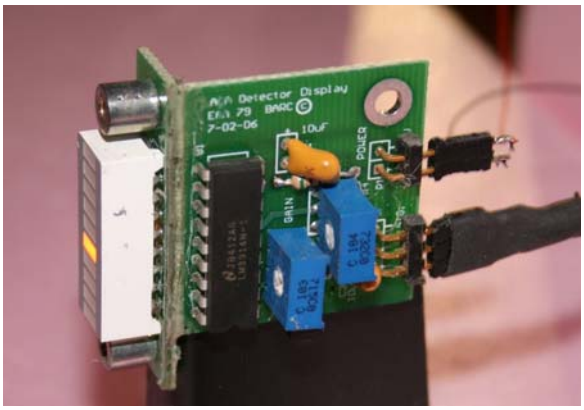
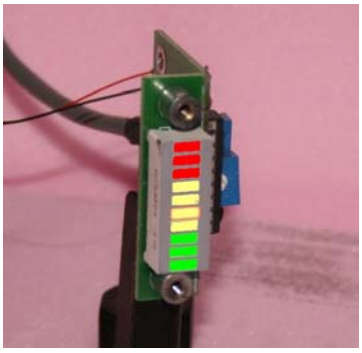
This months project
Angle of Attack Indicator. –Dave Barker
EAA Chapter 79
This device is really just a simple weather vane with the axis mounted horizontally to indicate relative wind in the vertical direction as opposed to azimuth for a weather vane on the barn. Why AOA (Angle Of Attack) ? Because it can tell you what the aircraft is really doing compared to the typical variable incidence of the Pitot tube rigidly mounted under the wing. The pivoting vane of the AOA detector always flies directly into the relative wind. The angle it makes with the attack angle of the wing can be measured and provides accurate flight status in high pucker- factor maneuvers such as short take off and landing attitudes. The pick-up makes use of a linear Hall effect sensor. This is a device that outputs a voltage proportional to the strength of a magnetic field. The Vane of the AOA carries a small permanent magnet that rotates with the Vane relative to the Hall sense device located on the Delrin mount sleeve. The output voltage is used to drive a panel mounted 10-segment multicolor bargraph display. The display LED's change position and color from Green to Yellow to Red as the angle of attack increases.

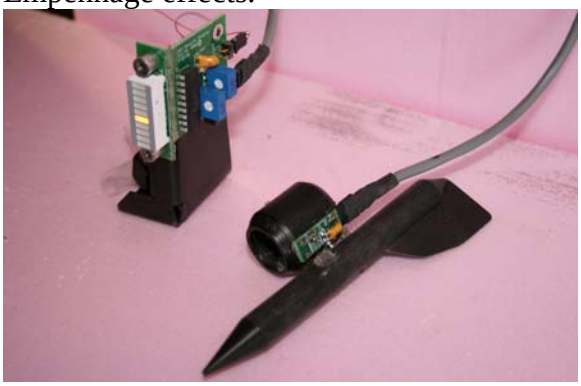


The AOA display board requires minimal panel space, but should be mounted high on the panel to stay within your peripheral field of vision while looking outside.



All LEDs ON (Not the normal display)

The hardest part of this project is deciding where to mount the vane assembly. And then routing the connecting cable through the wing to the sensor. The sensor vane needs to be located in the undisturbed airflow away from prop blast and wing Empennage effects.

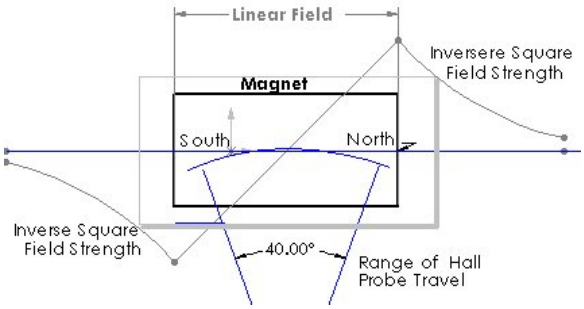


Display and Sensor

In many aircraft mounting parallel to the side of the Pitot tube structure is a good choice. My plane has a typical heated Pitot tube structure and I build a Delrin ring carrier for the Hall sensor and pivot that slides on the Pitot tube and positions the vane parallel and slightly behind the Pitot intake port.

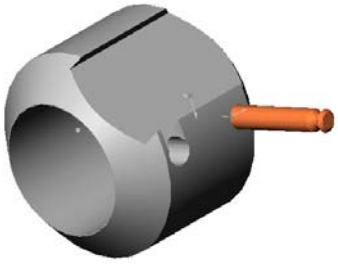
The vane and fin itself can be formed from plastic. I used a piece of Delrin rod equipped with an aluminum fin. It mounts on a 1/8" stainless steel pivot shaft. The vane carries a small 0.375" long rectangular permanent magnetic mounted in the inboard face of the vane about 1/4" ahead of the pivot shaft. The North to South side face of magnet rolls about the pivot parallel to the hall sensor face. By keeping the arc travel

within the physical length of the magnet we can achieve a linear position voltage output from the Hall sensor versus angle of displacement of the moving vane.

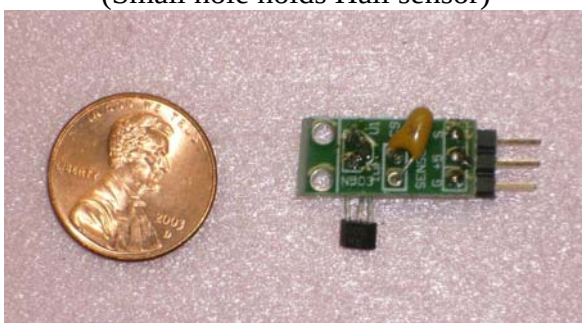


Hall output voltage vs. position

AOA Vane and Mount with Hall Sensor

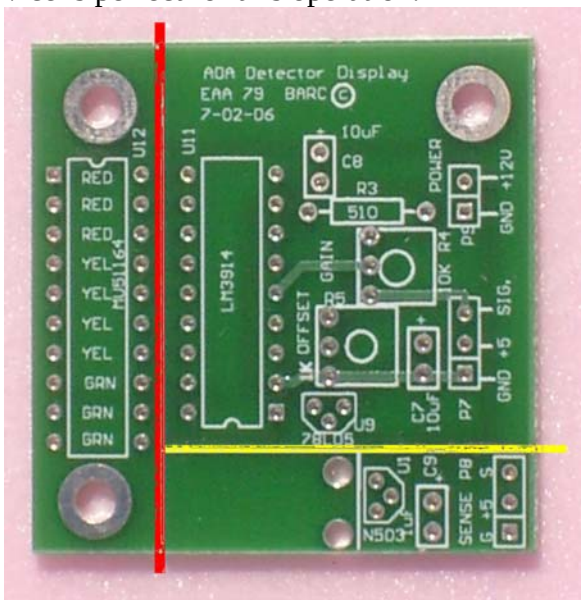


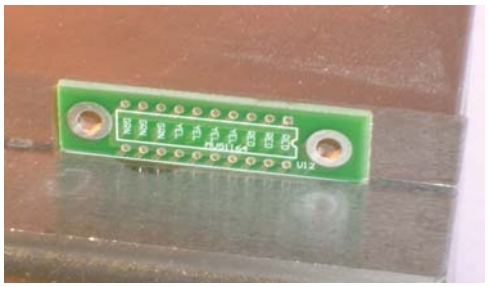
Mount and pivot bearing and vane shaft
(Small hole holds Hall sensor)



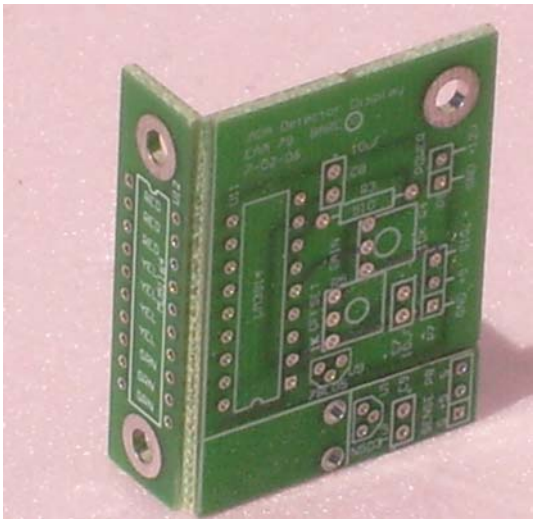
Board with plug and Hall sensor mounted on bottom side of PC board

To minimize aircraft panel real estate, the top side of the PC board is scored about .030" deep (Red Line below) along the side of the bargraph display. Mount the bare board in a machine vice with the jaw edge along the score mark and bend the board back against the sharp (square) edge. A mill vice is perfect for this operation.





Place in vice at the score line and
Break scored line backwards for 90° fold



By carefully pushing the display portion backwards over the sharp edge of machine vise, the PC board folds the display portion 90^{o} without breaking the connecting traces on the back surface. Hold it in the 90^{o} position, and fill the gap with glue. If this is done carefully, you will not break any of the copper traces on the backside of the board. However, if you do damage a copper trace, scrape off the green solder mask on the broken trace, tin and bridge solder it with fine copper wire. The sensor portion of the circuit board is cut all the way through and can be broken out completely after the display section fold process.
Trim off the unused portion of the Hall sensor board remnant, and install the Hall device magnetic field sensor, plug and capacitor. This PC board is mounted on the Delrin ring sleeve support, which in turn carries the moving vane equipped with its permanent magnet. The magnet moves across the face of the Hall sensor as the aircraft pitches up and down.

Assembly
Populate the board with the components as shown on the board annotation and the photos. Solder the parts in place and additionally solder the touching display and driver chip leads at the board fold. (This will provide additional structural strength)
Install Hall sensor and plug on back side of the PC board. Mount is the Pitot tube mount slot. Hall sensor should be flush with the Mount surface.

AOA Vane Mounted next to Pitot tube

The most tedious portion of the job is usually the routing of the connecting cable (two conductor plus shield) from the sensor thru the wing to the aircraft instrument panel.

Calibration
The display board has two blue adjusting trimpots that allow scaling to fit the aircraft performance type. This will vary if you are flying a trike or a jet. The uppermost trimpot on the display board sets the gain. I.e. How many bars the display moves up and down with each degree of vane rotation. The lower trimpot is an offset adjustment. This moves the span position (bottom green display element turn ON). This bottom Green LED should be ON when the aircraft is in straight and level flight. The upper RED light should turn on at the stall angle for your particular aircraft and wing design. A range of somewhere between 15^{o}– 40^{o} for most aircraft types.
Note: In ground calibration you will be pitching the vane downward to set the gain trimpot. Which is the same as the wing pitching upward while the vane maintains a constant position to the relative wind.
Please note the gain and offset pots are somewhat interactive and will require some iteration to zero in on optimum.

Finally, **Please, Please if you are going to check out the limits of performance of your aircraft. Do it with lots of altitude!!!!! This device is an indicator. It will <u>not</u> rescue you from sloppy pilotage!**
Dave Barker -copyright 3/06 revised 9/08

The AOA kit consists of:

Electronic components

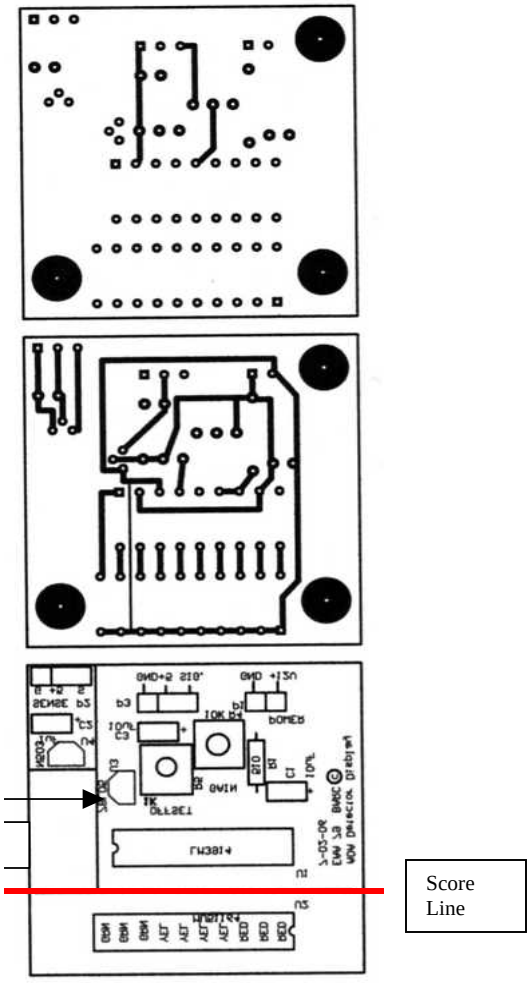
- Double sided PC Display boards
- Cut and scored
- N305 Hall magnetic sensor
- LM 78L05 Regulator
- LM 3914 Bargraph Drive
- MV5A164 Multicolor LED Display
- 10K & 1K Pot
- 510 ohm resistor
- 1uF Capacitor
- 10uF Capacitor
- 3 pin plugs (2)
- 2-pin plug (1)
- Cable termination connectors. (2)
- Power terminal (1)
- 20 feet of 2 conductor + shield cable

Mechanical parts

- ¼" x 4-40 swage type mount (2)
- Prefab Delrin Sensor vane and fin
- Post axle components
- 0.374" x 0.1" x0.1"Smarium Cobalt Magnet
- Delrin Pitot tube Mount Assembly

To order

Go to: www.barkeraircraft.com



Top, Bottom & Overlay
PC board layout