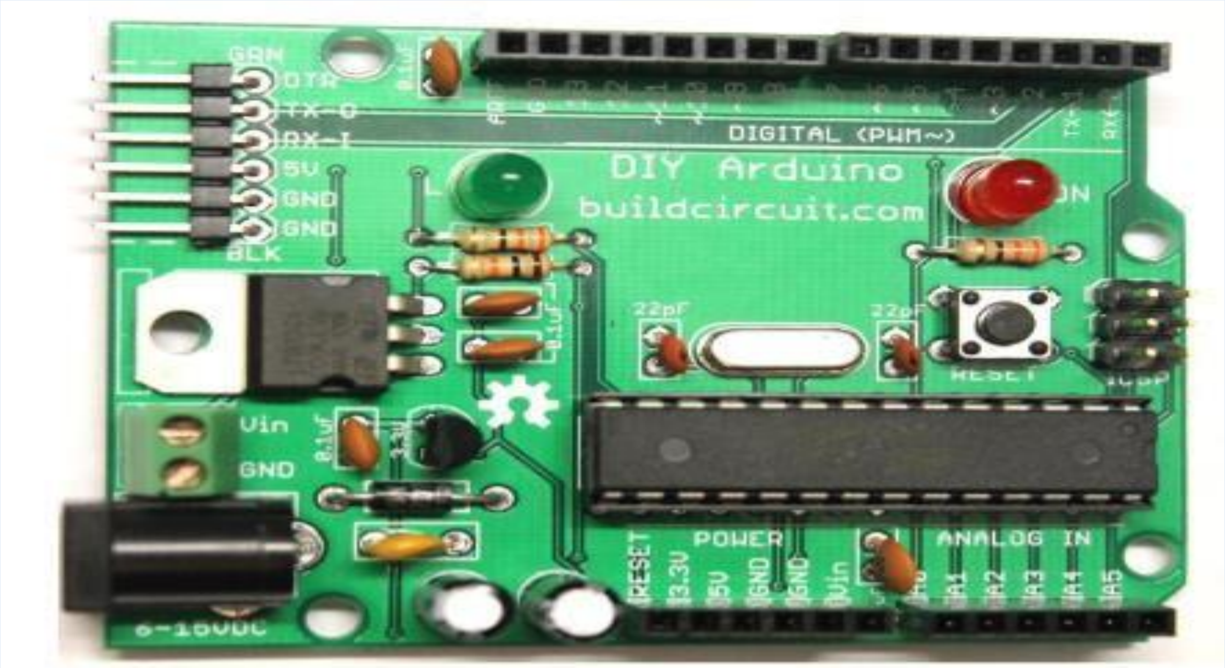
MICROCONTROLLER AND EMBEDDED SYSTEM



Project Report: Single-Layer Board Design with ATmega328P

Fahad Mahmood (221678)

TEAM INFORMATION:

TEAM NAMES

1. **Fahad Mehsood- 221678**
2. **Hammad Mustafa 221711**

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1. Introduction:

This project involves the design and implementation of a single-layer board using the ATmega328P microcontroller. The board includes a push button for input, an LED for output (connected to pin 13), a 5V relay, and a voltage sensor using resistors R1 and R2.

2. Schematic Design:

2.1 ATmega328P Microcontroller:

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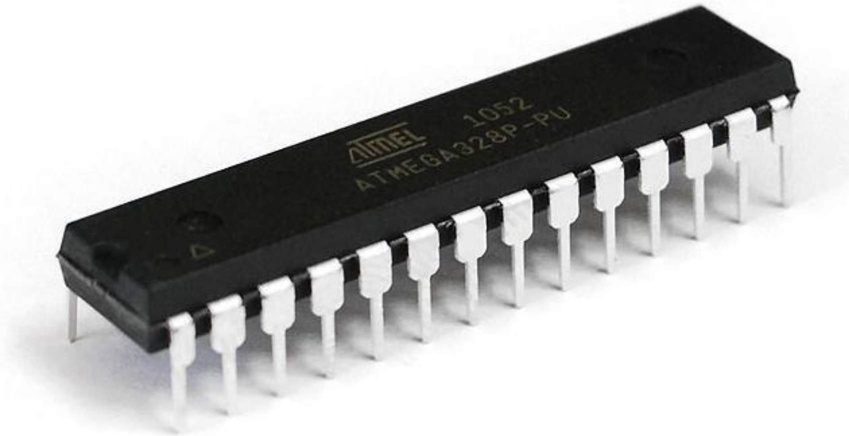

The ATmega328P is centrally placed on the schematic for efficient connectivity. Key connections include:

- **Power Supply**:
  - VCC (Pin 7) connects to +5V.
  - GND (Pin 8) connects to ground.
- **Programming and Communication:**
  - RX (Pin 2) and TX (Pin 3) for serial communication.
  - RESET (Pin 1) with an external pull-up resistor.
- **Analog Input:**
  - AVCC (Pin 20) connects to the +5V.
  - AREF (Pin 21) optional for external voltage reference.
- **Crystal Oscillator:**
  - XTAL1 (Pin 9) and XTAL2 (Pin 10) connect to an external crystal oscillator.
- **Digital I/O:**
  - Digital Pins (e.g., Pin 13) used for digital input/output functions.

This layout ensures a clear and organized design for future modifications and easy understanding.

2.2 Push Button:

The push button is placed for user input near the schematic edge. Key details:

- **Connection to Digital Pin:**
  - Connected to a digital pin (e.g., Pin 2) on the ATmega328P.
- **Pull-Up Resistor:**
  - Includes a 10kΩ pull-up resistor between the digital pin and VCC.
- **Button State Detection:**
  - Pressing the button establishes a connection to ground, causing the digital pin to read a LOW state. Ideal for user-triggered events in the system.

2.3 LED:

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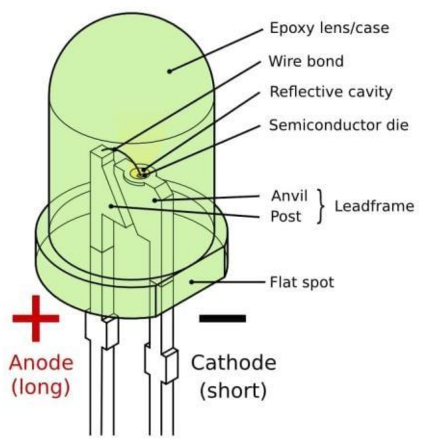


The LED is connected to Pin 13 on the ATmega328P with a current-limiting resistor (e.g., 220Ω):

- **Connection:**
  - Anode of the LED connects to Pin 13.
  - Cathode of the LED connects through a 220Ω current-limiting resistor to GND.

This simple setup allows Pin 13 to control the LED, and the resistor ensures safe current flow to the LED, preventing damage.

2.4 5V Relay:

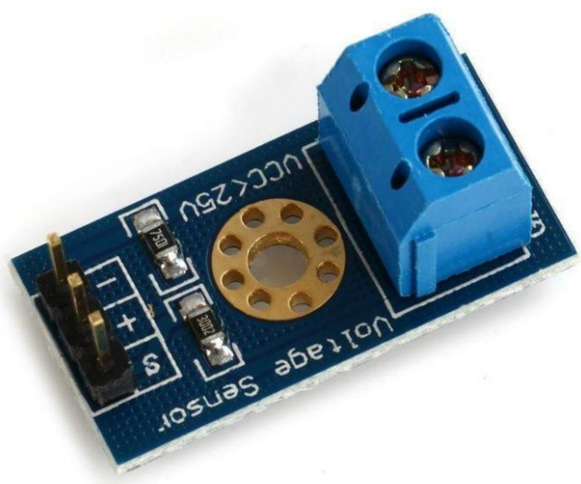
The 5V relay is strategically placed on the schematic for efficient control. Key details:

- **Placement:**

- Positioned for ease of connectivity and control, typically near the microcontroller.

- **Control Pin Connection:**
  - The control pin of the relay is connected to a digital pin, for instance, Pin 3 on the ATmega328P microcontroller.

2.5 Voltage Sensor:



The voltage sensor is designed using resistors R1 and R2. Key details:

- **Design:**
  - Utilizes a voltage divider configuration with resistors R1 and R2.
  - The midpoint of the voltage divider is connected to an analog pin, e.g., A0 on the ATmega328P microcontroller.

This configuration allows the microcontroller to measure the voltage at the midpoint of the divider, providing a proportional representation of the input voltage for further analysis or monitoring.

3. PCB Design:

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3.1 Component Placement:

Components are strategically placed on the PCB for optimal layout and functionality:

- **Microcontroller and User Interface:**
  - ATmega328P positioned centrally for easy access.
  - Push button and LED grouped for user interaction.
- **Peripheral Components:**
  - 5V relay located near the microcontroller for efficient control.
  - Voltage sensor components (R1 and R2) placed close to the analog pin.
- **Spacing and Organization:**
  - Components spaced for clear signal paths and neat organization.
  - Logical grouping ensures ease of identification and modification.

3.2 Routing and Connections:

Tracks are carefully routed to ensure proper connectivity:

- **Signal Paths:**
  - Routes connect each component to their designated pins on the microcontroller.
  - Tracks maintain adequate spacing to avoid interference.
- **Relay Control:**
  - Digital tracks connect the microcontroller's control pin to the relay for reliable switching.
- **Analog Signal Routing:**
  - Analog tracks connect the voltage sensor midpoint to the specified analog pin.

3.3 Power Supply:

The power supply is essential for proper functionality:

- **5V Power Source:**

  - A 5V power source is integrated directly into the PCB design.
  - This source ensures a stable and regulated voltage supply for the microcontroller and connected components.
- **External Power Option:**
  - Provisions for external power supply connections are included for flexibility.

3.4 Ground Plane:

Optimal grounding is achieved through a dedicated ground plane:

- **Bottom Layer Ground Plane:**
  - A ground plane is established on the bottom layer of the PCB.
  - This ensures a solid ground reference, reducing noise and enhancing signal integrity.
- **Strategic Ground Connections:**
  - Components are connected to the ground plane for efficient grounding.
  - Proper spacing and direct connections contribute to a stable ground reference.

These design considerations in component placement, routing, power supply, and ground plane implementation contribute to the overall reliability and performance of the PCB.

4. Testing:

4.1 Proteus Simulation:

In the Proteus simulation, the designed PCB layout was tested virtually for proper functionality:

- **Screenshots:**

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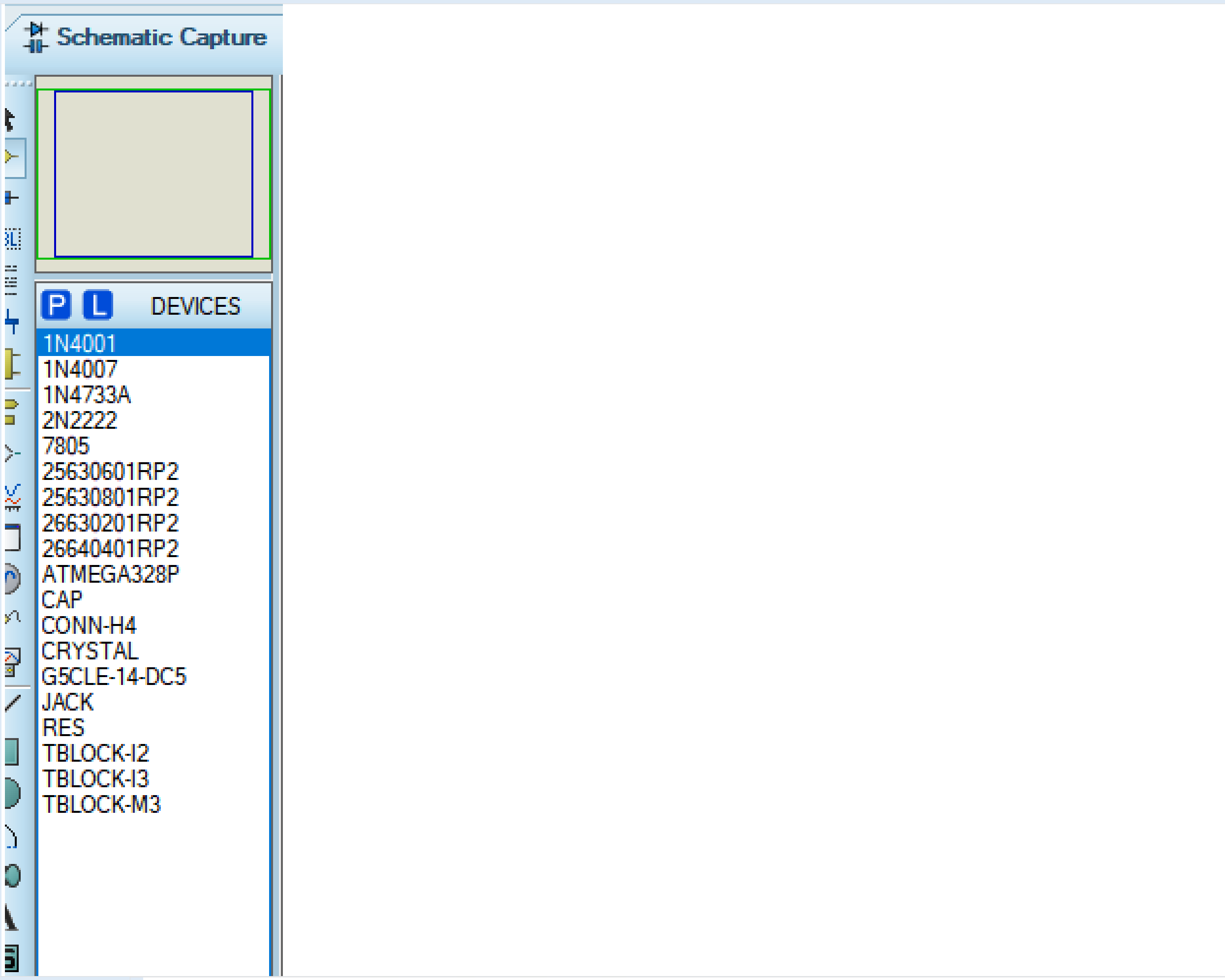

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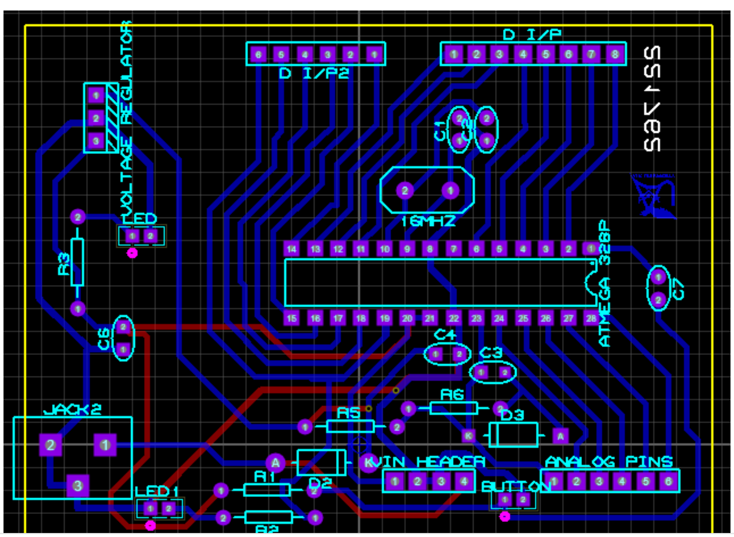

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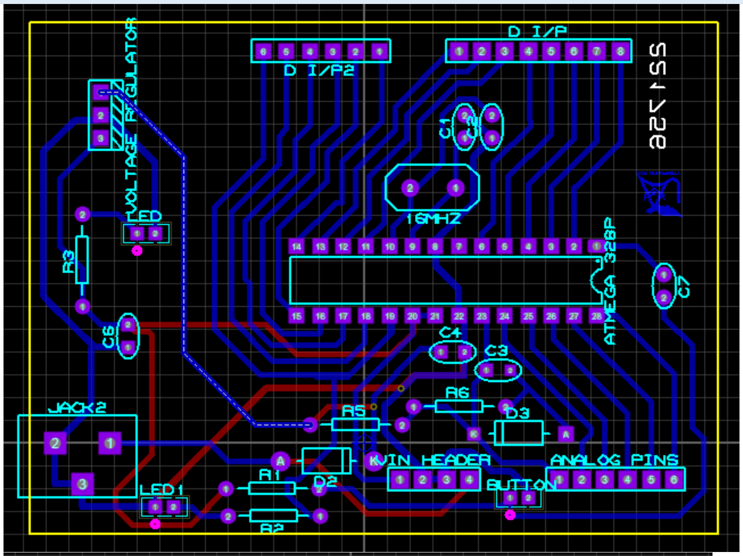
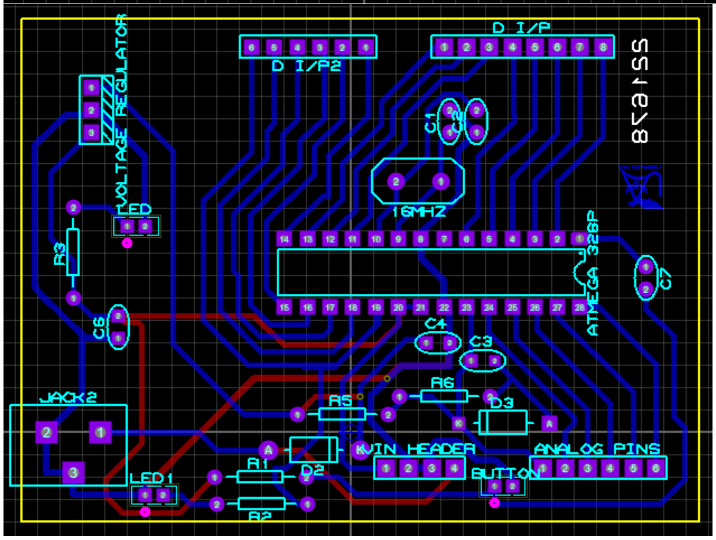
- 

- 

- **Description:**
  - Ensured proper connectivity by simulating the activation of each component individually.
  - Verified that the digital signals, analog readings, and relay control functioned as expected.

4.2 PCB Fabrication:

The PCB fabrication process involved translating the design into physical form:

- **Generation of Gerber Files:**
  - Gerber files were generated from the PCB design software, containing all necessary information for fabrication.
- **Fabrication Process:**
  - The Gerber files were sent to a PCB manufacturing service.
  - The fabricated PCB was checked for accuracy and quality upon receipt.
- **Challenges Faced:**

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- [Describe any challenges faced during the fabrication process and how they were addressed.]

4.3 Assembly and Component Placement:

Assembling the physical PCB involved careful placement of components:

- **Description:**
    - Components were placed according to the layout, ensuring correct orientations.
    - Soldering was performed meticulously to avoid shorts or cold joints.

4.4 Power-Up and Functional Testing:

The assembled PCB was powered up, and functional testing was conducted:

- **Power-Up Process:**
    - Connected the PCB to a 5V power supply and ensured proper voltage levels.
- **Functional Testing:**
    - Verified the functionality of each component: push button, LED, relay, and voltage sensor.
    - Checked for any anomalies or unexpected behavior.

4.5 Heartbeat Test Program:

The Heartbeat test program was implemented to validate the functionality of the LED on pin 13:

C Code:

```
#include <avr/io.h>
#include <util/delay.h>

int main(void) {
    // Configure Pin 13 as output
    DDRB |= (1 << DDB5);

    while (1) {
        // Toggle LED on Pin 13
        PORTB ^= (1 << PORTB5);
        _delay_ms(500);  // Delay for 500 milliseconds
    }

    return 0;


}
```

5. Results and Observations:

5. Results and Observations:

The testing phase yielded the following results and observations:

- **Proteus Simulation:**
  - The Proteus simulation accurately represented the designed PCB, and all components responded as expected.
  - Digital signals, analog readings, and relay control demonstrated proper functionality.
- **PCB Fabrication:**
  - The fabricated PCB matched the design specifications, with accurate placement of components and clear, well-defined tracks.
  - Challenges faced during fabrication were successfully addressed, ensuring a high-quality board.
- **Assembly and Component Placement:**
  - Physical assembly mirrored the virtual design, and components were correctly placed with meticulous soldering.
  - Visual inspection confirmed the absence of shorts or cold joints.
- **Power-Up and Functional Testing:**
  - Powering up the PCB resulted in stable voltage levels, indicating a successful power supply design.
  - Functional testing validated the proper operation of each component, including the push button, LED, relay, and voltage sensor.
  - No unexpected behavior or anomalies were observed during testing.
- **Heartbeat Test Program:**
  - The Heartbeat test program successfully demonstrated the blinking of the LED on Pin 13, confirming the microcontroller's functionality.

Overall: The designed single-layer board met the project requirements, providing a reliable platform for user input, output, and sensor integration. The testing phase validated the integrity of the PCB design, ensuring it functions as intended in both simulation and real-world scenarios.

6. Conclusion:

Achievements:

- Successful integration of push button, LED, 5V relay, and voltage sensor.
- Accurate Proteus simulation ensuring virtual-real alignment.
- Overcoming fabrication challenges for a robust PCB.
- Comprehensive testing validating functionality.

Challenges:

- Overcame hurdles in PCB fabrication processes.

Key Learnings:

- Significance of accurate simulation for issue identification.
- Nuances of PCB fabrication and Gerber file generation.
- Systematic testing for component functionality and power supply integrity.
- Code implementation for basic functionality (Heartbeat test program).

Overall: The project represents a significant milestone, providing valuable insights into hardware design, simulation, and testing methodologies. Overcoming challenges enhanced problem-solving skills, and the project serves as a strong foundation for future endeavors

8. References:

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