Electrolytic Tilt Sensor

Introduction

Electrolytic tilt sensors are non-signal conditioned sensing elements. The function of an electrolytic tilt sensor is to measure an angle or a null or level position with reference to gravity. The angle may be expressed in anyone of the following: degrees, arc minutes (1/60th of a degree) or arc seconds (1/60th of an arc minute). These angles are generally referenced to a perpendicular line to gravity called a null or a zero point. The amount of tilt from this point can be expressed as either positive or negative angle [2].

A single axis sensor would only measure an angle in one direction. To measure an angle in all directions, for example, to a compass heading, a dual axis sensor or two singles axis sensors mounted 90 degrees to each other would be required. This would allow the measurement to be made in any direction by combining the readings of both axes as seen in figure 1.

Figure 1: An electrolytic tilt sensor
Structure and operation

Single axis

Dual axis
The tilt sensor functions like a liquid potentiometer. The electrically conductive fluid creates a variable resistance between the electrodes. When the sensor is in the null or balanced position, the resistances between the centre electrode to each outside electrode are equal. Tilting the sensor from its balanced position changes the two resistances producing an electrical output proportional to the tilted angle. The major electrolytic salts are chosen from metal cations, such as sodium, potassium, lithium, calcium and cesium, of which the ionic species offer good conductivity at every level of dilution. The electrolytic salts are also selected from anions, such as nitrate, carbonate, acetate and hydroxide, which resist chemically combining with the metallic elements of the metal electrode materials. Solvents may include methanol, ethanol, butanol, propanol and isopropanol that provide the ability to control the viscosity of the electrolyte, related directly to the response time of tilt sensor[1].

Electrolytic tilt sensors must be operated in the AC mode. Any DC will cause the level to become unstable and even inoperable. The amount of current through the level must not exceed the maximum. The maximum excitation voltage is 5 volts. Currents that are above the typical recommended value will cause the level to self heat and the readings will drift. The impedance value of the level must be specified to match the type of circuit used in order to limit the current.
Figure 2: Structure of Electrolytic Tilt Sensor

Excitation
The electrolytic tilt sensor(level) can be energized in a number of ways depending on the applications and performance required. Typically, there are two ways to energize and read the level.

One way to energize the level is the use of a bridge type circuit as shown in figure 3. This configuration allows for the adjustment of the bridge resistors to match the internal impedance of the level. It must be noted that the electrolyte's impedance will change with temperature. The impedance is inversely proportional to temperature. This can cause readings to change with temperature when the level is in an unbalanced position. Therefore, temperature compensation is required in an uncontrolled environment.
Another way to energize the level is to excite the outer electrodes and read from the center as shown in figure 4. This method will ensure that only the ratio of the impedance is measured and not the absolute value of the impedance. The electrolyte's impedance over the desired temperature range must not cause the current through the level to exceed the maximum value. Since the impedance is inversely proportional to temperature, an increase in temperature would cause an increase in current.
The output ports of a micro-controller are a good example of a drive circuit for the level, as long as each port exhibits equal source and sink currents thus preventing any DC component to the level. The output can be sampled between each port change by an analog to digital converter.

Temperature sensitivity of the sensor can be divided into two areas. The first, steady state changes, is simplest to consider. As temperature goes up, scale factor goes down, linearly. All sensor scale factors change by 0.067% per degree F as a nominal number. The second, transient temperature conditions cause the greatest difficulty when they create left to right gradients. These are significantly attenuated when a potting compound having low thermal conductivity is used to completely encapsulate the sensor.
Applications

The applications for electrolytic tilt sensors are extremely diverse, touching most industries in some way. Some of the areas where electrolytic tilt sensors are used are:

- Aircraft flight controls
- Automobile security system
- Construction equipment
- Robots
- Thermostats
- Video game Controllers

Avionics manufacturers use high precision tilt sensors in gyroscopes. The automotive industry uses tilt sensors in wheel alignment machines for measuring caster and camber angle and for security and RV leveling systems. In construction industry the application of tilt sensors range from safety systems in cranes, man lifts to providing reference data of various types of lasers. The electrolytic tilt sensors are also used to satellite antenna positioning, geo-technical monitoring and tilt compensation in electronic compasses.[4]

Conclusion

Electrolytic tilt sensors are capable of producing extremely accurate pitch and roll measurements in a variety of applications. These devices lend themselves to both narrow and wide angular range measurements and easily maintain their small size and high accuracy.[3] The performance and reliability of electrolytic tilt sensors continues to set the standard for fluid filled devices. Hence, electrolytic tilt sensors have succeeded in widening its presence in the market. Also, the future appears more promising with planned improvements in design, materials and manufacturing techniques.
References