Vehicle Interior Lighting System: A Review

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***Abstract*— Ambient light feature is becoming a signature feature of vehicles. It is not only effective as a mood lighting or as an entertainment feature but also as a driver assistant system. The lighting system can be controlled automatically according to vehicle operating conditions or a manual control can be given to user. This paper presents a brief survey of existing vehicle ambient lighting system. Future scope gives an idea about the new technologies like voice and gesture recognition that can be integrated in existing lighting systems.**

***Keywords*— interior lighting, driver assistance, vehicle safety, automotive networks, LED**

I. INTRODUCTION

Automotive industry has been going through remarkable changes from last few decades. Electronics can be said as a key player in this transformation. Vehicle interior and exterior lighting is one of the area of interest for Electronics engineers. This is the area where lot of improvement can be done for enhancing driving experience using smart electronic techniques. Technological advancement, such as packaged LED and LED panel for automotive interior lighting is expected to create huge impact in automotive sector.

Over the past few years, more and more vehicles are starting to offer interior lighting as a standard or optional feature. Vehicle interior lighting is no more just a roof lamp provided so that you can find your things inside car. The concept has changed completely. Vehicle interior lighting is the soft illumination around the car's centre console, door handles and pulls, cup holders and sometimes completely across the dashboard and in the vehicle's footwells.

Typically, vehicle interior lighting is seen as a purely cosmetic feature, serving no inherent vehicle safety function. But the lighting may increase a driver's perceived safety and quality of the car, according to a new study conducted by BMW and the Lighting Engineering Group at Ilmenau University of Technology in Germany.

Vehicle interior lighting increases spatial perception, making the vehicle's interior feel bigger at night. A soothing interior lighting stimulates an emotional atmosphere that decrease driver fatigue by keeping him calm and focused. Moreover, drivers think that ambient lighting increases the perceived quality of the car's materials and design. They also found that the lighting made a car's controls easier to use.

The global automotive intelligent lighting market is expected to grow in few upcoming years. The rising demand for advance intelligent interior lighting and advantages associated with automotive intelligent lighting are expected to drive the global market for automotive intelligent lighting.

Interior lighting is closely related to driver's mind. Instead of looking at it as a 'feel good thing', we can actually use it for driver assistance. A system can be designed which can provide driving assistance using interior lighting along with the decorative features for enhancing driving experience.

II. LITERATURE REVIEW

The literature survey is carried out to know the importance and features of vehicle interior lighting. It provides a guideline that what advancements can be done and how we can make use of interior lighting as a safety feature. It starts with the study of effect of interior lighting on driver following the ideas for controlling the lighting and its implementation using automotive communication protocols.

Grimm, "Requirements for an Ambient Interior Lighting System for Motor Vehicles", [1] have studied typical ambient light levels while driving at night. One of the conclusions of the study is that, the major effects of ambient lighting are largely dependent on colour of light, intensity and size of the light source.

Hanneke Hooft van Huysduynen, "Ambient Light and its Influence on Driving Experience", [2] provides very useful information about the psychological effects of different colours on the driver's mood. For example when the driver crosses speed threshold, the whole car cabin can be illuminated by Green colour which helps to increase concentration. It indirectly tells that interior should create positive impact on the driver's mind and it shouldn't distract driver.

Michael Mueller, "Interior lighting system of a motor vehicle and a method for controlling the same", [3] presents an overall idea about vehicle interior lighting and different methods for controlling. The intensity and colour of interior lighting in this system can be automatically changed corresponding to change in operating parameter related with vehicle environment like temperature and speed. The interior lighting system may include a sensor for sensing the current state of air conditioner or a heating system which will act as an input to control system. Or a temperature sensor can be

used for detecting vehicle interior temperature. Control unit will compare sensor output with set point temperature and light varies accordingly. For example if cooling of air conditioner is required or temperature goes above set point then a colour which gives cooling effect may be set in lighting. Similarly a warm light colour can be set when temperature goes below set point. In another way, interior lighting can be a function of vehicle speed. At higher speeds, high concentration is required. Green is said to be the colour which provides high concentration. Hence, when vehicle runs at higher speeds, Green light can be illuminated. In this way, vehicle operating parameters can have a control over interior lighting.

Timothy Prodin, "Vehicle Interior lighting system with welcome and farewell stages", [4] proposed an interior lighting system featuring different stages of lighting, defined by conditions like vehicle entry status, door opening-closing, ignition etc. System uses a CAN bus on which all sensor outputs, for checking different conditions, are taken. System uses photo sensor, door locks and door condition sensor. Control units receives these sensor outputs though CAN and controls light in three different light zones defined in the system. Zone one consist of lighting on cup holders, storage bin, console whereas zone two includes footwells and zone three made up of pull handles, latch handles, map pockets and door sills. For example in first welcome stage, at least one light from zone one gets illuminated at low intensity. The stage starts with the activation of vehicle entry system and ends after opening of any door of car. Then second welcome stage starts which ends after vehicle enters in operating mode. In this stage lights from zone one and zone two are illuminated at high intensity. Intensity control is provided in ambient stage. And the cycle completes with a farewell stage which ends after closing of all doors. It seems like all these stages are actually operated by sensors but user also can control the colour of lighting by using a colour selection device interfaced with the controller. It is a fairly intelligent system, cleverly divided into different stages which are ultimately controlled by sensors along with the user control.

Andreas Locken, "An Experiment on Ambient Light Patterns to Support Lane Change Decisions", [5] in which they proposed a system for detecting front and back running vehicles and assist the driver in lane changing by using interior lighting. The study looks at a driver as an operator, who may get fatigued. The paper showcases the development of an in vehicle ambient light display for providing a continuous information to driver about vehicle's state. Paper states that light can be a powerful feature to convey important non critical information. It takes a situation of lane change on a highway. System helps the driver if the driver wants to change the lane and wants to know about closing car. The scenario is particularly decided by taking into account the accidents caused by ignoring closing cars while overtaking. System uses a fixed-based driving simulator for experimentation. Simulation is done by SILAB. Adaftuit NeoPixel RGB LEDs are used for light displays with a semitransparent foil on it to avoid blinding of driver. So that it looks smoother. System uses Arduino microcontroller as central processing unit. For this experiment, 19 drivers possessing driving licenses were hired as participents. Two different patterns, discrete and continuous are used to help driver in lane change decisions. Discrete light pattern uses one colour for particular distance of a closing car according to the ISO standard. When a car is closer than the closing threshold, warning is given as an amber light. As soon as the car enters within blind spot area, light will turn red. And then the system has continuous light pattern in which light moves continuously. The paper claims to provide a novel use of ambient lighting to assist driver in lane change rather than merely creating moods. Even though the timings of the discrete light pattern were based on ISO 17387, the drivers reported that light indication came too late to support their decision making. However, the continuous light pattern tend to reduce the number of missed overtaking opportunities. The paper concludes with the future plan to make adaptive light patterns depending on driver's uncertainty.

Murilo Cervi, "Omnibus Interior Lighting System Using LEDs and Automotive Communication Network", [6] presents an intelligent interior lighting system for bus interior. It uses an automotive communication network LIN (Local Interconnect network) for controlling LEDs. System also uses CAN (Controller Area Network) to establish communication with other bus systems. Paper states the advantages of using LED in interior lighting over filament and other light sources like small size, robustness to shocks and vibrations, long life and reduced environmental heating. Intensity of LED can be controlled from null to maximum by controlling its forward current without damaging its life. A PWM waveform with controlled duty cycle does this job. System uses LIN as a low cost alternative to CAN to control several nodes from central control. LIN needs a communication interface based on SCI and most of the low cost microcontrollers have that. The system is divided into three parts as main lighting, help lighting and read lighting. User is having full control on the system lighting parameters like lighting level, timing, mitigated turn on and off and the system behaviour through an interface. The read light has local control and central control can just enable that. System comprises of a master node which must handle both LIN and CAN to communicate with slave nodes and other bus systems respectively. A user interface is connected to master via CAN which is composed of a panel with one power switch, four configuration switches and LCD display. Each slave node includes six LEDs in series arrangement. Same microcontroller can be used in all nodes as they all execute same functionality. LED lighting level is controlled through PWM. LDR is used so that the light could not exceed a certain level. Additionally, timing can be set with main and help subsystem. After certain time limit, LEDs will turn off automatically.

III. FUTURE SCOPE

All the systems so far use interior lighting either as a purely decorative function or as a warning system. A fewer

controls are provided to user when lighting is used to show the status of vehicle.

It is possible to integrate both the decorative and warning features in an ambient light system. Both the features can depend on each other. For example decorative feature can be used as a standard function and when it is required to alert the driver about vehicle status like 'high speed', the warning feature will turn on by interrupting mood lighting routine. Different light colours can be assigned to differentiate between decorative and warning feature. In this way interior light can be used as a mood lighting as well as warning light system.

All current system provide user control using switches or manual touchpads where user can select colour. In both the cases, driver has to use his/her hand to select the colour. This can deviate driver's attention. Some other triggers like voice or gesture can be provided to control light colour and intensity. A voice control can be provided using small voice recognition system integrated in the infotainment unit of vehicle. Voice control can also be achieved by using a mobile application. Driver can connect the phone with the control unit though cable or wirelessly using Bluetooth technology. The commands provided by user will get recognized over mobile phone and sent to the control unit which will change lighting accordingly.

Gesture control can also be a very good option for controlling light. A gesture recognition system will recognize, for example hand gestures which are decoded and provided to the central control unit. It will change the light colour or intensity accordingly.

IV. Conclusions

Vehicle interior lighting system can be used to enhance the mood of driver. Apart from this decorative feature, it can also provide a very good driver assistance. Lighting can be used to warn the driver about current vehicle status and helps driver to make decisions according to it.

New technologies like voice and gesture recognition can also be integrated in the ambient lighting system to provide better control mechanism.

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