Last month we explored roll axis modes of operation and their relevant circuits. We will now turn our attention to the pitch axis with a primer on an alternative method of deriving pitch information. From the time of Elmer Sperry's groundbreaking work on autopilot design, the gyroscope has provided attitude information to the computer. In the late 1970s, however, S-TEC, Inc., Mineral Wells, Texas (now Meggitt/ S-TEC), designed and began to produce a line of autopilots that did not use a gyroscope for pitch information. Instead they used a pressure transducer and accelerometer in combination to provide this data. Most of their product line today, which includes the 50, 55, 55X, 60, 60PSS and 65 Series autopilots, rely upon this technology. Bendix/King has also designed the KAP140 autopilot that utilizes the same principles.

A solid state pressure transducer is connected to the static port of the aircraft to sense altitude. It is excited by a clean (quiet) DC voltage from the computer. In the S-Tec systems the static sensor is external to the computer, typically located in close proximity to the static port. Bendix/King as an alternative chose to include this sensor as an integral part of their panel mounted product. These sensors provide a signal between the supply voltage and ground, proportional to the absolute pressure on the port. Because the output is ratiometric to the supply voltage, any changes to the supply voltage will cause a corresponding change in the signal and the accuracy/stability is maintained. See Figure 1 below

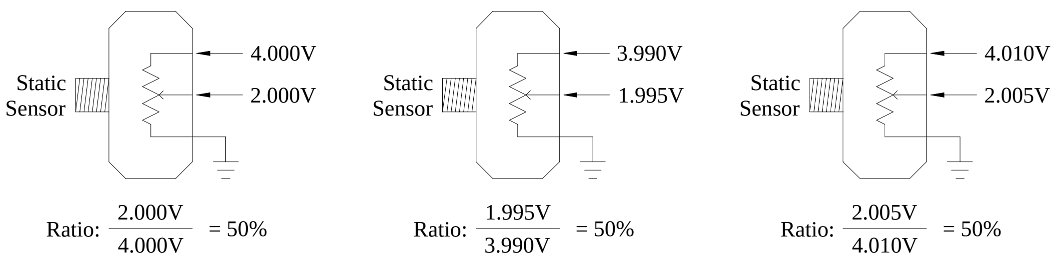

Figure 1 Ratiometric ratio stays the same if voltage supply varies.

The pressure transducer is a device used for long term stability. However, for short term stability such as found in turbulence, abrupt power or elevator/trim control input changes, there is a need for a quick response. The accelerometer partners with the pressure transducer to fill this need. The accelerometer output typically is passed through filters to remove noise and voltage offsets and monitored for deviations from one "G" of gravity. This signal also doubles as a pitch limiter. In S-TEC's autopilots, when the G load exceeds +/- 0.6 Gs, the pitch and trim solenoids are disconnected momentarily to protect the airframe. Likewise in the Bendix/King KAP 140, the accelerometer protects the aircraft from G loads exceeding -0.3G and +0.4G (or -9.7 and +12.9 ft/sec^2 relative to the long term average acceleration).

Therefore, in Altitude Hold Mode (ALT), the solid state pressure transducer is being used as an altitude reference with the accelerometer correcting for short term upsets from turbulence, etc.

Another pitch mode commonly found in autopilots is Vertical Speed Hold (VS). In this instance, the computer is looking for a specified *rate of change* from the pressure transducer, again with the accelerometer correcting for short term upsets.

When an autopilot flies an ILS approach, the aircraft follows the Localizer signal in Altitude Hold Mode (ALT) until it intersects the Glideslope signal. At this point it continues flying the Localizer for lateral guidance but disengages from ALT and pitches down to track the Glideslope signal. This signal is descending to the runway touchdown point at approximately a 3º angle. In S-TEC autopilots, a -500 ft/min vertical speed command is produced at the Altitude Hold (ALT) / Glideslope Coupled (GS) transition point which becomes the default rate of descent in lieu of an error from the Glideslope receiver. This vertical speed command is then modified as necessary by deviations in the Glideslope needle to keep it centered. The Bendix/King KAP 140 operates in a similar manner.

While use of the static pressure sensor/accelerometer combination provides an affordable method of deriving pitch control, it has two areas of susceptibility not found in a gyro derived pitch autopilot. The first is the need for the computer (with integral accelerometer) to be mounted in the instrument panel exactly as the manufacturer specifies - that is, structurally rigid and at the proper inclination. Should the computer be allowed to move in turbulence, the sensing of actual G forces will be incorrect and the subsequent response will be inadequate. Should the computer tray not be strapped properly and the computer allowed to sag, the G forces sensed will vary as a function of this angle. This can be the difference between a crisp, well controlled aircraft and one that is barely acceptable. It can also lead to a potentially dangerous variation in pitch limiter response. See Figure 2 below.

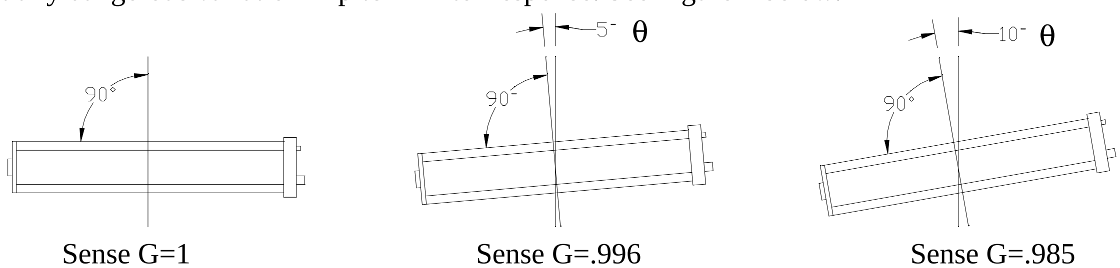

Figure 2 Installation limitations.

Another area of susceptibility found in static pressure sensor/accelerometer based autopilots is the ability to discern ever smaller differences in air pressure for basic attitude/altitude control. At sea level, there is approximately 14.7 lbs/in^2, 30"Hg, or 1013 mb of atmospheric pressure. With a pressure lapse rate of roughly 2% per thousand feet at lower elevations, a small altitude change equates into an easily measured voltage. As the altitude increases, however, the pressure decreases producing commensurately smaller voltage changes from which the computer must recognize and produce a reaction. It is imperative that the aircraft controls are properly rigged and cable tensions and forces are within manufacturer's specifications. In many instances, a pitch porpoise is not due to a fault in the autopilot components but the result of airframe deficiencies. Figure 3 shows the relationship between altitude and atmospheric density.

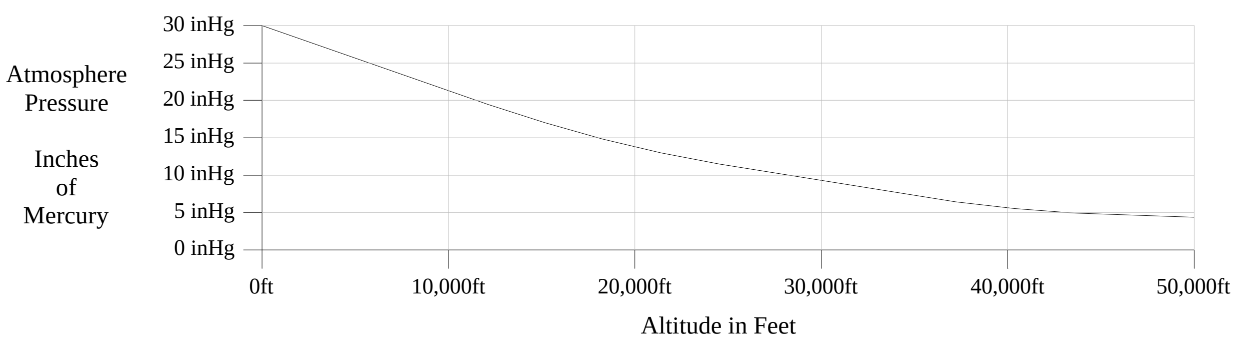

Figure 3 Altitude and atmospheric density relationship.

The pressure sensor/accelerometer based autopilot provides a cost effective alternative to gyro based autopilots. They have become increasingly popular in the General Aviation fleet due to their price/performance ratio.

Next Month: We pause our series on autopilots to review aircraft electrical systems