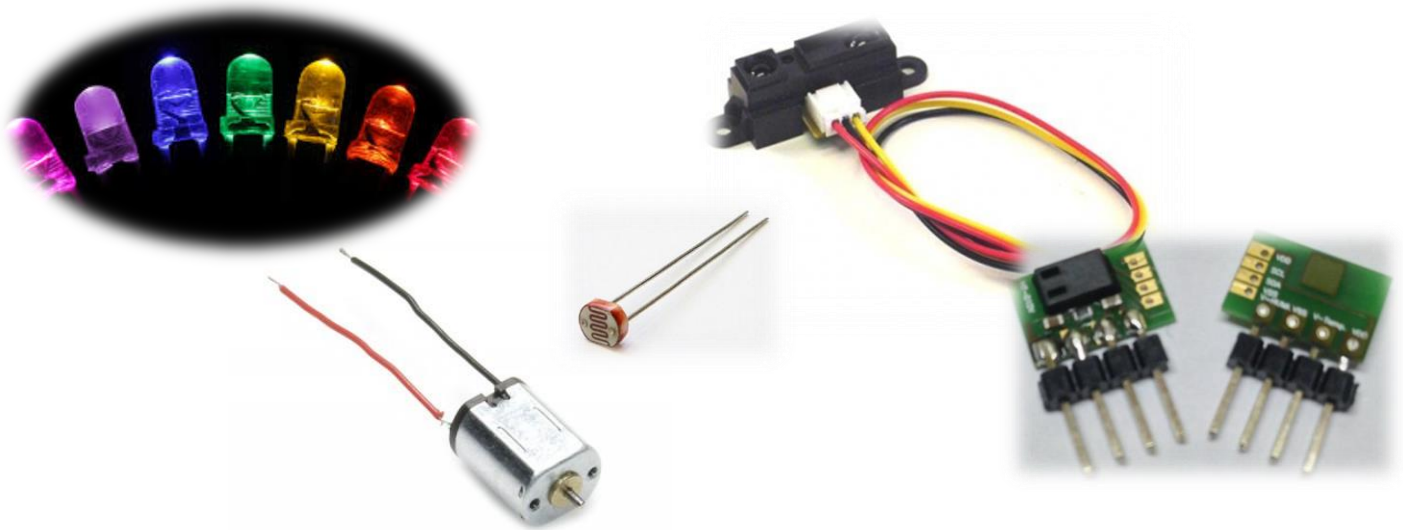
Ⅱ. ARTIK 기술 교육

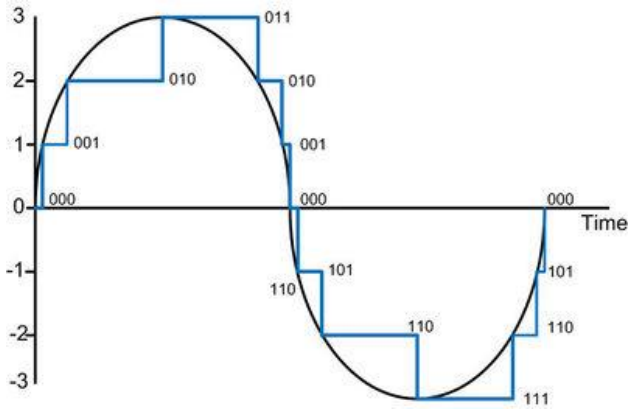
3. Analog Control(1)



Analog / Digital Converter

■ ADC(Analog/Digital Converter)

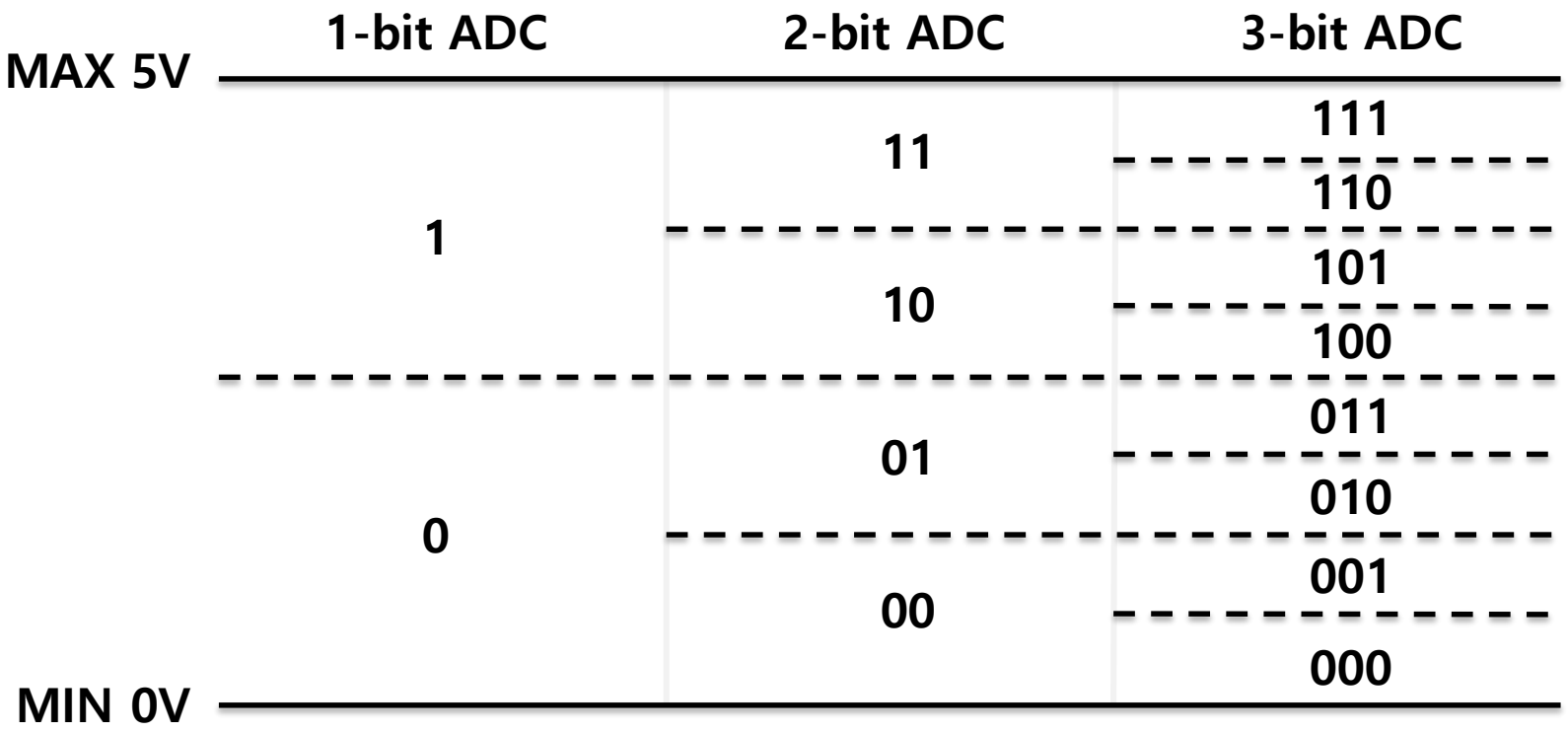
- An apparatus that converts an analog signal (sensor) to digital data (computer, MCU, etc.)
- Depending on the range of the physical quantity to be measured and the application purpose of the system, the one with the appropriate resolution and precision is used.
- Resolution
  - Minimum change of analog input to change digital output value by one class
  - Minimum analog amount that the ADC can represent
  - The minimum data range of the output is $1/2^n$, in case of n-bit ADCs
- Conversion time
  - Time required to perform A / D conversion
  - Expressed in terms of sampling rate per second



Analog / Digital Converter

■ ADC example

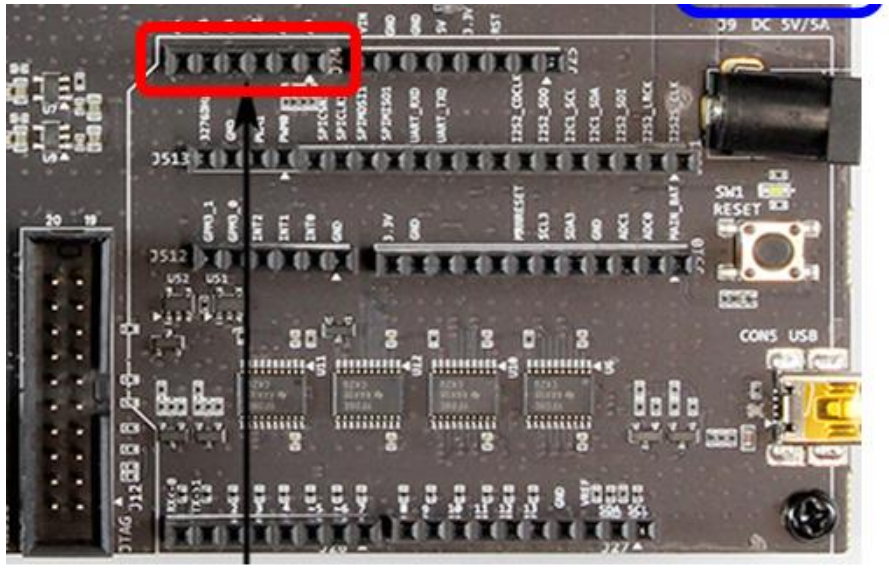
- The ADC interface of ARTIK 520 converts the analog input signal into 12-bit binary code.



ADCs in ARTIK

■ ADC pins

- J24[A0] (Analog input 0)
- J24[A1] (Analog input 1)



(1) ARTIK5 Board

Header J24 (analog inputs)

PIN [SILKSCREEN]	MAPPING
J24[A0]	Analog input 0
J24[A1]	Analog input 1

(2) ARTIK5 Pin mapping(J24)

List of examples

Photoresistor(CdS) example

- Using C compiler

Infrared(IR) sensor example

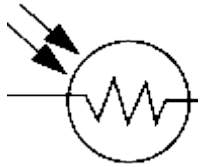
- Using Linux command line
- Using C compiler

Humidity/Temperature sensor example

- Using C compiler
- Using Arduino IDE

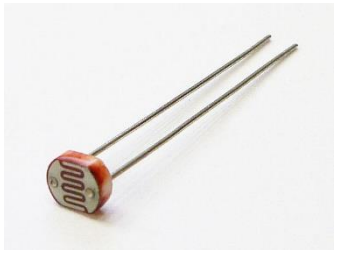
Photoresistor (CdS)

■ Symbol of Photoresistor

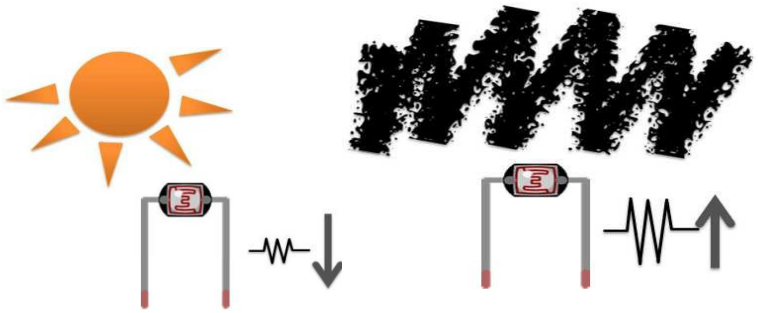


■ CdS Sensor

- A sensor varing with the intensity of the debt
- Features
  - The photoconductive sensor, which is an N-type semiconductor, diffuses resistance according to the illuminance because the electrons in the N-type semiconductor become free electrons when the light energy is received.
  - Small diameter CdS has a smaller illuminance measurement range
  - The allowable operating temperature range is-30 ~ +60 ℃



(1) 조도센서(cds)

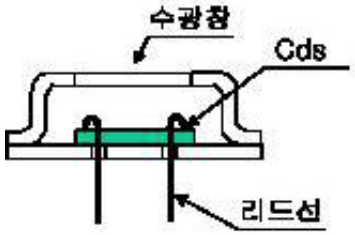


(2) 조도에 따른 저항값의 변화

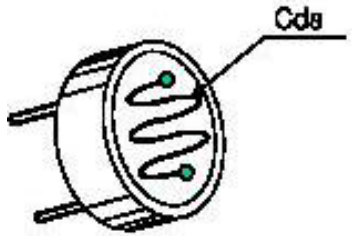
Photoresistor (CdS)

Structure of Photoresistor

- CdS is placed in a sealed container, and the light receiving window is made of transparent plastic or glass
- Two leads with no polarity



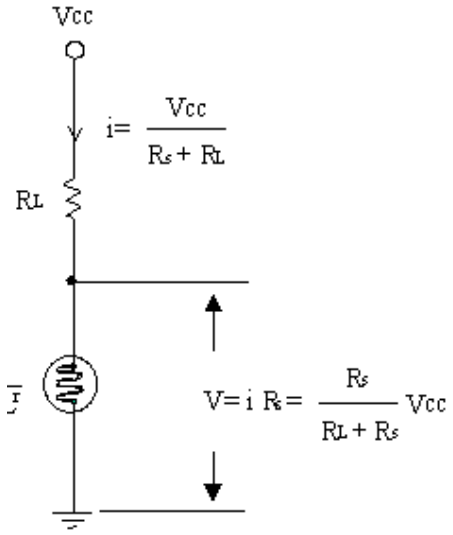
(1) CdS 의 구조



(2) CdS의 외형도

Output voltage

- The CdS resistance (R_s) decreases, the current Increases when light comes in.
- CdS resistance(R_s)and load resistance(R_L) is direct connection
- Current $i = \frac{V_{cc}}{R_S+R_L}$
- CdS voltage $V = \frac{R_S}{R_S+R_L}V_{cc}$



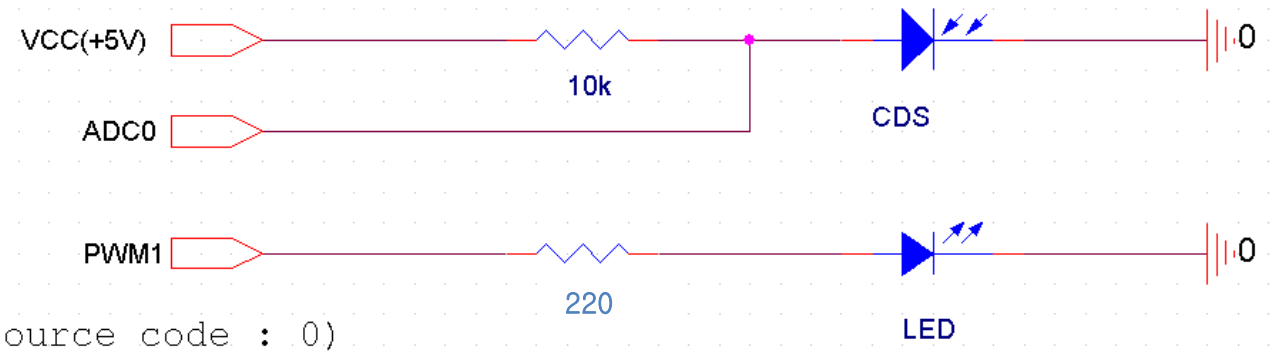
(3) CdS 회로도

C Compiler Example

Required Hardware

- ARTIK 5 beta developer kit
- Illuminance sensor (GL5528)
- LED
- 10K ohm resistor, 220 ohm resistor
- Breadboard
- Connector wires

Circuit Configuration



(Source code : 0)

(PWM Pin : 0)

C Compiler Example

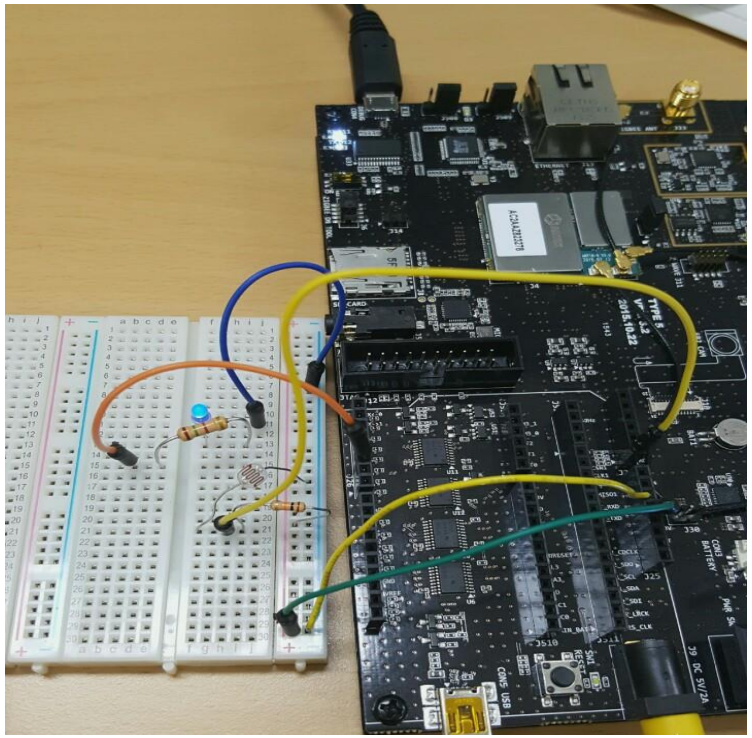
Source Code

```
#include <stdio.h>
#include <stdlib.h>
#include <stdbool.h>

#define ANALOG_PIN 0          // A0
#define PWM_PIN 0
#define PERIOD 1000000


int analogRead(int pin) {
   FILE * fd;
char fName[64];
char val[8];

// open value file
sprintf(fName,
                "/sys/devices/126c0000.adc/iio:device0/in_volt
age%d_raw", pin);
                fd = fopen(fName, "r");
                if (!fd) {
                                printf("Error: can't open analog
voltage value₩n");
                                return -1;
                }

                fgets(val, 8, fd);
                fclose(fd);
                return atoi(val);
}
```

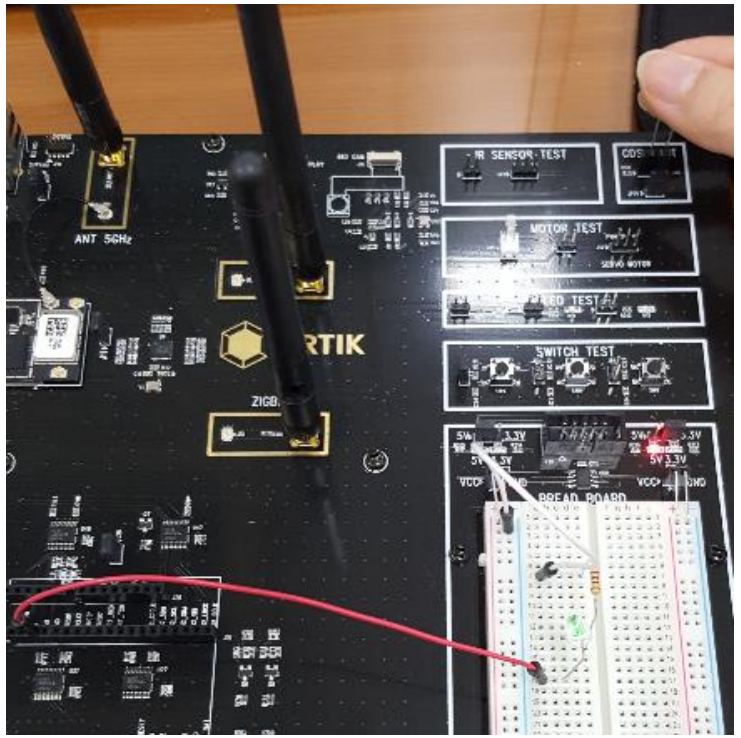
```
int testSensor() {
                long SenVal = 0;
                int i;
                for (i = 0; i < 10; i++) {
                                SenVal =
analogRead(ANALOG_PIN);
                                if (SenVal == -1) return -1;
                                printf("Voltage_raw: %d ------
--- %d₩n", SenVal, 10-i);
                                sleep(1);
                }
                return 0;
}

int Con_duty(int duty)
{
   pwmPin(0, PERIOD, duty, 1);
}

int main(void) {
   long SenVal = 0;

   while(1) {
      SenVal = analogRead(ANALOG_PIN);
      printf("val : %d₩n", SenVal);

      if(SenVal > 900) { Con_duty(1000000); }
      else if((SenVal <= 900) && (SenVal > 700))
{Con_duty(800000); }
      else if((SenVal <= 700) && (SenVal > 500))
{Con_duty(600000); }
   }
}
```

C Compiler Example

■ Execution result



ARTIK 520

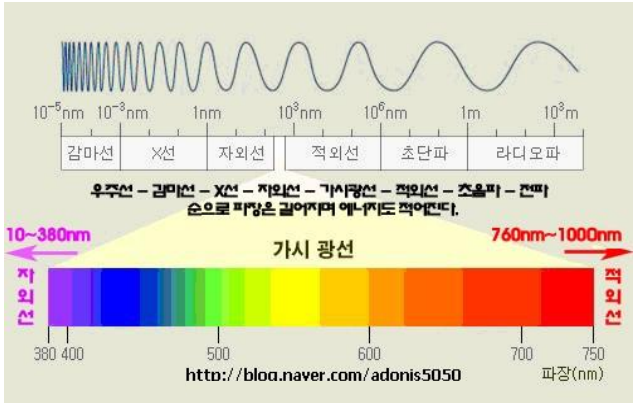


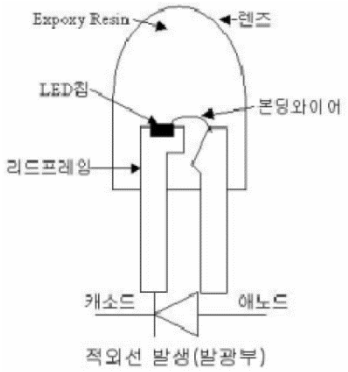
PS-ED500

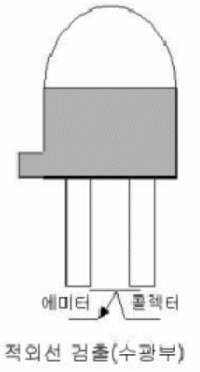
Infrared(IR) Sensor

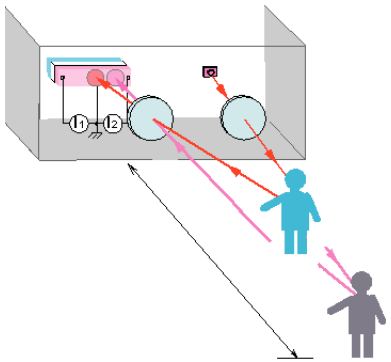
■ Infrared(IR) Sensor

- A device that detects physical quantities and stoichiometries such as temperature, pressure, and intensity of radiation using infrared rays and converts them into electrical quantities capable of signal processing
- In general, conversion formula is needed to measure physical quantities by sensors.
- Sending-light part : Emits light of a certain frequency
- Receiving-light part : Detect diverging light
- Sending-light part → Reflection on an object → Receiving-light part ⇒ Confirm the object existence and calculate the distance



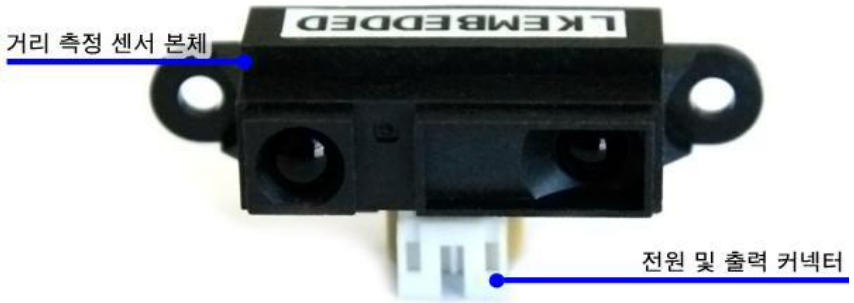


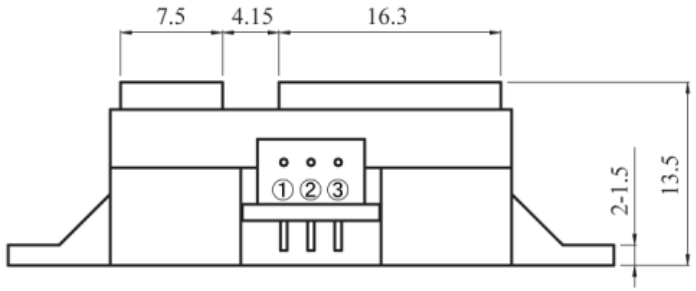




Infrared(IR) Sensor

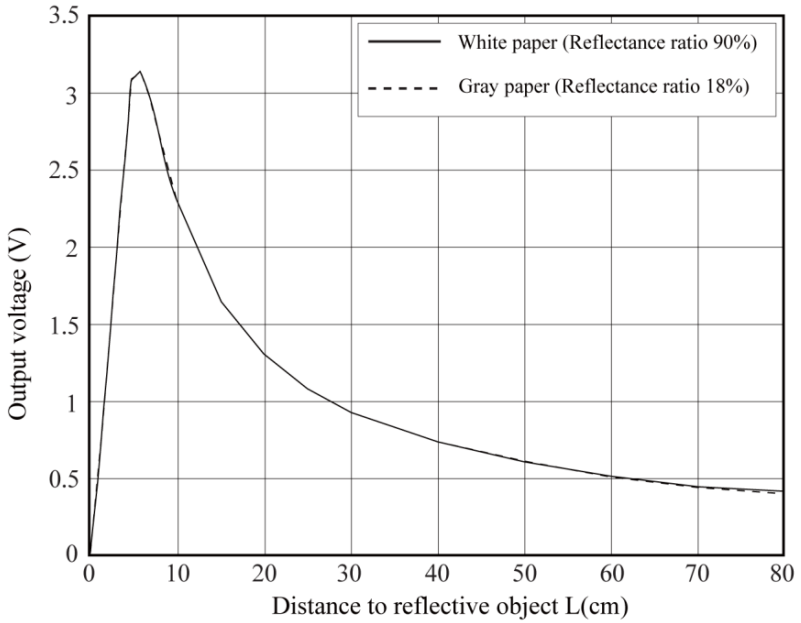
■ Infrared(IR) Sensor





Connector signal

	signal name	케이블 색상
①	Vo	노란색
②	GND	검정색
③	Vcc	빨간색

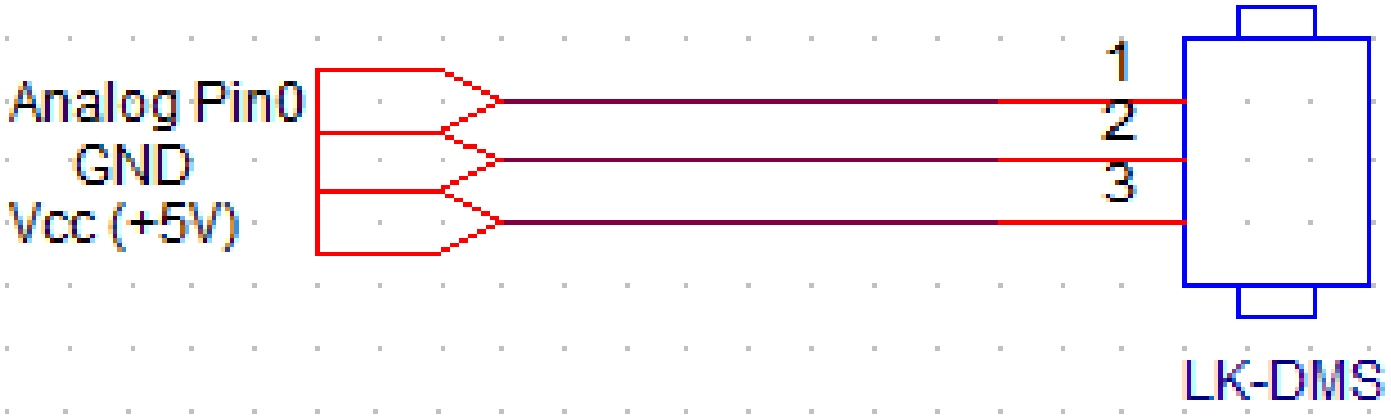


Using Command Line

Required Hardware

- ARTIK 5 beta developer kit
- IR sensor (LK-DMS)
- Breadboard
- Connector wires

Circuit Configuration



Using Command Line

Command

- Read a raw voltage from ADC0 of ARTIK 520
  - *cat /sys/devices126c0000.adc/iio:device0/in_voltage0_raw*
- Read a raw voltage from ADC1 of ARTIK 520
  - *cat /sys/devices126c0000.adc/iio:device0/in_voltage1_raw*

```
[root@localhost ~]# cat /sys/devices/126c0000.adc/iio:device0/in_voltage0_raw
2074
[root@localhost ~]# cat /sys/devices/126c0000.adc/iio:device0/in_voltage0_raw
2029
```

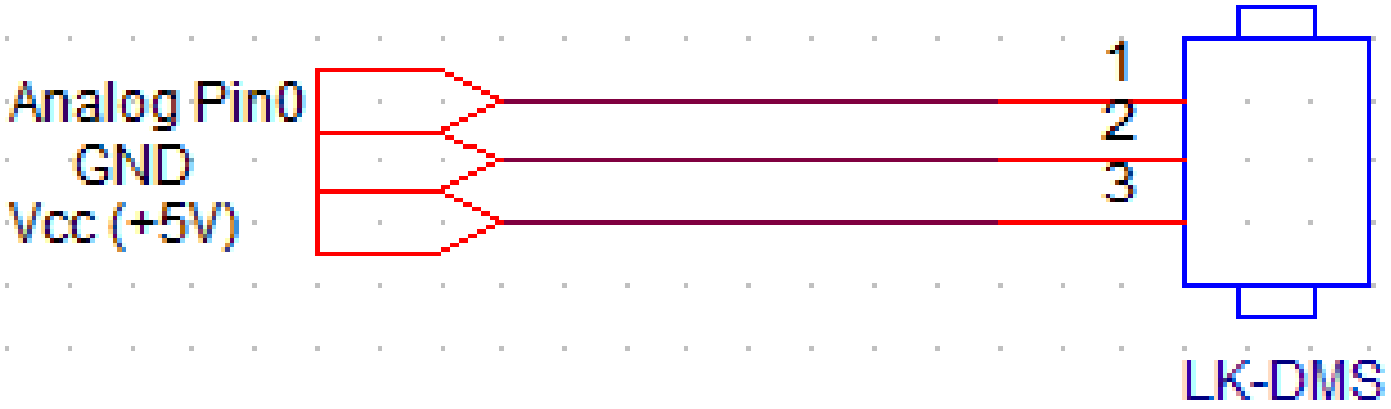
- It returns a raw measurement value, so you should convert it to a voltage measurement. The equation :
  - (Voltage) = (in_voltage X_raw)*0.439453125 [mV], for ARTIK module
  - (Voltage) = (in_voltage X_raw)*0.439453125*2 [mV], for ARTIK development board

C Compiler Example

Required Hardware

- ARTIK 5 beta developer kit
- IR sensor (LK-DMS)
- Breadboard
- Connector wires

Circuit Configuration



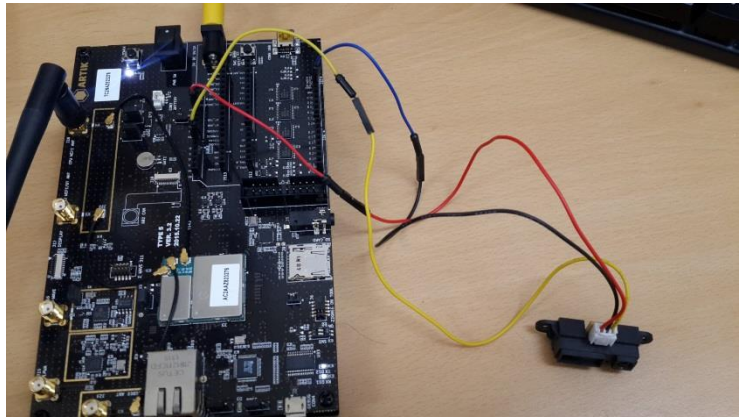
C Compiler Example

■ Source Code

```
#include "wiringARTIK.h"

#define ANALOG_PIN 0    // A0

int main(void) {
    int SenValue = 0;

    while(1) {
        SenValue = analogRead(ANALOG_PIN);
        printf("val : %d₩n", SenValue);
    }
}
```

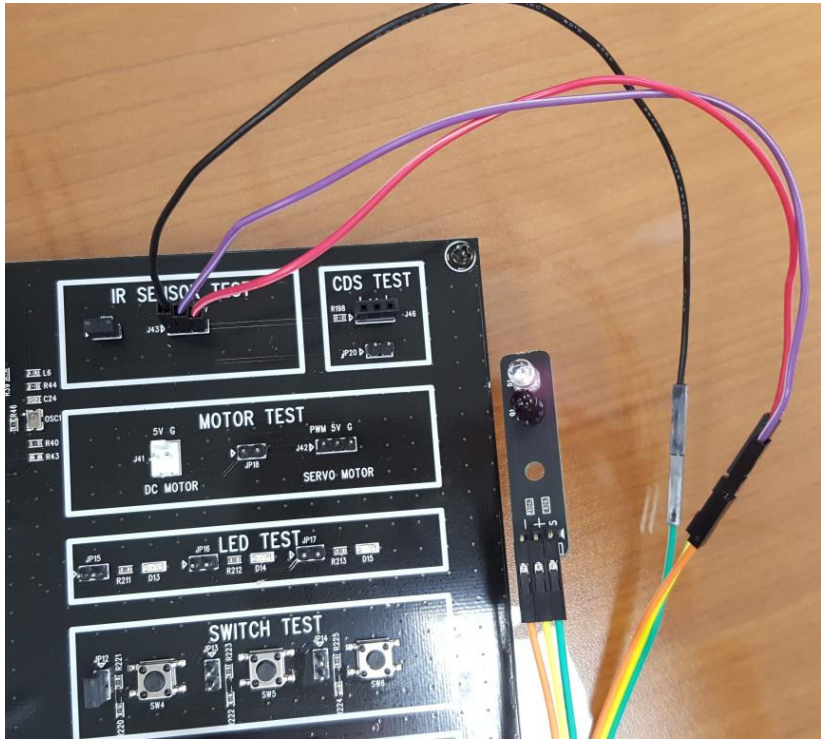
C Compiler Example

■ Execution result



Red – 5V, Black – GND, Yellow – A0

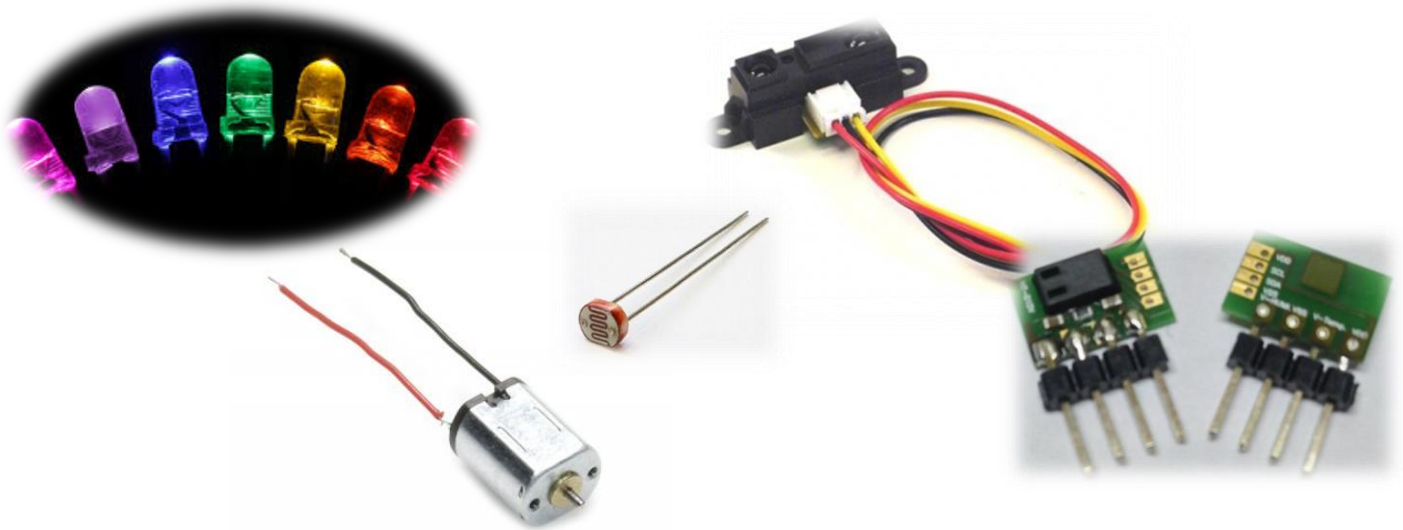
ARTIK 520



PS-ED500

Ⅱ. ARTIK 기술 교육

4. Analog Control(2)



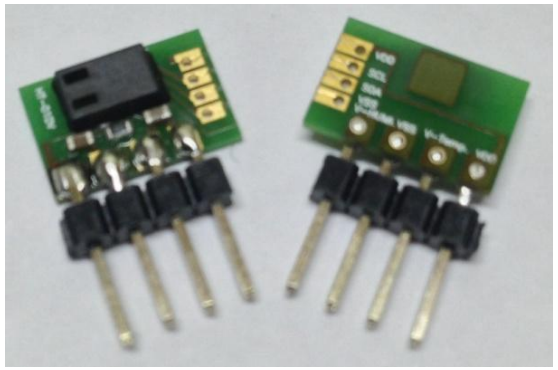
Humidity/Temperature Sensor

■ Humidity/Temperature sensor

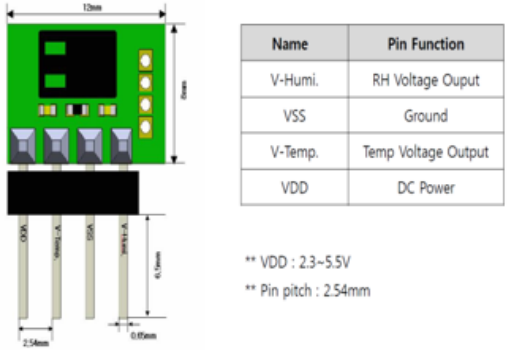
- Humidity sensor :Use the react to humidity and the influence of electric current flow
- Temperature sensor : Use a thermal resistor whose resistance varies with temperature
- Humidity/Temperature sensor : Modular product with temperature sensor and humidity sensor on one board

■ HT-01DV & ETH-01DV

- Integrated sensor of capacitive humidity sensor and band gap temperature sensor
- Convert digital measurement to voltage and output



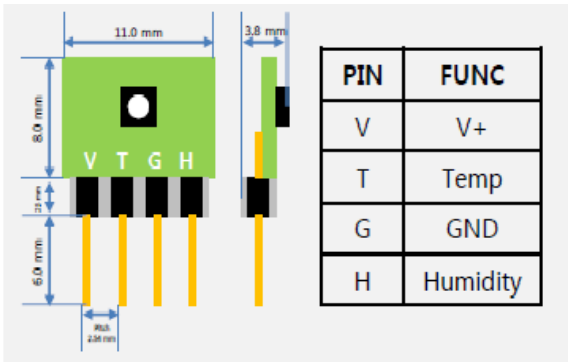
(1) 온/습도 센서(HT-01DV)



Name	Pin Function
V-Humi.	RH Voltage Ouput
VSS	Ground
V-Temp.	Temp Voltage Output
VDD	DC Power

** VDD : 2.3~5.5V
** Pin pitch : 2.54mm

(2) 온/습도 센서(HT-01DV) Pin



PIN	FUNC
V	V+
T	Temp
G	GND
H	Humidity

(3) 온/습도 센서(ETH-01DV) Pin

Humidity/Temperature Sensor

■ HT-01DV specifications

▪ Specifications

항목		상대습도			온도		
		Min	Typ	Max	Min	Typ	Max
Resolution			14 bit			14 bit	
Operating Range		0		100%RH	-40 ℃		120 ℃
Accuracy	Typical		±2.5%RH			±0.5 ℃	
	Maximal		Fig. 1 참조			Fig. 2 참조	
Hysteresis			< ±1.5%RH			n/a	
Response Time			10 sec		15 sec		25 sec

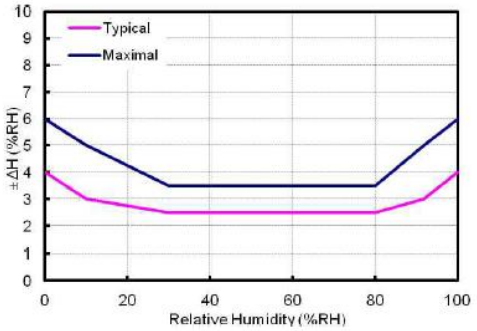


Fig.1

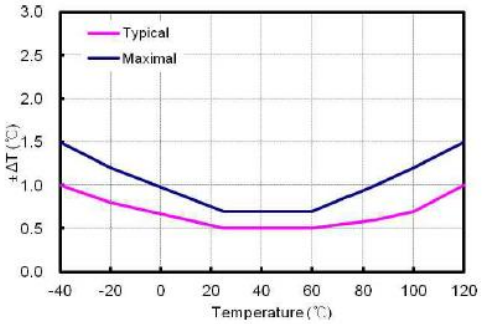
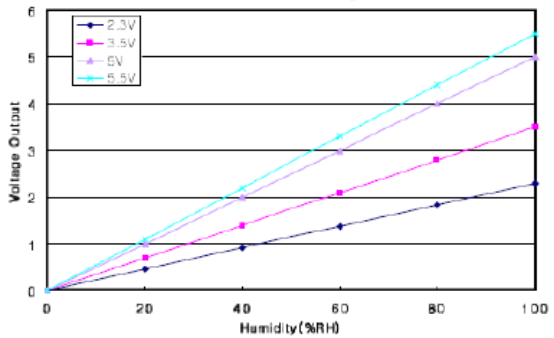


Fig.2

▪ Signal output

- Change the analog input data to the actual temperature / humidity unit

<Humidity Output>

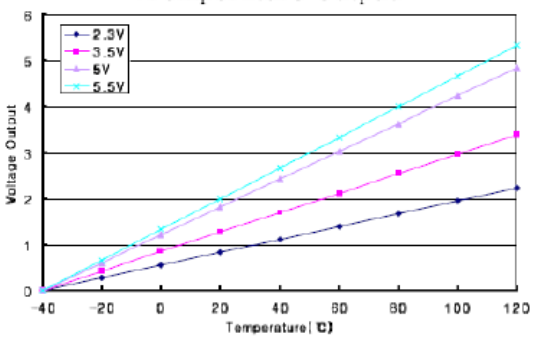


Equations

$V_{out} = (V_{in}/100) \times \%RH$

$\%RH = V_{out}/(V_{in}/100)$

<Temperature Output>



Equations

$V_{out} = (V_{in}/165) \times (℃+40)$

$℃ = V_{out}/(V_{in}/165)-40$

Humidity/Temperature Sensor

■ ETH-01DV specifications

▪ Specifications

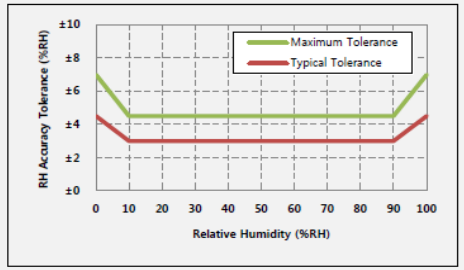
Humi Specifications

Range	0~100%RH
Accuracy (@ 25℃)	±3.0%RH(10 to 90%RH)
	±4.5%RH(Other Range)
Hysteresis	±0.8%RH @ 25℃
Resolution	14bit
Response time	time < 8s (τ63)

Temp Specifications

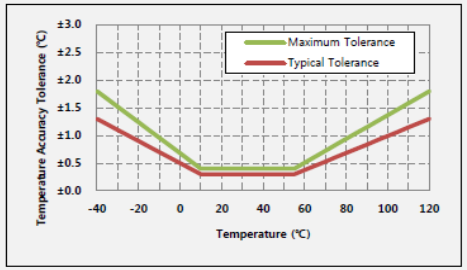
Range	-40~125℃
Accuracy	±0.3℃ (10 to 55℃)
	±1.3℃(Other Range)
Resolution	14bit
Response time	>2s (τ63)
Long term drift	< 0.03 ℃/yr

Tolerance



Tolerance of Relative Humidity @ 25℃

Fig.1



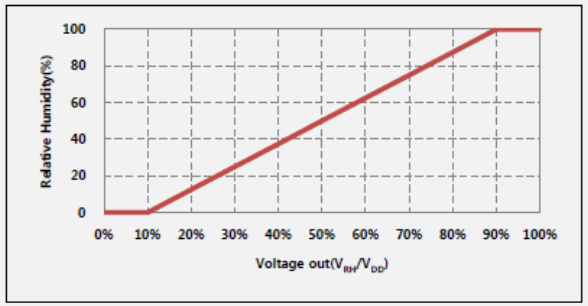
Tolerance of Temperature

Fig.2

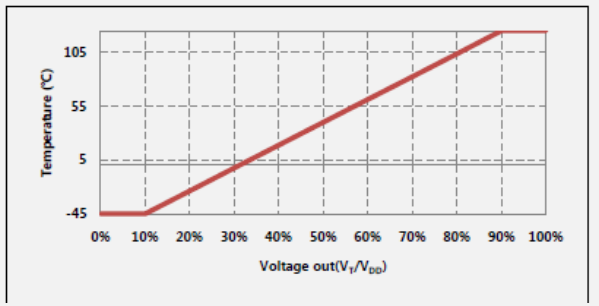
▪ Signal output

- Change the analog input data to the actual temperature / humidity unit

<Relative Humidity output>



<Temperature output>



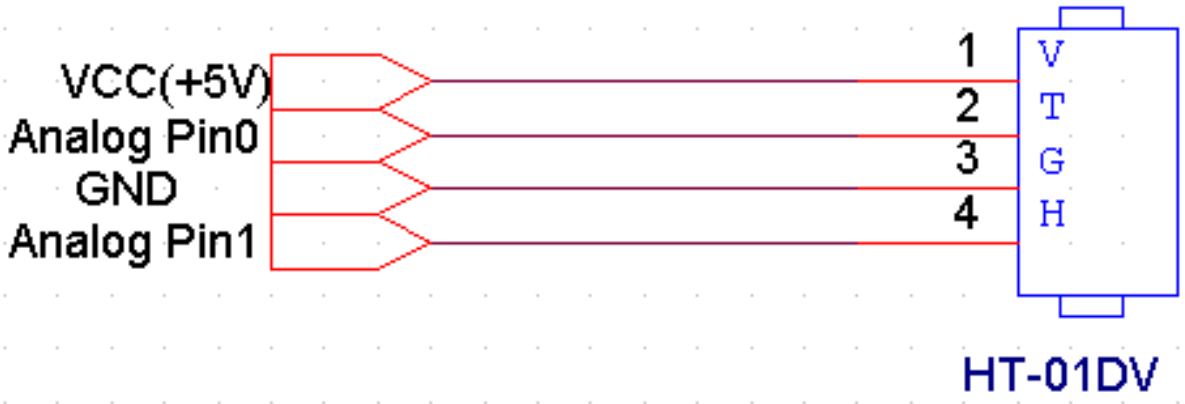
Changing point	HT-01DV	ETH-01DV
Output Formula	RH[%] = $(V_{RH} \div V_{DD}) \times 100$ T[℃] = $(V_T \div V_{DD}) \times 165 - 40$	RH[%] = $(V_{RH} \div V_{DD}) \times 125 - 12.5$ T[℃] = $(V_T \div V_{DD}) \times 217.75 - 66.875$

C Compiler Example

Required Hardware

- ARTIK 5 beta developer kit
- Humidity/Temperature sensor (HT-01DV)
- Breadboard
- Connector wires

Circuit Configuration



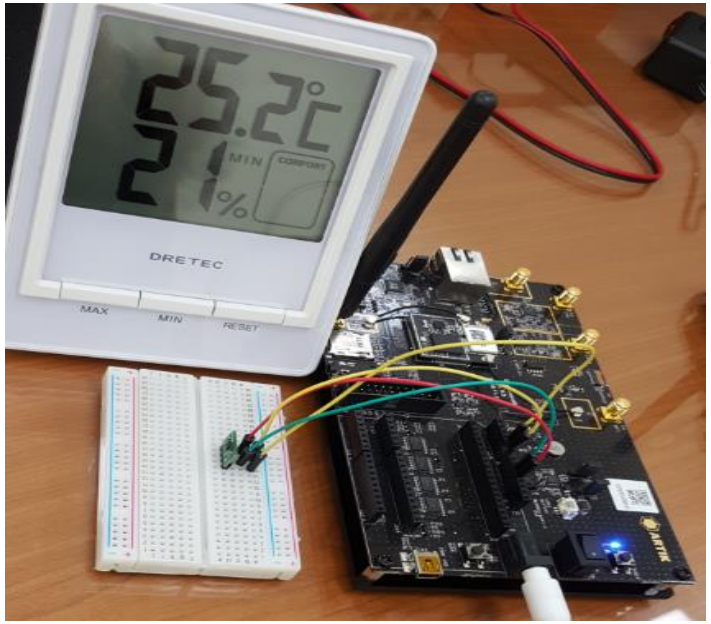
C Compiler Example

Source Code

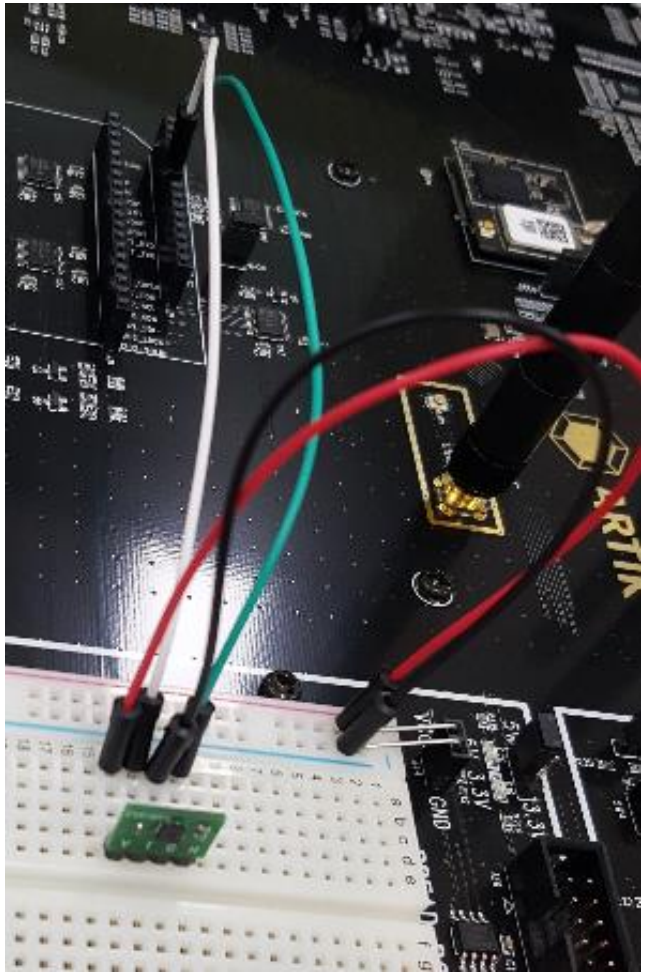
```
#include "wiringARTIK.h"

#define ANALOG_PIN0 0   // A0
#define ANALOG_PIN1 1   // A1

int main(void) {
        float SenVal1 = 0;
        float SenVal2 = 0;
        float vol1 = 0;  // temperature voltage
        float vol2 = 0;  // humidity voltage
        float tem = 0;
        float hum = 0;

        while(1) {
                SenVal1 = analogRead(ANALOG_PIN0);
                SenVal2 = analogRead(ANALOG_PIN1);

                vol1 = (SenVal1*0.439453125)*2;   // mV단위로 변환
                vol2 = (SenVal2*0.439453125)*2;

                tem = -66.875 + 218.75*(vol1/5000);
                hum = -12.5 + 125*(vol2/5000);

                printf("==================================₩n");
                printf("val1 : %2.2f | temperature : %2.2f₩n", SenVal1, tem);
                printf("val2 : %2.2f | humidity    : %2.2f₩n", SenVal2, hum);
                printf("==================================₩n");

                sleep(1);
        }
        return 0;
}
```

C Compiler Example

■ Execution result



ARTIK 520



PS-ED500

C Compiler Example

■ Execution result

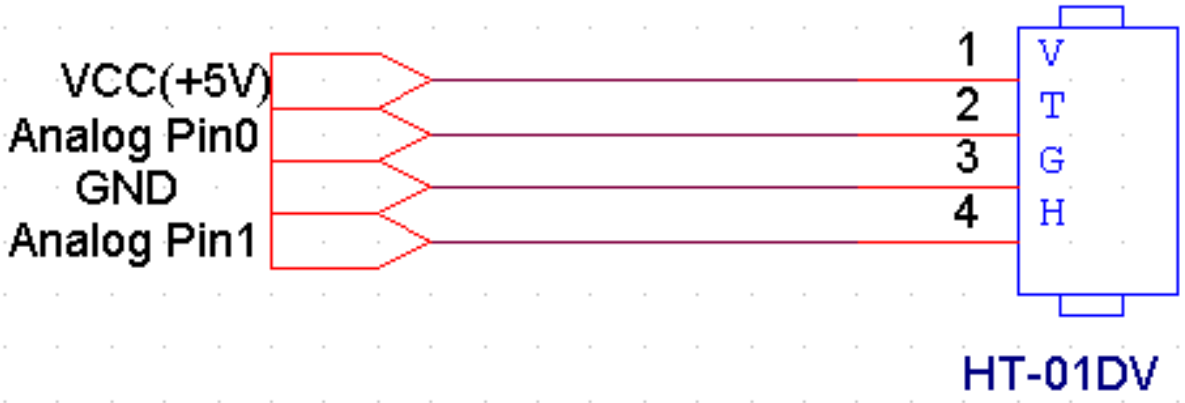
```
[root@localhost ~]# ./sensor
==================================
val1 : 2404.00 | temerature : 25.14
val2 : 1535.00 | humidity    : 21.23
==================================
==================================
val1 : 2404.00 | temerature : 25.14
val2 : 1531.00 | humidity    : 21.14
==================================
==================================
val1 : 2407.00 | temerature : 25.26
val2 : 1530.00 | humidity    : 21.12
==================================
==================================
```

Using Arduino IDE

Required Hardware

- ARTIK 5 beta developer kit
- Humidity/Temperature sensor (HT-01DV)
- Breadboard
- Connector wires

Circuit Configuration



Using Arduino IDE

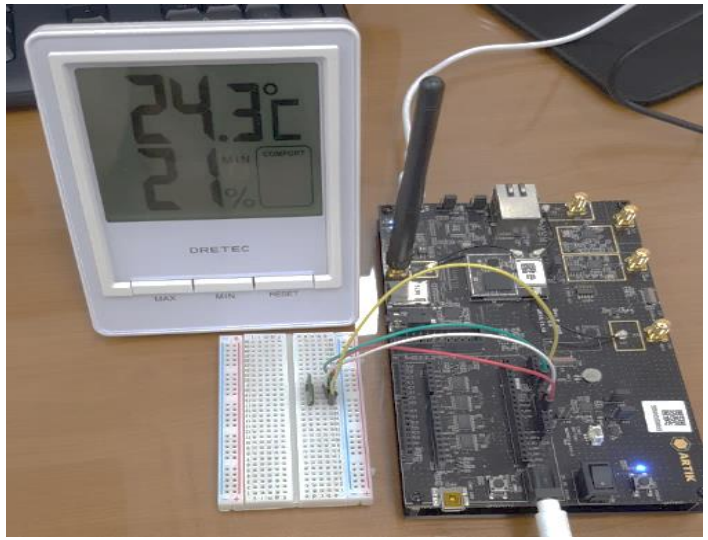
■ Arduino Source Code

HTSensor

```
#include <DebugSerial.h>

int voltage_raw0, voltage_raw1;
float voltage0, voltage1;
float temperature, humidity;

void setup() {
  DebugSerial.begin(9600);
}

void loop() {
  voltage_raw0 = analogRead(0);
  voltage_raw1 = analogRead(1);
  voltage0 = voltage_raw0*0.439453125*2;
  voltage1 = voltage_raw1*0.439453125*2;
  temperature = -66.875 + 217.75*(voltage0/5000);
  humidity = -12.5 + 125*(voltage1/5000);

  DebugSerial.print("Temperature : ");
  DebugSerial.println(temperature);
  DebugSerial.print("Humidity : ");
  DebugSerial.println(humidity);
  delay(5000);
}
```

Using Arduino IDE

■ Execution result



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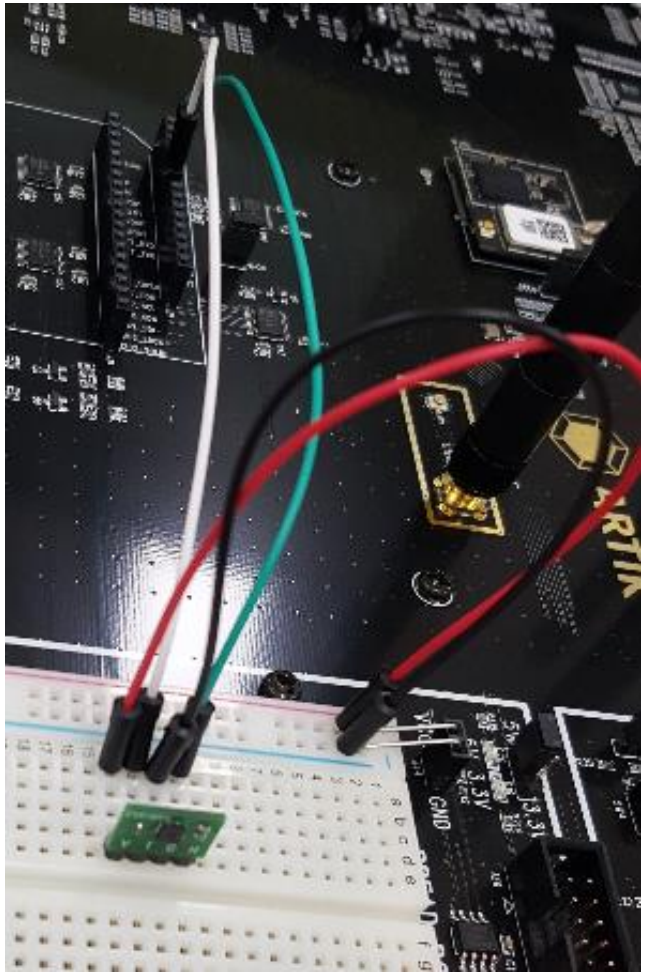
```
Temperature : 24.34
Humidity : 21.56
Temperature : 25.06
Humidity : 22.04
Temperature : 24.45
Humidity : 21.71
Temperature : 25.06
Humidity : 21.93
Temperature : 25.10
Humidity : 22.00
Temperature : 24.41
Humidity : 21.71
```



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