

Project proposal Matthew Batkin

by Matthew Batkin

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**Smart Children's Night Light with Motion and
Ambient Light Control Using a PIC
Microcontroller**

by

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Contents

Table of Figures.....	2
1. Introduction	3
2. Background to the Proposed Research.....	4
3. Research Problem statement	6
4. Research Aim & Objectives	7
5. Methodology.....	8
5.1 Methods.....	8
5.2 Materials	8
6. Project Plan	9
7. References	10

Table of Figures

Figure 6-1 Gantt Chart	9
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1. Introduction

Modern electronic engineering emphasises the creation of adaptive, sustainable, and efficient systems. Lighting systems are now being transformed by automation and embedded intelligence. Traditional home lighting relies on manual operation or static illumination levels, whereas modern smart systems use environmental feedback to optimise performance and energy use. This project aligns with the continuing drive toward sustainable innovation, integrating control theory, embedded design, and user-centred development. In domestic settings, lighting plays a vital role in comfort and safety, especially for children who may wake during the night and feel disoriented in complete darkness. Conventional night lights often remain on continuously, consuming unnecessary energy and emitting constant light that can disrupt sleep cycles. Addressing this issue requires an intelligent system capable of adapting to ambient conditions and human activity in real time 

The proposed Smart Children's Night Light with Motion and Ambient Light Control Using a PIC Microcontroller will sense both movement and environmental brightness, adjusting its output automatically. The system will illuminate softly when a child moves in a dark room and gradually reduce brightness once the room becomes still or well-lit. This design demonstrates applied knowledge of microcontroller programming, sensor interfacing, and control logic. It will operate at low voltage to ensure safety and rely on minimal power to maintain sustainability. The project embodies the principles of smart engineering by combining low-cost components with efficient functionality and aims to provide a reproducible design that could be implemented in wider domestic or educational contexts. 

From an educational perspective, the project builds professional engineering competencies such as research, design, testing, and evaluation . It will require detailed problem-solving, analysis, and documentation—key skills for any embedded systems engineer. The prototype serves as both a functional artefact and a learning platform to explore how low-power electronics and programming logic can be integrated to address real-world challenges.

2. Background to the Proposed Research

This section provides a comprehensive explanation of the field in which the project is situated, outlining key developments, emerging trends, and relevant technologies in the domain of intelligent lighting control. It summarises significant contributions from previous research and identifies the knowledge gap that informs the present project. As an initial literature review, it critically evaluates existing studies to establish the context, relevance, and need for further investigation into affordable, sensor-based smart lighting systems.

Smart lighting systems form a crucial component of modern home automation and energy management technologies. They integrate embedded control, sensing, and communication to provide adaptive illumination based on environmental and user factors. In traditional domestic lighting, illumination levels remain fixed and rely on manual operation, leading to energy waste and inconsistent lighting comfort. In contrast, smart lighting systems combine microcontrollers with sensors such as light-dependent resistors (LDRs) and passive infrared (PIR) motion detectors to deliver dynamic, automated lighting control. As a result, these systems contribute not only to convenience and safety but also to sustainability objectives **by optimising power consumption and reducing carbon emissions** [1].



Ali et al. [1] established the foundation for intelligent lighting through their work on microcontroller-based lighting systems with ambient sensors, demonstrating that such designs can reduce electricity consumption by up to 40%. Their study provided a functional model for adaptive brightness control, in which real-time environmental data inform illumination levels. Similarly, Lee and Chen [2] developed energy-efficient LED-based systems capable of adjusting brightness in response to environmental lighting conditions. Their research confirmed that feedback-controlled illumination enhances visual comfort while reducing electricity costs, representing a fundamental shift from static to responsive lighting solutions. These developments align with the wider trend of integrating embedded intelligence into household technologies to achieve more sustainable living.

Further research expanded the role of motion sensing in lighting control. Patel et al. [3] demonstrated that motion-activated domestic lighting using PIR sensors significantly reduces unnecessary power consumption by ensuring illumination is only active during occupancy. PIR technology detects variations in infrared radiation emitted by humans, allowing lights to respond efficiently to movement. Rahman et al. [4] advanced this concept by combining PIR and LDR sensors in a hybrid control model that considered both motion and ambient brightness. This combination allowed systems to operate more precisely activating only under low-light conditions when motion is detected. However, many such designs rely heavily on Internet of Things (IoT) integration and cloud-based monitoring, introducing higher cost, energy use, and maintenance complexity. These dependencies make them unsuitable for compact, low-cost, stand-alone systems such as those envisioned in this project.

The choice of microcontroller has been central to advances in smart lighting design. Santos et al. [5] compared PIC and Arduino platforms, concluding that PIC devices are superior for low-power embedded systems due to their smaller current draw and faster start-up times. The PIC16F877A, selected for this project, includes integrated Pulse Width Modulation (PWM) and Analog-to-Digital Conversion (ADC) modules, enabling efficient real-time control of LEDs and sensors without external components. Smith [6] highlights that such integrated features reduce circuit complexity and improve response accuracy, making the PIC family ideal for energy-efficient embedded applications. The use of internal PWM allows fine-tuned LED dimming that minimises flicker and supports gradual transitions, essential for maintaining user comfort in nighttime environments.

Lighting quality, particularly for children, extends beyond technical efficiency to psychological and physiological wellbeing. Morales and Yoon [7] examined the influence of lighting transitions on sleep quality, concluding that gradual adjustments are less disruptive than abrupt on/off changes. Their research supports the adoption of PWM-based dimming to produce soft, continuous transitions in brightness. Similarly, Li et al. [8] introduced adaptive brightness algorithms that respond dynamically to diurnal rhythm and ambient illumination, promoting visual comfort and reducing fatigue. Zhang and Wang [9] focused specifically on adaptive lighting for children's bedrooms and observed measurable improvements in comfort and restfulness. However, their proposed system required advanced networked controllers and cloud-based feedback mechanisms, limiting affordability and accessibility. This gap in the literature underscores the need for self-contained, cost-effective smart lighting solutions that achieve comparable functionality without reliance on expensive infrastructure.

Recent advancements in LED technology have further accelerated the adoption of smart lighting. LEDs are inherently more energy-efficient, long-lasting, and thermally stable compared with traditional fluorescent or incandescent bulbs. These characteristics make them ideal for embedded control, as they can be driven directly by low-voltage circuits. Moreover, their compatibility with PWM control enables smooth brightness regulation with minimal energy loss [2], [10]. The move toward low-voltage, solid-state lighting complements global efforts to reduce energy demand and environmental impact, positioning LED-based systems as a cornerstone of sustainable domestic technology.

Safety and reliability remain essential considerations in electrical product design. The British Standards Institution's BS EN 60598 standard [10] outlines the necessary requirements for luminaire safety, including low-voltage operation, protective insulation, and mechanical stability. Adherence to such standards ensures that smart lighting systems remain both safe and efficient when deployed in domestic settings, especially those intended for use around children. By following these safety principles, the current project aims to develop a low-risk and user-friendly system that aligns with best practices in engineering ethics and product sustainability.

In summary, the literature illustrates steady progress in integrating sensors and microcontrollers for efficient lighting control. Major contributions have improved automation, comfort, and energy efficiency. However, existing systems often depend on costly IoT connectivity or complex infrastructure that restricts scalability in domestic contexts. The identified research gap lies in developing a self-contained, affordable, and energy-efficient lighting system capable of adaptive operation without external networks. Addressing this gap forms the rationale for the project. Smart Children's Night Light, which combines PIR and LDR sensors with a PIC microcontroller to achieve intelligent control while maintaining simplicity, safety, and sustainability.

3. Research Problem statement

Despite advances in home automation, there is still a shortage of affordable night-light systems for children that incorporate both motion detection and ambient light control. Most commercially available products either provide constant illumination or rely on complex networked technologies. This project seeks to design and evaluate a stand-alone, PIC-based solution that provides adaptive brightness and low energy consumption in a safe and sustainable way.

4. Research Aim & Objectives

Aim:

To design, construct, and evaluate a PIC-based smart night light that automatically adjusts illumination according to movement and ambient light, improving child comfort, safety, and energy efficiency.

Objectives:

1. Review and analyse existing smart lighting systems and identify performance limitations.
2. Design a prototype integrating a PIR motion sensor, LDR sensor, and PIC microcontroller for adaptive control.
3. Develop embedded firmware implementing PWM dimming and automatic timing functions.
4. Experimentally test and evaluate system performance in terms of response speed, power consumption, and illumination uniformity.



5. Methodology

5.1 Methods

The project employs an experimental design methodology supported by simulation, hardware prototyping, and quantitative testing. Circuit design will be conducted in Proteus Design Suite to simulate sensor inputs, control logic, and output behaviour. Firmware will be written in C using proteus and the CCS compiler, which provides control at register level for precise timing and resource management.

Testing will take place in the classroom/workplace, starting with simulation verification and progressing to prototype assembly. Data will be collected of brightness variation, and response delay. These results will be analysed statistically to assess reliability and performance consistency. Accuracy will be measured by the response of the system to varying light levels and motion proximity. Quantitative evaluation will involve repeated trials under controlled conditions to validate the system's reproducibility and ensure accurate results.

The design process incorporates risk management and ethical awareness. Risks such as component failure, wiring faults, or coding errors will be managed through modular design, staged testing, and version control. A simple risk log will track issues, with mitigation such as simulation before hardware build, use of low-voltage circuits, and backup components. Time delays will be reduced by following the project plan with built-in contingencies. The project remains low risk under university guidelines, with all testing conducted safely and ethically. However, the ethical form will be submitted for transparency. Sustainability will be promoted through efficient power use and recyclable materials, aligning with BS EN 60598 [10].

5.2 Materials

Hardware Components

- PIC16F877A microcontroller
- PIR motion sensor
- LDR sensor (for ambient light detection)
- LED and driver transistors
- 5V regulated DC power supply
- Breadboard, jumper wires, resistors, capacitors, and PCB materials

Software Tools:

- CCS Compiler
- Proteus Design Suite
- Microsoft Excel
- Microsoft Word and Visio

The chosen hardware provides an optimal balance of cost, reliability, and availability. All components are easily sourced and compatible with low-voltage operation, ensuring compliance with household safety standards. The software tools were selected for their compatibility with PIC programming workflows and their ability to produce reproducible, testable outcomes.

6. Project Plan

The project will run over twelve weeks, with around three hours dedicated weekly to research, design, testing, and evaluation. Regular supervisory meetings will support progress tracking, while milestone targets will structure workload distribution. This approach aligns with standard project management principles, allowing for risk monitoring and iterative improvement. Figure 6-1 below summarises planned tasks and deliverables.

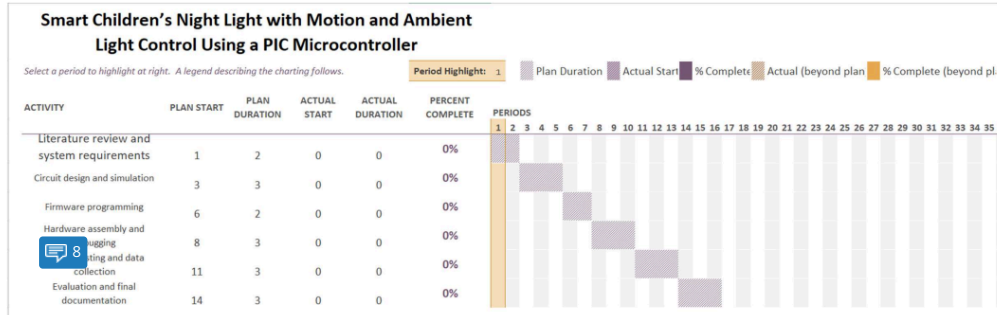


Figure 6-1 Gantt Chart

7. References

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- [7] A. Morales and H. Yoon, "The effect of gradual light transitions on sleep quality in children," *Light. Res. Technol.*, vol. 52, no. 2, pp. 189–201, 2020.
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- [9] Q. Zhang and X. Wang, "Adaptive lighting and its effects on child sleep behaviour," *Light. Res. Technol.*, vol. 53, no. 5, pp. 545–558, 2021.
- [10] British Standards Institution, *BS EN 60598: Luminaires – Safety Requirements*, London, U.K.: BSI, 2023.

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GRADEMARK REPORT

FINAL GRADE

72/100

GENERAL COMMENTS

Project Proposal – ACCA6020 Independent Project

Student: Matthew Batkin

Intro / Aims & Objectives: 15/20

The aim and objectives are clear, well organised, and steps of the project. The problem statement also provides justification by highlighting gaps in existing night-light. Both sections could be strengthened by adding more details (e.g., expected response speed or power saving) giving one or two concrete examples of current product limitations to further reinforce the motivation.

Clear aim and problem statement, but adding measures and specific examples would strengthen it.

Background to the Project / Literature Review :18/20

The literature review is thorough, well-structured, and demonstrates a strong understanding of smart-lighting technologies. It could be strengthened further by summarising the key limitations of existing systems. Eg: cost ranges, delays, or dependence on cloud connectivity.

Well Structured!

Project Design :20/30

The Project design is clear and well organised, covering simulation, prototyping, testing, few risk management and ethical considerations.

However, the methodology would benefit from more detail on how data will be collected and measured. Adding system diagrams, test conditions, and performance criteria would make the section more interesting.

Clear and appropriate, but needs more detail.

Resources / Planning : 9/15

The Gantt chart provides a basic project outline, but it needs more detail. It should include hardware procurement, integration milestones, parallel tasks, contingency or a clear validation phase, and preparation for testing and presentation in order to fully represent a project run to completion.

Clear, appropriate, but needs more details.

Document Presentation : 10/15

Clear ideas are presented, but the structure can be improved. After the introduction, the report should cover the problem statement, aim, objectives, and then the study in the correct sequence. Applying justified alignment improve the overall appearance by making the text look balanced

Neat presentation: improved topic organization recorded

TOTAL : 72/100

PAGE 1

PAGE 2

PAGE 3



Comment 1

Need for this project is well explained.



Comment 2

Using justified alignment to distribute the text more evenly would enhance the presentation.



Comment 3

Needs more explanation on how it is linked with education and research?

Example : how the prototype will be used in a learning context?

PAGE 4



Comment 4

well said!

PAGE 5



Comment 5

Adding a clearer summary of issues such as cost, slow response, and cloud-dependence would make the review even stronger.

PAGE 6

PAGE 7



Comment 6

A few measurable details (like expected speed or power savings) could be added.



Comment 7

More details on how data will be collected and measured is required.



Comment 8

It would be beneficial to develop a broader and clearer Gantt chart that includes specific milestones, hardware procurement and assembly stages, integration and testing phases, a validation phase, parallel tasks where appropriate, risk-allowance or buffer time, contingency time, and preparation for user testing and the final presentation.