SQ-SEN TILT SENSORS

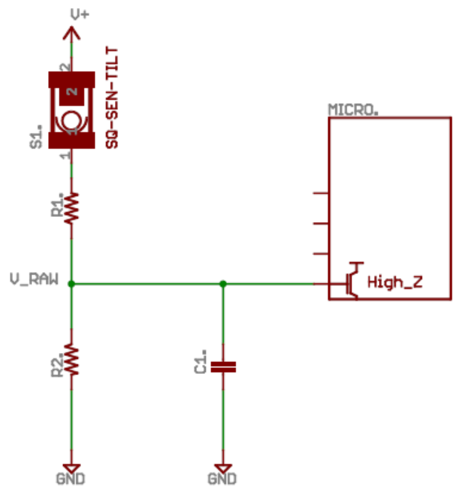
APPLICATION NOTE | **DEBOUNCE, LOW PASS FILTER AND TRIGGER**

APPLICATIONS

- Tilt detection
- Security
- Screen orientation

HIGHLIGHTS

- Strong debounce filter
- Superior performance rejecting spurious bumps / tilting
- No firmware debounce required
- Trigger tunable from 0.001 - 2 seconds
- Ultra low power
- Passive cost ~$0.02 at 10K
- For use with SQ-SEN-3xx, 5xx, 6xx, and 8xx series sensors

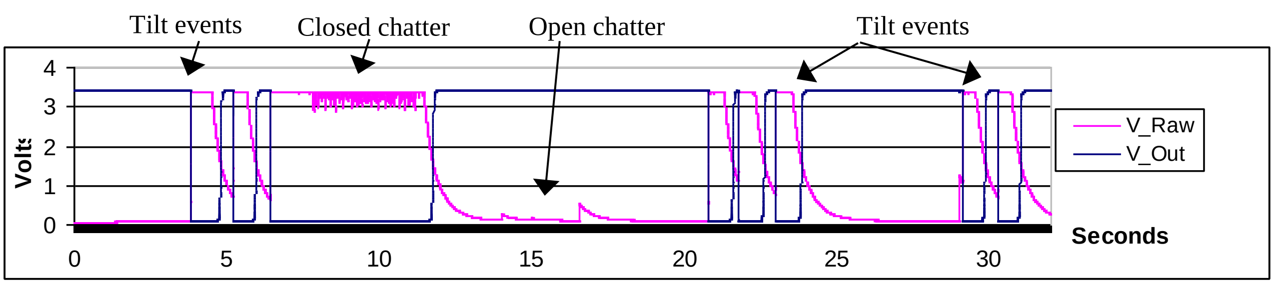


EXAMPLE OUTPUTS FROM VARIOUS SETTINGS

Example component values are provided on the following pages.

BEHAVIOR

Triggers after 0.001 seconds of closure event. Resets after 0.1 seconds of open state. Highly effective at eliminating switch chatter.



See notes on following page for test circuit.

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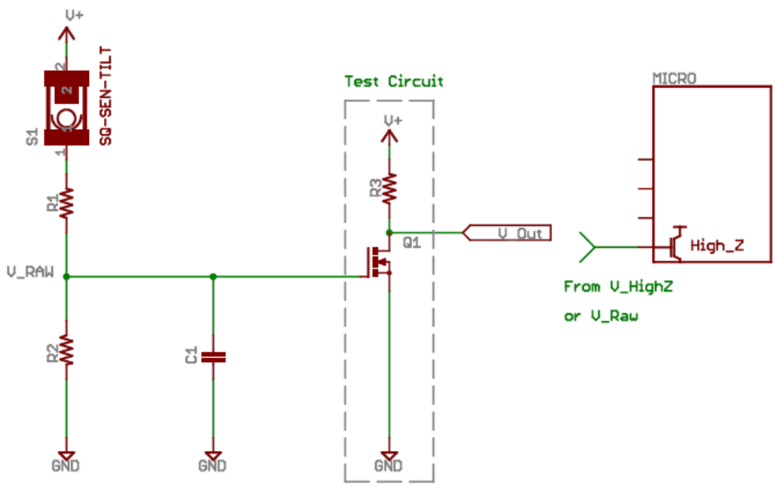
BUFFERING & TESTING



VALUES

Vcc = 3.3 V
R1 = 1 kΩ
C1 = 0.01 uF
R2 = 2.5 mΩ
R3 = 1 MΩ

COMPONENTS AND NODES

R1	Charges C1 and limits the continuous current drain through the sensor and. The RC time constant of R1*C1 controls how fast the circuit will trigger after the sensor is closed. By using a small value for R1, a very fast response to a closed signal can be achieved.
R2	Leaks stored charge off of C1 and limits the continuous current drain through the sensor. The RC time constant of R2*C1 controls how fast the circuit will rest after the sensor is opened. Because the circuit is designed for ultra low current, a large value of R2 is desirable (to limit continuous current drain). Accordingly, R1 needs to be much smaller than R2 so the R1-R2 ration (voltage divider) allows full swing voltage to occur. If R1 is too large, the voltage on C1 will not climb high enough to trigger the base of the Q1. Typical FET turn on voltage is about 1.7 V.
C2	Provides low pass filtering. The time constant for charging (when the sensor is closed) is equal to R1*C1. The time constant for discharging (when the sensor is open) is equal to R2*C1. Low leakage capacitors can improve performance.
Q1	The FET provides an ultra high impedance input for detecting the voltage accumulated on C1. When the C1 voltage crosses the FET trigger voltage, it will change state from open to closed or visa versa. A low cost N-channel FET is suitable such as the 2N7000 or 2N7002. The cost is around $0.02 at 10K.
R3	Since the circuit is designed to guarantee the FET will be open when the sensor is at rest in an open state, the value of R3 can be relative low. A good starting point would be to use a value of 100K for R3.
MICRO	If interfacing to a microcontroller, the impedance of its input pin needs to be very high. Pull ups should be disabled. If the input impedance is not high enough to achieve a high Z/R1 ratio, then pin can be driven with V_Out from the FET (seen in example).

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BEHAVIOR

At rest, Q1 will have a guaranteed high (open) output and will produce a low going signal when the switch is closed. A key feature of this circuit is that it will always settle in a low current (open) when the sensor is at reset in its open position. If a normally low output is desired, then R3 can be moved to the emitter side of the FET.

NOTES

The Test Circuit above should be use to verify correct functionality and sensitivity. By measuring V_Out with an oscilloscope, an intuitive understanding of the circuit's behavior can be gained.

Measuring V_Raw with a standard oscilloscope or voltage meter **WILL DRAMATICALLY ALTER** the behavior of the circuit. Typical oscilloscopes have input impedance from 1M to 10M and this will load the high impedance node causing severe voltage droop. This is why the Test Circuit shown above is recommend for prototyping.

In many applications, connecting the output of the FET (V_Out) to the host microcontroller's input pin provides improved performance when compared to using V_Raw.

NON-MICROCONTROLLER APPLICATIONS

Applications that do not make use of a microcontroller can also be constructed from the above circuit. By replacing R3 with a LED, buzzer or other load, a simple movement detection indicator can be constructed. Depending on the choice of the Q1 FET, higher loads can be driven (i.e. connecting power direly to a GPS receive unit, turning on a motor etc.).

TUNING

To increased time the switch-opening time constant, increase R2 or C1. If using the FET buffer typical values for R2 from are 1 MΩ to 10 MΩ. If driving a microcontroller pin directly, the practical limit for R2 might be in the 5 MΩ range depending on the input impendence of the pin. If the switch-opening time constant is not fast enough, you can lower the C2 value – but this will reduce the chatter damping. A good balance can be achieved between noise rejection and response time.

The value for C1 is not critical. Values from 0.01 uF to 0.1 uF are suitable depending on the desired time constants.

The FET example can be used for Vcc down to about 2.0 V. Typical FET turn on voltages are around 1.7 V, but at reduced voltages the time constant will increase modestly.

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