Smart Software Project

Lab: Week 3
SmartCAR
LED Control

Prof. HyungJune Lee
hyungjune.lee@ewha.ac.kr

이화여자대학교
EWHA WOMANS UNIVERSITY

Today

- Lab announcement

- SmartCAR LED Control
- PWM: Pulse Width Modulation
  - Digital-to-Analog Converting Method

- Lab assignments #2-1, #2-2

- Course announcement

Class Schedule

Week	Lecture Contents	Lab Contents
Week 1	Course introduction	Arduino introduction: platform & programming environment
Week 2	Embedded system overview & source management in collaborative repository (using GitHub)	Lab 1: Arduino Mega 2560 board & SmartCAR platform
Week 3	ATmega2560 Micro-controller (MCU): architecture & I/O ports, Analog vs. Digital, Pulse Width Modulation	Lab 2: SmartCAR LED control
Week 4	Analog vs. Digital & Pulse Width Modulation	Lab 3: SmartCAR motor control (Due: HW on creating project repository using GitHub)
Week 5	ATmega2560 MCU: memory, I/O ports, UART	Lab 4: SmartCAR control via Android Bluetooth
Week 6	ATmega2560 UART control & Bluetooth communication between Arduino platform and Android device	Lab 5: SmartCAR control through your own customized Android app (Due: Project proposal)
Week 7	Midterm exam	
Week 8	ATmega2560 Timer, Interrupts & Ultrasonic sensors	Lab 6: SmartCAR ultrasonic sensing
Week 9	Infrared sensors & Buzzer	Lab 7: SmartCAR infrared sensing
Week 10	Acquiring location information from Android device & line tracing	Lab 8: Implementation of line tracer
Week 11	Gyroscope, accelerometer, and compass sensors	Lab 9: Using gyroscope, accelerometer, and compass sensors
Week 12	Project	Team meeting (for progress check)
Week 13	Project	Team meeting (for progress check)
Week 14	Course wrap-up & next steps	
Week 15	Project presentation & demo I (Due: source code, presentation slides, & poster slide)	Project presentation & demo II
Week 16	Final week (no final exam)	

Lab Session

- Practice in-lab programming exercises based on the lecture materials
- Upload source codes for lab assignments in Ewha Cyber Campus after the lab session
  - Due: 11:59pm on the lab day
- Once you are done, you can leave the session after checking with me or TA
- Or, continue to work on programming for other homework assignments

Lab Policy

- 1) Please check out your SmartCAR (& Nexus 7 tablet) as soon as you arrive at the classroom
- 2) Please complete lab assignments
- 3) Upload required files to Ewha Cyber Campus
- 4) Check with me or TA
- 5) Please remove files that you created or downloaded in your computer after you are done
  - Remove your project completely
- 6) Please shut down your computer before you leave
- 7) Return the checked-out SmartCAR (& Nexus 7 tablet) to TA

Lab Announcement

- Please review C programming language
- I posted a brief document that includes C essentials in Ewha Cyber Campus
- Without this fundamental, it is very difficult for you to learn new embedded programming skillsets

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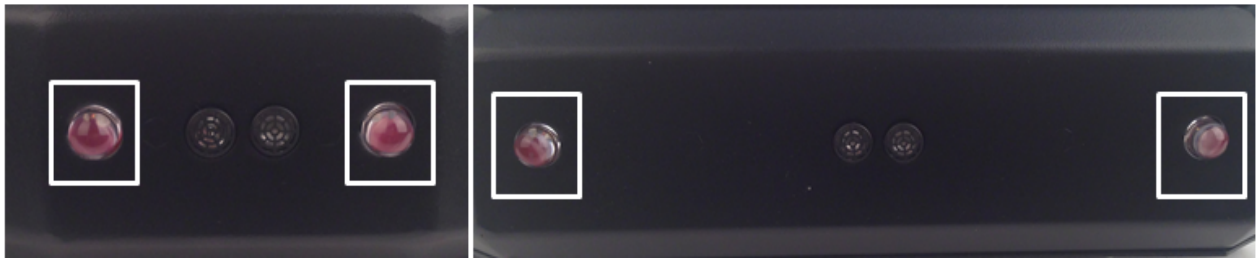
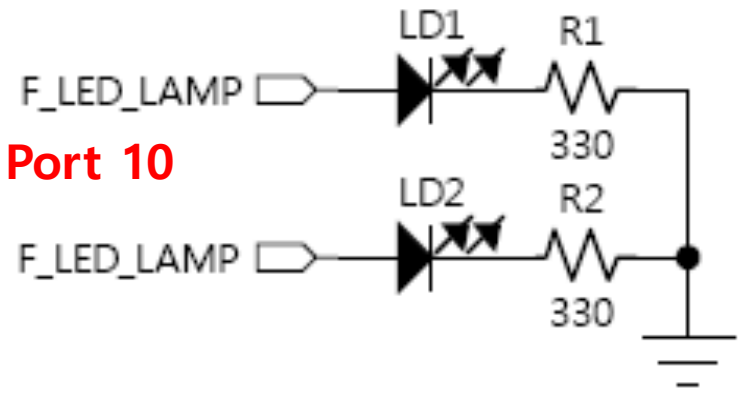
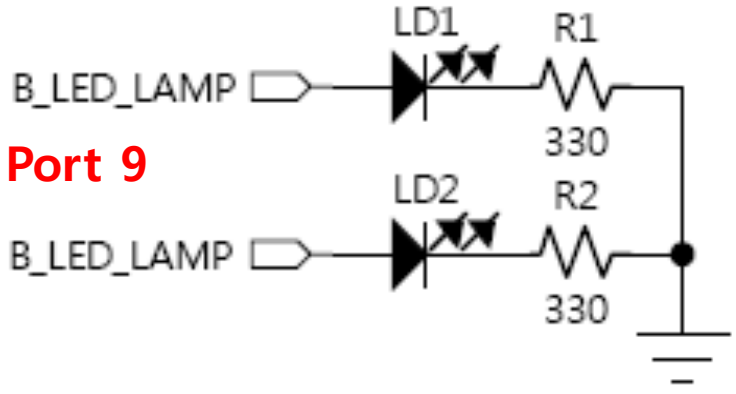
Circuit for Front LED & Rear LED

- Front LED(Left) & Rear LED (Right)



- Front LED (Left: White), Rear LED (Right : Red) LED circuit





LED Example

- Front LED should be turned ON for 1 second and OFF for 1 second, repeatedly

```
#define FRONT_LED_PIN 10
#define REAR_LED_PIN 9

void setup(){
   pinMode(FRONT_LED_PIN, OUTPUT);
}

void loop(){
   digitalWrite(FRONT_LED_PIN, HIGH);
   delay(1000);
   digitalWrite(FRONT_LED_PIN, LOW);
   delay(1000);
}
```

Lab Assignment #1-1

- Program using Arduino IDE and Androx Studio

- Front LED should be turned ON, while rear LED should be turned OFF for 1 second
- Then, front LED should be turned OFF, while rear LED should be turned ON for 1 second
- Repeat the above operations
- Upload your sketch file to Cyber Campus
- Show your result to TA or instructor

Lab Assignment #1-1

```
#define FRONT_LED_PIN 10
#define REAR_LED_PIN 9

void setup(){
   pinMode(FRONT_LED_PIN, OUTPUT);
   pinMode(REAR_LED_PIN, OUTPUT);
}

void loop(){
   digitalWrite(FRONT_LED_PIN, HIGH);
   digitalWrite(REAR_LED_PIN, LOW);
   delay(1000);

   digitalWrite(FRONT_LED_PIN, LOW);
   digitalWrite(REAR_LED_PIN, HIGH);
   delay(1000);
}
```

Lab Assignment #1-2

- Use Androx Studio from now on!
- Front LED is initially OFF
- Rear LED is initially ON
- Front LED should be gradually brightening for about 3 seconds, and gradually darkening for about 3 seconds, repeatedly
- At the same time, rear LED should be gradually darkening for about 3 seconds, and incrementally brightening for about 3 seconds, repeatedly

- Hint) Use "analogWrite()"

- Upload your 1) lab1_2.h and 2) lab1_2.cpp file to Cyber Campus
- Show your result to TA or instructor

Lab Assignment #1-2

```
#include "lab1_2.h"

#define FRONT_LED_PIN      10
#define REAR_LED_PIN       9

boolean increasing = true;
int front_led_value = 0;

//The setup function is called once at startup of the sketch
void setup()
{
        pinMode(FRONT_LED_PIN, OUTPUT);
        pinMode(REAR_LED_PIN, OUTPUT);
}
```

Lab Assignment #1-2

```
void loop()
{
        analogWrite(FRONT_LED_PIN, front_led_value);
        analogWrite(REAR_LED_PIN, 255-front_led_value);
        delay(12);  /* 3000ms/256 ~= 11.7ms */

        if (increasing == true)
                front_led_value++;
        else
                front_led_value--;

        if (front_led_value > 255) {
                front_led_value = 254;
                increasing = false;
        }
        else if (front_led_value <0) {
                front_led_value = 1;
                increasing = true;
        }
}
```

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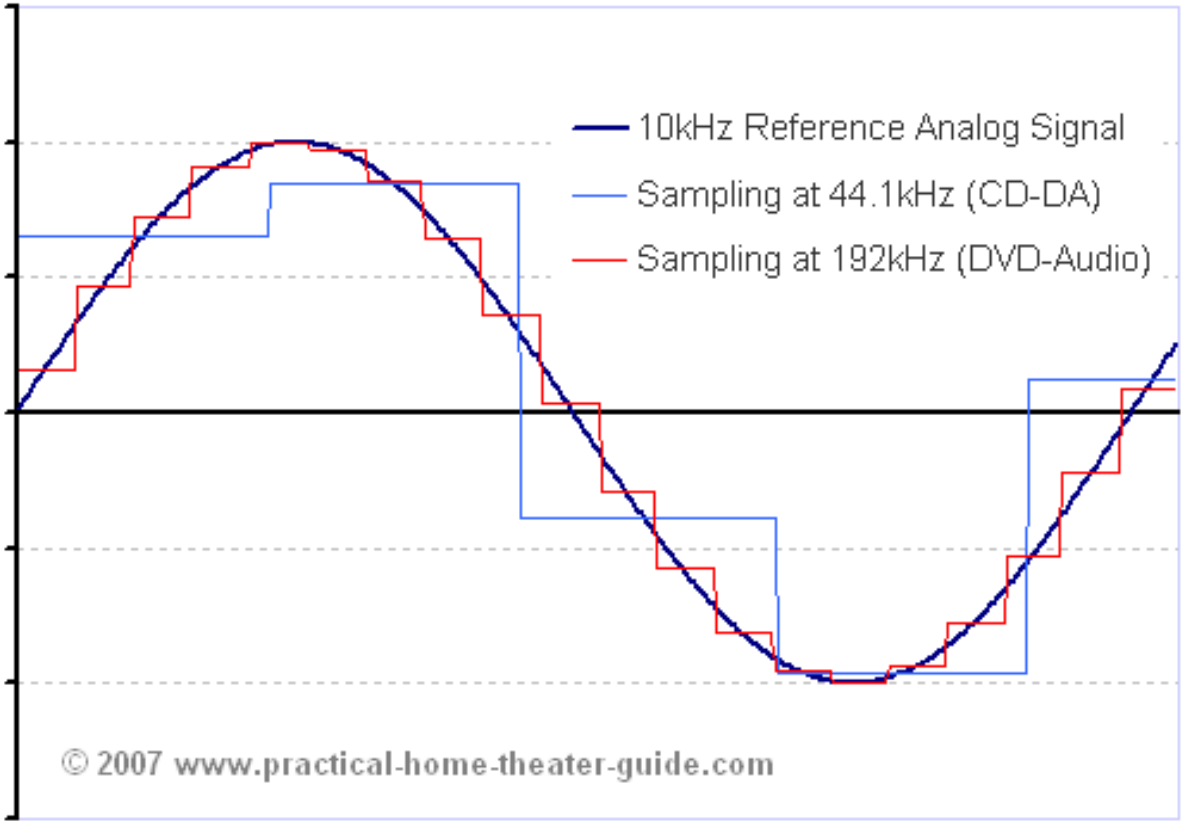
Analog vs. Digital

- Think about music stored on a CD: an analog signal captured on digital media
  - Sampling (with sampling rate)
  - Discretization (with discretization level)



Arduino Analog Input

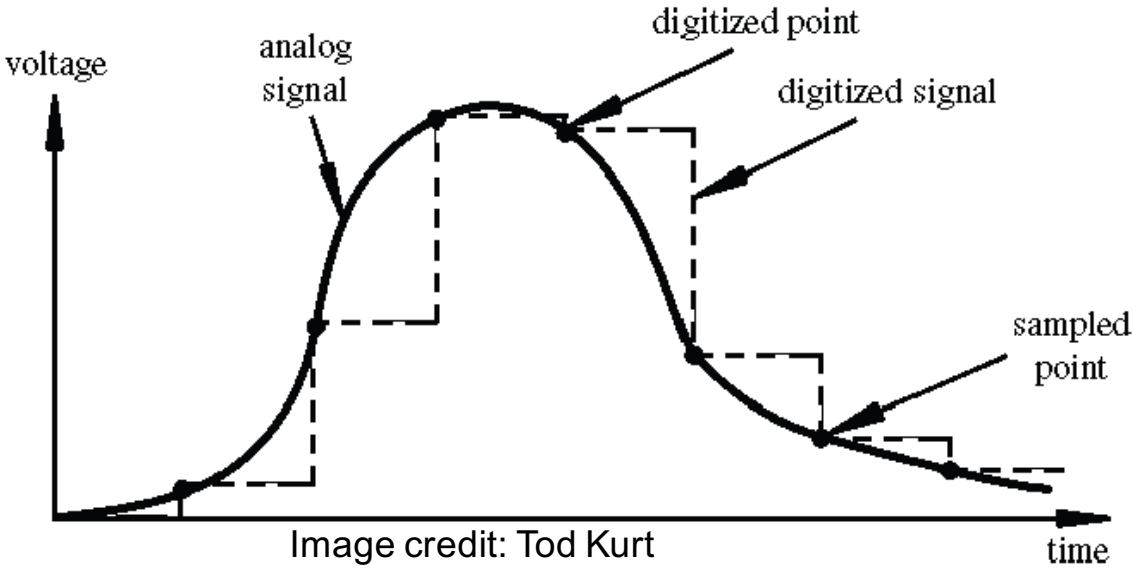


Image credit: Tod Kurt

- *Resolution*: the number of different voltage levels (i.e., *states*) used to discretize an input signal
- Resolution values range from 256 states (8 bits) to 4,294,967,296 states (32 bits)
- The Arduino uses 1024 states (10 bits)
- Smallest measurable voltage change is 5V/1024 or 4.8 mV
- Maximum sample rate is 10,000 times a second

Analog Output

- Can a digital device produce analog output?

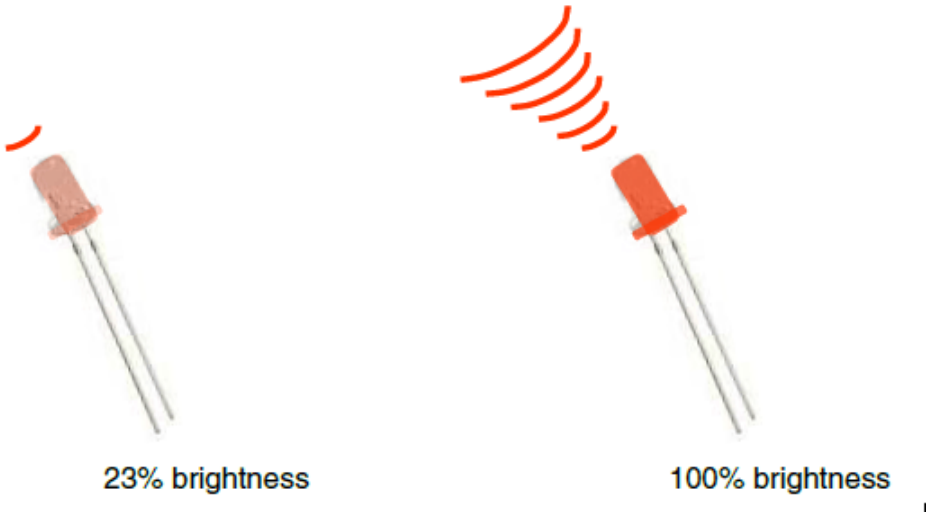
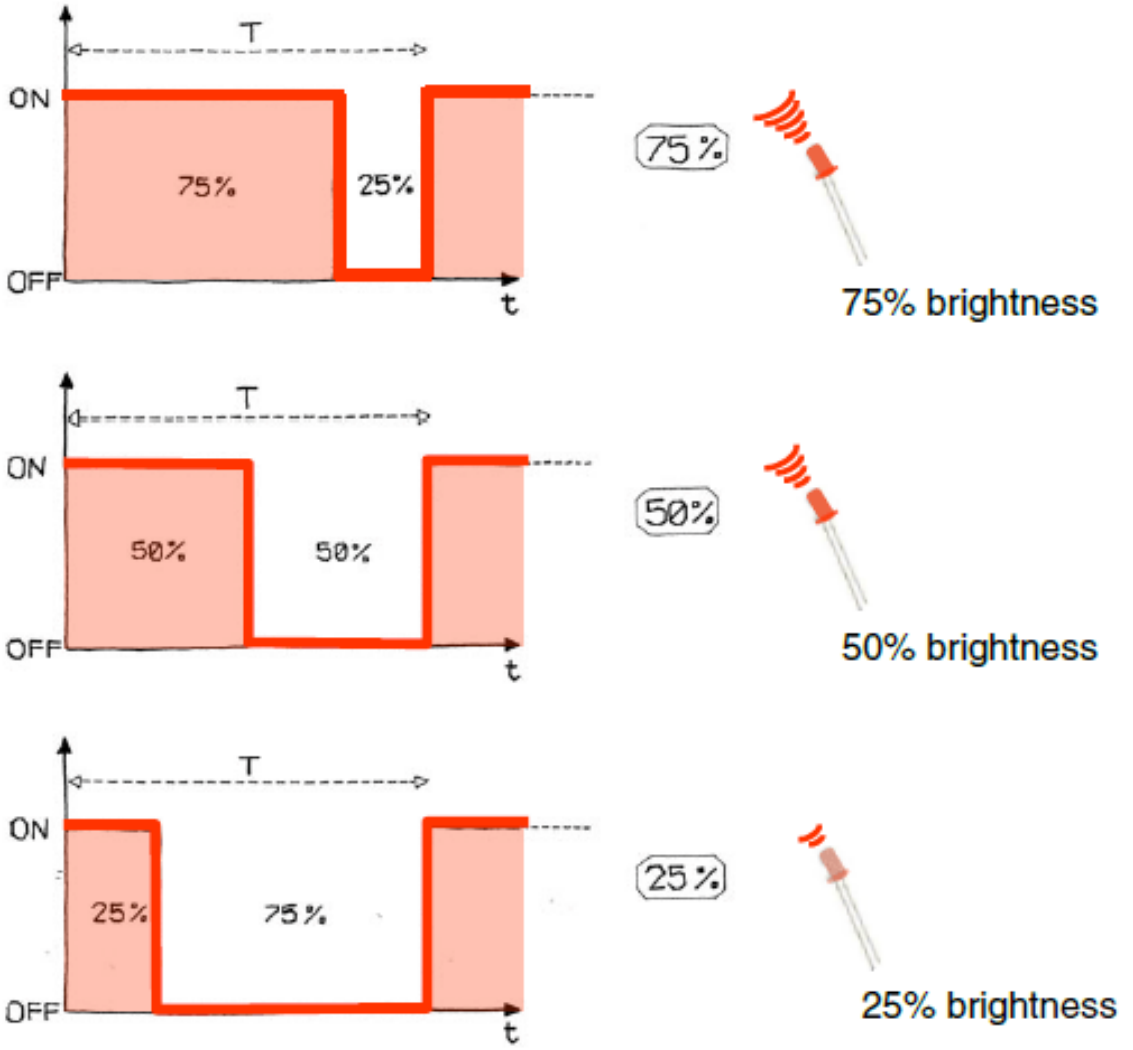


Image from *Theory and Practice of Tangible User Interfaces* at UC Berkley

- Analog output can be simulated using pulse width modulation (PWM)

Pulse Width Modulation

- Can't use digital pins to directly supply say 2.5V, but can pulse the output on and off really fast to produce the same effect
- On-off pulsing happens so quickly, the connected output device "sees" the result as a reduction in the voltage



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PWM Duty Cycle

Output voltage = (on_time / cycle_time) * 5V

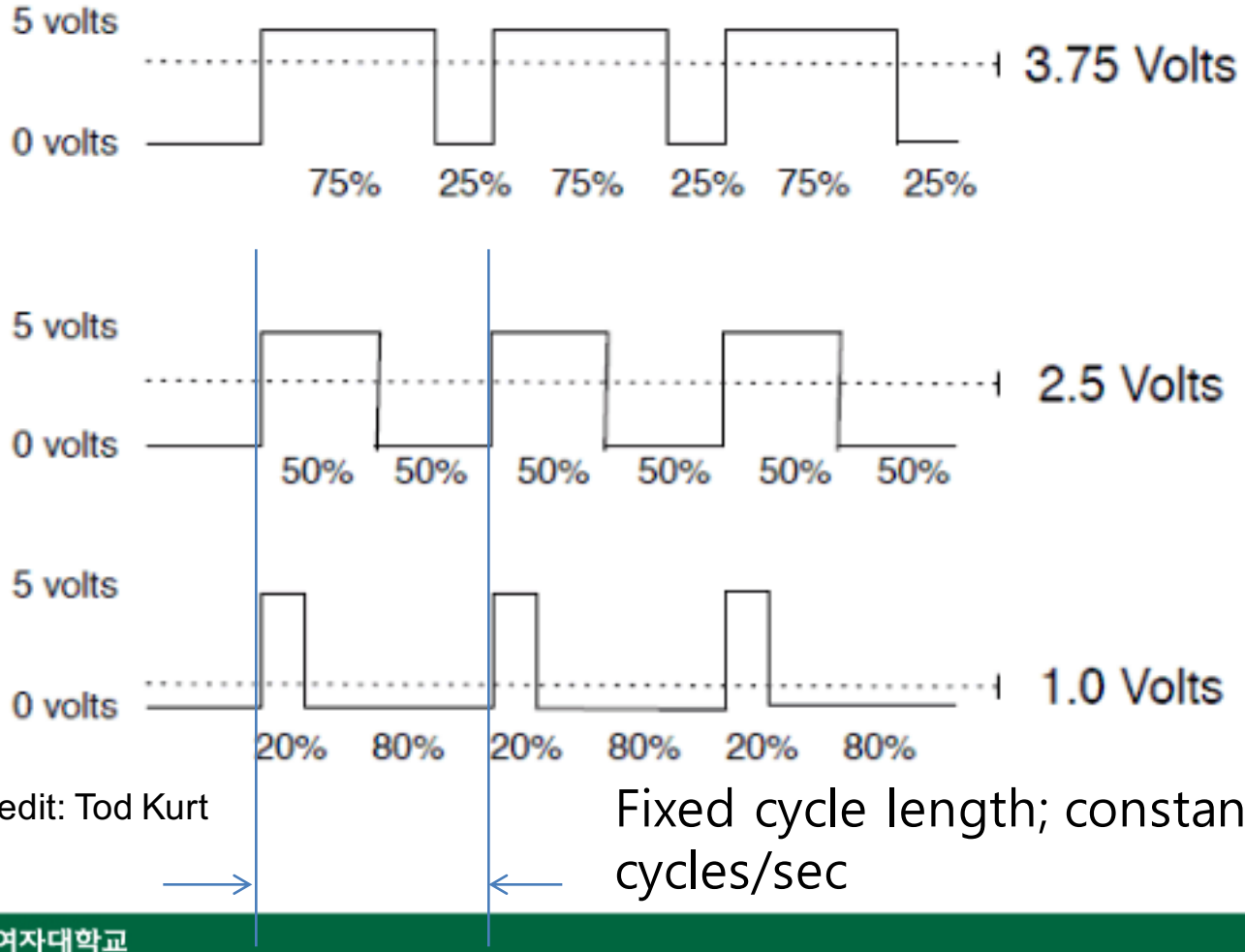

Image credit: Tod Kurt

Fixed cycle length; constant number of cycles/sec

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Lab Assignment #2-1

- Use Androx Studio from now on!

- Rear LED is initially ON (100%)
- After 2 seconds, rear LED's brightness is 75%
- After 2 seconds, rear LED's brightness is 50%
- After 2 seconds, rear LED's brightness is 25%
- After 2 seconds, rear LED is OFF

- Requirement) Use "digitalWrite()", not "analogWrite()"
- Hint) Use PWM
- 1) What happens when you set the cycle time to 100ms?
- 2) What happens as you decrease the cycle time to 50ms and 20ms?

- Upload your 1) lab2_2_easy.h and 2) lab2_2_easy.cpp file to Cyber Campus
- Show your result to TA or instructor

Lab Assignment #2-1

```
#define FRONT_LED_PIN 10
#define REAR_LED_PIN 9

void myAnalogWrite(int pin, int percent, int time) {
   //int pin: pin number
   //int percent: brightness 0% ~ 100%
   //int time: brightness remains the same during this time in ms
}
void setup(){
   pinMode(REAR_LED_PIN, OUTPUT);
}

void loop(){



}
```

Lab Assignment #2-2

- Rear LED is initially ON
- Rear LED should be gradually darkening for 10 seconds and eventually OFF

- Requirement) Use "digitalWrite()", not "analogWrite()"
- Hint) Use PWM

- Upload your 1) lab2_2_adv.h and 2) lab2_2_adv.cpp file to Cyber Campus
- Show your result to TA or instructor

Lab Assignment #2-2

```
#define FRONT_LED_PIN 10
#define REAR_LED_PIN 9

void myAnalogWrite(int pin, int percent, int time) {
   //int pin: pin number
   //int percent: brightness 0% ~ 100%
   //int time: brightness remains the same during this time in ms
}
void setup() {
   pinMode(REAR_LED_PIN, OUTPUT);
}

void loop() {


}
```

Course Announcement

- Next lecture, we will continue to study
  - Analog vs. Digital
  - Pulse Width Modulation
  - Arduino Mega2560 board
    - I/O ports
- Next lab session, we will cover
  - Motor control