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## **MEMS Micro Joystick Specification**



**Knowles Acoustics**  
1151 Maplewood Drive  
Itasca, IL 60143

## 1. DESCRIPTION AND APPLICATION

### 1.1 DESCRIPTION

KJ-33000 is an ultra low-power MEMS (Micro Electro Mechanical System) based input device, also known as a joystick. It converts movement of the joystick button up to 1mm from the center into two 4-bit digital values representing X and Y displacements.

### 1.2 APPLICATION

Joystick is developed for hand held telecommunication and electronic devices. Refer to manufacturer's website ([www.knowles.com](http://www.knowles.com)) for application notes.

## 2. PART MARKING

Parts are marked with 2 numbers on the top surface of the case.

1234567 - Job identification number

KJ-33000 - Joystick assembly part number

## 3. TEMPERATURE RANGE

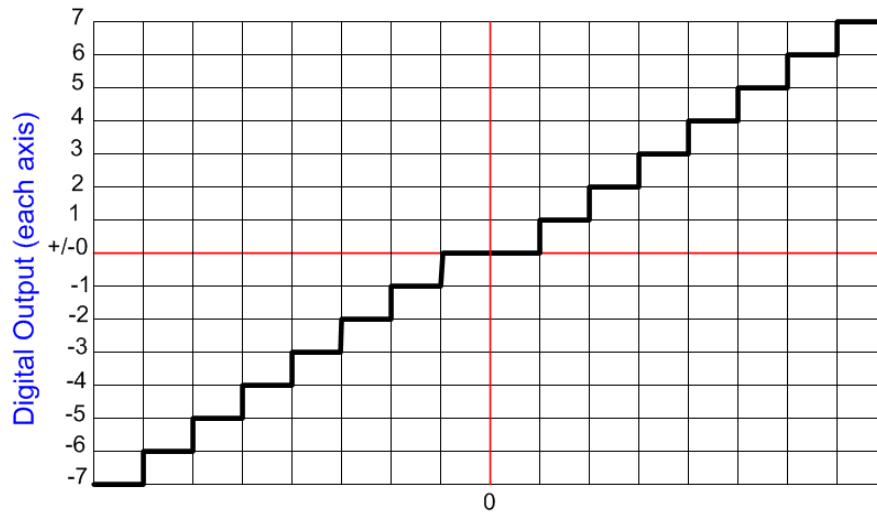
Operating Temperature Range: -25° to 70°C

Storage Temperature Range: -40° to 85°C

## 4. THEORY OF OPERATION

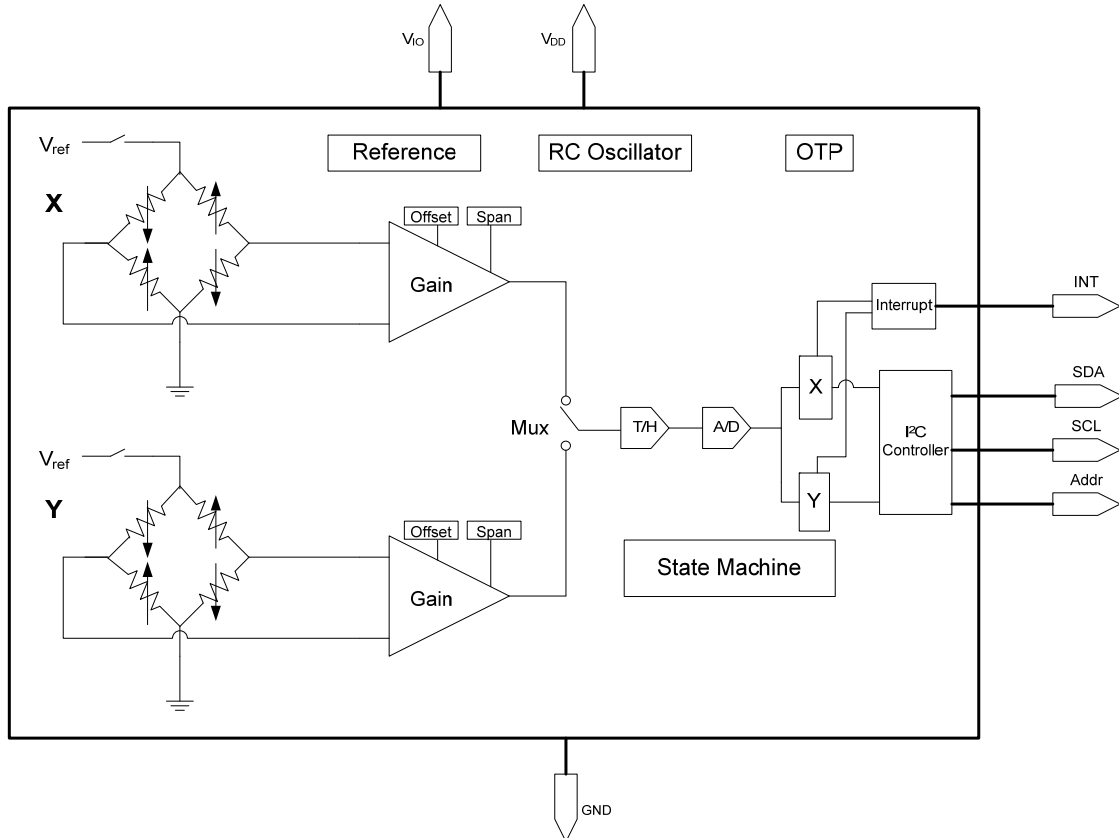
The KJ-33000 is a silicon MEMS Piezo-resistive sensor with an integrated CMOS interface. Piezo-resistive bridges measure the strain induced in the silicon when a joystick movement causes internal spring mechanism to place a load on the MEMS. An A/D converter converts the bridge signal into a 4-bit digital code. This code is communicated to the user via an I<sup>2</sup>C interface. The 4-bit signal is encoded as a sign/magnitude number. This means that there are two zero values (+/-0). A transfer function that is typical for each axis is depicted in the figure below.

Joystick Transfer Function



## 5. ELECTRICAL SPECIFICATIONS

### 5.1 SCHEMATIC DIAGRAM OF CIRCUIT



### 5.2 Absolute Maximum ratings

Parameter	Symbol	Minimum	Maximum	Units	Notes
Power Supply Voltage	$AV_{DD}, V_{DD}$	-0.3	3.6	V	
I/O Voltage	$V_{IO}$	-0.3	$V_{DD} + 0.3$	V	
ESD			2	kV	All pins human body model

### 5.3 Recommended Operating Conditions

Parameter	Symbol	Minimum	Typical	Maximum	Units	Notes
Power Supply Voltage	$AV_{DD}, V_{DD}$	2.6	3.3	3.6	V	
I/O Voltage	$V_{IO}$	1.5	1.8	$V_{DD}$	V	

## 5.4 ELECTRICAL CHARACTERISTICS UNDER RECOMMENDED OPERATING CONDITIONS

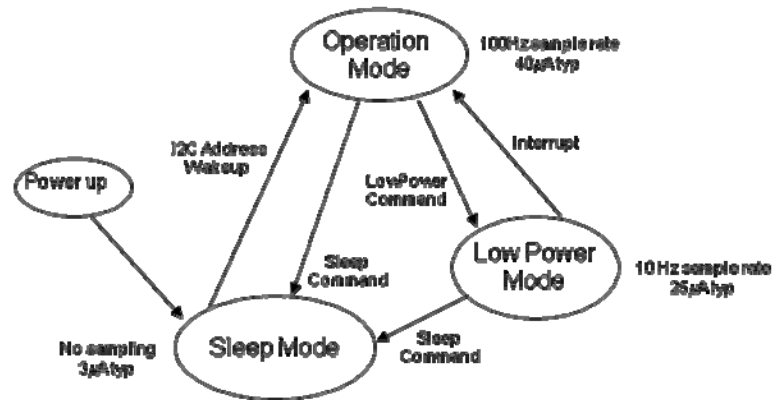
Typical values at 25°C,  $V_{DD} = 2.8V$

Parameter	Symbol	Minimum	Typical	Maximum	Units	Notes
System Current Operation	$I_{OP}$		40	100	$\mu A$	
System Current Low Power	$I_{LP}$		25	50	$\mu A$	
System Current Sleep	$I_{SLEEP}$		3	10	$\mu A$	
Resolution	RES		16		Counts	Each Axis
Input / Output Levels	Input High Voltage	$V_{IH}$	$0.65 * V_{IO}$		V	
	Input Low Voltage	$V_{IL}$		$0.35 * V_{IO}$	V	
	Output High Voltage	$V_{OH}$	$V_{IO} - 0.3$		V	
	Output Low Voltage	$V_{OL}$		0.3	V	
Input Leakage Current			1.9	9.4	$\mu A$	
Input Off-State Leakage Current			0.02	0.04	$\mu A$	
I <sup>2</sup> C Clock Rate	$f_{CK}$			400	kHz	I <sup>2</sup> C Fast Mode
Sample Rate – Operation Mode	$f_{SOP}$		100		Hz	
Sample Rate – Low Power Mode	$f_{SLP}$		10		Hz	

## 6. INTERFACE SPECIFICATIONS

### 6.1 OPERATING MODES:

The KJ-33000 has three operational modes. When the device is powered up, it is in the Sleep Mode. Only the I<sup>2</sup>C interface is active and the current draw is minimized. When the device is read it wakes up into normal Operation Mode. In this mode, the sensor is sampled at 100Hz. The first read from Sleep Mode contains stale data. A write to the I<sup>2</sup>C address will send the device into either Low Power Mode or Sleep Mode depending on the value of the least significant bit.



### 6.2 I<sup>2</sup>C CONTROLLER

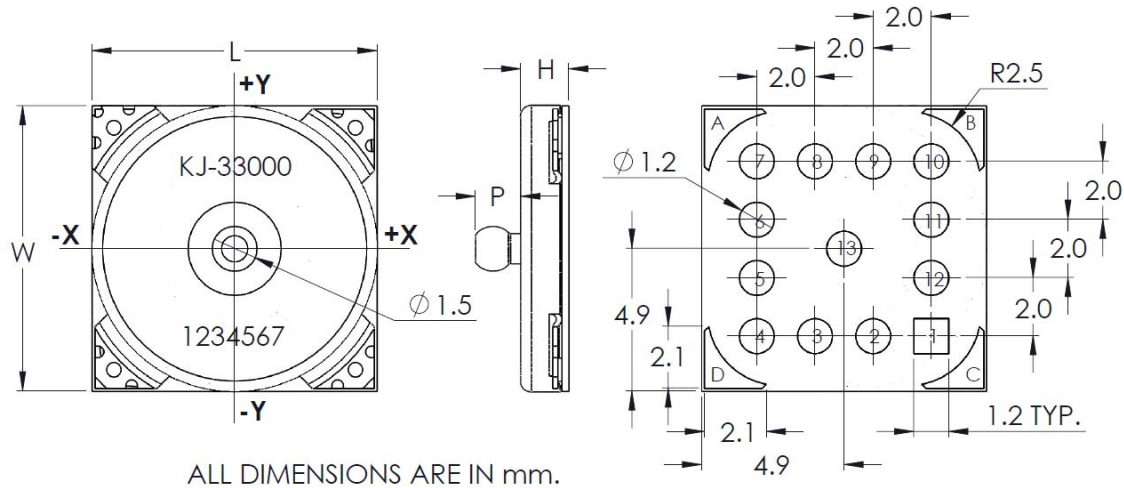
The I<sup>2</sup>C controller can operate up to 400 KHz (fast mode). Seven bit addressing is implemented. The pre-programmed I<sup>2</sup>C address is 0x38. If the Addr line is tied to V<sub>DD</sub>, the device will respond to address 0x39.

A read initiated from the device returns two bytes. The first byte contains a left justified 4 bit value for the X axis while the second byte contains a left justified 4 bit value for the Y axis. The least significant 4 bits of both bytes are zero filled.

A write initiated to the device will send it into either Low Power Mode or Sleep Mode depending on the value of the least significant bit. A '1' corresponds to Low Power Mode while a '0' corresponds to Sleep Mode.

The open drain interrupt line is asserted (low level) on a change in either the X or Y value. No interrupts are generated when there are consecutive zeros on both axes.

## 7. MECHANICAL SPECIFICATIONS

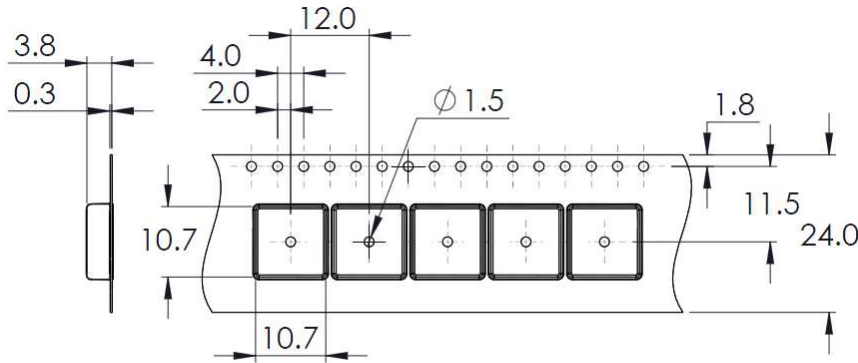


ITEM	DIMENSION	TOLERANCE	UNITS
LENGTH (L)	9.85	±0.10	mm
WIDTH (W)	9.85	±0.10	mm
HEIGHT (H)	1.65	±0.05	mm
POST HEIGHT (P)	1.55	±0.05	mm

PIN #	PIN NAME	TYPE	DESCRIPTION
1	AV <sub>DD</sub>	Source	Analog power supply: 3.3V typical
2	V <sub>IO</sub>	Source	I/O power supply: either 1.8V or connect to V <sub>DD</sub>
3	TEST	Digital I	Test mode select: normally connect to ground
4	Addr	Digital I	Even/Odd address select line
5	SCL	Digital I	I <sup>2</sup> C clock line
6	INT	Digital O	Open drain interrupt line
7	SDA	Digital I/O	Open drain I <sup>2</sup> C data line
8	V <sub>PP</sub>	Source	Programming power supply: Connect to V <sub>DD</sub>
9	V <sub>SS</sub>	Source	Digital Ground
10	V <sub>DD</sub>	Source	Digital power supply: 3.3V typical
11	N/C	----	No Connection
12	AV <sub>SS</sub>	Source	Analog Ground
13	N/C	----	No Connection
A	Case	----	Ground
B	Case	----	Ground
C	Case	----	Ground
D	Case	----	Ground



## 8. PACKAGE DETAIL

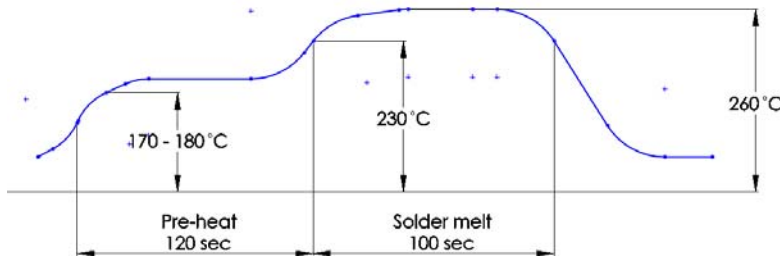


ALL DIMENSIONS ARE IN mm.



Part Number	Reel Width (mm)	Reel Diameter (inches)	Joystick Quantity on Reel
KJ-33000-004	24	13	1500

## 9. RECOMMENDED REFLOW TEMPERATURE PROFILE



Stage	Temperature Profile	Time (Maximum)	Notes
Pre-Heat	170 ~ 180 C	120 sec.	1. Do not board wash after reflow process. Board washing and cleaning agents can damage the device. 2. Do not expose to ultrasonic processing or cleaning. 3. Number of Reflows = Recommended no more than 3 cycles.
Melt	Above 230 C	100 sec.	
Peak	260 C Maximum	30 sec.	

## 10. RELIABILITY SPECIFICATIONS

Test	Description
Thermal Shock	100 cycles air-to-air thermal shock from -40°C to +85°C with 15 minutes shock. (IEC 68-2-4)
High Temperature Operating	500 hours at 85°C under bias. (IEC 68-2-2 Test Ba)
Low Temperature Operating	500 hours at -40°C under bias. (IEC 68-2-1 Test Aa)
Humidity Operating	85°C/85% R.H. for 500 hours under bias. (JESD22-A101A-B)
Sinusoidal Vibration	20G, 20 to 2,000 Hz Sinusoidal sweep; 16 minutes in each orientation (vertical and horizontal). Mil-Std-883E, method 2007.2, condition A; IEC 60068-2-6
Random Vibration	Acceleration Spectral Densities (m2/s3): 0.10 at 5 Hz, 2.20 at 12 Hz, 2.20 at 20 Hz, and 0.04 at 200 Hz and 500 Hz. 10 minutes in each orientation (vertical and horizontal). IEC 60068-2-34
Electrostatic Discharge	3 discharges of 8kV direct contact discharge to the case (IEC 6100-4-2) and 3 discharges of 2kV direct contact to I/O terminals. (MIL 883E, Method 3015.7)
Reflow	3 passes through reflow oven with peak temperature of 260°C
Tumble	0.5m for 300 tumbles.
Travel Life Cycles	500,000 Cycles Full Axis Travel.
Max Overload	50N for 5 seconds in the X and Y directions. 100N for 5 seconds in the Z direction when load is applied to case corner.

## 11. RELIABILITY SPECIFICATIONS

Stress above the Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only. The device may not function when operated at these or any other conditions beyond those indicated under “Electrical Specifications”. Exposure beyond those indicated under “Electrical Specifications” for extended periods may affect device reliability.

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