# Tilting at satellites

**Tilt sensors aren't new, but conditioning electronics improve stability, reduce errors, and make these transducers accurate enough to let antennas lock onto satellite signals.**

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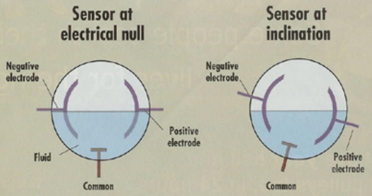
Mobile satellite applications such as news-gathering vans need accurate position feedback from tilt sensors to align the antenna with the appropriate satellite.

An inclinometer puts out an electronic signal proportional to the angle of tilt, relative to level. Internally, the inclinometer consists of a tilt sensor and signal-conditioning electronics. These normally reside in one enclosure with either a cable or connector.

The most commonly used tilt sensor in inclinometers is an electrolytic fluid-filled type. Electrolytic tilt sensors need an ac excitation voltage


The Spectrotilt RS-232 electronic inclinometer features an accuracy of ±0.3° over ±60° angular sensing range and a 12-bit RS-232 output signal. It uses a proprietary electrolytic tilt sensor, which is a hermetically sealed, glass/ceramic hybrid. Combined with digital electronics, full ESD and EMI protection, and an aluminum housing, the entire assembly is encased in an epoxy-based potting compound for environmental protection.




Single-axis electrolytic tilt sensors from Spectron are filled with an electrically conductive fluid called an electrolyte. It's sealed within a glass or ceramic cavity to conduct between the common, positive, and negative electrodes. When at electrical null (i.e., level), both electrodes are evenly submerged within the fluid, which remains level. This produces a balanced (equal) signal output between the positive and negative electrodes and common.

As the sensor rotates about its axis, the amount of surface area submerged within the fluid rises for one electrode and simultaneously drops for the other, creating an imbalance in the output. This imbalance, or ratio, of one electrode to the other, is directly proportional to the angle of rotation.

and deliver an ac output voltage. The signal-conditioning electronics generate the ac excitation and subsequently demodulate the ac-voltage output.

The sensors work in an ac Wheatstone bridge. At null or level, sensors produce a signal equal to 50% of the total scale factor or output setting. With angular movement in either direction, this ratio changes proportionally.

Fluid-filled inclinometers have traditionally had the advantage of low cost. Unfortunately, at angular and operating temperature extremes of −40 to 70°C, accuracy errors have been as high as 2.7°, too high for accurate positioning. This is due to the relatively large linearity and temperature coefficient errors intrinsic to all fluid-filled inclinometers. Newer sensors, however, use on-board linearity and temperature-error-correction routines to eliminate errors inherent in fluid-filled inclinometers. These include output nonlinearity errors and temperature effects of null and scale factors.

Fluid-filled inclinometers are also used in construction equipment. Cranes and boom lifts use inclinometers for sensing boom angle. Road graders and pavers use them for controlling blade angle. Crawler drills used in the mining industry use inclinometers to monitor and control the drill mast angle. Other applications are as diverse as wheel-alignment systems and vehicle/platform leveling and monitoring.

Mobile antenna platforms are another application. These systems must precisely align with the satellite they track. Small positional-pointing errors of the antenna can severely degrade signal strength and quality. Errors of a fraction of a degree can be deleterious. So satellite antenna-positioning systems rely on the accuracy of sensors giving positional feedback.

Mobile applications such as satellite news-gathering vans demand an antenna that can repeatedly line up with the appropriate satellite. Positioners read various sensors to automatically put the antenna on the proper azimuth (deviation from true north) and elevation (slope) angle. This is known as the pointing solution and is calculated using antenna latitude and longitude and the satellite longitude. The azimuth position of the antenna is normally measured using a flux gate compass, which is an electronic version of the familiar mechanical pointer-type compass. An electronic inclinometer measures the elevation angle. ■