ECE 372 – Microcontroller Design

Pulse Width Modulation
(Output Compare Module)

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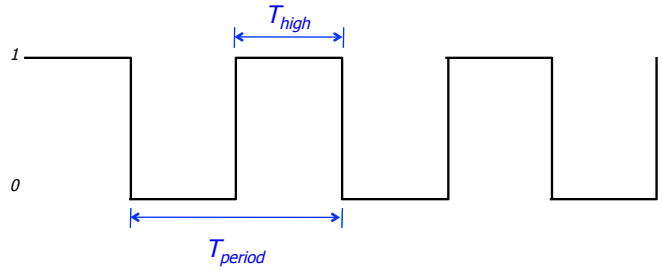
Pulse Width Modulation

- Pulse Width Modulation (PWM)
  - Modulates an output signal to provide an average voltage output between a logic low and logic high
  - Pulse width defined by *period*
    - PWM Period: Total length of the full pulse cycle (low and high time)
  - Modulation is defined by *duty cycle*
    - *Duty Cycle: Percentage of time the output signal is high*
    - Duty Cycle = T_{high}/T_{period}



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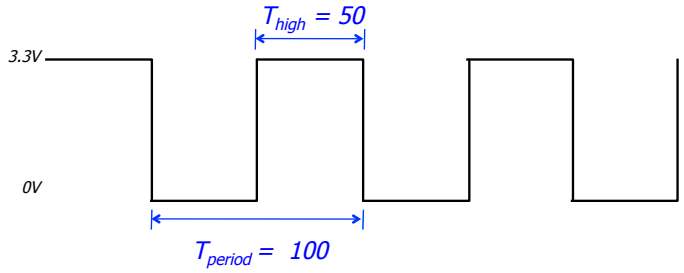
Pulse Width Modulation

- Pulse Width Modulation (PWM) *(cont.)*
  - Average voltage output is controlled by voltage of logic high output and duty cycle
    - For PIC24F, a 50% duty cycle would produce a 1.65 V output
    - 3.3V * 50% = 1.65V



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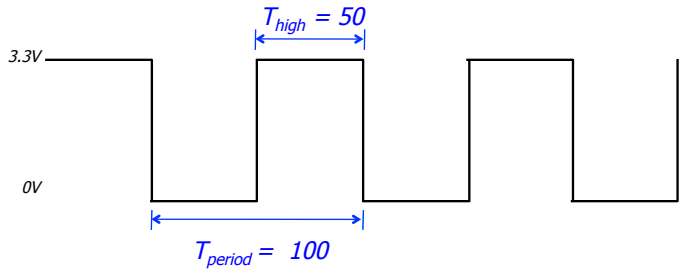
- Pulse Width Modulation (PWM) *(cont.)*
  - *If average voltage output is controlled by duty cycle, does the period matter?*
  - Yes:
    - 1. PWM period will affect the resolution of
    - 2. The resulting waveform of the PWM output may be important
      - For example, refresh rate of pulse width modulated LED output must be fast enough to not notice the pulse



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- PIC24F
  - Pulse width modulation is controlled by the output compare module (OCM)
    - Timer 2/Timer 3: Controls period of PWM output
    - OCxCON: *configure output compare module*
      - OCTSEL: configures clock source (i.e. period) to use either Timer 2 (0) or Timer 3 (1)
      - OCM: Controls mode of OCM (110 or 111 for pulse width modulation)
    - OCxR: *configures output compare register to control high time/duty cycle*
      - Only configured during initialization to specify initial PWM period
    - OCxRS: *configures output compare register to control high time/duty cycle of next PWM cycle*
      - Value loaded into OCxR for nextPWM period
      - Value written must be between 0 and the PWM period

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Pulse Width Modulation

- PIC24F
  - PWM Period = (PRy+1) * T_{CY} * Timer Prescaler
  - F_{PWM} = 1 / (PWM Period)
  - PWM Duty Cycle Resolution = $\log_2 F_{CY} / (F_{PWM} * \text{Timer Prescaler})$

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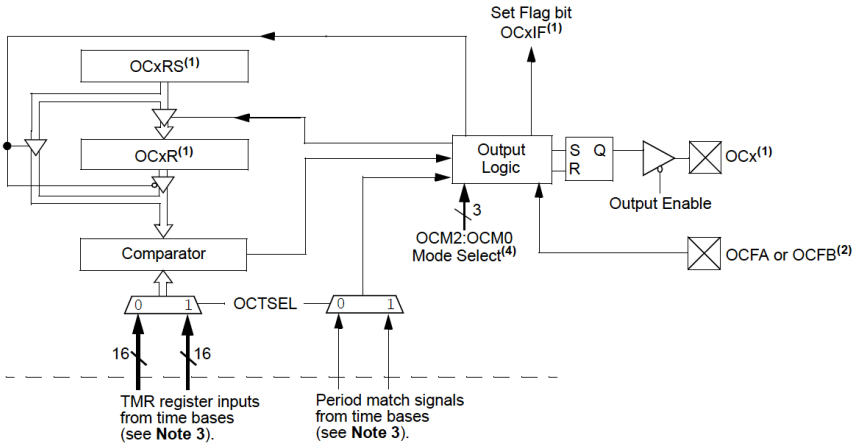
PIC24F Output Compare Module



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Pulse Width Modulation

- PIC24F
  - Output of OCM is controlled through peripheral pin mapping

Function	Output Function Number(1)	Output Name
NULL(2)	0	NULL
C1OUT	1	Comparator 1 Output
C2OUT	2	Comparator 2 Output
U1TX	3	UART1 Transmit
$\overline{\text{U1RTS}}$(3)	4	UART1 Request To Send
U2TX	5	UART2 Transmit
$\overline{\text{U2RTS}}$(3)	6	UART2 Request To Send
SDO1	7	SPI1 Data Output
SCK1OUT	8	SPI1 Clock Output
SS1OUT	9	SPI1 Slave Select Output
SDO2	10	SPI2 Data Output
SCK2OUT	11	SPI2 Clock Output
SS2OUT	12	SPI2 Slave Select Output
OC1	18	Output Compare 1
OC2	19	Output Compare 2
OC3	20	Output Compare 3
OC4	21	Output Compare 4
OC5	22	Output Compare 5

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PWM Controlled DC Motor

- H-bridge used to provide directional control of DC motor
- Pulse width modulation used to control speed