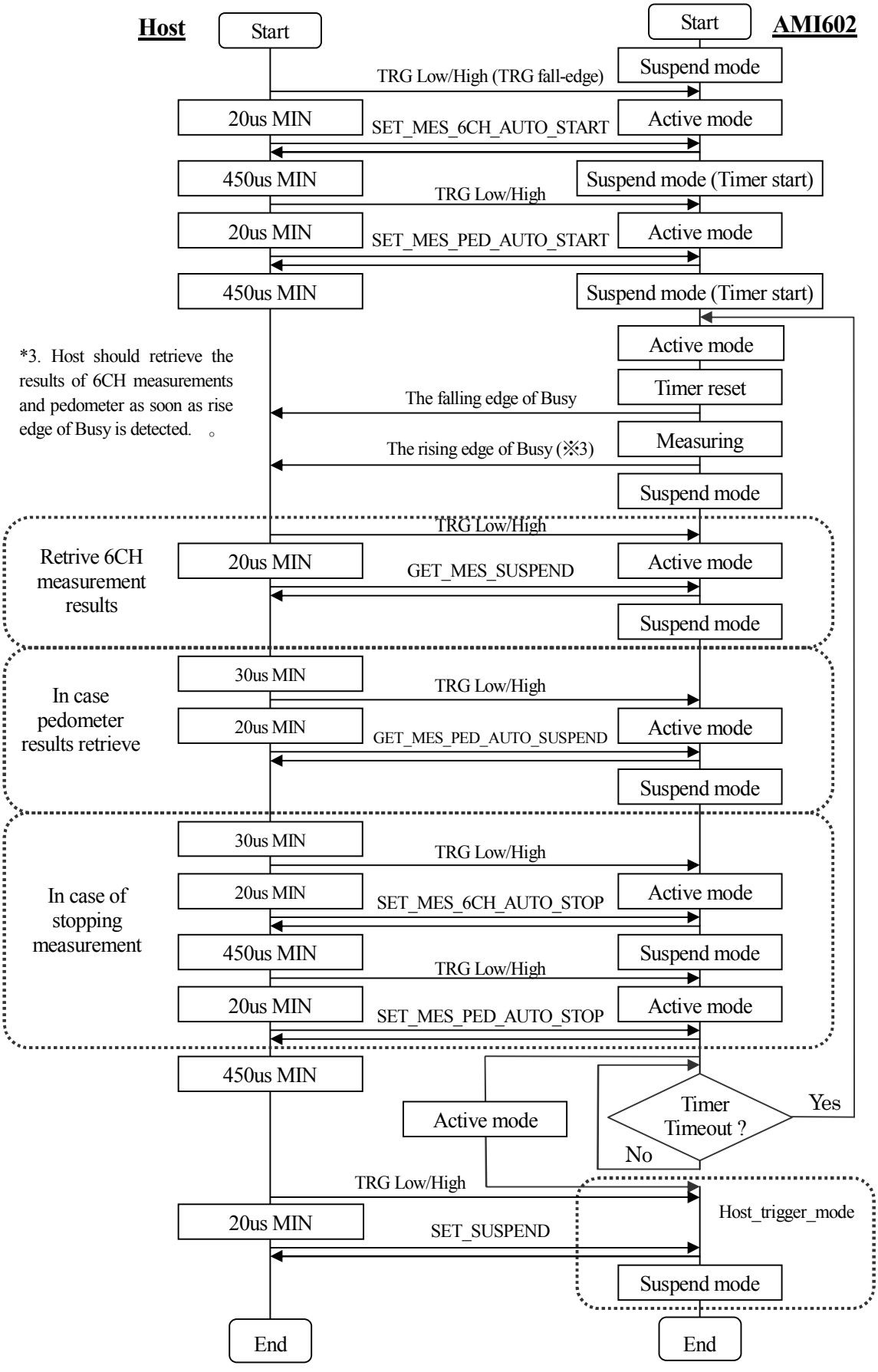


*1. Required time for AMI602 to detect the fall-edge of TRG and become able to communicate

*2 Required time for AMI602 to acknowledge next command

14-6. Measurement Sequence in Sensor Trigger mode

Following is the measurement sequence in which pedometer and 6CH measurements are carried out simultaneously.



[15] Bus Command Functional Chart

15-1. Read Command

No	command	*1.	code	function	read data size	read data	
1	GET_COSR	NG	0x11	Read out offset coarse	6byte	1byte : CH 1 offset coarse 2byte : CH 2 offset coarse 3byte : CH 3 offset coarse 4byte : CH 4 offset coarse 5byte : CH 5 offset coarse 6byte : CH 6 offset coarse	Please refer to SET_COSR
2	GET_FINR	NG	0x12	Read out offset fine	6byte	1byte : CH 1 offset fine 2byte : CH 2 offset fine 3byte : CH 3 offset fine 4byte : CH 4 offset fine 5byte : CH 5 offset fine 6byte : CH 6 offset fine	Please refer to SET_FINR
3	GET_MES_SUSPEND *2.	Pass	0x28	After read out the measurement data, transfer to Suspend mode	9byte	Please refer to 11-3. Format of GET_MES_SUSPEND/ GET_MES	Please refer to 14-2 Measurement Sequence
4	GET_MES *2.	Pass	0x14	Read out the measurement results	9byte	Please refer to 11-3. Format of GET_MES_SUSPEND/ GET_MES	Please refer to 14-2 Measurement Sequence
5	GET_DAT	NG	0x21	Read out the origin and offsets from data_buf	6byte	1byte : data_buf[index][0] 2byte : data_buf[index][1] 3byte : data_buf[index][2] 4byte : data_buf[index][3] 5byte : data_buf[index][4] 6byte : data_buf[index][5]	Please refer to 15-3. Read-In Procedure of Origin and Sensitivity
6	GET_FIRMWARE	NG	0x17	Read out the Firmware version	7byte	1byte : major version 2byte : minor version 3byte : year High-byte 4byte : year Low-byte 5byte : month 6byte : day 7byte : reserved	
7	GET_MES_PED_AUTO_SUSPEND	Pass	0x32	Read out walking step number and walking time (sec), then transfer to the Suspend mode	9byte	1byte : step number (High byte) 2byte : step number (|) 3byte : step number (|) 4byte : step number (Low byte) 5byte : walk time (High byte) 6byte : walk time (|) 7byte : walk time (|) 8byte : walk time (Low byte) 9byte : pedometer status 0:stop 1:walking check 2:walking status	Value range Step number：0 – 0xFFFFFFFF Walking time：0 – 0xFFFFFFFF
8	GET_MES_AVG	NG	0x33	Read out the averaging number	1byte	1byte : averaging number of the measurement 0x00 : 4times 0x01 : 16times	Please refer to CHG_MES_AVG
9	GET_GAIN	NG	0x10	gain 値を読み出す。	6byte	1byte : CH 1 gain 2byte : CH 2 gain 3byte : CH 3 gain 4byte : CH 4 gain 5byte : CH 5 gain 6byte : CH 6 gain	SET_GAIN を参照
10	GET_PED_TH	NG	0x36	Get the thresholds of pedometer	17byte	1byte : TH0 2byte : TH1 3byte : TH2 4byte : TH3 5byte : TH4 6byte : TH5 7byte : TH6 8byte : TH7 9byte : TH8 10byte : TH9 11byte : TH10 12byte : TH11 13byte : TH12 14byte : TH13 15byte : TH14 16byte : TH15 17byte : TH16	16-1. Refer to the thresholds
11	GET_MES_T	NG	0x15	Get the temperature sensor value	2byte	1 byte : temperature(High byte) 2 byte : temperature (Low byte)	

*1. Usable commands are shown “Pass”, unusable commands are shown as “NG” in Sensor Trigger mode.

*2. These are not usable when Sensor Trigger mode pedometer solely is operating.

15-2. Write Command

No	command	*1.	code	function	Write data size	Write data	
1	REQ_MES	NG	0x55	Make requirement for the measurements	0byte	—	Please refer to 14-2 Measurement Sequence
2	SET_PWR_DOWN	NG	0x57	Transfer to Power Down mode	2byte	2byte : dummy data	set value power down "pd" power down
3	SET_SUSPEND	NG	0x75	Transfer to Suspend mode	2byte	2byte : dummy data	set value Suspend "sp" Suspend
4	SET_COSR	NG	0x5b	Set offset coarse (used in offset adjustment)	6byte	1byte : CH 1 offset coarse 2byte : CH 2 offset coarse 3byte : CH 3 offset coarse 4byte : CH 4 offset coarse 5byte : CH 5 offset coarse 6byte : CH 6 offset coarse	Parameter range:0-7
5	SET_FINR	NG	0x5c	Set offset coarse (used in offset adjustment)	6byte	1byte : CH 1 offset fine 2byte : CH 2 offset fine 3byte : CH 3 offset fine 4byte : CH 4 offset fine 5byte : CH 5 offset fine 6byte : CH 6 offset fine	Parameter range:12-51
6	SET_INDEX_DAT	NG	0x63	Set index of data_buf	1byte	index of 1byte : data_buf	Parameter range:0-4 Please refer to 14-3. Read-In Procedure of Origin and Sensitivity
7	SET_AEN	NG	0x74	Set Enable/Disable of accelerometers	1byte	1byte : 1: Enable 0: Disable	
8	SET_MES_6CH_AUTO_START	Pass	0x64	Start 6CH sensor triggered measurement	3byte	1byte : measurement cycle nubmer 0:20ms, 1:40ms, 2:60ms 3:80ms, 4:100ms 2-3byte : dummy data	dummy data set value start "st" start Switch accelerometer's Enable/Disable in AMI602
9	SET_MES_6CH_AUTO_STOP	Pass	0x65	Stop 6CH sensor triggered measurement	2byte	2byte : dummy data	dummy data set value end "ed" end
10	SET_MES_PED_AUTO_START	Pass	0x77	Start pedometer	2byte	2byte : dummy data	dummy data set value start "st" start Switch accelerometer's Enable/Disable in AMI602. Step number in pedometer is cleared。
11	SET_MES_PED_AUTO_STOP	Pass	0x78	Stop pedometer	2byte	2byte : dummy data	dummy data set value end "ed" end Step number in pedometer is cleared
12	CLR_PED_SUSPEND	Pass	0x79	Clear the step number of pedometer is	0byte	-	-
13	CHG_MES_AVG	NG	0x80	Change the number of measurement averaging	1byte	1bytes : Measurement averaging number	set value Average number of the measurement 0x00 4 times (default) 0x01 16times
14	SET_GAIN	NG	0x61	Set gain (used in gain adjustment)	6byte	1byte : CH 1 gain 2byte : CH 2 gain 3byte : CH 3 gain 4byte : CH 4 gain 5byte : CH 5 gain 6byte : CH 6 gain	Parameter range:0-63
15	SET_PED_TH	NG	0x83	Set thresholds of pedometer	16byte	1byte : TH0 2byte : TH1 3byte : TH2 4byte : TH3 5byte : TH4 6byte : TH5 7byte : TH6 8byte : TH7 9byte : TH8 10byte : TH9 11byte : TH10 12byte : TH11 13byte : TH12 14byte : TH13 15byte : TH14 16byte : TH15 17byte : TH16	16-1. Please refer to the thresholds

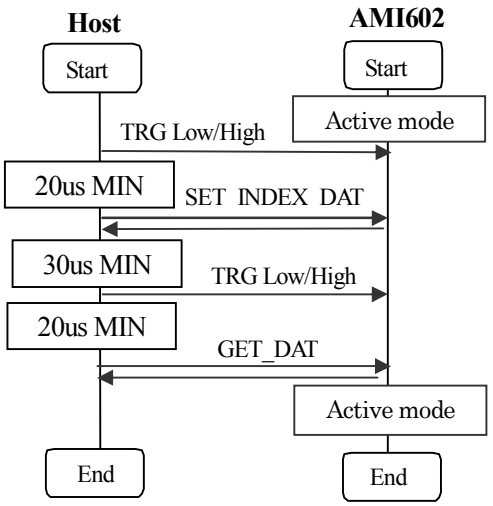
*1. In Sensor Trigger mode, usable commands are shown "Pass", unusable commands are shown as "NG"

15-3. Read-In Procedure of Origin and Sensitivity

Origin, sensitivity, etc are stored in the ROM of AMI602. Below the Read-In Procedure of Origin and Sensitivity is shown:

Step1 : Set which values (origin/sensitivity, etc) are read.

Step2 : Read in the values



Below a summary chart of the data read by GET_DAT is shown.

Table for the data list read by GET_DAT

Item number	Index set by SET_INDEX_DAT	Read-in data in response to GET_DAT					
		Byte1	Byte2	Byte3	Byte4	Byte5	Byte6
1	0	CH1 : Origin		CH2 : Origin		CH3 : Origin	
		High byte	Low byte	High byte	Low byte	High byte	Low byte
2	1	CH4 : Origin		CH5 : Origin		CH6 : Origin	
		High byte	Low byte	High byte	Low byte	High byte	Low byte
3	2	CH1 : Sensitivity of Magnetometer		CH 2 : Sensitivity of Magnetometer		Reserved	
		High byte	Low byte	High byte	Low byte	High byte	Low byte
4	3	Reserved		Reserved		CH6 : Sensitivity of Magnetometer	
		High byte	Low byte	High byte	Low byte	High byte	Low byte
5	4	CH3 : Sensitivity of Accelerometer		CH4 : Sensitivity of Accelerometer		CH5 : Sensitivity of Accelerometer	
		High byte	Low byte	High byte	Low byte	High byte	Low byte
6	30	CH1 : AD output change corresponding to 1 offset fine change		CH2 : AD output change corresponding to 1 offset fine change		CH6 : AD output change corresponding to 1 offset fine change	
		High byte	Low byte	High byte	Low byte	High byte	Low byte
7	9	Serial number		Reserved		Reserved	
		High byte	Low byte	High byte	Low byte	High byte	Low byte

Note) The standard physical quantity of magnetic sensitivity is 1gauss, the standard physical quantity for acceleration sensitivity is 2g.

[16] Pedometer

16-1. Threshold Values

Symbol	Threshold	Description	Initial value	Recommended value	Unit for 1LSB	Setting Range (*3)
TH0	Judging time for "Stop" to "Walking Check"	Sampling period at stop. Judging time of transfer from Stop to Walking Check (*5)	50 (2 sec)	50	40 ms	1 to 50
TH1	Acceleration from "Stop" to "Walking Check"	Threshold value of acceleration to judge the transfer from Stop to Walking Check.	20	50	1 mg	1 to 255
TH2	Judging time for "Waking Check " to "Stop"	One judging time of transfer from Walking Check to Stop	25 (1 sec)	25	40 ms	2 to 255
TH3	Judging number of "Walking Check" to "Stop"	Judging number of acceleration difference within the time TH2 compared with the threshold TH4. If this number is within consecutively the preset number, the status is judged to be Stop	3	3	1 time	1 to 255
TH4	Acceleration from "Walking Check" to "Stop"	Threshold value of acceleration to judge the transfer from Walking Check t o Stop.	20	50	1 mg	1 to 255
TH5	Stepping threshold 1	Acceleration change of stepping (dynamic acceleration) Threshold value for upward movement (*1)	80	30	1 mg	1 to 255 (*4)
TH6	Stepping threshold 2	Acceleration change of stepping (dynamic acceleration) Threshold value for downward movement (*1)	80	15	1 mg	1 to 255 (*4)
TH7	Stepping threshold 3	Minimum time duration for stepping (*2)	5 (200 ms)	5	40 ms	1 to 255
TH8	Judging time for "Walking Stop"	In Walking, if no stepping is observed in certain time, transfer to the Walking Check.	50 (2 sec)	50	40 ms	1 to 255
TH9	Digital filter setting 1	Digital filter constant for first degree IIR	4	4	coefficient	1 to 255
TH10	Digital filter setting 2	Digital filter constant for second degree IIR (*6)	9	9	coefficient	1 to 255
TH11	Digital filter setting 3	Digital filter constant for vertical axis judgment	100	50	coefficient	1 to 255
TH12	Amplitude number of acceleration change	Amplitude number of acceleration change in 5 steps.	1 回	15	15 (15 times)	1 to 255
TH13	Walking period setting 1	Minimum time of 2-step cycle to detect 2-step walking period in 6-step judgment	10 (400ms)	15	40 ms	1 to 255
TH14	Walking period setting 2	Maximum time of 2-step cycle to detect 2-step walking period in 6-step judgment (*7)	30 (1200ms)	50	40 ms	1 to 255
TH15	Walking period setting 3	2-step walking period error in 6-step judgment to detect 2-step walking period	13 (520ms)	18	40 ms	1 to 255
TH16	Walking period setting 4	2-step walking period interval check number to to detect 2-step walking period in 6-step judgment	3 (3 times)	3	1 time	1 to 4

(*1) Step is accepted when both upward and downward movements are above each threshold

(*2) Within in this interval after the first step, even if the acceleration change larger than TH5 or TH6 is observed, it is not considered to a step.

(*3) Correct pedometer operation will not be assured when the parameters out of the setting range is set.

(*4) The value should be larger than "TH1" or "TH4".

(*5) "6CH data" + "pedometer" operates 40 msec only

(*6) "TH10" should be bigger than "TH9".

(*7) "TH14" should be bigger than "TH13"

16-2. Pedometer Managing Status

Status	Description
Stop	Small acceleration which can not be attributed to walking
Walking Check	Acceleration exist, checking walking or not
Walking	Walking (including running). Steps are counted by the pedometer in this status. Walking time is defined as the time in this Walking status.

16-3. Status Transfer Conditions

Status Transfer	Transfer Conditions
Stop to Walking Check	3-axis accelerometer data at present moment and 2 seconds (**TH0**) before are compared, and found that the difference exceeds **TH1**.
Walking Check to Stop	3-axis accelerometer data never exceeded **TH4** within 3 seconds (**TH3**) at 40ms sampling.
Walking Check to Walking	Step (**TH5, TH6, TH7**) is observed regularly for 6 steps. If the status transferred from Walking Check to Walking, 6 steps are added to the step number and the time for the 6 steps is added to walking time.
Walking to Walking Check	No step was observed for 2000ms (**TH8**).The sensor attitude is significantly changed (the gravity axis are changed).

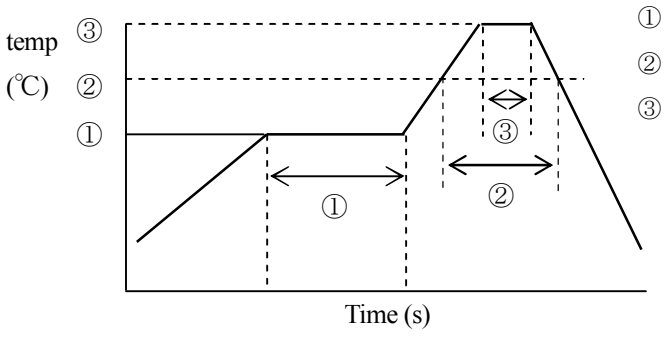
[17] Environmental and Mechanical Characteristics

Test Item	Test Method	Preparation *	Evaluated Characteristics	n(C=0) [LTPD]
Vibration	10～500Hz、100m/s^2	—	Electric, Mechanical Characteristics	11[20%]
Mechanical Shock	20,000m/s^2、±X,Y,Z each 3 times	—	Electric, Mechanical Characteristics	11[20%]
Free Fall Test	170cm、±X,Y,Z each 1 time in succession.	—	Electric, Mechanical Characteristics	11[20%]
Repeated Fall Test	5～30cm、±X,Y,Z each 10 times in succession.	—	Electric, Mechanical Characteristics	11[20%]
Solderability	+235±5℃、2±0.2sec、25±2.5mm/s	(2)	Wetability	22[10%]
Solder Heat Resistance	Infrared reflow (See Fig.1), 2 times.	—	Electric Characteristics	22[10%]
High Temperature Storage	+125±2℃、1,000h	—	Electric Characteristics	22[10%]
Low Temperature Storage	-40±3℃、1,000h	—	Electric Characteristics	22[10%]
Temperature Humidity Storage	+45±2℃、90±5%RH、100h	(1)	Electric Characteristics	22[10%]
Temperature Humidity Cycling Test	(-20～+60) ±2℃×(90～95%)RH、6h、40 cycles	—	Electric Characteristics	22[10%]
High Temperature Operation	+125±2℃、+3.6V、1,000h	(1)	Electric Characteristics	22[10%]
High Temp/Humidity Bias	+45±2℃、90±5%RH、+3.6V、100h	—	Electric Characteristics	22[10%]
ESD Sensitivity (Human Body Model)	100pF、1.5kΩ、±1,000V、3 times	—	Electric Characteristics	11[20%]
ESD Sensitivity (Machine Model)	200pF、0Ω、±200V、5 times	—	Electric Characteristics	11[20%]
Latch Up Strength (changed by capacitor)	200pF、0Ω、±100V、3 times	—	Electric Characteristics	11[20%]
Circuit Board Flex	Support Span 90mm、Flex 3mm、5±1sec hold	—	Electric Characteristics	22[10%]
Sensor Body Strength	φ4.0mm pressure jig, 10N、10±1sec hold	—	Mechanical Characteristics	22[10%]

* [Preparation]

(1) Reflow condition: Fig. 1

(2) Water vapor aging: 4H



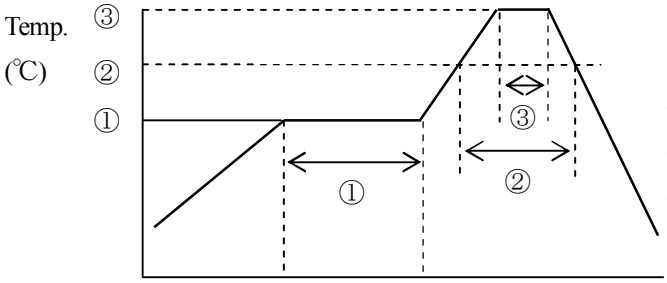
① Pre-heat : (+180～+200℃) × (less than 120sec.)

② +220℃ band with : more than 50sec.

③ Soldering : +250℃ peak (240℃ less than 10sec.)

Fig 1 . IR Reflow Heat Condition

[18] Reflow Soldering Conditions



① Pre-heat：(+150～+190℃) × (90±30 sec)
② +220℃ band widht：20～50 sec
③ Soldering：+235～+250℃ peak (less than 10sec)
④ Heating atomosphere：air or N_2
⑤ Number of Reflow times：2

Fig.2 Reflow soldering condition

For repair, + 250～+270℃×30 sec or less, heating time 150 or less (including 70 sec pre-heat)
If the device contains moisture, bake the device before repair.

[19] Notes

1) This device uses a C-MOS IC. Please take precautions to prevent damage due to electrical static discharge.
2) Memory data in OTP is not rewritable.
3) In order to obtain stable operation we recommend placing a ceramic capacitor (capacity more than 1.0 μF) between VDD and VSS and a ceramic capacitor (capacity more than 0.1μF) between VID and VSS.
4) The writing pattern to VDD and VSS should be as wide as possible in order to reduce high frequency impedance.
5) Storage Method (moisture-proof and packed condition)
   a) Please do not leave the device in the following environments:
   * High temperature and high humidity
   * Places with direct sun light
   * Places with extreme temperature changes
   * Dusty places
   * In corrosive gas
   b) Recommended storage temperature and humidity:
   * +5℃～+30℃, below 70%RH, please use device within one year.
   (If the device does not used over one year, the specification may not be satisfied.)
6) Usage after Opening the Moisture Proofed Packaging
   a) Please apply devices within 7days under the condition of +5℃～+30℃、below 70%RH.
   The storage in the moisture-proof room (+5℃～+30℃、below 30%RH) is recomended.
   b) When the devices storage in the moisture- proof room (+30℃、below10%RH), please apply them within 1 year.
   c) Over 7days after opening the package with a) condition above, please apply baking according to the following conditions.

   ＜Baking Conditions＞
   i) +60℃×168Hr or +40℃×200Hr by taping condition
   ii) +125℃×24Hr by heat resistant tray
   iii) Maximum 2 times for baking
   ※ It is recommended to wear out after opening package for the first time.
7) If the component is dropped from a height greater than 5 cm or directly impacted by a hard object during assembly, it should be discarded and not used.