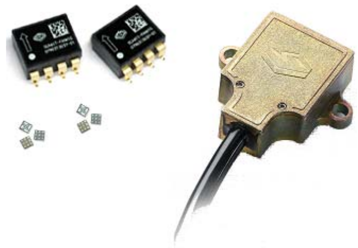
TILT SENSING



OBJECTIVE

Using an inclinometer to measure something is horizontal, vertical or at a certain angle.

DESCRIPTION OF APPLICATION

In many applications it is desirable to make sure that something is vertical or horizontal relative to earth's gravity field. In many countries, for example there are regulations relating to lifts or cranes that require some kind of tilt monitoring. This is particularly important for equipment used for human transportation. Off-road vehicles need tilt information to avoid accidents or to keep some critical part at a certain angle. Some vehicles like self-inclining trains use tilting to compensate for centrifugal acceleration. Here the inclinometer helps to keep the gravity force perpendicular to the floor. Optical instruments such as planar lasers often need to be horizontal or vertical. In many cases there is a need to measure tilt in two perpendicular directions.

RECOMMENDED PRODUCTS FOR THE APPLICATION

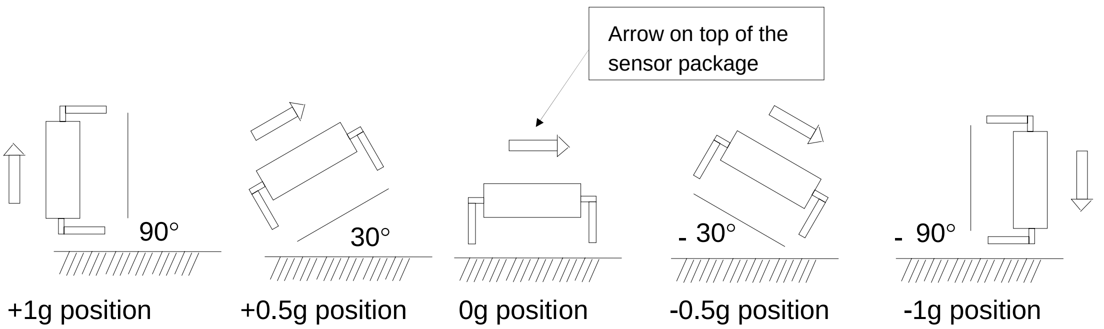
Three device series are applicable. The SCA61T- Series is for single-axis measurements and the SCA100T-Series is for dual-axis measurements. The SCA103T-Series is for highly accurate single-axis measurements. The SCA610-C23H1G or SCA610-C28H1G can be used in special cases where there is the need for a rapid dynamic response.

These are printed circuit board (PCB) mountable components in pre-moulded plastic packages and have their measurement direction parallel to the plane of the (horizontally mounted) PCB. They differ from each other in the measuring range and frequency response:

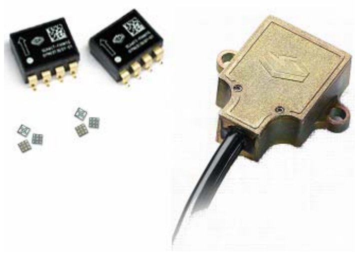
SCA61T-FAHH1G with 4V/g having ±0.5g ⇔ ±30° and the –3dB point at min. 8Hz,
SCA61T-FA1H1G with 2V/g having ±1g ⇔ ±90° and the –3dB point at min. 8Hz,
SCA610-C23H1G with 1.333V/g having ±1.5g ⇔±90° and the –3dB point at min. 20Hz and
SCA610-C28H1G with 1.2V/g having ±1.7g ⇔±90° and the –3dB point at min. 20Hz respectively (1g = acceleration of free fall in earth's gravity field = 9.8m/s2)

PRINCIPLE OF OPERATION FOR VTI'S PRODUCTS

VTI's products are accelerometers and measure the component of earth's gravity in the measuring direction (indicated by the arrow). This means that the output is proportional to 1g * SIN (Phi), where Phi is the inclination angle relative to the 0g position.



VTI TECHNOLOGIES



ACCURACY CONSIDERATIONS

Main error components are:

1. Zero Point Error
   In most cases the most significant error component is the zero point error. In the range –25 … +85°C it is ±10mg (6δ limit) and the temperature dependence is typically ±0.1mg/°C. The room temperature variation can be reduced by calibration at an instrument level (field calibration).

2. Error Caused by the SIN Function
   When used as an inclinometer the output of the accelerometer is proportional to 1g * SIN (Phi + Phi0), where Phi is the inclination angle and Phi0 the internal mounting error. The internal mounting error is maximum of ±2.9° corresponding to ±50mg. This error is of importance, when using large inclination angle amplitudes and is seen as an addendum to the non-linearity (Typically ±5mg in ±0.5g and ±10mg in ±1g).

3. Sensitivity Error
   The sensitivity error is ±1,5% (-25 … +85°C), resulting in maximum ±20mg in FAHH1G and ±40mg in FA1H1G.

4. Cross-axis Sensitivity
   The cross-axis sensitivity (5%) shows how much perpendicular acceleration or inclination is coupled to the signal. It has the same source, i.e. mounting error, as item 2).

5. Rectification of Vibration
   The effect of high frequency vibration is strongly suppressed by the over-damped sensing element (upper cut-off freq. f_{-3dB} = 2 … 10Hz). In an extreme case high amplitude vibrations (>5g) may cause a measurable zero point shift.

6. Ratiometric Error
   For the best performance the supply voltage should be kept at 5V or at a stable voltage in the range 4.75 … 5.25V. If the supply voltage changes, it may result in a maximum error of 2%, i.e. for FA1H1G @ +5V => 5±0.25V a maximum of 5mg error from the Vdd/2 value.

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