Laboratory 8: ADC Voltage Measurement with Potentiometer and UART Communication on TM4C123GH6PM"

Experiment Sheet

Lab Experiment:

Purpose: The purpose of this lab experiment is to learn how to interface the ADC (Analog-to-Digital Converter) with a potentiometer connected to pin PE3 (ADC0 channel 3) on the TM4C123GH6PM microcontroller. The potentiometer's voltage is measured by the ADC, then transmitted over UART to a terminal for display. Additionally, this experiment demonstrates how to control LEDs based on the measured voltage, using the GPIO pins to indicate different voltage ranges visually.

Essential Knowledge:

- **Analog-to-Digital Conversion (ADC):** ADC is used to convert an analog signal (such as the voltage from a potentiometer) into a digital value that the microcontroller can process. The ADC resolution on the TM4C123GH6PM is 12 bits, which provides a digital value range from 0 to 4095. The voltage range is determined by the reference voltage (commonly 3.3V).
- **UART Communication:** UART (Universal Asynchronous Receiver/Transmitter) is a communication protocol that allows serial communication between devices. In this experiment, UART is used to send the ADC-measured voltage value from the microcontroller to a terminal or PC for monitoring. The communication is set up with a baud rate of 9600 and 8 data bits.
- **GPIO (General Purpose Input/Output):** GPIO pins are used for digital input and output tasks. In this experiment, GPIO is used to control LEDs based on the voltage reading from the potentiometer, providing a visual feedback mechanism.
- **Voltage to LED Mapping:** In this experiment, the LEDs are mapped to different voltage ranges:
    - **0V to 1V:** Red LED (PF1)
    - **1V to 2V:** Blue LED (PF2)
    - **Above 3V:** Green LED (PF3)
- **Voltage Calculation:** The ADC converts the input voltage into a 12-bit digital value. The voltage can be calculated using the formula:
  Voltage = (ADC value * Reference Voltage) / Max ADC Value,
  where the maximum ADC value is 4095 (12-bit resolution) and the reference voltage is typically 3.3V.

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1. Introduction: This experiment demonstrates how to interface the ADC and UART peripherals of the TM4C123GH6PM microcontroller. A potentiometer is connected to pin PE3 (ADC0 channel 3), and its voltage is measured using the ADC. The measured value is then transmitted via UART to a terminal, and LEDs are controlled based on the voltage reading. This process illustrates the use of low-level ADC and UART communication for embedded systems.

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2. Hardware Setup:

- **Microcontroller:** TM4C123GH6PM
- **UART Pins:** PA0 (Rx), PA1 (Tx) for UART communication.
- **ADC Channel:** PE3 (ADC0 channel 3) connected to the wiper of a potentiometer.
- **LEDs:** Connected to Port F (PF1-PF3) to indicate voltage ranges.

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3. Experiment Procedure:

Step 1: Set up UART communication

- Enable the UART0 clock and configure the GPIO pins (PA0 and PA1) for UART communication.
- Set up the UART parameters (9600 baud, 8 data bits, 1 stop bit).

Step 2: Configure the ADC

- Enable the ADC clock and configure the ADC for sampling the analog input on PE3.
- Set up the ADC to use a specified trigger (e.g., timer interrupt or polling).

Step 3: Measure Voltage

- Use the ADC to sample the potentiometer's voltage connected to pin PE3 and convert it to a digital value.
- Perform a calculation to convert the digital value to a voltage (e.g., using the formula: V = (ADC value * reference voltage) / max ADC value).

Step 4: Display the Measured Voltage

- Transmit the measured voltage over UART.
- Convert the voltage value to a string and send it as a message (e.g., "Measured Voltage: 3.3 V").

Step 5: Control LEDs Based on Voltage

- Use the voltage range to control the state of the RGB LEDs connected to Port F. The voltage ranges and corresponding LED colors are as follows:
    - **0V to 1V:** Red LED (PF1)
    - **1V to 2V:** Blue LED (PF2)

- **Above 3V:** Green LED (PF3)

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4. Additional Details:

- **LED Color Control:**
  - **Red LED (PF1):** Lights up when the measured voltage is between **0V and 1V**.
  - **Blue LED (PF2):** Lights up when the measured voltage is between **1V and 2V**.
  - **Green LED (PF3):** Lights up when the measured voltage exceeds **3V**.
- **Voltage Calculation:**
  - The ADC converts the measured voltage into a 12-bit digital value, with 0 representing 0V and 4095 representing the reference voltage (e.g., 3.3V).
  - The voltage value is then calculated by multiplying the ADC value by the reference voltage and dividing by the maximum ADC value (4095).
  - Example formula: Voltage = (ADC value * 3.3V) / 4095.
- **UART Communication:**
  - The UART module is used to transmit the measured voltage value as a string to a terminal. This allows the user to view the measured voltage on a PC or other device connected via serial communication.
  - Ensure that the UART baud rate is set to 9600 to match the terminal settings.

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5. Results and Observations:

- The measured voltage from the potentiometer will be displayed in the terminal connected to the UART.
- The LED color will change depending on the voltage level:
  - **Red LED (PF1):** For voltage between **0V and 1V**
  - **Blue LED (PF2):** For voltage between **1V and 2V**
  - **Green LED (PF3):** For voltage **above 3V**
