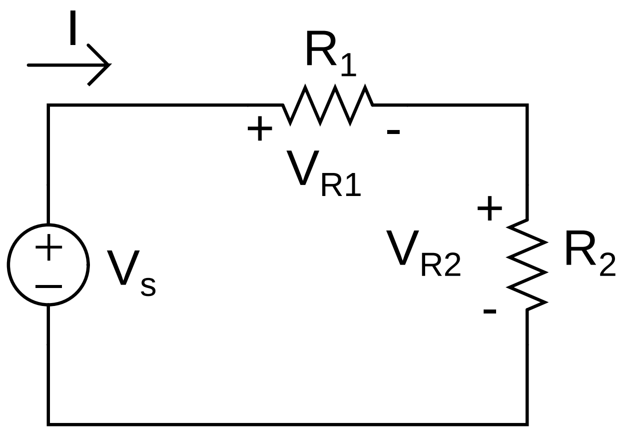
Task 1

Given the circuit in Figure 1(a) and the values in Table 1(b), calculate the voltage V_{R2}.



(a) Resistors in series

Symbol	Value
R_1	$1\,\text{k}\Omega$
R_2	$4\,\text{k}\Omega$
V_s	$20\,\text{V}$

(b) Values of components

Figure 1: Circuit and table of values

Task 1 Solution

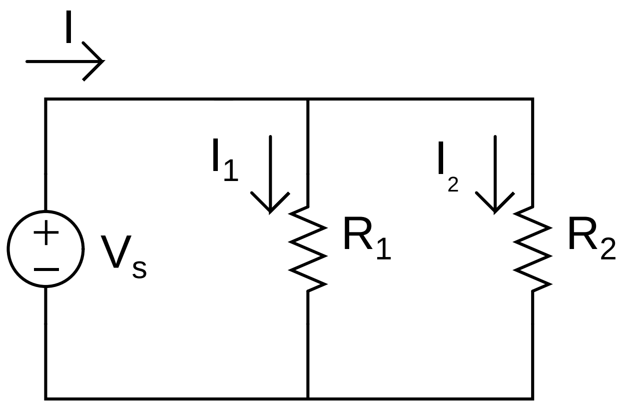
The combined resistance of the resistors is $R_{TOT} = R_1 + R_2 = 1\,\text{k}\Omega + 4\,\text{k}\Omega = 5\,\text{k}\Omega$

This means that the current running through the circuit is $I = \frac{V_S}{R_{TOT}} = \frac{20\,\text{V}}{5\,\text{k}\Omega} = 4\,\text{mA}$.

Therefore, $V_{R2} = I \times R_2 = 4\,\text{mA} \times 4\,\text{k}\Omega = \underline{16\,\text{V}}$

Task 2

Given the circuit in Figure 2(a) and the values in Table 2(b), calculate the current I_2.



(a) Resistors in parallel

Symbol	Value
R_1	$10\,\text{k}\Omega$
R_2	$10\,\text{k}\Omega$
V_s	$10\,\text{V}$

(b) Values of components

Figure 2: Circuit and table of values

Task 2 Solution

The combined resistance of the resistors is $\frac{1}{R_{TOT}} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{10\,\mathrm{k\Omega}} + \frac{1}{10\,\mathrm{k\Omega}} = \frac{2}{10\,\mathrm{k\Omega}}$, which leads to $R_{TOT} = \frac{10\,\mathrm{k\Omega}}{2} = 5\,\mathrm{k\Omega}$

This means that the current running through the circuit is $I = \frac{V_S}{R_{TOT}} = \frac{10\,\mathrm{V}}{5\,\mathrm{k\Omega}} = 2\,\mathrm{mA}$.

Therefore since R_1 and R_2 are the same then, $I_1 = I_2$ and $I = I_1 + I_2 = 2 \times I_2$. This means that $I_2 = 2\,\mathrm{mA}/2 = \underline{1\,\mathrm{mA}}$

Task 3

Suppose that you are going to measure V_s with a voltmeter, as shown in Figure 3.

To have an accurate measurement, the output impedance R_{Out} and the input impedance R_{In} should be selected so that one is small and the other is large.

Which should be small, and which should be large? Why?

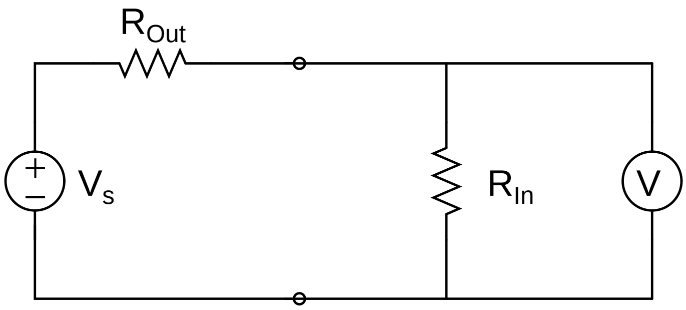


Figure 3: Voltage source and voltmeter

Task 3 Solution

R_{IN} should be large, so that there is only a small current goint through the voltmeter. The voltmeter symbol on the drawing is an ideal voltmeter, and there will not go any current through it. To make the voltmeter real, a resistor (R_{IN}) is placed in parallel to represent current leakage.

The voltage supply on the drawing is an ideal voltage supply, and to make it real a resistor R_{OUT} is placed in series with it to represent leakage. R_{OUT} should therefore be small so that $V = V_S - R_{OUT} \times I \approx V_S$

Task 4

Suppose that one of output pins on the AVR microcontroller is connected to a load as illustrated in Figure 4. The voltage drop over the diode is 2 V when conducting, and the current trough the diode must not exceed 20 mA. The value of resistor R_{out} is 50 Ω. How large must R_{in} be in order to not exceed the ratings of the diode?

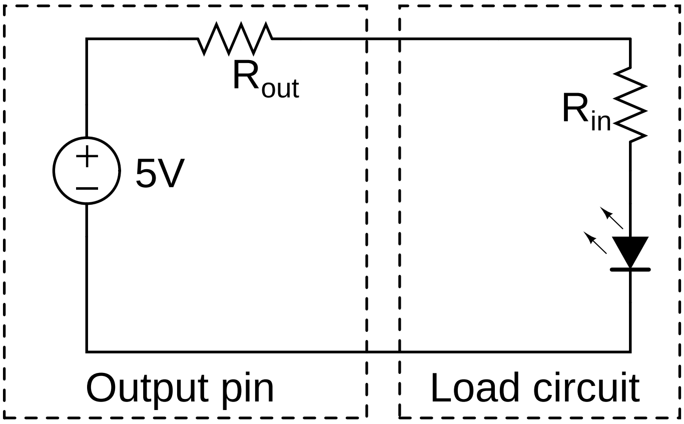


Figure 4: Microcontroller and load circuit

Task 4 Solution

$$V_S = V_{RTOT} + V_{LED} \Rightarrow V_{RTOT} = V_S - V_{LED} = 5\,\mathrm{V} - 2\,\mathrm{V} = 3\,\mathrm{V}$$
$$R_{TOT} \geq V_{RTOT} = \frac{3\,\mathrm{V}}{20\,\mathrm{mA}} = 150\,\Omega$$
$$R_{TOT} = R_{OUT} + R_{IN} \Rightarrow R_{IN} = R_{TOT} - R_{OUT} = 150\,\mathrm{ohm} - 50\,\Omega = \underline{100\,\Omega}$$

Task 5

Explain the terms RAM, ROM and Flash memory.

Task 5 Solution

RAM: is short for Random Access Memory. Data can be read and written to provided that it has power supply (RAM is therefore volatile). The reason it is called Random Access, is because all data can be accessed in the same amount of time in any random order. This is opposed to harddiscs which will have varying access time depending on where on the disc the data lies. RAM is mostly used as main memory in a computer or microcontroller.

ROM: is short for Read-Only Memory. This is fixed data that can only be read, and cannot be modified (or in reality is very difficult to modify). This is often used in firmware (software that is very closely tied to hardware). ROM is non-volatile, meaning that the data is not lost if the power supply is lost.

Flash: is a developed form of EEPROM (Electrically Erasable Programmable Read-Only Memory), which again is developed from ROM. EEPROM can program new ROM by applying an electric current and erasing the whole memory and then applying the new data. Flash works in the same way, but it only needs to erase small blocks of memory instead. Flash is also non-volatile. Flash is often used is memory cards, USB flash drives, solid-state drives, and now also in phones and other devices to store data.

Task 6

Suppose that you are the designing a quadrotor with GPS navigation and a video camera system to make video recordings from the air.

Explain how a microcontroller is suited for the control of the system, i.e. which operations aboard the quadrotor falls under the domain of the microcontroller.

Interesting webpage:
`http://www.grasp.upenn.edu`
`http://www.grasp.upenn.edu/success_story/swarm_nano_quadrotors`

Task 6 Solution

Microcontrollers are esspecially suited to control quadrotors.

- Read, filter and transform sensor input into measurements
- Calculate actuation on the motors depending on the measurements
- Set the actuation on the motors
- Read GPS data and and calculate the position of the quadrotor
- Take images from video camera and record or stream them to user via radio signals.
- Communicate with remote control so it can be controlled from the ground
- Play rock music on speakers while it is souring through the sky!