**Department of Computer Engineering**

*CpE 3201 – Embedded Systems*

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| **Laboratory Report** | | | |
| **Laboratory Exercise No.:** | 4.0 | **Date Performed:** | March 13, 2024 |
| **Laboratory Exercise Title:** | Timers (Timer1, Timer2 and CCP Module) | | |
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**Part I.** Data

**Table 1.0 –** *LE4-7 Calculations for PIC16F877A PWM Implementation*

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| --- | --- | --- | --- | --- | --- | --- | --- |
| FREQUENCIES  (Hz) | DUTY CYCLE  (%) | FOSC | PRESCALER | PERIOD  (s) | DUTY CYCLE  (s) | PR2  (HEX) | CCPR1L: CCP1CON<5: 4> (HEX) |
| 300 Hz | 10% | 4Mhz | 16 | 0.003333333 | 0.000333333 | CF | 53 |
| 300 Hz | 25% | 4Mhz | 16 | 0.003333333 | 0.000833333 | CF | D0 |
| 300 Hz | 50% | 4Mhz | 16 | 0.003333333 | 0.001666667 | CF | 1A1 |
| 300 Hz | 75% | 4Mhz | 16 | 0.003333333 | 0.0025 | CF | 271 |
| 300 Hz | 95% | 4Mhz | 16 | 0.003333333 | 0.003166667 | CF | 318 |
| 500 Hz | 10% | 4Mhz | 16 | 0.002 | 0.0002 | 7C | 32 |
| 500 Hz | 25% | 4Mhz | 16 | 0.002 | 0.0005 | 7C | 7D |
| 500 Hz | 50% | 4Mhz | 16 | 0.002 | 0.001 | 7C | FA |
| 500 Hz | 75% | 4Mhz | 16 | 0.002 | 0.0015 | 7C | 177 |
| 500 Hz | 95% | 4Mhz | 16 | 0.002 | 0.0019 | 7C | 1DB |
| 1000 Hz | 10% | 4Mhz | 16 | 0.001 | 0.0001 | 3E | 19 |
| 1000 Hz | 25% | 4Mhz | 16 | 0.001 | 0.00025 | 3E | 3F |
| 1000 Hz | 50% | 4Mhz | 16 | 0.001 | 0.0005 | 3E | 7D |
| 1000 Hz | 75% | 4Mhz | 16 | 0.001 | 0.00075 | 3E | BC |
| 1000 Hz | 95% | 4Mhz | 16 | 0.001 | 0.00095 | 3E | EE |

*\*NOTE: We can skip manual calculations for CCP1CON and CCP1L. Since we have a total of 10 bits available (CCP1L: 8 MSB + CCP1CON<5:4>: 2 LSB), we can directly use bit shifting to set the duty cycle value if we know the timer's maximum count (CCPR1L:CCP1CON<5:4>)\**

**Part II.** Calculations

**LE4 – 7:**

**300 Hz:**

Period = 1/f

Period = 1/300

Period = 0.0033 s

PR2 = [(Period)/(4 x Tosc x Prescale Value)] – 1

PR2 = [(0.0033s) / (4 x 4,000,000 x 16)] – 1

**PR2 = 20710 or 0xCF**

**300 Hz w/ 10% Duty Cycle**

PWM Duty Cycle = 0.1 x 0.0033s

PWM Duty Cycle = 0.00033s

(CCPR1:CCP1CON<5:4>) = (PWM Duty Cycle) / (Tosc x Prescale Value)

(CCPR1:CCP1CON<5:4>) = (0.00033s) / ([1/4,000,000] x 16)

**(CCPR1:CCP1CON<5:4>) = 8310 or 0x53**

**300 Hz w/ 25% Duty Cycle**

PWM Duty Cycle = 0.25 x 0.0033s

PWM Duty Cycle = 0.00083s

(CCPR1:CCP1CON<5:4>) = (PWM Duty Cycle) / (Tosc x Prescale Value)

(CCPR1:CCP1CON<5:4>) = (0.00083s) / ([1/4,000,000] x 16)

**(CCPR1:CCP1CON<5:4>) = 20810 or 0xD0**

**300 Hz w/ 50% Duty Cycle**

PWM Duty Cycle = 0.50 x 0.0033s

PWM Duty Cycle = 0.001666667s

(CCPR1:CCP1CON<5:4>) = (PWM Duty Cycle) / (Tosc x Prescale Value)

(CCPR1:CCP1CON<5:4>) = (0.001666667s) / ([1/4,000,000] x 16)

**(CCPR1:CCP1CON<5:4>) = 41710 or 0x1A1**

**300 Hz w/ 75% Duty Cycle**

PWM Duty Cycle = 0.75 x 0.0033s

PWM Duty Cycle = 0.0025s

(CCPR1:CCP1CON<5:4>) = (PWM Duty Cycle) / (Tosc x Prescale Value)

(CCPR1:CCP1CON<5:4>) = (0.0025s) / ([1/4,000,000] x 16)

**(CCPR1:CCP1CON<5:4>) = 62510 or 0x271**

**300 Hz w/ 95% Duty Cycle**

PWM Duty Cycle = 0.95 x 0.0033s

PWM Duty Cycle = 0.003166667s

(CCPR1:CCP1CON<5:4>) = (PWM Duty Cycle) / (Tosc x Prescale Value)

(CCPR1:CCP1CON<5:4>) = (0.003166667s) / ([1/4,000,000] x 16)

**(CCPR1:CCP1CON<5:4>) = 79210 or 0x318**

**500 Hz:**

Period = 1/f

Period = 1/500

Period = 0.002 s

PR2 = [(Period)/(4 x Tosc x Prescale Value)] – 1

PR2 = [(0.002s) / (4 x 4,000,000 x 16)] – 1

**PR2 = 12410 or 0x7C**

**500 Hz w/ 10% Duty Cycle**

PWM Duty Cycle = 0.1 x 0.002s

PWM Duty Cycle = 0.0002s

(CCPR1:CCP1CON<5:4>) = (PWM Duty Cycle) / (Tosc x Prescale Value)

(CCPR1:CCP1CON<5:4>) = (0.0002s) / ([1/4,000,000] x 16)

**(CCPR1:CCP1CON<5:4>) = 5010 or 0x32**

**500 Hz w/ 25% Duty Cycle**

PWM Duty Cycle = 0.25 x 0.002s

PWM Duty Cycle = 0.0005s

(CCPR1:CCP1CON<5:4>) = (PWM Duty Cycle) / (Tosc x Prescale Value)

(CCPR1:CCP1CON<5:4>) = (0.0005s) / ([1/4,000,000] x 16)

**(CCPR1:CCP1CON<5:4>) = 12510 or 0x7D**

**500 Hz w/ 50% Duty Cycle**

PWM Duty Cycle = 0.50 x 0.002s

PWM Duty Cycle = 0.001s

(CCPR1:CCP1CON<5:4>) = (PWM Duty Cycle) / (Tosc x Prescale Value)

(CCPR1:CCP1CON<5:4>) = (0.001s) / ([1/4,000,000] x 16)

**(CCPR1:CCP1CON<5:4>) = 25010 or 0xFA**

**500 Hz w/ 75% Duty Cycle**

PWM Duty Cycle = 0.75 x 0.002s

PWM Duty Cycle = 0.0015s

(CCPR1:CCP1CON<5:4>) = (PWM Duty Cycle) / (Tosc x Prescale Value)

(CCPR1:CCP1CON<5:4>) = (0.0015s) / ([1/4,000,000] x 16)

**(CCPR1:CCP1CON<5:4>) = 37510 or 0x177**

**500 Hz w/ 95% Duty Cycle**

PWM Duty Cycle = 0.95 x 0.002s

PWM Duty Cycle = 0.0019s

(CCPR1:CCP1CON<5:4>) = (PWM Duty Cycle) / (Tosc x Prescale Value)

(CCPR1:CCP1CON<5:4>) = (0.0019s) / ([1/4,000,000] x 16)

**(CCPR1:CCP1CON<5:4>) = 47510 or 0x1DB**

**1000 Hz:**

Period = 1/f

Period = 1/1000

Period = 0.001 s

PR2 = [(Period)/(4 x Tosc x Prescale Value)] – 1

PR2 = [(0.001s) / (4 x 4,000,000 x 16)] – 1

**PR2 = 620 or 0x3E**

**1000 Hz w/ 10% Duty Cycle**

PWM Duty Cycle = 0.1 x 0.001s

PWM Duty Cycle = 0.0001s

(CCPR1:CCP1CON<5:4>) = (PWM Duty Cycle) / (Tosc x Prescale Value)

(CCPR1:CCP1CON<5:4>) = (0.0001s) / ([1/4,000,000] x 16)

**(CCPR1:CCP1CON<5:4>) = 2510 or 0x19**

**1000 Hz w/ 25% Duty Cycle**

PWM Duty Cycle = 0.25 x 0.001s

PWM Duty Cycle = 0.00025s

(CCPR1:CCP1CON<5:4>) = (PWM Duty Cycle) / (Tosc x Prescale Value)

(CCPR1:CCP1CON<5:4>) = (0.00025s) / ([1/4,000,000] x 16)

**(CCPR1:CCP1CON<5:4>) = 6310 or 0x3F**

**1000 Hz w/ 50% Duty Cycle**

PWM Duty Cycle = 0.50 x 0.001s

PWM Duty Cycle = 0.0005s

(CCPR1:CCP1CON<5:4>) = (PWM Duty Cycle) / (Tosc x Prescale Value)

(CCPR1:CCP1CON<5:4>) = (0.0005s) / ([1/4,000,000] x 16)

**(CCPR1:CCP1CON<5:4>) = 12510 or 0x7D**

**1000 Hz w/ 75% Duty Cycle**

PWM Duty Cycle = 0.75 x 0.001s

PWM Duty Cycle = 0.00075s

(CCPR1:CCP1CON<5:4>) = (PWM Duty Cycle) / (Tosc x Prescale Value)

(CCPR1:CCP1CON<5:4>) = (0.00075s) / ([1/4,000,000] x 16)

**(CCPR1:CCP1CON<5:4>) = 18810 or 0Xbc**

**1000 Hz w/ 95% Duty Cycle**

PWM Duty Cycle = 0.95 x 0.001s

PWM Duty Cycle = 0.00095s

(CCPR1:CCP1CON<5:4>) = (PWM Duty Cycle) / (Tosc x Prescale Value)

(CCPR1:CCP1CON<5:4>) = (0.00095s) / ([1/4,000,000] x 16)

**(CCPR1:CCP1CON<5:4>) = 23810 or 0xEE**