The Evolution of Automotive Transmissive Sensors

Keeping pace with the electronification of automobiles

Look inside any car built since 2010 and you'll find a dizzying array of electronics. This evolution from mechanical to electronic devices is requiring components to evolve or, like the dinosaurs, die. Components need to be not only robust, but highly accurate for complex applications. We can see this process very clearly by looking at what has happened over the past several generations of transmissive sensors, where the battle for survival of the fittest continues to go on. We invite you in this article to journey with us through the evolution of transmissive sensors from simple through-hole packages to sophisticated rugged surface-mount technologies.

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The Pre-Triassic Period

At the dawn of the Pre-Triassic era, slotted interrupters also known as transmissive sensors in automotive systems took the form of an emitter-detector pair in through-hole packaging that was wave-soldered to a printed circuit board. The emitter and detector were facing each other so that if anything came between them, the output current of the photodiode or phototransistor would change. This change would be relayed to a controller and something would happen: a motor would start or stop, an indicator light would turn on or off, or a bag of chips would fall to the bottom of a vending machine.

The Triassic Period

The position of the discrete components could be difficult to precisely control. One might be higher than the other or at a slight angle; the leads might be bent, or during handling they could become disoriented. This posed a problem for the system because the output current from the detector would vary from board to board. The controller might be looking for a certain signal level and, without an exact orientation, it wouldn't get it. An evolutionary leap was ushered in by Vishay, which molded the discrete components in a common plastic housing to ensure exact orientation. This required several different package versions, each with a different gap between the emitter and detector, with a photodiode or phototransistor output, and with a different lead bend for horizontal or vertical gaps.

The TCPT- and TCUT1300X01 Period

Automotive customers needed a transmissive sensor that could operate at higher temperatures and was qualified to the AEC-Q101 standard. The molding compound of the emitter and detector limited the operating temperature. Based on the techniques used in Origami, Vishay designed a lead-frame based, custom formed sensor that used emitter and detector chips without lenses. With a gap of 3.0 mm and tightly controlled chip placement, the operating temperature increased from a maximum of 85 °C to 105 °C. Following Orwellian theory of one detector good, two detectors better, Vishay created a transmissive sensor with two phototransistors. With two, steering angle sensors could not only detect a code wheel but could also determine direction and speed, which is critical input to electronic stability control (ESC) units.

The advantage of this sensor's construction over standard slotted interrupters includes:

- Tighter tolerances of package outline dimensions and contact pads
- Tighter tolerance of optical axis
- Improved mechanical design flexibility due to wider and optimized gap
- Better co-planarity of contact pads for mounting to PCB

The TCPT- and TCUT1350X01 Period

Ever-demanding automotive customers needed the sensor to operate at still higher temperatures, to work in near-engine compartments and harsh environments up to 125 °C. With some inspired design changes, Vishay was able to manufacture slotted interrupters that met this specification. In addition, the typical output current of the phototransistor was increased from 0.6 mA to 1.6 mA.

The TCPT- and TCUT1600X01 Period

Imagine the lowly knob on your dashboard which controls the radio volume or the menu of your center console display. It is an appendage that commands little thought when not being turned or pushed. Yet lately Vishay Opto has given that knob a great deal of thought, especially that push function. Back in the day, designers could use the TCPT1300X01 sensor to determine the position of the knob but would have to design completely separate circuitry for the push. Not anymore. The transmissive sensor has evolved further to include the TCPT- and TCUT1600X01 which has a deeper channel. This deeper channel enables design engineers to redesign their code wheel to include a push function. The channel still has a gap width of 3 mm and two detector windows, but the depth has increased from 2.8 mm to 4.5 mm.

The TCUT1630X01 Period

While the increased dome height of 4.5 mm will be sufficient for some applications, automotive customers need the added capability to be able to change the resulting action depending on the position of the knob when it is pushed. To fully meet this requirement, a third phototransistor and third window has been added. The overall size of the sensor has increased to enable this additional feature. While it is a 3-channel transmissive sensor, it is still an incremental encoder.

The Fully Evolved TCUT1800X01

The TCUT1800X01 is a 4-channel transmissive sensor designed for incremental and absolute encoder applications. The sensor combines two infrared emitters with four detector channels in a small, 5.5 mm x 5.85 mm x 7 mm surface mount package. In combination with an application specific code wheel or strip, the sensor is ideally suited for a wide range of applications such as rotary switches, incremental turn switches, and speed and motion control systems. The integration of four channels into the automotive-qualified package also makes this sensor an excellent choice for more complex applications such as automotive steering wheel encoding, where multiple channels or channel redundancy is required. Depending on the application, the sensor can work as an absolute encoder or incremental encoder. The Center for Automotive Research (CAR) at the University of Duisburg-Essen in Germany expects global car sales growth of 2.2% next year, and in all these cars will be a whole lot of electronic systems; from the engine to safety and security, from comfort and convenience to navigation and instrumentation. Vishay optoelectronics will continue to lead the way in providing components that meet the challenges of an evolving automotive industry.