CPE301 – SPRING 2025

Design Assignment 3

Student Name: Ryan Sewell
Student #: 8000473785
Student Email: sewelr2@unlv.nevada.edu
Primary Github address: https://github.com/sewelr2
Directory: DA-Submissions/DA3
Video Playlist:
https://youtube.com/playlist?list=PLt45mEFhRV6ffOYRcGHhoI5aDeP3Zgqt5&feature=shared

The goal of the assignment is use GPIO and delays using Timers and Interrupts:

1. Generate three delays using three timers T0, T3, and T4.
    a. Implement a delay of 0.125ms using Timer 0 in normal mode. Count OVF occurrence if needed. Do not use interrupts. Turn 'on' PB5 LED (also monitor and verify using logic analyzer) for approx. 1.5 sec and 'off' for 1.5 sec.
    b. Implement a delay of 0.250ms using Timer 3 TIMER3_COMPA_vect interrupt mechanism in CTC mode. Count OVF occurrence if needed in the IRQ subroutine. Turn 'on' PB4 LED (also monitor and verify using logic analyzer) for approx. 2 sec and 'off' for 2 sec.
    c. Implement a delay of 0.100ms using Timer 4 TIMER4_OVF_vect interrupt mechanism in normal mode. Count OVF occurrence if needed in the IRQ subroutine. Turn 'on' PB3 LED (also monitor and verify using logic analyzer) for approx. 1 sec and 'off' for 1 sec.

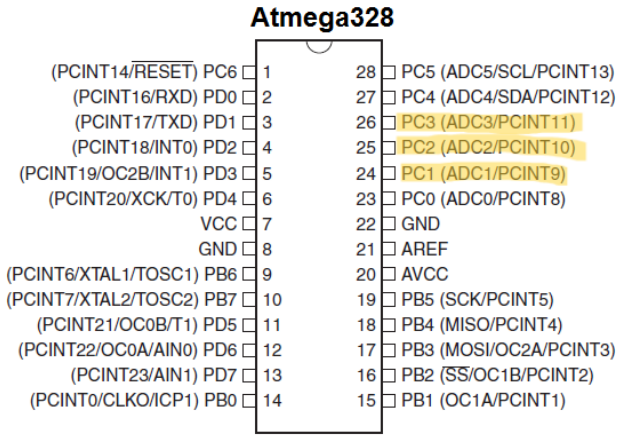
1. COMPONENTS LIST AND CONNECTION BLOCK DIAGRAM w/ PINS

Microchip Studio
- Assembler
- Simulator
- Debugger

Atmega328PB-Xmini PC

Multi-Function Shield
- LEDs

Logic Analyzer



2. INITIAL/MODIFIED/DEVELOPED CODE OF TASK 1/A

```
#define F_CPU 16000000UL
#include <xc.h>
#include <avr/io.h>
#include <util/delay.h>

#define DELAY_125US_COUNT 12000 // 1.5 sec delay

int main(void)
{
	DDRB |= (1 << PINB5); //Set PB5 as LED output


    while(1)
    {
		// Turn on LED
        PORTB |= (1 << PINB5);
		for (uint16_t i = 0; i < DELAY_125US_COUNT; i++)
		{
			TCNT0 = 6; // Load 6 into TCNT0 to count 250 ticks
			TIFR0 |= (1 << TOV0); // Clear timer0 overflow flag
			TCCR0B = (1 << CS01); // Start Timer0 with prescaler = 8
			// Wait for 125 us
			while (!(TIFR0 & (1 << TOV0)));
		}

		PORTB &= ~(1 << PINB5); // Turn off LED
		for (uint16_t i = 0; i < DELAY_125US_COUNT; i++)
		{
			TCNT0 = 6; // Load 6 into TCNT0 to count 250 ticks
			TIFR0 |= (1 << TOV0); // Clear timer0 overflow flag
			TCCR0B = (1 << CS01); // Start Timer0 with prescaler = 8
			// Wait for 125 us
			while (!(TIFR0 & (1 << TOV0)));
		}
    }

	return 0;
}
```

3. INITIAL/MODIFIED/DEVELOPED CODE OF TASK 1/B

```
#include <xc.h>
#define F_CPU 16000000UL
#include <avr/io.h>
#include <avr/interrupt.h>
#include <avr/delay.h>

volatile uint16_t timer3_count = 0;
#define TIMER3_MAX_COUNT 8000 // 2 sec delay
```

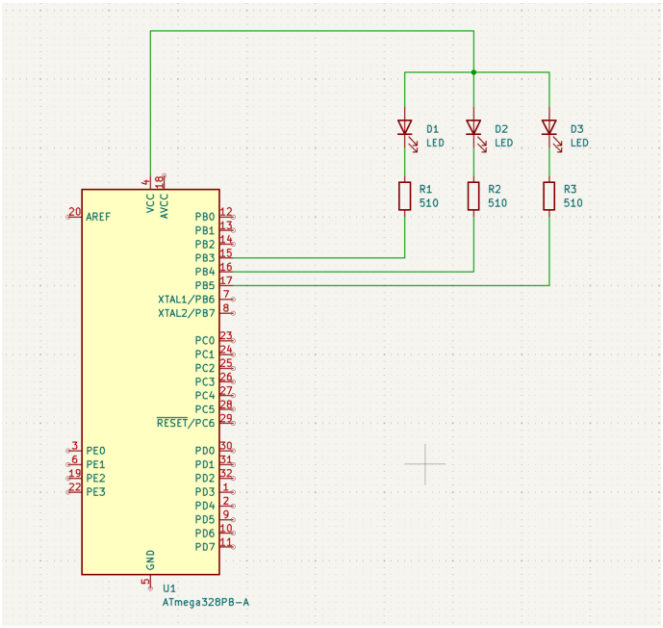
```
ISR(TIMER3_COMPA_vect)
{
        timer3_count++;
        if (timer3_count >= TIMER3_MAX_COUNT)
        {
                PORTB ^= (1 << PINB4); // Toggle LED
                timer3_count = 0;
        }
}

int main(void)
{
        DDRB |= (1 << PINB4); // Set PB4 as LED output

        // Configure Timer3 for CTC mode
        TCCR3A = 0; // Normal operation
        TCCR3B = (1 << WGM32); // CTC mode

        OCR3A = 499; // Prescaler set to 8, 500 ticks needed
        TCCR3B |= (1 << CS31); // Start Timer3, prescaler = 8

        TIMSK3 |= (1 << OCIE3A); // Enable Timer3 compare

        sei(); // Enable global interrupts

    while(1)
    {
        // Interrupt loop controls LED
    }

        return 0;
}
```

4. INITIAL/MODIFIED/DEVELOPED CODE OF TASK 1/C

```
/*
 * main.c
 *
 * Created: 03/28/25 13:52:00
 *  Author: sewel
 */

#include <xc.h>
#define F_CPU 16000000UL
#include <avr/io.h>
#include <avr/interrupt.h>

volatile uint16_t timer4_count = 0;
#define TIMER4_MAX_COUNT 10000  // 1 sec delay (10000 * 100µs)

ISR(TIMER4_OVF_vect)
{
```

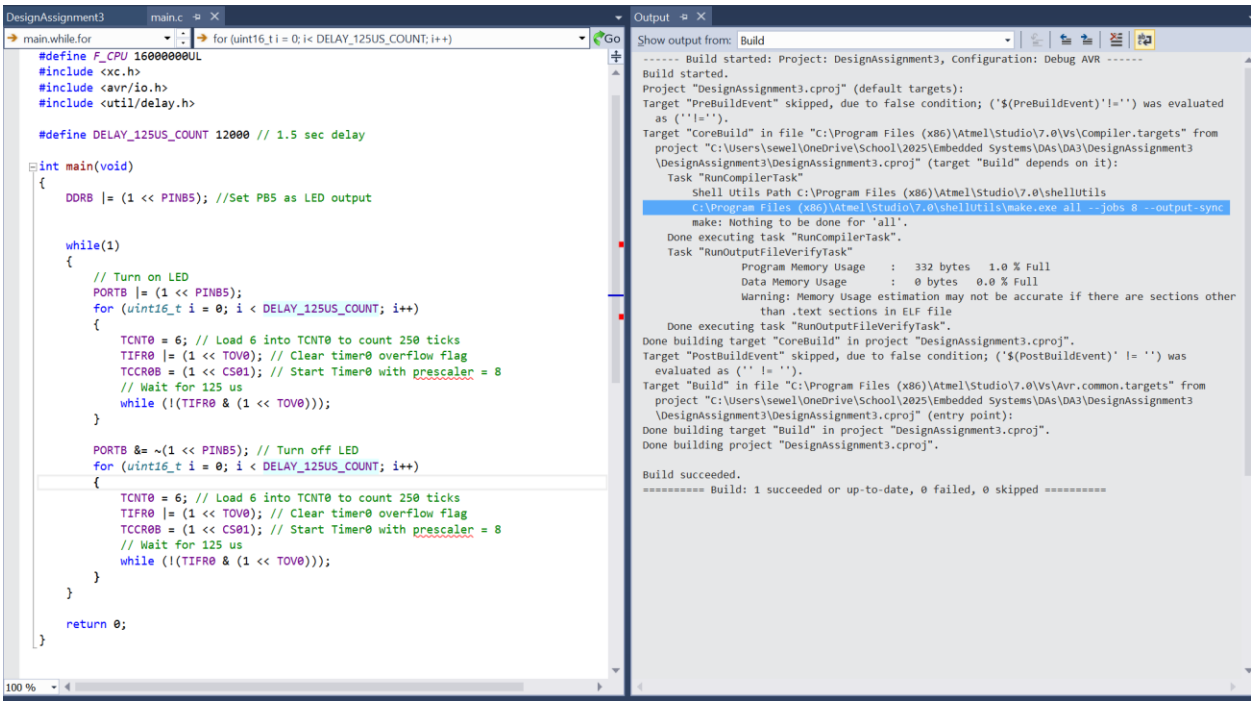
```
        TCNT4 = 65336; // Load TCNT4 with 100 us period

        timer4_count++;
        if (timer4_count >= TIMER4_MAX_COUNT)
        {
                PORTB ^= (1 << PB3); // Toggle LED
                timer4_count = 0;
        }
}

int main(void)
{
        DDRB |= (1 << PINB3); // Set PB3 as LED output

        TCCR4A = 0; // Timer4 normal mode
        TCCR4B = (1 << CS41); // Start Timer4 with prescaler = 8

        TCNT4 = 65336; // Load Timer4 for the first overflow after 100us

        TIMSK4 |= (1 << TOIE4); // Enable Timer4 overflow interrupt

        sei(); // Enable global interrupts

    while(1)
    {

    }

        return 0;
}
```

5. SCHEMATICS



6. SCREENSHOTS OF EACH TASK OUTPUT (ATMEL STUDIO OUTPUT)

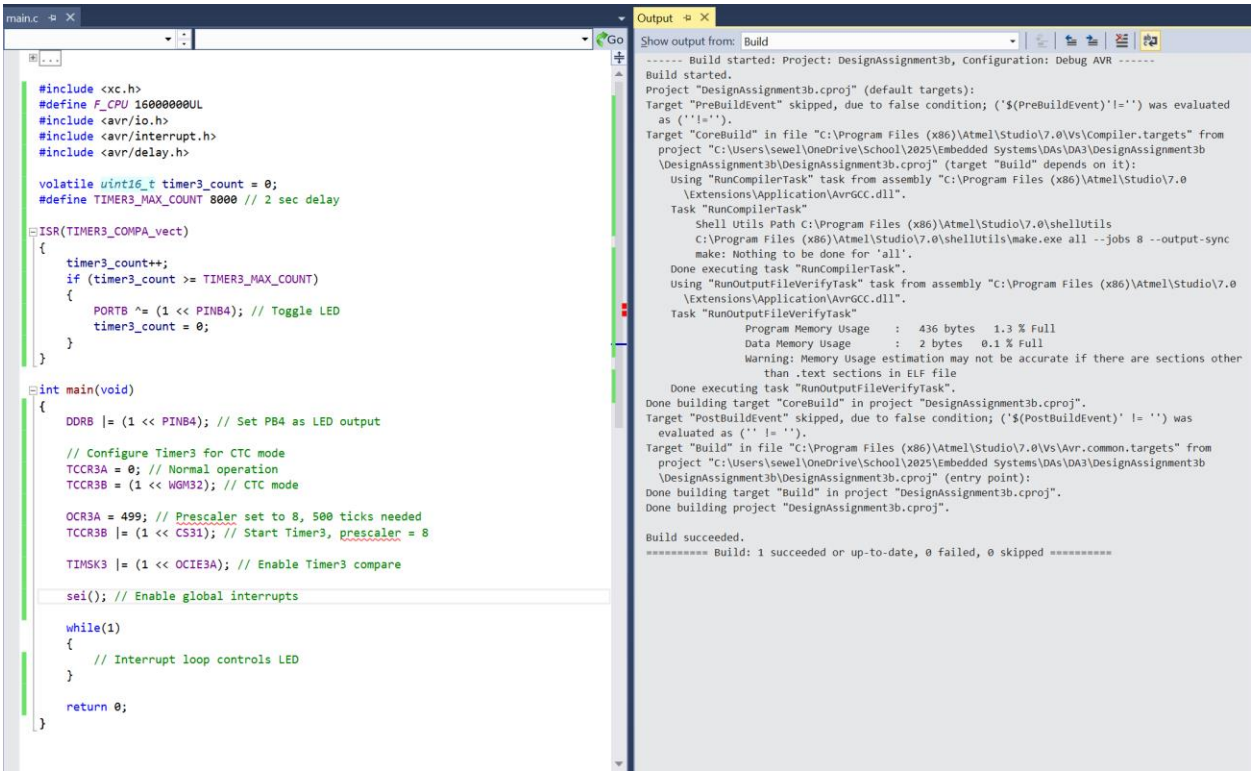
Task 1:



```
#define F_CPU 16000000UL
#include <xc.h>
#include <avr/io.h>
#include <util/delay.h>

#define DELAY_125US_COUNT 12000 // 1.5 sec delay

int main(void)
{
    DDRB |= (1 << PINB5); //Set PB5 as LED output


    while(1)
    {
        // Turn on LED
        PORTB |= (1 << PINB5);
        for (uint16_t i = 0; i < DELAY_125US_COUNT; i++)
        {
            TCNT0 = 6; // Load 6 into TCNT0 to count 250 ticks
            TIFR0 |= (1 << TOV0); // Clear timer0 overflow flag
            TCCR0B = (1 << CS01); // Start Timer0 with prescaler = 8
            // Wait for 125 us
            while (!(TIFR0 & (1 << TOV0)));
        }

        PORTB &= ~(1 << PINB5); // Turn off LED
        for (uint16_t i = 0; i < DELAY_125US_COUNT; i++)
        {
            TCNT0 = 6; // Load 6 into TCNT0 to count 250 ticks
            TIFR0 |= (1 << TOV0); // Clear timer0 overflow flag
            TCCR0B = (1 << CS01); // Start Timer0 with prescaler = 8
            // Wait for 125 us
            while (!(TIFR0 & (1 << TOV0)));
        }
    }

    return 0;
}
```

```
------ Build started: Project: DesignAssignment3, Configuration: Debug AVR ------
Build started.
Project "DesignAssignment3.cproj" (default targets):
Target "PreBuildEvent" skipped, due to false condition; ('$(PreBuildEvent)'!='') was evaluated
  as (''!='').
Target "CoreBuild" in file "C:\Program Files (x86)\Atmel\Studio\7.0\Vs\Compiler.targets" from
  project "C:\Users\sewel\OneDrive\School\2025\Embedded Systems\DAs\DA3\DesignAssignment3
  \DesignAssignment3\DesignAssignment3.cproj" (target "Build" depends on it):
    Task "RunCompilerTask"
        Shell Utils Path C:\Program Files (x86)\Atmel\Studio\7.0\shellUtils
        C:\Program Files (x86)\Atmel\Studio\7.0\shellUtils\make.exe all --jobs 8 --output-sync
        make: Nothing to be done for 'all'.
    Done executing task "RunCompilerTask".
    Task "RunOutputFileVerifyTask"
                Program Memory Usage    :   332 bytes   1.0 % Full
                Data Memory Usage       :   0 bytes   0.0 % Full
                Warning: Memory Usage estimation may not be accurate if there are sections other
                   than .text sections in ELF file
    Done executing task "RunOutputFileVerifyTask".
Done building target "CoreBuild" in project "DesignAssignment3.cproj".
Target "PostBuildEvent" skipped, due to false condition; ('$(PostBuildEvent)' != '') was
  evaluated as ('' != '').
Target "Build" in file "C:\Program Files (x86)\Atmel\Studio\7.0\Vs\Avr.common.targets" from
  project "C:\Users\sewel\OneDrive\School\2025\Embedded Systems\DAs\DA3\DesignAssignment3
  \DesignAssignment3\DesignAssignment3.cproj" (entry point):
Done building target "Build" in project "DesignAssignment3.cproj".
Done building project "DesignAssignment3.cproj".

Build succeeded.
========== Build: 1 succeeded or up-to-date, 0 failed, 0 skipped ==========
```

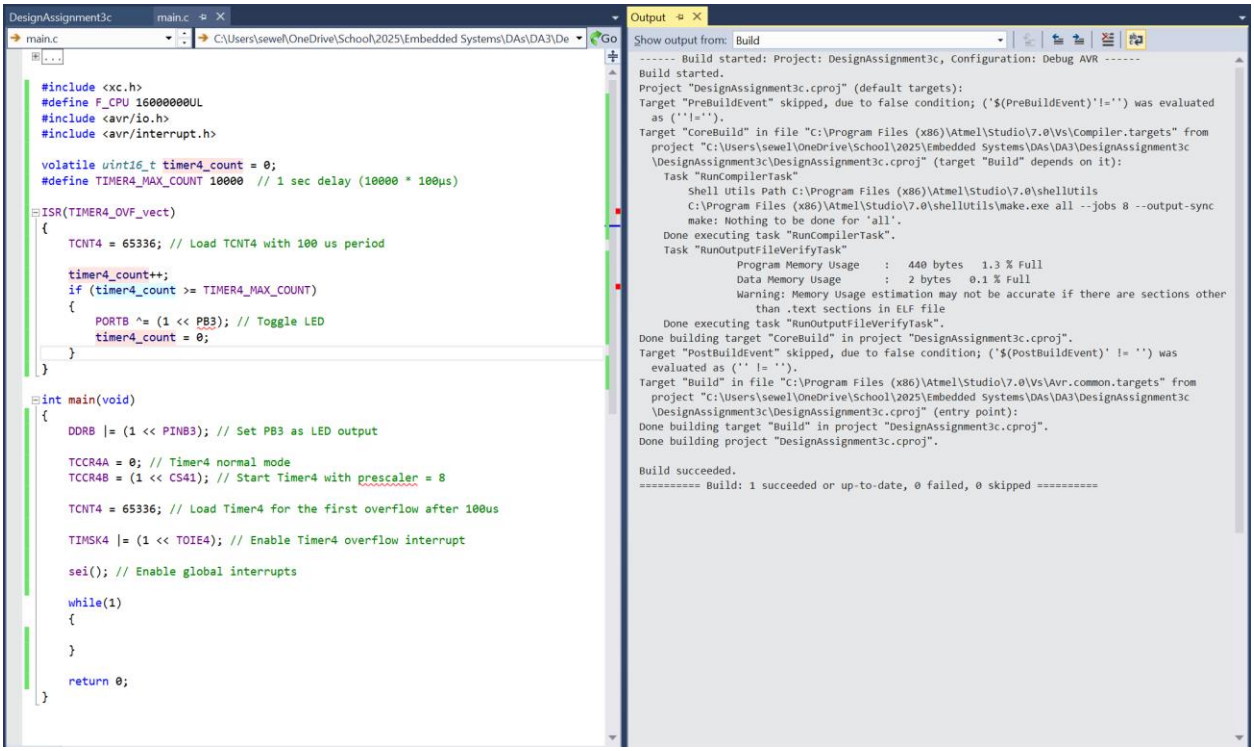
Task 2:



```
#include <xc.h>
#define F_CPU 16000000UL
#include <avr/io.h>
#include <avr/interrupt.h>
#include <avr/delay.h>

volatile uint16_t timer3_count = 0;
#define TIMER3_MAX_COUNT 8000 // 2 sec delay

ISR(TIMER3_COMPA_vect)
{
    timer3_count++;
    if (timer3_count >= TIMER3_MAX_COUNT)
    {
        PORTB ^= (1 << PINB4); // Toggle LED
        timer3_count = 0;
    }
}

int main(void)
{
    DDRB |= (1 << PINB4); // Set PB4 as LED output

    // Configure Timer3 for CTC mode
    TCCR3A = 0; // Normal operation
    TCCR3B = (1 << WGM32); // CTC mode

    OCR3A = 499; // Prescaler set to 8, 500 ticks needed
    TCCR3B |= (1 << CS31); // Start Timer3, prescaler = 8

    TIMSK3 |= (1 << OCIE3A); // Enable Timer3 compare

    sei(); // Enable global interrupts

    while(1)
    {
        // Interrupt loop controls LED
    }

    return 0;
}
```

```
------ Build started: Project: DesignAssignment3b, Configuration: Debug AVR ------
Build started.
Project "DesignAssignment3b.cproj" (default targets):
Target "PreBuildEvent" skipped, due to false condition; ('$(PreBuildEvent)'!='') was evaluated
  as (''!='').
Target "CoreBuild" in file "C:\Program Files (x86)\Atmel\Studio\7.0\Vs\Compiler.targets" from
  project "C:\Users\sewel\OneDrive\School\2025\Embedded Systems\DAs\DA3\DesignAssignment3b
  \DesignAssignment3b\DesignAssignment3b.cproj" (target "Build" depends on it):
    Using "RunCompilerTask" task from assembly "C:\Program Files (x86)\Atmel\Studio\7.0
      \Extensions\Application\AvrGCC.dll".
    Task "RunCompilerTask"
        Shell Utils Path C:\Program Files (x86)\Atmel\Studio\7.0\shellUtils
        C:\Program Files (x86)\Atmel\Studio\7.0\shellUtils\make.exe all --jobs 8 --output-sync
        make: Nothing to be done for 'all'.
    Done executing task "RunCompilerTask".
    Using "RunOutputFileVerifyTask" task from assembly "C:\Program Files (x86)\Atmel\Studio\7.0
      \Extensions\Application\AvrGCC.dll".
    Task "RunOutputFileVerifyTask"
                Program Memory Usage    :   436 bytes   1.3 % Full
                Data Memory Usage       :   2 bytes   0.1 % Full
                Warning: Memory Usage estimation may not be accurate if there are sections other
                   than .text sections in ELF file
    Done executing task "RunOutputFileVerifyTask".
Done building target "CoreBuild" in project "DesignAssignment3b.cproj".
Target "PostBuildEvent" skipped, due to false condition; ('$(PostBuildEvent)' != '') was
  evaluated as ('' != '').
Target "Build" in file "C:\Program Files (x86)\Atmel\Studio\7.0\Vs\Avr.common.targets" from
  project "C:\Users\sewel\OneDrive\School\2025\Embedded Systems\DAs\DA3\DesignAssignment3b
  \DesignAssignment3b\DesignAssignment3b.cproj" (entry point):
Done building target "Build" in project "DesignAssignment3b.cproj".
Done building project "DesignAssignment3b.cproj".

Build succeeded.
========== Build: 1 succeeded or up-to-date, 0 failed, 0 skipped ==========
```

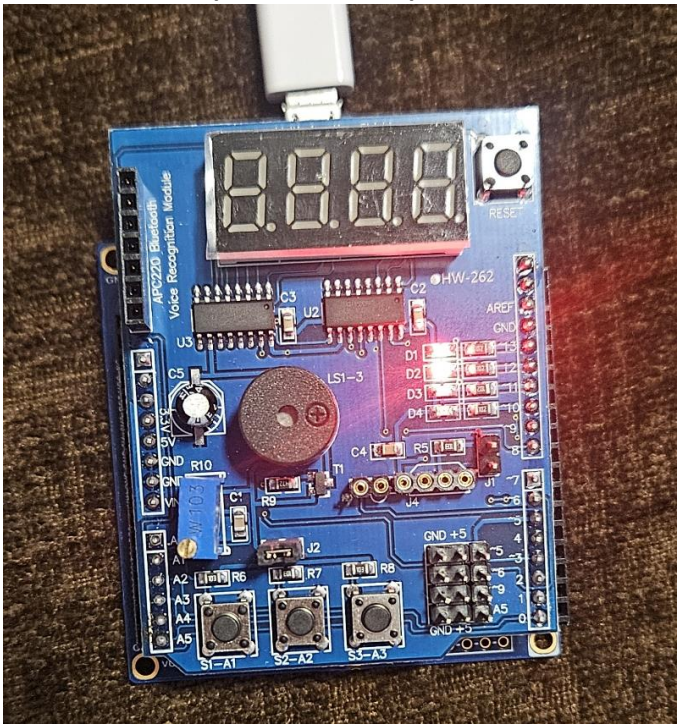
Task 3:



```
DesignAssignment3c
main.c
main.c
C:\Users\sewel\OneDrive\School\2025\Embedded Systems\DAs\DA3\De
Go
...

#include <xc.h>
#define F_CPU 16000000UL
#include <avr/io.h>
#include <avr/interrupt.h>

volatile uint16_t timer4_count = 0;
#define TIMER4_MAX_COUNT 10000  // 1 sec delay (10000 * 100µs)

ISR(TIMER4_OVF_vect)
{
    TCNT4 = 65536; // Load TCNT4 with 100 us period

    timer4_count++;
    if (timer4_count >= TIMER4_MAX_COUNT)
    {
        PORTB ^= (1 << PB3); // Toggle LED
        timer4_count = 0;
    }
}

int main(void)
{
    DDRB |= (1 << PINB3); // Set PB3 as LED output

    TCCR4A = 0; // Timer4 normal mode
    TCCR4B = (1 << CS41); // Start Timer4 with prescaler = 8

    TCNT4 = 65536; // Load Timer4 for the first overflow after 100us

    TIMSK4 |= (1 << TOIE4); // Enable Timer4 overflow interrupt

    sei(); // Enable global interrupts

    while(1)
    {

    }

    return 0;
}
```

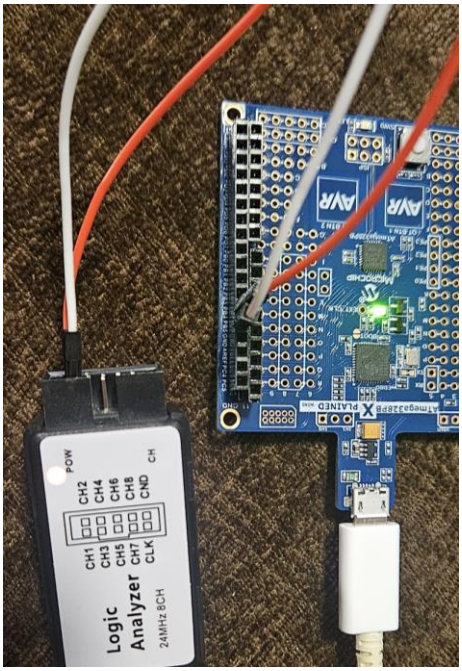
```
Output
Show output from: Build
------ Build started: Project: DesignAssignment3c, Configuration: Debug AVR ------
Build started.
Project "DesignAssignment3c.cproj" (default targets):
Target "PreBuildEvent" skipped, due to false condition; ('$(PreBuildEvent)'!='') was evaluated
  as (''!='').
Target "CoreBuild" in file "C:\Program Files (x86)\Atmel\Studio\7.0\Vs\Compiler.targets" from
  project "C:\Users\sewel\OneDrive\School\2025\Embedded Systems\DAs\DA3\DesignAssignment3c
  \DesignAssignment3c\DesignAssignment3c.cproj" (target "Build" depends on it):
    Task "RunCompilerTask"
        Shell Utils Path C:\Program Files (x86)\Atmel\Studio\7.0\shellUtils
        C:\Program Files (x86)\Atmel\Studio\7.0\shellUtils\make.exe all --jobs 8 --output-sync
        make: Nothing to be done for 'all'.
    Done executing task "RunCompilerTask".
    Task "RunOutputFileVerifyTask"
                Program Memory Usage     :   440 bytes   1.3 % Full
                Data Memory Usage        :   2 bytes   0.1 % Full
                Warning: Memory Usage estimation may not be accurate if there are sections other
                    than .text sections in ELF file
    Done executing task "RunOutputFileVerifyTask".
Done building target "CoreBuild" in project "DesignAssignment3c.cproj".
Target "PostBuildEvent" skipped, due to false condition; ('$(PostBuildEvent)' != '') was
  evaluated as ('' != '').
Target "Build" in file "C:\Program Files (x86)\Atmel\Studio\7.0\Vs\Avr.common.targets" from
  project "C:\Users\sewel\OneDrive\School\2025\Embedded Systems\DAs\DA3\DesignAssignment3c
  \DesignAssignment3c\DesignAssignment3c.cproj" (entry point):
Done building target "Build" in project "DesignAssignment3c.cproj".
Done building project "DesignAssignment3c.cproj".

Build succeeded.
========== Build: 1 succeeded or up-to-date, 0 failed, 0 skipped ==========
```

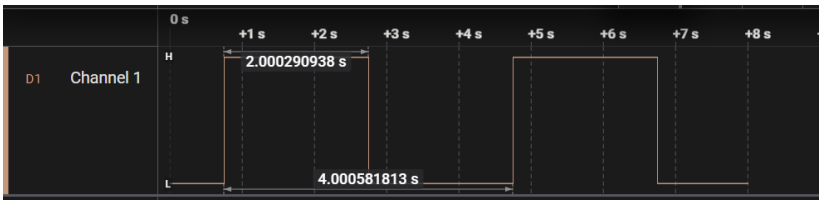
7. SCREENSHOT OF EACH DEMO (BOARD SETUP)



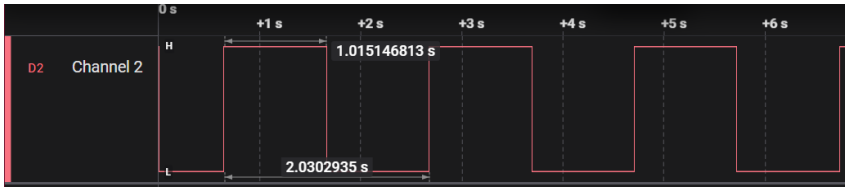
Task 1:

Task 2:





Task 3:



8. VIDEO LINKS OF EACH DEMO

All tasks in one video

Link:

https://youtu.be/TaM0TgI6_yo

9. GITHUB LINK OF THIS DA

Task 1:

Task 2:
…

Student Academic Misconduct Policy
http://studentconduct.unlv.edu/misconduct/policy.html

"*This assignment submission is my own, original work*".
Ryan Sewell