

Modelling and Developing an Intelligent Road Lighting System Using Power-Line Communication

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Abstract – The development of a suitable system which will control street lighting ballasts depending on traffic flow, communicate data between each street light along the Power-Line and sense passing traffic. This paper offers the methodology of the system, environmental benefits, commercial benefits and safety benefits of such a unique system. It also shows topics that have been researched to date and potential future development paths this research could take.

1. INTRODUCTION

Background

Current street lighting systems use vast amounts of energy to light our roads at night. The Sodium lights use between 200W and 2kW each depending on location. In some countries such as Norway, around 20% of all the electricity produced is used by road lighting. Although in the UK this figure is much lower the amount of electricity consumed is greater. By implementing a control system a large proportion of this electricity could be saved.

A lighting system allows streetlights to be dimmed or turned off when there is no benefit for them to be turned on. This is of particular importance on a rural road where traffic may only go past every 20 minutes in the middle of the night or on a dangerous stretch of road where it would not be economical to currently erect street lighting such as at an accident prone bend. No other similar system has been found to exist that could carry out this task.

2. AIMS AND OBJECTIVES

The aim of this project is to produce a device that can be fitted to existing street lights or integrated into future lighting ballasts. The device must be capable of detecting passing traffic through its sensor and communicating numbers to differently addressed lamp posts. The model produced can be used to demonstrate the principle of operation of the system and serve as a test bed for development of the software to control the lighting ballasts.

3. STANDARDS

The system currently uses narrowband transmission principles for transmission and reception of data between the lamp posts utilizing the European Committee for Electro-technical Standardization, CENELEC, EN50065, which covers the communications requirements for transmitting and receiving signals over the LVDM in the frequency range of 3 kHz to 148.5 kHz. [1],[2][3],[4],[5].

4. POTENTIAL COMMERCIAL BENEFITS

The cost of a system has to be effective against the amount of electricity used. If the light could be turned off for around 30% of the night the system would pay for itself in less than a year. This would entail that a car would pass down the road around every 10 minutes for the majority of the darkness hours. This is based on the model cost, current electricity prices of around 14p / kWh and potential installation costs. Development of the project will reduce the cost from the model cost (currently around £70) and as electricity prices increase, will make the project even more viable.

5. POTENTIAL SAFETY BENEFITS

By making it more cost effective over both lifetime and installation costs, the project could make it viable for local councils to illuminate dangerous stretches of roads that are

sporadically used in the middle of the night. This could improve safety and reduce accidents.

6. MODEL SPECIFICATIONS

The basic model that has been produced includes 4 light units. These units communicate data along the Power-Line by using X-10 protocol. The units are controlled by PIC16F628a chips and have various visual status LED's and all the required hardware to modulate / demodulate the communication signals. Figure 1 shows the chip layout for the PIC 16F628a.

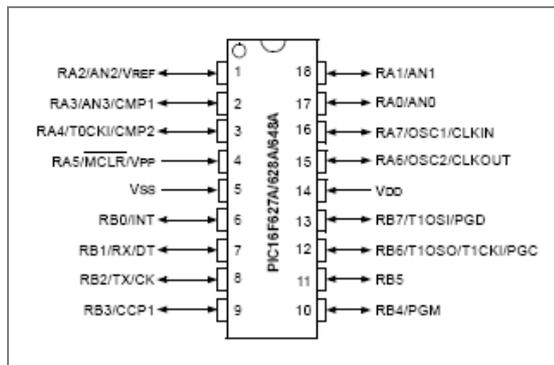


Figure 1 Chip Layout PIC 16F628a

Contactor / Ballast Regulator	AC / DC Converter	Power-line Connection
12V Distribution Bus	PIC Processor	Receive / Transmit Filter & Oscillator
Vehicle Sensor	TTL Control Circuit	Modulator / Demodulator

Figure 2 Project Block Schematic

7. EXPERIMENTATION

Experiments were carried out to perform feasibility measurements on a HPS (High Pressure Sodium) lighting arrangement. This involved measuring power consumption, current consumption, power factor change and light output increase. The results from the power consumption against time were measured using a power analyser with respect to time. This is shown in Figure 3. Particular attention to power after switching shows that there is no large power spike when the lamp is turned on.

The HPS lamp used was a 400W rated Osram Son T-Plus and unbranded ballast. The light gained in intensity for about the first minute but when switched on again retains its heat and takes a shorter time to reach full brightness.

Based on these facts the project is feasible but may need to be cycled to retain the heat in the system for efficient use if used without a ballast regulator.

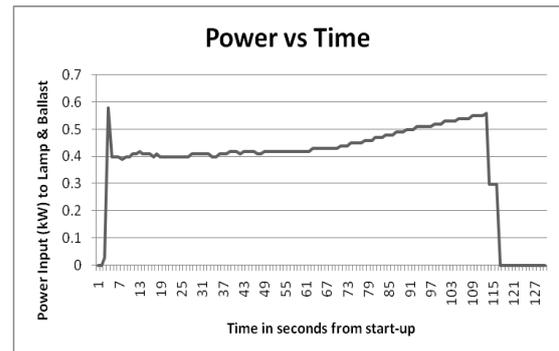


Figure 3 Power consumption of a HPS assembly

8. CURRENT LAYOUT

Figure 4 shows the built up model of 4 units and a close up view of a single unit. It includes PIR sensors which could be replaced with microwave detectors on the production model but are adequate for demonstration purposes.



Figure 4 Built Up Model

The circuit in each unit is identical, but each unit can be addressed by a set of four DIP switches. This only gives an address of 1 – 8 which is enough to communicate with all modules within range on the power-line. The PIC microprocessor can perform simple subtractions and send small numbers between each unit. This enables each unit to predict that a vehicle will be passing the light shortly and can illuminate when it is required to do so based on the warm up time for the bulb. The units transmit signals at low frequencies down the power-line using a further PIC. The overall circuit is shown in Figure 5.

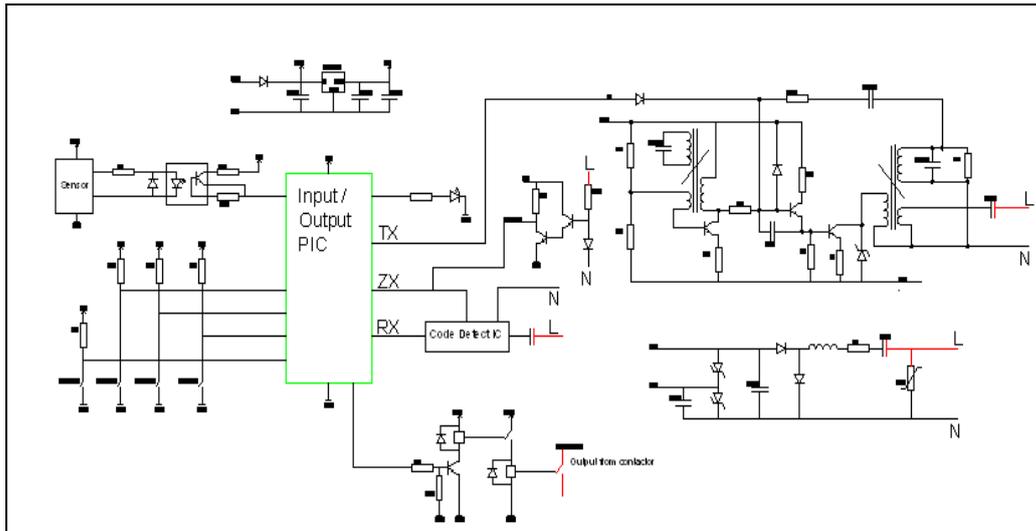


Figure 5 Circuit Schematic

9. CONCLUSIONS AND FUTURE WORK

Throughout this research we have not found any existing system that performs a similar task of detecting traffic in rural roads that can transmit data along the power-lines and turning on lights for the section of the road which is about to be used.

Further research is ongoing into traffic flow in various locations of British countryside to determine a suitable test road for the system. The existing system is feasible to mass produce and has merits to deliver environmental, safety and commercial benefits to both the manufacture and end user.

We have experienced that the X-10 protocol is relatively slow and the production version would need to process data faster.

Future work looks at eliminating this problem by using higher speed transmission protocols. The model also needs to reduce in size and although the cost is feasible at present could be reduced further.

The design of a second model that eliminates these problems and reduces cost by around 50% is underway.

The model can also be adapted to be used in many other scenarios such as machine control and plant automation.

10. REFERENCES

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