

RECIPIENT

SPECIFICATIONS

Product No. : X2A000161000200

MODEL : XV4001BD

SPEC. No. :

DATE: Jan. 19. 2015

SEIKO EPSON CORPORATION

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- ① This delivery specification document is applied to the gyrosensor “XV4001BD” used for car navigation systems.
- ② This product corresponds to "RoHS Directive".
- ③ This Product supplied (and any technical information furnished, if any) by SEIKO EPSON Corporation shall not be used for the development and manufacture of weapon of mass destruction or for other military purposes. Making available such products and technology to any third party who may use such products or technologies for the said purposes are also prohibited.
- ④ The products listed here are designed as components or parts for electronics equipment in general consumer use. We do not expect that any of these products would be incorporated or otherwise used as a component or part for the equipment which requires an extra high reliability, such as satellite, rocket and other space systems, and medical equipment, the functional purpose of which is to keep life.

II. Model type

XV4001BD

III. Packaging method

Packaging method follows our packaging standard.

IV. Gratuitous warranty period

We'll replace the products for free if defective products due to our failure are found within a year from the purchase date.

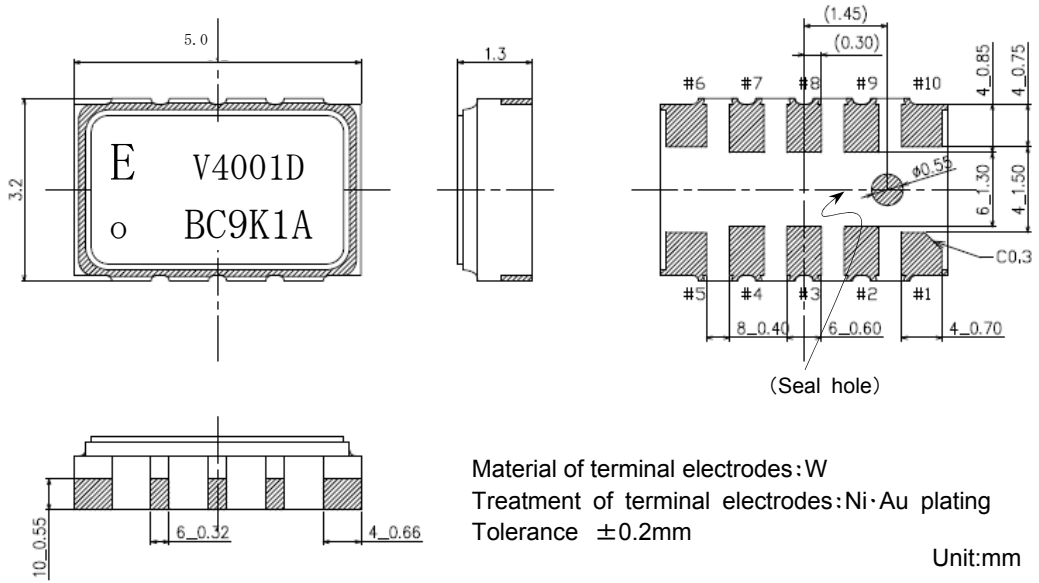
V. Revision and abolition of specification

Revision and abolition of this specification are supposed to be done based on the agreement between your company and SEIKO EPSON Corporation.

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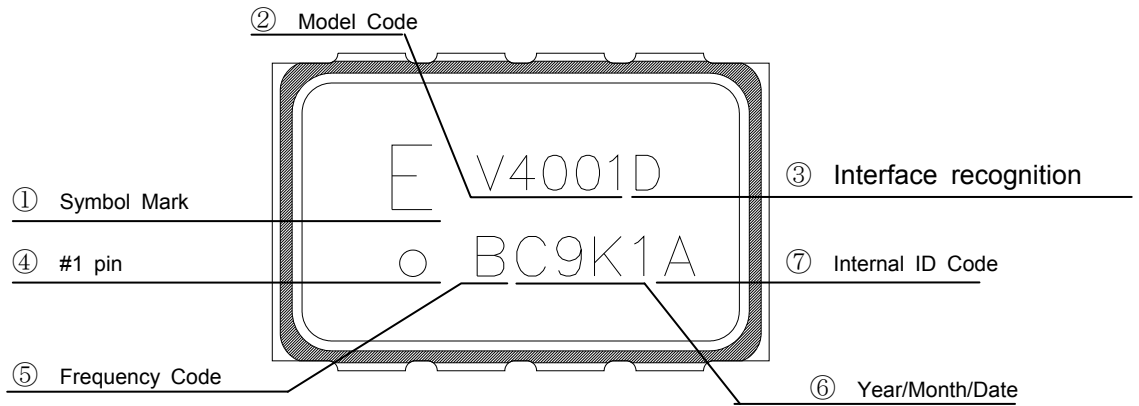
1. Outline dimensions and Materials of terminal electrodes



2. Functions of terminals

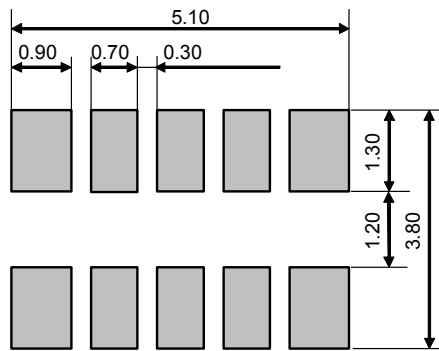
Pin No. XV4001B*	I/O	Function
1	Reserved	Do not use this pin
2	SCLK	Clock input
3	SS	Chip select
4	VDD	Power supply
5	Reserved	Do not use this pin
6	Reserved	Do not use this pin
7	GND	GND terminal
8	MOSI	Command input
9	MISO	SPI: Data output
10	Reserved	Do not use this pin

3. Marking illustration



4. Soldering pattern

A solder pattern example is shown as below. For your actual design, please optimize the pattern to meet your design considerations such as mounting density, soldering reliability, ease of mounting, etc. Please mount the device so that solder doesn't adhere to any portion of the seal hole (package underside)



Unit : mm

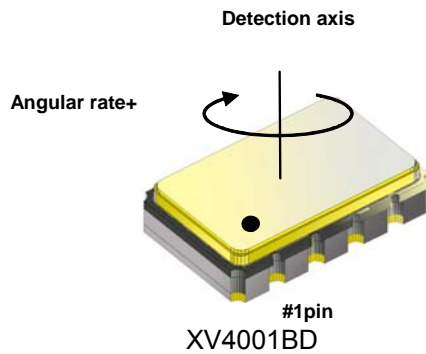
5. Functions

5-1) Detected signal and detection direction

The gyro sensor detect angular rate of rotation.

We show the relation for detection direction and detection polarity on angular rate as follows.

The gyro sensor output angular rate data in 16bit (complement form of 2)



5-2) Serial Interface

The gyro sensor support SPI (4wires, 3wires)

The part is inserted the function of detecting communication error.

Command code error flag output

Check Sum

5-3) Self test function

The gyro sensor is inserted self test function. The implemented self test result is transmitted with communication response (DIAG)

5-4) Temperature sensor

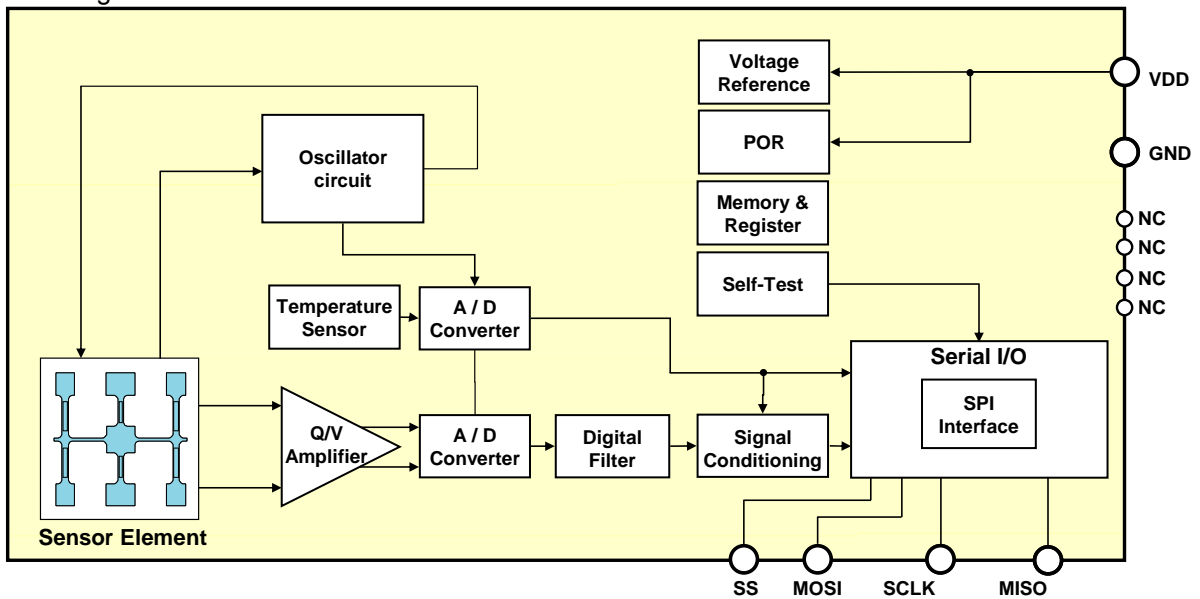
The gyro sensor is inserted temperature sensor. Temperature data is outputted with 11bit, complement form of 2

5-5) Power On Reset

The gyro sensor is inserted the Power On Reset (hereinafter referred to as POR) circuit.

POR signal needed for resetting logic circuit at start-up of voltage is outputted.

6. Block diagram



7. Electrical characteristics

7-1) Absolute maximum rating

Parameter	unit	Standard			condition
		Min.	Typ.	Max.	
Supply voltage VDD	V	-0.3		4.0	VSS=GND=0V
Input voltage	V	-0.3		VDD+0.3	VSS=GND=0V
Storage temperature	°C	-50		+105	

If the value exceed absolute maximum rating for even a moment, it may be the root of degradation, break and eventually product lifetime become shorter.
Please use within absolute maximum rating

7-2) Recommended operating conditions

Parameter	unit	Standard			condition
		Min.	Typ.	Max.	
Supply voltage VDD ^{*1}	V	3.0	3.3	3.6	VSS=GND=0V
Operating temperature	°C	-40		+85	Operation only
Extended operating temperature ²	°C	+85		+95	
Voltage start-up time	ms	0.2		100	VDD 0%→90%
Clock frequency for SPI communication ^{*3}	MHz	0.08		10	
Clock frequency for I ² C communication ^{*3}	kHz	80		400	
Refresh rate of angular rate data ^{*4}	Hz		100	300	
Temperature data update rate	Hz			10	

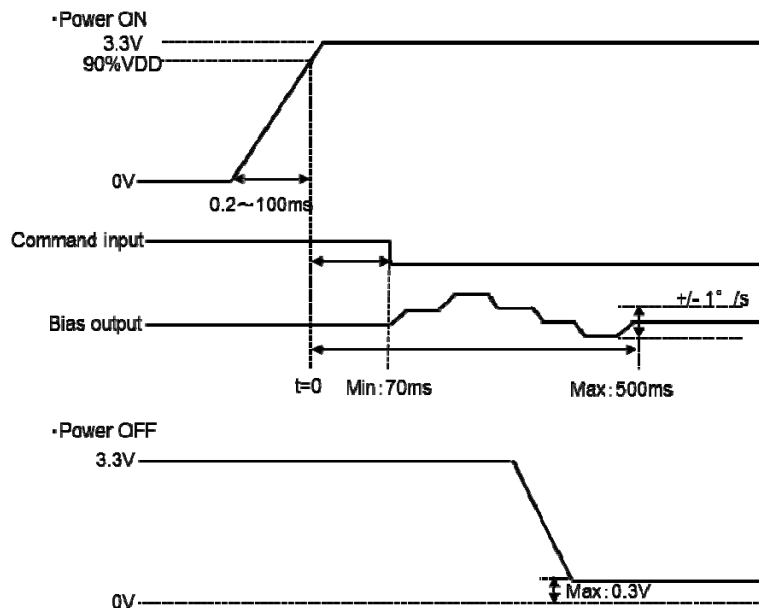
*1. Analog power supply and Digital power supply are in common.

*2. If you use the communication clock of multiple of drive frequency, the angler rate output may be shifted.

*3. We recommend acquiring angular rate output at less than 100 Hz.

If you use our part exceeding our recommended operating condition (even if the value does not exceed absolute maximum rating), the characteristic may be out of specification and the reliability be degraded.
Therefore please take your operating condition carefully.

7-3) Operating sequence



<Notice>

The gyro sensor is inserted POR circuit.

Please use the part in the voltage start up time of 0.2ms~100ms to avoid the operation error of POR circuit.

Please input the communication command taking more than 70ms after inputting voltage

As the operation error may occur with voltage input from the middle electrical potential, please set the electrical potential of voltage shutdown in lower than 0.3V

7-4) DC Characteristics

VDD = 3.0~3.6V , VSS = GND = 0V , Ta = -40~+85 °C

Parameter	unit	Standard			condition
		Min.	Typ.	Max.	
Logic input voltage Hi level	V	VDD*0.7			
Logic input voltage Low level	V			VDD*0.3	
Logic output voltage Hi level (Communication terminal)	V	VDD*0.7			Load current 4mA
Logic output voltage Low level (Communication terminal)	V			VDD*0.3	Load current 4mA

7-5) Characteristics

(If you do not specify, the below values are at VDD = 3.0~3.6V , VSS = GND = 0V , Ta = -40~+85 °C)

Parameter	unit	Standard			condition
		Min.	Typ.	Max.	
Drive frequency	kHz	49.0	50.3	51.6	
Detuned frequency	Hz	500	800	1100	
Scale factor	LSB/(°/s)		370		
Scale factor tolerance	%	-1.5		+1.5	Ta=+25 °C
Scale factor variation with temp.	%	-2.5		+2.5	Ta=+25 °C reference
Bias	LSB		0		Ta=+25 °C
Bias tolerance	°/s	-2.0		+2.0	Ta=+25 °C Without aging
Bias variation with temp.	°/s	-3.0		+3.0	Ta=+25 °C reference
Bias stability 1	°/s	-0.6		+0.6	1s~5min after start-up Bias at 1s reference
Bias stability 2	°/s	-0.4		+0.4	5min~15min after start-up Bias at 5min reference
Bias drift gradient	°/s/(7.5°C)	-0.8		+0.8	-40°C→+85°C Temperature change is only rise direction. Calculate at 7.5°C step
Rate range 1	°/s	-70		+70	Guaranteeing Non linearity
Non linearity	%FS	-0.5		+0.5	Ta=25°C -60°/s to +60°/s FS=±70°/s
Frequency characteristic	Hz	9	10	11	LPF Gain -3dB bandwidth
Cross axis sensitivity	%	-5		+5	Ta=+25 °C -60°/s to +60°/s
Start up time	ms			500	
Current consumption	mA		3.5	4.0	not rotation and not

				communicating
Output noise	°/s RMS		0.05	VDD=3.3V Ta=+25 °C Calculated value from the data in 500 measuring points on communication rate of 100sps

7-5) Temperature sensor

VDD = 3.0~3.6V , VSS = GND = 0V , Ta = -40~+85 °C

Parameter	unit	Standard			condition
		Min.	Typ.	Max.	
Output code	LSB	-25	0	+25	Ta=+25 °C
Temperature output accuracy	°C	-5		5	
Temperature coefficient	LSB/°C	4.9	5.1	5.5	

8. Serial Interface

Serial I/F can be selected from 4-wire SPI, 3-wire SPI.

The function and terminal processing in Serial Interface terminal and each communication method are as below.

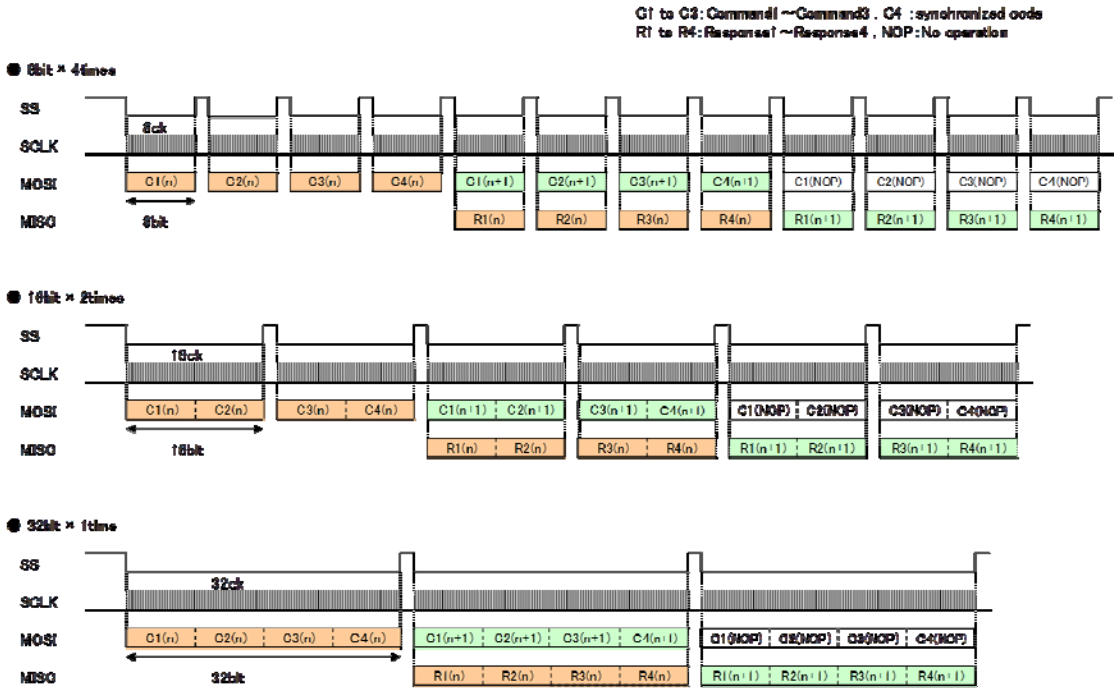


Pin name	4-Wire SPI	3-Wire SPI
SCLK	Clock input pin	Clock input pin
SS	Chip select input pin	Lo fixed
MISO	Data output pin	Data output pin
MOSI	Data Input pin.	Data Input pin.

8-1) 4-Wire SPI

8-1-1) Correspondence frame

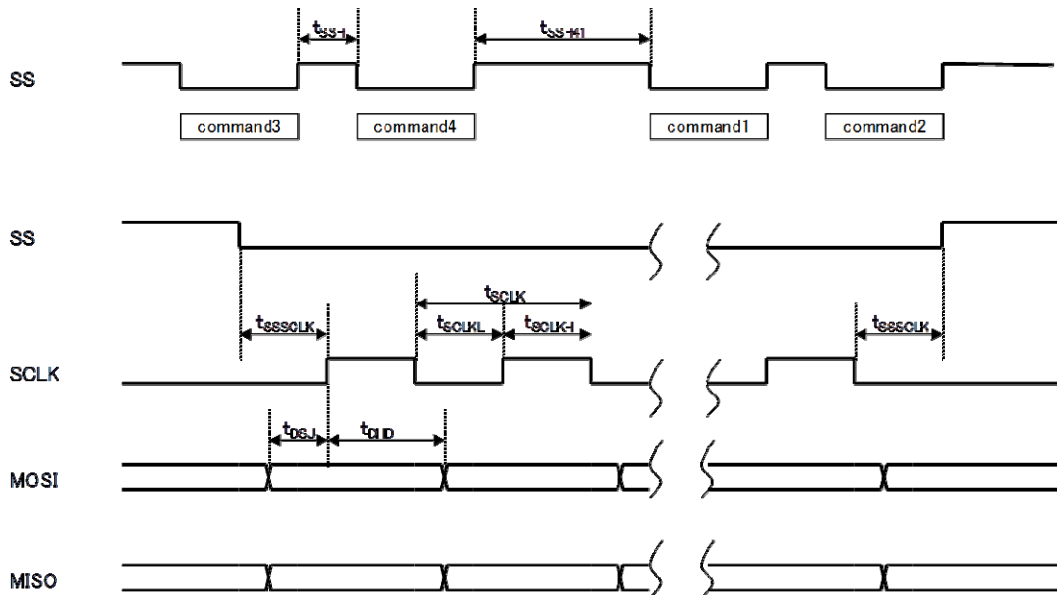
SPI communication command/response is separated by 32bit and can select 8bit X4, 16bit X 2 or 32bit X1. Each command/response frames are as below;



SS=L area becomes effective. Please do not input the clock and data when SS=H area.

8-1-2) Timing Chart

According to following condition Max. 10MHz SPI I/F is available.



symbol	Item	Standard			Unit
		Min.	Typ.	Max.	
tSSH	SS H width(command-command)	100			ns
tSSH41	SS H width(command4-command1)	25			us
tSSSCLK	SCLK before and after SS edge:(between L)	45			ns
tSCLKH	SCLK H width	45			ns
tSCLKL	SCLK L width	45			ns
tSCLK	SCLK cycle	100			ns
tDSU	Input data setup time	25			ns
tDHD	Input data hold time	25			ns

8-1-3) Command/response list

Command /response list is as below. Command4 is stable by synchronous discernment code.
Command parameter as below (8-1-4)

Parameter	Command1 (bit31~bit24)	Command2 (bit23~bit16)	Command3 (bit15~bit8)	Command4 (bit7~bit0)
Output angular rate	(48)h	(26)h	(53)h	(58)h
Temperature sensor output	(50)h	(2A)h	(17)h	
Software reset start 1	(1C)h	(4E)h	(67)h	
Software reset start 2	(5C)h	(6E)h	(77)h	
Software reset cancel	(04)h	(42)h	(23)h	
NOP(No Operation)	(30)h	(1A)h	(0F)h	

Parameter	Response1 (bit31~bit24)				Response2 (bit23~bit16)	Response3 (bit15~bit8)							Response4 (bit7~bit0)															
Output angular rate	CEF	DIAG	0	0	ARU	010010	CS4-0	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0					
Temperature sensor output								0	0	0	0	0	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0					
Software reset start 1								0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Software reset start 2								0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Software reset cancel								0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NOP(No Operation)								0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

CEF:Command error flag. Response "0" in normal case.

Response "1" if input command code is irregular (or wrong)

(Response "H" if synchronous discernment code(Command4) is irregular (or wrong)).

DIAG:Self-test result flag. Response "1" if found internal error.

When the DIAG flag is "1", please do not use the value of the angular rate and temperature sensor output because the value might be abnormal.

When the DIAG flag change into "0" from "1", please send a Software reset command.

ARU:Angular rate output renewal flag. Response "1" when rewrite angular rate data and response "0" after output the response for angular rate output command.

CS4-0:Check-Sum signal consist of 5bit. Check-Sum covers Response1 bit31-24, Response2 bit23-21, Response3 bit15-8 and Resonse4 bit7-0, total 27bits.

8-1-4) Command details

(1) Angular rate output

Output data are 2's complements. It becomes the 16bit output of mark bit +15bit.

(2) Temperature sensor output

Output data are 2's complements. It becomes the 11bit output of mark bit +10bit.

(3) Software reset

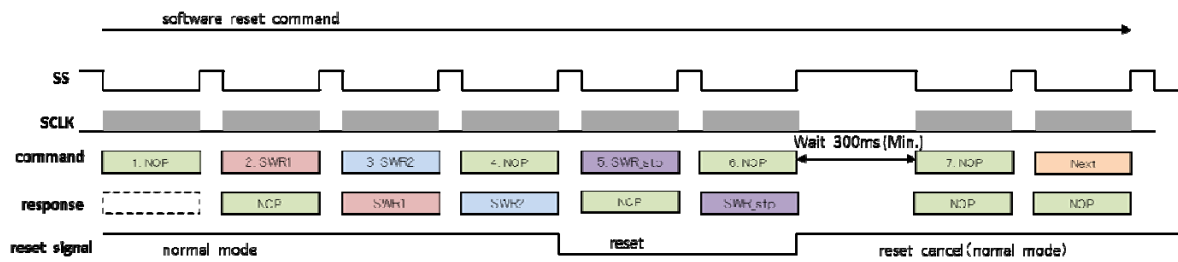
It reset a logic circuit by command.

The sequence of the reset is follows. Please send seven commands with the following turns.

1. "NOP"
2. "Software reset start1"
3. "Software reset start2"
4. "NOP"
5. "Software reset cancel"
6. "NOP" wait 300ms(Min.)
7. "NOP"

Waiting time of 300ms(Min.) is necessary between command 6 and command 7.

Timing chart is shown below.



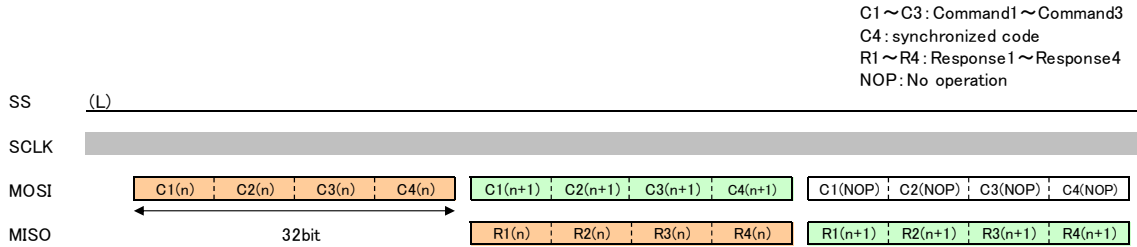
8-2) 3-Wire SPI

8-2-1) Correspondence frame

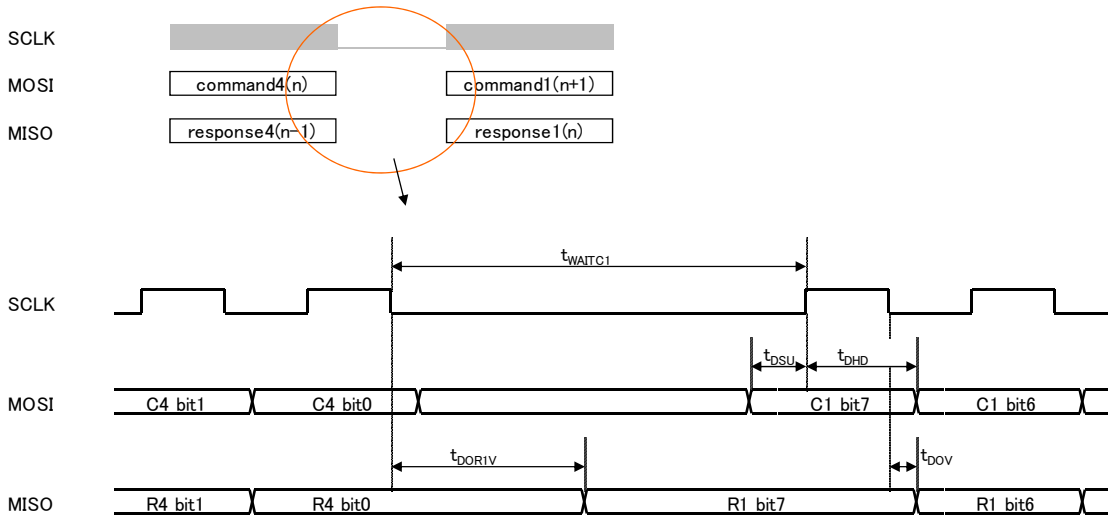
3-Wire SPI, please set SS in Low.

3-Wire SPI communication command/response is separated by 32bit only.

Command/response frames is as below;



8-2-2) Timing Chart



symbol	Item	Standard			Unit
		Min.	Typ.	Max.	
tSCLKH	SCLK H width	45			ns
tSCLKL	SCLK L width	45			ns
tSCLK	SCLK cycle	100			ns
tDSU	Input data setup time	25			ns
tDHD	Input data hold time	25			ns
tWAITC1	SCLK wait time(command4-command1)	25			us

8-2-3) Command/response list

The command/response is the same as 4-Wire SPI. Please refer to (8-1-3)

8-2-4) Command details

The command/response is the same as 4-Wire SPI. Please refer to (8-1-4)

9. Environmental characteristics and mechanical characteristics

9-1) Environmental characteristics and mechanical characteristics

(Our test conditions :We evaluate our parts on below items at below conditions)

No.	Item	Test condition
1	High temp. storage test	+105°C×1000h
2	Low temp. storage test	-55°C×1000h
3	High temp. bias test	+85°C×1000h×3.6V
4	High temp. high humidity bias test	+85°C×85%RH×3.6V
5	Heat cycle test	-50⇄+105°C 1000cyc
6	Pressure cooker test (PCT)	+121°C×96%RH×288h
7	Vibration	10-40Hz 1.5mm, 40-2000Hz 5G 20min/cyc×12cyc 3 direction
8	Electrostatic discharge (ESD)	HBM : 2kV MM : 200V
9	External Visual, Dimension	That words and numbers marking readable External dimension should be fulfilled.
10	Board Flex *1	Bend width reaches 2mm and hold for 60sec
11	Solderability *1	The dipping area of more than 95% should be covered with new solder.
12	Solder heatproof test	Air reflow (treatment : 3 times) IPC/JEDEC J-STD-020D.1

9-2) Stability standard for environmental characteristics and mechanical characteristics

Item	Condition	Standard			Unit
		Min.	Typ.	Max.	
Scale factor	VDD=3.3V, Ta=+25°C, Tolerance from initial value	-5		+5	%
Bias	VDD=3.3V, Ta=+25°C, Tolerance from initial value	-5		+5	°/s

<Notice>

9-2-1) Each standard value is the value that obtained by testing each item independently.

9-2-2) Measurement should be done after 2~24H-storage under normal temperature after completion of each test.

9-2-3) Standard measurement conditions for each measurement are as follows (JIS-C0010)

Normal temperature +25°C±10°C

Relative humidity 50%RH±25%RH

9-2-4) Pre processing (reflow 3 times) before the test must be conducted for tests No.1~7.

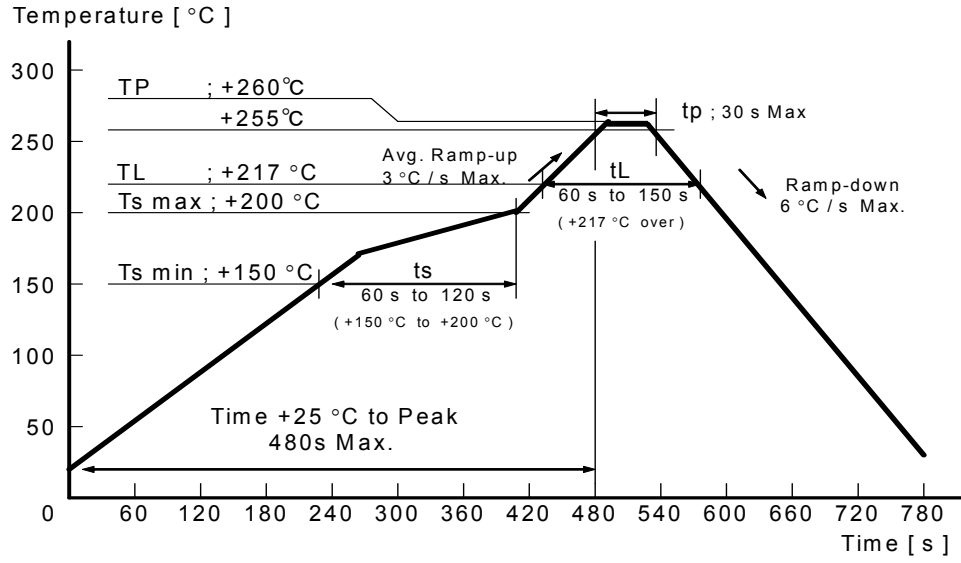
XV4001BD : Reflow 3 times

As we take 3times reflow, we measure the value after leaving 24hours at room temp.

We set the value as initial value.

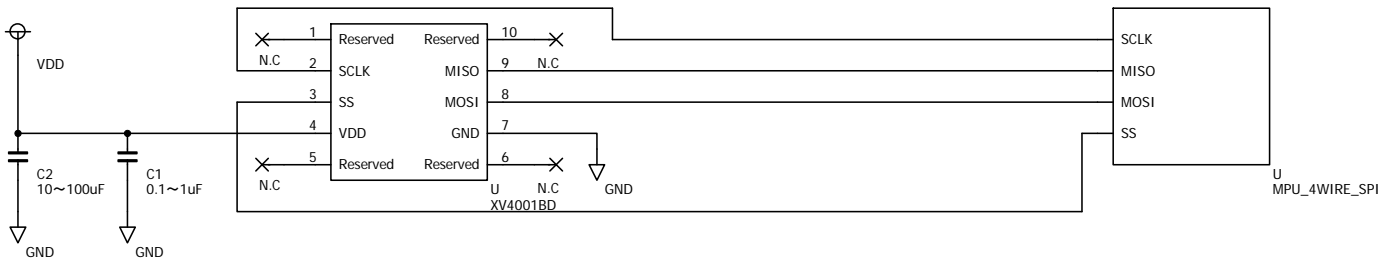
*1. We observe the condition on No.10,11 with appearance check after test.

9-2-6) Heating treatment conditions at reflow (JEDEC J-STD-020D)

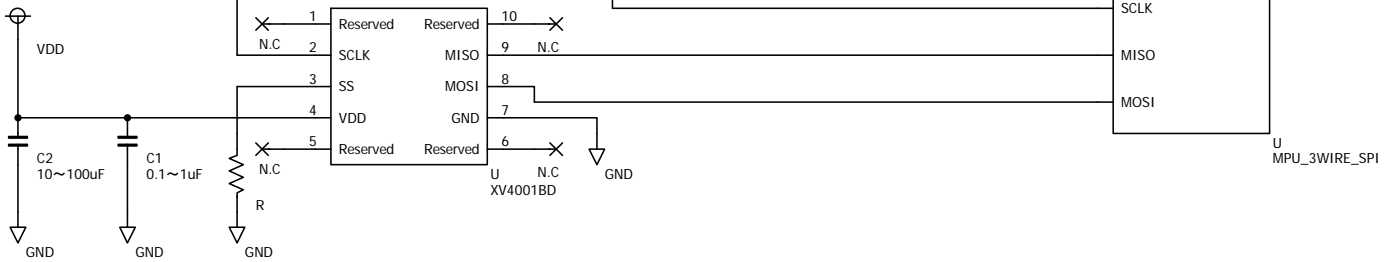


10. Reference circuit

ex. 4-Wire SPI



ex. 3-Wire SPI



•C1: This is bypass condenser.

We recommend putting the condenser (0.1 to 1μF) which is good characteristic at high frequency on the position as close as the sensor terminal

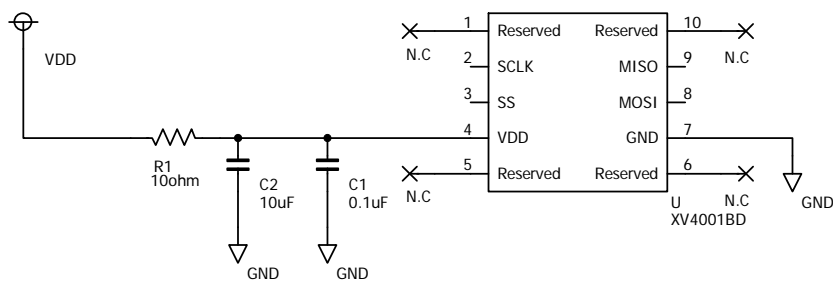
•C2: This is voltage backup condenser.

As the voltage backup condenser is not inserted inside the sensor, please surely insert condenser : C2
Please also put the condenser of around 10 to 100uF as backup condenser for VDD.

If you can not remove the noise on voltage line only with bypass condenser, we recommend making Low Pass Filter (referring to below) to avoid inputting noise in sensor voltage.

Please select the resistance value as the supply voltage will not be below 3.0V.

ex. Power Line Filter



Precaution for your design

- The detuned frequency is 800Hz±300Hz. Please make your board design to avoid putting the resonance frequency of the board in the detuned frequency. Please also put our part on fixed area of board which is less influence from vibration
- As you mount our part (vacuum-chucking, mechanical chucking, mounting on the circuit board), the excessive shock may make the characteristics of quartz products change or deteriorate. Therefore please set up the condition so that the shock becomes as small as possible. Please be sure to test in your site before use and confirm that there is no influence on the characteristics.
- The sensor element drive in 50.3kHz(Typ.) to detect the angular rate. If closer frequency to drive frequency and signal having frequency factor of high-order harmonic are inputted to the sensor, the angular rate signal output of sensor may be influenced. Please carefully consider the prevention for decoupling of voltage and the setting for communication frequency in serial interface
- Please do not draw other signal lines on near sensor and backside area of package to avoid the operation error with electromagnetic induction and electrostatic induction from other signal lines. Please also do not draw other signal lines in cross.
- Please check the vibration, shock, noise and take your prevention. If we can get your board design information, we give our advice for your design.

11. Handling precaution

★★ Crystal device is accurate instrument. Please pay attention to below issues ★★

1. This crystal product is designed in consideration of shock resistance. However it may be destroyed depending on the condition of dropping and impact.
If you mistakenly drop the part, do not use it because we can not guarantee the characteristic.
2. If you apply ultrasonic oscillation (ex.ultrasonic washing, Printed circuit board cutting) to our product, the crystal may be cause resonant destruction under some use conditions. Since we can not specify your use conditions (type of washing machine · Power · Time · position of machine), we can not guarantee the operation of our product after you apply ultrasonic oscillation. If you have no choice but to apply it, please be sure to examine and set up the conditions beforehand.
3. We guarantee the sensor itself with this specification. Please surely implement the mounting test at your side before using our part to confirm no influence to the characteristic. Please also confirm it when the condition is changed.
Be careful not to collide the gyrosensor with the machinery or with other circuit board when/after mounting.
4. Anti-static protection circuit is contained in this product. However, when the excessive static electricity is charged, IC may break. So please use conductive ones for packing and carrying containers. And use the soldering iron and the measurement instrument that don't have high-voltage leakage and take anti-static measures such as grounding when handling.
5. The limitation of your reflow is up to 3 times. If you find the soldering fail, please fix them with soldering iron. In the case, please use the iron with lower temperature than +350°C and within 3 seconds (You should not use blower) .
6. We recommend our land size when you make the circuit board.
7. This product has a noise which frequency is same as that of drive frequency. It's necessary to remove it by proper filter circuit.
8. This sensor is designed not to interfere easily even if you operate several sensors closely. However, in some cases, the sensors may interfere by vibration of circuit board or common impedance of power supply. Please check them before use at your side.
9. This sensor is inserted POR circuit. Please use the part in the voltage start up time of 0.2ms~100ms to avoid the operation error of POR circuit. As the operation error may occur with voltage input from the middle electrical potential, please set the electrical potential of voltage shutdown in lower than 0.3 V
10. Please do not use the part under the condition which may occur short between terminals with dewfall etc.

P A C K I N G S P E C I F I C A T I O N

TAPING REEL SPEC.

Spec. Ceramic Package 5 x 3.2 Size
Gyro Sensor

Establishment Jan. 19. 2015

TAPING SPECIFICATION

I . Application

This document is applicable to Ceramic package 5 x 3.2 size.

II . Contents

Item No.	Item	Page
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[7]	Storage time limit	
[8]	Handling	

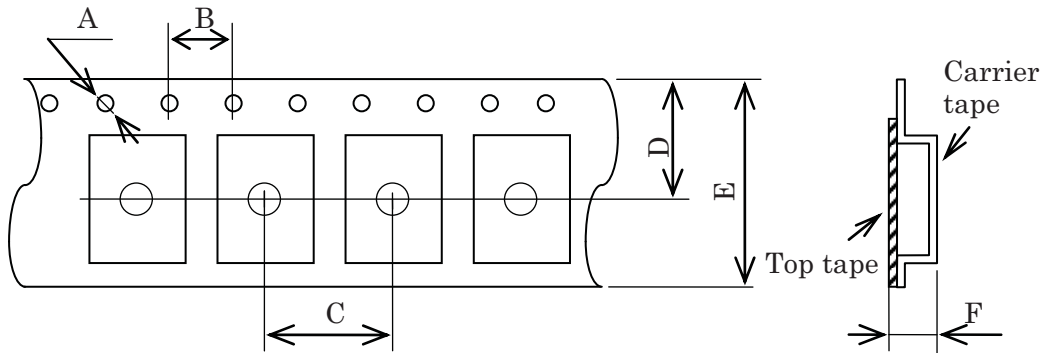
【 1 】 Taping specification

Subject to EIA-481-1A & EIAJ RC-1009B.

(1) Tape dimensions

Material of the carrier tape : Black conductive PS

Material of the top tape : PET (Antistatic)

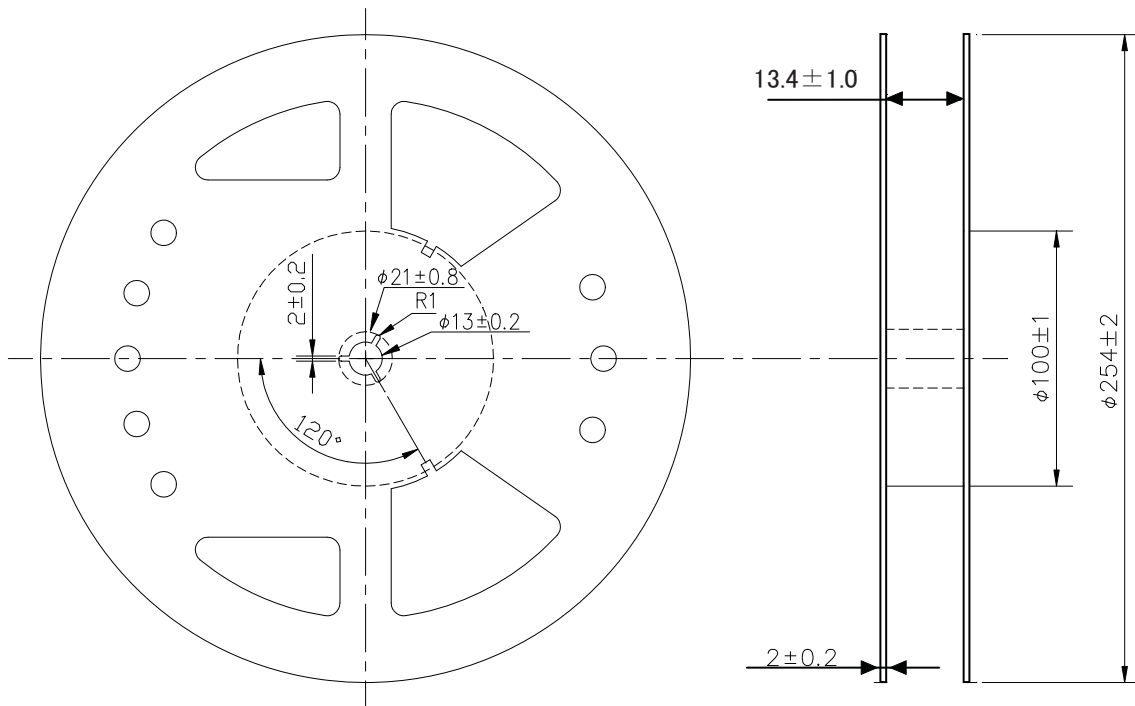


Symbol	A	B	C	D	E	F
Value	$\phi 1.5$	4.0	8.0	7.25	12.0	2.1

Unit : mm

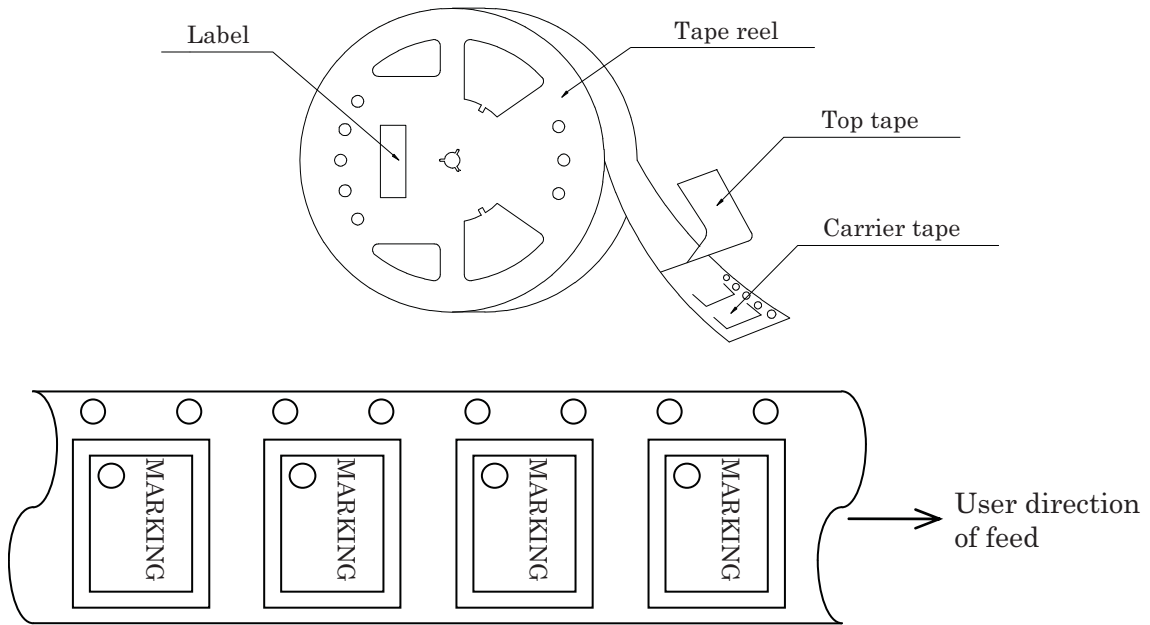
(2) Reel dimensions

Material of the reel : Black conductive PS

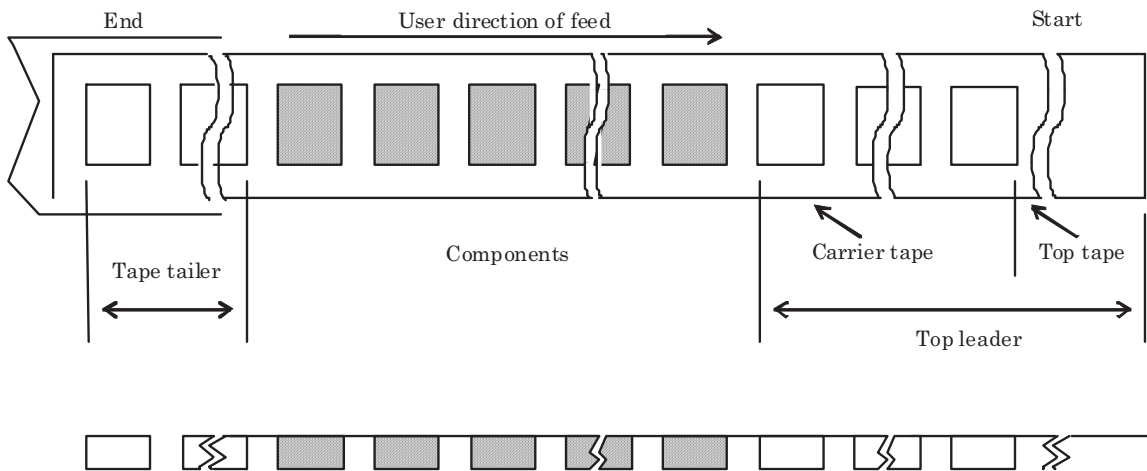


(3) Packing

1) Tape & reel Tape type : L



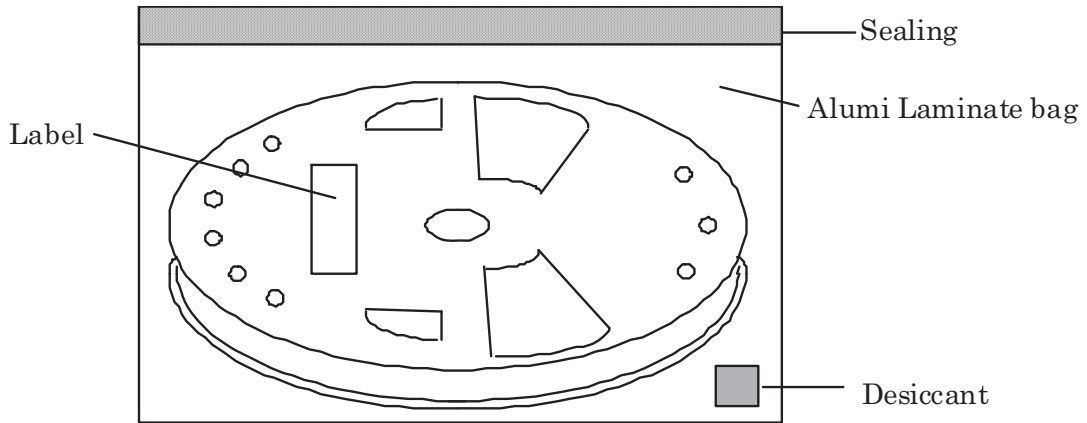
2) Start & end point



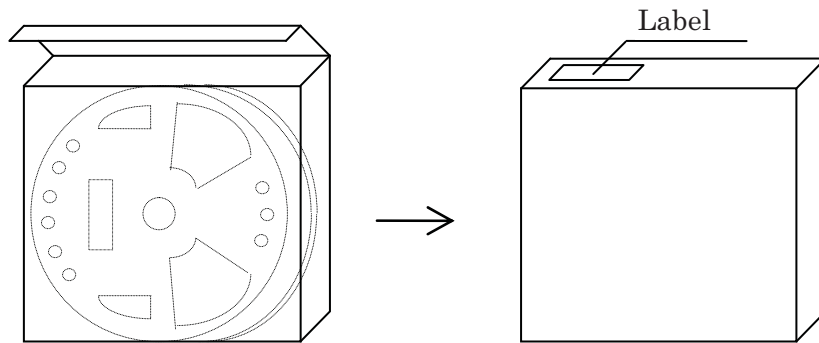
Item		Empty pocket
Tape leader	Top tape	Min. 1000 mm
	Carrier tape	Min. 160 mm (Min. 20 pockets)
Tape tailer	Top tape	Min. 0 mm
	Carrier tape	Min. 160 mm (Min. 20pockets)

【 2 】 Inner carton

a) Packing to antistatic bag

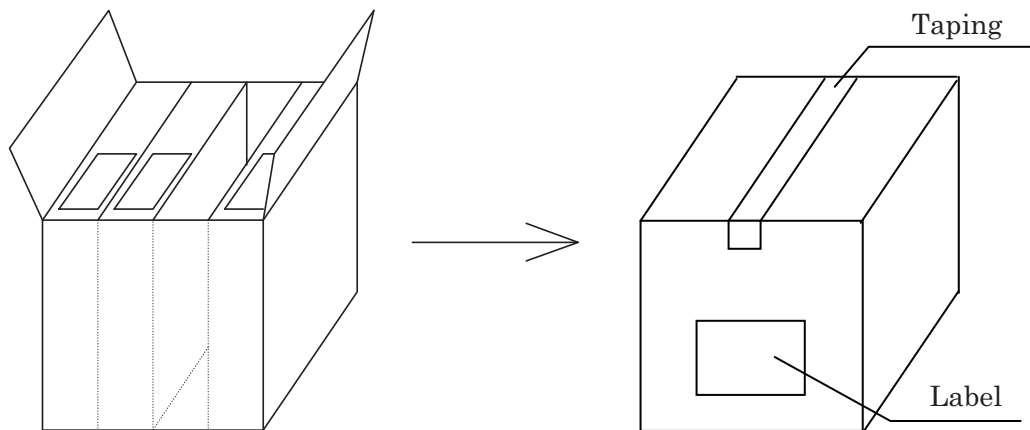


b) Packing to inner carton



【 3 】 Shipping carton

Packing inner carton into outer carton (Max. 6 reel)
Fill a cavity with a buffer material



【 4 】 Marking

- (1) Reel marking
 - Reel marking shall consist of :
 - 1) Parts name
 - 2) Frequency
 - 3) Lot No.
 - 4) Quantity
 - 5) Manufacturing date or symbol
 - 6) Manufacturer s date or symbol
 - 7) Others
- (2) Inner carton marking
 - Same as reel marking
- (3) Shipping carton marking
 - Shipping carton marking shall consist of :
 - 1) Parts name
 - 2) Quantity

【 5 】 Standard Quantity

- 1000 pcs./reel

【 6 】 Storage environment

- (1) JEDEC J-STD-020C.1 Moisture Sensitivity Level1
 - After opening in conditions 30 °C or less and 85%RH or less
- (2) To open the packing just before using.
- (3) Not to expose the sun.
- (4) Not to storage with some erosive chemicals.
- (5) Nothing is allowed to put on the reel or carton to prevent mechanical damage.

【 7 】 Storage time limit

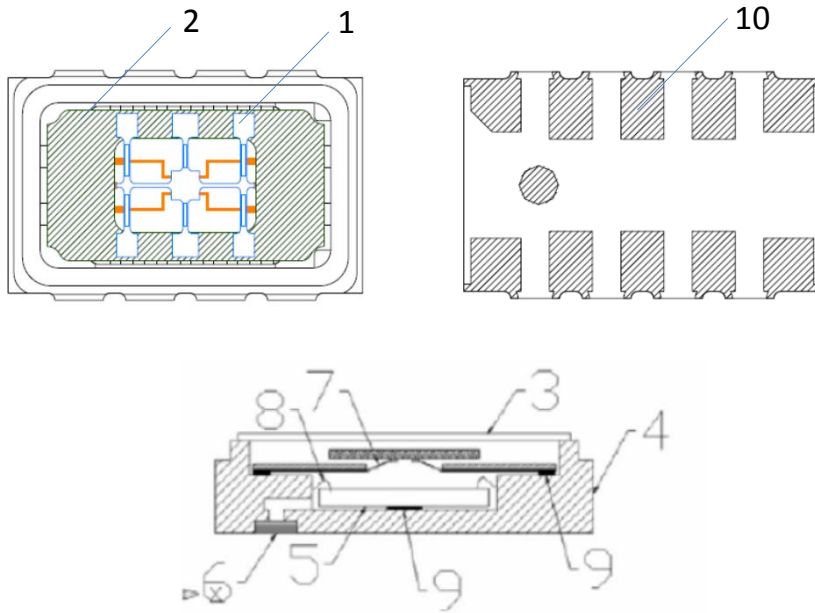
1 year in storage environment

【 8 】 Handling

- (1) To handle with care to prevent the damage of tape, reel and products.
- (2) In one side of the reel is held, it may cause getting out of the place.

XV4001BD Structure/material.

2015.1.19
SEIKO EPSON CORPORATION



No	Component Parts	Specification
1	Crystal Blank	SiO ₂
2	TAB	Polyimide
3	Lid	Kover / Ni Plating
4	Package	Ceramic, Agwax, Kover
5	IC	Si
6	Sealing	Au + Ge
7	Inner lead	Cu / Ni Plating / Au Plating
8	Wire	Au
9	Electric conduction adhesives	Ag • Epoxy resin
10	Electrode film	W Metalize + Ni Plating + Au Plating

Reliability Test Data

Type : XV4001B × series

(Lead-Free)

DATE :2015.1.19

SEIKO EPSON CORP.

**Micro devices Operations Division .
TD・CS Quality Assurance Department.**

Reliability Test Data

Product Name :XV4001B× series

弊社評価条件

弊社では環境特性及び機械的特性を下記試験条件により評価しています。

Specification Page 11No.	ITEM	TEST CONDITION	Scale Factor (Ref.value: 370LSB)	Bias (Ref.value: 0LSB)	Appearance	TEST Qty [n]	FALL Qty [n]
1	Height temperature Exposure (Storage)	+105°C×1000h	Initial±5%	Initial±5°/s	Marking-readable	77	0
2	Low temperature Exposure	-55°C×1000h	Initial±5%	Initial±5°/s		77	0
3	Operational Life	+85°C×3.6V×1000h	Initial±5%	Initial±5°/s		77	0
4	Biased Humidity	+85°C×85%RH×3.6V×1000h	Initial±5%	Initial±5°/s		77	0
5	Heat cycle test	-50°C↔+105°C 1000cycles	Initial±5%	Initial±5°/s		77	0
6	Pressure Cooker Test	121°C x 96%RH x 288 hours	Initial±5%	Initial±5°/s		45	0
7	Vibration	10to40Hz, 1.5mm 40to2000Hz, 5G's	Initial±5%	Initial±5°/s		30	0
8	ESD	HBM:2kV MM:200V	Initial±5%	Initial±5°/s		15	0
9	Solderability	JESD22-B102E	Termination must be 95% covered with fresh solder.			15	0

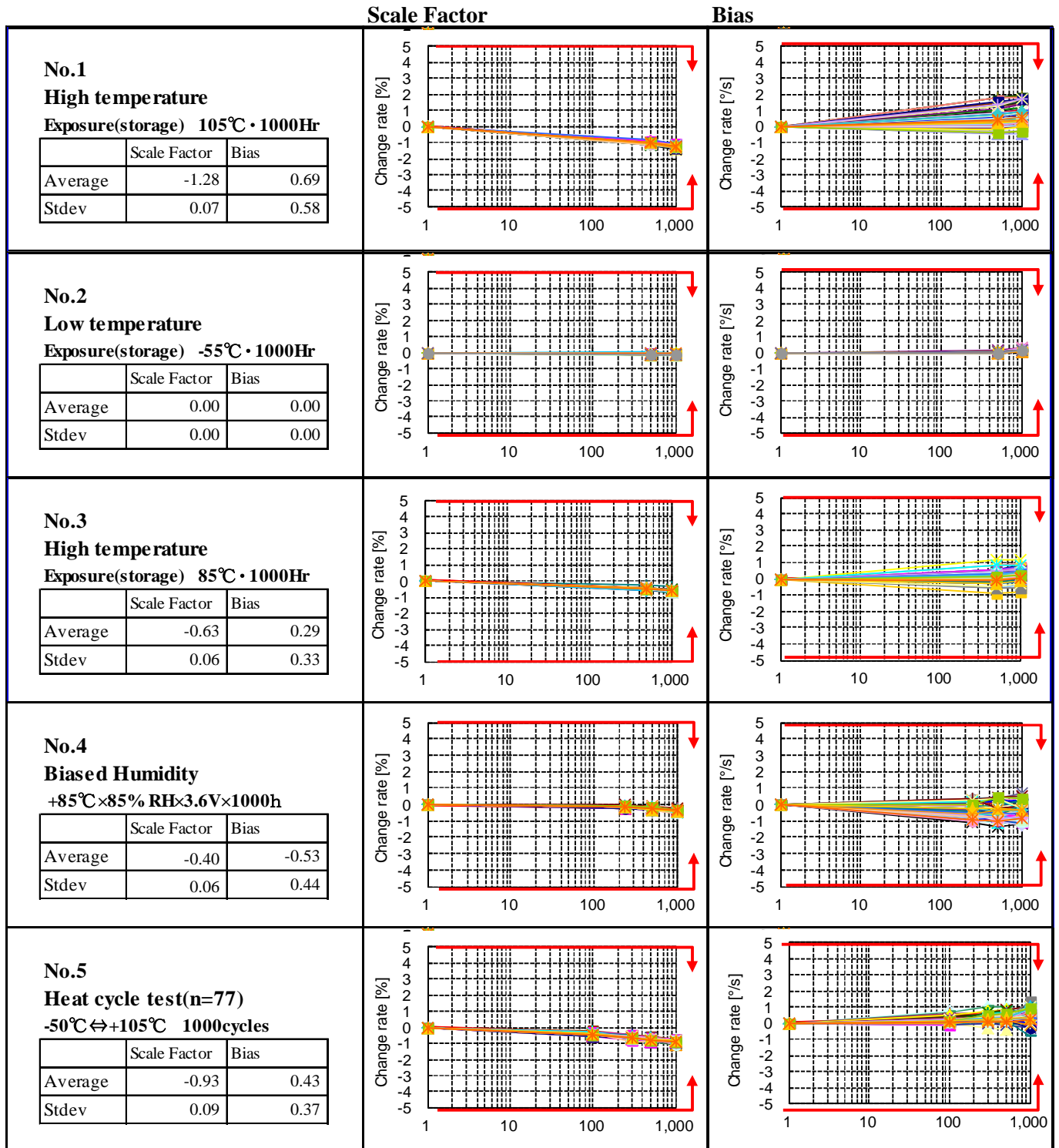
Note

1. Each standard value Normal temperature 25°C ± 10°C
2. Measurement should Relative humidity 50%RH ± 25%RH
3. Per processing (reflow 3 times) before the test must be conducted for tests No.1 ~8.

Then data measured after 2 ~24H storage under normal temp is to be set to the initial data.

Reliability Test Data

Product Name : XV4001B ×



Reliability Test Data

Product Name : XV4001B ×

	Scale Factor	Bias																																
<p>No.6 Pressure Cooker Test (n=45) 121°C x 96% RH x 288 hours</p> <table border="1"> <thead> <tr> <th></th> <th>Scale Factor</th> <th>Bias</th> </tr> </thead> <tbody> <tr> <td>Average</td> <td>-1.27</td> <td>0.13</td> </tr> <tr> <td>Stdev</td> <td>0.11</td> <td>0.21</td> </tr> </tbody> </table>		Scale Factor	Bias	Average	-1.27	0.13	Stdev	0.11	0.21																									
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