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Automatic headlight controlling of vehicle using ambient light sensor based on phototransistor

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This paper proposes an efficient method to control the headlight intensity of the vehicle using ambient light sensor (ALS) based on phototransistor with the principle of pulse width modulation. The main responsibility of this automatic headlight control is to control the intensity of the headlight based on the ambient light. The intensity of the headlight will be low when the ambient light intensity is high and vice versa.

I. INTRODUCTION

According to recent research maximum road accident occur during the night time where it is completely dark lighting condition. So driving at night time is usually more dangerous than driving during day time for sure. While driving at night, the headlight must be kept ON, otherwise, it will be difficult to find the routes, other vehicles, turning points etc., but if the intensity of the light is very high it will directly influence the vision of the opposite vehicle driver, which is the cause of many road accidents. This necessitates the importance of varying the intensity of the headlights, or else the glare from the headlight can blind the opposite driver which would lead to accidents. It will be tough for the drivers to control the intensity while driving. To ensure comfort of the drivers and safety of the passengers this automatic headlight control system using ambient light sensor is helpful. Generally speaking, the main approach to automate headlight is to detect potential light objects using some image processing algorithms, then apply certain rules to decide if high beam should be used or not. While such solution is relatively easier and quicker to develop, it usually suffers from the drawbacks such as difficulty of deployment in different geographical regions, lack of robustness to the change of weather and road conditions, as well as expensive system fine-tuning The brightness of the surrounding is sensed using the Ambient Light Sensor (ALS). If the brightness in the surrounding is high, then the value of sensor becomes high. Signals are generated according to the value of sensor to lower the headlight intensity. In chapter II, state of the art of light sensor is discussed and then concept of light sensor based on phototransistor will be explained. A hardware interface is used between the real time system and LabVIEW software. The NI my RIO has

- my RIO Expansion Port (MXP) Breakouts
- Power Input Cable
- USB Device Cable
- USB Host Cable (Not Included in Kit)
- LEDs
- Mini System Port (MSP) Screw-Terminal Connector
- Cables of in/out audio and Button0.

A. *Structure of light sensor or ambient light sensor*

Ambient light sensors are also known illuminance or illumination sensors, brightness sensors or simply light sensors. One very important application for ALS technology is in automotive industry. Here, the ALS enables automatic control of headlights over a wide range of illumination conditions from a dark environment to direct sunlight.

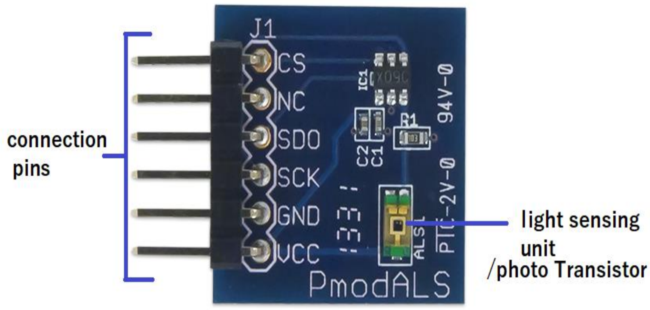

Fig. 1: Ambient light sensor based on phototransistor [1]

Ambient light sensor (ALS) constructed with phototransistor which is connected to the supply voltage and ground. The output voltage varies according to the incident light on the phototransistor.

The Pin Connections of ALS are

- CS-Chip Select(active low signal)
- NC-No Connect
- SDA-Serial Data Out(to my RIO SPI MISO)
- SCL- Serial Clock signal(from myRIO to SPI CLK)
- GND-Ground
- Vcc +3.3

After setting up ambient light sensor with proper component such as analog to digital converter and pulse with modulation device, we can easily measure the light intensity and control the headlight system by maintaining duty cycle of headlight. By arranging these devices and attaching them together we can ensure an automatic headlight controlling of vehicle which will play a significant role in reducing road accident rate in dark environment.

B. *Scientific Comparison of light sensors*

In industry there are many type of light sensor used. The most common sensors are phototransistors, photodiodes and photo resistors. These sensors are also widely used in automotive industry in various purposes.

I. Photoresistor

light-dependent resistor is widely used photo resistor which is shortly known as LDR as figure 2 shown below.

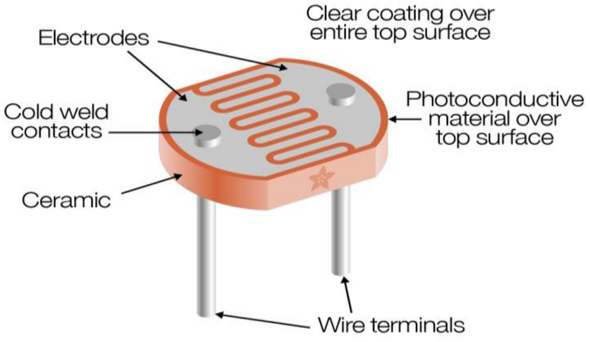

Fig. 2: Light dependent sensor (LDR)

LDR is developed with semiconductors like cadmium sulfide, which changes electrical value from dark environment to sunny environment such as day lighting condition.

II. Photodiodes

It is another name of light sensor mostly used in electronic devices where light intensity needs to be measured. It is constructed with silicon and germanium material.

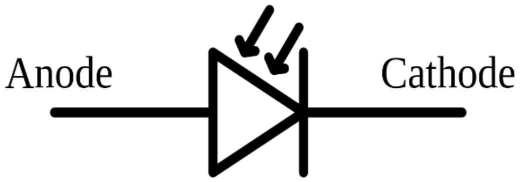

Fig. 3: Anode and cathode construction of photodiode

The photodiode basically is a two terminal PN junction device which is operated in reverse bias. It has a small transparent window on it which allows light to hit the PN junction

III. Phototransistors

A phototransistor is generally more capable light sensor which is an ordinary bi-polar transistor where the base area is exposed to the illumination.

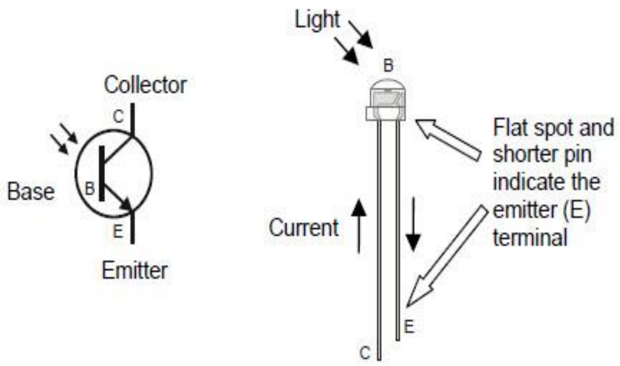

Fig. 4: Phototransistor with components

phototransistor is a photo-junction device that is exactly similar to a regular transistor except that it has a light sensitive base terminal or collector base junction to be precise.

C. Limitation and solution

As Table 1 shown below there are few really comparable parameter to discuss about limitation and benefits of using these light sensors.

TABLE I.
COMPARABLE PARAMETERS OF LIGHT SENSORS

Parameters	Photoresistor	Phototransistor	Photodiode
Accuracy	not stable	+/- 75%	less 40%
Electricity	varies	2.6 mA	3µA
Response Time	55ms	15µs	6ns
Range	1 to 100 lux	1k to 100 klux	7 to 50 klux
Amplification of signal	no signal amplification	provides signal amplication	no signal amplification

Comparing from TABLE 1 it is seen that in terms of accuracy phototransistor delivers most accurate output when it needs to provide real time data to the circuit board. In terms of rang support photo transistor has the highest support which really important when a light sensor senses the light intensity from long range area. Photo resistor can detect intensity of light up to 100 lux where photo transistor detects it up to 100 Klux. To ensure the safety of vehicle's most accurate and highly responsive sensor should be used as it can safe driver's and passenger's life. Phototransistor has an extra feature which amplification. It can also amplify the signal when it is needed which photo resistor or photodiode cannot do it. So comparing all those parameters we can sum up by this, Phototransistor has:

- High accuracy rate
- Long range capability
- Signal amplification
- Aceptable electricity flow
- Suitable response time

D. Structure of the paper

To showcase of our work, this paper is divided into four sections where in section 3 implementation and in section 4 concept are discussed.

II. CONCEPT

A. Working techniques of phototransistor

Photo transistor works from a specific design of circuit. That circuits performs specific function as needed. As figure 5 and 6 indicates the fundamental of photo transistor circuits. In Figure 5(A) a common-emitter amplifier is displayed. At the base light input causes the output (V_{OUT}) to decrease from high to low.

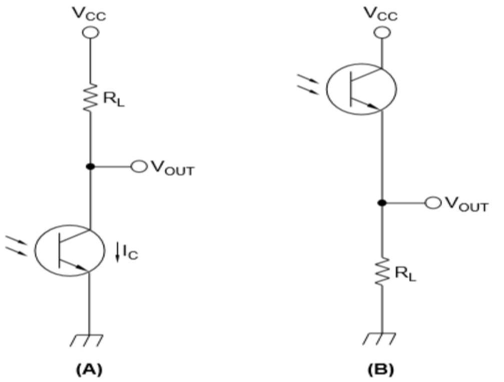

Fig. 5: Phototransistor circuit

In the Figure 5(B) the circuit is a common-collector amplifier with an output (V_{OUT}) increasing from low to high with response to light input. For the circuit in Figure 9 is to operate in the switching mode, the load resistor (R_L) must be set in relation with the collector current,

$$(I_C) \text{ as } \quad V_{CC} < R_L \times I_C. \tag{1}$$

Phototransistor with a base is used by the circuit indicated in Figure 6(A). A R_{BE} resistor is connected between base and emitter reduces the influence of dark current when handling at a high temperature.

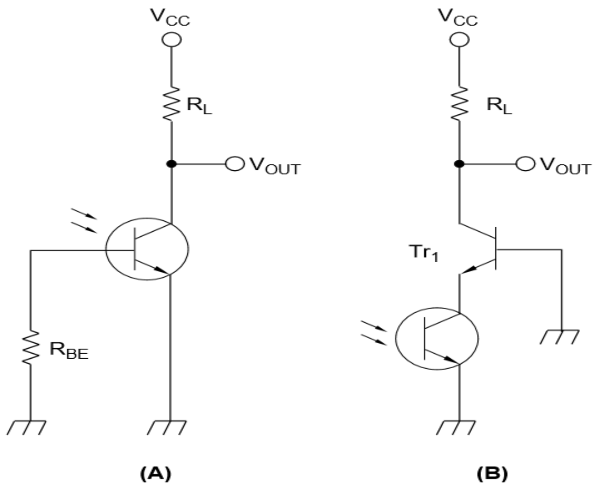

Fig. 6: Phototransistor circuit

In Figure 6(A) an extra R_{BE} circuit is added. The circuit shown in Figure 6(B) conducts a cascade connection of the grounded-base transistor (T_{R1}) so that phototransistor can be less loaded and as a result the response can be improved.

B. Amplification of phototransistor

Figure 7 indicates that transistor amplifiers which are generally developed to amplify the collector current of the phototransistor using a transistor (T_{r1}). In the Figure 7(A) the circuit that increases the output from high to low is based according to a light input.

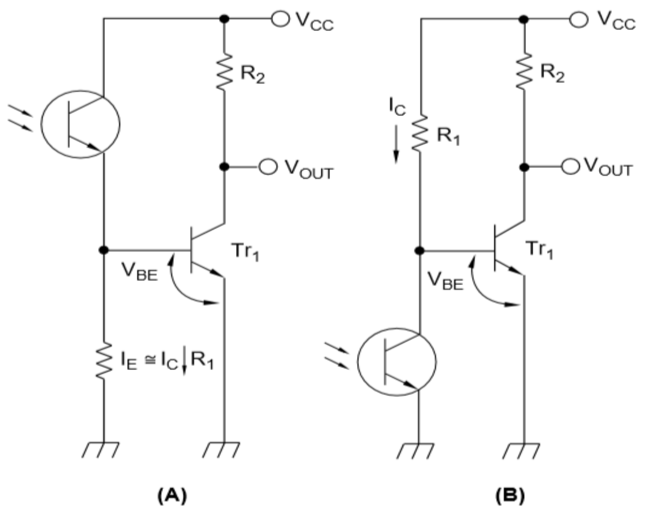

Fig .7: Amplification using Transistor [2]

The value of resistor R_1 depends on the light intensity of input, ambient temperature, response speed for verify the following conditions.

$$R1 < VBE/ ICEO, R1 > VBE \tag{2}$$

Where I_{CBO} is noted as the dark current and I_C is the collector current of phototransistor

C. Technique of modulated signal

As Figure 8 indicates the circuit which is used to detect a modulated signal such as AC or plus signal. The photo transistor consists of a base terminal with a fixed bias via resistor R_1 and R_2. An R_4 emitter resistor operates the resistor DC output voltage constant.

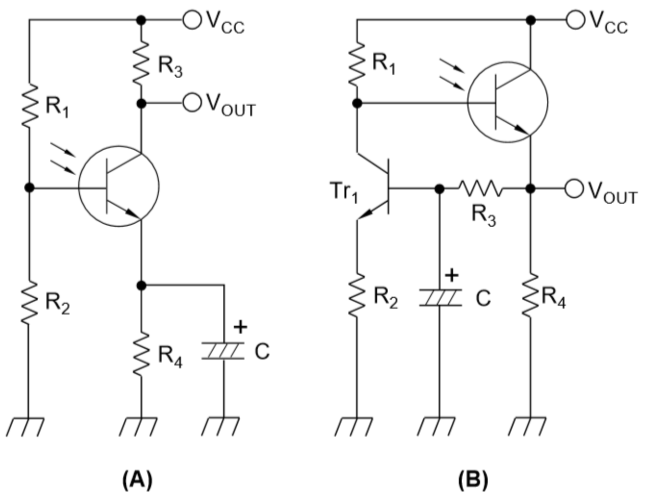

Fig. 8: Phototransistor circuit [2]

A modulated signal delivers a base current through bypass capacitor is C effecting current amplification as a result the signal is greatly amplified. Finally, after using amplifier circuit with operational amplifier we can see the output voltage progress with irradiation intensity in the following Figure 9.

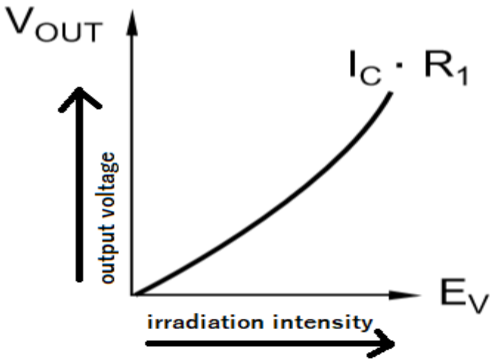

Fig. 9: Output voltage Vs. irradiation intensity [3]

III. IMPLEMENTATION

The track and hold circuit is connected to analog to digital converter. It produces an 8 bit sample. ALS also contains the SPI bus interface. The SPI is the ultimate point of contact back to the NI my RIO SPI input to either the port A or port B.

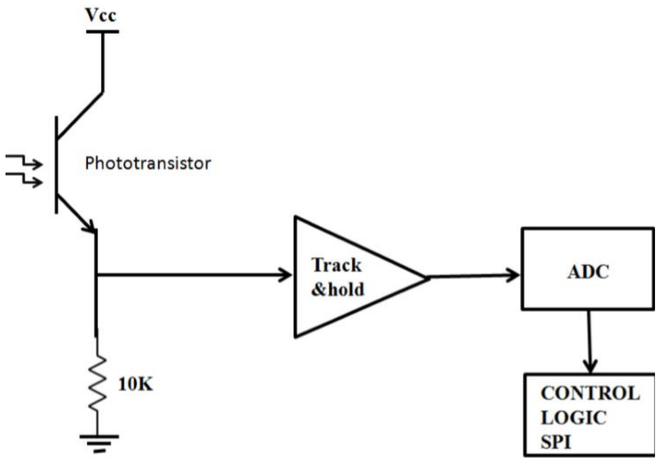

Fig.10: Phototransistor with analog to digital converter (ADC)

A. *Working with analog converter*

Analog Converter works in Two Modes,

- Track Mode
- Hold Mode

It is initiated with the track mode. Chip select might be usually high; it was marked greatly low to begin a conversion cycle. This switches the converter to hold mode. Serial clock should be normally high. The serial clock pulses are initiated when the chip select is dropped. Serial data out is in the high impedance state. As soon as the chip select is dropped serial data becomes active. The first data bit generated by the serial data out is the most significant bit. After the 8th data bit is clocked out, the converter switches back to its track mode. The chip select will be initiated as high to proceed the next conversion cycle.

B. *Varying light intensity*

Pulse Width Modulation (PWM) Signal is an analog signal generated using a digital source. For varying the light intensity, Pulse Width Modulation seems to constitute the most effective means to accurately control the illumination. In PWM, the brightness is operated by square pulse modulation of the driving current and by setting the duty cycle of the pulse train. The behavior of the pulse width modulation is based on two components:

- Duty Cycle
- Frequency

The duty cycle refers the amount of time where signal is in a high (ON) state as a percentage of the total time of it needs to complete one cycle as Figure 11 shown below. The frequency indicates how fast the PWM completes a cycle (i.e. 1000 Hz would be 1000 cycles per second), and also how fast it switches between high and low states.

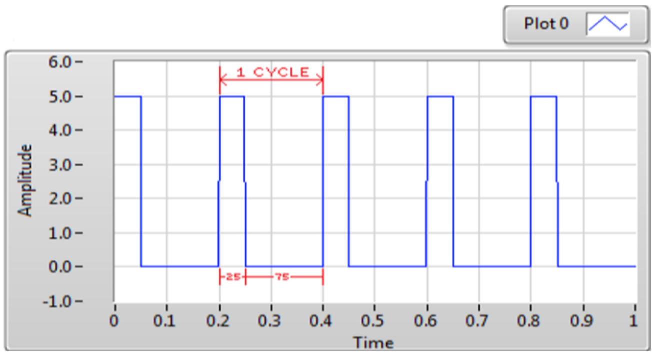

Fig. 11: Duty Cycle 25% [4]

Taking cycling a digital signal OFF and ON at a fast enough rate, and with a certain duty cycle, the output will come out to behave such as a constant voltage analog signal when powering the devices.

C. *Controlling headlights*

Ambient Light Sensor detects the surrounding brightness. On connector B ALS is connected to the SPI bus. SPI bus can be connected to connector A or connector B. The connector B also provides 3.3 v to ALS. The conversion cycle starts with dropping the Chip Select (CS) value. Digital output block is set to 0 by giving a false constant so that the chip select is dropped to the low value. The SPI express VI block is read on every single frame. The frame length needed is 16 bits. The non-default values, clock phase and clock polarity are need to be selected. The output of the express VI is an array of 16 bit unsigned integers. The data direction is that the Most Significant Bit (MSB) first. So by using the index array the individual values are pulled off. The extraneous bits can be removed using the logical shift to the right. The values are converted to unsigned 8 bit integers. Then the values are displayed in the front panel.

And finally, the conversion cycle should be completed by switching the chip select to a high state. The sensor values are given into the case structure. For the different sensor values, PWM signals are generated and the headlight of the vehicle is operated according to the brightness of surrounding.

The digital output 1 changes the chip select to low state to start the conversion cycle of the analog converter to switch it from track mode hold mode. The SPI express VI calculates a single frame and generate it to the application it is being currently used. After that digital output 2 switches the chip select to track mode again. The index array function reads the information which is 16 bit from the SPI express VI. The 16 bit value is right shifted by 5 units and is converted to 8 bit value.

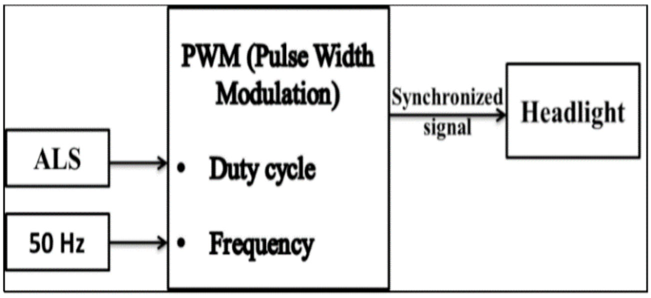

Fig.12: Controlling headlight with synchronized signal

The PWM are used to renew the light intensity as specified in Pulse Width Modulation. With respect to 8 bit value, A case structure is used to vary the duty cycle.

IV. EXPERIMENTAL RESULT

The sensor was tested at different ambient conditions and its performance is evaluated. The sequences were acquired and the PWM signal is generated accordingly. For different variations in the ambient light intensity in surrounding the headlight intensity of the vehicle is varied. It will be efficient for the driver to automatically control the headlight intensity whenever it is necessary. Figure 12, Figure 13, Figure 14 indicates the headlight of the vehicle under different brightness.

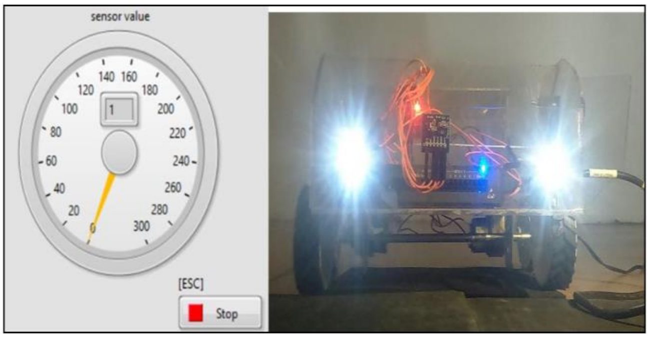

Fig. 12: Headlight is glowing during dark lighting condition [4]

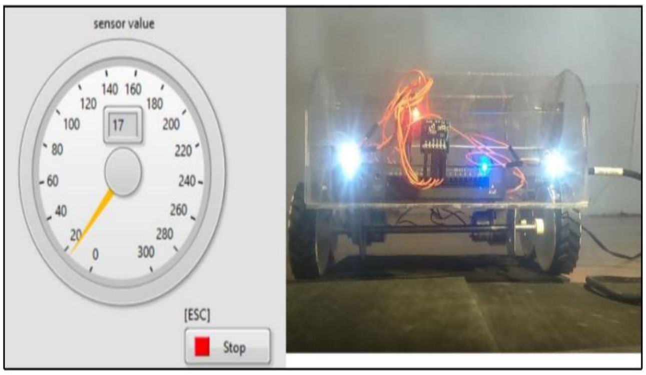

Fig. 13: Headlight is glowing in medium intensity while surrounding In neither too dark nor too bright. [4]

Fig. 14: Headlight is turned off when surrounding is fully bright [4]

V. CONCLUSION

During driving the vehicle automatic headlight control system using ambient light sensor based on transistor is focused upon providing a comfortable driving experience for the driver and also a safe travel experience for the passengers on the road. This is developed through varying the headlight intensity corresponding to the environmental light intensity using an ambient light sensor based on photo-transistor. It can be set into vehicle's body where surrounding light can easily be detected by the sensor, such as rear glass side of vehicle. This is effective for drivers who often don't concentrate on the headlight intensity. The safety is ensured at the same time when the battery power consumption is also optimized. This can be most efficient during night or dark times and in regions with varying light intensity.

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