To: BYD Company Limited

XV-9000 series
Technical Specification for Angular Rate Sensor
- Preliminary -

Model type **XV-9100LP / LV / CD**

XV-9300LP / LV / CD

Preliminary

Registration May 1, 2013

SEIKO EPSON CORPORATION
Microdevices Operations Division

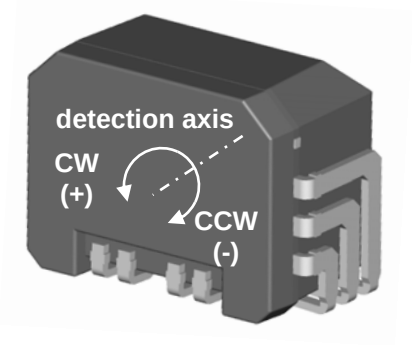
Application scope

This document is applied to the angular rate sensor “XV-9100LP/LV/CD” or “XV-9300LP/LV/CD” used for automotive.

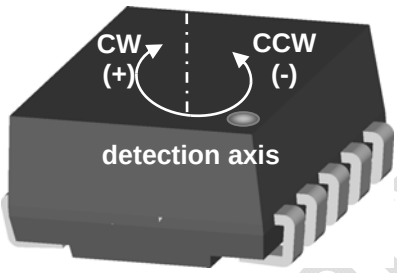
1. Functions

1-1) Detected rate and direction

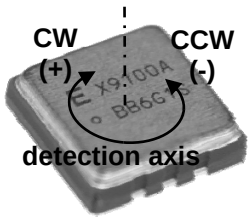
This sensor detects angular rate of rotary motion. The detectable direction and output polarity is shown as below. When angular rate is applied, CW(+) direction will increase the output voltage and CCW(-) direction will decrease the output voltage. Please confirm the direction before mounting.



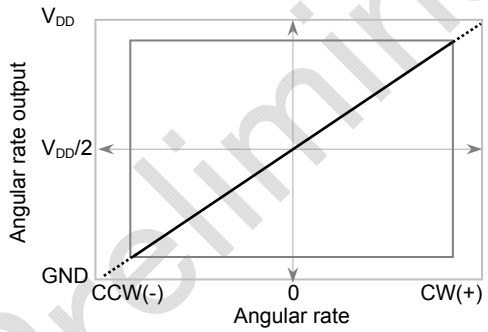
XV-9100LP, XV-9300LP



XV-9100LV, XV-9300LV



XV-9100CD, XV-9300CD



1-2) Diagnoses

This sensor has the always-on diagnosis function. This function judges whether signal level in the sensor circuit is within predefined range or not. When the sensor output is normal, DIAG terminal shows “L”, and if abnormal behavior is detected, “H” is shown on this terminal.

Please don’t use the angular rate output when the DIAG output shows “H”.

1-3) Primary check

This sensor has the primary check function at power on. The primary check is the function to indicate some abnormal condition which cannot be detected by our diagnosis function. If your system cannot get the predefined output, pleases judge that the sensor is not working correctly.

Please refer to 2-6) for the details.

1-4) Ratio-metric

This sensor has the ratiometric function. The ratiometric function is to change sensitivity and zero point voltage at stable mode according to the change of supply voltage. This function enables to reduce detection error of the angular rate.

Please be sure to use VDD and A/D converter through the common power supply.

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2. Electrical characteristics

2-1) Absolute maximum ratings

Parameter	Symbol	Rating	Unit	Note
Supply voltage	V_{DD}	-0.3 ~ +7.0	V	V_{SS}=GND=0V
Storage temperature	T_{STG}	-40 ~ +125	°C	

Stresses beyond those listed under *absolute maximum ratings* may cause permanent damage to the device.

2-2) Recommended operating conditions

Parameter	Symbol	Rating		Unit	Note
Supply voltage	V_{DD}	+4.75 ~ +5.25		V	V_{SS}=GND=0V
Operating temperature	T_{OPR}	-40 ~	+125	°C	XV-9x00LP/LV
			+105		XV-9x00CD
Output current (Vout)	I_{VO}	-50 ~ +50		µA	

An Operation is only guaranteed for voltage and temperature specifications in Electrical characteristics section.

2-3) Sensor characteristics (V_{DD}=4.75V to 5.25V, T_{OPR} unless otherwise specified)

Parameter	Symbol	Condition	Specification			Unit
			MIN	TYP	MAX	
Scale Factor	S_o	XV-9100	-	4.0* V_{DD}	-	mV/(°/s)
		XV-9300	-	1.2* V_{DD}	-	
Scale Factor tolerance	S_T	Ta=+25°C	-2	-	+2	%
Scale Factor variation with temperature	S_v	Ta=+25°C referece	-3	-	+3	%
Bias	V_0		-	V_{DD}/2	-	V
Bias tolerance	V_{0T}	XV-9100, Ta=+25°C	-2	-	+2	°/s
		XV-9300, Ta=+25°C	-5	-	+5	
Bias variation with temperature	V_{0V}	XV-9100, Ta=+25°C reference	-3	-	+3	°/s
		XV-9300, Ta=+25°Creference	-15		+15	
Detection range	I	XV-9100, Ta=+25°C	-100	-	+100	°/s
		XV-9300, Ta=+25°C	-300	-	+300	
Nonlinearity	NI	Ta=+25°C	-0.5	-	+0.5	%FS
Minimum output range	V_{outL}	V_{DD}=5.00V, RL=100kΩ	-	-	0.15	V
Maximum output range	V_{outH}	V_{DD}=5.00V, RL=100kΩ	4.85	-	-	V
Frequency response	BW	XV-9100, -3dB point	10.0	10.5	11.1	Hz
		XV-9300, -3dB point	50.0	52.6	55.3	
Cross axes	CS	Ta=+25°C	-5	-	+5	%

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Parameter	Symbol	Condition	Specification			Unit
			MIN	TYP	MAX	
Start-up time	T_{st}	no-loaded, from VDD 90% to Bias ±3°/s	-	-	300	ms
Current consumption	I_{dd}	no-loaded	-	5.5	10.0	mA
Output Noise	rN	XV-9100, no-loaded, 200ms at 5kHz sampling	-	-	1	(°/s)p-p
		XV-9300, no-loaded, 200ms at 5kHz sampling	-	-	2	
Noise Density	rND	XV-9100, no-loaded, 5Hz	-	0.007	-	(°/s)/√Hz
		XV-9300, no-loaded, 10Hz		0.010		

2-4) Diagnosis characteristics

(V_{DD}=4.75V to 5.25V, T_{OPR} unless otherwise specified)

Parameter		Symbol	Condition	Specification			Unit
				MIN	TYP	MAX	
DIAG output							
	during normal condition	VOL	V_{DD}=5.00V, IOL=-2mA	0	-	0.5	V
	during fault condition or “CHECK”=5V	VOH	V_{DD} =5.00V, IOH=+2mA	4.5	-	5.0	V
Primary check output							
	Vout tolerance (provisional angular rate signal volume)	Vcas	Ta=+25°C	V_0+0.7	V_0+0.9	V_0+1.1	V
	Vout variation with temperature	Vcast	Ta=+25°C referece	-15	-	+15	%
Primary check input							
	check input voltage	VIH		0.7* V_{DD}	-	-	V
		VIL		-	-	0.3* V_{DD}	
	check input current	IIL	CHECK=GND	-1.0	-	-	µA
		IIH	CHECK= V_{DD} =5.00V	-	-	+200	µA

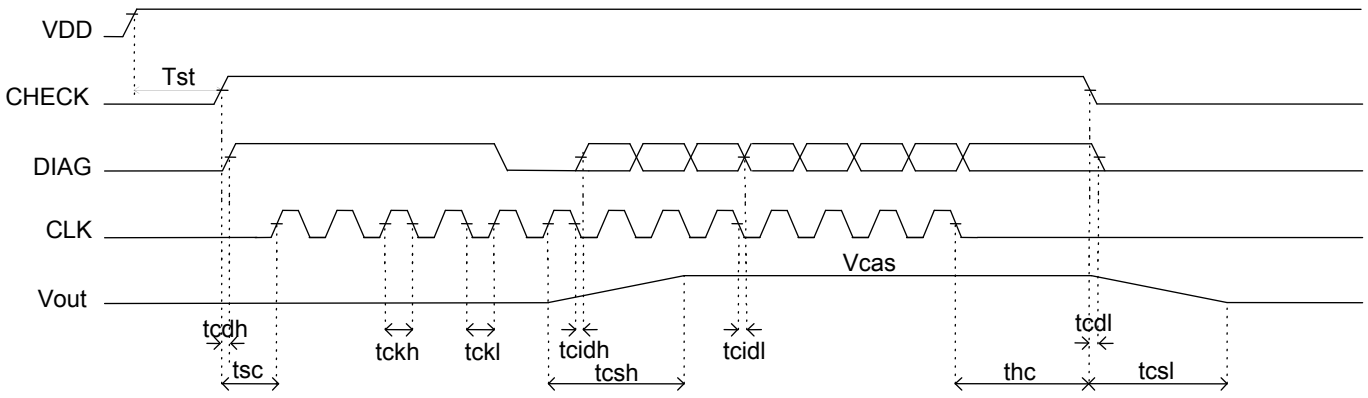
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2-5) Primary check AC characteristics

(V_{DD}=4.75V to 5.25V, T_{OPR} unless otherwise specified)

Parameter	Symbol	Condition	Specification			Unit
			MIN	TYP	MAX	
CHECK setup time	tsc		1	-	-	µs
CHECK hold time	thc		1	-	-	µs
DIAG High transition time	tcdh		-	-	1	ms
DIAG Low transition time	tcdl	ID code is 1 LSB	-	-	1	ms
CLK High time	tckh	Invalid time	-	-	9	µs
		Valid time	30	-	-	µs
CLK Low time	tckl	Invalid time	-	-	9	µs
		Valid time	30	-	-	µs
ID_OUT High transition time	tcidh		-	-	25	µs
ID_OUT Low transition time	tcidl		-	-	25	µs
Vout transition time	tcsh	XV-9100 from CLK6 rise to Vcas ±3°/s	-	-	120	ms
	tcsl	XV-9100 from CHECK Lo to Vo ±3°/s				
	tcsh	XV-9300 from CLK6 rise to Vcas ±3°/s	-	-	40	ms
	tcsl	XV-9300 from CHECK Lo to Vo ±3°/s				
ID code (TBD with customer)	ID	XV-9100	$(17)_{dec} = (00010001)_{bin}$ Decimal '17' as an example			-
		XV-9300	$(18)_{dec} = (00010010)_{bin}$ Decimal '18' as an example			

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2-6) Primary check operation

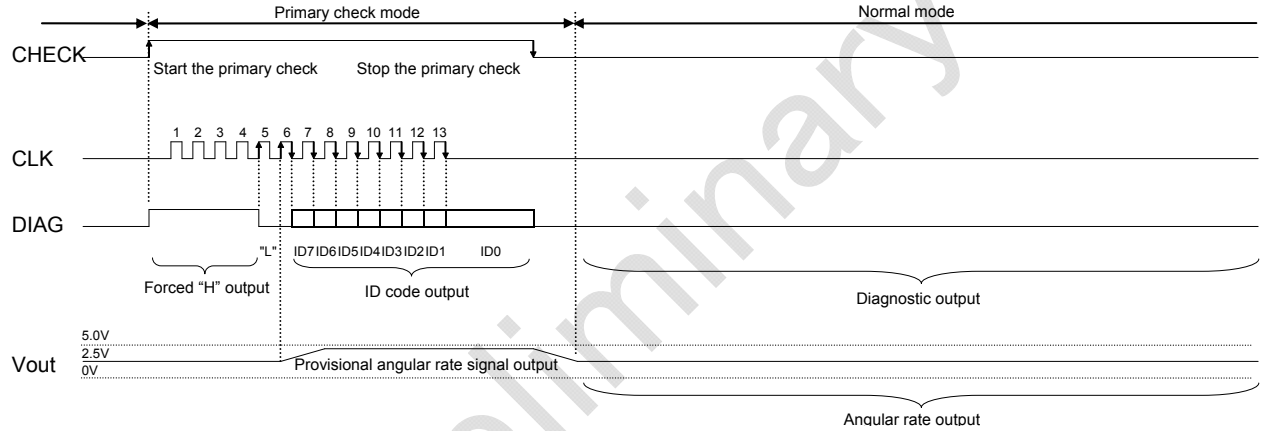
This angular rate sensor has a primary check function. It is able to confirm an action of DIAG terminal, an ID code of the sensor and a state of the sensor with a provisional angular rate.

When the CHECK becomes “H”, primary check function starts and DIAG becomes “H”. At the rising edge of CLK5, DIAG becomes “L”.

Synchronized with the falling edge from CLK6 to CLK13, ID code written in EEPROM comes out from DIAG. Output of ID code is sent as MSB first. The initial ID code has a “17” (00010001) who is XV-9100 and “18” (00010010) who is XV-9300, respectively. However, initial ID code data can be change for the customer request.

From the rising edge of CLK6 to the falling edge of CHECK, a provisional angular rate sensor voltage comes out from Vout terminal. If CHECK=”L” input comes when primary check mode is active, the primary check stops and the control circuit is reset.

Primary check

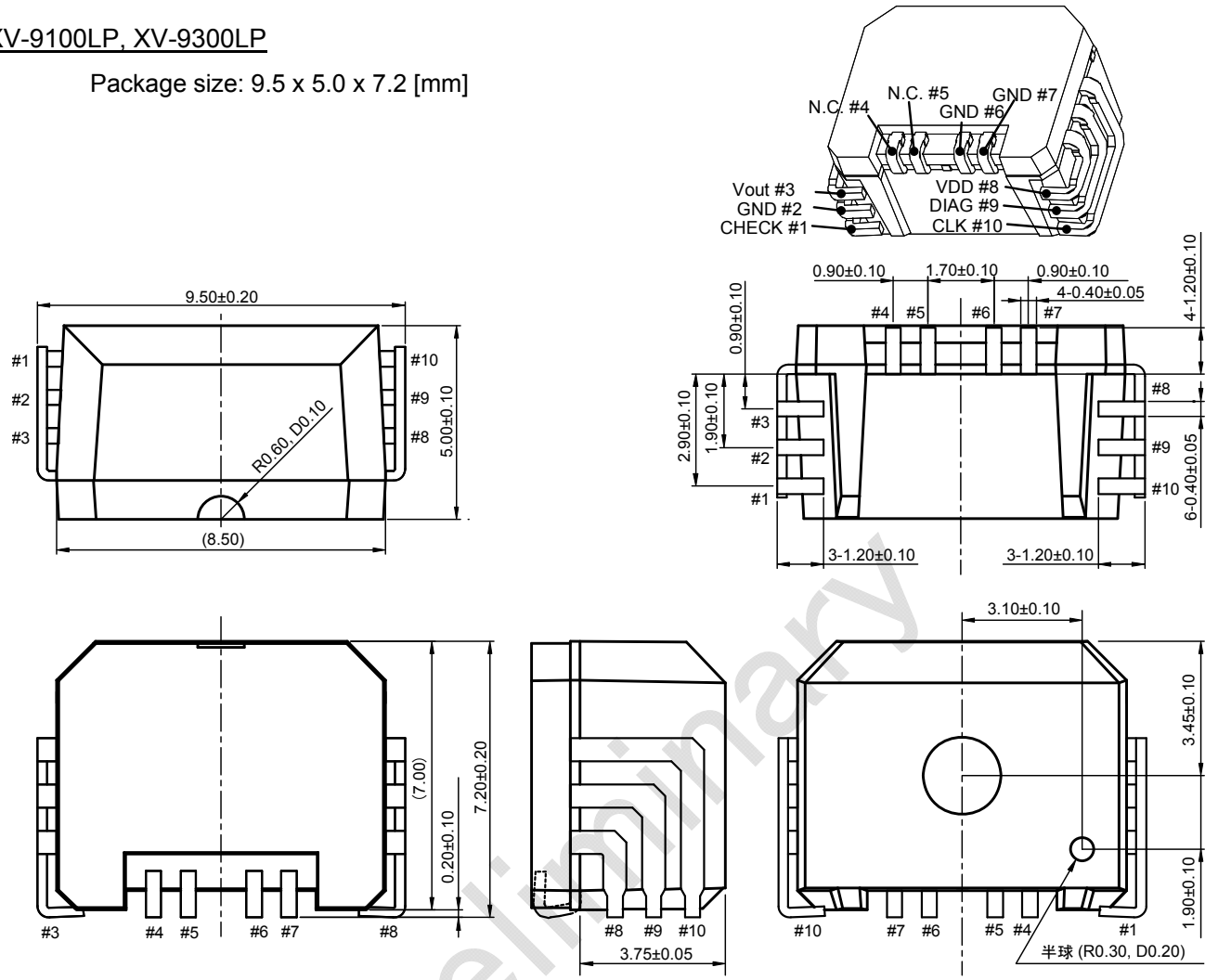


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3. Outline dimensions & Function of terminals

XV-9100LP, XV-9300LP

Package size: 9.5 x 5.0 x 7.2 [mm]



unit: mm

XV-9100LP, XV-9300LP functions of terminals

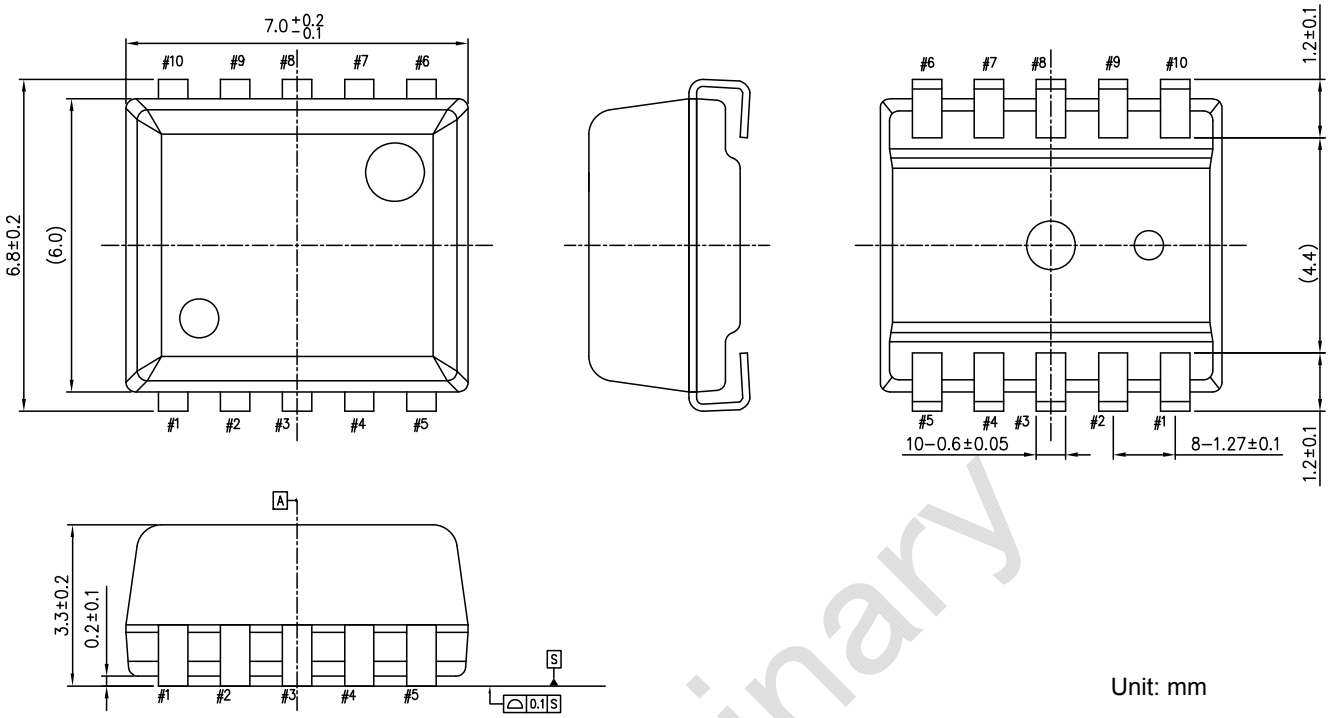
Pin No.	Pin Name	Function
1	CHECK	Primary check trigger
2	GND	GND terminal
3	Vout	Angular rate output
4	N.C.	Internal test pin
5	N.C.	Internal test pin
6	GND	GND terminal
7	GND	GND terminal
8	VDD	+5.0V Power supply
9	DIAG	Diagnosis output
10	CLK	Primary check clock

*) N.C.: not connected pin 4&5

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XV-9100LV, XV-9300LV

Package size: 7.0×6.8×3.3 [mm]



Unit: mm

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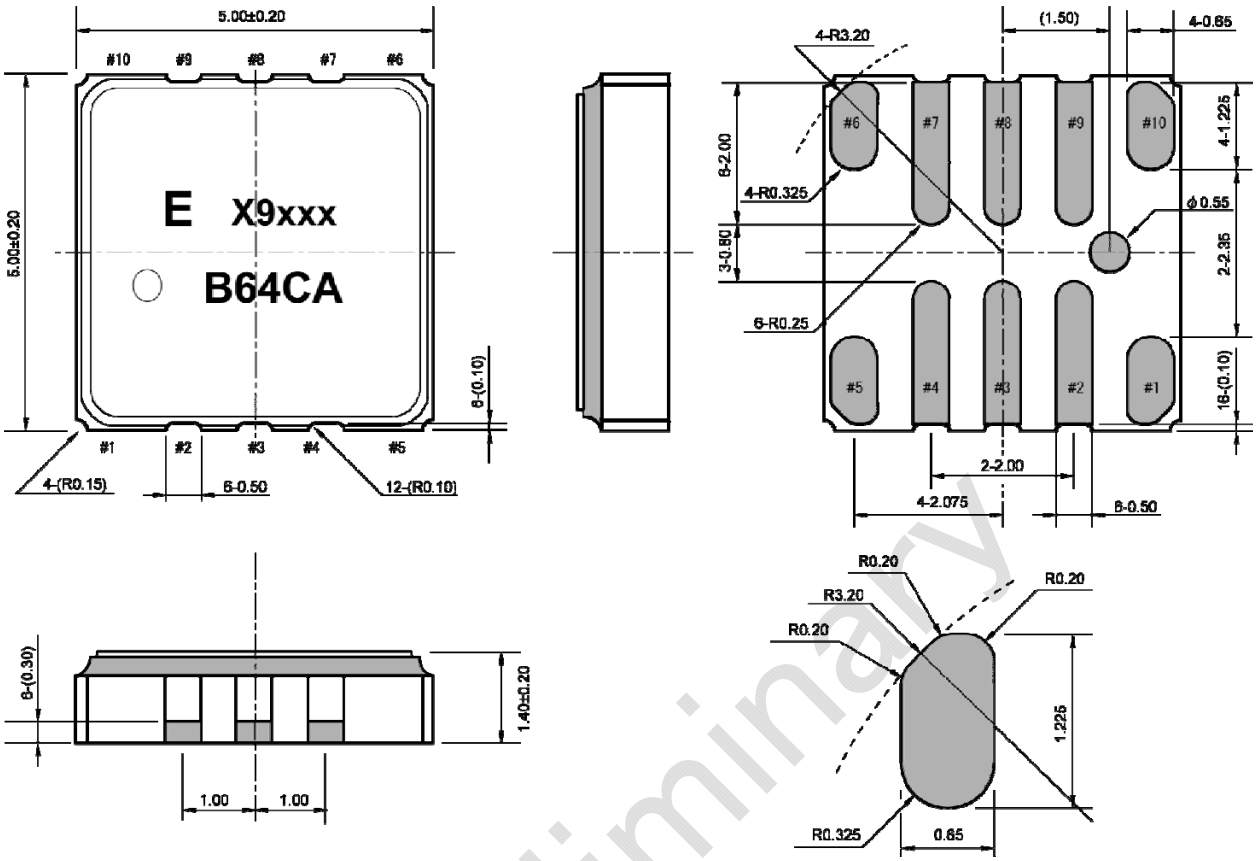
XV-9100LV, XV-9300LV functions of terminals

Pin No.	Pin Name	Function
1	GND	GND terminal
2	CLK	Primary check clock
3	DIAG	Diagnosis output
4	VDD	+5.0V Power supply
5	GND	GND terminal
6	N.C.	Internal test pin
7	Vout	Angular rate output
8	GND	GND terminal
9	CHECK	Primary check trigger
10	N.C.	Internal test pin

*) N.C.: not connected pin 6&10

XV-9100CD, XV-9300CD

Package size: 5.0×5.0×1.4 [mm]



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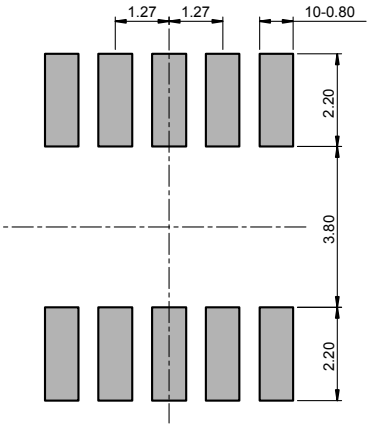
XV-9100CD, XV-9300CD functions of terminals

Pin No.	Pin Name	Function
1	GND	GND terminal
2	CLK	Primary check clock
3	DIAG	Diagnosis output
4	VDD	+5.0V Power supply
5	GND	GND terminal
6	N.C.	Internal test pin
7	Vout	Angular rate output
8	GND	GND terminal
9	CHECK	Primary check trigger
10	N.C.	Internal test pin

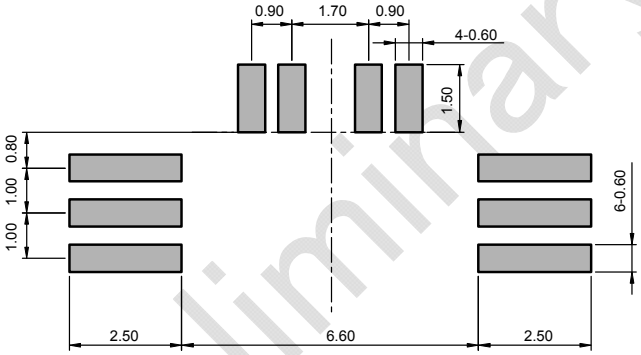
*) N.C.: not connected pin 6&10

4. Soldering pattern

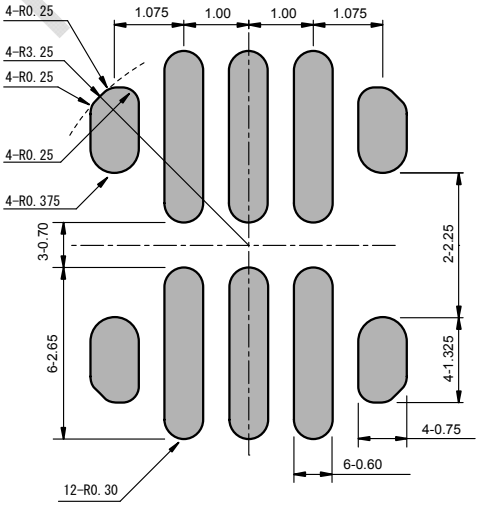
One of the design examples is shown as below. In actual designing, please optimize the pattern in consideration of mounting density, soldering reliability and easiness of mounting etc.



XV-9100LV, XV-9300LV



XV-9100LP, XV-9300LP



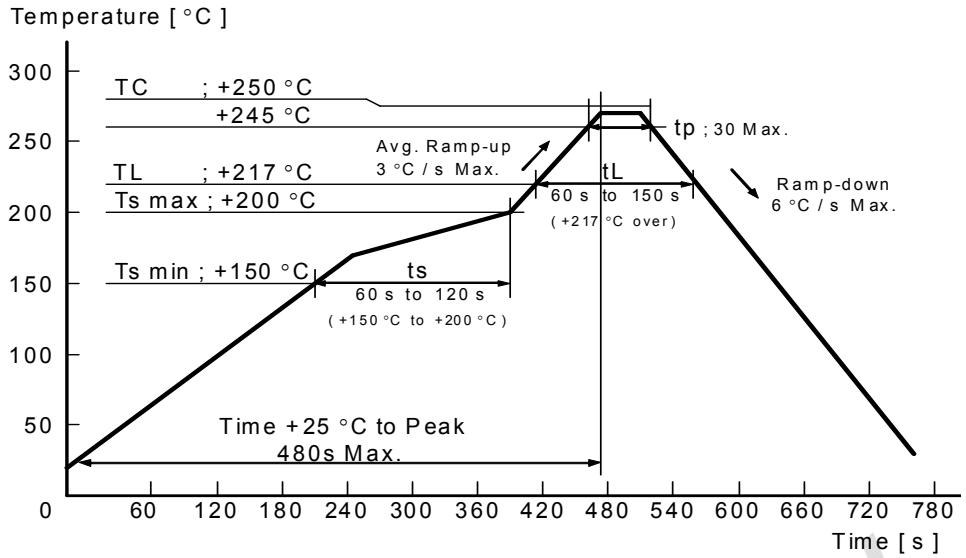
XV-9100CD, XV-9300CD

Footprint (recommended)

Unit: mm
Tolerance: ±0.05mm

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Reflow heating treatment conditions

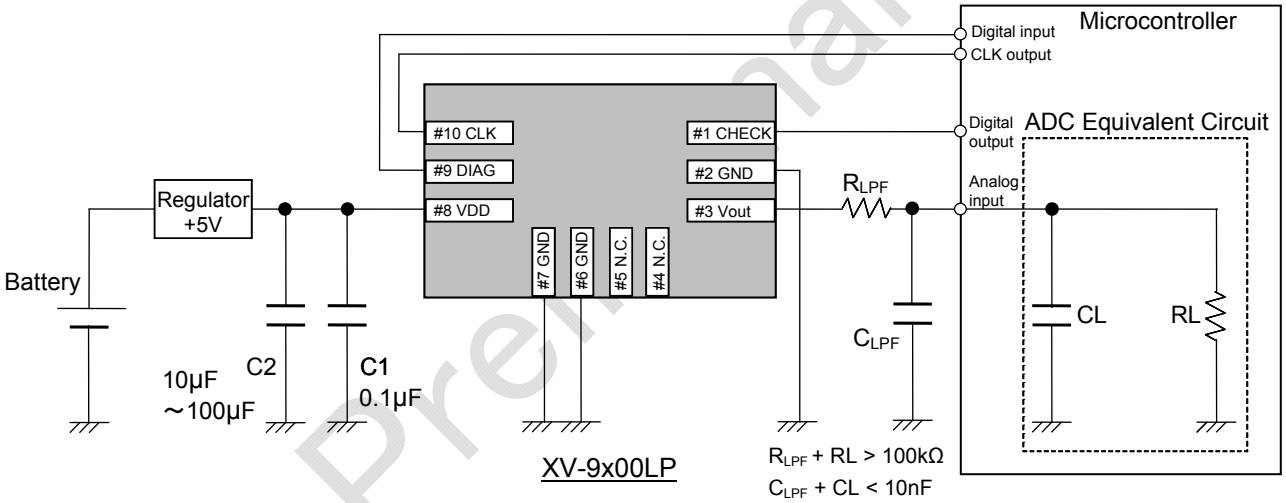


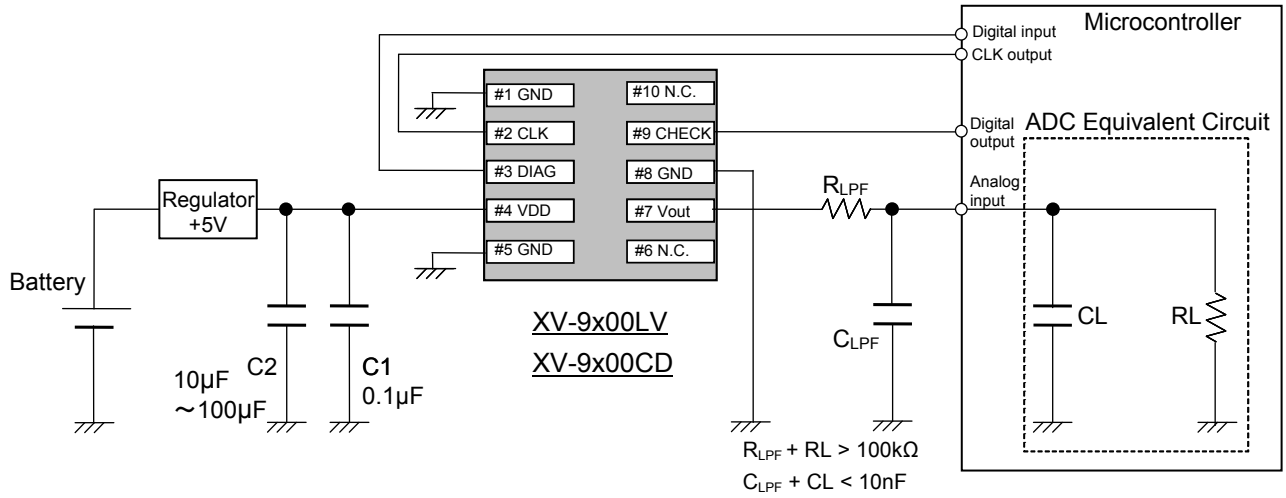
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5. Recommended circuit

1. Apply a bypass capacitor C1 with 0.1µF and good high frequency characteristic, close to the terminals of the sensor. The ground terminal of the capacitor should be connected to analog ground using via holes.
2. The sensor does not have a power supply back-up function, thus a back up capacitor C2 with 10µF to 100µF should be mounted.
3. For robust EMS of 'DIAG' & 'Check' pin, external capacitor with 1µF will be connected to ground.
4. Use the same power supply for the sensor and the A/D converter.
5. Do not connect NC-terminals of the sensor to electrical terminals on the PCB.
6. In case of the sensor output signal connected to the ADC, an aliasing noise will be occurs based on sampling theory. It's necessary to eliminate using an anti-aliasing LPF.
7. This sensor is designed not to easily interfere even if multiple sensors are operated closely and simultaneously. However, in some cases, the sensors may interfere by common impedance of power supply. Please check them before use.
8. In case of using a sensor in outside vibration, please carefully check and do protection from vibration.
9. To avoid malfunctions caused by induction from other signal lines, please design the circuit pattern so that other signal lines would not be located near /above the sensor and output signal line doesn't cross the other signal lines.

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6. Handling Precautions

Please handle carefully paying attention to the next points.

This product is designed highly carefully for quality. However it may be varying characteristics or abnormal behavior depending on the condition of customer's usage. So please add continuous monitoring for DIAG terminal output to your system. If DIAG shows "H" (abnormal behavior), there is a possibility that the sensor is failure, so please consider fail-safe design in your system.

1. This product is designed in consideration of shock resistance. However it may be destroyed depending on the condition of dropping and impact. **Please do not use the product, in case it falls accidentally or it is applied excessive shock, as it can not be guaranteed after these.**
2. If excessive shock is generated when a product is automatically mounted (vacuum-chucking, mechanical chucking, mounting on the circuit board), it will lead to change or degradation of the characteristics. Therefore, please set up the condition such that shock is as small as possible. Please be sure to test in your site before use and confirm that there is no influence on the characteristics. And confirm similarly when the condition is changed.
3. This product contains circuits that protect from electrostatic discharge. However, if static electricity is excessive, the IC may break. Therefore, the packing material and container carrying the product should use a conductive material. And use the soldering iron and the measurement instrument that don't have high-voltage leakage and take countermeasure against static electricity such as grounding when handling.
4. If you apply ultrasonic vibration (ex. Ultrasonic washing、Printed circuit board cutting) to this product, the crystal and Si-MEMS may be cause resonant destruction under some use conditions. Since we can not specify your use conditions, we can not guarantee the operation of our product after you apply ultrasonic vibration. When ultrasonic vibration is unavoidable, be sure to test and confirm operation of product before use in your company.
5. You can reflow up to 1 times. The condition for use of soldering iron to correct for soldering mistake should be +350 °C or less and for less than 3 seconds.
6. We will recommend the circuit board be designed by our recommended footprint.
7. Please do not use the product in an environment where the short-circuit can be generated between terminals from moisture and condensation.
8. This product has a noise of the same frequency as drive frequency. It's necessary to remove the noise using a suitable filter circuit.
9. This product is designed not to interfere easily even if multiple ones are operated closely and simultaneously. However, in some cases, the products may interfere by vibration of circuit board or the common impedance of a power supply. Please be sure to check before use.
10. When there is an excessive vibration coupling to the product, please confirm influence of vibration and do protection against vibration.
11. The moisture sensitivity level is MSL 3 in the XV-9x00LP and MSL 2 in the XV-9x00LV. About the managing method in the packaged state, please refer to the packaging standard.

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