

GE1354 Introduction to Electronic Design

Lab 2: Mini Project 1

Objectives:

- Apply ohm's law to solve practice problem
- Get Familiar with micro:bit block functions (analog read, on button) and programming
- Design a resistor-testing system using micro:bit

**Every student is to complete this mini-project individually.
Remember to bring back your micro:bit, battery pack, USB cable, and notebook**

1 Background

1.1 Ohm's Law

A resistor is a device that provides fixed resistance. As stated by Ohm's Law (see Unit 2 Lecture Notes), at a constant temperature, the electrical current flowing through a fixed linear resistance is directly proportional to the voltage applied across it, and also inversely proportional to the resistance. Mathematically, we have

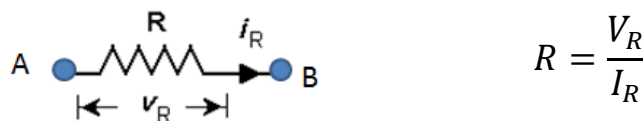


Fig.1 Ohm's Law

1.2 Voltage Divider

Given a closed path (a loop), it is known that sum of the voltage dropped in a closed path circuit is equal to the source voltage applied (Known as **Kirchhoff's Voltage Law**). Refer to Fig. 2. Therefore, the value of V_p is a portion of V_s governed by R_1 and R_2 , as reflected by the following equations:

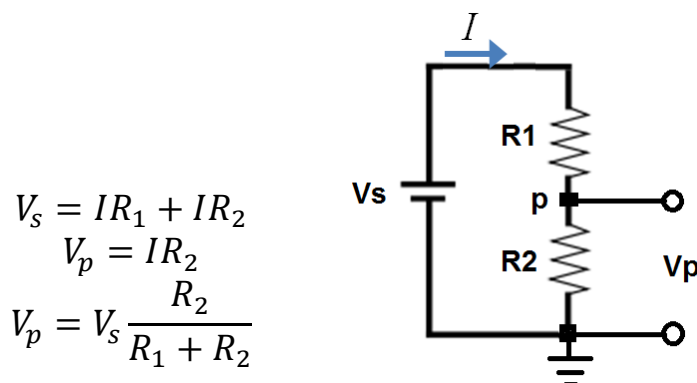


Fig. 2. A voltage divider based on resistors

2 Design Idea and Related Block Functions

Fig. 3 shows the RGB-R module that you made in Lab 1.

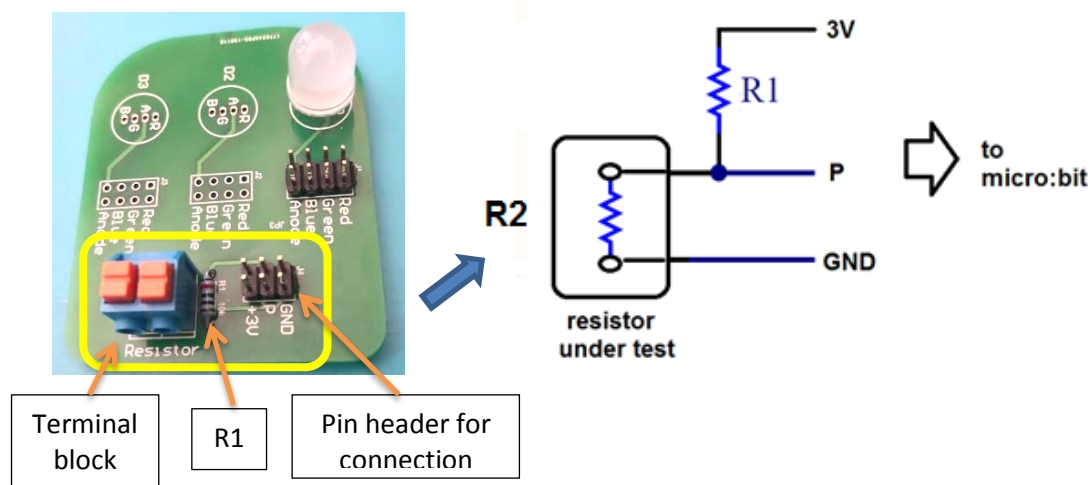


Fig.3 Voltage divider in RGB-R module

The resistor R_1 and the Terminal block (with a resistor R_2 inserted) form a series of resistors as a voltage divider as shown in Fig. 3. To measure the resistance of the resistor R_2 , we need to apply voltage to 3V and GND pin, then read the voltage of P. Based on the following equation, we can get back R_2 from V_p when R_1 and V_s are known).

$$V_p = V_s \frac{R_2}{R_1 + R_2} \quad (1)$$

2.1 Connecting your module to microbit

To measure the voltage of point P, the RGB-R module can be connected to micro:bit as follows.

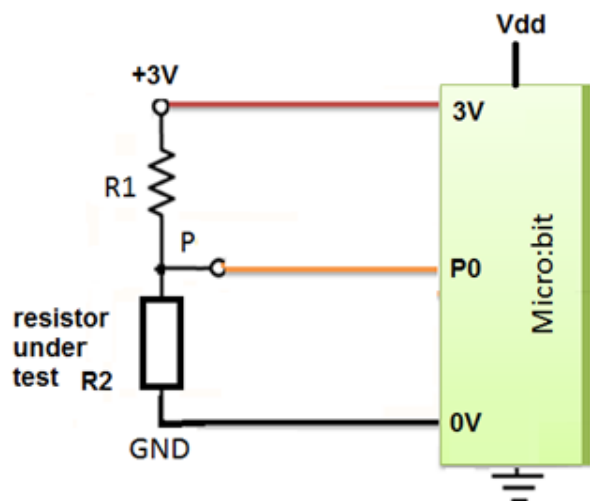


Fig.4 Connecting RGB-R module's voltage divider to micro:bit

Also, the following must be noticed:

1. You should measure the resistance value of R_1 (as you did in Task 3 of Lab 1)
2. You should measure the voltage at the pin labeled "3V" after connecting the battery pack or the USB cable. The actual voltage is depended on the status of the battery (or the USB), and is very likely not equal to 3V ("3V" is just a label).

2.2 analog read

Micro:bit can measure the voltage of a pin using the following command (analog read, see the Lecture Notes SR2):

analog read pin P0 ▼

The function is applicable to P0-P4 and P10. It performs analog-to-digital conversion and returns a digital value in a range of 0-1023. The relationship between the digital value and the voltage is given by

$$ADC = Round\left(\frac{V_{in} \times 1024}{V_{dd}}\right) \quad (2)$$

where ADC is the digital value, V_{in} is the voltage at the pin.

Also, from the obtained digital value, we can estimate the voltage of a pin using the following equation

$$\tilde{V}_{in} = V_{dd} \times \frac{ADC}{1024} \quad (3)$$

Remark: $\tilde{V}_{in}$ may not be exactly the same as V_{in} . The difference is called quantization error.

2.3 Event triggered – Button

Micro:bit can monitor some specified event. One example is to monitor whether a button is pressed or not. The block function is shown below:



Fig.5 Button event function block

For button A or B, this event handler works when the button is pushed down and released within 1 second. When the event occurs, the included codes will be executed. When finished, it returns to main process (Note: The included codes should be simple and contain no pause).

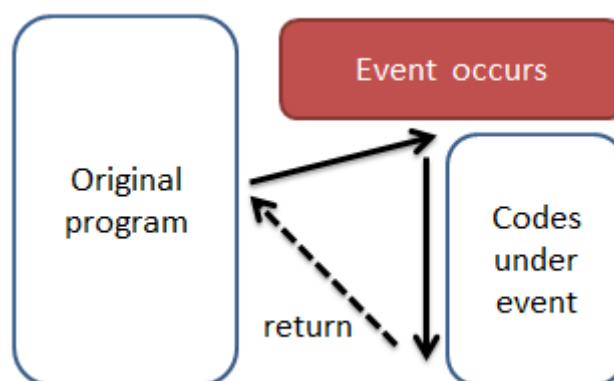


Fig.6 When event occurs, codes under event block will execute.
When finish, return to main process.

3. Design Task

There are 3 different levels of design. You can decide whether they are to be completed in separated programs or in a single program. However, you should not skip the lower level.

DESIGN TASKS

Level 1: Read P's voltage once by pressing the Button A, and then display the digital value to the screen repetitively. Press Button B to clear off the screen.

Level 2: Similar to Level 1, but display the resistor value (round to nearest ohm) to the screen. Press Button B to clear off the screen.

Level 3: Similar to Level 2, in addition to display the resistor value (round to nearest ohm) to the screen, according to the measured precision of the resistor value, turn on the RGB-LED:

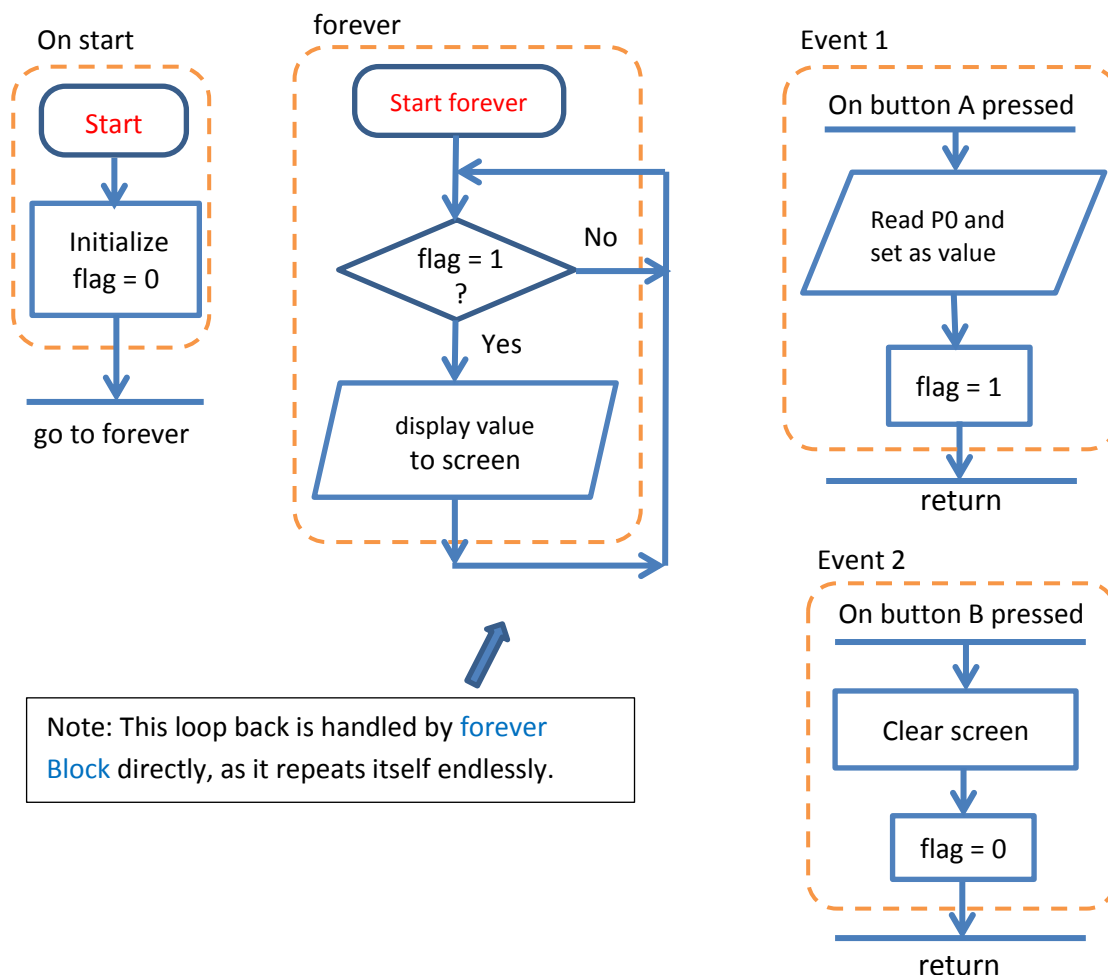
- a) Within $\pm 5\%$ of the nominal value, show red color
- b) More than $\pm 5\%$ but within $\pm 10\%$ of the nominal value, show green color
- c) More than $\pm 10\%$ of the nominal value, show blue color

[Note: In practice, the nominal value specified in your program should be based on the color band of the testing resistors. However, for testing purpose, we assume the nominal value is 910Ω (if necessary, you may change this nominal value), so that different colors can be shown when you test the resistors.]

Press Button B to clear off the screen and also turn off the RGB-LED

For Levels 1 and 2, you can refer to Fig. 4 for the connections between the RGB-R module and micro:bit,. For level 3, you have to add back the connections to the RGB LED, similar to what you did in Lab 1. Since P0 is used to measure the voltage of P, you can use P1, P8, P2 for RGB LED. Also, remember to connect 3V pin to the ANODE (A).

The flow chart for **Level 1** is given below for your reference:



Other Hints for Level 2 and 3:

- a) For Level 2, you'll need to derive equation to find the resistance value of R_2 (the one that inserted to the terminal block), based on the Eq. (1)-(3)
- b) For Level 3, you'll need to get the nominal value of the tested resistor by reading the color code, and determine the range for different colors. If-then-else is used to turn on LED according to the value. Note: You already learnt how to turn on different colors in Lab 1.

4. Demo and Report Worksheet

Demonstration

You must give the demonstration of the completed levels to the grader during the Lab session.

A few resistors will be given. Record the measure value (by micro:bit) and the nominal value (by reading the color code) for each resistor. These values can be compared and discussed in Sec. 4 of your report.

Report Submission

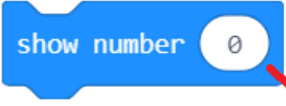
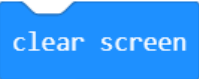
You should submit a report for the highest level that you can complete (eg. if you finished Level 1-3, report Level 3). A report template can be found in CANVAS. The report must be submitted to CANVAS (in word or pdf format) by 2-March-2019 11:59pm (Sat). **Mark will only be given if you have attended the Lab and given the demo successfully.** Late submission penalty is applied and 20% will be deducted per day (less than 24 hours also counted as one day).

Important Note: Copying other's work (even partly) is considered as an academic dishonest, and the case will be reported to the University. It will lead to disciplinary action against students who were involved, including the one who copied the other and the original writer.

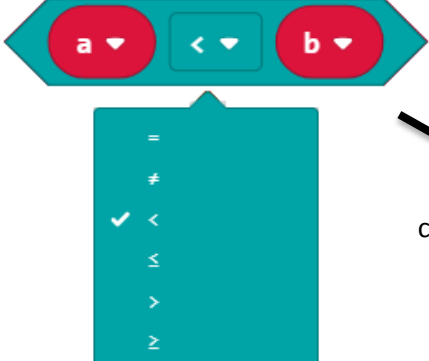
Appendix: Other useful block functions in this mini-project

You can refer to the reference document in CANVAS for more block functions.

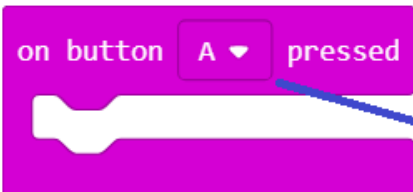
Basic Blocks <https://makecode.microbit.org/reference/basic>

Blocks	Functions
	Show a number on the LED screen. It will slide left if it has more than one digit.
	Turn off all the LEDs of the LED screen
	Pause for a given time (in millisecond)

Logic <https://www.microbit.co.uk/blocks/boolean>

Blocks	Functions
	If the condition is met, then run the codes after the keyword "then"
	If the condition is met, then run the codes after the keyword "then". Otherwise, run the codes after the keyword "else".
	Return True or False based on the comparisons
	Return True or False based on the result of logical AND / OR two conditions

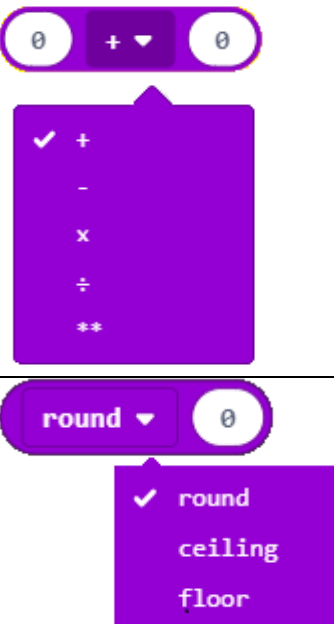
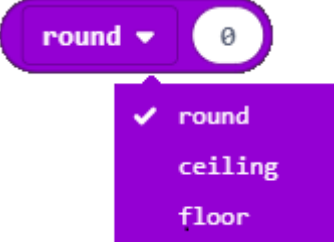
Input <https://makecode.microbit.org/reference/input>

 option: A, B, A+B	Do something (those blocks being included) when a button (A, B or both A+B) is pressed and released.
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Pin <https://makecode.microbit.org/reference/pins>

	Set the specified pin as either 0 or 1 (output 0V or Vdd, respectively) Available pins: P0-P16, P19-P20
	Read and return the value from the specified pin. Range is 0 – 1023 Available pins: P0-P4, P10

Maths <https://makecode.microbit.org/blocks/math>

Blocks	Functions
	Return the result of the mathematical calculation (+, -, x, /, exponent)
	Round: return the nearest integer of a number Ceiling: round up a number to the nearest integer Floor: round down a number to the nearest integer

Variables <https://makecode.microbit.org/blocks/variables>

Blocks	Functions
	Let a variable to a given value
	increase (+) or decrease (-) the variable by a given value (positive or negative value)