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APPLICATION NOTE

Tilt Vibration Sensor

TVS0713.180

Revision 1.0 2014 September 16

Index

1. Sensor evaluation

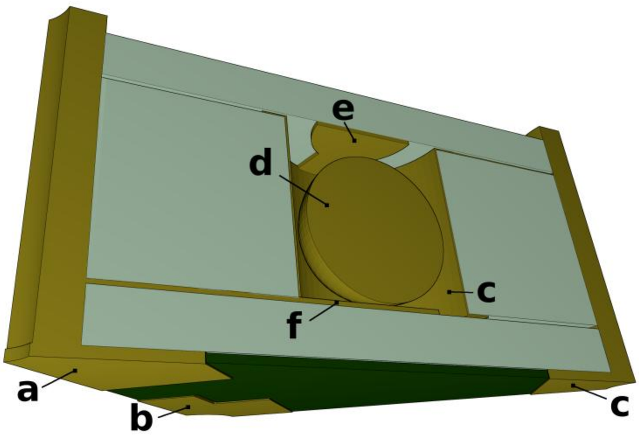

Figure 1: Tilt vibration sensor

a) Bottom connector
b) Top connector
c) GND connector
d) Micro ball
e) Top contact pad
f) Bottom contact pad

The tilt vibration sensor TVS0713.180 is **not necessarily closed** when **at rest**. Only in 70% - 99% of time it will be closed when at rest as shown in Figures 2 - 4. The circuit and/or the software of the electronic device should evaluate state changes from open to closed or closed to open instead of steady states open or closed.
If the sensor is at one DC-level (e.g. high), a slight vibration may cause the sensor signal to toggle. This fake motion cannot be filtered out by the “Small filter circuit” and has to be handled by the µC software. If a hardware solution is needed for this situation the DC part of the signal has to be filtered out first by a high pass filter to get a defined rest state output.

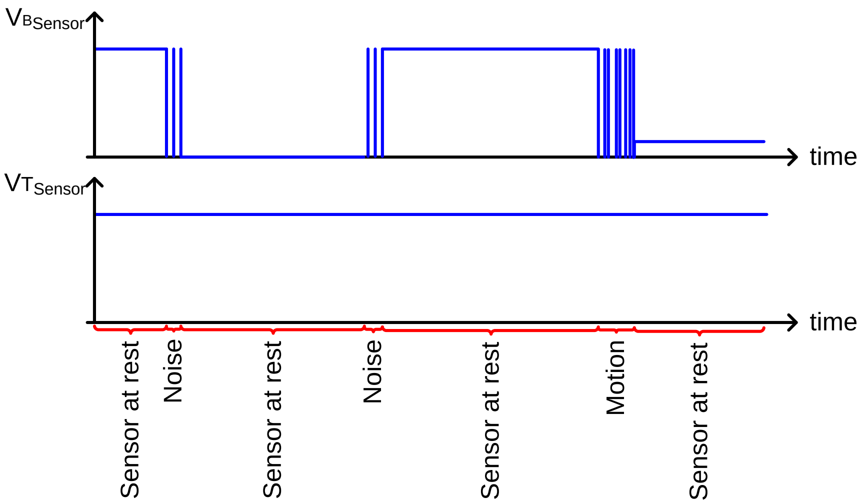

Figure 2: Tilt vibration sensor, contacts not necessarily closed at rest (idealized plot).
Top connector on idle during sensor orientation between 270° and +90°

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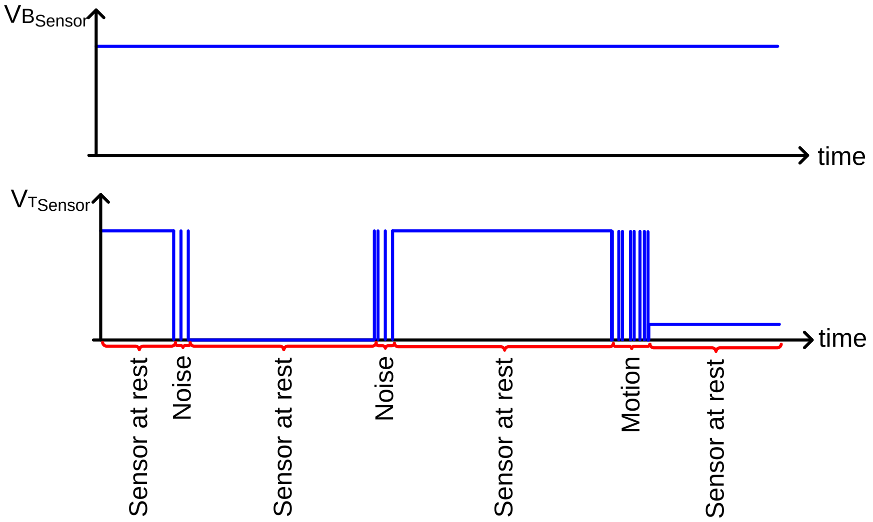


Figure 3: Tilt vibration sensor, contacts not necessarily closed at rest (idealized plot).
Bottom connector on idle during sensor orientation between 90° and 270°

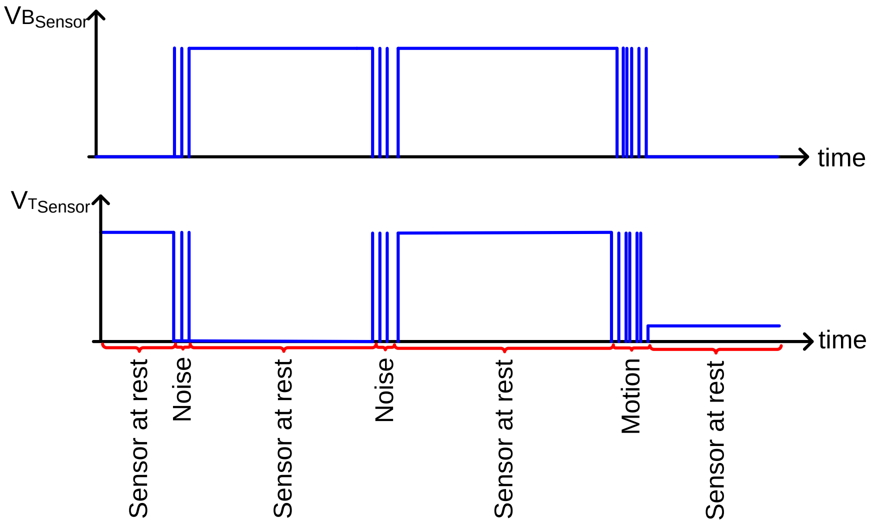
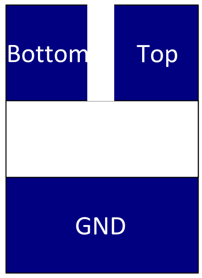
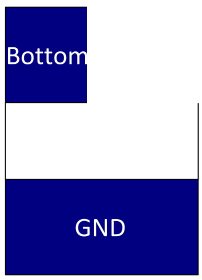


Figure 4: Tilt vibration sensor, contacts not necessarily closed at rest (idealized plot).
Both connectors are active in vertical (90° or 270°) position. Both can be open but not closed at the same time.

2. Operating modes

2.1 General description

There are four options available to connect the TVS0713.180.

TVS0713.180 **Mode description**	**TVS0713.180** **Electronic symbol**	**TVS0713.180** **Footprint**
Tilt vibration mode: The top connector of the Tilt vibration sensor is at idle as long as the ball is located on the contact pad of the bottom side (see Figure 2). When the sensor is turned upside down the ball will be in contact with the pad of the top side. In this case the bottom connector will be at idle (see Figure 3). Both connectors are active in vertical position of the sensor (see Figure 4) where the ball can roll between both of the pads. It is possible that both connectors are. But the micro ball can only close one connector at a time.		
Unidirectional bottom mode: If the top connector is unused the sensor will operate as a unidirectional sensor (see MVS1006.01). The sensor is open when mounted in upside down position, so that the micro sphere is on the top side of the sensor, which has no contact.		

<table>
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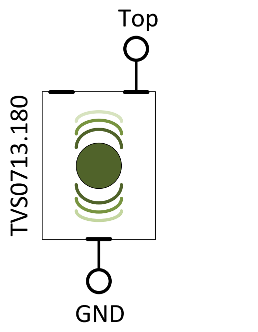
<td>Unidirectional top mode:
If the bottom connector is unused the sensor will operate as a unidirectional sensor (see MVS1006.01).
The sensor is open when not mounted in upside down position.</td>
<td>
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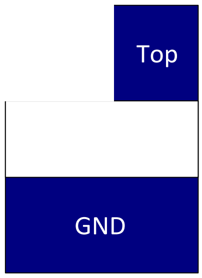
<td>
</td>
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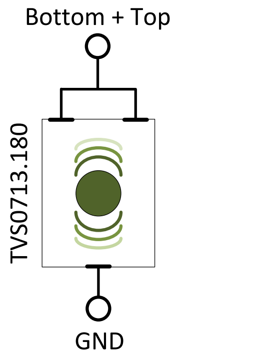
<tr>
<td>Omnidirectional mode:
When both connectors are shorted the sensor will operate as an omnidirectional sensor (see MVS0409.02 / MVS0608.02)
The orientation detection will be lost..</td>
<td>
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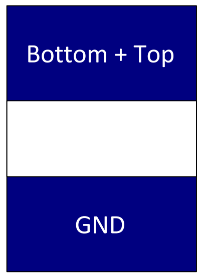
<td>
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3. Basic circuit

3.1 General description

The simplest circuit with a minimum of component requirement is shown in Figure 5.
R1 should be chosen to limit the maximum current through the sensor to a maximum value of 2 mA.

3.2 Basic Circuit

For each connector the signal processing has to be realized separately with the exception of the omnidirectional mode. The following circuits show the different operating modes for the TVS0713.180.

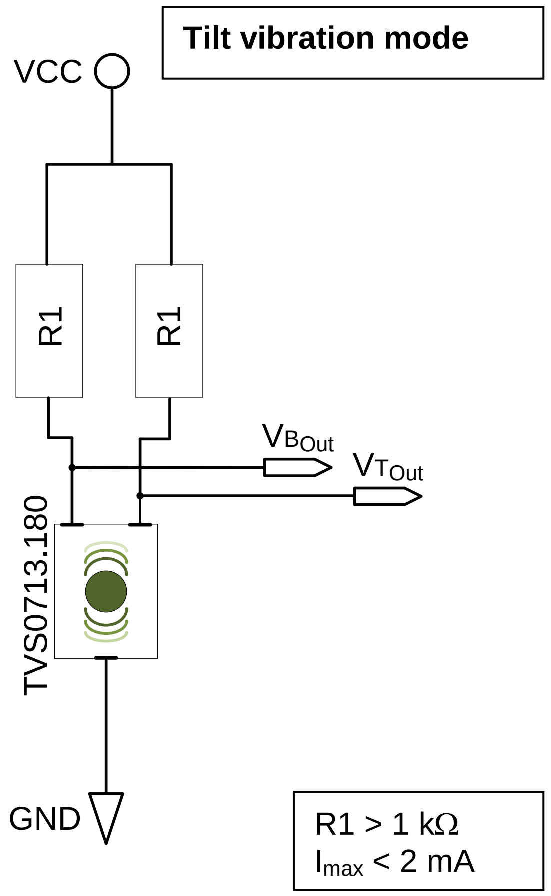

Figure 5: Basic circuit in Tilt vibration mode.

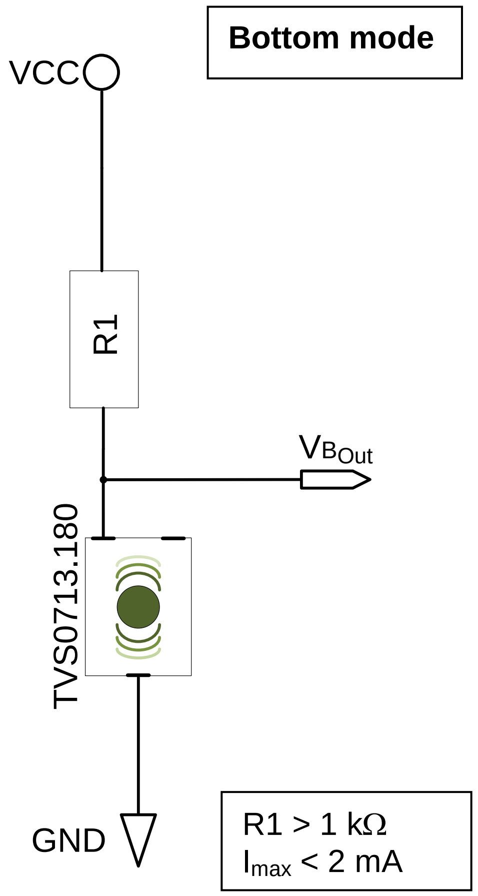

Figure 6: Basic circuit in Bottom mode.

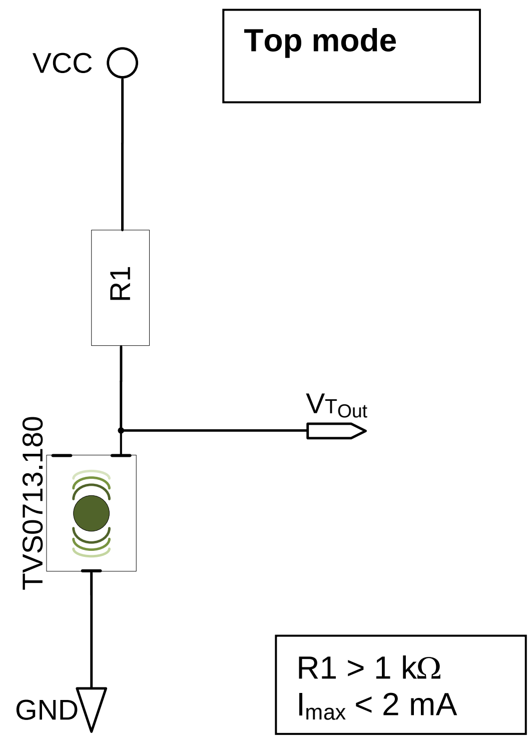

Figure 7: Basic circuit in Top mode.

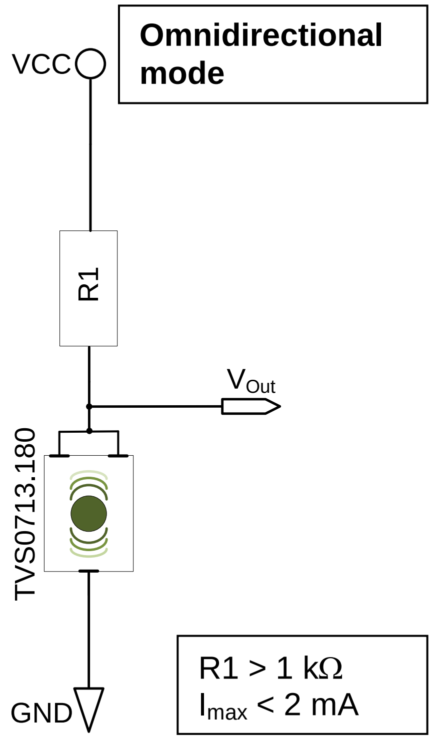

Figure 8: Basic circuit in Omnidirectional mode.

4. Filter Circuit

4.1 General description

In order to reduce the sensitivity of the sensor, a small capacitor can be added to the evaluation circuit presented in Figure 9. Additionally to the capacitor C1 a resistor R2 is applied, which limits the current through the sensor when the capacitor impedance is low.
For low power applications high values of R1 and R2 can be used to limit the current. If high resistor values are used, the circuit impedance must be considered. For the resistive voltage divider a good value of R1 is 5.1M, and R2 can be between 1 kΩ and 1 MΩ, depending on the desired output voltage swing.
C1 can be varied on a range of 10 pF to 1 nF for different filter options. A larger C1 value e.g. 100 nF will turn the peaks of the output into an analog average value shown in Figure 10.

4.2 Circuit

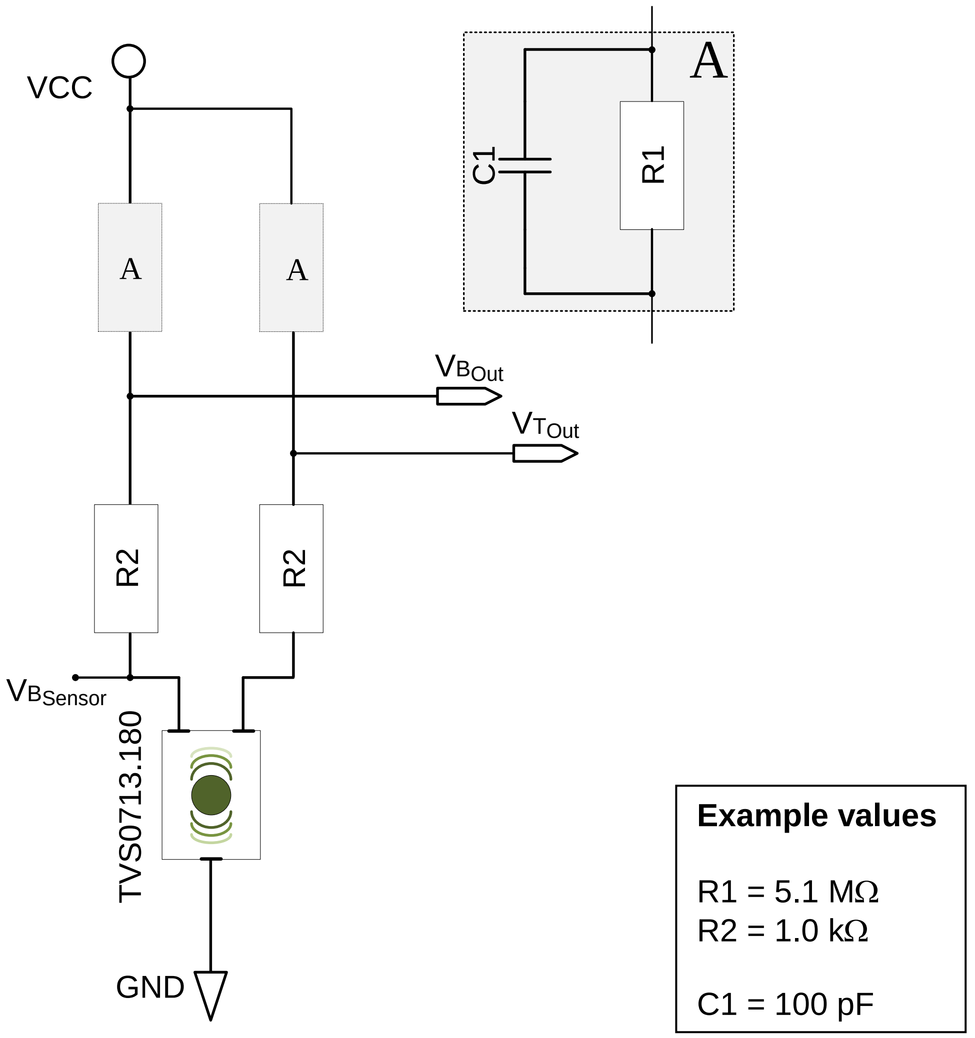

Figure
9: Filter Circuit for the Tilt vibration mode

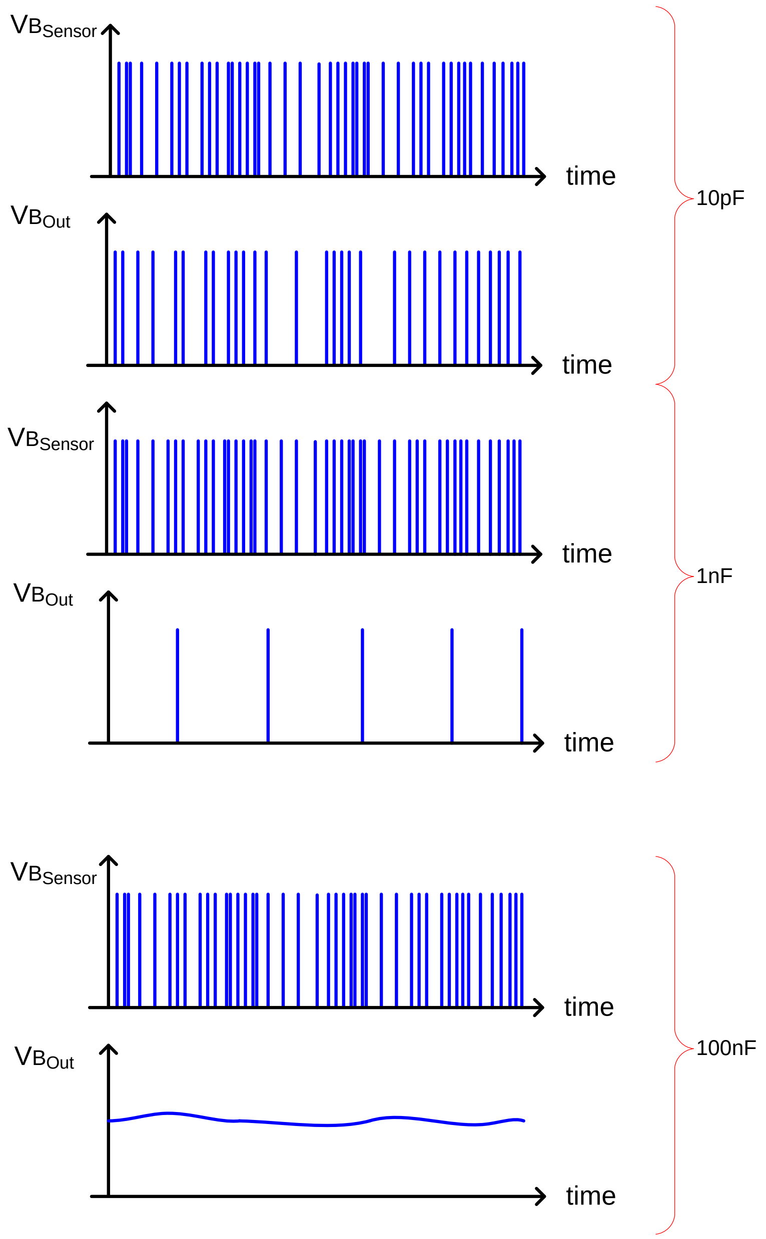

Figure 10: Function diagram. Idealized plot of the bottom connector.

5. Not recommended circuit

5.1 General description

It's not recommended to connect a capacitor from any supply directly to the sensor. When the sensing mechanism opens and closes, a large inrush current will occur. It will potentially damage the contacts and reduce life of the Sensor.

5.2 Circuit

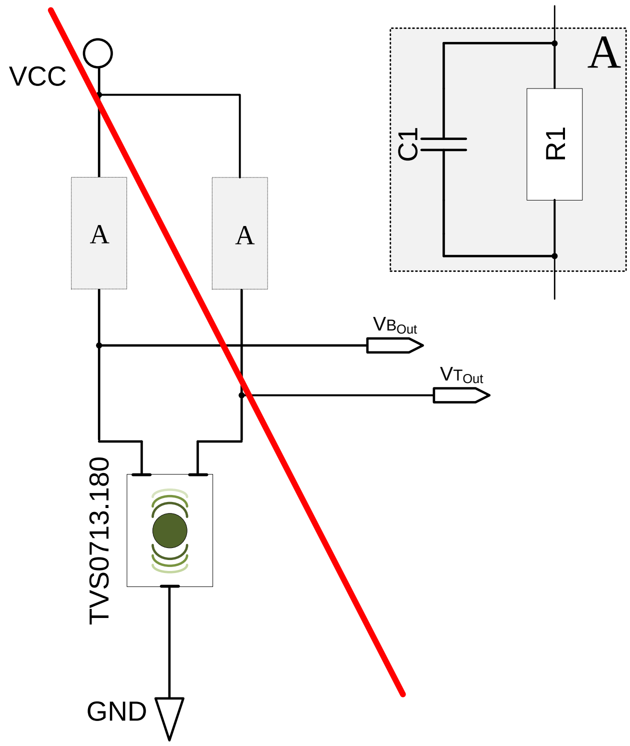

Figure 11: Not recommended circuit

6. Measuring Note

When measuring with an oscilloscope, it is recommended to use the 10 x probe with a high input impedance for circuit debugging. If 1 x probe is used, the additional resistance of the probe will interfere with the measurement and cause a large voltage drop.

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7. Defined rest state output

7.1 General description

The tilt vibration sensor is not necessarily closed when at rest. Only in 70% - 99% of time it will be closed when at rest.
This circuit depicted in Figure 12 can be used if the output signal needs to be **low** when the sensor is at rest.
For low power applications high values of R1 and R2 can be used to further limit the current, however the circuit impedance must be considered. Depending on the desired output voltage swing resistor values of 1 MΩ can be used for R1 and 1 kΩ for R2.
The capacitive voltage divider determines the filter characteristics. C2 should be ≥ 5•C1. A value of 100 pF for C1 keeps the high sensitivity of the sensor. A large C1 value e.g. 100 nF will turn the peaks of the output into an analog average value.

7.2 Circuit

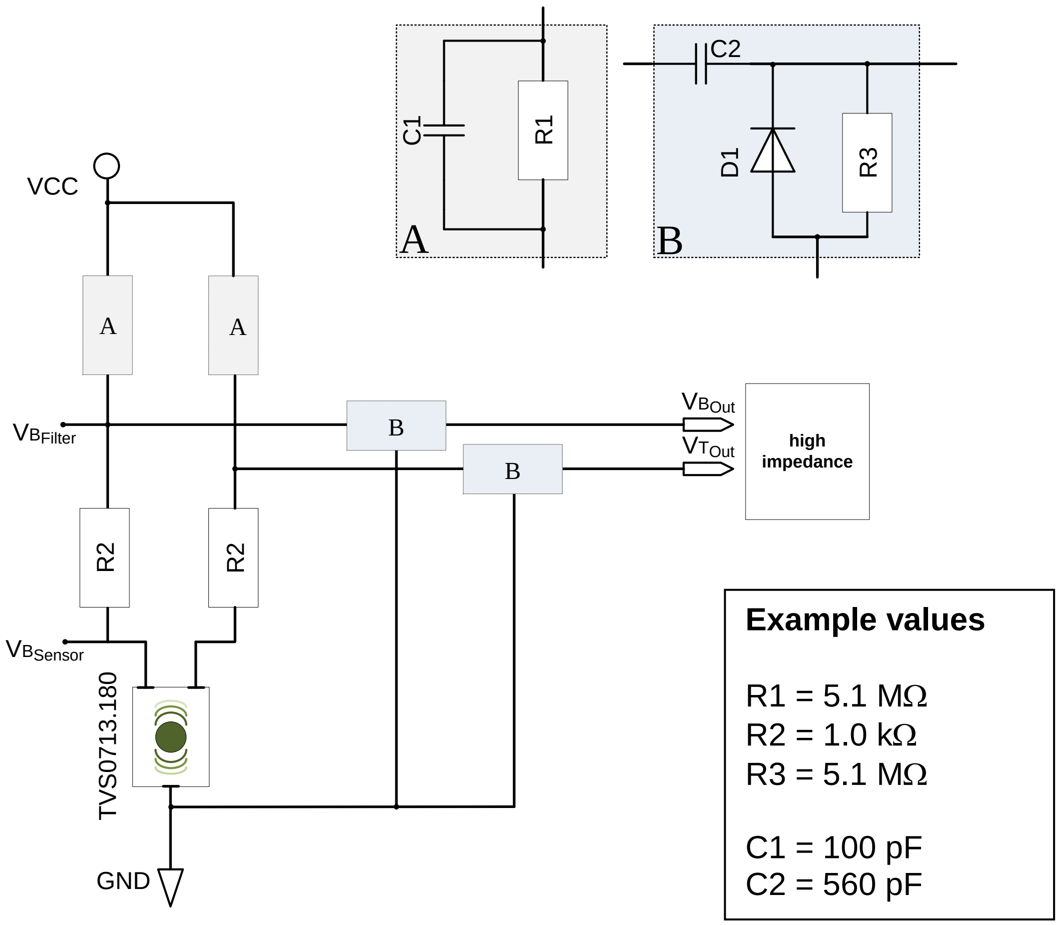


Figure 12: Defined rest state output for the Tilt vibration mode.

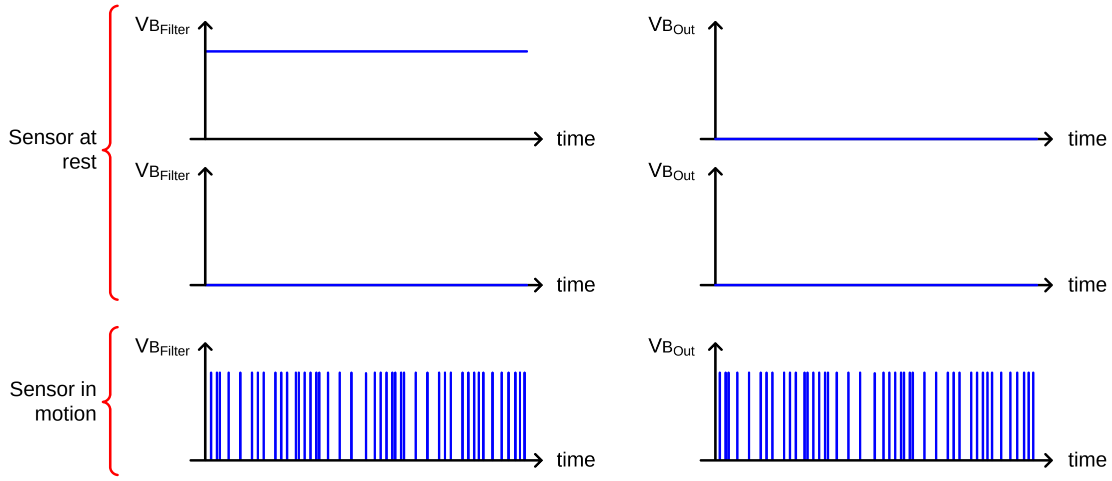


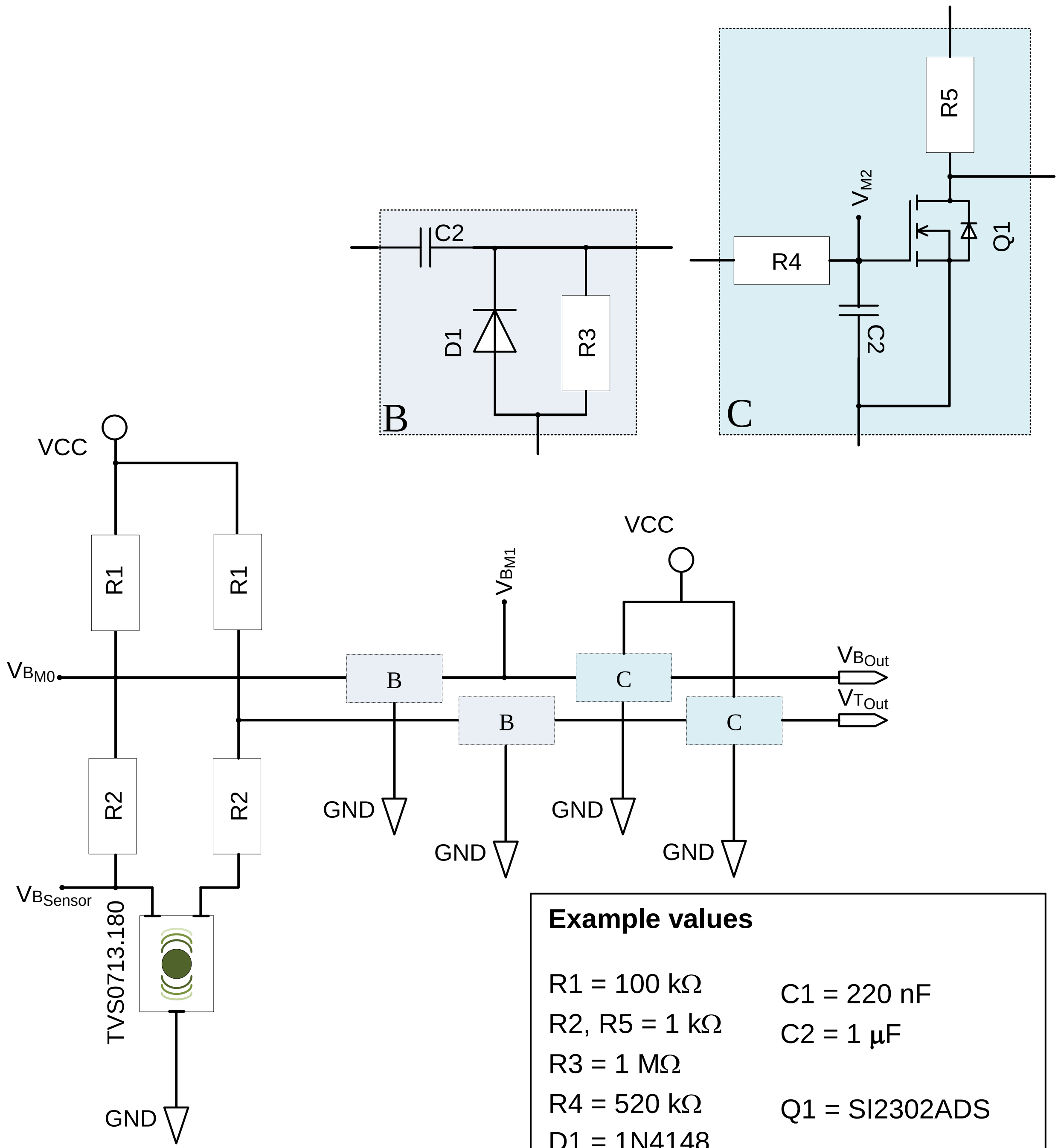
Figure 13: Function diagrams. Idealized plot of the bottom connector.

8. Delay circuit

8.1 General description

This circuit can be used, if the output signal needs to be **noise insensitive**, and **high** when the sensor is at rest (see Figure 14).
To increase the noise insensitivity, change the value of C2 in a range of 220 nF – 4.7 µF (for values ≥1 µF use tantal capacitors).
An increase of C2 increases the inactivity of the circuit. Therefore a longer excitation is required to reach the threshold voltages!

8.2 Circuit



Example values

R1 = 100 kΩ
R2, R5 = 1 kΩ
R3 = 1 MΩ
R4 = 520 kΩ
D1 = 1N4148

C1 = 220 nF
C2 = 1 µF

Q1 = SI2302ADS

Figure 14: Delay circuit for the Tilt vibration mode.

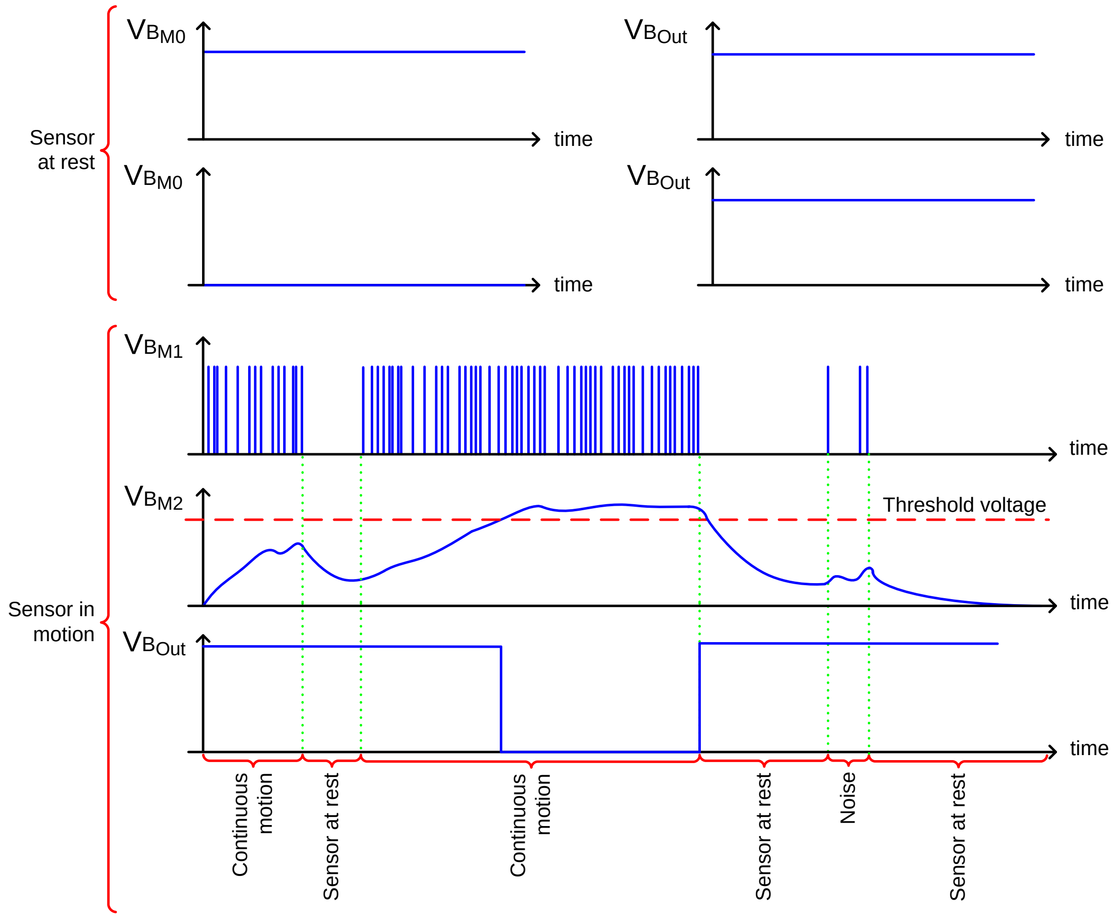


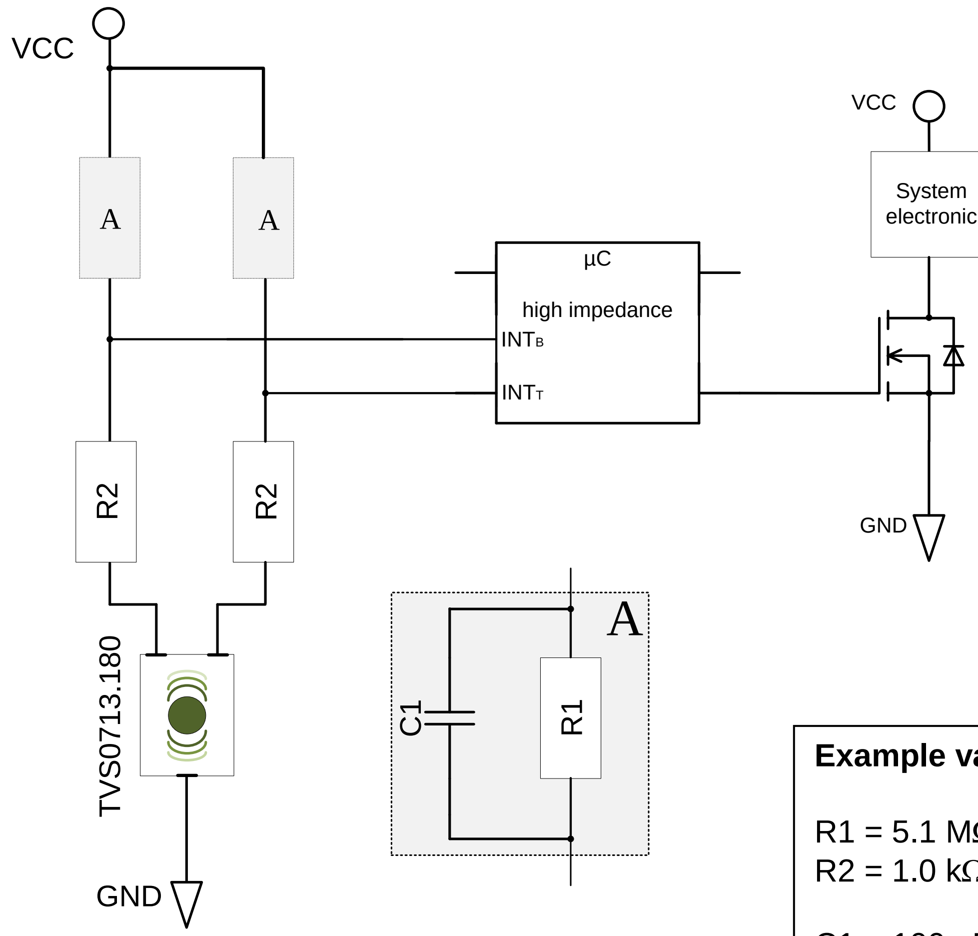
Figure 15: Function diagrams. Idealized plot of the bottom connector line.

9. Digital filter

9.1 General description

The Tilt vibration sensor is connected to a low power micro controller to activate consumer electronics systems while in motion. When the device comes to rest, it is powered down (or up) by the microcontroller after a short delay time. The whole system is able to enter an idle mode with a current consummation of less than 0.6 µA, depending on the micro controller used.
The algorithms digitally filter the sensor signal and allow easy adjustment of triggering sensitivity of the sensor to the applications requirement. Furthermore the algorithms eliminate the effect of sensitivity differences from sensor to sensor that naturally occur.

9.2 Circuit



Example values

R1 = 5.1 MΩ
R2 = 1.0 kΩ

C1 = 100 pF

Figure 16: Digital filter for the Tilt vibration mode.

9.3 Schematic

The micro vibration sensor is connected in series with a 5.1 MOhm resistor, limiting the current running through the sensor. If the vibration sensor detects motion, a trigger signal is sent to the micro-controller and a timer delay will be started. Now it will be checked if there is a pulse in a time slot of e.g. 500ms. If there is no pulse the microcontroller is falling back into sleep mode after a short time. If there is a pulse after 500ms, check the following 500ms for a pulse etc. If threshold is reached, switch to a high power state or alarm. Vary the time and the amount of the time slots for different applications.

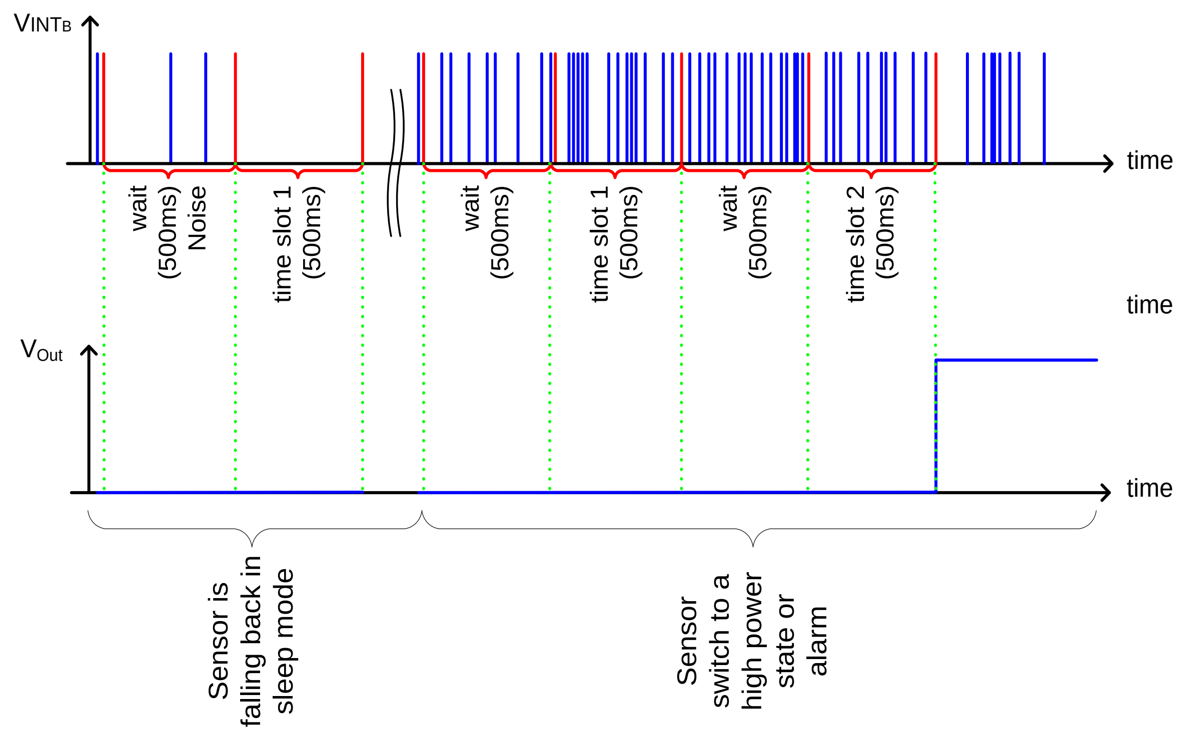


Figure 17: Function diagrams. Idealized plot of the bottom connector line.

9.4 Implementation

- Timer: Generating a timer of e.g. 500ms.
- Input: Vibration sensor connected to an interrupt pin of the microcontroller to trigger an edge while in sleep mode.
- On interrupt signal: Disable further ext. interrupts.
- On time slot: Check for further pulse in a time slot of 500ms. If pulse detected, increment pulse counter variable by 3. Every 500ms, decrement pulse counter variable by 1 to decrease the value over time.
- Theshold: If the predefined pulse counter reach the threshold of 4 (4*500ms = 2 seconds of motion), switch to a high power state or alarm.

Definitions and program

• pulse_counter = 0	counter variable
• inc_value = 3	constant value to be added when motion detection in time slot
• dec_value = 1	constant value to be substracted if no motion is detected
• max_counter = 8	constant value to prevent overflow
• threshold = 4	constant value to switch to a high power state or alarm 4 corresponds 2 seconds

- Initialize sleep_counter = 0
- Initialize pulse_detected = FALSE
- Initialize alarm = FALSE
- Initialize sleep_max_counter = threshold * 2

On interrupt signal

• Disable further ext. interrupts	// first impulse detected
• Timer delay of e.g. 500ms	// wait 500ms before checking for pulses

Do every 500ms

```
•  Check for pulses in a time slot of e.g. 500ms         // check for further pulses
•  If pulse_detected == TRUE
          If pulse_counter < (max_counter – inc_value)  // check for possible overflow
          pulse_counter = pulse_counter + inc_value      // increment pulse counter
•  If pulse_counter > dec_value                          // check for possible underflow
          pulse_counter = pulse_counter - dec_value      // decrement pulse counter
•  If pulse_counter >= threshold
          alarm = TRUE
          sleep_counter = 0
•  Else
          alarm = FLASE
          sleep_counter = sleep_counter + 1              //increment shutdown counter
•  If alarm == TRUE
          Alarm                                          // switch to a high power state
                                                         or alarm
•  If sleep_counter == sleep_max_counter
          Enable ext. interrupts
          Power down microcontroller                     // for max power saving
```

10. MOSFET Circuit

10.1 General description

To reduce the floating of the output please use the circuit below, by decoupling with a MOSFET, the situation is defused. Please note, when measuring with an oscilloscope, it is recommended to use the 10x probe for circuit debugging.

10.2 Circuit

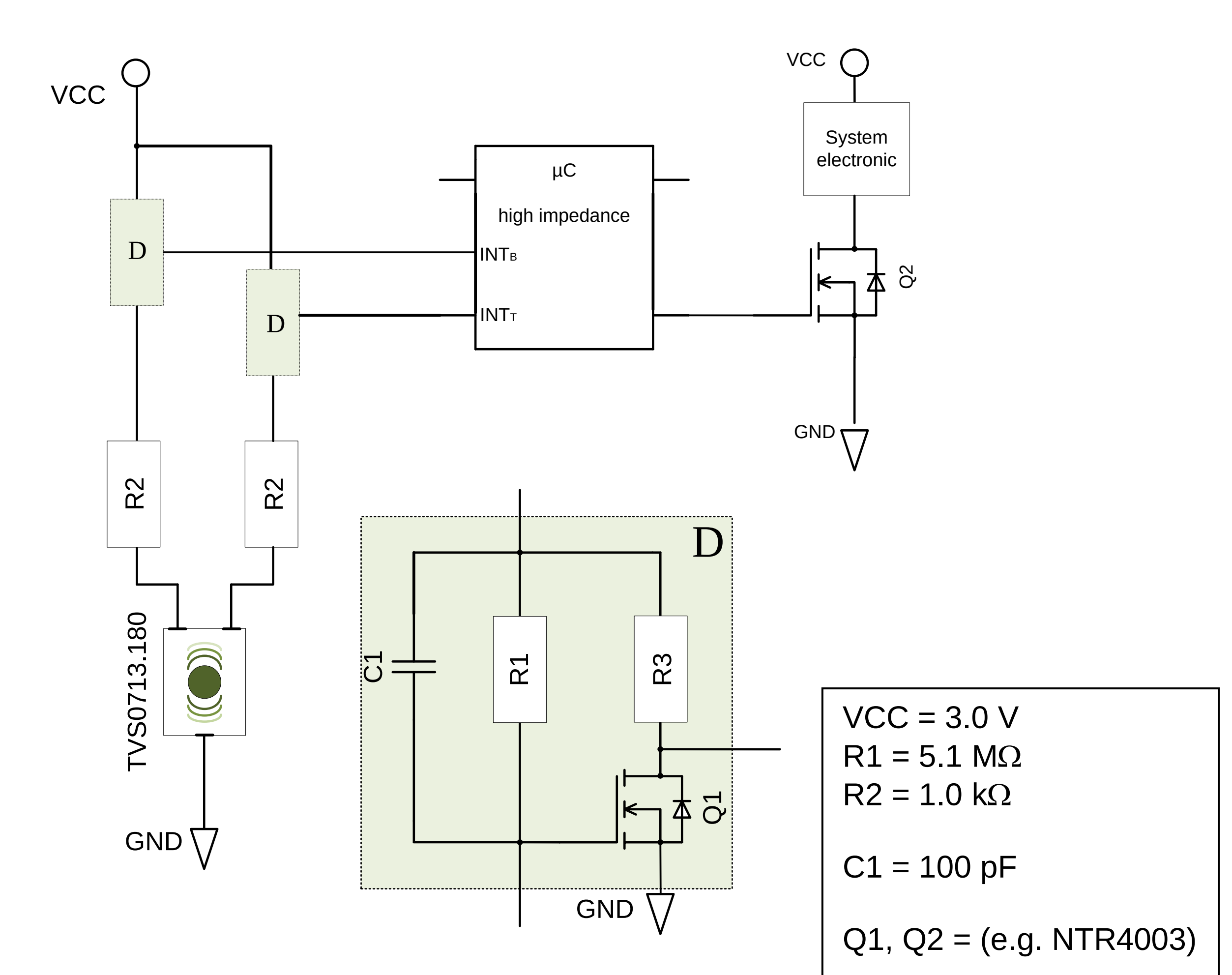


Figure 18: MOSFET Circuit

NOTES:

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