ADVANCES IN ELECTROLYTIC SENSOR DESIGN and THEIR USE IN THE NEW GENERATION OF CRASH DUMMIES.

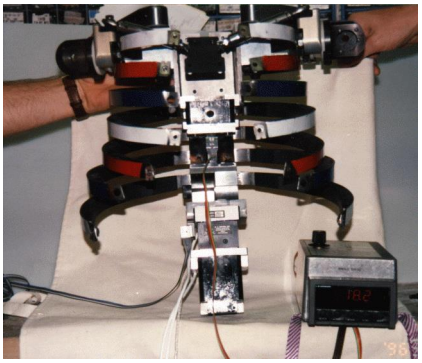
In the past, one of the problems associated with automotive crash testing has been the difficulty in reproducing the desired initial position of the dummies within the automobile. With the increased complexity of the crash dummy design and automobile variations, crash testing became more important and the significance of properly positioning and orienting the crash dummy increased greatly.

As part of an ongoing effort to learn, predict and assess injury as a result of automotive accidents, new and more advanced crash dummies are being designed and tested. In the forefront, GESAC Inc., located in Kearneysville, West Virginia, is currently working on a contract for National Highway Traffic Safety Administration to design and build the next generation crash test dummy for automotive safety testing. The new dummy, named THOR, features many technological advances over previous crash dummies to create a more lifelike test subject with greater injury assessment capabilities. THOR features over 100 channels of data which help to quantify the amount of damage that a person would be likely to suffer during the automotive accident.

With the help of Advanced Orientation Systems, Inc. (AOSI) www.aositilt.com ; a NJ based transducer and electronics developer, which developed the first line of POLYMER based electrolytic tilt sensors, the task of positioning the crash dummy has been made much easier using the five tilt sensors which have been incorporated into THOR's spinal assembly.

One sensor has been mounted on each of the following segments of the dummy:

the pelvis,
the lumbar spine,
the lower thoracic spine,
the neck,
the head.



These sensors are used to provide a complete electronic orientation of the crash dummy's posture before crash testing. Because of revolutionary non glass rugged shatter proof tilt sensor construction, the same set of tilt sensors can be used in multiple crash tests. The sensors selected for this application are the DX-045D-045 Dual Axis Inclination Sensors, which are the first polymer based electrolytic tilt sensors manufactured in OEM quantities, have a resolution of

about 22 arcsec, a superior near-linear range of up to +-70 arcdeg and a monotonous range approaching +-90 arcdeg.

TILT SENSORS and their BENEFITS for SYSTEM DESIGN

In search of ways to reduce manufacturing costs, increase product quality, consistency and reliability; specially formulated chemically resistant polymers and hi-temperature sealing compounds were proven to endure reliable leak proof operation. AOSI's mass production process guarantees sensors with high dimensional and electrical consistency and a rugged shatter proof structure, which does not require any external housing to protect them. While transported or when in use polymer sensors can sustain high vibrations and shocks. That fact assured that DX-045D-045 is the appropriate sensor to survive during crash testing.

During the positioning of the dummy within the automobile, each tilt sensor is connected to a hand held display, which was designed by GESAC. This display features the EZ-TILT-3000-045 analog angle conversion module and additional circuitry to convert the voltage output from the tilt sensor module to a display of the various angles in degrees. This tilt sensor display provides the technician a readout of the dummy's posture in both pitch and roll axis. The hand held display is disconnected from the tilt sensors prior to running the impact test and then reconnected at the end of the test to determine the final position of the dummy. One display module is used to read multiple sensors, which became possible due to great sensor to sensor consistency.

PRINCIPLE OF SENSORS OPERATION

In general, polymer electrolytic tilt sensors require the same type of AC excitation wave-form as the old type glass electrolytic tilt sensors, however the circuitry is much simpler. FIG 1 shows a general purpose dual axis angle conversion module. When utilizing this method of sensor's excitation, the user will have total independent control over each axis gain and offset.

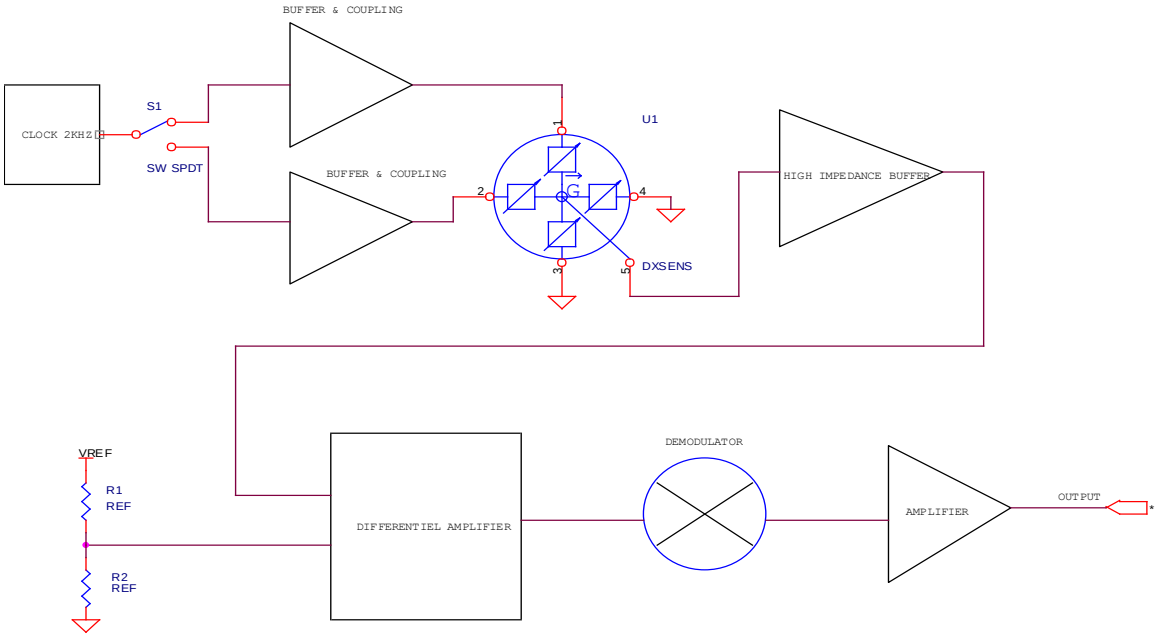


FIG.1

The reason the circuitry is considerably less complicated, is due to the fact that the polymer sensors are consistent from unit to unit and thus the circuitry does not have to compensate for the irregularities in symmetry as is usually done with glass sensors. These symmetry irregularities are most evident when the tilt sensor or tilt system is subjected to thermal ambient changes. These thermal drifts are due to two factors: (1) change in conductivity of electrolyte (which defines sensor's impedance) and (2) structural deformation(s) due to material expansion and contraction. Structural deformation errors are kept to a minimum in the AOSI polymer electrolytic tilt sensors due to their unique design and production process. All associated electronic angle conversion modules are designed not to be sensitive to changes in end to end (measured outside pin to outside pin) impedance enabling these modules to be less susceptible to thermal drifts when used with AOSI polymer sensors. In most cases when the sensor is positioned at null, the temperature drift is not noticeable. On average the scale factor thermal drift could be defined as 0.08%/degC.

FIG. 2 demonstrates the influence of temperature on the scale factor of SX-070D-LIN single axis linear wide range sensor with EZ-TILT-3000 uncompensated angle conversion module:

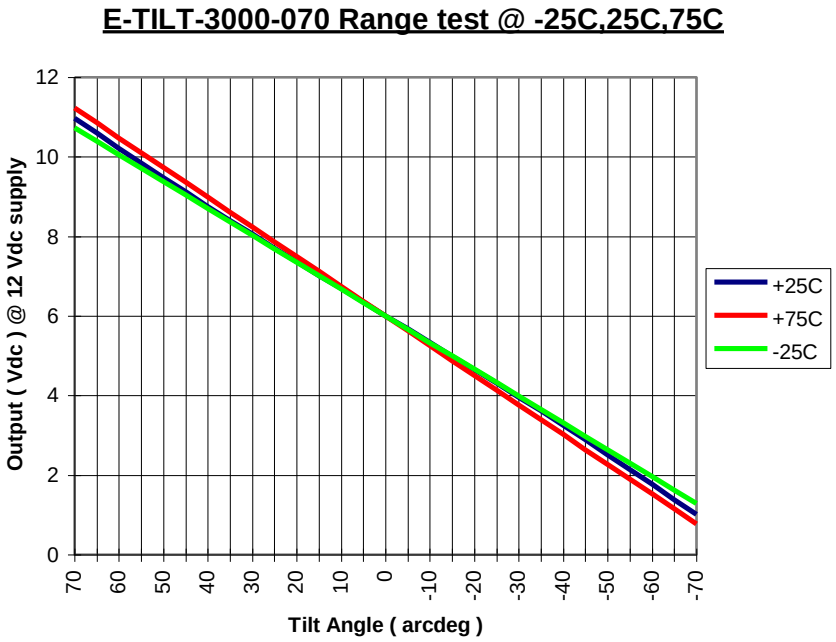


FIG.2

RELATED OLD STYLE SENSOR TECHNOLOGIES

Glass electrolytic tilt sensors are reliable yet costly for angle measurement. These glass parts are very fragile and require special handling precautions due to their susceptibility for breakage. As a single component, glass electrolytic tilt sensors may provide long term performance, however for OEM projects, use of these glass bubbles may become quite costly. As glass has many anomalies and is susceptible to cracking, glass sensors should be treated to relieve material stress and surface strain. Custom intricate mounting, odd and inconsistent external shapes, special external enclosures, and 100% necessary testing usually double or triple the final cost. Fragile

support structures and inconsistent performance leave users with technical doubts about possible aging problems and sensor usefulness.

SOLID STATE INCLINOMETERS

When reviewing the technologies of other tilt sensors, for some general purpose applications in non-temperature variable environments, solid state sensors (accelerometers) can be quite useful. However, their high sensitivity to thermal gradients make them inaccurate and unreliable. Special high current consuming heat inducing devices are required to minimize the output to temperature dependency. In some cases, more than 0.5A is consumed by the accelerometer based units in order to allow them to be relatively insensitive to external temperature variations and therefore makes accelerometer based units impractical for portable (battery powered) applications. The other disadvantage when using solid state tilt sensors in conjunction with heat inducing devices, is that the sensing system would require a warm-up time of several minutes upon power-up. The behavior of the system during power-up is unpredictable and unstable, and in some applications can cause total system failure. When used to detect small angles or in high gain setting the noise level often higher then the signal itself, therefore the associated measurement will not be accurate.

In comparison to solid state tilt sensing modules, polymer based electrolytic tilt sensing units use much less power then their accelerometer based counterparts. Only 2ma@5Vdc are required to run a standard Dual Axis angle conversion module complete with the sensing element.

FIG. 3 demonstrates the typical performance of DX-008D dual axis POLYMER tilt sensor at its full linear range.

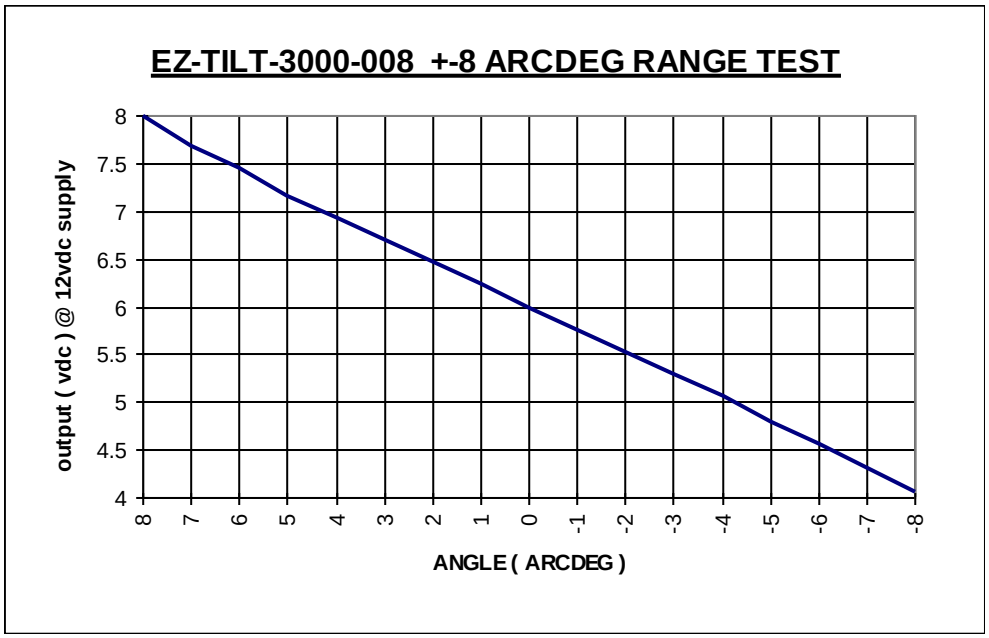


FIG.3

APPLICATIONS & NEW TILT SENSING PRODUCTS

All AOSI angle conversion modules are based on advanced CMOS design. EZ-TILT 3000; AOSI's standard analog output dual axis angle conversion module is available in two versions. (1) standard power-up and (2) enhanced speed power-up. The enhanced speed power-up version provides accurate angle information for both tilt axis within 100 mSec after power-up. This excitation scheme makes this version perfectly suitable for applications where short duration signal polling is required. These analog output modules are ratiometric and can operate with a unipolar or bipolar supply.

For applications where high resolution is required, AOSI has broken the sub arcsec barrier with its SX-003D-NULL ultra high resolution nulling electrolytic tilt sensor. By utilizing the foremost advances in ceramics and material deposition, this sensor is able to offer consistent repeatability and resolution of better then one third of an arcsec. Hermetically sealed and flat mountable; this sensor remains fully functional in full military temperature range of -55C to +125C.

FIG 4 demonstrates the performance of the sensor in a near null region.

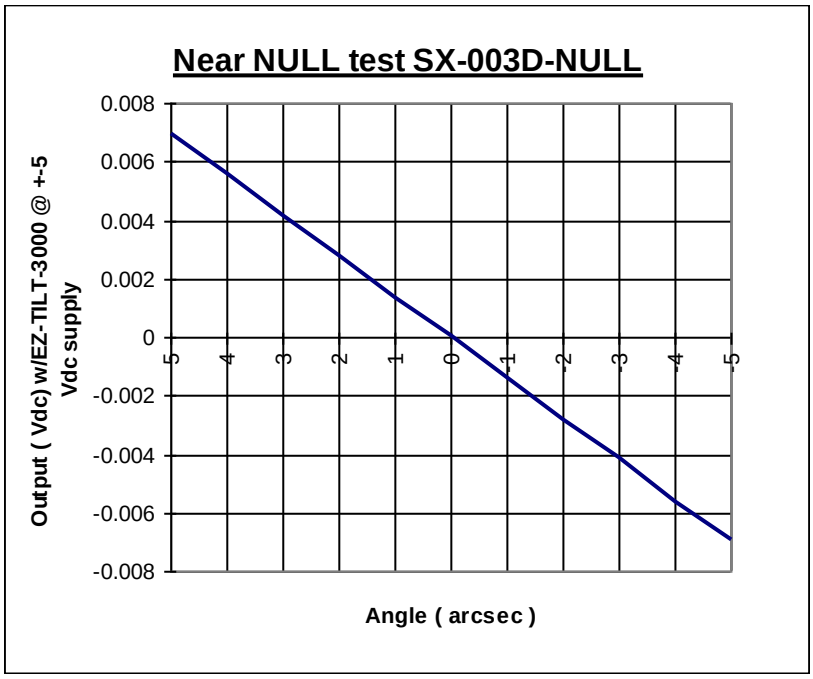


FIG.4

These inclinometers save the cost of expensive gyros on all types of test equipment in the aerospace industry. Applications for this sensor include construction lasers, range finders, 3 axis rate & position tables, and other instruments in the auto, construction and surveying industries.

Responding to the demand for a miniaturized version of an angle conversion module that includes the capability of computer interfacing; AOSI has introduced their EZ-TILT 1000 (see FIG 5). This advanced IC provides total sensor excitation, 8-bit conversion, and RS-232 communication available in either 18pin DIP or SO18 packages.

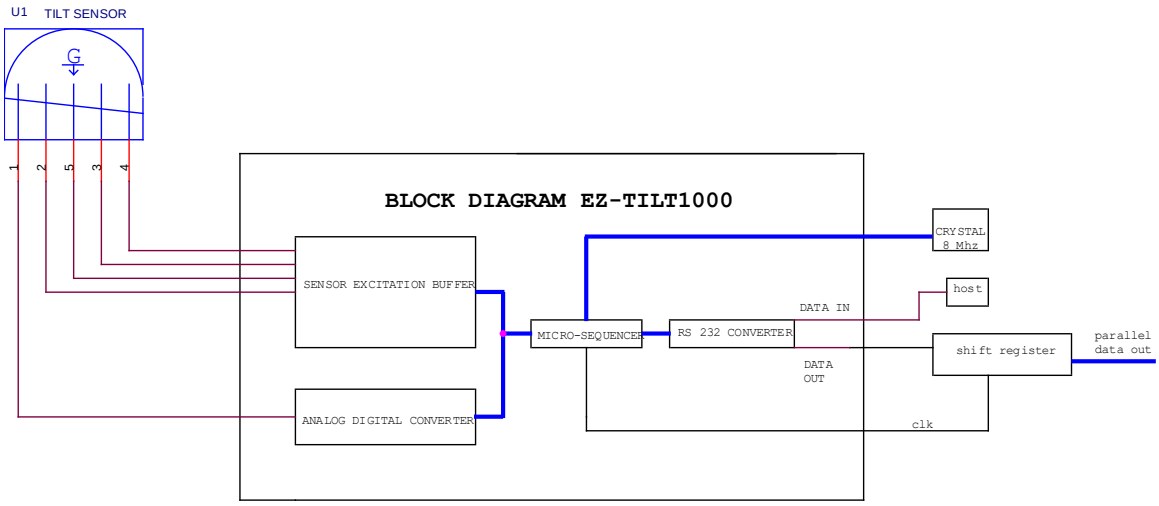


FIG.5

For higher resolution applications, AOSI provides their EZ-TILT 2000; a 12-bit angle conversion module. In a small 2" by 2" SMT assembly, this unit packs precision excitation, high speed conversion and high speed RS-232 communication port. Software is included at no extra cost to allow easy and direct communication from any PC with serial port.

To satisfy the need for a reliable low cost navigation tool, AOSI has developed an advanced HEADING and DUAL TILT AXIS system, which is built on a 2" x 2" assembled PCB, and has a total height including sensing elements of less then an inch. The unit provides continuous heading and tilt information over the standard RS-232 interface. The AZIMUTH is generated by a rotating core magnetic sensor which outputs a combination of SIN and COS of the heading angle with an interpolated 1 degree accuracy. The tilt information is available with 12 bit resolution and includes adjustable GAIN for both tilt axis, thus letting reliable angle measurement reach almost +-90arcdeg. This LOW cost COMPASS/TILT module is perfectly suitable for numerous navigation, research, training, construction, entertainment and other precision navigation, orientation and leveling applications. If required, this module is capable of operating with any single or dual axis electrolytic tilt sensor. AOSI upon request supplies compasses calibrated and tested, with data stored in EXCEL format on 3.5" disk. FREE Demo software facilitates custom module calibration, data acqusition, data averaging, and storage to a standard spreadsheet format and includes "SOFT NORTH".

In response to an increase in car theft EZ-ALARM is a LOW COST advanced microprocessor controlled Omni-directional ANTI-LIFT module to be used on all types of Vehicle Security systems. In its EVALUATION form the EZ-ALARM is a 2"x2" module able to detect angular position deviations from previously remembered vehicle orientation. The module includes error detection algorithms to minimize false alarm activations which may occur due to snow, rain, temperature, sudden short shock, etc. The design complies with THATCHAM guidelines as stated in sections: Iss. 02, BV02 and AA02. Includes internal supply regulation and Low stand-by current. Output is a standard NPN transistor in an Open Collector configuration. The design includes 8 hardware selectable detection levels and a self detecting SERIAL communication port to PC through standard terminal mode at 600 to 19200 Baud rates. Alarm active time could be hardware selected between 2msec and 580 msec. The module could operate with DX-008D

sensor for higher sensitivity in a +-20 arcdeg tilt range. The unit could be produced as a small potted module with 3 terminals to fit currently marketed vehicle alarms or to be incorporated into future designs of custom or general purpose security systems.

New Polymer based electrolytic tilt sensors offer users a powerful combination of benefits. Structural consistency, reduced size, low profile, and PCB mounting are very important qualifying factors. High volume applications such as VR HMDs, wheel alignment, and medical devices greatly benefit from unsurpassed consistency in sensors' performance. The new material advances of the sensors combined with the custom electronic packages offered, provide the user with new and reliable methods for computing and accurately finding angles quickly in a cost effective way. As in GESAC's case, AOSI's research and development efforts will provide users with numerous and highly accurate angle solutions in the future. The use of the tilt sensors manufactured by Advanced Orientation systems, Inc. has allowed users of THOR to have very repeatable positioning of dummy within the test cars and sleds. To answer your measuring and design problems AOSI has on staff team of engineers specializing in electronics, mechanics and metrology.

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