TECH TIME

Helpful tips for the Avionics Technician

BY AL INGLE

This month the gyro horizon (or vertical gyro) used with position based autopilots is examined from an electrical point of view. Specifically, we want to know how the gyro senses and transmits attitude information to the autopilot computer. There are many ways of creating these signals but all share some common traits. At the fundamental level, we must first begin with basic transformer theory.

When an AC source current flows through the turns of an inductor, the generation of a counter-voltage and the storage of energy during each half cycle is due to its self inductance. If another inductor, not connected to the original AC current source, is positioned so that the expanding and contracting magnetic field of the first inductor cuts across its turns, a current will be induced into the second coil. A load such as a resistor may be connected across the second coil to consume the energy transferred magnetically from the first inductor. This phenomenon is called *mutual inductance*.

Two inductors positioned so that the magnetic field of one induces a current into a second inductor are said to be coupled. The inductor creating the magnetic field can be considered the primary, while the inductor having current induced into it can be considered the secondary. Any two coils having mutual inductance comprise a *transformer*. The amount of coupling can be increased by placing the inductors closer to one another or winding the inductors around a common iron core. Also, the direction of current flow induced into the secondary is dependent upon the direction of current flow in the primary. Figure 1 shows the electrical depiction of a transformer with an air core, Figure 2 shows an iron core transformer.

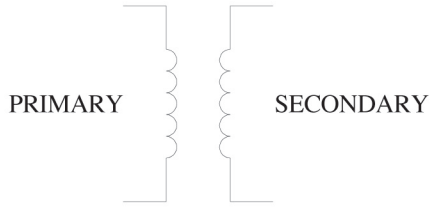

Figure 1 Air core transformer.

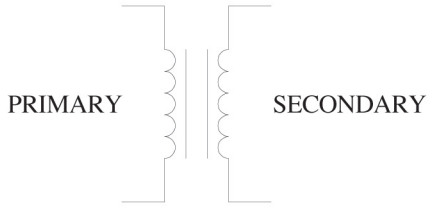

Figure 2 Iron core transformer.

In the case of a gyro horizon or vertical gyro, there is a pitch and roll "transformer" for each axis the autopilot controls. The primary of each transformer is excited with AC current from either the aircraft's 400 Hz power or from an AC power source within the autopilot computer. The secondary is typically two windings (inductors in series).

The primary and secondary coils for each axis are mounted within the gyro assembly such that when an aircraft is in level flight, there is no output from the two coils in the secondary except for a small residual voltage. When an aircraft rolls in one direction, an iron bar, typically connected to the rotor assembly, couples more of the primary's magnetic field to one coil causing that signal to dominate over the less coupled coil. This dominance and therefore output signal increases as the bank angle increases. As the aircraft returns to level flight and proceeds into an opposite turn, the output signal decreases to its null and then begins to increase with bank angle as the other coil's output is dominant. The autopilot computer compares the phase of the roll attitude signal with the phase of the excitation signal and can determine whether the aircraft is in a right or left hand bank. In a perfect world, the attitude signal is either exactly in phase or 180° out of phase with its excitation. There does not seem to be any convention in the industry i.e. right bank equals

in phase, etc., so be sure to review the manufacturer's maintenance literature. This same scenario is repeated in the pitch axis. Again, there is no standard i.e. climb equals in phase, etc., so a maintenance review is necessary before troubleshooting.

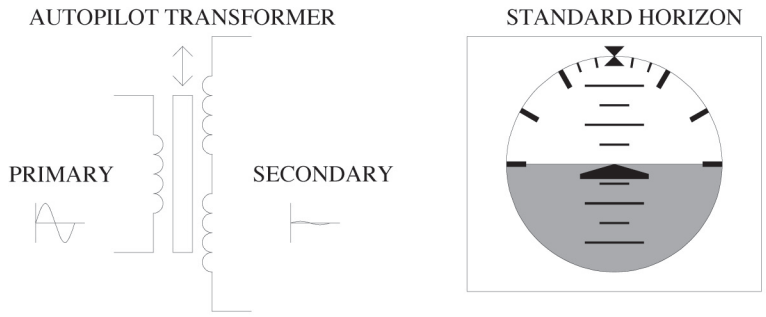

Figure 3 Attitude gyro in level flight and the resultant roll output.

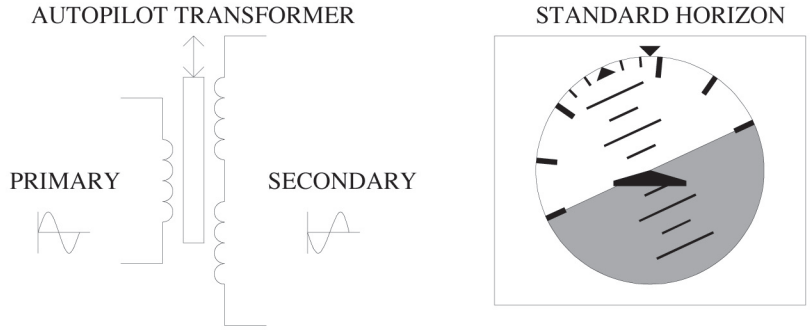

Figure 4 Attitude gyro in 25° right bank and the resultant roll output.

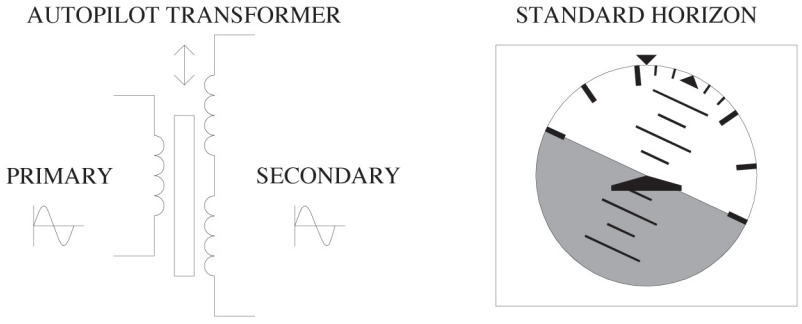

Figure 5 Attitude gyro in 25° left bank and the resultant roll output.

Roll and pitch output levels vary among autopilot manufacturers. They range from a low of 3 mV/° for roll and 6mV/° for Pitch to 200 mV/° for roll and pitch. The output levels are a function of the input excitation voltage, the coupling between the primary and secondary coils and the turns ratio of the resultant transformer. But there is another important anomaly that must be dealt with if we are to effectively utilize the signals produced by our attitude transformer. The secondary signals may be processed properly by our autopilot computer only if they are 0° or 180° with respect to the excitation. The reactance of the transformer and associated circuitry, however, creates an unwanted phase shift that must be dealt with.

Next Month: More autopilots