Fundamentals of Electronic Circuitry for Electrolytic Tilt Sensors

Engineering Application Note
Document #9723

WARNING: ***Use of DC current can permanently polarize the electrolyte and irreversibly damage the sensor.***

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A task to design electronic circuitry to properly drive electrolytic tilt sensors could become an unpredictable challenge even to the most experienced hardware design engineer. The design engineer should not only concentrate on a task of precise signal timing, but also to control and eliminate the DC current from flowing through the tilt sensor. This unwanted current could be a "*KISS of DEATH*" to the whole angle measurement stage. The other concern is control of the charge that is being delivered to the sensor. It is not enough to generate a periodic waveform and drive the sensor. The waveform should be maintained at 50% duty cycle at all times. In the event that the waveform is not symmetrical, the sensor may accumulate charge and output some electrical value which could be mistaken for actual tilt. The following electronic diagram (FIG 1) demonstrates a simple way to excite the single axis tilt sensor by using a standard compactor as an oscillator. Diodes perform the function of a demodulator. The DC voltage output proportional to tilt allows users easy low cost testing and utilization of all types of single axis tilt sensors. C1 should be a tantalum capacitor.

When using dual axis sensors with the following circuit (FIG-1) please note the following:

1. Select diagonal 3 pins (out of two diagonals)
2. Number them sequentially (1=left, 2=center, 3=right)
3. Connect as shown on the schematic below (FIG 1) instead of TX1.
4. Hold the sensor perpendicular and tilt in the plane of the selected diagonal.

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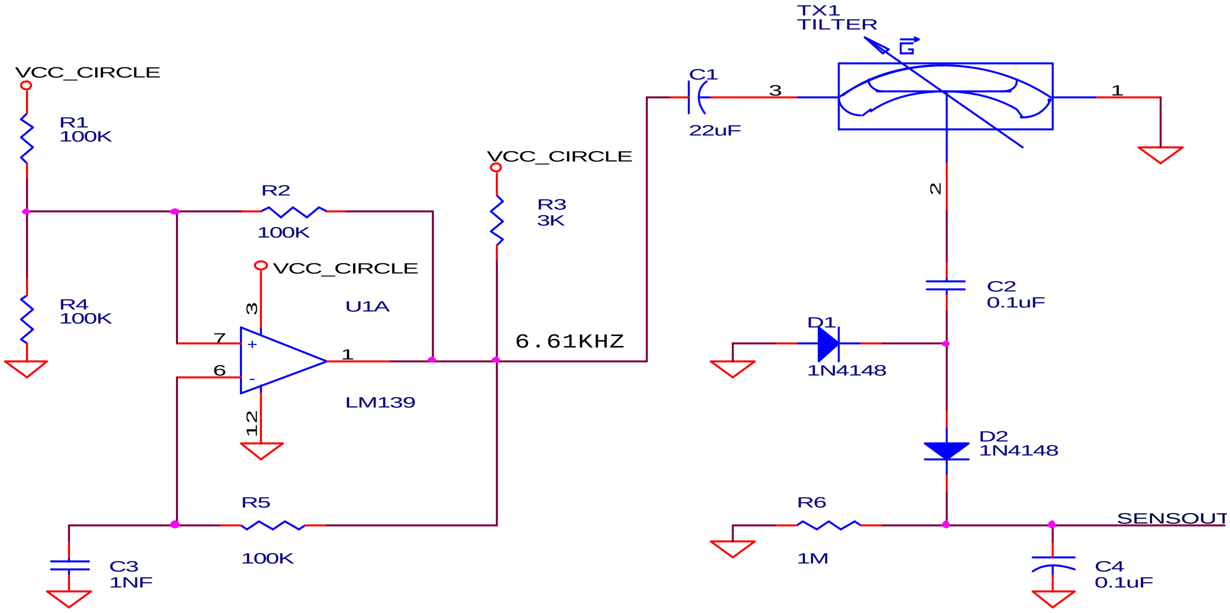

FIG-1

When starting to design a circuit to utilize dual axis electrolytic tilt sensors it is practical to start from the alternating axis excitation technique. In this method each sensing axis is excited for a fraction of a second just long enough to produce a stable output for the currently excited axis. The circuit in FIG-1 could be used as a global driver while having the two external pins of each diagonal switched in and out periodically. It is very important to synchronize the select signal with the proper axis being excited at the same time. This is crucial for proper axis separation.

The block diagram (FIG-2) shown below is a general proposed method for the excitation of any dual axis tilt sensor. As stated above, this method is based on alternating excitation of both axis by the same waveform generator or clock. Precise synchronization with the output stage will allow proper separation of outputs for both axis. The speed of switching between tilt axis will define the update rate of the output signal. Suggested switching rate 10 - 100 Hz. Two SX (single axis) sensors, when center terminals are joined, could be excited using the same principle. In this case sensors could be of different types and provide different range and scale factor characteristics for each axis. In order to maintain stable output, the Vcc should be well regulated. In the event of an unstable power source, the user may experience drift at null and unpredictable change of scale factor (Vdc/arcdeg). When using dual axis sensors and the excitation technique as per FIG-2, the tilt direction for each axis will correspond to the plane of each diagonal crossing at the center pin. For applications requiring temperature compensation, a simple feedback loop can be added at the last output stage for each axis giving independent control for thermal compensation in case two different single axis sensors are used. If a dual axis sensor is selected for that application, the temperature correction stage should be added at the first signal processing stage before axis separation occurs. Please

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note that the scale factor thermal dependency of electrolytic tilt sensors is about (neg0.08% / deg C). Standard LM-50 type temperature sensors are perfectly suited to be used in the full thermal operational range.

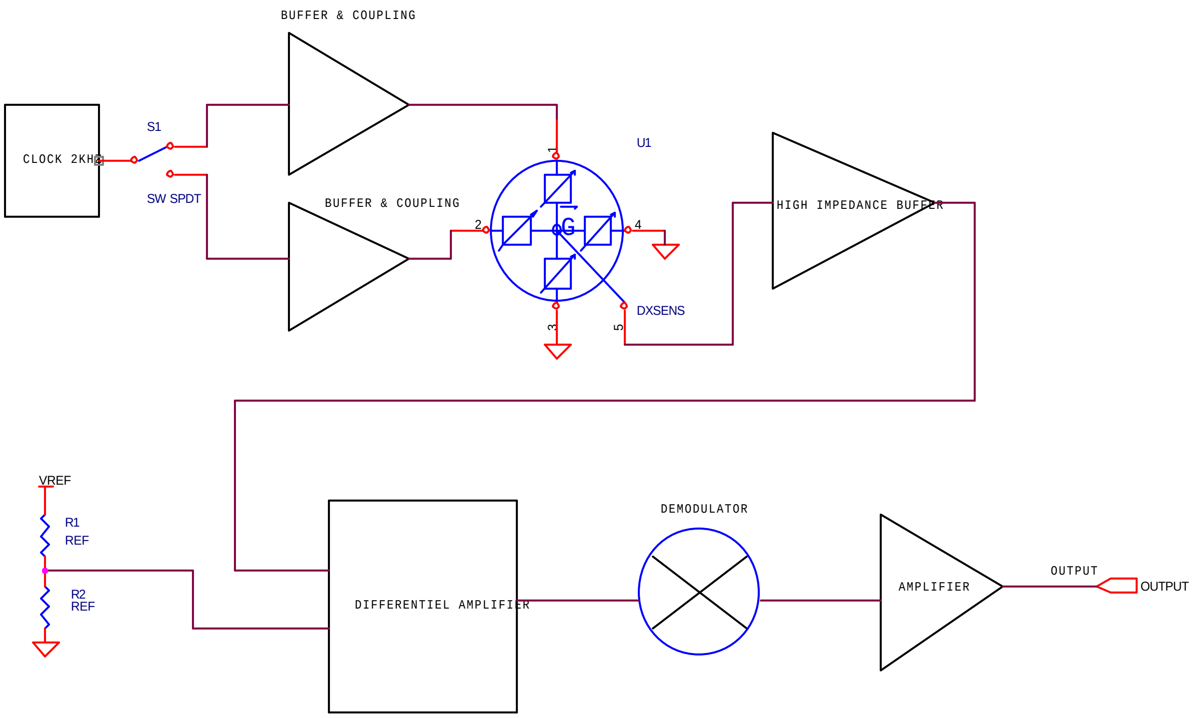

FIG-2

It is important to note that when using alternating axis excitation technique the designer should precisely control the number of positive and negative pulses delivered to each axis. In case the number of pulses are not equal, the sensor will accumulate electrical charge which may result in permanent damage to the sensor and inaccurate tilt measurement.

This method is considered reliable for applications requiring low to medium accuracy tilt measurements. For applications where high accuracy is required other avenues of signal conversion are available, and are contingent on individual applications.

Some methods suggest exciting the sensor with multiple oscillators of common base, thus creating timing zones where voltage levels on various pins make the dual axis sensor behave as a single axis sensor. This method, if properly developed, will result in a very precise angle conversion module for any dual axis electrolytic tilt sensor based on a common pool of electrolyte.

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The following block diagram FIG-3 demonstrates a custom SINGLE IC design for a dual axis conversion module. Not only that this module excites both axis of tilt, but it also outputs data in a serial format compatible with RS-232 format in 8 bit resolution. The unit operates at 9600 or 19200 baud rate.

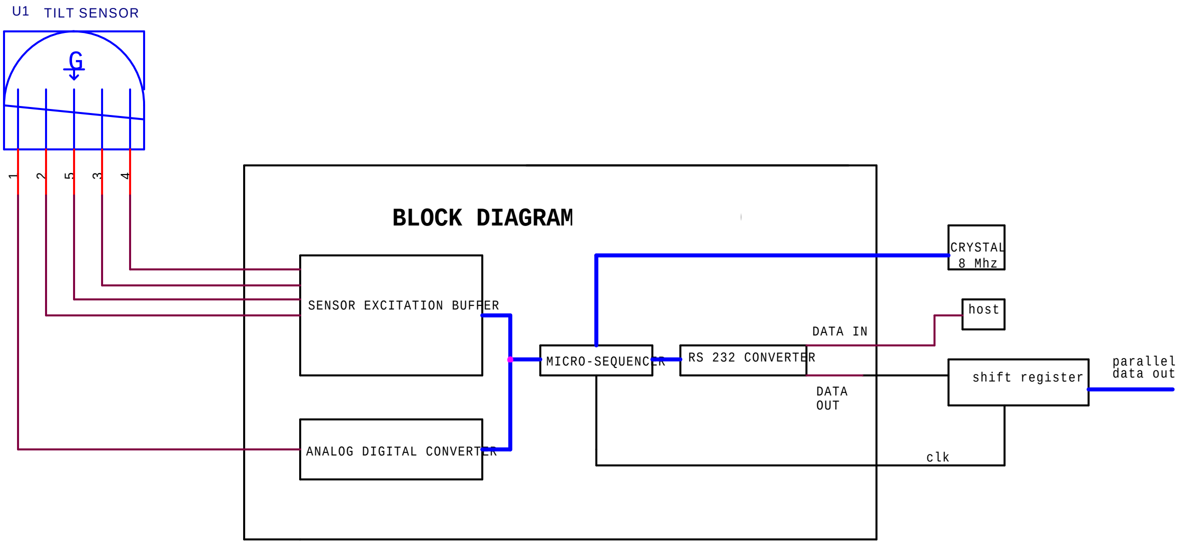

FIG-3

EZ-TILT-1000 utilizes the two oscillator approach dot drive the sensing element. During precisely synchronized time intervals the dual axis tilt sensor behaves as a single axis tilt sensor, thus allowing easy angle interpretation. This is true for both axis of tilt.

All electronic modules do not utilize diagonal tilting of the sensor, but operate when the sensor is tilted in a plane 45o off the diagonal as indicated by the schetch below: Stars represent pins, and X / Y represesnt the direction of tilt.

```
*         *

     *    --------> X

*         *
     I
     I
     I
     Y
```


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