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Feed Forward Neural Network Based Light Intensity Control of Networked LED Light System

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ABSTRACT

The use of a neural network technique to establish the relationship among dimming levels of luminaires and illuminance at the user tables. The neural network then will be included in sensor feed forward illumination control for the smart networked LED-lighting system[9]. The accuracy of the model depending on the configuration of the neural network and characteristics of the LED-lighting system will be examined. The daylight effect is beyond the scope of this research and will be investigated in future work.

Keywords: *ARM7 Microcontroller, LCD, LDR, PIR.*

1. INTRODUCTION

With rapidly increasing energy demand all over the world, saving lighting energy in building environments has become increasingly important since lighting accounts for a considerable portion, typically more than 20% of energy consumption in buildings. This has led to the exploration of not only new lighting technologies such as solid-state lighting (SSL) but also a smarter approach to utilize these SSL[2] systems. In the aforementioned smart lighting systems, it is the illumination control that plays a crucial role in reducing the energy consumption of the building lights. At present, there are already some forms of illumination controllers generally used to turn on/off lighting luminaires or adjust dimming levels of luminaries such that the consumed power reduces while the visual comfort of users is well kept. It is common in the lighting industry nowadays to design the lighting system using a zoning approach. While trying to achieve energy saving and human preference at the same time, traditional control approaches encounter the problem of complexity in deciding which luminaire should light up which area. To soften this problem, a zoning approach groups several luminaires in one zone together to be adjusted by one controller and with the corresponding sensors. The approach then transforms the control problem to become multiple single input single-output (SISO). The first disadvantage of the approach, however, is that designers have to manually preset the zoning for luminaires, lit area, and sensors. Moreover, the interactions among the zones still exist, and thus, either the control response is low or energy saving is lost because these interactions are neglected during the design phase. In lighting applications such as in a common shared-space office with multiple LED luminaires, the smart illumination control problem can be formulated as to automatically adjust dimming levels of the LED luminaires to ensure sufficient luminance at users' tables at minimized energy consumption. In this problem, on the one side, information on occupancy of users at their working tables which is detected by occupancy sensors is essentially necessary. On the other side, information on luminance at their tables is optional owing to the following reasons. The first reason is that this type of information can be evaluated based on illumination modeling. The second reasons that luminance sensors placed on the office tables may affect the working users and, vice versa, users may affect the function of these sensors accidentally. Without using illuminance sensors, several researchers have used simulation software to conduct the lighting configuration and establish the relationship between luminaires and illuminance. The major drawback of this published state-of-the-art approach is that, for different buildings, the lighting setting for networked lighting system has to be manually changed. Moreover, in many cases, the simulation software could not accurately imitate the real environment. In addition, it is difficult to set up the simulation software in microcontrollers (MCUs) and digital signal processors, and thus, the use of a personal computer (PC) is compulsory.

I. Block Diagram

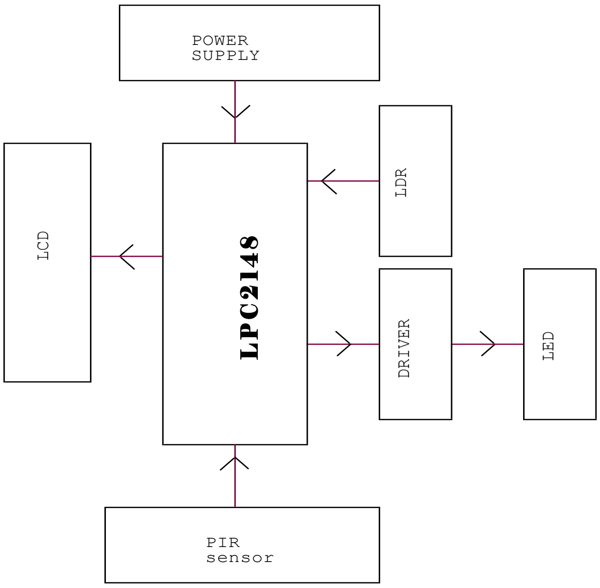

Fig 1: Block Diagram of Light Illumination Network

a. Working

There is provided an infrared sensor unit for deactivating an electrical appliance when left unattended by its user. The sensor unit includes a passive infrared sensor for sensing the user through a field of infrared light provided within a viewable distance of the electrical appliance. An adjustable timer is in electrical communication with the passive infrared sensor for counting toward a predetermined amount of time when the user is not sensed within the field of infrared light. The sensor unit further includes a controller device which is in electrical communication with the adjustable timer for deactivating the electrical appliance upon reaching the predetermined amount of time.

A Passive Infra-Red[10] (PIR) sensor is an electronic device commonly used in security lighting, and burglar alarm systems. A PIR sensor is a motion detector which detects the heat (infrared) emitted naturally by humans and animals. When a person in the field of vision of the sensor moves, the sensor detects a sudden change in infrared energy and the sensor is activated and it will send a signal to the microcontroller, then the controller will switch on the led based on room light which shown in Figure.1.

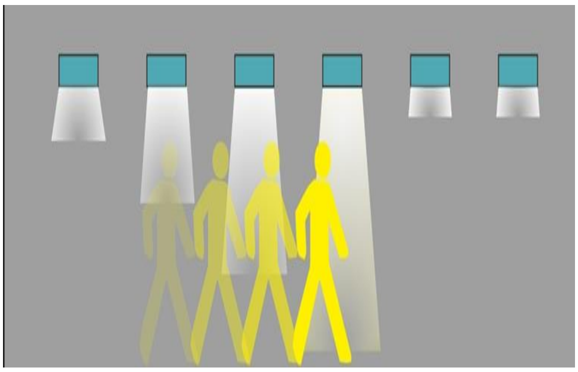

Figure.2: Passive Infrared (PIR) Sensor

b. Circuit

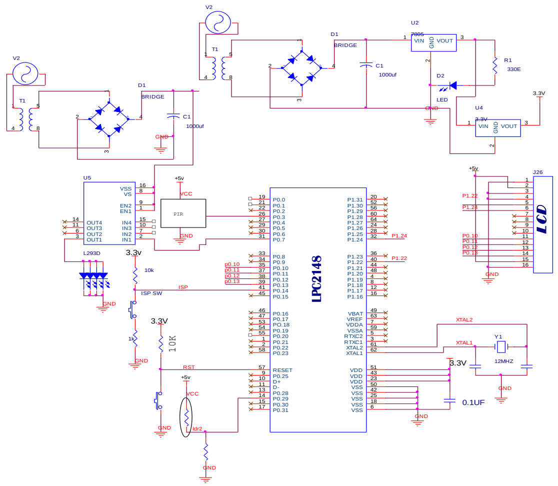

Fig 3: Schematic Circuit Diagram of Light Intensity Control Network

II. LDR[8]

A photo-resistor or light dependent resistor or cadmium sulfide (CDS) cell is a resistor whose resistance decreases with increasing incident light intensity. It can also be referenced as a photoconductor. A photo-resistor is made of a high resistance semiconductor. If light falling on the device is of high enough frequency, photons absorbed by the semiconductor give bound electrons enough energy to jump into the conduction band. The resulting free electron (and its whole partner) conduct electricity, thereby lowering resistance. For its operation, a photo-resistor requires a power source because it does not generate photocurrent; a photo-effect is manifested in the change in the material's electrical resistance.

For better sensitivity and lower cell resistance, the distance between the electrodes should be reduced and the width of the sensor should be increased. This suggests that the sensor should be very short and very wide.

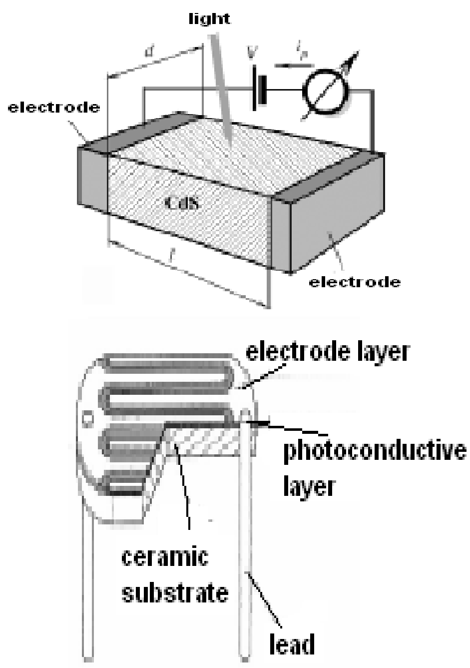

Fig 4: Light Dependent Resistor

III. Voltage Divider Circuits[5]

In electronics, a voltage divider (also known as a potential divider) is a simple linear circuit that produces an output voltage (Vout) that is a fraction of its input voltage (Vin). Voltage division refers to the partitioning of a voltage among the components of the divider. A simple example of a voltage divider consists of two resistors in series or a potentiometer. It is commonly used to create a reference voltage, and may also be used as a signal attenuator at low frequencies. A voltage-divider circuit with LDR is following:

IV. Possible Circuits

There are just two ways of constructing the voltage divider, with the LDR at the top, or with the LDR at the bottom:

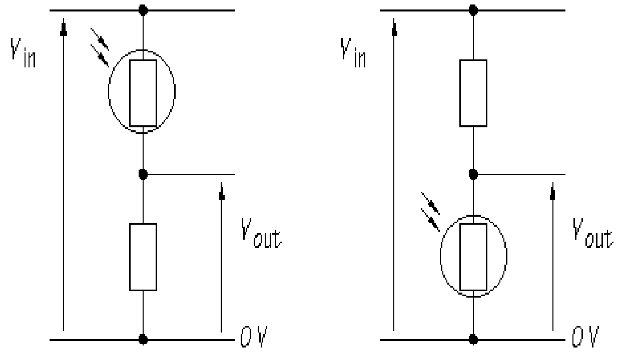

Fig 5: Voltage Divider Circuit with LDR

You are going to investigate the behavior of these two circuits. You will also find out how to choose a sensible value for the fixed resistor in a voltage divider circuit.
Remember the formula for calculating *V*out:

$$V_{\text{out}} = \frac{R_{\text{bottom}}}{R_{\text{bottom}} + R_{\text{top}}} \times V_{\text{in}}$$

a. Driver (L293D)

L293D

- Featuring Unit rode L293 and L293D Products Now From Texas Instruments
- Wide Supply-Voltage Range: 4.5 V to 36 V
- Separate Input-Logic Supply
- Internal ESD Protection
- Thermal Shutdown
- High-Noise-Immunity Inputs
- Functional Replacements for SGS L293 and SGS L293D
- Output Current 1 A Per Channel (600 mA for L293D) Peak Output Current 2 A Per Channel (1.2 A for L293D) Output Clamp Diodes for Inductive Transient Suppression (L293D)

b. Description

The L293 and L293D are quadruple high-current half-H drivers. The L293 is designed to provide bidirectional drive currents of up to 1 A at voltages from 4.5 V to 36 V. The L293D is designed to provide bidirectional drive currents of up to 600-mA at voltages from 4.5 V to 36 V. Both devices are designed to drive inductive loads such as relays, solenoids, dc and bipolar stepping motors, as well as other high-current/high-voltage loads in positive-supply applications. All inputs are TTL compatible. Each output is a complete totem-pole drive circuit, with a Darlington transistor sink and a pseudo-Darlington source. Drivers are enabled in pairs, with drivers 1 and 2 enabled by 1,2EN and drivers 3 and 4 enabled by 3,4EN. When an enable input is high, the associated drivers are enabled and their outputs are active and in phase with their inputs. When the enable input is low, those drivers are disabled and their outputs are off and in the high-impedance state. With the proper data inputs, each pair of drivers forms a full-H (or bridge) reversible drive suitable for solenoid or motor applications. On the L293, external high-speed output clamp diodes should be used for inductive transient suppression. A VCC1 terminal, separate from VCC2, is provided for the logic inputs to minimize device power dissipation. The L293and L293D are characterized for operation from 0°C to 70°C.

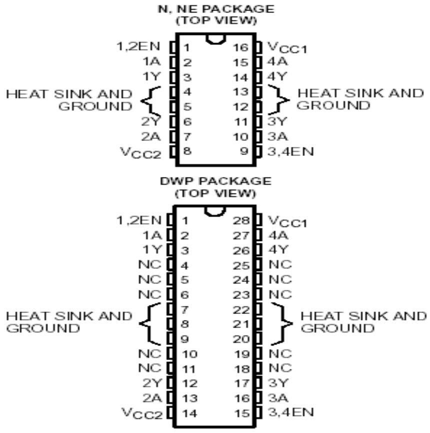

Fig 6: L293D Pin Diagram

2. ADVANTAGES

- Light Control Increases Comfort and may improve Productivity.
- All Lights Dimmers save Energy
- All Light Sources Use Less Energy When Dimmed.
- Dimming Saves Energy and the Environment While Enriching Your Life.

3. CONCLUSION

In this paper, a sensor base illumination control approach of a networked LED-lighting system using a feed forward neural network has been presented. The approach has shown its effectiveness in tackling the nonlinearity characteristics of the networked LED-lighting system in the office test bed. With the merits of low cost, ease of installation, flexibility, high accuracy, and fast response, it proves to be a promising candidate for the control of the future smart and energy-efficient networked LED-lighting system. Experimental results have been shown to validate the guidelines on how to configure the neural network as well as the energy saving functionality.

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