TECH TIME

Helpful tips for the Avionics Technician

BY AL INGLE

This month we continue our series on autopilot theory and operation by performing a real world inspection of the autopilot as installed in the aircraft. We have previously discussed ground tests and a flight evaluation of the fundamental roll and pitch loops. This includes how to determine when the aircraft is flying straight and level, the proper operation of the servos, clutches, control cables, amplifier gain, nulls, damping and autotrim response. It is now time to check for the autopilot's response to inputs as directed from the pilot.

Depending upon the autopilot manufacturer and type, a great deal can be learned about an autopilot by operating the pitch or attitude modifier. In many Bendix/King autopilots, in attitude (ATT) mode, depressing the pitch modifier changes the aircraft's attitude 1 degree for every second the button is depressed. Or alternatively, depressing the pitch modifier in altitude hold (ALT) mode causes the selected altitude to change at 500-600 feet/minute as long as the modifier is depressed. Determine from the Pilot's Operating Handbook the range of pitch modifier action for the autopilot being flown and test accordingly. In the ALT mode this is additional confirmation of the gain or gyro/computer interface.

Having previously tested pitch and roll ATT modes, we can now move to a commanded operation. In level flight, ALT mode selected, set the heading bug on the directional gyro or HSI directly under the lubber line at the 12:00 o'clock position and select HDG on the autopilot mode controller. Most autopilots should smoothly fly the selected heading within 2 degrees. Next select a heading on the HSI or DG that is 90 degrees to the right of the current heading and hold the knob so that the heading error remains at 90 degrees even with the aircraft in a banking turn. The heading mode is now saturated and will command at its maximum roll angle, or approximately *standard rate*. Perform the same test except select the heading on the HSI or DG 90 degrees to the left of the lubber line and hold the knob so that the error remains at 90 degrees. Again the heading mode will saturate at its maximum roll angle which should be approximately the *standard rate*. If the aircraft banks at angles more or less than specified, the roll gain interface between the gyro and computer may be incorrect. A simple check of roll gain is to adjust the HDG bug 10 degrees right or left of the current heading and check for the corresponding bank angle. A rule of thumb is you should expect 10 degrees of bank. The *difference* between the right and left bank angles is usually not more than +/- 2 degrees in most autopilots. In other words, if the specification is 24 degrees, you are allowed 22 to 26 degrees. If your difference exceeds this, you may have a gyro fault (gyro horizon in position based autopilots or turn coordinator in rate based autopilots).

The *standard rate* is a rate of turn that has been deemed safe for flight under instrument conditions. For aircraft in our industry this is 3 degrees of heading change per second or 2 minutes to fly in a circle or simply a two minute turn. Remember that the bank angle varies with airspeed for a standard rate turn. A simple rule of thumb formula describes this relationship:

Bank Angle for 2 Minute Turn = True Airspeed x 0.15

Therefore, at 200 Knots you would expect to bank approximately 30 degrees for a standard rate turn.

Note also the altitude changes when turning to new headings. When banking the aircraft there is less lift and the aircraft will pitch down until sensed by the autopilot and corrected. When you roll out of a turn there is now more lift and the aircraft will pitch up and the autopilot must react accordingly. Generally, 50-60 feet of altitude gain or loss is acceptable. If you gain an appreciable amount of altitude when turning in one direction and lose a corresponding amount of altitude when turning in the opposite direction (in position based autopilots) you may have a gyro horizon that is not properly adjusted.

Lastly, the published bank angle of your autopilot is determined by its certification in that aircraft and may vary from standard rate, but is typically close to it.

If the autopilot has a Flight Director, the "V" bars or commanding pointers (found in some older Honeywell models) must be set to rest directly above or centered in the associated symbol in the Flight Director Indicator. The Flight Director commands should correspond with the actions of the autopilot i.e. they should indicate straight and level flight when the aircraft is doing so and accurately reflect the bank and pitch changes. In most autopilots there are adjustments to eliminate the minor offsets seen by the pilot.

Moving on to the pitch axis, we have previously established what constitutes proper pitch stability. With the aircraft at cruise airspeed, select heading (HDG) and altitude hold (ALT) modes and engage the autopilot. Allow the aircraft to stabilize and then slowly reduce power until the aircraft is flying at its minimum certificated airspeed for the autopilot coupled mode. The altitude should remain within 40-50 feet of that initially selected and the electric trim should begin to trim up. After the airspeed has stabilized, depress the Control Wheel Steering button (CWS) or disconnect the autopilot. Either of these actions will disengage the servos from the aircraft controls. There should be no pitch forces or "pitch bump" felt. If there is a noticeable pitch action, the automatic trim is not functioning properly. If flaps are allowed during approaches, you may want to check them during this test. Remember to check for any published limits in using the flaps and beware that they can induce significant pitch changes.

Reengage the autopilot in the ALT mode (or release the CWS button) and advance the power to establish the aircraft at high cruise airspeed. As the aircraft accelerates, the automatic trim should begin to trim down to compensate for the additional lift being generated from the increase in airspeed. After the airspeed has stabilized, disconnect the autopilot or depress the CWS button and check for any pitch response. As in slow flight, there should be no noticeable pitch action or "pitch bump".

Failure to hold altitude may be a function of the altitude hold (ALT) or autotrim circuitry. If the autotrim system is responsive and operating in both directions as described above, then you may have other problems. Since autopilots must sense the ambient air for altitude hold computation, they are connected to the static system. High performance autopilots that operate at flight levels above 18,000 feet often have airspeed inputs as well. Common problems associated with altitude hold are water in the static and/or pitot lines, small amounts of water that freeze at altitude but thaw and do not present a problem at lower altitudes (and in the service shop) and kinked or open pitot/static lines. A static line that vents into the cabin is not presenting a true and instantly changing pressure that the computer needs. Furthermore, due to the Venturi effect, the pressure in the cabin is typically lower than the ambient pressure. The static lines should be free of any obstructions or sharp bends and if the STC or TC specifies any type of modification to the static system i.e. installation of a damping bulb, it should be installed in the recommended location.

Remember that many panel mounted autopilot computers have the static line connected to the rear of the unit. When sliding the computer back into the tray, you may kink the static line behind the instrument panel causing unacceptable performance. Also, should the computer be removed for service, you have now opened the static system and the aircraft is no longer certified for IFR flight. Check the static system before troubleshooting any autopilot problem (with a pitch axis installed) and recheck it as part of your return to service. You may also want to reference the static check in the subsequent logbook entry.

We are now ready to test the navigational features of the autopilot.

Next Month: More autopilots