# Smart Lighting and Control using MSP430 & Power Line Communication

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## Abstract
Smart Lighting is a lighting technology designed for energy efficiency. It includes high efficiency fixtures, day lighting and automatic controls that make adjustments based on conditions such as occupancy. This smart lighting system is connected through power line which is also used for communication. Power Line Communication (PLC) is a technology which uses power lines as physical media for data transmission. PLC can offer a "no new wires" solution because the infrastructure has already been established. PLCs are used for transmitting data at rapid speed through a power line in a house, an office, a building and a factory etc. Here, the existing alternating current (AC) power wires serve as a transmission medium by which information is relayed from an AC source. Present paper deals with design and development of a smart lighting system which is controlled by MSP430 microcontroller and power line communication.

**Key Words** – MSP430, Power Line Communication (PLC), Sensors, Smart Lighting System

## Introduction
Since the first caveman learned to control fire, humans have shaped and used light in a constantly expanding array of technologies. Yet lighting – "Smart lighting" – could do much more, according to E. Fred Schubert, Wellfleet Senior Constellation at Rensselaer. Usually lighting consumes a lot of electrical energy every day all around the world. According to the statistics, 20 to 50 percent of total energy consumed in homes and offices are used for lighting. What is surprising is that over 90 percent of the lighting energy expense used for some of the buildings is unnecessary due to the over illumination. The cost of lighting can be very realistic.
PLC utilizes the power line infrastructure in a home, office or other building, both indoor and outdoor, for networking and communication thereby eliminating the expense and inconvenience of new wires or antenna – based networks. The power line can be an extremely difficult and noisy communications medium, characterized by several unpredictable and strong forms of interference. In this paper, we give solutions to overcome the interference and reliability problems that can occur on the power line and offer low cost, robust and superior performance. Reliable, low cost PLC technology enables ubiquitous applications for residential and business markets. PLC opens a whole new world of business opportunities to appliance and electric devices manufacturers, utilities and other service providers, with no need to install new cables or jacks. With PLC, every electrical outlet can become a communication node, part of a PLC network.

## I. Smart Lighting System

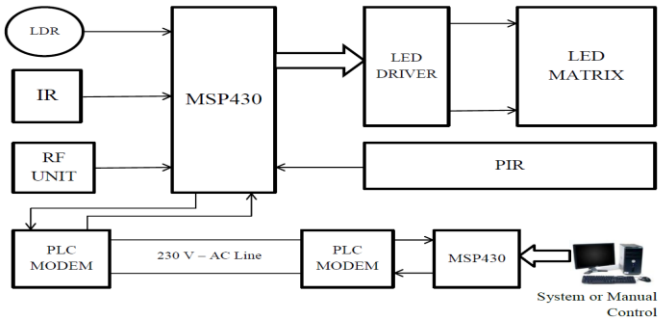


**Figure 1:** Block diagram of Smart Lighting and Control using MSP430 & PLC modem

The lighting model uses Light Emitting Diodes (LEDs) which are driven by a driver. This lighting model is controlled by MSP430 microcontroller which receives the commands from the master microcontroller or from a manually controlled system. The communication between transmitter and receiver happens through power lines using PLC modem. To this lighting model different sensors are also connected as shown in the diagram. The details about the sensors are given below.

*A. SENSORS*

*1. Passive Infrared Sensor*

A Passive Infrared sensor (PIR sensor) is an electronic device that measures infrared (IR) light radiating from objects in its field of view. PIR sensors are often used in the construction of PIR-based motion detectors. Apparent motion is detected

when an infrared source with one temperature, such as a human, passes in front of an infrared source with another temperature, such as a wall. This is not to say that the sensor detects the heat from the object passing in front of it but that the object breaks the field which the sensor has determined as the "normal" state. Any object, even one exactly the same temperature as the surrounding objects will cause the PIR to activate if it moves in the field of the sensors.

*2. Infrared Receiver Modules*

These IR receiver modules are used here for remote control systems. These modules are miniaturized receivers for infrared remote control systems. Figure 3 gives the block diagram of IR receiver module. PIN diode and preamplifier are assembled on lead frame, the epoxy package is designed as IR filter. The demodulated output signal can directly be decoded by the microcontroller. TSOP348.. is the standard IR remote control receiver series for 3V supply voltage, supporting all major transmission codes.

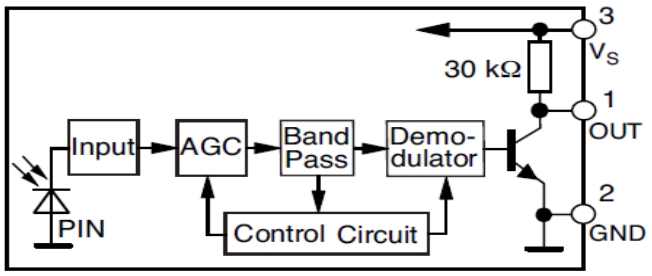


Figure 2: Block diagram of IR receiver module

*3. Light Dependent Resistor*

Light dependent resistor (LDR) is a resistor whose resistance decreases with increasing incident light intensity; in other words, it exhibits photoconductivity. 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. 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 hole partner) conduct electricity, thereby lowering resistance.

## II. MSP430 MICROCONTROLLER

The MSP430 is a mixed-signal microcontroller family from Texas Instruments. Built around a 16-bit CPU, the MSP430 is designed for low cost and, specifically, low power consumption embedded applications.

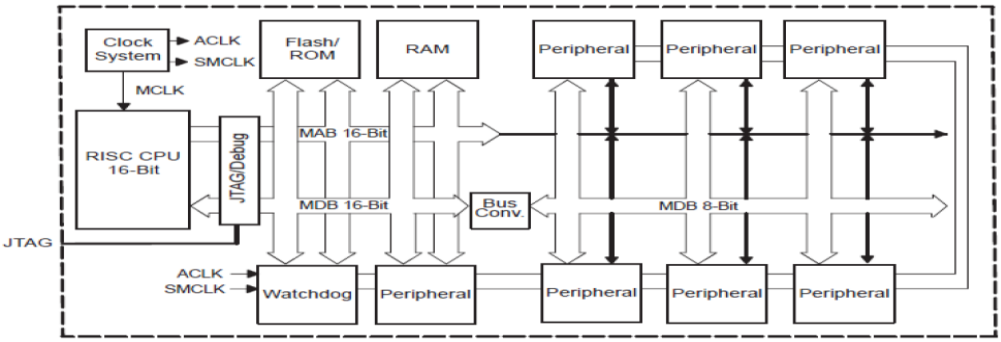


Figure 3: MSP430 Architecture

The MSP430 can be used for low powered embedded devices. The electric current drawn in idle mode can be less than 1 microamp. The top CPU speed is 25 MHz. It can be throttled back for lower power consumption. The MSP430 also utilizes six different Low-Power Modes, which can disable unneeded clocks and CPU. This allows the MSP430 to sleep, while its peripherals continue to work without the need for an energy hungry processor. Additionally, the MSP430 is capable of wake-up times below 1 microsecond, allowing the microcontroller to stay in sleep mode longer, minimizing its average current consumption. Note that MHz is not equivalent to Million instructions per second (MIPS), and different architectures can obtain different MIPS rates at lower CPU clock frequencies, which can result in lower dynamic power consumption for an equivalent amount of digital processing.

The MSP430 incorporates a 16 – bit RISC CPU, peripherals, and a flexible clock system that interconnect using a von-Neumann common memory address bus (MAB) and memory data bus (MDB). Partnering a modem CPU with modular memory – mapped analog and digital peripherals, the MSP430 offers solutions for demanding mixed – signal applications. Figure 3 gives the architecture of MSP430.

Key features of the MSP430x1xx family include:

- Ultralow – power architecture extends battery life
  - 0.1 µA RAM retention
  - 0.8 µA real-time clock mode
  - 250 µA / MIPS active
- High – performance analog ideal for precision measurement
  - 12 – bit or 10 – bit ADC --- 200 ksps, temperature sensor
  - 12 – bit dual – DAC
  - Comparator – gated timers for measuring resistive elements
  - Supply voltage supervisor
- 16 – bit RISC CPU enables new applications at a fraction of the code size.
  - Large register file eliminates working file bottleneck
  - Compact core design reduces power consumption and cost
  - Optimized for modern high – level programming
  - Only 27 core instructions and seven addressing modes
  - Extensive vectored – interrupt capability
- In – system programmable Flash permits flexible code changes, field upgrades and data logging.

## III. Power Line Communication

Power Line Communication is a communication technology that enables sending data over existing power cables. This means that, with just power cables running to an electronic device (for example) one can both power it up and at the same time control / retrieve data from it in a half – duplex manner. PLC is the usage of electrical power supply networks for communication purposes. In this case, electrical distribution grids are additionally used as a transmission medium for the transfer of various telecommunications services. The main idea behind PLC is the reduction of cost and expenditure in the realization of new telecommunication networks.

The application of electrical supply networks in telecommunications has been known since the beginning of the twentieth century. The first Carrier Frequency Systems (CFS) had been operated in high-voltage electrical networks that were able to span distances over 500 km using 10-W signal transmission power. Such systems have been used for internal communications of electrical utilities and realization of remote measuring and control tasks. Also, the communications over medium- and low-voltage electrical networks has been realized. Ripple Carrier Signaling (RCS) systems have been applied to medium- and low-voltage networks for the realization of load management in electrical supply systems.

### *A. STANDARDS*

The communications over the electrical power supply networks is specified in a European standard CENELEC EN 50065, providing a frequency spectrum from 9 to 140 kHz for powerline communications (Tab. 1). CENELEC norm significantly differs from American and Japanese standards, which specify a frequency range up to 500 kHz for the application of PLC services.

| Band | Frequency Range (in KHz) | Max. Transmission Amplitude (in V) | User Dedication |
|---|---|---|---|
| A | 9 – 95 | 10 | Utilities |
| B | 95 – 125 | 1.2 | Home |
| C | 125 – 140 | 1.2 | Home |

Table 1: CENELEC bands for power line communication

CENELEC norm makes possible data rates up to several thousand bits per second, which are sufficient only for some metering functions (load management for an electrical network, remote meter reading, etc.), data transmission with very low bit rates and the realization of few numbers of transmission channels for voice connections. However, for application in modern telecommunications networks, PLC systems have to provide much higher data rates (beyond 2Mbps). Only in this case, PLC networks are able to compete with other communications technologies, especially in the access area.

### *B. TECHNOLOGY BENCHMARK*

The following table compares the different technologies depending on the required baud rate, target price and system performance.

| | Price | Baud rate | Distance | Network coverage | Power consumption | Deployment cost | Operational cost |
|---|---|---|---|---|---|---|---|
| PLC | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| BPL | ✗ | ✓ | ✗ | ✗ | ✗ | ✓ | ✓ |
| ZIGBEE | ✓ | ✓ | ✗ | ✗ | ✓ | ✗ | ✓ |
| RFISM | ✓ | ✗ | ✓ | ✗ | ✗ | ✗ | ✓ |
| GSM/GPRS | ✗ | ✓ | ✓ | ✓ | ✗ | ✗ | ✗ |

Table 2: Comparison of PLC with other technologies

PLC: Power Line Communications
BPL: Broadband PL
RF ISM: Radio Frequency in Industrial, Scientific and Medical radio band

## IV. Conclusions

Thus we provide a smart lighting system using MSP430 microcontroller which helps to reduce energy usage and cost by eliminating over – illumination and unnecessary waste. This system provides centralized control of all lighting within a home or commercial building, allowing easy implementation of scheduling, occupancy control, daylight harvesting and more through power line communication. This system also supports demand response and will automatically dim or turn off lights to take advantage of demand response incentives and cost savings.

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**Mr. Gurjeet Singh** is a **Founder Director and Design Head** of **Gill Instruments Pvt. Ltd.**, Electronic City, Bangalore. Gill Instruments is a Third party Company of Texas Instruments. Gill Instruments provides design solutions in the area of Embedded Systems and Manufacture Development tools for MSP430 family. He worked with General Electric Bangalore for 1 year. He holds a Bachelor's degree in **Electronics & Telecommunication** from J.N.E.C Aurangabad. He has been working closely with Texas Instruments for university programs. He has taken the initiative to set up embedded system labs across the country in various universities and Engineering colleges. He contributed some of the best development tools available today for embedded system designs. He also conducts 3 day Embedded System design workshop, where he has trained more than Five thousand engineers in the past 6 years.