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, heading (HDG), altitude hold (ALT) and autotrim operation.

Continue the evaluation of autopilot performance by first establishing the aircraft at normal cruise speed and at a safe altitude. Identify a VOR station more than 30 nautical miles away, tune and center the needle, then add 10 degrees of course error so that the needle swings full scale. Engage the autopilot, select the HDG mode and command a heading that will create a 45 degree intercept angle to the desired VOR radial. Now arm the NAV mode (if applicable) and fly the heading until the VOR needle is captured. If the autopilot does not have Nav Arm/Capture capability, then select the Nav mode at the 45 degree intercept angle. The capture transition will be a function of needle displacement and rate. The autopilot should couple the NAV deviation needle smoothly and turn to the radial without overshooting. The deviation needle should come to rest directly under the lubber line and quantifies the smooth transition.

Many autopilots do not monitor the Nav flag. In these cases, you may turn off the Nav receiver and fly the CRS arrow just like a HDG bug. In this way you can determine if there are any offsets present. Remember, however, that in the NAV mode most autopilots have a *washout* feature in which the CRS signals are minimized over time allowing the autopilot to accurately track the needle even in a crosswind. To regain normal CRS action, select HDG, then back to the NAV mode to reset this washout feature. Another method of observing the offset of an autopilot is by monitoring the GPS cross track feature, if one is installed.

We are now ready to check the approach functions of the autopilot. Figure 1 is representative of the vertical and lateral profiles that the autopilot will be flying.

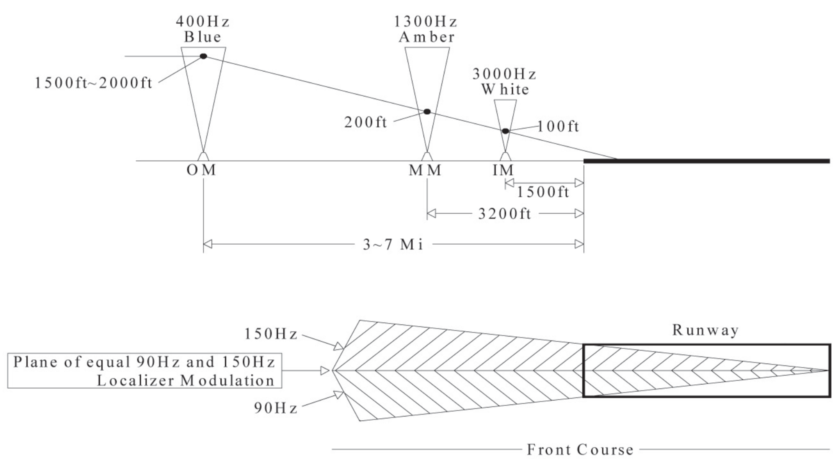

Figure 1 Typical ILS approach (Glide Slope/Marker Beacon/Localizer).

Select APR mode and fly a GPS approach (if installed) to the longest runway available. It is of paramount importance that cross track error is at a minimum. You should be on an extension of the centerline, assuming in this scenario that the waypoint is aligned with the center of the runway. Historically, general aviation autopilots were only coupled to standard +/- 150 mV lateral signals. Today, with the advent of GPS approaches, roll steering has come into vogue with input signals that act in a similar manner to the HDG signals. Roll steering "AC" voltages change phase at the zero crossing point, with "DC" voltages at null and varying positively or negatively through the crossing point as designed. Coincident with the GPS approach, tune the No.2 Navigation receiver to the Localizer frequency as a secondary check of course alignment.

To check the operation of the ILS coupled approach, you may select the ALT and HDG modes, then NAV (Arm, if applicable), then manually fly with the HDG bug as needed to execute the procedure turns or other rapid changes in heading required for proper intercept and/or alignment on the localizer. As the localizer needle centers, the Nav mode (localizer) should couple smoothly without overshoot. Review Figure 1 and remember that your position on the approach sets the sensitivity of the autopilot due to the approximately 3 degree width of the signal.

The autopilot computer does not know where it is on the approach without some other guidance. Therefore, it is important that the aircraft be flown at normal approach speeds, in the landing configuration and that the approach be initiated far enough out to allow the autopilot computer to settle into a proper approach configuration. For safety and performance reasons there are long-term time constants and sequences which must be satisfied in the Approach mode before the autopilot will couple.

After intercepting the localizer, there should be no overshoot and the CRS washout feature will be evident as in the NAV mode in the event of a crosswind (within the design limits of the correction angle). There may be more wing movement because the priority is for the aircraft to stay centered on the localizer, typically within one needle width. In other words, the autopilot should act more like a human pilot, foregoing grace for results.

For glideslope coupling, after the aircraft is aligned with the localizer, it is usually approaching the runway beneath the centered glideslope signal and captures from below (some autopilots allow capture from above and below the glideslope-consult your Pilot's Operating Handbook). As the glideslope needle descends through the zero crossing point in the navigation display, the ALT disengages and the glideslope couples. There should be an immediate pitch down by the autopilot so that the aircraft can begin to follow the glideslope signal that is descending at approximately a three degree angle. This is also a good time to lower the gear and flaps, if applicable.

The autopilot should fly without oscillation and typically within one needle width to the decision height (DH). Note that as the aircraft approaches the decision height (DH), about 200 feet above the ground, the autopilot may not hold the glideslope needle closely as the cone of signal gets ever smaller. Experience from the author is that the aircraft flies increasingly above the "on glideslope" path, which is an error on the side of safety. At this distance from the runway, however, we are not dealing with a large vertical displacement. What is important is that the aircraft is flown smoothly, aligned with the runway, and autopilot disconnect produces no discernable pitch action.

Autopilot manufacturers have incorporated different methods of varying the gain to compensate for the radial nature of ILS signals and the effects of flaps. The reception of marker signals (OM, MM), radar altimeter trips at absolute altitude points along the approach, complex timing verses gain algorithms and flap position feedback devices may be utilized. It is important when troubleshooting a coupled approach problem that the technician fully understand how the gain is controlled and ensure that these systems are functioning correctly.

Next Month: More autopilots