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Design of ECU for Automatic Headlight Beam Control during City Driving

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ABSTRACT:

Automating the task of high beam switching will significantly reduce glare from oncoming vehicles and thus improving night time driving safety. To avoid temporary blindness and glare from oncoming vehicles, automatic high beam controller is developed. This can be achieved by fixing RF transmitter at starting points of cities. Once a vehicle enters the city, the headlight beam Electronic Control Unit (ECU) in the vehicles receives signal from RF transmitter and the light beam of headlight of the vehicle is automatically switched to a low beam. Once the vehicle leaves the city by crossing RF transmitter the user input is enabled by ECU and the driver can change the beam either high or low manually according to his need. The circuit has been designed and simulated in the Proteus software and accurate switching of the high beam is achieved. This proposed system shows better performance, which will result in safe and glare-free driving at night times.

KEYWORDS:

RF transmitter; RF receiver; Headlight; Light beam; Electronic control unit; Safety

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1. Introduction

Driving at night is dangerous and requires more attention by the drivers. According to the national highway traffic safety administration, road fatalities triple during the night when compared to day. Depth perception, colour recognition and peripheral vision can be compromised in the dark and the glare of headlights from an oncoming vehicle can temporarily blind a driver. Light is electromagnetic radiation. These lights are visible to human eyes whose wavelength is 400-700 nanometres. Human eyes are adaptable to a particular range of vision. There are two types of vision namely photopic and scotopic vision which occur in bright and dark conditions respectively. Our eyes take 4 seconds to change between these two visions. This TROXLER effect claims that as the brightness increases, the strain to focus an object also increases which will increases the response time of the person who is subjected to this condition. The necessity of headlight is very important during a night drive, even though it assists the driver for better vision during night travel, it is responsible for more accidents.

The headlight can be switched either a high (bright) beam or low (dim) beam by the driver manually based on his need. During dark conditions where there is no other source of light, a high beam is used. In all other cases, a low beam is preferred. But the improper usage of the high beam can cause discomfort to the person coming in the opposite direction. It glares the driver for a moment which results in temporary blindness. This small distraction is the main cause of many road accidents. So, there is a need for an automatic high beam controller to improve driver's visibility at night time by automatically controlling vehicle's high beam which will help the drivers to drive safely. Our proposed work focuses on controlling high beam of the vehicle only within the city limits. This is because outside the city there may be separate lanes in highway roads, so there is limited chance of glare from oncoming vehicles. Hence, we decided to build a simple, low-cost ECU for an automatic high beam controller which will turn off the high beam of the vehicle when it enters the city limit.

2. Literature survey

Automatic vehicle high-beam headlight control system is developed to detect distant tail lamps and switching to low beams by detecting nearby traffic. The methodology approached here is a camera-based vision system that acquires and processes images of the region in front of the vehicle and extracts enough information about size, position, colour and intensity of light sources to dim the vehicle's headlights [1]. Automatic dipper system is developed to overcome the inconvenience and accidents due to sudden glare produced by oncoming vehicle with a high beam. A camera is used for visual detection of headlights and this data will be sent to Raspberry Pi after processing the input from the camera with Maximal Stable Extreme Regions (MSER) blob detection algorithm. A trigger will be sent by the Raspberry Pi in the form of a signal which is used for dipping the high beam [2]. Programmable automotive headlight system is an ultra-low latency reactive visual system developed to improve anti-glare high beams and driver visibility during snow storms.

The image sensor observes the road environment in front of the vehicle. The processing unit analyses data from the image sensor and controls the headlight beam via a spatial light modulator (SPM). SPM modifies the beam by varying intensity over space and time [3]. A Wireless Sensor Network (WSN) based controller is developed to transmit the sensor data between the cars. The proposed system will sense the light intensity from oncoming vehicle. The microcontroller will compare the received light intensity with the threshold intensity and send signal via X-Bee to other's vehicle system. This signal will get received in other system where the light intensity is decreased with the help of a pulse width modulator [4]. An intelligent headlight control system is developed using machine learning concept to control automatically the vehicle's beam during night driving to reduce accidents happening due to glare. The vehicle's state of beam can be controlled by detecting oncoming/ preceding traffic as well as urban areas with the help of images captured by cameras.

Support Vector Machine (SVM) and adboost are the two machine learning approaches which have been used in this system [5]. Limitations observed in previous works are camera-based system that is expensive [1], requires complex hardware integration and reflections from trailing vehicles [2], the prototype is not compact to fit within actual vehicle headlight compartments and the system is not more reliable in the presence of vehicular vibrations and heat [3], the system is not effective in case of streetlight effects and climatic changes [4] and the system involves two machine learning approaches which is a lengthy process [5]. To overcome the above limitations, our proposed work is focused to develop a simple, low-cost ECU for automatic high beam control system. This system will turn off high beam of the vehicle when it enters the city limit.

3. Proposed methodology

The proposed system is to control the high beamline of the vehicle depending on signal received by RF receiver. Both RF transmitter and RF receiver operate at radio frequency. The reason for choosing RF transmission is that radio frequency waves can travel through large distances without any interruption, making it suitable for long-range applications. Also, RF signals can travel even when there is an obstruction between the transmitter and receiver. Comparatively, RF transmission is stronger and more reliable than IR transmission. Table 1 explains the functions of the components used in proposed system. The purpose of interfacing the RF receiver to 8051 MCU is to stay on same conditions either low beam or high beam until another logic signal is provided by RF transmitter. 8051 MCU was introduced in 1981 by Intel Corporation. It is an 8-bit microcontroller with Harvard architecture, designed for various applications in the field of automobile, industrial processing, medical applications etc. The decoder output is given to 8051 MCU which is programmed to control high beamline of the vehicle based on the input signal.

The block diagrams for transmitter and receiver side of the proposed system are shown in Figs. 1 and 2 respectively. RF transmitter circuit will be fitted in city entry and exit points. On the other hand, RF receiver circuit will be fitted in every vehicle which is collaborated with a high beamline of the front headlights. 9V battery is given as a DC power source for RF transmitter circuit. The automotive 12V battery can be used as a power source for RF receiver circuit. As the operating voltage is 5V for RF receiver, a voltage regulator (LM7805) is used to convert 12V power supply into 5V.

Table 1: Functions of the components

Component	Function
RF Transmitter	Receives serial data from the encoder and transmits it wirelessly through its antenna.
RF Receiver	Receives the transmitted serial data and should be operated at the same frequency as that of the transmitter.
Encoder IC (HT12E)	Converts the parallel data which is going to be transmitted by the RF transmitter into serial data.
Decoder IC (HT12D)	Converts the serial data which is received by the RF receiver into parallel data.
8051 MCU (AT89C51)	Switches the transistor to actuate the relay coil based on the input signal obtained from the RF receiver. It maintains the headlight beam in the same state until another signal is received.

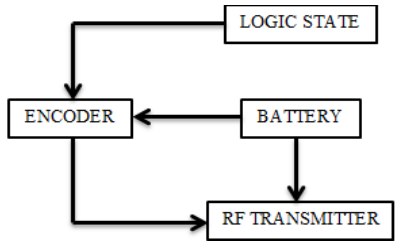

Fig. 1: Block diagram for transmitter side

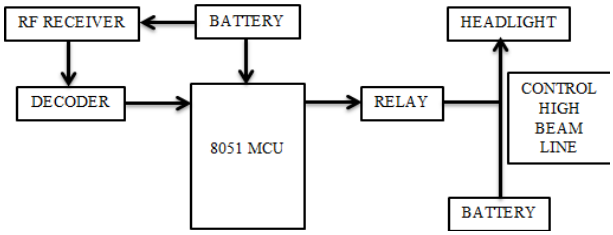

Fig. 2: Block diagram for receiver side

Two RF transmitters are used in proposed system. One RF transmitter is to make the high beam circuit and another one is to break the high beam circuit. The transmitter which makes high beam circuit is denoted by (H-High) while the transmitter which breaks the high beam circuit is denoted by (L-Low). The proposed system is implemented by fixing a pair of L and H transmitters in both the city entry and exit points. The transmitter continuously transmits the signal in the form of RF waves to its surrounding area. When the car crosses L transmitter, these RF waves are obtained in the form of a signal which is received by RF receiver through the antenna. This signal is sent to the decoder for converting serial data into parallel data. The output of decoder is given to 8051 MCU and the electro-mechanical relay is connected to 8051 MCU via a NPN transistor. In this case, the signal is received from L transmitter; hence the relay coil de-energizes and breaks

the high beam circuit. So, the high beamline is cut off by the relay actuator, which leads to changing of high beam to low beam condition. On the other hand, when the car crosses H transmitter, the same operations would take place except that relay coil energizes and makes high beam circuit. In this case, driver can control the beam of vehicle according to his convenience.

4. Hardware and software design

Our first target is to implement this proposed system in the city, entry and exit points as in highways, there will be isolation of roads into two parts, so there is no problem with driver's visibility. So, we are going to fit two RF transmitters in city entry and exit points at certain distance between them and RF receiver circuit in the car. One RF transmitter for transmitting the signal to make the high beam circuit (0100-H) and another one for transmitting the signal to break the high beam circuit (1000-L). In entry point of the city, the transmitters are fixed in the order H followed by L at a distance of 100m between them. On the other side in exit point of the city, the transmitters are fixed in the order L followed by H at a distance of 100m between them as shown in Fig. 3. According to the above arrangement of transmitters, when a car enters the city, it initially receives the high beam signal while crossing the transmitter H and then receives low beam signal while crossing the transmitter L. So, the car is going to travel only with low beam inside the city, as the high beam is cut-off using relay as per circuit diagram.

Fig. 3: Area within the city

Similar conditions will be applicable for leaving the city also. According to the arrangement of transmitters in the exit point of the city, when a car nearing the city exit point, it initially receives low beam signal while crossing the transmitter L and then receives the high beam signal while crossing the transmitter H. So, the car headlight can be controlled by the driver only when the signal is received from transmitter H, as the high beam circuit is closed by relay as per the circuit diagram. Once the vehicle is out of the city, the driver can change the headlight to a high beam or low beam according to his convenience. RF transmitter will transmit the signal through the antenna. The parallel data is sent to encoder IC by giving logical input to D6, D7, D8, D9 pins and these data are converted into serial data and then sent to DATA pin of RF transmitter. The main function of encoder is to convert parallel data into serial data. These data are available in D6, D7, D8 and D9 pins of encoder IC. In this circuit, we use only two data pins to control high beam of the vehicle. To transmit required signal to control high beam, we use two logic states in two data pins D6 and D7. The transmitter circuit for proposed system is shown in Fig. 5.

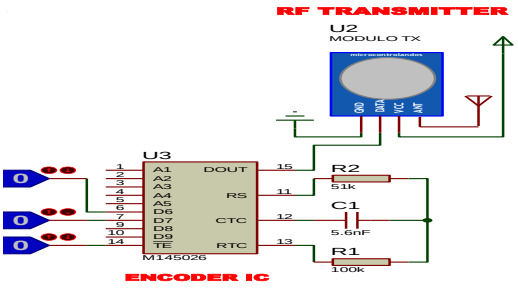

Fig. 4: Transmitter circuit

The corresponding serial data is received by RF receiver through antenna. This serial data is sent to decoder IC through the DATA pins of RF receiver. The main function of decoder is to convert serial data into parallel data. These data are available in D6, D7, D8 and D9 pins of decoder IC. The obtained parallel data is sent to 8051 MCU through the D6 and D7 pins of Decoder IC. A transistor is a switching device, used to drive the relay (make and break the circuit). The base of the NPN transistor is connected to the 8051 MCU. Depending upon the signal received by the RF receiver, the relay energizes to make the high beam circuit or de-energizes to break the high beam circuit. A freewheeling diode is a connected parallel to the relay coil to protect the 8051 MCU. The receiver circuit for the proposed system is shown in Fig. 5. The headlight is connected to the automotive 12V battery. The high beamline of the headlight is connected with an electromechanical relay. The switching of the high beam is controlled by the transistor. Here, the transistor acts as a driver which drives relay based on the signal received from 8051 MCU. The headlight wiring for the proposed system is shown in Fig. 6.

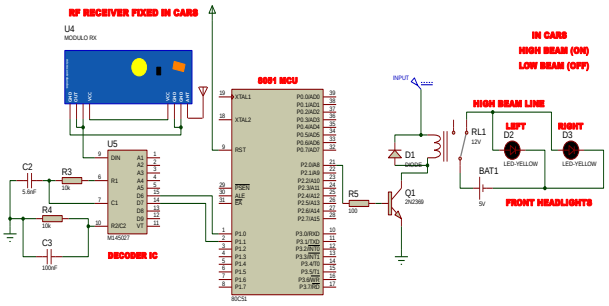

Fig. 5: Receiver circuit

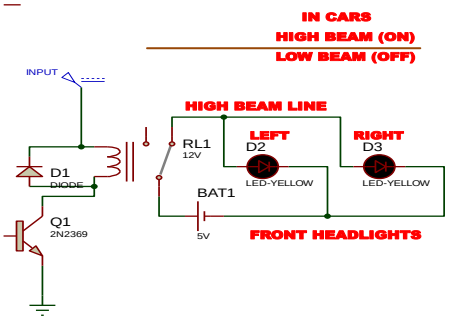

Fig. 6: Headlight wiring

Proteus design suite is a software used for building and simulating circuits and debugging embedded applications based on various microcontrollers. Keil for 8051 is a compiler used for compiling the embedded C

program. The header files are added for AT89C51 controller at starting of the program. The address for used ports is declared. The output of decoder which is the input for 8051 MCU is sent to P1.0 and P1.1 pins of the controller. Hence those two pins are declared as a single bit input pin. The relay coil is connected to the P2.0 pin of the controller via a NPN transistor. Hence that pin is declared as a single bit output pin. Initially the two input pins are set as IN1 = 1 and IN2 = 1. The output pin is set as OUT1 = 0. The "Do while" loop is used in the program to perform the required function.

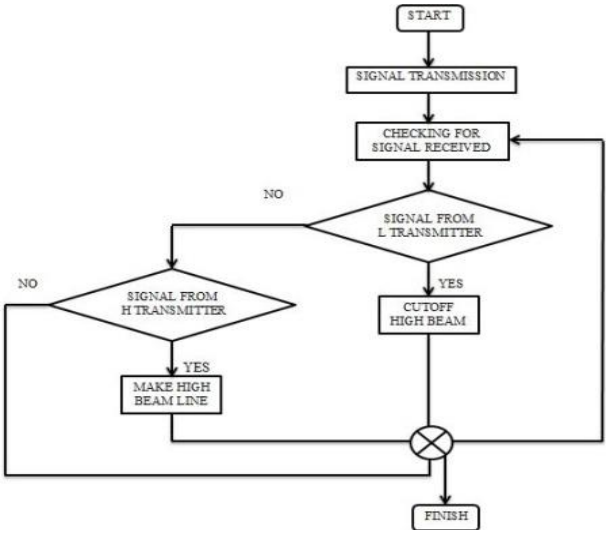

Fig. 7: Flowchart of proposed ECU

5. Results and analysis:

Fig. 8 (a), when the logic 1 is given at the D7 pin of encoder IC, the relay coil (RL1) energizes and makes the high beam circuit. Fig. 8 (b), when the logic 1 is given at the D6 pin of encoder IC, the relay coil (RL1) de-energizes and breaks the high beam circuit. Once the vehicle receives the above signal, it will travel with only a low beam until another logic signal 1 is given at the D7 data pin. Logic table and accident analysis for the proposed system are shown in Tables 2 and 3 respectively. With the help of the proposed system, the accidents happening at night time due to the problem of temporary blindness caused by unnecessary usage of the high beam within city limits is very much reduced. The proposed system is also more reliable, has a better transmission rate and a cost-effective one and it can be easily installed in vehicles.

Table 2: Logic table

Transmitter	Signal	Type of beam in car
H	0100	High beam / driver control
L	1000	Low beam

Table 3: Accident analysis

Automatic high beam controller	Type of beam within the city limit	Discomfort / headlight glare to drivers	Possibility of accidents
Present	Low Beam	Less	Less
Absent	Driver control (low or high)	More	More

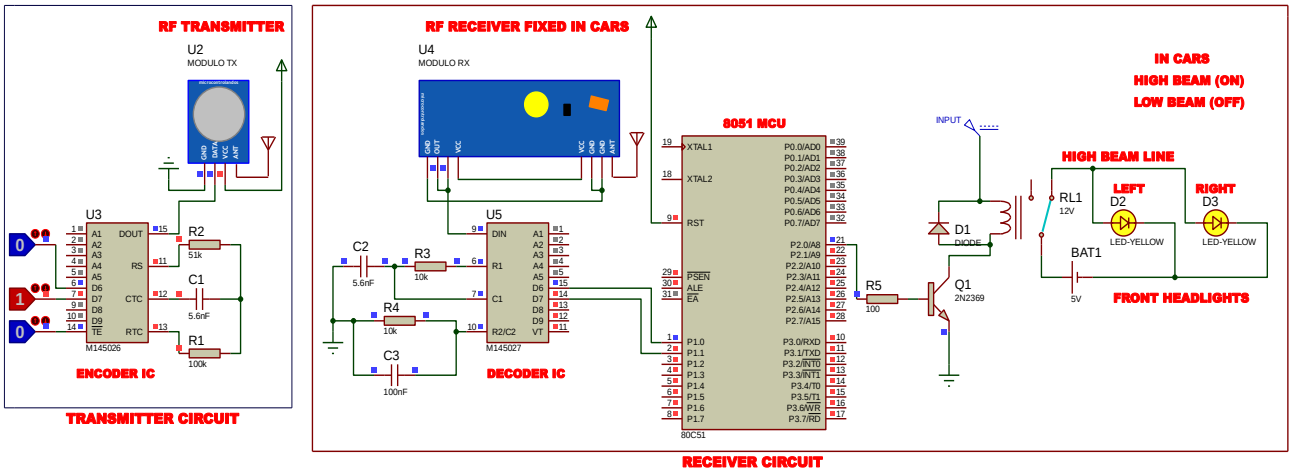

Fig. 8(a): Simulation result for automatic beam control system when leaving the city limit

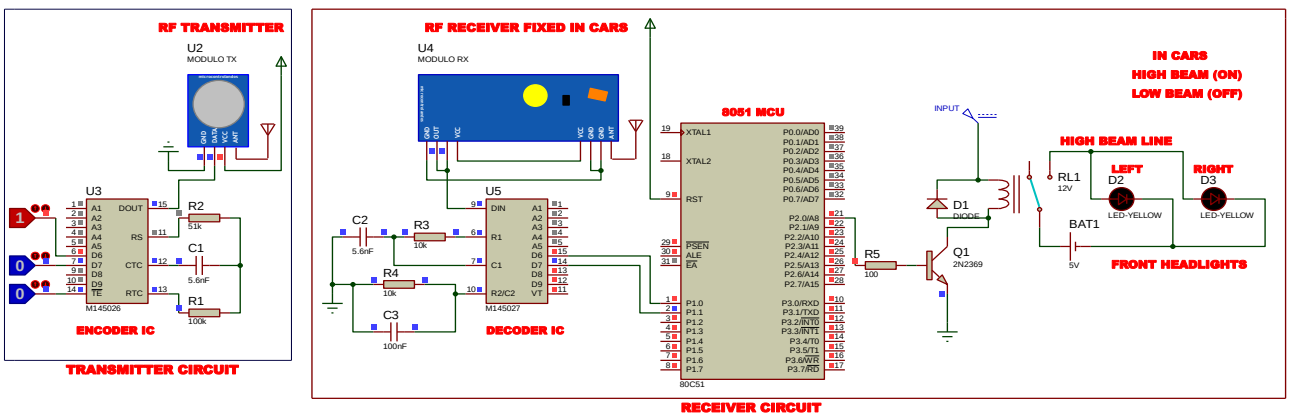

Fig.8 (b) Simulation result for automatic beam control system when entering the city limit

6. Conclusion

The automatic high beam controller which aims to automatically control a vehicle's beam state to low while entering the city is presented in this paper. There is no need for a separate power supply for the RF receiver circuit as it is taken from the automotive 12V battery. Its power consumption is too low which is an added advantage to this proposed system. Another existing solution for this problem includes the camera mounted on the windshield to detect the light from the oncoming vehicle. Comparatively, the proposed automatic beam control system is more reliable, having better RF communication between the transmitter and the receiver without any interruption and a cost-effective one. This will attract both the car manufacturers and consumers to integrate this proposed system as an add-on feature in vehicles which will reduce the rate of road accidents due to high beam during nights.

REFERENCES:

[1] J.S. Stam. 2001. Automatic vehicle high-beam headlamp control system, *SAE Technical Paper 2001-01-0318*. https://doi.org/10.4271/2001-01-0318

[2] B. Jaint, S. Arora, S. Saxena, C. Singh and S. Indu. 2017. Automatic dipper system using camera in vehicles, *Proc. IEEE Region 10 Symp.*, Cochin, India. https://doi.org/10.1109/TENCONSpring.2017.8070050.

[3] R. Tamburo, E. Nurvitadhi, A. Chugh, M. Chen, A. Rowe, T. Kanade and S.G. Narasimhan. 2014. Programmable automotive headlights, *Proc. European Conf. Computer Vision Part IV*, 8692, 750-765. https://doi.org/10.1007/978-3-319-10593-2_49.

[4] A. Tripathy, D Kayande, J. George, J. John and B. Jose. 2015. WiLights - A wireless solution to control headlight intensity, *Proc. Int. Conf. Tech. for Sust. Dev.*, Mumbai, India. https://doi.org/10.1109/ICTSD.2015.7095866.

[5] Y. Li, N. Haas and S. Pankanti. 2011. Intelligent headlight control using learning-based approaches, *Proc. IEEE Intelligent Vehicles Symp.*, Baden-Baden, Germany. https://doi.org/10.1109/IVS.2011.5940541.