ELEG 4325 Embedded Systems Design

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Final Project:

Smart Temperature Monitor System

Introduction

Real-Life Problem to Be Solved

Temperature monitoring is a crucial requirement in diverse fields such as food preservation, medical storage, industrial operations, and even personal environments like homes and offices. Failure to maintain optimal temperature levels can result in severe consequences, such as spoiled food, equipment failure, or reduced safety.

For instance, in cold storage applications, temperature deviations may lead to the spoilage of perishable goods. Similarly, in server rooms, improper temperature control can lead to equipment overheating and downtime. Addressing such issues requires a reliable and responsive temperature monitoring system.

Need Identification

A system is needed that can:

1. Continuously monitor the ambient temperature in real-time.
2. Display the temperature readings for user awareness.
3. Operate efficiently with minimal power consumption and maximum accuracy.

Problem Statement

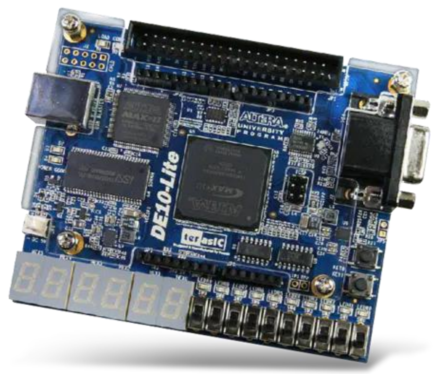
Design and implement a smart embedded system that can monitor the ambient temperature using a digital temperature sensor and display real-time readings. The system should provide a compact, cost-effective, and reliable solution for various temperature-sensitive applications.

Proposed Solution

Using the DE10-Lite FPGA development board as the core, this project leverages an ARM-based Nios II processor to process digital temperature readings from a DHT11 sensor. The system will showcase the readings on a terminal interface and ensure scalability for extended applications.

Overview

Background of ARM Microcontroller



ARM microcontrollers are industry-standard in embedded systems, known for their energy efficiency, high performance, and adaptability. The ARM-based Nios II processor emulates these qualities, making it ideal for FPGA-based solutions.

Key Features of ARM-based Nios II Processor

- **Customizability**: Users can tailor the processor configuration to their application requirements.
- **Peripheral Integration**: Supports various modules like GPIO and UART for interfacing.
- **Low Power Consumption**: Ensures efficient operations, especially in portable systems.

Role of the DE10-Lite Board in the Project

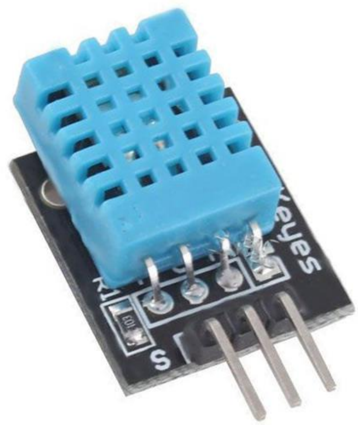
The DE10-Lite development board features an Altera MAX 10 FPGA, supporting the implementation of Nios II soft processors. Its programmable logic and GPIOs make it suitable for interfacing with the DHT11 sensor and handling data processing and display tasks.

System Design and Implementation

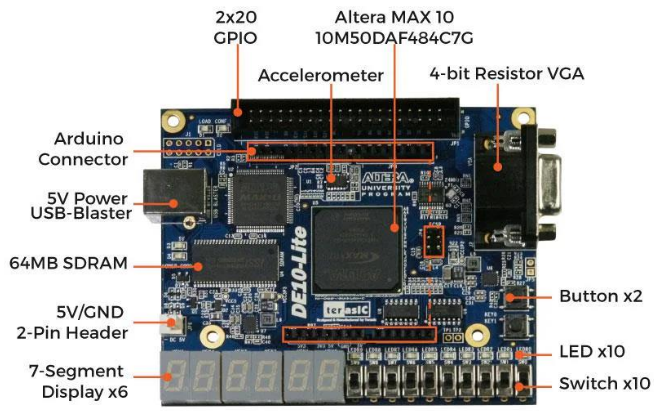
Design Overview

The system integrates three main components:

1. A temperature sensor (DHT11) for capturing ambient temperature.



2. The DE10-Lite FPGA board, which processes the sensor’s output via the Nios II processor.

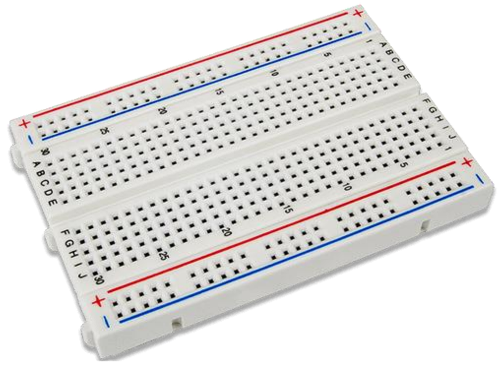


3. An output display interface to show real-time temperature readings.

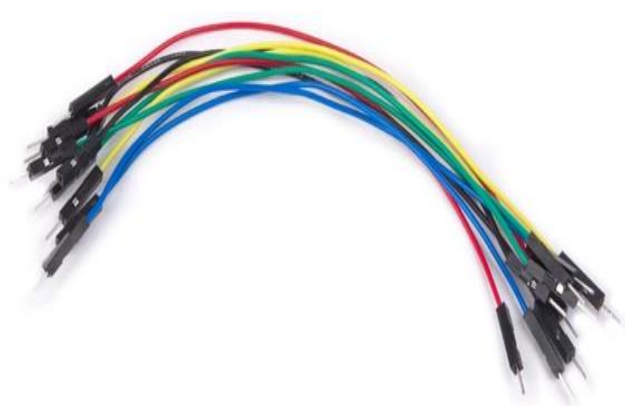
Components

Hardware

- **DE10-Lite FPGA Board**: Core system for implementing the processor and interfaces.
- **DHT11 Temperature Sensor**: Provides digital data representing temperature and humidity.
- **Breadboard and Jumpers**: For sensor connections and prototyping.

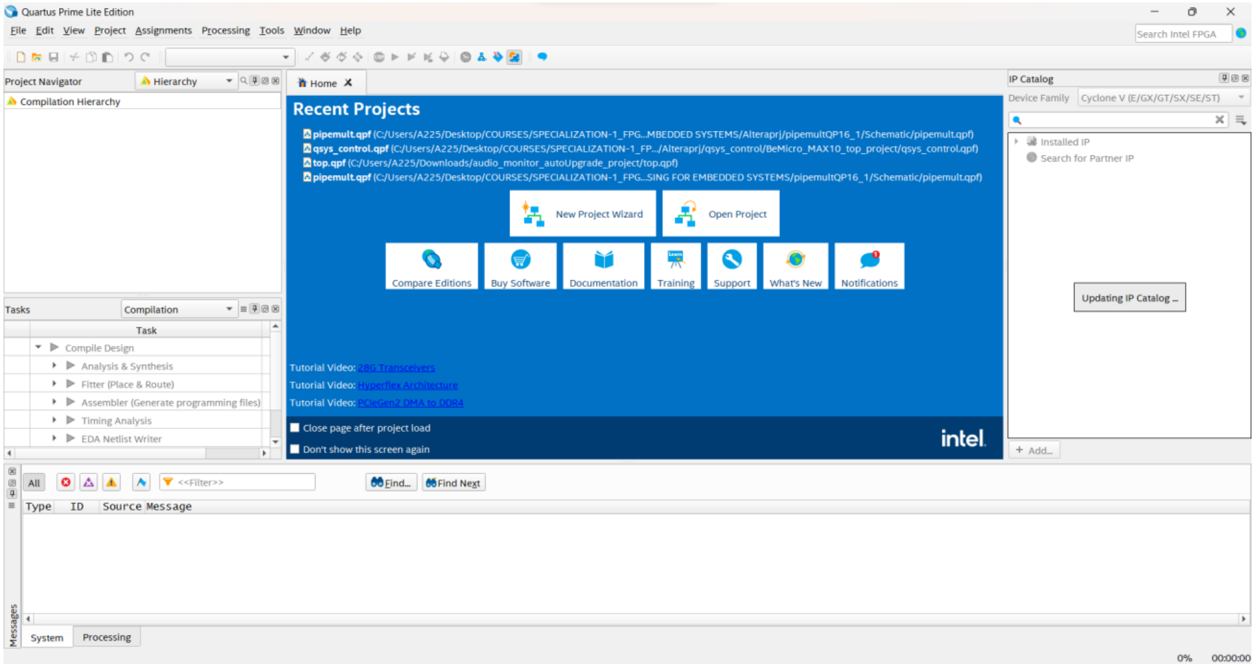


- **Power Supply**: Powers the FPGA board and sensor.



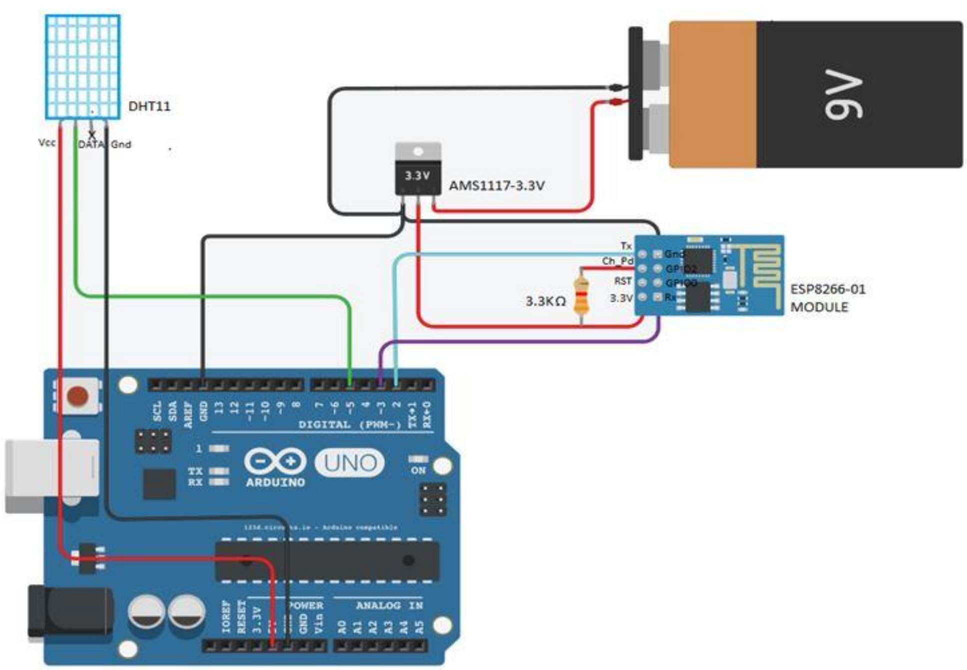
Software

- **Quartus Prime Software**: Used for FPGA configuration, processor design, and component integration.



- **Nios II IDE (Eclipse)**: For writing and uploading the processor's C program to handle sensor data.

Implementation Steps



1. **Hardware Setup**:

    a. Connect the DHT11 sensor to the DE10-Lite board.
    b. Use the sensor's Data pin and connect it to a GPIO pin of the FPGA with a pull-up resistor.
2. **FPGA Configuration**:
    a. Design the system architecture using Quartus Prime Platform Designer.
    b. Add a Nios II processor, a GPIO block for sensor data, and a UART module for terminal display.
3. **Software Development**:
    a. Write a program in the Nios II IDE to:
        i. Read temperature data from the DHT11 sensor.
        ii. Process the data to convert raw readings into Celsius values.
        iii. Display the temperature on a terminal.
4. **System Testing**:
    a. Verify the system with controlled temperature inputs.
    b. Use a reference thermometer to validate the accuracy of readings.

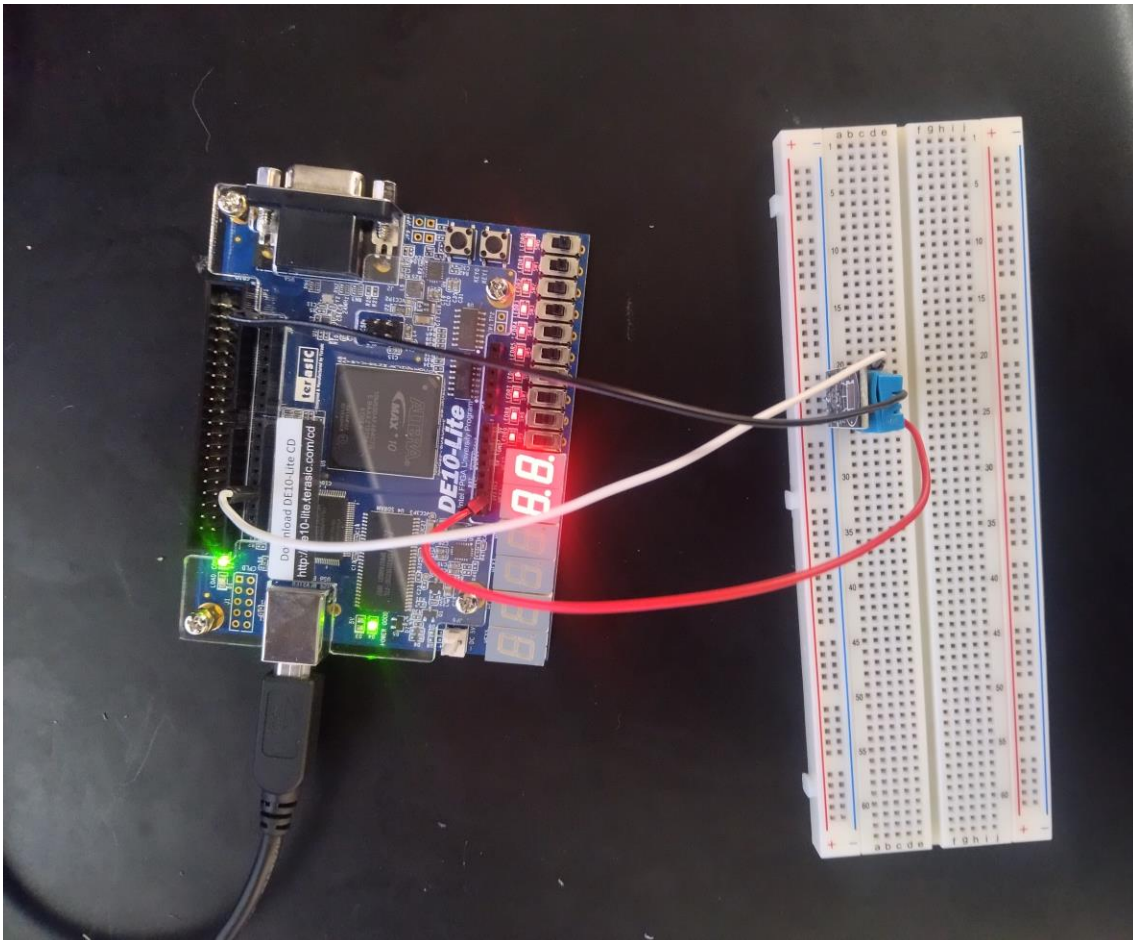
Results and Analysis

Expected Results

- Accurate real-time temperature readings displayed on a terminal interface.
- The system should demonstrate responsiveness to changes in ambient temperature.

Analysis

- Compare temperature readings with a standard thermometer to assess accuracy.
- Measure response time for data acquisition and display.
- Evaluate system stability during continuous operation.



Results indicating the temperature of the room at 88 degrees Fahrenheit for the

Discussion

Applications

- **Home Automation**: Monitoring room temperature for smart HVAC systems.
- **Industrial Use**: Ensuring proper temperature levels in machinery environments.
- **Medical Applications**: Maintaining safe storage conditions for temperature-sensitive drugs.

Impact on Industry

This project highlights the adaptability of ARM-based embedded systems for real-world applications. Such systems are vital for IoT devices and automation, particularly in temperature-critical scenarios.

Conclusion

This project successfully implements a smart temperature monitoring system using the DE10-Lite FPGA and DHT11 sensor. It demonstrates how embedded systems can address critical needs efficiently and reliably, showcasing the potential for further scalability in industrial and consumer applications

References

1. Intel FPGA University Program DE10-Lite User Manual.
2. DHT11 Temperature and Humidity Sensor Datasheet.
3. ARM Cortex-M Technical Reference Manual.
4. Quartus Prime Software Documentation.