LABORATORY

Microelectronic Control Systems

EXPERIMENT:

Levitating Magnet

Please read the whole document before starting the experiment. This document contains 5 preparation jobs. It is mandatory to make all preparation jobs in written form! Without a written document that includes all preparation jobs it is not possible to pass this experiment.

1 The experiment set-up

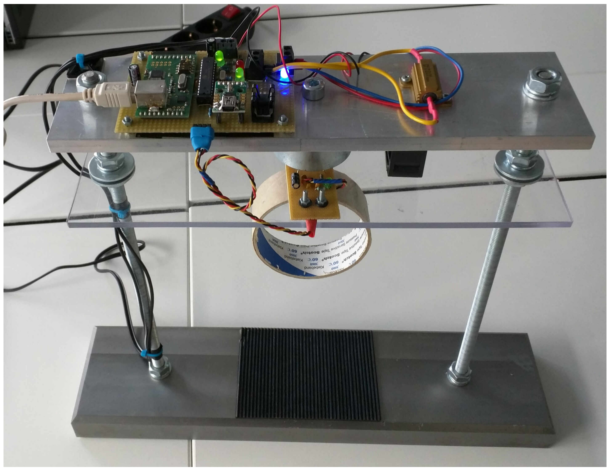

Figure 1: Experiment Setup

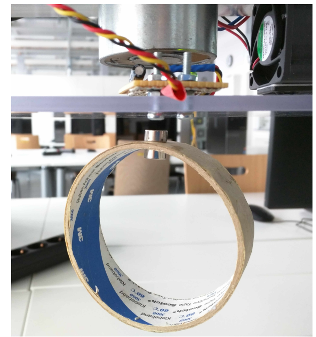

Figure 2: Levitating Magnet

In this experiment there is one permanent magnet that should levitate in a stable position in the air, see Figure 1 and 2. To be able to do this the gravity force must have an oppose force. In this experimental setup, a fixed permanent magnet is used to rise the levitating magnet. Only this two forces would be very unstable. So there is a hall effect sensor and an electric-magnet. The hall effect sensor is the position sensor and the electric-magnet will push the levitating magnet down. The electromagnet has approximate the same power like the fixed magnet.

So we have:

- Actor: Electromagnet
- Sensor: Hall effect sensor

The hall effect sensor will measure all magnetic fields. Therefore, the magnetic fields generated by the fixed magnet and the electromagnet will also be measured. It it your part to write a software controller that calculates the true value for the levitating magnet only.

A schematic drawing of the mechanical part is in Figure 3.

Prepare 1: What will happen, if the electric-magnet is constantly on with full power?

1.1 Electronic

The electronic part is shown in Figure 4. Please have a look at the schematic diagram. The electric magnet is controlled with an PWM signal.

Prepare 2: What is the function of the diode D5? Why is R1 a high power resistor with 25W?

Prepare 3: To eliminate the PWM signal at the hall effect sensor, there is a low pass filter with R5 and C10. What is the barrier frequency of this filter?

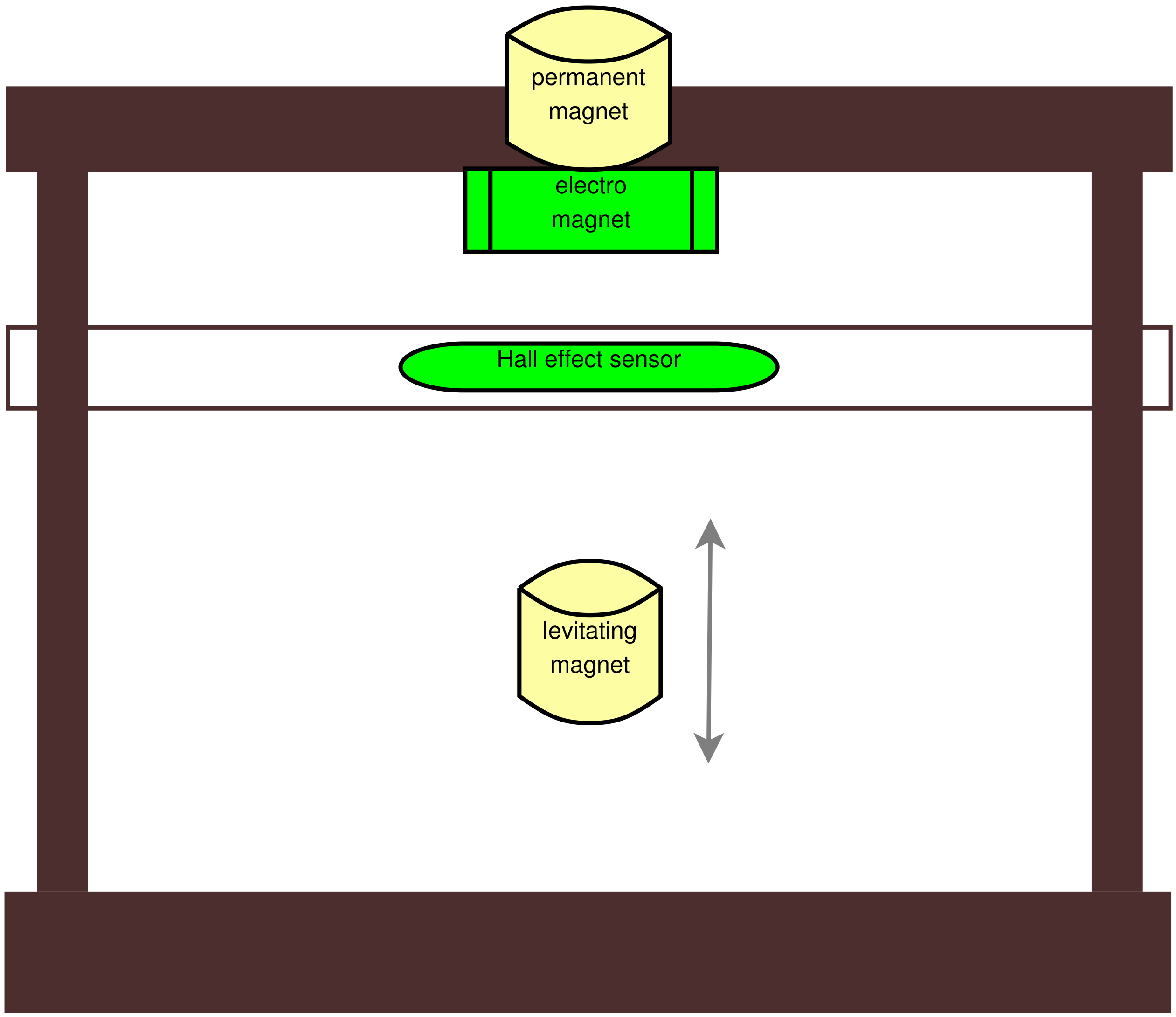

Figure 3: The mechanical part

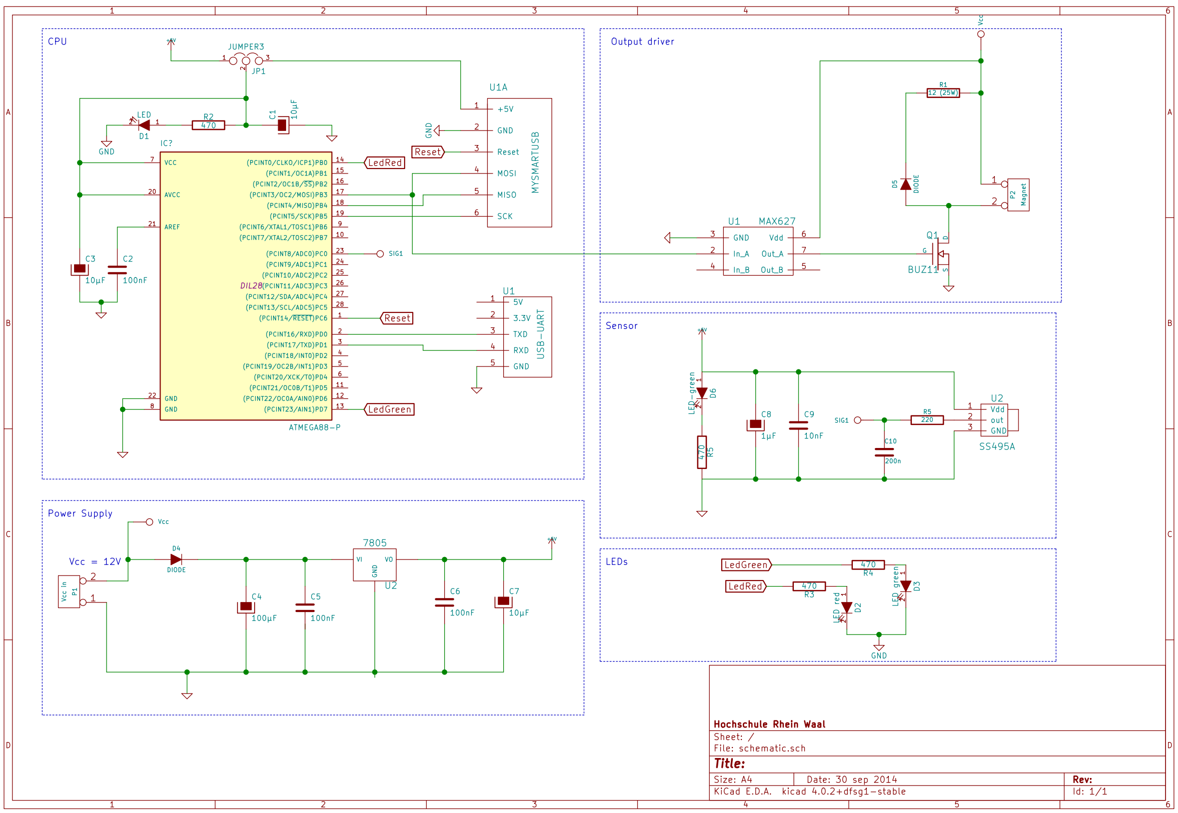

Figure 4: The electronic

1.2 The hall effect sensor

Prepare 4: What is the result in 10-bit value when SS495A measures no magnetic field in range?

You can find the datasheet of this sensor here: http://www.mouser.com/ds/2/187/honeywell-sensing-ss490%20series-solidstate-product--947420.pdf

2 The challenge

The challenge is to write a program, that holds the magnet in a levitating position. The magnet should not fall down or move to the top. You will get a few problems:

- The hall effect sensor is affected by the electromagnet. So solve this, the first step is to write a function to calculate the position of the magnet. An automatic calibrate function could be useful.
- The controller must react very fast, so write efficient code
- You need to find good controller parameter.

Prepare 5: Why is a simple P controller not possible?

If all at this point is complete and works fine, inform the staff. You must be able to show and explain all steps you have done. The next steps are optional.

If your controller program works fine, try to use the serial communication to set the position of the levitating magnet. It it possible change the position of the levitating magnet up and down for 2mm.

3 Appendix

Here are some additional information's.

3.1 Microcontroller

The microcontroller is the same type like the one from the MyAVR board. Different is here the clock rate, because this experiment needs a very fast reaction from the microcontroller.

- Type: Atmel Mega88
- Clock rate: 20MHz

3.2 Magnetic force

The magnetic force is:

$$F = \frac{1}{4\pi\mu_0} \; \frac{p_1 * p_2}{r^2}$$

The left part $\frac{1}{4\pi\mu_0}$ is a constant value. The right part has p_1 and p_2. In this experiment the controller can reduce p_1 to approx zero, when the electromagnet is constant on. The field of the electric magnet neutralizes the field of the fixed permanent magnet!

p_2 is the levitating magnet and a constant value.

The distance r has a squared effect!

3.3 Hints

- Use the red and green LED for debugging
- You can use the prescaler 64 for the ADC (overclocking), when only the highest 8 bit are used
- Use the free running mode for the ADC and execute your controller for every complete ADC result
- Use the maximum PWM speed that is possible (prescaler = 1), use Fast-PWM with 8 bit