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Implementation of Automatic Efficient and Proportional Lighting Control and Management System Based On ARM Architecture and Wireless Communication

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Abstract: --In past different light sources are available which result in high power consumption. This paper focuses on controlling light intensity by using LED light source.LED light source which is used to replace previous traditional light sources or equipments. Here, light intensity control can be achieved by using Zigbee wireless network. LED illumination level can be controlled using received data from various sensor and performing operations in different modes. Automatic and efficient light control can be done which result in effective power conservation. System implementation includes IEEE802.15.4 protocol, ARM architecture and few sensors.

Keywords: -- Light Emitting Diode (LED), ARM9, ARM7 (LPC2148), Zigbee protocol, LM35, LDR, IR.

I. INTRODUCTION

The term lighting controls is typically used to indicate stand-alone control of the lighting within a space. A lighting control system is an intelligent network based lighting control solution that incorporates communication between various system inputs and outputs related to lighting control with the use of one or more central computing devices. Lighting control systems are widely used on both indoor and outdoor lighting of commercial, industrial, and residential spaces. Lighting control systems serve to provide the right amount of light where and when it is needed.

The term lighting control system refers to an intelligent networked system of devices related to lighting control. These devices may include relays, occupancy, photocells, light control switches or touch screens, and signals from other building systems. Adjustment of the system occurs both at device locations and at central computer locations via software programs or other interface devices. Lighting control systems typically provide the ability to automatically adjust a lighting device's output based on Daylight availability using photocells which means electric lighting energy use can be adjusted by automatically dimming and/or switching electric lights in response to the level of available daylight. Reducing the amount of electric lighting used when daylight is available is known as daylight harvesting.

II. SYSTEM HARDWARE

In this section, ARM9, ARM7, few sensors are discussed.

2.1 ARM9 (Mini2440 | S3C2440 ARM9 Board):

Fig1: Friendly ARM

The Friendly ARM Mini2440 is a single board computer based on a Samsung S3C2440 ARM9 microprocessor. The S3C2440A is developed with ARM920T core, 0.13um CMOS standard cells and a memory complier. Its low power, simple,

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elegant and fully static design is particularly suitable for cost- and power-sensitive applications. It adopts a new bus architecture known as Advanced Micro controller Bus Architecture (AMBA).

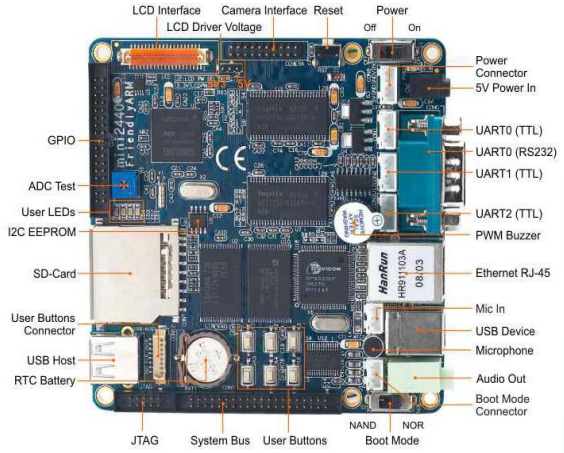

Fig2. Hardware resources

16-bit registers. This is possible because THUMB code operates on the same 32-bit register set as ARM code. THUMB code is able to provide up to 65% of the code size of ARM, and 160% of the performance of an equivalent ARM processor connected to a 16-bit memory system.

Fig3. ARM7 (LPC2148) board

2.2 ARM7 (LPC2148):

The ARM7TDMI-S is a general purpose 32-bit microprocessor, which offers high performance and very low power consumption. The ARM architecture is based on Reduced Instruction Set Computer (RISC) principles, and the instruction set and related decode mechanism are much simpler than those of micro programmed Complex Instruction Set Computers. This simplicity results in a high instruction throughput and impressive real-time interrupt response from a small and cost-effective processor core. Pipeline techniques are employed so that all parts of the processing and memory systems can operate continuously. Typically, while one instruction is being executed, its successor is being decoded, and a third instruction is being fetched from memory.

The ARM7TDMI-S processor also employs a unique architectural strategy known as THUMB, which makes it ideally suited to high-volume applications with memory restrictions, or applications where code density is an issue. The key idea behind THUMB is that of a super-reduced instruction set. Essentially, the ARM7TDMI-S processor has two instruction sets:

• The standard 32-bit ARM instruction set.
• A 16-bit THUMB instruction set.

The THUMB set's 16-bit instruction length allows it to approach twice the density of standard ARM code while retaining most of the ARM's performance advantage over a traditional 16-bit processor using

2.3 Temperature Sensor (LM35):

In this project, in order to monitor the temperature continuously and compare this with the set temperature preprogrammed in the microcontroller, initially this temperature value has to be read and fed to the microcontroller. This temperature value has to be sensed. Thus a sensor has to be used and the sensor used in this project is LM35. It converts temperature value into electrical signals. LM35 series sensors are precision integrated-circuit temperature sensors whose output voltage is linearly proportional to the Celsius temperature. The LM35 requires no external calibration since it is internally calibrated to provide typical accuracies of ±1⁄4°C at room temperature and ±3⁄4°C over a full −55 to +150°C temperature range.

The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with single power supplies, or with plus and minus supplies. As it draws only 60 µA from its supply, it has very low self-heating, less than 0.1°C in still air. The LM35 is a versatile device which may be used for a wide variety of applications, including oven controllers and remote temperature sensing. The device is easy to use (there are only three terminals) and will be within 0.02°F of a surface to which it is either glued or cemented.

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Fig4. Temperature Sensor (LM35)

2.4 LightDependentResistor (LDR):

A Light Dependent Resistor (LDR, photoconductor, or photocell) is a device which has a resistance which varies according to the amount of light falling on its surface. It can also be referred to as a photoconductor or CdS device, from "cadmium sulfide," which is the material from which the device is made and that actually exhibits the variation in resistance with light level. They will be having a resistance of 1 MOhm in total darkness, and a resistance of a 1 to 10 of KOhm in bright light.

A photoelectric device can be either intrinsic or extrinsic. 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 hole partner) conduct electricity, thereby lowering resistance. LDRs are very useful especially in light/dark sensor circuits. Thus in this project, LDR plays an important role in controlling the appliances based on the intensity of light i.e., if the intensity of light is more (during daytime) the loads will be in off condition. And if the intensity of light is less (during nights), the loads will be in on condition.

Fig5.Light Dependent Resistor

2.5 IR Sensor:

All objects emit some form of thermal radiation, usually in the infrared spectrum. This radiation is invisible to our eyes, but can be detected by an infrared sensor that accepts and interprets it. The IR sensor is a very simple device that works by reflecting infrared light off of an object and detecting the reflecting with a photo-transistor that is tuned to the same frequency of light. The LED is mounted next to the photo-transistor; however, the emitted light from the LED does not directly shine into the photo-transistor. Appropriate values for resistance are in series with both the LED to limit current and the photo-transistor in order to show a voltage drop based on distance to the object in front of the sensor.

The effective range of the sensor is a few centimeters. Object detection can be enhanced by placing a reflective surface between the object and the sensor. When the object passes between the sensor and reflective surface, a large drop will be observed in the output signal.

Fig6:.IR LED

IR RX:

The 555 timer is an integrated circuit (chip) implementing a variety of timer and multivibrator applications. The 555 Timer is a monolithic timing circuit that can produce accurate and highly stable time delays or oscillations. The timer basically operates in one of the two modes—monostable (one-shot) multivibrator or as an astable (free-running) multivibrator. In the monostable mode, it can produce accurate time delays from microseconds to hours. In the astable mode, it can produce rectangular waves with a variable duty cycle. The 555 can source or sink 200 mA of output current, and is capable of driving wide range of output devices. The output can drive TTL (Transistor-Transistor Logic) and has a temperature stability of 50 parts per million (ppm) per degree Celsius change in temperature, or equivalently 0.005 %/°C.

Fig7: Pin digram of 555 timer

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2.6 LCD:

To display interactive messages we are using LCD Module. We examine an intelligent LCD display of two lines, 16 characters per line that is interfaced to the controllers. The protocol (handshaking) for the display is as shown. Whereas D0 to D7th bit is the Data lines, RS, RW and EN pins are the control pins and remaining pins are +5V, -5V and GND to provide supply. Where RS is the Register Select, RW is the Read Write and EN is the Enable pin. The display contains two internal byte-wide registers, one for commands (RS=0) and the second for characters to be displayed (RS=1).

The most common type of LCD controller is HITACHI 44780 which provides a simple interface between the controller & an LCD. These LCD's are very simple to interface with the controller as well as are cost effective. The most commonly used *ALPHANUMERIC* displays are *1x16* (Single Line & 16 characters), *2x16* (Double Line & 16 character per line) & *4x20* (four lines & Twenty characters per line). When *RS* is low (0), the data is to be treated as a command. When RS is high (1), the data being sent is considered as text data which should be displayed on the screen. The *ENABLE* pin is used to latch the data present on the data pins. A HIGH - LOW signal is required to latch the data. The LCD interprets and executes our command at the instant the EN line is brought low. If you never bring EN low, your instruction will never be executed.

Fig8. 2x16 LCD display

2.7 LED:

LEDs are semiconductor devices. Like transistors, and other diodes, LEDs are made out of silicon. LEDs are used as indicator lamps in many devices and are increasingly used for general lighting. Appearing as practical electronic components in 1962, early LEDs emitted low-intensity red light, but modern versions are available across the visible, ultraviolet, infrared wavelengths, with very high brightness.

When a light-emitting diode is switched on, electrons are able to recombine with holes within the device, releasing energy in the form of photons. This effect is called electroluminescence, and the color of the light (corresponding to the energy of the photon) is determined by the energy band gap of the semiconductor. An LED is often small in area (less than 1 mm^2), and integrated optical components may be used to shape its radiation pattern. LEDs have many advantages over incandescent light sources including lower energy consumption, longer lifetime, improved physical robustness, smaller size, and faster switching.

Fig9: Typical LED and LED circuit symbol

2.8 ZIGBEE NETWORK:

Zigbee is the name of a specification for a suite of high level communication protocols using small, low-power, low data rate digital radios based on the IEEE 802.15.4 standard for wireless personal area networks (WPANs). The Zigbee standard uses small very low-power devices to connect together to form a wireless control web. A Zigbee network is capable of supporting up to 254 client nodes plus one full functional device (master). The standard supports 2.4 GHz (worldwide), 868 MHz (Europe) and 915 MHz (Americas) unlicensed radio bands with range up to 75 meters.

IEEE 802.15.4 is a standard which specifies the physical layer and medium access control for low-rate wireless personal area networks (LR-WPAN's).This standard was chartered to investigate a low data rate solution with multi-month to multi-year battery life and very low complexity. . It is operating in an unlicensed, international frequency band. A key component of the Zigbee protocol is the ability to support mesh networks. In a mesh network, nodes are interconnected with other nodes so that at least two pathways connect each node. Connections between nodes are dynamically updated and optimized in difficult conditions. In some cases, a partial mesh network is established with some of the nodes only connected to one other node.

Mesh networks are decentralized in nature; each node is self-routing, self healing and able to connect to other nodes as needed. The characteristics of mesh topology and ad-hoc routing provide greater stability in changing conditions or failure at single nodes. The Zigbee specification identifies three kinds

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of devices that incorporate Zigbee radios, with all three found in a typical Zigbee network.

- A coordinator, which organizes the network and maintains routing tables.
- Routers, which can talk to the coordinator, to other routers and to reduced-function end devices.
- Reduced-function end devices, which can talk to routers and the coordinator, but not to each other.

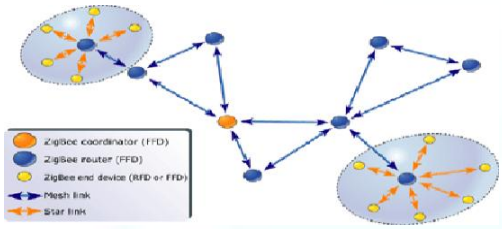

Fig10:.Zigbee Network

IV.SYSTEM IMPLEMENTATION & RESULTS

In the implementation of system, different modules are used as shown in figure 11.

Transmitter section:

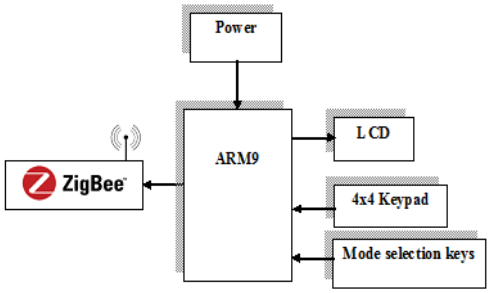

Fig11 (a) Transmitter section

Lighting section:

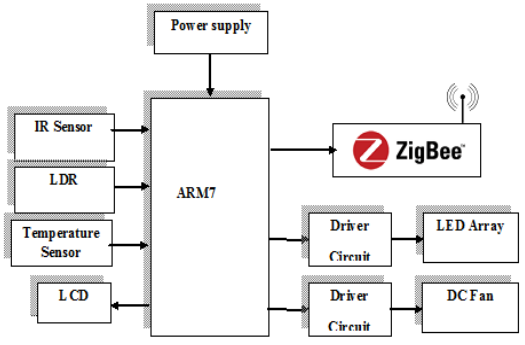

Fig11 (b) Lighting section

As shown in above figure system contains transmitter section and lighting section or receiving section. Transmitter section consists of control chip ARM9, LCD for display, Keypad for password authentication, mode selection keys and Zigbee Tx for data transmission. Whereas, receiving section consists of main control chip ARM7, few sensors like LDR, IR and Temperature sensors, Zigbee Rx for data receiving and end devices like LED bunch and DC Fan. Implementation of system can be done by using 3 modes of operation. Each mode varies in its functionality.

When mode1 is selected using mode selection key by user, the receiving section startup LDR mode.LCD displays outside illumination automatically. The sensor will send outside illumination data to the controller. If outside light is bright then LED light is dark i.e.no light.

User selects mode2; receiver section starts up in IR mode. Here, IR used for object detection which generates different voltage levels.IR Tx and IR Rx which have 555timer are used for mode functionality. When any object detected or identified by sensor then this data will be sent to controller which further produces different presupposed lighting effects. Objects which are detected are incremented then resulting output light effects will also varies.

In mode3, operation includes both LDR and IR sensors. Here, both sensors data is transmitted to ARM controller to produce various light illumination levels. Depending upon data received light effects will be changed.

Temperature sensor will be active and send data to controller. Here, LCD display outside temperature. Controller produces different PWM signals to DC fan or motor to obtain variation in speed of DC fan. For particular temperature, fan starts and rotates and depending upon the temperature changes occurred then the fan speed also changes.

By using different modes, system implemented and corresponding outputs are observed. Zigbee Transmitter and Zigbee receiver plays a crucial role in system implementation by transferring data from transmitter section to receiver section.

Algorithm:

STEP1: Initialize ARM9, ARM7, sensors & Zigbee.
STEP2: Enter authenticated password for operation.
STEP3: On ARM9 display, select mode1 from mode selection menu.

STEP4: ARM7 starts in LDR mode. If LDR=1 then output light is bright. If LDR=0 then output light is dark.
STEP4: Select mode2 from mode selection menu. IR sensor which varies LED light effects based on predefined conditions.
STEP5: Mode3 is selected. LDR and IR conditions checked to observe variation in output light.
STEP6: Temperature sensor data given to controller. Based on predefined conditions controller generates different PWM signals for Speed.
STEP7: Mode changed according to requirement.
STEP8: Stop the process.

Fig12 (a): ARM9 as transmitter section

Fig12 (b): Lighting section when the power is ON

IV.CONCLUSION

In this paper a system for light control using Zigbee network and ARM architecture have been developed. Using LED lights and different modes of operation which result in efficient light intensity and also energy saving. Zigbee technology provides additional advantage to this system. User gets suitable light effects and temperature control. All the end devices controlled automatically which made easy operation and secure.

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