Opto-mechanical Orientation Sensor SFH 7710
Application Note

Abstract

This application note describes the function and operation of the orientation sensor SFH 7710.

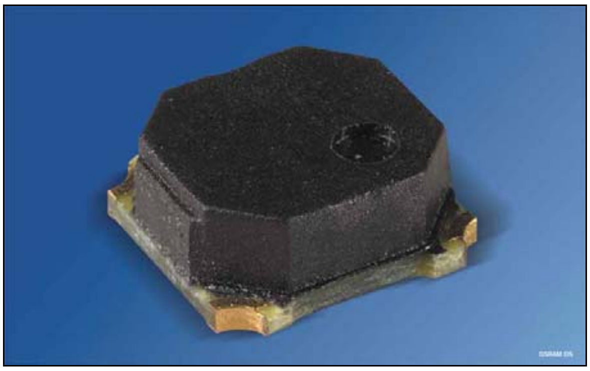


Figure 1: The orientation sensor SFH 7710

Introduction

The SFH 7710 is an opto-mechanical orientation sensor which detects vertical upright and horizontal orientations. It is based on a moving mass (a steel ball) which is controlled by gravity. The position of the ball corresponds to the orientation of the sensor. It is detected by a light barrier at one end of the ball's path (Figure 2). The light barrier consists of a phototransistor (PT) and a light emitting diode (LED). If the phototransistor is unblocked, it receives light and generates a photocurrent. An ASIC pulses the emitter, measures the photocurrent during the emitter on-time and sets the tilt sensor output to ground (ball is blocking the light) or to open drain (ball is not blocking the light). Therefore a pull up resistor is needed to provide high voltage under open drain condition. In order to limit the output current of the sensor when the output is low, the pull up resistor should be 10kΩ or 100kΩ.

The sensor has the following features:

- Digital output signal
- Operating voltage 2.3 to 3.6V
- (4.4 x 4.4 x 1.8)mm SMT package
- Low current consumption

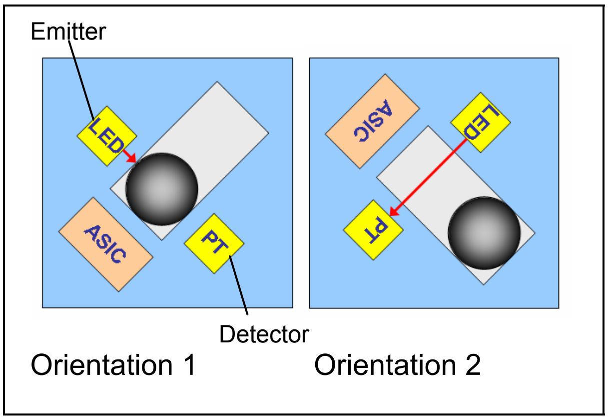


Figure 2: Function of the SFH 7710
Orientation 1: Light path is blocked by ball
Orientation 2: Light reaches the detector

This application note describes the function of the sensor. For further technical data please refer to the datasheet.

Applications for orientation sensors

Orientation Sensors are designed to detect the orientation of an electronic device they are implemented in. They can be used wherever there is a need to know if a device is vertical or horizontal:

- Digital cameras to automatically recognize whether pictures are taken in portrait or landscape format

- Portable devices with displays in order to rotate the image according to the device's orientation (Figure 3)
- Devices which need a defined horizontal position to operate (e.g. electronic compass)
- Any application in which the distinction between horizontal or vertical upright positions matter.

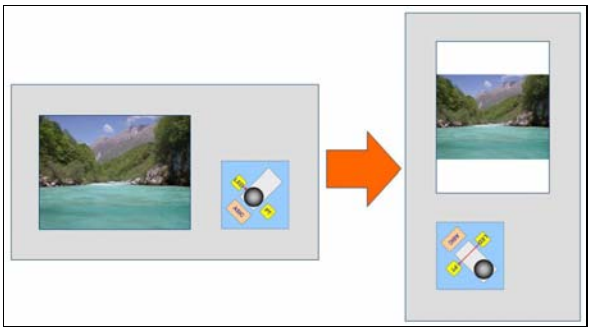


Figure 3: Image orientation in displays is a typical application of orientation sensors

Operation of the SFH 7710

Figure 4 shows a block diagram of the sensor and the operating circuit.

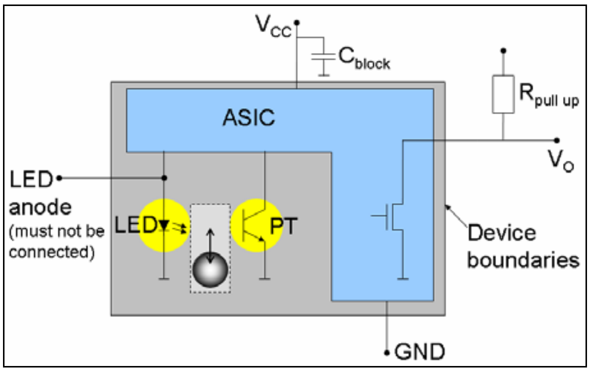


Figure 4: Block diagram of the sensor

To reduce the mean current consumption, an ASIC drives the emitter and detector in a pulsed operation mode. The analog signal of the phototransistor is amplified and converted by a Schmitt Trigger into a digital high/low signal, which is directly related to the orientation of the sensor. According to the output signal a latch is set. This latch keeps the state of the output transistor until the next active period of the emitter / phototransistor pair. Figure 5 shows the block diagram of the ASIC.

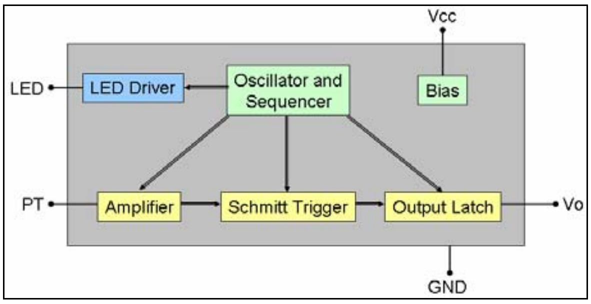


Figure 5: Block diagram of the ASIC

This way the sensor does not need any active external control. The open drain output can be read any time. When the supply voltage is disconnected, the output is in a defined state (open = high). To obtain a good reaction rate at low average current consumption the pulsed operating mode is designed to detect the state of the sensor every 90ms. A defined power start up sequence sets the output to low for the first 90ms after the sensor is connected to the supply voltage to allow a test of pin 1, 2 and 4. If any one of those Pins is not connected, the output stays high. For details of the power start up sequence, please refer to the datasheet. The output voltage V_O can differ from the supply voltage V_{CC} as shown in the data sheet.
The SFH 7710 is insensitive to an unstable power supply. It can handle voltage variations of 200 mV at a frequency range of up to 20 kHz. Generally it is advised to use a blocking noise reduction capacitor close to the sensor Vcc pin. Depending on the application, the size of this capacitor may vary between 100 nF and 1 µF (Figure 4).

Tilting behaviour of the sensor

The output signal of the sensor is controlled by a moving steel ball, which interrupts the light barrier when the sensor is tilted in one direction (Figure 2). Mechanical friction causes an undefined hysteresis effect.

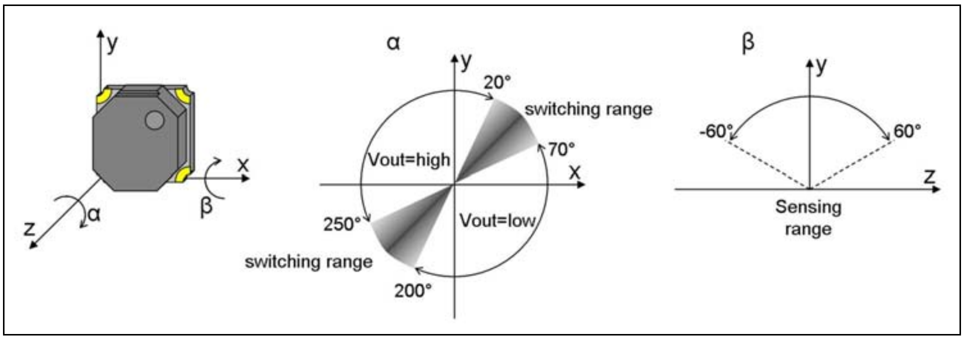


Figure 6: Switching behaviour of the SFH 7710:
α denotes the switching angle; β denotes the incline to the vertical plane.

Figure 6 shows the two defined states of the sensor in relation to the tilt angle α relative to the shown sensor orientation at left. Between 250° and 20° and 70° and 200°, the sensor is set to V_o "high" and V_o "low", respectively. At angles between 20° and 70° or 200° and 250°, the status is undefined. Because the sensor function is based on the force of gravity, it does not work in a horizontal position. A maximum incline angle β of 60° / -60° between the sensor and the vertical is required to ensure its functionality (Figure 6). Due to the mechanical hysteresis, the actual switching angle and thus the output signal depends on the tilting direction: When turning the sensor from a vertical to a tilted position (Figure 7), the switching angle is between 45° and 70°. In the other direction (horizontal -> vertical) it is between 45° and 20°.

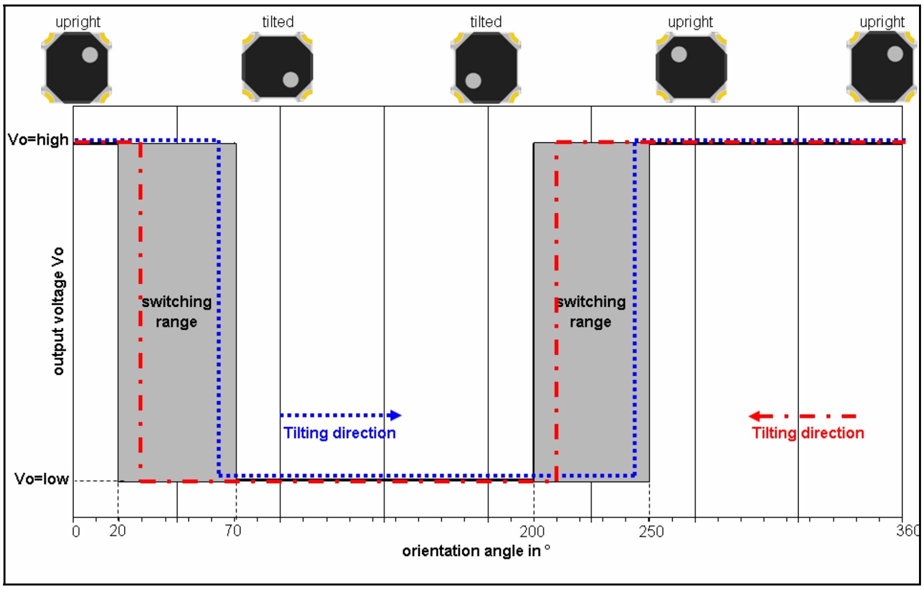


Figure 7: Switching behaviour of the SFH 7710: dependence of the switching angle on the tilting direction.

Placement of the sensor

A mark on the cover of the SFH 7710 indicates the orientation of the sensor. The upright orientation is indicated by the orientation mark in the upper left or upper right corner (Figure 8). As a default position of the sensor an upright orientation is suggested.

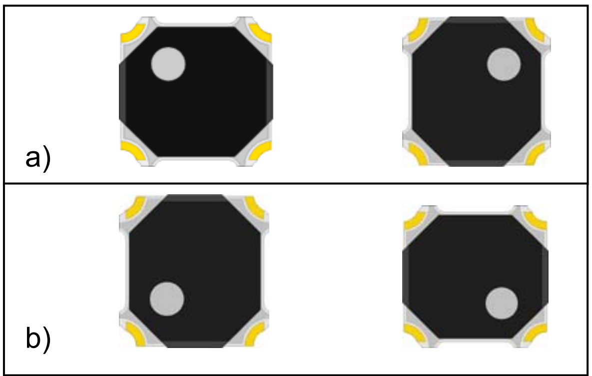


Figure 8: The SFH 7710 in a) upright positions and b) tilted positions

In this state the output transistor is blocked (high impedance) so that there is only a very small leakage current (< 1µA) through the output pin. Therefore the overall power consumption is minimized.
Figure 9 shows the location of the ball track relative to the orientation mark.

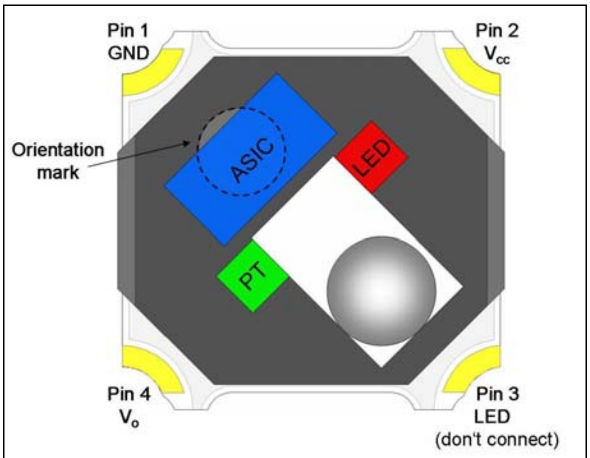


Figure 9: Position of the orientation mark relative to the ball track

The Sensor is insensitive to magnetic fields.

Figure 10 shows the orientation of the SFH 7710 in the tape.

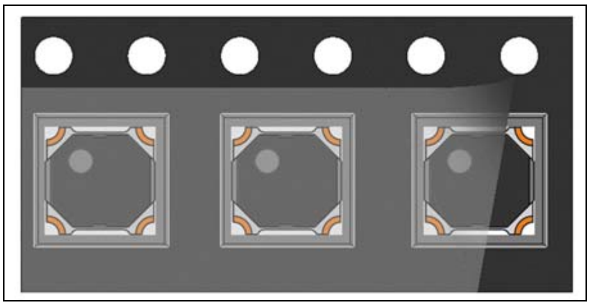


Figure 10: Orientation of the SFH 7710 in tape.

Due to its compact package design the sensor is limited to detect one tilt direction, as illustrated by Figure 11. It takes two sensors for applications where vertical and horizontal directions need to be detected. This provides flexibility to designs where the detection of non-perpendicular directions is required. A design engineer can place two sensors according to the wanted orientation.

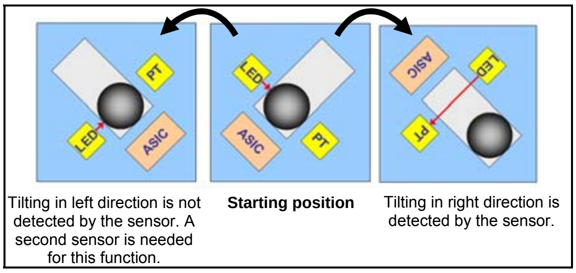
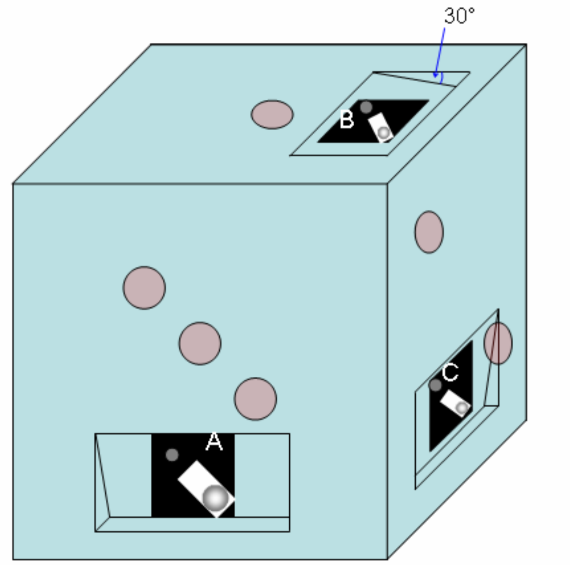


Figure 11: The compact SFH 7710 detects tilting in one direction.

The following example (Figure 12) shows how to detect all three dimensions with three SFH 7710 orientation sensors. To make sure the ball is in a defined position when the part is lying flat the sensors are mounted with an incline of 30°.



pips / sensor	1	2	3	4	5	6
A	1	0	1	0	1	0
B	1	0	0	1	1	0
C	1	1	1	0	0	0

1: output transistor is open => V_o = high.
0: output transistor is closed => V_o = low

Figure 12: The orientation of a dice is detected by three sensors

Main characteristics of the SFH 7710

Table 1 summarizes the main characteristics of the SFH 7710. For further details, please refer to the datasheet.
The device is RoHS compliant.

Parameter	Value
Size L x W x H [mm]	4.4 x 4.4 x 1.8
Switching angle [deg]	20 … 70 200 … 250
Supply voltage [V]	2.3 … 3.6
Mean current consumption [µA]	50 max.

Table 1: main characteristics of SFH 7710

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