CTC and Duty Cycles

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Goals:
The goal of the lab is to modify the given code to produce a waveform duty cycle over a suitable period corresponding to an internal 1 MHz clock.

Equipment Usage
For this lab the following equipment will be used:

- LED
- Atmega328P
- AVR Studio
- AVRISP mkII

Background:
Clear Timer On Compare
In previous labs, timer overflow was automatic occurring once the register had reached its peak value. For this lab, we will gain more control by choosing to clear our timer when it meets a specific value as opposed to it running a certain number of clock cycles. By initializing the proper WGM bits, the timer can be set to clear when it reaches the specified value placed in the OCRx register.

Output Compare Register
The Output Compare Register (OCRx) is related to the Output Compare Pin (OCx) and timer (TCNTx). By placing a specific value in the register, you can dictate that point where the timer set and resets it timer. The behavior of the OCRx is similar to normal timer behavior. The important use of the OCRx is that it is tied to a specific pin on the microcontroller.

Compare Match Output
Compare Match Output bits (COMx) are the bits that control the operation of the pin tied to the OCRx register. These bits are located in the TCCRx register. Manipulating these bits allows the user to control the behavior of the pin connected to the OCRx register. It is important to remember that the manipulation of these bits is also dependent of the mode of operation set by the WGM bits (i.e. Normal, CTC, Fast PWM, etc). Below is a table for the bit manipulation for Timer0.
Calculations:
On the next page are two figures that provide examples on how to calculate the proper OCR value for a specific frequency. In Figure 1, the examples shows that given a specific frequency and duty cycle, you can calculate both the require prescaler and OCR value. In the second figure, shows how to calculate the frequency given a desired clock and OCR value.

\[
\text{duty cycle} = \frac{\text{on_time}}{(\text{on_time} + \text{off_time})} \times 100
\]
\[
\text{o/p Voltage} = \text{duty_cycle} \times \text{i/p Voltage}
\]
\[
\text{PWM_freq} = \frac{\text{clk}}{(\text{prescaler} \times (1+\text{MAX}))}
\]

C code:
```c
#include <avr/io.h>
int main(void)
{
    DDRD = 0xFF;
    OCR0A = 128;
    TCCR0B = 1;
    TCCR0A = 0x83;
    while (1);
}
```
Assembly code:

SBI DDRD, 6

BEGIN:
LDI R20, 17
OUT OCR0A, R20
LDI R20, 0x83
OUT TCCR0A, R20
LDI R20, 1
OUT TCCR0B, R20

WHILE1:
RJMP WHILE1

Prelab:
Q1. Explain the function of each opcode in given assembly code. (Hint: Follow "AVR Instruction Set Manual" from Atmel)
Q2. Expand each register used in C code and describe function of each bit in the register.

Lab Experiments:

Experiment 1: Program with the given code and demonstrate to the TA.
Experiment 2: Set Timer1 (both PB1 and PB2) with time period anywhere between 1 - 10 sec and duty cycle between 0 - 100. Show necessary calculation.

Post-Lab Deliverables:

1) Submit a copy of your code from each of the above parts (a-d)
   a. Comment your code extensively
   b. Include calculations/justifications of your values (OCR TCCR)
2) Answer to attached questions
3) Altium PCB and Netlist of your circuit