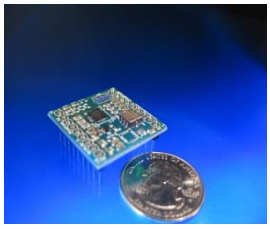
DATASHEET

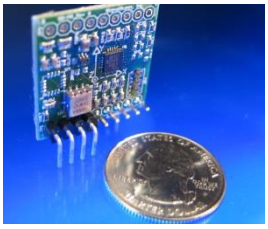
SQ-PTS

PROGRAMMABLE MEMS TILT SWITCH

±70 ° DUAL AXIS, 360 ° SINGLE AXIS, DIGITAL OUTPUT



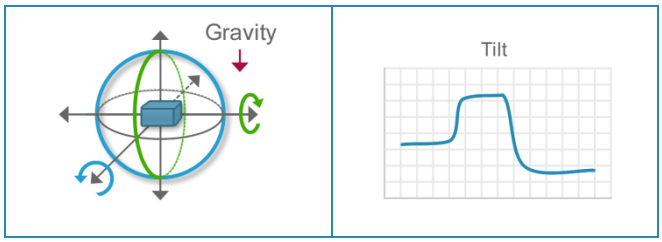
SQ-PTS-HMP



SQ-PTS-VMP

THEORY OF OPERATION

The inclinometer uses 2 factory calibrated accelerometers to measure and compute angles made between its axes, and the gravity vector. The trigonometric conversions between acceleration and angle are made by an onboard processor. Additional processing filters spurious acceleration and vibrations to reduce the impact on the resulting output angle.



FUNCTION

- ± 70 ° dual axis angle measurement
- 360 ° single axis angle measurement

APPLICATIONS

- Reliable on/off tilt switching
- Machine control

DESCRIPTION

The tilt sensor module provides a digital level output if pre-programmed angle thresholds are exceeded. The two standard digital outputs can be configured at the factory as two different angle thresholds. In addition 4 additional input/output lines can be factory configured for a variety of functions on a semi-custom basis, greatly simplifying designs that require accurate, reliable angle detection

FEATURES

- ± 1 ° accuracy
- 0.10 ° resolution
- Configurable trigger angles
- Configurable hysteresis (Schmitt trigger) for debounce
- Configurable reset and trigger delay
- Configurable filtering and bandwidth
- Low temperature drift
- High reliability solid-state MEMS
- Digital filtration for stable measurement

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ABSOLUTE MAXIMUM RATINGS

PARAMETER	MIN	TYPICAL	MAX	NOTES
Voltage on +*Vcc* - without regulator - NR option	0.3 V		4.2 V	with respect to GND
Voltage on +*Vcc* - with regulator - R option	0.3 V		5.8 V	
Voltage on any input pin			5.8 V	with respect to GND
Peak-to-peak supply noise - without regulator -NR option			50 mV	
Peak-to-peak supply noise - with regulator - R option			200 mV	
Operating temperature	-40 ° C		85 ° C	
Shock survivability			500 *g*	where 1 *g* is assumed to be = 9.81 m/s^2
Operating vibration			0.25 *g*	

Note: Exposure to conditions outside of the Absolute Maximum Ratings may damage the device. Prolonged exposure to conditions at the Absolute Maximum Ratings may result in degraded performance of the device over time.

ELECTRICAL CHARACTERISTICS

[Test conditions: 3.3v regulator, 25 ° C unless otherwise specified]

PARAMETER	MIN	TYPICAL	MAX	NOTES
Supply voltage - without regulator - NR option	2.9 V		3.5 V	with respect to GND
Supply voltage - with 3.0 volt regulator - 3.0R option	3.2 V		5.8 V	12 V tolerant versions also available. Consult factory.
Supply voltage - with 3.3 volt regulator - 3.3R option	3.5 V		5.8 V	
Supply current - HP option		4.6 mA		
Supply current - LP option		1.6 mA		
Output voltage*	0.3 V		0.9 × *Vcc*	See note below regarding Vcc.
Input voltage High	2.0 V			
Input voltage Low			0.8 V	
Output voltage High	0.895 × *Vcc*		*Vcc*	
Output voltage Low	0 V		0.100 × *Vcc*	
Output impedance – Trigger 1 and Trigger 2		10 KΩ		
Output impedance – Trigger 3 and Trigger 4		1 Ω		Max sink current =10 mA

***Note:** For the NR model (without onboard regulator), *Vcc* is the voltage supplied to the device. For the 3.0R and 3.0R models (3.0 V or 3.3 V onboard regulators), *Vcc* is 3.0 V or 3.3 V respectively. If your application requires using a 12 V supply, consult factory for 12 V tolerant models.

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PERFORMANCE PARAMETERS

[Test conditions: 3.3v regulator, 25 ° C unless otherwise specified]

PARAMETER	SPECIFICATION		NOTES			
Angle accuracy (differential) - HP option	± 1 °		From any angle to any other angle within range			
Angle accuracy (differential) - LP option	± 2 °					
Angle resolution	0.1 °					
Alignment accuracy	± 2 °					
Angle range - dual axis mode	± 70 ° (X and Y tilt)		Dual axis X and Y tilt angle ranges with respect to horizontal.			
Angle range - single axis mode	360 ° (Z rotation)		Single axis angle measurement valid while Z axis (vector normal to circuit board) is within ± 45 ° of horizontal.*			
Typical angular drift due to temperature. Values represent 1 sigma confidence in tilt mode. - IND option			**Angle range**			
			± 10 °	± 45 °	± 70 ° *	360 ° (single axis)
	Temperature range	15 C to +35 C	± 0.06 °	± 0.06 °	± 0.3 °	± 0.1 °
		0 C to +70 C	± 0.3 °	± 0.3 °	± 1.6 °	± 0.6 °
		-40 C to +85 C	± 0.4 °	± 0.4 °	± 1.7 °	± 0.8 °
Typical angular drift due to temperature. Values represent 1 sigma confidence in tilt mode. - LC option			**Angle range**			
			± 10 °	± 45 °	± 70 ° *	360 ° (single axis)
	Temperature range	15 C to +35 C	± 0.3 °	± 0.3 °	± 1.7 °	± 0.6 °
		0 C to +70 C	± 1.3 °	± 1.4 °	± 7.8 °	± 2.8 °
		-40 C to +85 C	± 1.9 °	± 2.1 °	± 8.5 °	± 4.2 °

* **Note:** Useable up to +/- 80 ° with degraded accuracy.
****Note:** Angle ranges measured with respect to deviations from horizontal.

OUTPUT CHARACTERISTICS

PARAMETER – HP AND LP VERSIONS	TYPICAL	NOTES
Update rate - HP option	40 Hz	Analog update rate and Digital serial packet rate
Update rate - LP option	5 Hz	
Warm up time from power on - S option	1.0 s	Angle jitter and vibration are digitally filtered
Measurement settling time - S option	0.5 s	
Warm up time from power on - F option	0.2 s	
Measurement settling time - F option	0.1 s	

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PIN CONFIGURATION

PIN	SIGNAL NAME	USAGE
1	GND	
2	NC	Solder to open circuit for mechanical stability. **Do not** connect to GND.
3	NC	Solder to open circuit for mechanical stability. **Do not** connect to GND.
4	Logic	Digital Input – High (or open) selects Active High logic output on triggers, Low selects Active Low logic output on triggers. Solder to open circuit for mechanical stability if not used. **Do not** connect to GND.
5	+Vcc	
6	XTrigger 1	Digital Output - Transitions logic level when trigger threshold is exceeded. Configure Logic pin to set this as High→Low or Low→High. Solder to open circuit for mechanical stability if not used. **Do not** connect to GND. High output impedance.
7	YTrigger 2	Digital Output - Transitions logic level when trigger threshold is exceeded. Configure Logic pin to set this as High→Low or Low→High. Solder to open circuit for mechanical stability if not used. **Do not** connect to GND. High output impedance.
8	Dual Axis Tilt Mode / Single Axis Gimbaled Mode Select	Digital Input – High (or open) selects Dual Axis Tilt Mode (D), Low selects Single Axis Gimbaled Mode (S). If not used, solder to open circuit for mechanical stability.
9	Zero Set	Digital Input – Transition from High→Low sets zero position and saves to non-volatile memory. Solder to open circuit for mechanical stability if not used. **Do not** connect to GND.
10	NC	Solder to open circuit for mechanical stability. **Do not** connect to GND
11	XTrigger 3	Digital Output - Transitions logic level when trigger threshold is exceeded. Configure Logic pin to set this as High→Low or Low→High. Solder to open circuit for mechanical stability if not used. **Do not** connect to GND. Low output impedance.
12	YTrigger 4	Digital Output - Transitions logic level when trigger threshold is exceeded. Configure Logic pin to set this as High→Low or Low→High. Solder to open circuit for mechanical stability if not used. **Do not** connect to GND. Low output impedance.
13	NC	Solder to open circuit for mechanical stability. **Do not** connect to GND.
14	NC	Solder to open circuit for mechanical stability. **Do not** connect to GND.
15	/Reset & Prog 1	Digital Input – Active low reset. Bring low for >10 mS to reset device. If not used, solder to open circuit for mechanical stability. **Do not** connect to GND. Also used for FLASH programming.
16	Prog 2	Digital Input – If not used, solder to open circuit for mechanical stability. **Do not** connect to GND. Also used for FLASH programming.
17	NC	Solder to open circuit for mechanical stability. **Do not** connect to GND.
18	NC	Solder to open circuit for mechanical stability. **Do not** connect to GND.

***Note:** Grey boxes indicate a function is available only on a custom application basis. NC means "no connection".

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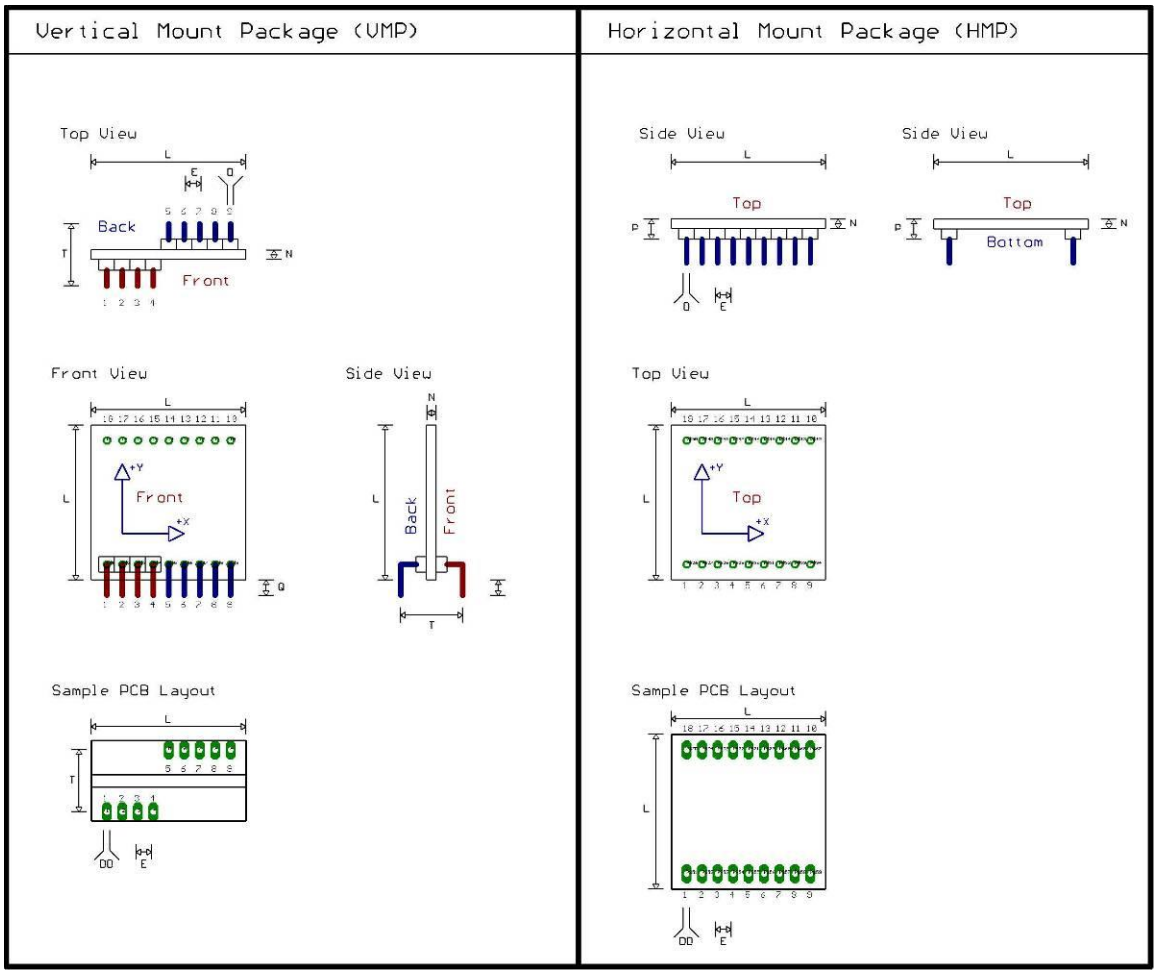
SQ-PTS SERIES PACKAGES



DIMENSIONS

DIMENSION	MILLIMETERS	INCHES	DESCRIPTION	NOTES
T	10.16	0.40	N/A	Pin center to center
L	25.40	1.00	Side length	
E	2.54	0.10	Pitch	Pin center to center
D	0.80	0.032	Pin diameter	
DD	1.00	0.040	Hole diameter	
N	1.63	0.064	PCB thickness	
S	20.32	0.80	Pin row spacing	Not shown on drawing

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DESIGN, LAYOUT, AND ASSEMBLY CONSIDERATIONS

1. Since the device is a subassembly of surface mount components, it is not suitable for automatic assembly or wave soldering.
2. Hand soldering of pins or SMT pads is specified for 3 seconds at 218 ºC.
3. Pins labeled NC (no connect) should be soldered to open connection pads / pins for mechanical stability.
4. The designer should test the device's output voltage through its entire desired angle range during prototyping to ensure that it is working properly in the application.
5. The device can be mounted vertically or horizontally, but the direction must be oriented correctly to measure the desired angles.
6. It is recommended that pins designated "future" be connected for forward compatibility.

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ORIENTATION

TERMINOLOGY

Gravity means a vector pointing from the device toward the center of the earth.
X means a vector parallel to the white silkscreen arrow "X" printed on the main circuit board.
Y means a vector parallel to the white silkscreen arrow "Y" printed on the main circuit board.
Z means a vector passing through the white silkscreen dot "Z" printed on the main circuit board, at 90º to the board.
Horizontal means the silkscreen arrow is pointing at a right angle to Gravity.
Straight Down means the silkscreen arrow is parallel to Gravity.
Straight Up means that the silkscreen arrow is anti-parallel to Gravity (i.e. pointing toward the sky).
Plumb Line is a line with a weight on the end hanging straight down.

DUAL AXIS TILT MODE

In Dual Axis Tilt Mode the X Tilt and Y Tilt angles are measured between Gravity and the white silkscreen arrows printed on the main circuit board. If you passed a Plumb Line through the inclinometer's X, Y, Z origin, the X and Y Tilt angles could be measure by placing a protractor's straight edge on the plum line and then reading the angles made with each arrow.

Y Tilt = Pitch (first angle)
X Tilt = Roll (second angle)

Holding Y Horizontal

When X is Horizontal, X Tilt = 90 º.
When X is Straight Up, X Tilt = ~180 º.
When X is Straight Down, X Tilt = ~0 º.

Holding X Horizontal

When Y is Horizontal, Y Tilt = 90 º.
When Y is Straight Up, Y Tilt = ~180 º.
When Y is Straight Down, Y Tilt = ~0 º.

SINGLE AXIS GIMBALED MODE

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In Single Axis Gimbaled Mode, the Z Rotation angle is defined as a rotation *about* the Z axis of the device. Typically, the inclinometer will be mounted using the VMP package for Single Axis Gimbaled Mode operation. For the Z Axis Rotation angle to remain in range, the Z Axis must be near horizontal. The Z axis should be kept to less than ± 45 º of deviation from horizontal.

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When X is Horizontal, Y is Straight Up, Z Rotation = 0 / 360 º.
When Y is Horizontal, X is Straight Down, Z Rotation = 90 º.
When X is Horizontal, Y is Straight Down, Z Rotation = 180 º.
When Y is Horizontal, X is Straight Up, Z Rotation = 270 º.

IMPORTANT NOTES

- Regardless of the mode, the inclinometer measures angles with respect to gravity. It cannot measure rotation about the gravity vector. All rotations about gravity are *invisible* to the sensor and are considered equivalent.

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ORDERING GUIDE

OPTIONS	CODE	OPTION	NOTES
Power regulator option	-NR	No onboard regulator	Special order only
	-3.0R	3.0 V onboard regulator	Special order only
	-3.3R	3.3 V onboard regulator	Standard version (stock)
Pin package option	-HMP	Horizontal mount package	Fits into standard 0.100" grid circuit board
	-VMP	Vertical mount package	Available for SQ-SI family only
	-NP	No pins installed	Fits inside potting box enclosures (SQ-ENCL-1)
Performance option	-HP	High performance	Better if power consumption is not a primary concern
	-LP	Low power	Better if low power consumption is critical
Accuracy	-IND	High accuracy	Suitable for industrial applications needing precise measurement
	-LC	Low cost	Suitable for high volume, lower accuracy, cost sensitive applications
Damping option (used for HP and LP version only)	-S	500 mS settling time	Better noise rejection, slower response time – This model uses a 0.5 second moving average filter to provide digital damping. This reduces the impact that spurious accelerations and vibrations have on the angle reading. This model will reject noise better than the "F" model, but with the tradeoff of a slower response time.
	-F	100 mS settling time	Faster response time, poorer noise rejection – This model uses a 0.1 seconds second moving average filter to provide digital damping. This model will respond more quickly to changes in angle than the "S" model, but with the tradeoff of poorer noise rejection.
Triggering	-XTRIG1	Specify angle and axis	High impedance output i.e. low drive current
	-YTRIG2	Specify angle and axis	
	-XTRIG3	Specify angle and axis	Low impedance output i.e. high drive current.
	-YTRIG4	Specify angle and axis	

X20 means trigger will trip when X Tilt is >= 20 degrees from horizontal in either direction.

Y10 means trigger will trip when Y Tilt is >= 10 degrees from horizontal in either direction.

Hysteresis	-HYST	Specify hysteresis angle	H2 means hysteresis of 2 degrees i.e. triggers trips at TRIG angle, but un-trips at (TRIG – 2 degrees).	

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RoHS (lead free)	-E	RoHS complaint, lead free	Special order

EXAMPLE PART NUMBER

SQ-PTS-3.3R-HMP-HP-IND-X1-Y1-X22-Y22-H2

ACCESSORIES

PART NUMBER	DESCRIPTION
SQ-ENCL-1	▪ Potting box enclosure. Fits models without pins installed (-NP option).

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LIMITATIONS AND WARNINGS

LIFE SAFETY

This product is not designed for use in life support and/or safety equipment where malfunction of the product can reasonably be expected to result in personal injury or death. Buyer uses this product in such applications at Buyer's own risk and agrees to defend, indemnify, and hold harmless SignalQuest, LLC. from any and all damages, claims, suits, or expenses resulting from such misuse.

DYNAMIC ENVIRONMENTS

The device is designed to be used to measure angles in a quasi-static environment where external vibrations and accelerations are kept to a minimum. Digital and analog signal processing methods are employed to reduce the effects of transient acceleration and small vibrations on the angle reading; however, under dynamic conditions where external accelerations or vibrations are present, the sensor's performance may be degraded.

VARIATIONS IN EARTH'S GRAVITY

This device is designed to be used near the earth's surface only. Substantial changes in gravity will degrade the performance of the sensor. This device is not intended or qualified to be used in aviation.

TESTING

The performance of each system is verified through build-time testing. Each system is tested before and after factory calibration to ensure reliable performance.

SYSTEM INTEGRATION TESTING

Thorough testing should be carried out prior to product release to insure system integration has not introduced unforeseen problems. The system integrator assumes the ultimate responsibility for the safety of the target application.

NOTICE

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FURTHER INFORMATION

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