

Tiltmeter Basics

Tech Note

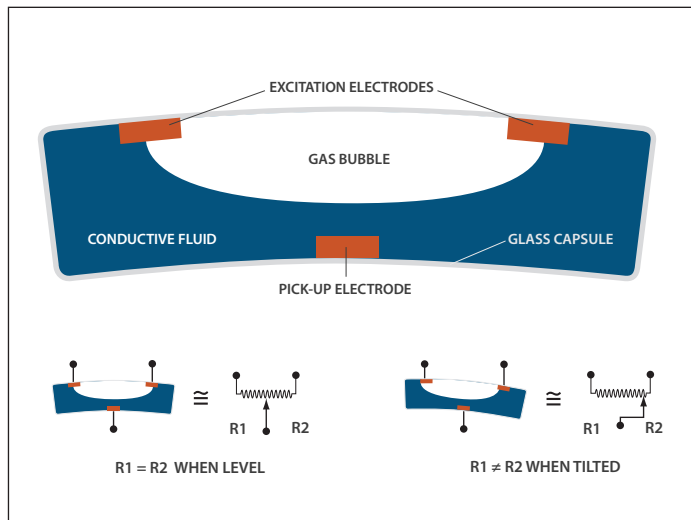


Figure 1. Electrolytic tilt sensor. Movement of the bubble changes the output at the pick-up electrode when an AC voltage is applied across the excitation electrodes.

The words *tiltmeter*, *inclinometer* and *clinometer* all refer to an inertially referenced device that measures angular rotation with respect to a vertical gravity vector, the most stable of all external references. At Applied Geomechanics we denote our highest-precision instruments as *tiltmeters*. We use the name *clinometer* for our general-purpose 900-Series products.

All Applied Geomechanics tiltmeters and clinometers include full signal conditioning electronics that produce stable output signals over a wide range of input voltages. This important feature means you can be confident that your measurements represent actual movement and not power supply variations. The high-level voltage, current, and serial outputs provided by our electronics assure reliable data delivery over long cables and wireless data links. As an added bonus, all of our tiltmeters include temperature measurement in their output.

We divide our tiltmeters into four different Series based on measurement resolution and angular range. Certain instruments report resolution in microradians or even nanoradians: a reflection of their high level of sensitivity.

Electrolytic Tilt Sensors

Applied Geomechanics tiltmeters and clinometers each contain one or more electrolytic tilt sensors. These sensors consist of a sealed glass or alumina vial that is partially filled with electrolytic liquid. This conductive fluid covers three or five internal electrodes according to the sensor type. The sensor's operation is based on the fundamental principle that an enclosed bubble, suspended in a liquid, always orients itself perpendicular to the vertical gravity vector. Traditional applications of this phenomenon include the humble carpenter's level and spirit levels on surveyor's transits and navigational sextants.

Electrolytic tilt sensors have no mechanical moving parts to break or wear out, and because tilt is referenced to gravity, they can be installed anywhere without the need for complicated levers or fixtures.

Electrolytic tilt sensors offer amazing performance in a small and affordable package. Dynamic range is the maximum measurement range divided by the smallest angle that can be detected with the sensor. Some of our sensors achieve a dynamic range greater than 120 db (>1,000,000:1).

How They Work

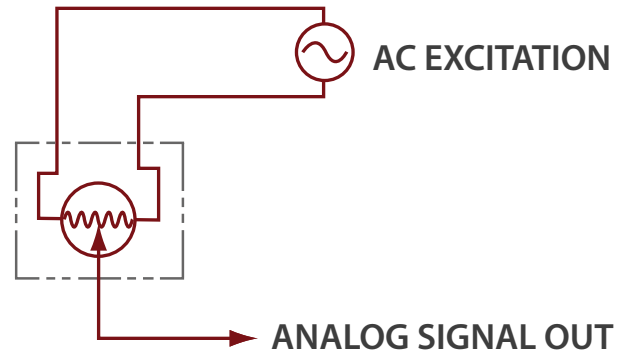
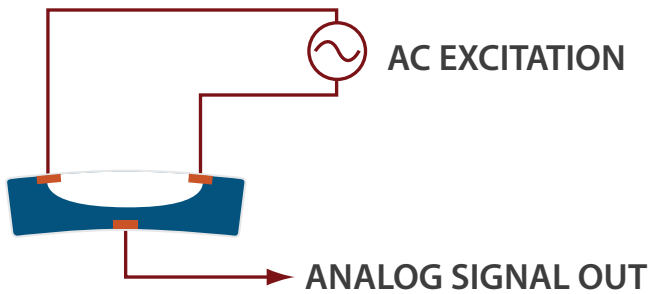
When the sensor is level, the conductive liquid covers an equal area on each excitation electrode; the AC resistances, R1 and R2, between the excitation electrodes and the pickup electrode are equal. When the sensor is tilted, however, the liquid covers more of one excitation electrode than the other and R1 and R2 are not equal.

How They're Used in the Tiltmeter

Applied Geomechanics tiltmeters operate electrolytic tilt sensors as AC voltage dividers (potentiometers). The tiltmeter's electronic circuitry creates a balanced AC signal that is applied differentially to the two excitation electrodes. The amplitude and phase of the output signal, measured at the pickup electrode, indicate the magnitude and direction of tilt movement.

Tilt sensors can also be operated as the active half of a Wheatstone bridge. The Wheatstone bridge circuit is mainly used for nulling (leveling) applications. Regardless of which type of circuit is used, only AC excitation may be applied to the sensor. Direct current damages the sensor by causing plating of the electrodes.

Our uniaxial tiltmeters use a single tilt sensor. Biaxial tiltmeters in our 500, 700 and 800-Series use two tilt sensors, oriented orthogonally. Our 900-Series biaxial clinometers use an electrolytic tilt sensor with five electrodes, arranged in the pattern of a cross. In this instance, biaxial tilt measurements are made by alternately exciting orthogonal pairs of electrodes.



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