직렬 및 병렬 회로와 디지털 데이터 출력

부산대학교 정보·의생명공학대학
정보컴퓨터공학부

직렬 및 병렬회로

목적

- 저항(Resistor)의 직·병렬결합회로에서 합성저항(R_T)을 구하기 위한 규칙들을 실험으로 입증

- 저항의 직·병렬결합회로를 이해

Ohm's Law

Georg Ohm (1789~1854)

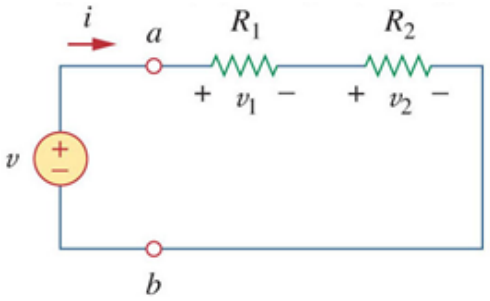
- **In a resistor, the voltage across a resistor is directly proportional to the current flowing through it.**

$$V = IR$$

  - The resistance of an element is measured in units of Ohms, Ω, (V/A)
  - The higher the resistance, the less current will flow through for a given voltage.

Resistors in Series

- Two resistors are considered in series if the same current pass through them
- The total resistance is: $R_T = R_1 + R_2$



- More generally, the total resistance equals the sum of the resistances.

$$R_T = R_1 + R_2 + R_3 + \cdots + R_N$$

- Because the same current I passes through each resistor, we can calculate the voltage across each resistor:

$$V_1 = IR_1, V_2 = IR_2, \cdots, V_N = IR_N$$

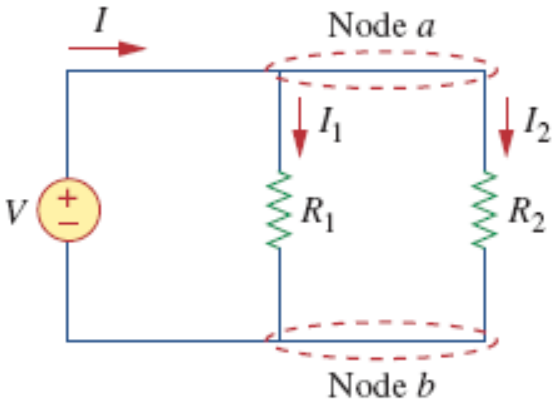
- This indicates the voltage drop across each resistor depends on its resistance

Resistors In Parallel

- **The two resisters are in parallel as they share the same nodes.**
  - both will have the same voltage drop across them.
- **We can express the current passing through both resistors as:**

$$I_1 = \frac{V}{R_1}, I_2 = \frac{V}{R_2}, I = I_1 + I_2$$

$$I = \frac{V}{R_1} + \frac{V}{R_2} = V\left(\frac{1}{R_1} + \frac{1}{R_2}\right) = \frac{V}{R_{eq}}$$



  - Solving for the equivalent resistance

$$\frac{\mathbf{1}}{\boldsymbol{R_T}} = \frac{\mathbf{1}}{\boldsymbol{R_1}} + \frac{\mathbf{1}}{\boldsymbol{R_2}}, \qquad \boldsymbol{R_T} = \frac{\boldsymbol{R_1 R_2}}{\boldsymbol{R_1 + R_2}}$$

- **The result for two resistors can be expanded for a circuit with N resistors:**

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots + \frac{1}{R_N}$$

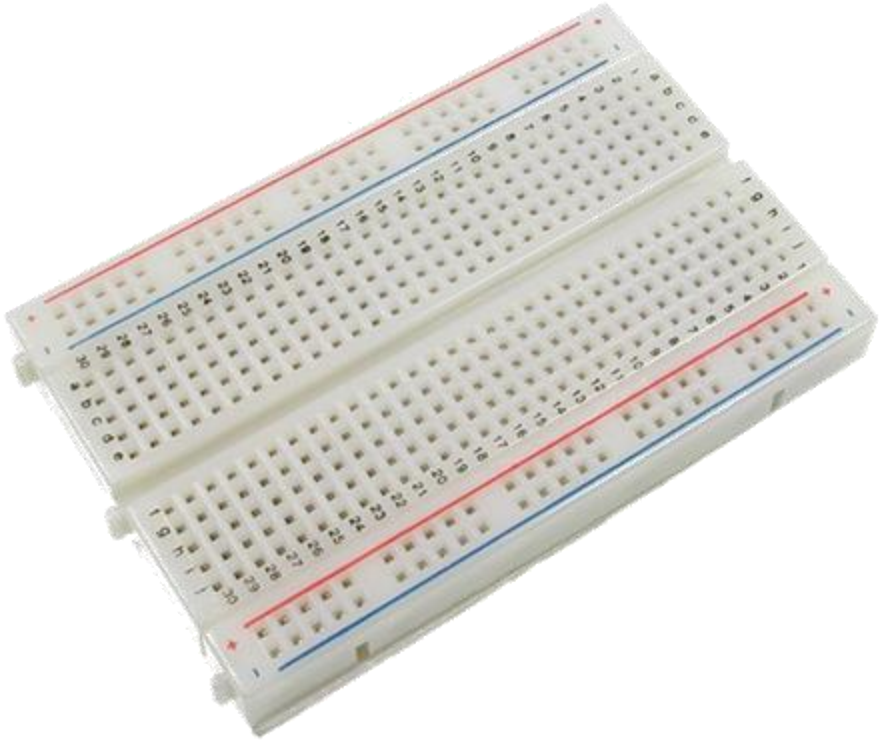
  - If all the resistors are the same, the resulting equivalent resistance is $R_T = \frac{R}{N}$

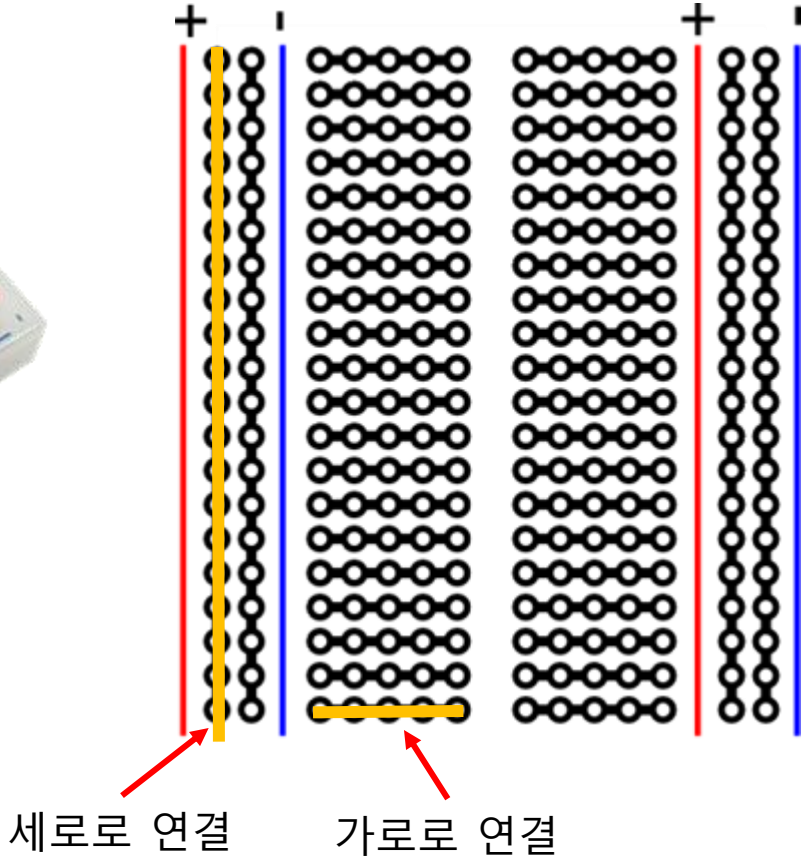
실험 도구

- 브레드 보드(Bread Board)
- 저항 (Resistor)
- 직류전원공급기 (DC Power Supply)
- 멀티미터 (Multimeter)

브레드보드(Breadboard)

❖ 전자 회로의 (일반적으로 임시적인) 시제품을 만드는데 사용하고 재사용 할 수 있는 무땜납 장치



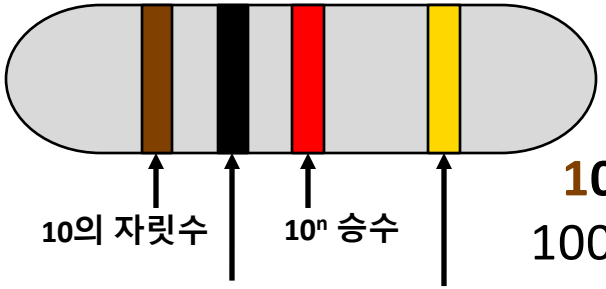


저항 (Resistor)

❖ 저항 읽는 법

150 x 10^1 = 1500Ω
=1.5KΩ

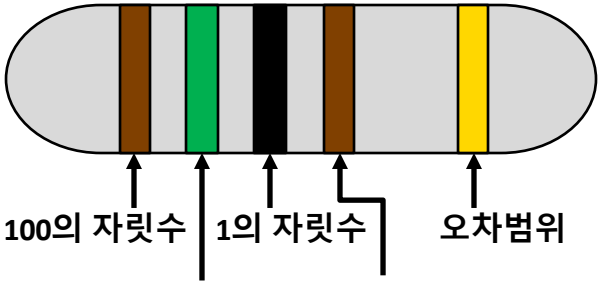
띠가 4줄인 경우



10 x 10^2 =
1000Ω =1KΩ

색	첫 번째 띠	두 번째 띠	세 번째 띠 (단위)	4번째 띠 (오차)	열계수
검정	0	0	$\times10^0$		
갈색	1	1	$\times10^1$	±1% (F)	100 ppm
빨강색	2	2	$\times10^2$	±2% (G)	50 ppm
주황색	3	3	$\times10^3$		15 ppm
노랑색	4	4	$\times10^4$		25 ppm
초록색	5	5	$\times10^5$	±0.5% (D)	
파랑색	6	6	$\times10^6$	±0.25% (C)	
보라색	7	7	$\times10^7$	±0.1% (B)	
회색	8	8	$\times10^8$	±0.05% (A)	
흰색	9	9	$\times10^9$		
금색			×0.1	±5% (J)	
은색			×0.01	±10% (K)	
없음				±20% (M)	

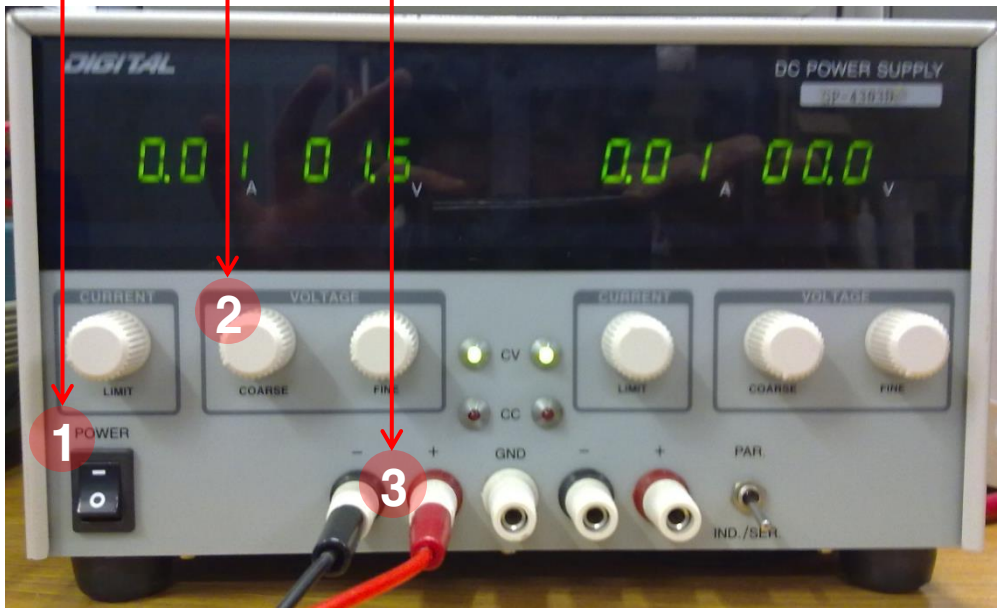
띠가 5줄인 경우 (정밀 저항)



색	첫 번째 띠	두 번째 띠	세 번째 띠	4번째 띠 (단위)	5번째 띠 (오차)
검정	0	0	0	×1	
갈색	1	1	1	$\times10^1$	±1% (F)
빨강색	2	2	2	$\times10^2$	±2% (G)
주황색	3	3	3	$\times10^3$	
노랑색	4	4	4	$\times10^4$	
초록색	5	5	5	$\times10^5$	±0.5% (D)
파랑색	6	6	6	$\times10^6$	±0.25% (C)
보라색	7	7	7	$\times10^7$	±0.1% (B)
회색	8	8	8	$\times10^8$	±0.05% (A)
흰색	9	9	9	$\times10^9$	
금색				×0.1	±5% (J)
은색				×0.01	±10% (K)
없음					±20% (M)

전원공급기

- ❖ 직류전원 공급장치
- ❖ 스위치
  - 전원 스위치
  - 전압조절 스위치
- ❖ 프로브 연결 위치



멀티미터

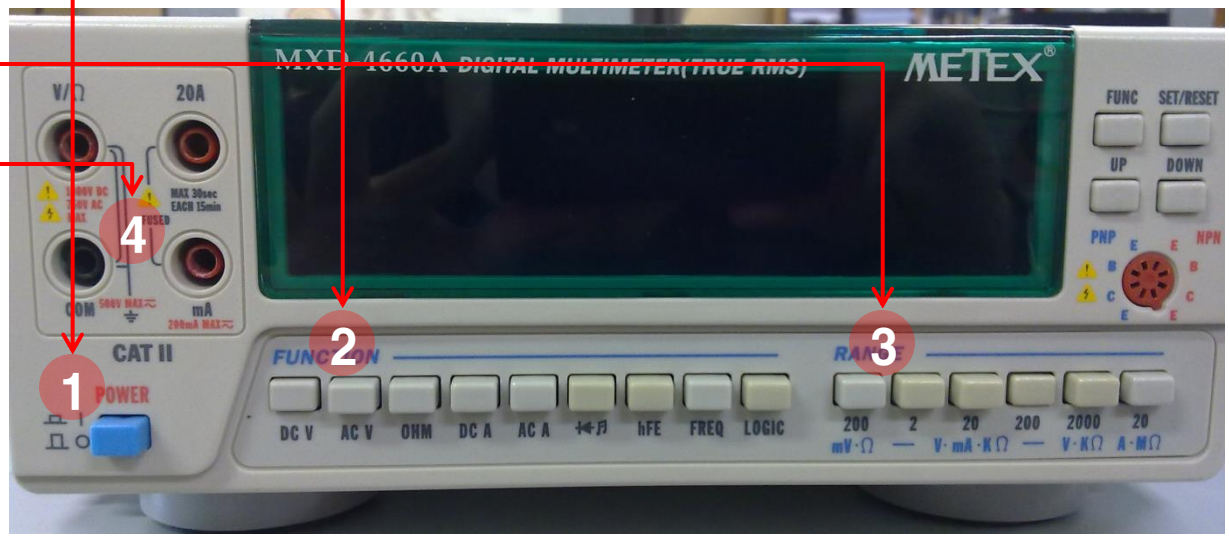
❖ 멀티미터(멀티테스터, 볼트/옴 미터 혹은 VOM)

- 여러가지의 측정 기능을 결합한 전자 계측기

❖ 스위치

- 전원 스위치
- 기능 선택 스위치
- 범위 선택 스위치

❖ 프로브 연결 위치



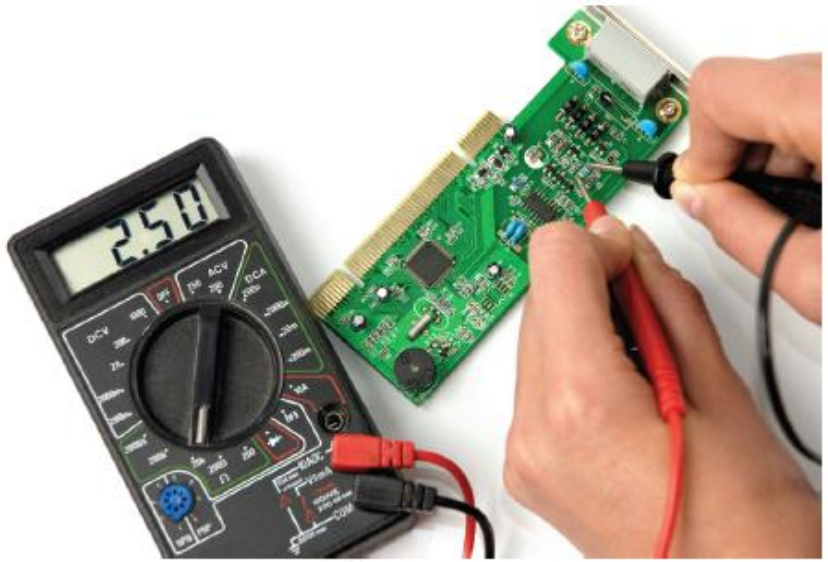
Measurement

- The three basic parameters that one may wish to measure in a circuit are voltage ,V, current, I, and resistance, R.
- The corresponding meters that can measures these parameters are the *voltmeter, ammeter, and ohmmeter* respectively.
- It is common these days to have a single meter that serves all three functions, called a multimeter.

Digital vs. Analog Multimeter

- **Multimeters come in two types: digital and analog.**
  - The digital meter converts the measured value to a digitized number and shows the value on a display.
  - The analog meter uses display the consists of a needle that moves across a calibrated meter. The needle points to the measured value.
- **Below are examples of both types of meter**

(a)



(b)

Figure 2.26
(a) Analog multimeter; (b) digital multimeter.
(a) © iStock; (b) © Oleksy Maksymenko/Alamy RF

Voltmeter

- To measure voltage, the voltmeter/multimeter is connected across the element to be measured.
- This configuration is referred to as a parallel connection.

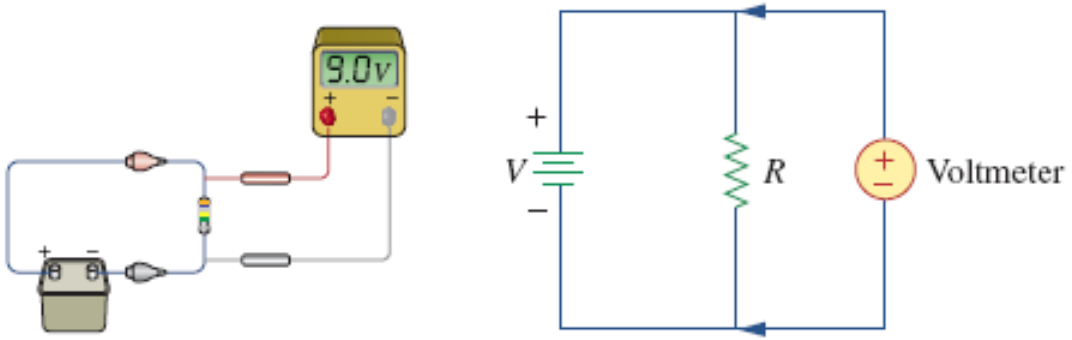


Figure 2.27
Measuring voltage.

Ammeter

- To measure current, the ammeter/multimeter is connected in series with the element.
- This means that the circuit must be “broken” in order to insert the meter.
- For a positive reading, current must enter the terminal marked as positive (+).

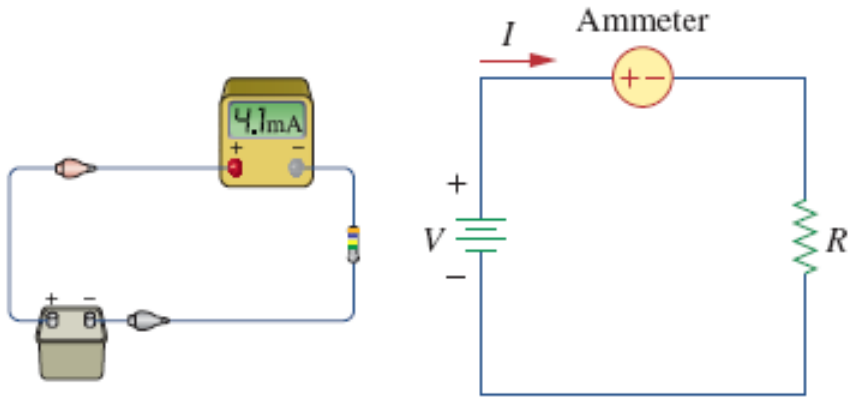


Figure 2.28
Measuring current.

Ohmmeter

- To measure resistance, the ohmmeter/multimeter must be connected across the element of interest.
- If this element is still connected within a circuit, the measured resistance may include other elements in the circuit.

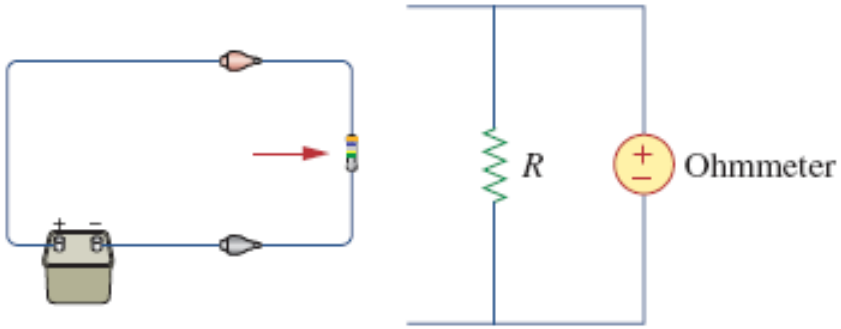


Figure 2.29
Measuring resistance.

Best Practices

- When working the any meter, it is best to follow these rules:

1. If possible, turn the circuit off before connecting the meter.
2. To avoid damaging the meter, set the range to the highest value first and turn it down as needed.
3. When measuring DC current or voltage observe proper polarity.

- When using a multimeter, make sure you set the meter in the correct mode (ac, dc, V, A, Ω), including moving the test leads to the appropriate jacks.
- When the measurement is completed, turn off the meter to avoid draining the meter's internal battery.

Safety

- When working on circuits, the possibility of electric shock is always present.
- The shock comes from current passing through your body.
- Depending on the amount of current, the effects can range from a tingling feeling to death.

TABLE 2.5

Electric shock

Electric Current	Physiological effect
Less than 1mA	No sensation or feeling
1 mA	Tingling sensation
5–20 mA	Involuntary muscle contraction
20–100 mA	Loss of breathing, fatal if continued

DC/AC Circuit Construction and Measurement

❖ Experiment Sequence

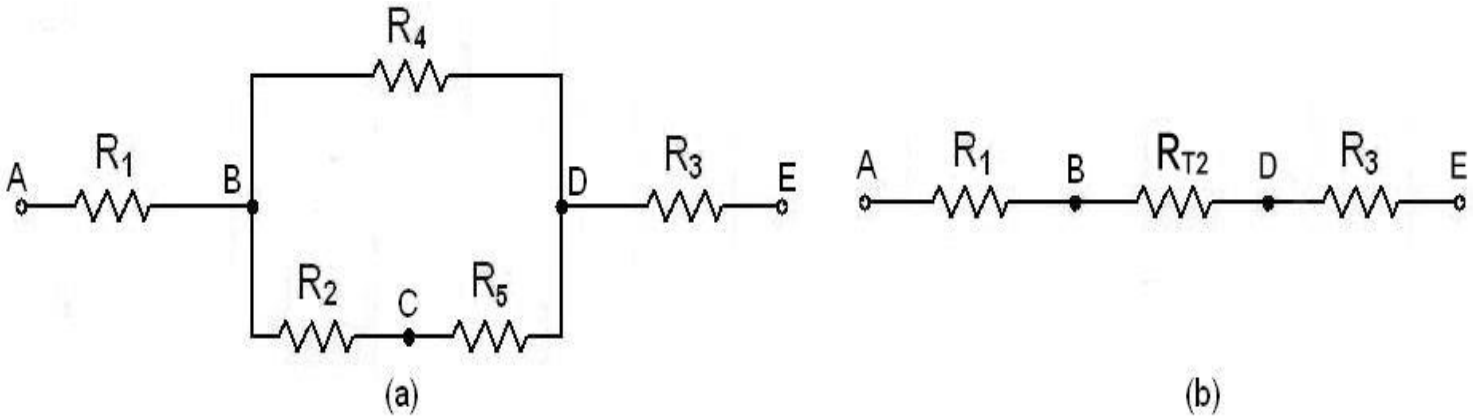
① Calculation of Resistance Value of a Resistor using Ohm's Law

② Measuring Resistance of a Resistor using a Multimeter

③ Constructing a Circuit on a Bread Board

④ Measuring Composite Resistance, Voltage and Current in the Circuit.

① Problems about Ohm's Law



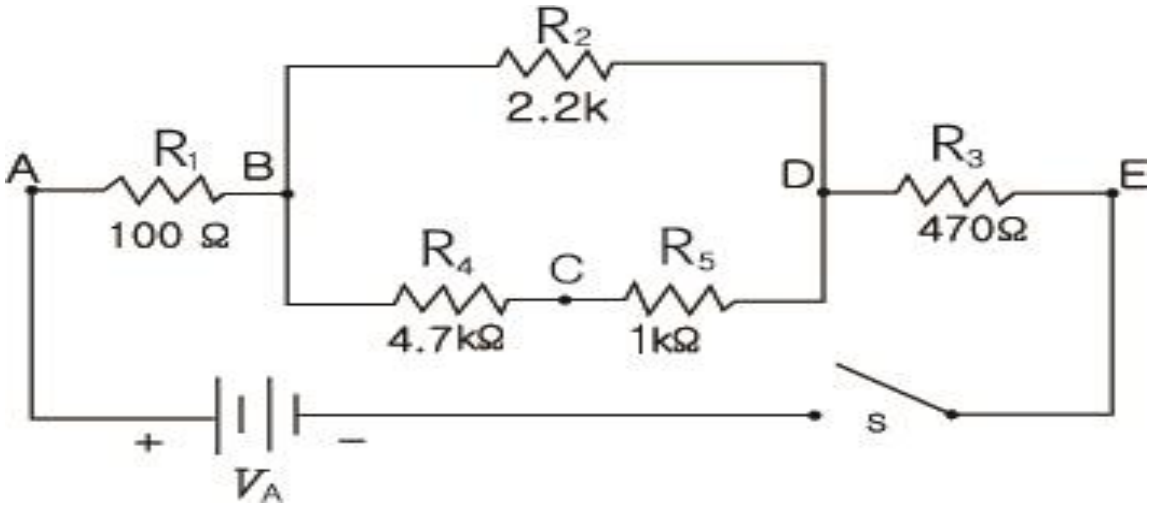
❖ What is the value of composite resistance R_{T2} between B and D ?

❖ What is the total value of composite resistance R_T between A and E ?

②, ③ Resistance Measurement and Circuit Construction

② Measure the resistance values of 100Ω, 470Ω, 1kΩ, 2.2kΩ, 4.7kΩ resistors in the following circuit diagram with a multimeter, then write the measured values in the table below. (PLMS LAB 3-1)

③ Construct a circuit according to the following circuit diagram on a Bread Board.



	R_1	R_2	R_3	R_4	R_5
Nominal	100Ω	2.2kΩ	470Ω	4.7kΩ	1kΩ
Measured					

Lab.3-1

④ Measuring Composite Resistance, Voltage and Current in a Circuit

1) Power off, then measure composite resistance R_{T2} between B and D
2) Power off, then measure composite resistance R_T between A and E
3) Connect 10V power source to the circuit
4) Measure the total voltage and the voltage across each resistor
5) Measure the total current I_T, current I_2 through R_2 and current $I_{4,5}$ through R_4 and R_5
6) Calculate resistance, voltage and current with Ohm's Law
7) Write both measured values and calculated values in the table below

1) Insert measured values in PLMS LAB 3-1, calculated values in Quiz 3-3

	R_{T2}	R_T	V_A	V_{AB}	V_{BC}	V_{CD}	V_{BD}	V_{DE}	V_{AE}	I_T	I_2	$I_{4,5}$
Calculated												
Measured												

디지털 출력

Arduino Digital I/O & Functions

❖ Arduino Digital I/O

- Arduino에서는 Digital Pin들에 들어오는 전압(0V~5V)을 읽거나 쓸 수 있음
- Digital이므로 쓰이는 값은 on(=5V, HIGH), off(=0V, LOW) 두 가지
- Digital Pin에서 값을 읽고 쓸 때 사용하는 함수 : digitalRead(), digitalWrite()
- Digital Pin은 입력 또는 출력 중 하나의 모드로 동작, 이를 조절하는 함수 : pinMode()

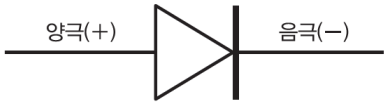
❖ Arduino Digital I/O Functions

- pinMode(pin, mode)
  - Configures the specified pin to behave either as an input or an output.
  - Parameters :
    - pin: the number of the pin whose mode you wish to set
    - mode: INPUT, OUTPUT, or INPUT_PULLUP
  - Returns : Nothing
- digitalWrite()
  - Write a HIGH or a LOW value to a digital pin
  - Parameters :
    - pin: the pin number
    - value: HIGH or LOW
  - Returns : Nothing
- digitalRead()
  - Reads the value from a specified digital pin, either HIGH or LOW.
  - Parameters
    - pin: the number of the digital pin you want to read
  - Returns : HIGH or LOW

LED (Light Emitting Diode)

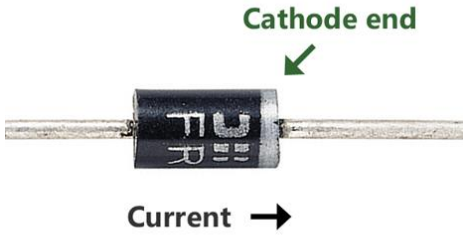
❖ 다이오드

- 양극에서 음극으로 순방향으로만 전류가 흐름



(a) 다이오드 기호

(b) 다이오드 외형



❖ LED : Light Emitting Diode, 발광 다이오드

- 순방향 연결에서 빛을 냄
- 화학물질에 따라 다양한 색상의 빛을 냄
- 리모컨의 적외선 LED, 살균 소독용 자외선 LED 등도 존재
- 데이터 핀에 연결하여 비트 단위 데이터 확인

(a) LED 기호

(b) LED 외형

Lab.3-2

Digital Output

❖ Experiment Sequence

① The Basic Functions for Digital I/O (Sketch 5-1, Textbook pp. 84)

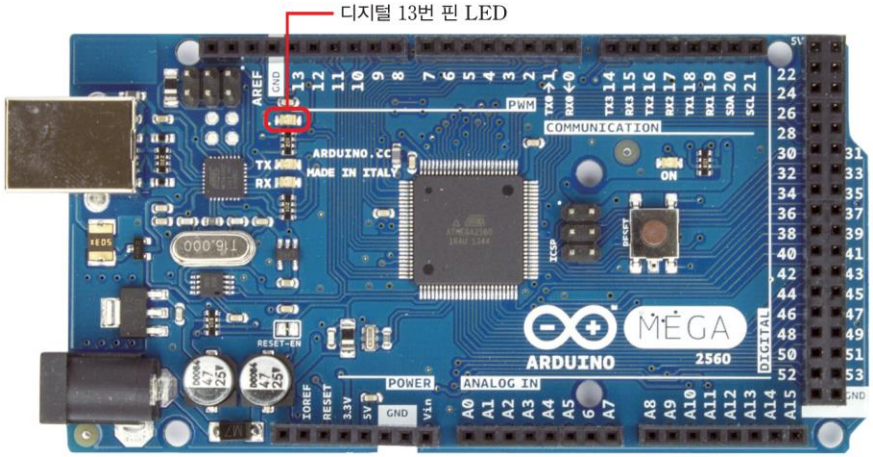
② Constructing the Circuit Connecting 4 LEDs on a Bread Board

③ Turning on 4 LEDs in Order (Sketch 5-2, Textbook pp. 86~87)

④ Check the Results

① The Basic Functions for Digital I/O

- Sketch 5-1, Textbook pp. 84
- #13 Digital Pin
  – Connected to embedded LED
- pinMode(), digitalWrite()
- delay(ms)



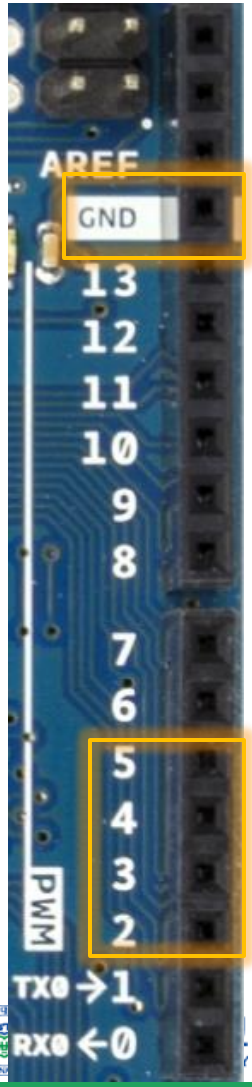
- Pauses the program for the amount of time (in milliseconds) specified as parameter

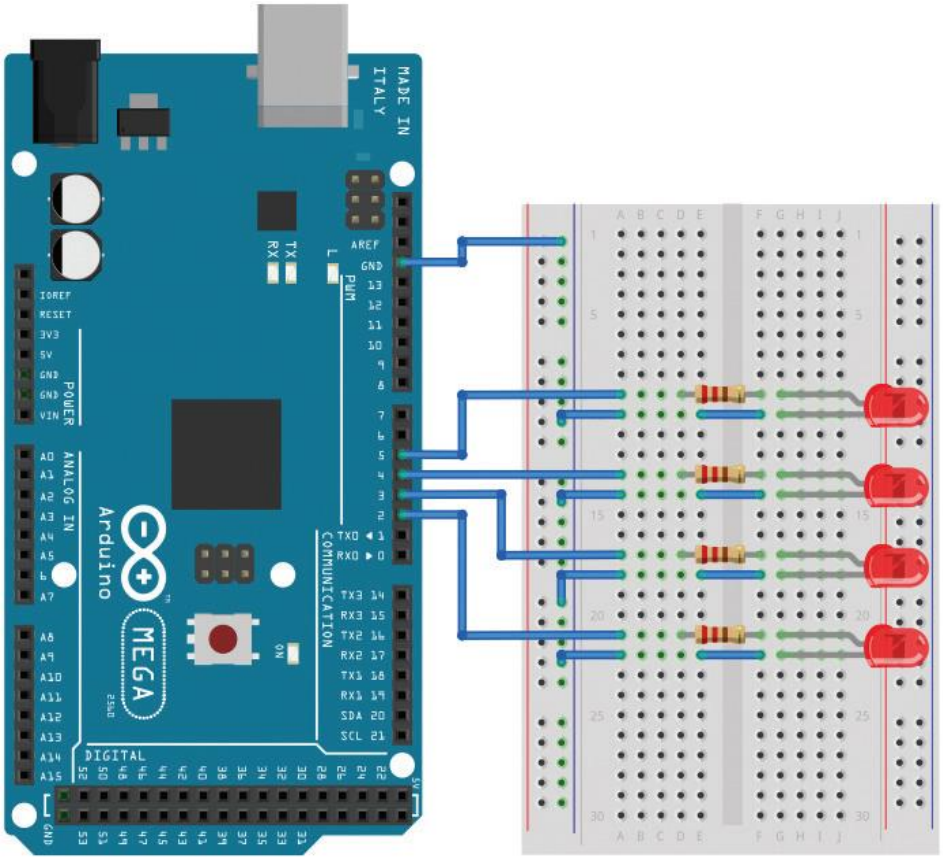
```
int led = 13;                          // Pin number for Digital I/O

void setup() {
    pinMode(led, OUTPUT);              // Sets the Digital Pin 13 as output
}

void loop() {
    digitalWrite(led, HIGH);           // Sets the digital pin 13 HIGH (1 or ON)
    delay(1000);                       // Waits for a second (1000ms)
    digitalWrite(led, LOW);            // Sets the digital pin 13 LOW (0 or OFF)
    delay(1000);                       // Waits for a second (1000ms)
}
```

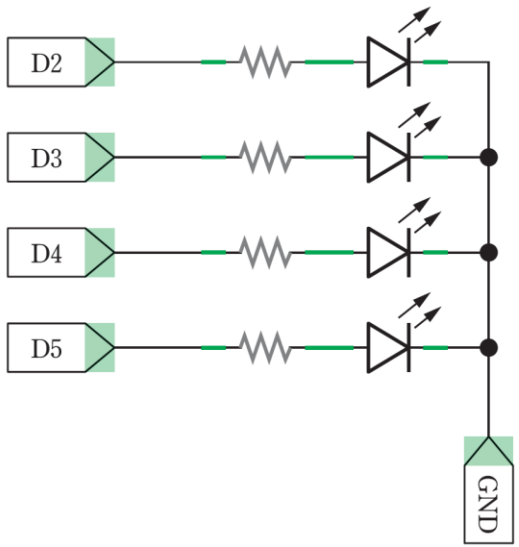
Lab.3-2

② Constructing the Circuit Connecting 4 LEDs on a Bread Board

- Connect 4 LEDs to Digital Pin #2~#5 and GND







③ Sketch for Turning on 4 LEDs in Order

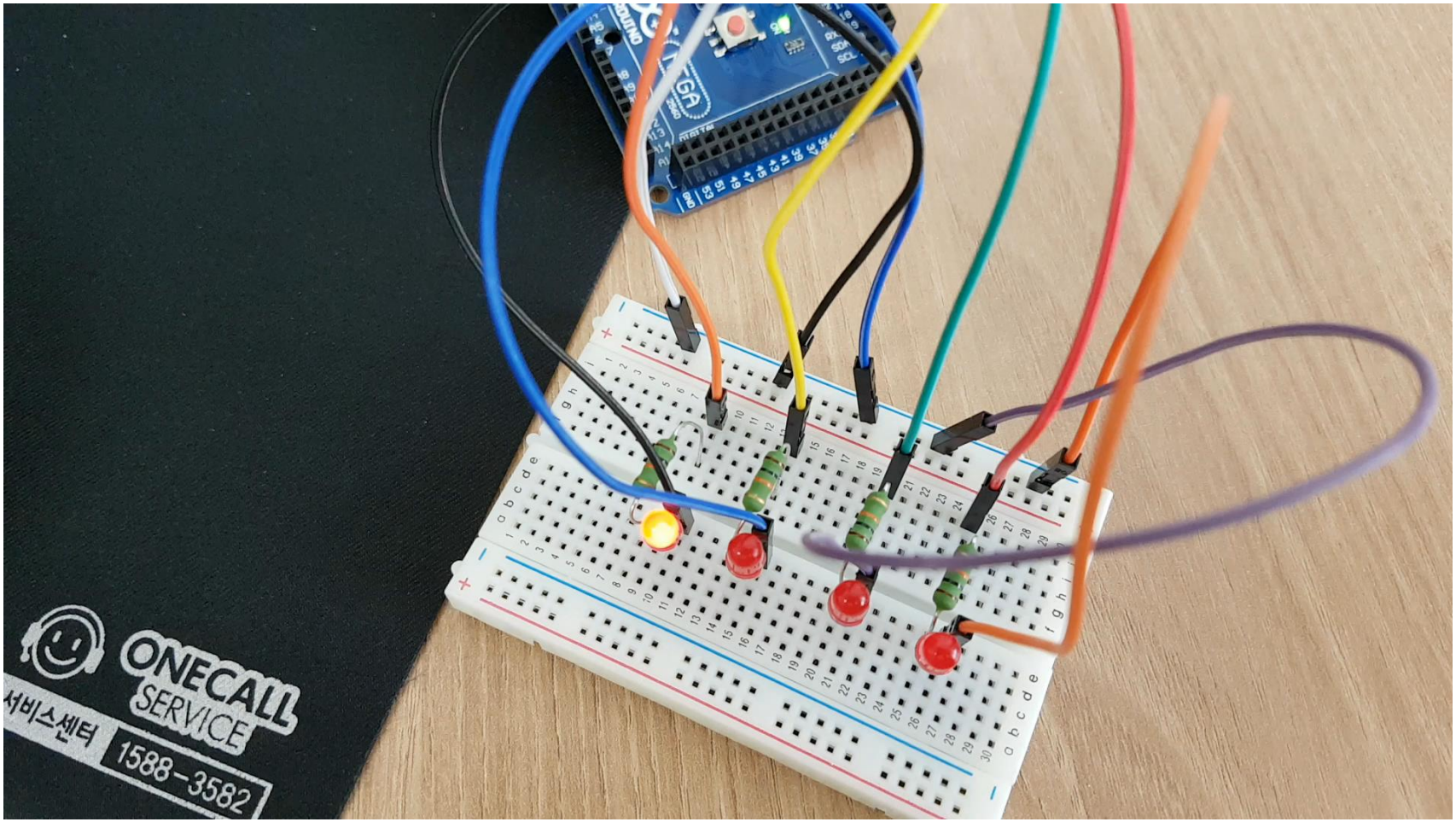
❖ Turning on 4 LEDs in order (Sketch 5-2, Textbook pp. 86~87)

```
int pins[] ={2,3,4,5};                  // Digital pins connected to LEDs
int state = 0;                          // Index for LED turned on currently

void setup() {
  Serial.begin(9600);                   // Sets the data rate for serial trans.
  for (int i = 0; i < 4; i++) {
    pinMode(pins[i], OUTPUT);           // Sets the Digital Pins as output
    digitalWrite(pins[i], LOW);         // Turn off LEDs initially
  }
}
```

```
void loop() {
  for (int i = 0; i < 4; i++) {
    if (i==state) {                     // Turn on just one LED
      Serial.print("O ");
      digitalWrite(pins[i], HIGH);
    } else {                            // Turn off the others
      Serial.print("X ");
      digitalWrite(pins[i], LOW);
    }
  }
  Serial.println();
  state = (state+1) %4 ;                // Switch to the LED turned on next
delay(1000);                            // Waits for a second
}
```

④ Check Results

1. Show your Sketch code and how it works
2. Answer to TA's questions and insert the score result to PLMS LAB 3-2



맺는말

❖ ATmega2560 µC

- CPU 내부에서는 8비트 단위로 데이터를 처리하지만
- 외부 연결에서는 Digital Pin을 통해 1비트 단위로 송수신

❖ Digital Pin을 통한 Digital Data 출력

- digitalWrite 함수로 비트 단위 출력이 가능하지만
- pinMode 함수로 출력으로 사용할 것임을 먼저 지정해야 함

❖ 의미 있는 단위, 즉, 바이트 이상의 데이터 송수신을 위해서는

- 비트 단위의 데이터를 연속적으로 전송하는 시리얼 통신이 사용됨
- 대표적인 시리얼 통신에는 UART, SPI, I2C 등이 있음

HW.3

Homework

❖ Practice 5.3 (Textbook pp.53)

- Write a Sketch code to turn on 4 LEDs repeatedly according to the patterns described in the table below. Notice that you have to create the patterns by using calculation, not pre-defined manner.

Patterns	Digital Pin			
	2	3	4	5
1				
2				
3				
4				
5				
6				

❖ 제출 방법

1. Insert your Sketch code to HW3 of PLMS.
2. Also, submit a link to a video recording the result of your work.

```
int pattern=1, shift;
if (index<4) shift = index;
else shift = 6-index;

for (int i=0; i<shift; i++)
  pattern = (pattern << 1) | 0x01;
```