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PV198 – One-chip Controllers

PWM

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What is PWM

- **PWM** – **P**ulse **W**idth **M**odulation
- A method of reducing the average power delivered by an electrical signal, by effectively chopping it up into discrete parts

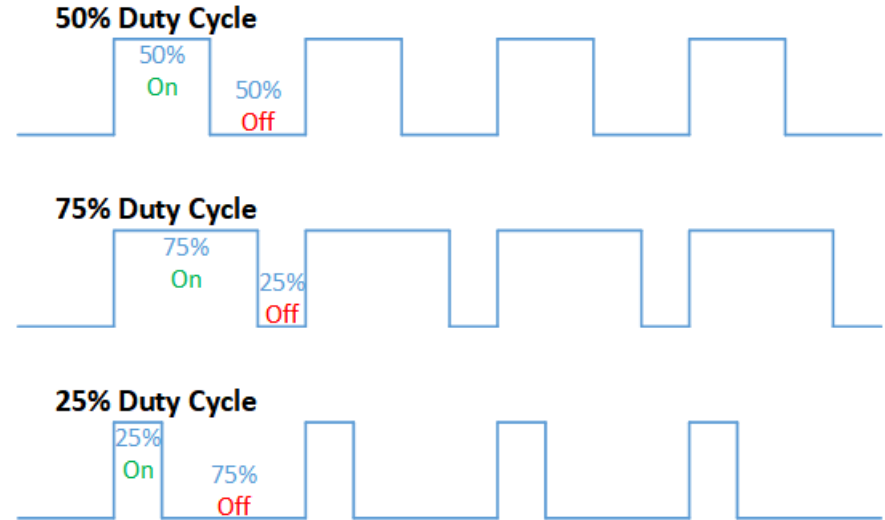


What is it used for

- Motor control
- Audio amplifiers
- Digital lighting

How does it work

- Switching fast enough for the application (low period)
- Changing duty cycle



https://en.wikipedia.org/wiki/Pulse-width_modulation#/media/File:Duty_Cycle_Examples.png
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PWM on FRDM-K66F

- FlexTimer Module (FTM)
 - 4 instances
 - 2 - 8 channels
- Timer/PWM Module (TPM)
 - 2 instances
 - 2 channels

Timer/PWM Module (TPM)

- Modes of operation:
 - Input capture
 - Output compare
 - **Edge-Aligned PWM**
 - **Center-Aligned PWM**
 - **Combine PWM**
 - Combine Input Capture

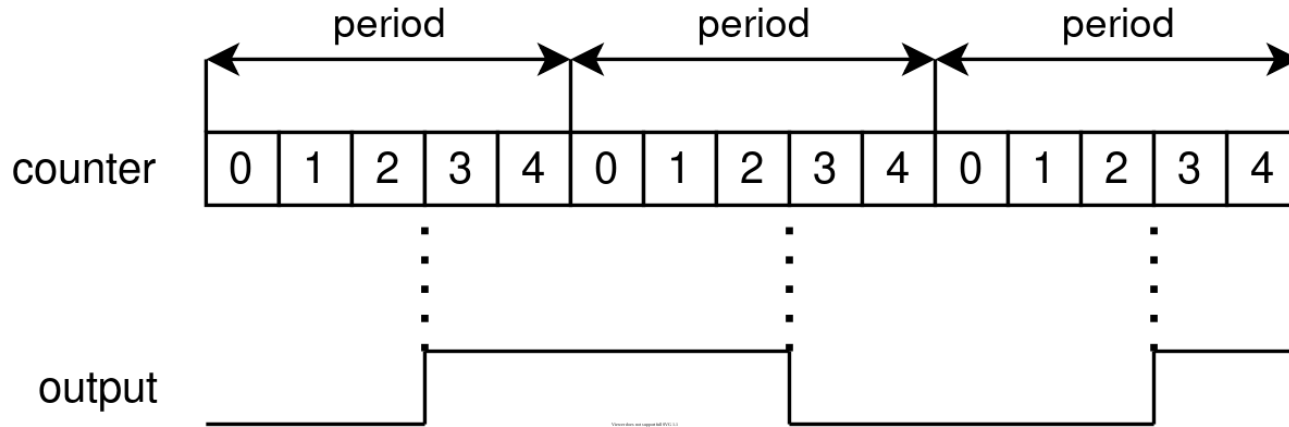
Input capture

- Detects edge in the input signal
- Configurable rising/falling edge detection
- Edge sets interrupt flag

- Read precise time from counter
- Example: ultrasonic distance sensor demo

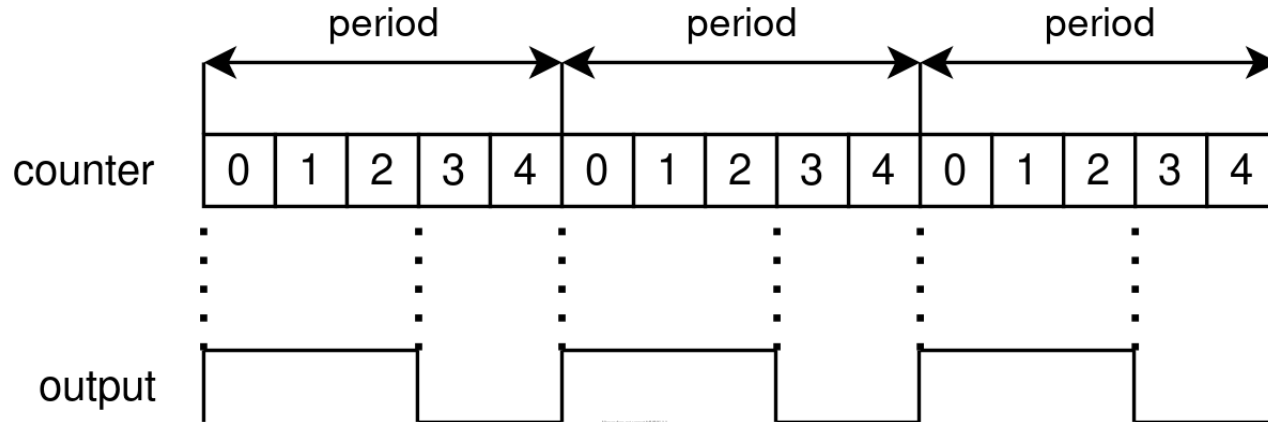
Output compare

- Generate timed pulses with programmable position, polarity, duration, and frequency



Edge-Aligned PWM

- Leading edge is aligned with the beginning of the period

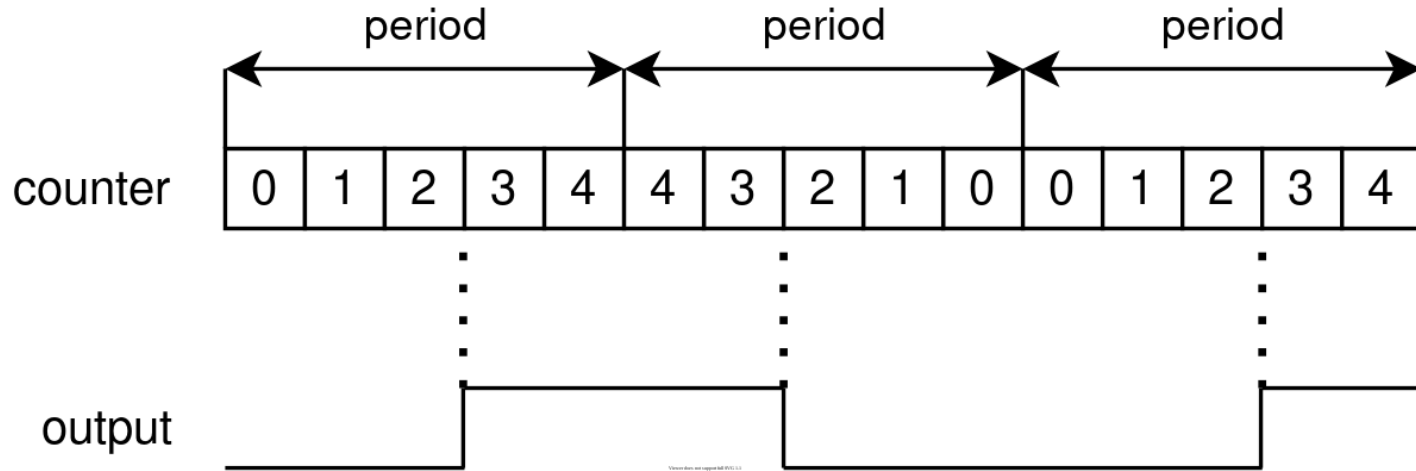




Center-Aligned PWM

- Counts up until it reaches MOD and then counts down until it reaches zero
- The pulse width center is when the TPM counter = 0

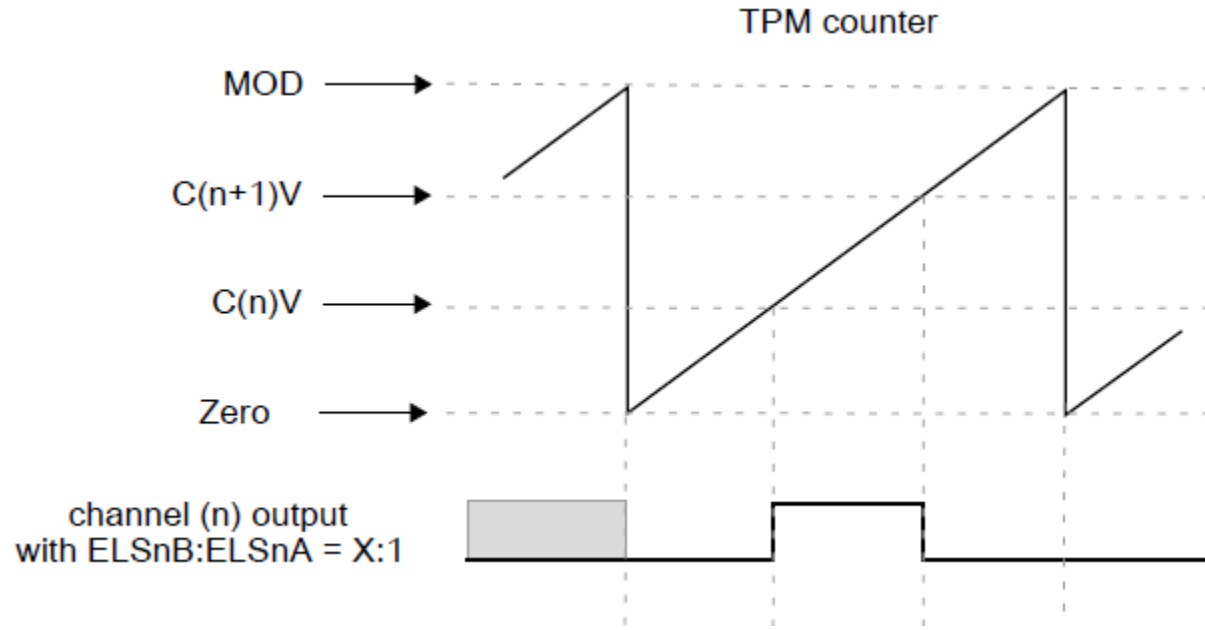
Center-Aligned PWM



Combine PWM

- Even channel (n) and adjacent odd channel ($n+1$) are combined to generate a PWM signal in the channel (n) output.

Combine PWM





Combine Input Capture

- Measure a pulse width of the signal

Application

- Create an application that turns on Blue LED with 20% intensity
- Use TPM or FTM peripheral
- Update your application to turn on Green and Red LED with 20% intensity (use FTM, because TPM is not available)

Code

```
const tpm_chnl_pwm_signal_param_t TPM_edge_pwmSignalParams[] = {
    {
        .chnlNumber = kTPM_Chnl_1,
        .level = kTPM_LowTrue,
        .dutyCyclePercent = 20
    }
};

void TPM_edge_init(void) {
    TPM_Init(TPM_EDGE_PERIPHERAL, &TPM_edge_config);
    TPM_SetupPwm(TPM_EDGE_PERIPHERAL, TPM_edge_pwmSignalParams, sizeof(TPM_edge_pwmSignalParams) /
sizeof(tpm_chnl_pwm_signal_param_t), kTPM_EdgeAlignedPwm, 24000U, TPM_EDGE_CLOCK_SOURCE);
    TPM_StartTimer(TPM_EDGE_PERIPHERAL, kTPM_SystemClock);
}
```

Stepper motor demo

- Which mode can we use to get 4 signals as shown in the picture?

Channel : duty 25%, shift 0%

Channel : duty 25%, shift 25%

Channel : duty 25%, shift 50%

Channel : duty 25%, shift 75%

Homework

- Write 3 functions, that sets intensity for each color.
- Download HSV_RGB.h from `study_materials/software`
- All you have to do is periodically iterate over all colors by updating `'H = (H + 1) % 360'`