Application Brief

Localized Light Sensors for Automotive Applications

TEXAS INSTRUMENTS

Introduction

Light sensors detect the presence or absence of light, as well as the intensity on a surface area measured in Lux. Light sensors are a low cost and energy efficient option to have automatic brightness adjustment as well as day/night detection. Ambient light sensors are becoming commonly found in automotive display applications, first introduced as a single optical sensor located on the front of the dashboard. Although this was sufficient for older vehicles, this could lead to poor performance in a new vehicle. Localizing the light sensor to the key affected areas where displays are being introduced such as the instrument panel, digital cockpit, rear and side view mirrors, and Head-Up-Displays provides the passengers a luxurious and safe experience with seamless transitions during changes in environment.

Market Trend

The automotive industry has had a large increase in the number and size of displays in new vehicles over the past years, including traditional display screens and more advanced augmented reality Head-Up-Displays. With displays such as these, having a localized sensor is crucial for the user experience, making Texas Instruments OPT4003-Q1 and OPT4001-Q1 automotive grade light sensors suitable solutions, especially due to the low power consumption and small packaging. The trend for displays in automotive applications is expanding to the front of the a passenger seat as well as into the back seat for rider entertainment. Creates a demand for advanced display systems which can be achieved through light sensors for optimal system functionality.

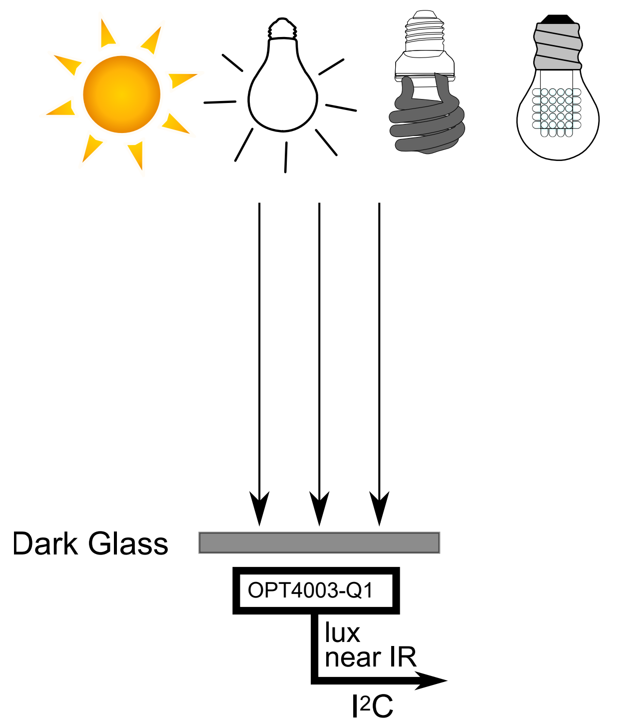

Figure 1. OPT4003-Q1

Latency

Latency is the time it takes for a signal to travel from point A to point B. In a light sensor, latency is how long it takes from the time that a light input is applied to the time that the digital output becomes available. The incorporation of the traditional centralized light sensor at the front of the dashboard is more prone to system latency when communicating with multiple displays, as seen in changes of the newer production of vehicles, creating lag and potential safety issues for the operator of the vehicle. In addition, as the complexity and number of displays in the system increases, the potential for latency increases. Texas instruments' optical sensors have a fast conversion time down to 600μs, providing a seamless experience for the driver and the passengers.

Copyright © 2024 Texas Instruments Incorporated

Table 1. Difference in light intensity throughout the day

	Closed Sunroof (Lux)			Open Sunroof (Lux)		
Time of Day	9:00am	1:30pm	7:30pm	9:00am	1:30pm	7:30pm
Instrument Panel	450	650	220	1631	717	352
Digital Cockpit	953	3750	337	1163	8433	465
Mirror Front	254	302	182	361	463	160
Mirror Back	2635	5450	28993	9607	6667	4607
Head-Up-Display	25367	95667	6467	26784	95667	46550
Backseat	125	220	106	1317	1013	247
Mirror Left	26633	24867	33533	28539	24867	33167
Mirror Right	27667	37500	7000	27833	37500	7067
Experiment Control	23833	96733	11600	23518	97067	11600

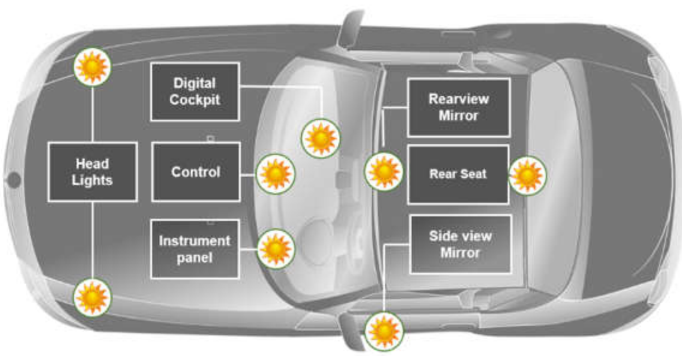

Figure 2. Labeled key affected areas

Data Table

To show the difference in the intensity of light at different locations in the vehicle throughout the day, an experiment using the TI OPT4003-Q1 was conducted. The results of this experiment is shown above in Table 1. The test consisted of holding the light sensor next to each key affected area and recording the data for each position. The main target locations are the instrument panel, Digital cockpit, rear and side view mirrors, Head-Up-Displays and a control for the experiment which is the traditional placement for a centralized light sensor. Each test was repeated with the sunroof open and with it closed to provide a new perspective on how much the light intensity can change just by this one factor. The first test conducted was one hour after sunrise to show low light conditions in the morning. The second test was conducted at midday to show the brightest time of day when the sun is in peak position. The third test was taken one hour before total darkness. From looking at the table the results are clear that regardless of the time of the day, the difference between each key affected area is still significant.

Display and Electrochromic Dimming Mirrors

Supplementary vision such as full display rear-view mirrors are a popular option for automotive manufacturers, providing a greater field of view and reducing blind spots for the driver by requiring a light sensor to accurately adjust the brightness of the display thorough out the day. Electrochromic tinting allows a mirror to change the reflectivity to reduce glare when needed. When no voltage is applied the electrochromic coating is clear, allowing normal reflectivity. It is the light sensors job to determine when to supply the voltage to turn on the anti-glare properties, therefore being an important player in the functionality of the design. The data in Table 1 suggests there is a wide gap in the lux readings from the front and back of the mirror, reading as low as 160Lux for the front of the mirror and as high as 28,000Lux for the back of the mirror. If the light sensor is placed at the traditional spot on the front of the dashboard, the mirror is receiving a much higher value of lux causing the display to be far dimmer than needed, leading to potential safety hazards for the driver and passengers. Having a localized light sensor for the mirror system is critical for more accurate readings and addressing safety concerns. Additionally, automotive manufacturers are implementing electrochromic side mirrors which need their own light sensor since the majority of the time the sun will be reflecting off the vehicle from an angle, requiring one side to be dimmer than the other.

Copyright © 2024 Texas Instruments Incorporated

Augmented Reality Head-Up-Display (HUD)

The Head-Up-Displays was originally introduced to the automotive industry in the 1990s with very minimal information and a small surface area to present the information such as, a single number for speed monitoring or a small direction arrow. Now Head-up-Displays are becoming larger and projecting all the critical driving information directly into the driver's field of view such as speed, speed limit, navigation cues, advanced safety features such as lane departure and collision warnings, thus improving driver reaction times and situational awareness. These systems are getting more advanced needing a more precise lux reading. Additionally, since the information displayed on the HUD is driver critical, the latency could lead to potentially dangerous situations. By localizing the light sensor, the system receives a quick and accurate reading minimizing potential safety hazards and latency within the mirror.

Infotainment Displays and Instrument Clusters

Automotive manufacturers have been transitioning from the traditional speedometer to a cluster display providing the driver with all the information needed to safely operate the vehicle in one place, as well as adding displays to the passenger side of the car. The instrument cluster is typically buried into the steering column allowing less light to hit the display. Through testing it is clear that this is the case since the sensor placed inside of the instrument panel is significantly lower than the rest of the affected areas as low as 220Lux, causing the display to be dimmed more than the other areas.

The automotive industry has been implementing infotainment displays into the back seats of the vehicle. The data suggests that there is a large difference in light intensity from the front of the car to the back of the car due to various factors such as darker window tinting and inclusion of the sunroof. The advancement of displays moving towards the back of the car require more attention than traditional vehicles with much fewer displays.

Conclusion

It is clear one centralized light sensor is not sufficient for the amount and size of displays in a vehicle today. The data suggests that having multiple light sensors localized to the key affected areas is the best solution since there is a wide gap in intensity readings across the vehicles displays at different times of the day. Localization is needed to control the settings for each display in order to optimize the diver experience, minimizing extremely bright or dim displays. Additionally, limiting the potential for latency providing the user with seamless transitions and added safety.

Trademarks

All trademarks are the property of their respective owners.

Copyright © 2024 Texas Instruments Incorporated

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to TI's Terms of Sale or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2024, Texas Instruments Incorporated