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Automotive convenience and safety systems rely on optical sensors

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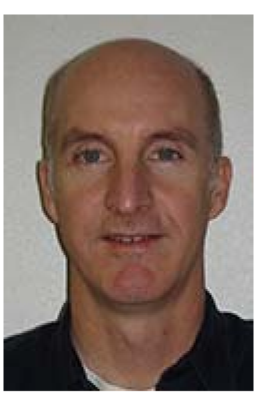

Twenty years ago, I worked for a flexible circuit manufacturer supplying to automotive instrument panel manufacturers. At that time, these manufacturers were wary of LED lighting. The tried and true twist-in bulb represented 99.9% of interior and exterior automotive lighting. If you wanted color, you put a colored film in front of the bulb. The state of lighting in automotive applications has changed significantly, but not dramatically. I still see bulbs used for overhead, door, trunk, and glove compartment lighting. More dramatic has been the use of optoelectronic sensors in automotive body electronic applications.

Let's start with the steering wheel and electronic stability control (ESC). ESC monitors the steering and vehicle direction. It determines the driver's intended direction by measuring the steering wheel angle through the use of optical interrupters or transmissive sensors. These sensors have an infrared emitter illuminating a phototransistor. When an object comes between them, the light is blocked. Two phototransistors can be used to not only measure the speed at which the steering wheel is being turned, but also its direction. Given that one-third of all traffic accidents could have been avoided using ESC, it is not surprising that in the United States federal regulations required that ESC be installed as a standard feature on all passenger cars and light trucks as of the 2012 model year.

Drivers don't give much thought to knobs and switches, but behind them are optically transmissive sensors used as part of an encoding system or as simple interrupters. One primary way of controlling the LCD display menu is through the use of the knob located in the center console. Turning to highlight a menu item and pushing to select it are accomplished using a sensor like the TCPT1300X01. Next time you shift into drive or turn on your blinker, know that a slotted interrupter is being used to optically sense the action. Adaptive headlights cast their beam in the direction of the curve a driver is steering through and ensure better visibility on winding roads. Within the headlights are small electric motors that turn them. A sensor like the TCPT1350X01, which can operate at temperatures as high at 125 °C, is used to encode the motor movement, thus controlling the motion of adaptive headlights.

Figure 1. TCPT1350X01 and TCUT1350X01 AEC-Q101-qualified slotted interrupters

Rain / light / tunnel sensors are found on high-end vehicles. Their primary function is to determine the amount of rain falling on the windshield to control the speed of the wipers. They can also be used to automatically turn on and off the headlights as the vehicle enters and exits a tunnel. Finally, they can determine the amount and direction of light as an input for climate control. My son asked me to turn off the air conditioning last weekend as we drove north to San Francisco. I was sitting in the sun and had to explain to him that our car did not have a "sun" sensor, so the "dad" sensor was the primary input. Each of these features relies on infrared emitters and photo detectors to function.

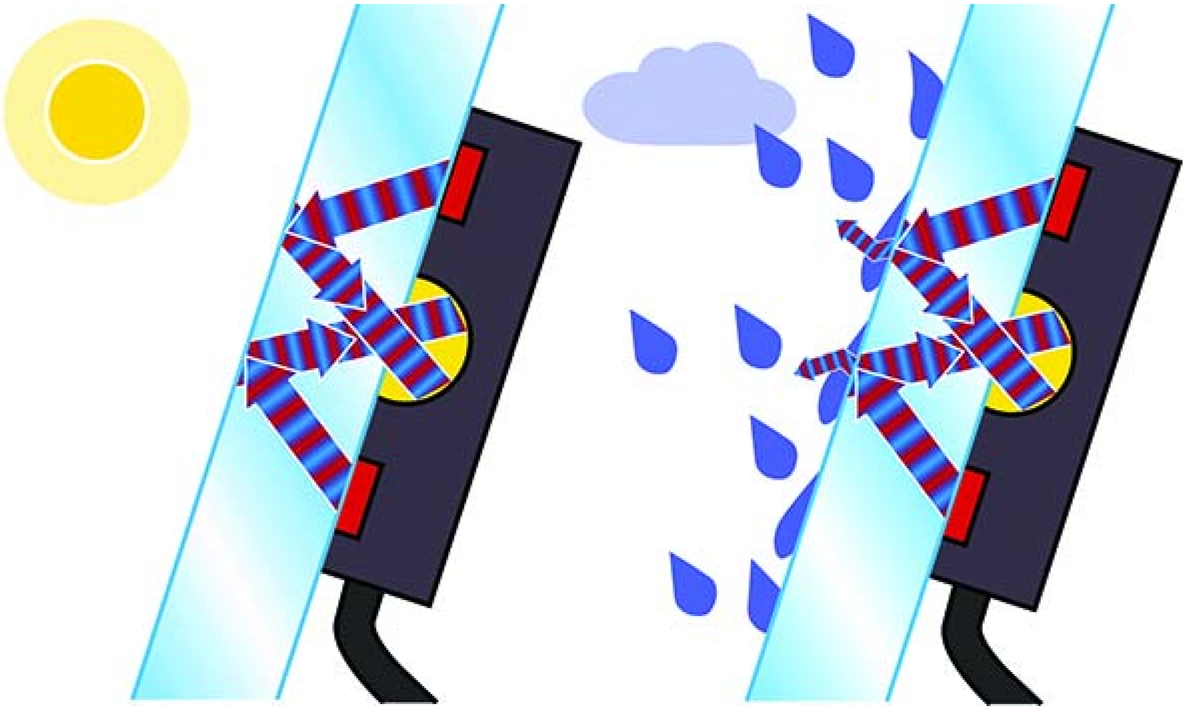

Figure 2. Rain sensor

Ambient light sensors have been used for decades to turn on and off headlights. With the introduction of high-resolution digital ambient light sensors, rear-view mirrors on high-end vehicles began to feature an auto-dimming function to reduce the glare from the headlights of vehicles traveling behind them at night. In addition, as larger and larger LCD monitors find their way into the dashboard of cars, the ambient light sensor will automatically control their backlight intensity. The screen will be bright during the day and dimmed at night for optimal viewing. This same sensor can be used to control the accent lighting in the cabin.

Many of these LCD monitors are used to control cabin features such as climate and sound systems, where a touch screen allows users to navigate through the menu of options. However, focusing on the touch can be as distracting as texting while driving. Instead, manufacturers are evaluating the use of gesture control, where a swiping motion is sufficient to move from screen to screen and up and down a menu system. Common gesture systems being evaluated include multiplexed infrared emitters with a reflective proximity sensor located above the monitor. They are precise enough to allow a touch-like selection without having to actually touch the screen as shown in the following gesture evaluation board.

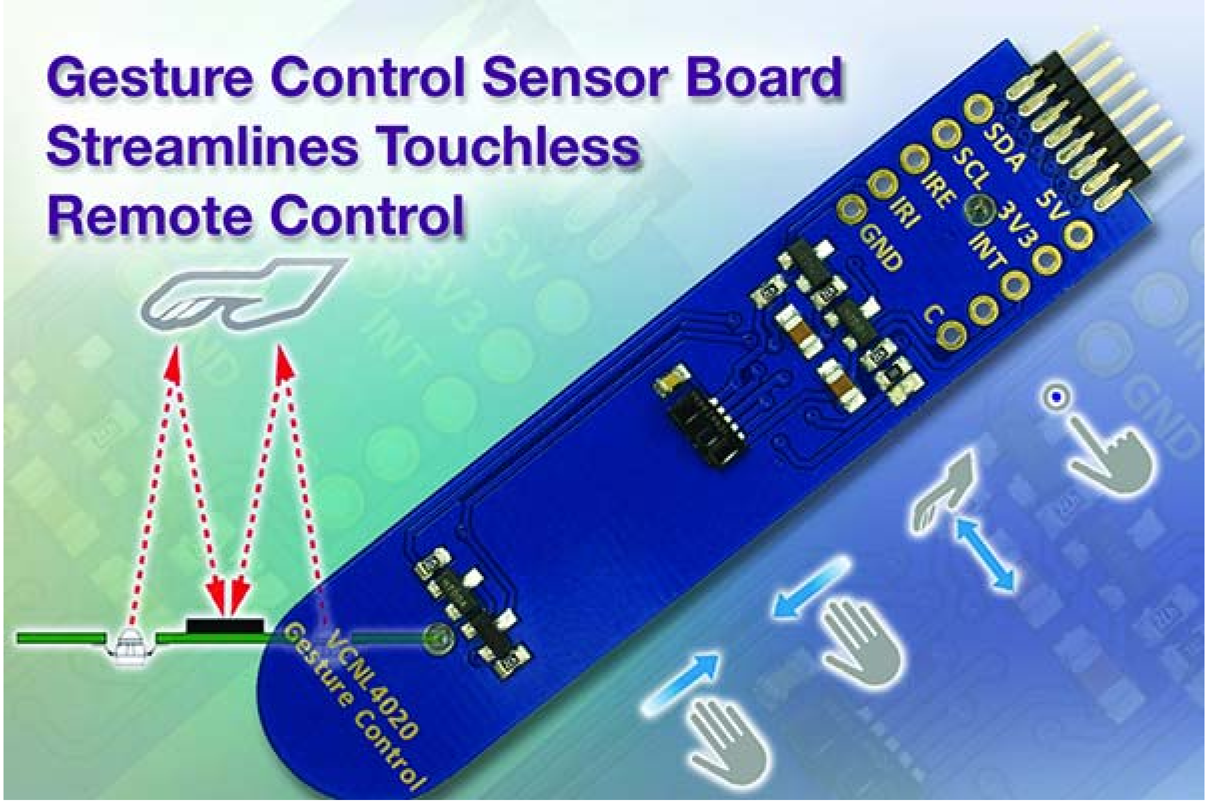

Figure 3. VCNL4020 Gesture-Control Evaluation Board

Wireless headphones are used with DVD players to entertain the back row occupants. Seldom — I couldn't say gone — are the days where "how much longer" is the mantra. Due to interference concerns, wireless car headphones use infrared emitters to transmit the sound and IR receivers to receive and provide the initial decoding of the sound. An IR receiver is also found in the DVD to control on / off, play and other remote control functions.

Moving out of the cabin to the outside of the vehicle, Ford introduced a foot-activated lift gateway in 2012. An RF sensor in the car detects when someone with the key fob is in proximity. It then enables a laser sensor under the rear bumper to detect reflected light off of the foot, which results in the trunk or gate opening. This could also be accomplished with a SurfLight™ infrared emitter with a collimating lens. Rear-view or back-up cameras could soon be a mandated feature on passenger vehicles. These same emitters can be used for nighttime illumination.

Night vision systems use either active infrared or passive infrared systems to increase the distance a driver can see beyond the reach of the headlights or in poor driving conditions. Active infrared systems pulse infrared emitters that are synchronized to a CMOS camera. The infrared will reflect off of objects beyond the vehicles headlights, and a heads-up display shows the reflected images. These systems are particularly useful in rain and snow and can extend vision to over 200 meters. Passive infrared sensors do not emit infrared light. Instead they are sensitive to the far infrared wavelengths and use a thermographic camera to display images.

Lane departure warning systems warn the driver if the vehicle is moving out of its lane on a freeway, unless a turn signal is on. They do not work below a certain speed, typically 35 mph. Camera-, laser-, or infrared-based systems are used to detect the lane markings. Camera-based systems parse the image, looking for straight or dashed lines to the right and left of the vehicle. Laser or infrared systems depend on the reflective contrast between the line and pavement and will be positioned at the corners of the vehicle. Both methods rely on visible lane markings. They typically cannot decipher faded, missing, or incorrect lane markings. Markings covered in snow render the system inoperative.

LEDs have made steady headway. They have replaced the bulb in most applications involving backlighting: instrument clusters, infotainment systems, switch backlighting, and climate control. They are used for brake lights, hazard lights, puddle lights, distinctive decorative lighting, and warning lights for blind spot and rear crossing alert systems. As color rendering improves, they are starting to be used in door lights and for cabin lighting. Higher end vehicles are allowing drivers to customize their interior color by using RGB LEDs that can be dialed in.

Within twenty years, hands-free driving will be a reality, at least on the freeway. Optoelectronic sensors will be doing the bulk of the sensing for us.

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