White Paper

Drive-By-Wire Concept

In aviation the term fly-by-wire means that the control surfaces of an aircraft are operated by actuators rather than via cables and rods, with electrical signals transmitting information from the cockpit to the actuators. The pilot's controls, such as the control stick and rudder pedals, are fitted with analog or digital transducers that generate electrical signals corresponding to the given command. The outputs of the transducers are processed through a stability augmentation computer. The computer compares the aircraft's actual motion, as sensed by gyros and accelerometers, and corrects it to a control law, improving the aircraft's handling.

Drive-by-wire is the same basic concept implemented in the automotive field, with purely mechanical/hydraulic steering, braking and engine control systems replaced by mechatronic (combining mechanical, electronic and software elements) components that allow for higher performance, extended functionality and, both through the control functions and reduction of weight, reduced fuel consumption.

Steer-by-wire

Steer-by-wire is a subset of the drive-by-wire concept. Conventional steering systems in automobiles use various forms of mechanical and hydraulic connections between the steering wheel and the steering valve, with the steering wheel rotation amplified by the steering valve to obtain a proportional articulation angle at the front wheels. Since the two systems (steering wheel and steering mechanism) are mechanically coupled, there is an inherent force feedback at the steering wheel proportional to the steering conditions. In a steer-by-wire system, real-time steering angular position feedback is required to send motion information to the driver. A motion encoder plays an important role in this critical application, and a high-resolution encoder is needed to provide the necessary positional accuracy. An absolute encoder is the best device for this role, since it is able to provide absolute position information immediately upon power-up and requires no external memory or reference point to remember the last position.

How Avago Technologies' AEAS-7000 Absolute Encoder is Applied in Steer – by - Wire

Encoders or motion sensors are electromechanical feedback devices that detect rotary or linear movements and translate them into interpretable electrical signals for the controller. Figure 1 below shows the basic components of an optical encoder.

The device consists of a light source, lens, patterned code wheel and an array of photodetectors. The code wheel rotates between the light source and photodetectors causing the light beam to be interrupted by the pattern of spaces and bars on the code wheel. The photodetectors generate currents according to the patterns, which are signal conditioned within the device and presented to the outside world in appropriate electrical signal form.

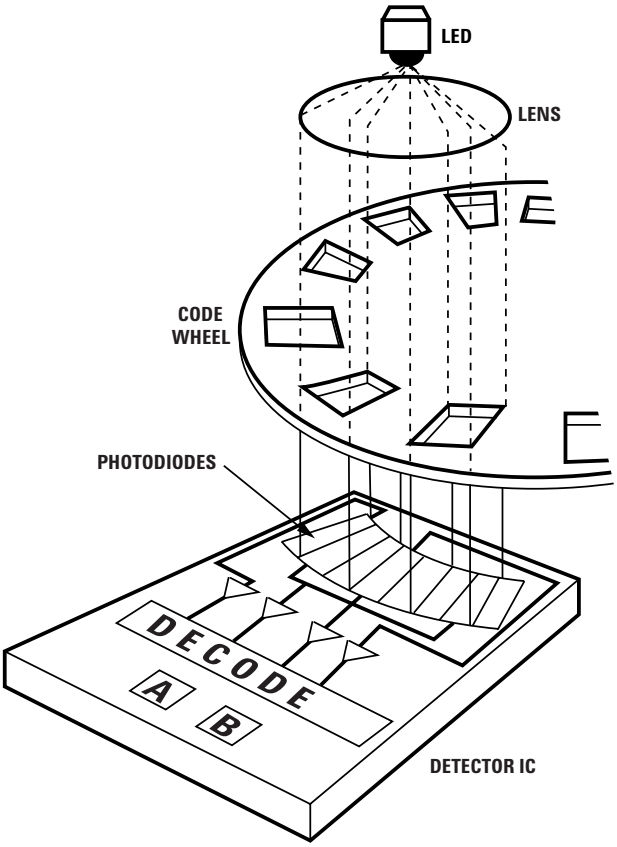

Figure 1. Optical encoder

There are two major categories of optical encoders: incremental and absolute.

Incremental encoders continuously generate toggling high and low logic states when they are subject to rotary or linear motion. The incremental encoder is a relative position feedback device, which means that the current position information is only incremental from the last position sensed. The drawback of this type of sensor is that upon device power up, initial position information is not provided. Hence, some form of homing will be required.

On the other hand, absolute encoders generate a unique code for each position, which means that they provide current position information instantly upon power up. The absolute encoder utilizes a binary or Gray code pattern as shown below in Fig. 2.

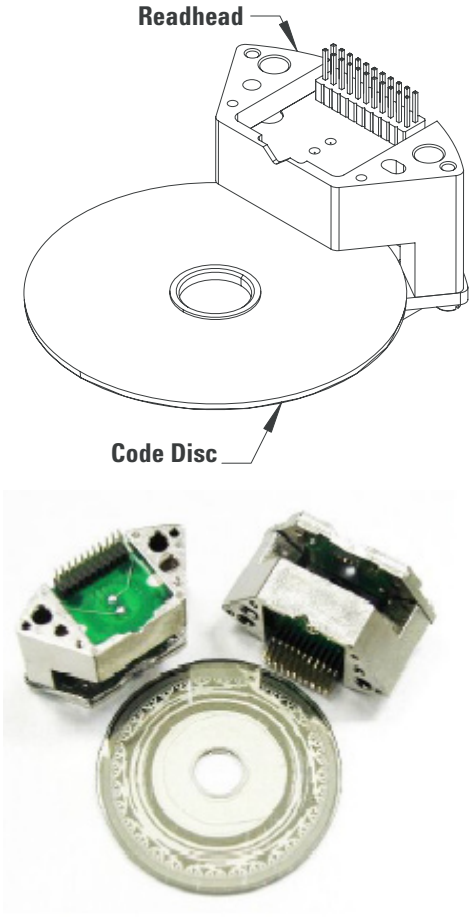

Figure 2. Absolute encoder

This makes the absolute encoder more suitable for a steer-by-wire application because of its ability to provide a unique binary or Gray code indicating the actual position of the shaft to which it is attached.

The Avago Technologies AEAS-7000 Absolute Encoder is a 16-bit-resolution absolute encoder, capable of sensing 2^{16} = 65,536 unique angular positions within a revolution of 360 mechanical degrees, with an accuracy of ± 2 bits when tested at 80 RPM. At lower speeds, the encoder can provide precise position information without any bit errors. The positional information is presented in the form of a Gray code.

The encoder incorporates serial communication with a data transmission rate of up to 16 MHz, which means that a 1 µs time frame is required to obtain 16-bit serial data. The AEAS-7000 is available with 13-bit and 16-bit serial data, based on a customer's requirement. The encoder comes in modular form, so the end user will be required to house it in an appropriate IP-rated package.

Adaptive Control

With drive-by-wire implemented in a vehicle, various adaptive controls can easily be provided. One example is adaptive control of the position of the vehicle's headlights.

Headlights equipped with adaptive front-lighting systems (AFS) are automatically pivoted to match the distribution of light with the vehicle's turning angle so that upcoming curves and intersections receive maximum illumination at the driver's gaze point (Fig. 3). The significant increase in light helps reduce driver stress and fatigue and improves the ability to see obstacles that fixed-beam headlamps might not illuminate.

Studies on swivel-beam headlamps have shown up to a 300-percent increase in the illumination of the driver's gaze point as the vehicle turns into a corner, with the additional corner illumination resulting in a 58-percent increase in the driver's ability to recognize an obstacle.

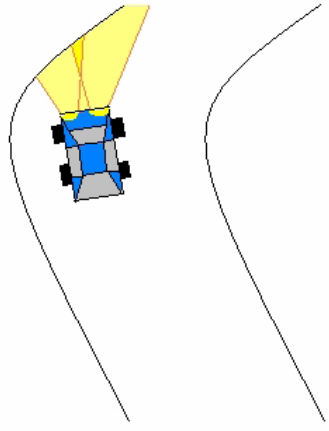

Figure 3. Coverage of adaptive headlights on a sharp curve

Such a headlight aiming headlight control technique can be accomplished using Avago Technologies' AEAS-7000 absolute encoder. Figure 4 shows the absolute encoder used in a vehicle combining steer-by-wire and adaptive headlight control.

For more information on AEAS-7000 Absolute Encoder, please refer Avago Technologies' website at http://www.avagotech.com for more information.

References

[1] Avago Technologies AEAS-7000 Plug and Play Ultra-Precision Absolute Encoder 16-bit Gray Code Datasheet.

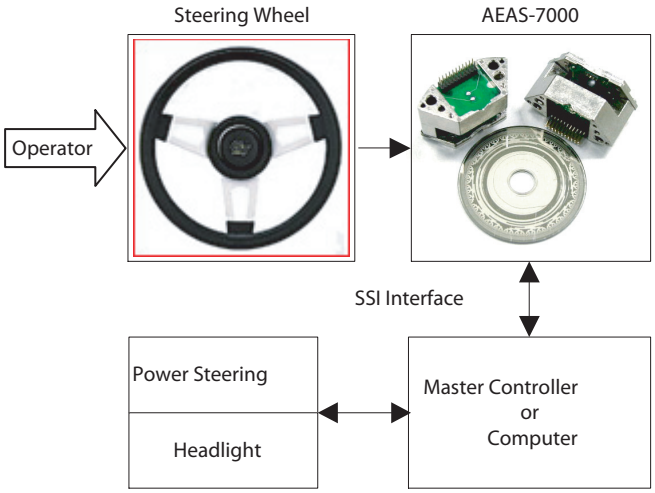

Figure 4. Absolute encoder used in the steer-by-wire application incorporating adaptive front lighting.

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