2021, Faculty of Electrical Engineering and Communication FEKT

WATER TANK CONTROLLER

Team members

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Link to this file in GitHub repository:

https://github.com/amwellius/DE2_Project_2021-22

Table of contents

Project objectives

This simple but useful application will help you to fully control your **water tank** (not only!) in the garden. Do you want to know how much water is left? Do you want to refill the tank? Or are you interested in controlling your own independent application based on the volume left in the tank?
No problem!
With our **Water Tank Controller** you will be able to:

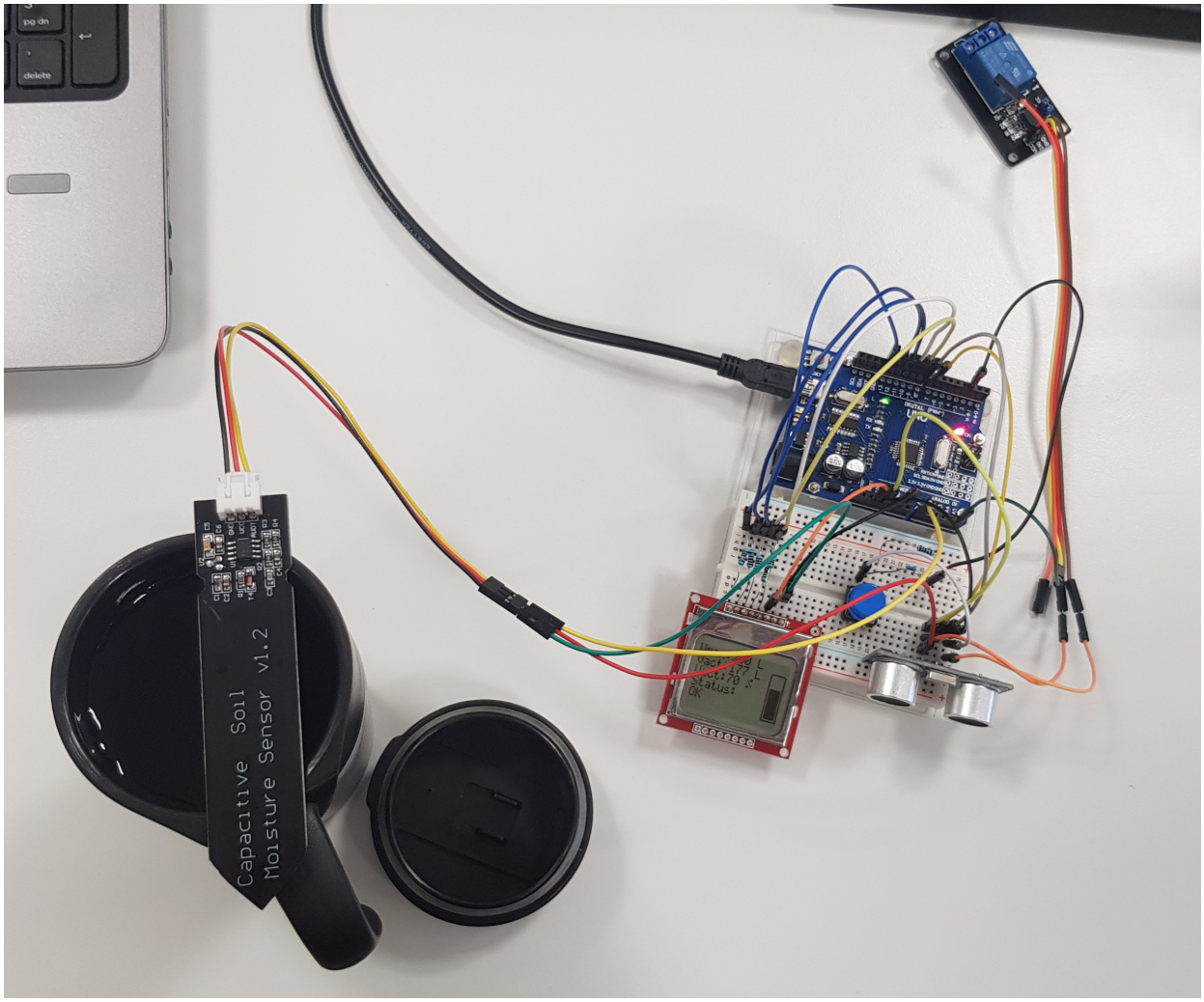
- know **current water level** in centimeters, percentage and liters,
- see **maximum** volume of the tank,
- use relays to control pump,
- prevent **owerflowing** the tank with extra sensor,
- see **graphic representation** of the water level.

Hardware description

As main programming board **Arduino UNO** is used. For displaying results **Nokia 5110 LCD display** was selected, **Relay module** and **button** (optional). Ultrasonic **HC-SR04** is the primary water level sensor. There is **Capacitive Soil Moisture Sensor v1.2** used as backup to prevent overflowing the tank when debris (leaves, flowers, pollen, ...) clogs in the tank sink. By small adjustments in the code it can be transformed into rain detector.

Arduino UNO + breadboard

Datasheet



Application uses a number of digital I/O pins, analog input pins and 3.3 V and 5 V power supply. Schematic can be seen here SCHEMATIC.

Nokia 5110 LCD display

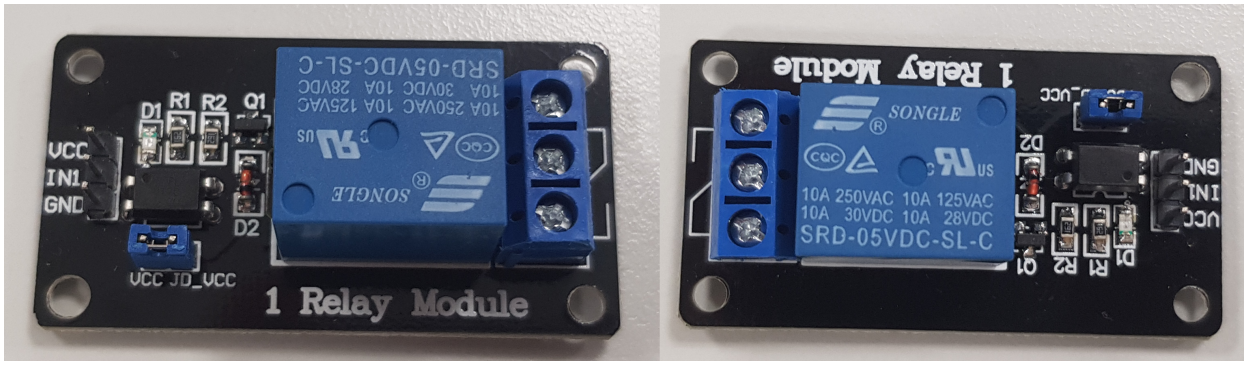
Datasheet

All output data is shown on Nokia LCD display. Third party library has been edited in order to use it with *Arduino UNO* and image display function was implemented. Display's resolution **84x48** allows to display many useful data or **graphic representation** of water level as well. Drawn images were converted to **byte arrays** to simplify the usege in *Microchip Studio*.
Picture below shows possible states.

Also some resistors had to be used to properly connect LCD to Arduino board.

Relay Module

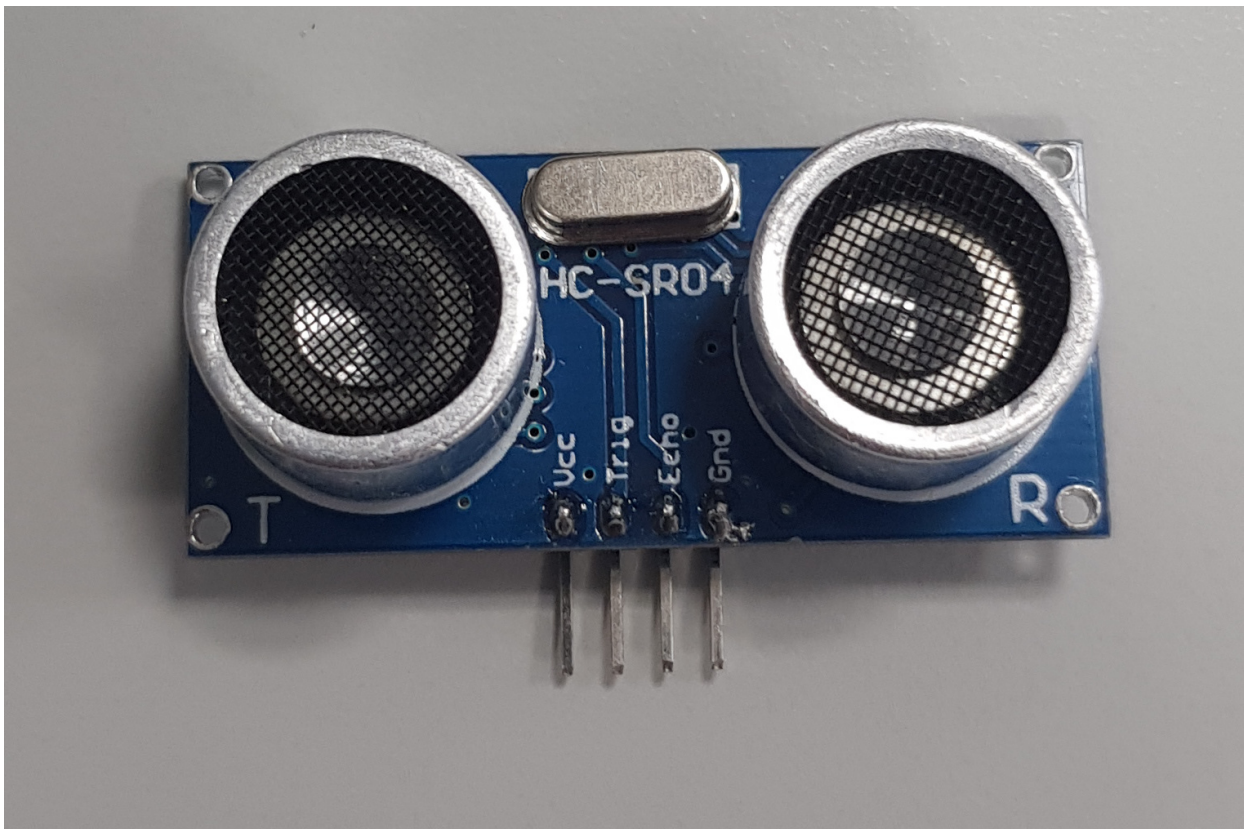
Datasheet



Usage of relay(s) is optional. **C code** has implemented section which toggles the relay module by pressing **button** connected to Arduio UNO. It can be connected to pump or solenoid to enable watering plants or other uses of the water. **A capacitor** inserted in cicruit (as RL low pass filter) helps to stabilize *overoscillations* generated by the button. By using hardware filter we were able to implement button handling with interrupt.

UltraSonic sensor HC-SR04

Datasheet



Main sensor for measuring the water level of the tank is **HC-SR04**. After entering its **dimensions** the sensor is calibrated. Providing it with short 10us pulse will result in receiving 8 cycles of 40KHz signal. This will be given by *ECHO pin*, so received value will be the time the wave travelled to the water and back to the sensor. Final distance can be obtained by this equation:

$$s = t \cdot 0.034/2$$

Where **t** is the received value on *ECHO pin* and **0.034** cames from the speed of sound *(340 m/s = 0.034 m/us)*. Sound wave travels from sensor to water, but from water to the sensor as well. That is why the result has to be devided by two. *Arduino UNO's* **timers** are used to measure width of received square signal. After calculation, distance in milimeters is returned. Its value is sent to other functions, so supplementary data can be sent to display on *Nokia LCD*.

Capacitive Water Lever Sensor

Datasheet

It is situated **a few centimeters** above main ultrasonic sensor. If ultrasonic **fails**, this option will prevent **overflowing** the water tank. Display will print **System overflow** message. Relay module can the programmed for specific behavior after getting to *overflow* stage, too (optional).
Sensor is connected to *analog input* pin, *GND* and *Vcc=5 V*. Its usage describes table below.

Value	Results in
<=850	System working properly.
>850	System malfunction!

Libraries description

Code for this application was written in **C**, compilated using **AVR/GNU C compiler** and **MicroChip Studio**. Project consists of several libraries, list of all files can be found below:

- `main.h` - main function header,
- `main.c` - includes main procedures and functions,
- `english_font.h` - characters for LCD display,
- `nokia_5110_lcd.h` - header for LCD display,
- `nokia_5110_lcd.c` - functions for LCD controlling,
- `water_symbols.h` - header for c file,
- `water_symbols.c` - byte maps (figures on LCD),
- `gpio.h` - input/output header,
- `gpio.c` - input/output functions,
- `timer.h` - header for timers in *Arduino UNO*,
- `HC-SR04.h` - header for *ultrasonic sensor*,
- `HC-SR04.c` - definitions for *ultrasonic sensor*.

All files are available here: `main.h`, `main.c`, `english_font.h`, `nokia_5110_lcd.h`, `nokia_5110_lcd.c`, `water_symbols.h`, `water_symbols.c`, `gpio.h`, `gpio.c`, `timer.h`, `HC-SR04.h`, `HC-SR04.c`.

Some important parts of codes will be discuss.

`main.c`

Example of controlling graphic representation of water level.

```
if (percentage == 100) selector = 10;
if (selector == 0) {
    LCD_write_bytes_xy_defined_width((unsigned char*)water_level_default, 14, 70,
} else {
    LCD_write_bytes_xy_defined_width((unsigned char*)all_water_states[selector],
}

// display maximum
itoa(tank_volume, distance_str, 10);
LCD_write_english_string(0, 0, "Vmax:");
LCD_write_english_string_continue(distance_str);
LCD_write_english_string_continue(" L");
```

`nokia_5110_lcd.h`

Functions used to control LCD Nokia Display.

```
void LCD_clear();
void LCD_init();
void LCD_write_byte(unsigned char dat, unsigned char command);
void LCD_write_english_string(unsigned char X,unsigned char Y,char *s);
void LCD_write_english_string_continue(char *s);
void LCD_write_english_string_continue_precise(char *s, uint16_t data_len);
void LCD_write_char(unsigned char c);
void LCD_set_XY(unsigned char X, unsigned char Y);
void LCD_write_init();
void LCD_write_whole_screen(unsigned char *cells, uint16_t cells_n, uint16_t star
void LCD_write_bytes_xy_defined_width(unsigned char *cells, uint16_t width, uint1
```

water_symbols.c

Example of byte map (icon of 70% left).

```
const unsigned char water_level_70[] = {
    // 'water level 70%', 14x35px
    0xfe, 0x01, 0x01, 0x01, 0x01, 0x01, 0x01, 0x01, 0x01, 0x01, 0x01, 0x01, 0x01,
    0xf8, 0xf8, 0xf8, 0xf8, 0xf8, 0xf8, 0xf8, 0xf8, 0xf8, 0xf8, 0x00, 0xff, 0xff,
    0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0x00, 0xff, 0xff, 0x00, 0xff,
    0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0x00, 0xff, 0x07, 0x04, 0x05, 0x05, 0x05,
    0x05, 0x05, 0x05, 0x05, 0x04, 0x07
};
```

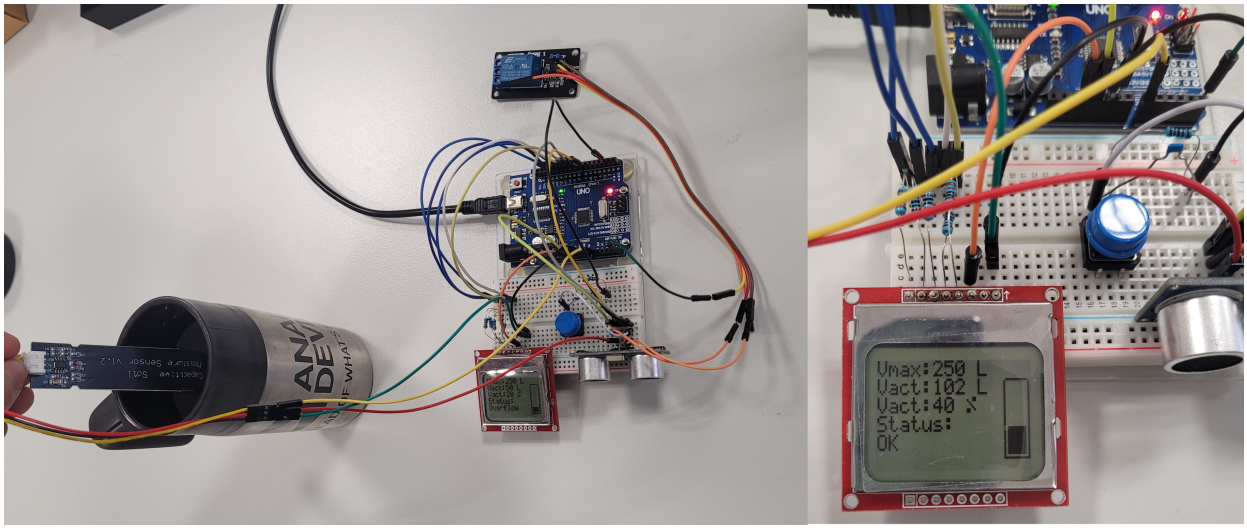
HC-SR04.c

Calculation of water level distance.

```
TCCR1B |= (1 << ICES1);                                          // Reset to r
        falling = ICR1;                                          // Read value
        counts = falling - rising;                               // Calc. diff
        dist = ((US_PER_COUNT * (uint32_t)counts) * 340) / 2000;    // Distance i

        for (int8_t i = 9; i >= 1; i--) {
            dist_vals[i] = dist_vals[i-1];
        }
        dist_vals[0] = dist;
```

Main application



The main purpose of this application is to automatize operation of regulating water level in specified tank. After knowing **volume of owned tank**, ultrasonic sensor connected to *Arduino UNO* board will measure the water level. *LCD Nokia 5110* display shows water level in *centimeters*, *percentage* and *maximum usable volume of the water-tank*. Application uses **one extra sensor** to control the maximum volume. It is situated few centimeters **above** the max bound of water (we do not want to fill the tank completely to prevent owerflow). If the water reaches this sensor LCD shows problem **(`Owerflow` , `Error`)** depending on the value of ultrasonic sensor.

Our product has the ability to interact with relay modules for external usage. These can be used to replenish the tank, irrigation pump control, DC fans, windows opening, and others.

How to use

1. Mount *Ultrasonic sensor* on the top of water tank. Sensor's reference **zero (100%)** is set to be 4 centimeters from the ultrasonic transceiver.

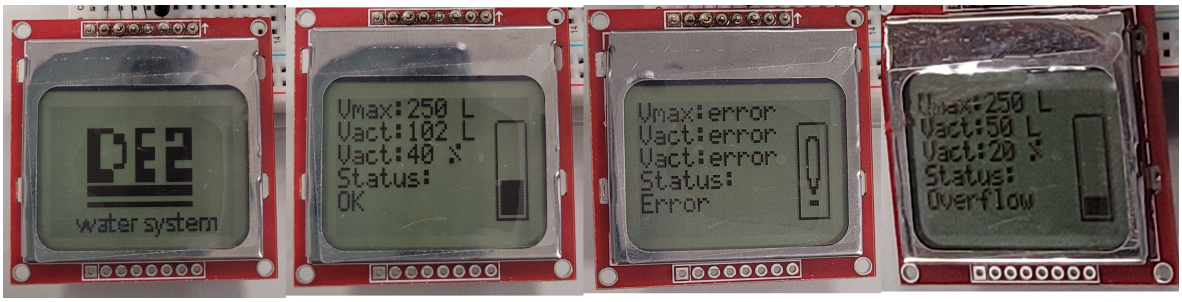
2. Mount *Capacitive sensor* about **1 centimeter** above max water height. (If ultrasonic fails, capacitive sensor will save it from drowning).

3. Insert dimensions of your water tank into *C code*. If maximum height of your tank is e.g. 100 cm, than insert only 96 cm, to prevent owerflow.

```
// Tank Volume
//**Enter values in cm !
#define TANK_X  ((uint32_t)80)
#define TANK_Y  ((uint32_t)80)
#define TANK_Z  ((uint32_t)96)
```

4. Application is now set up. The *Nokia LCD screen* provides needed information according figure below. User can see data as

- MAX volume of the tank in liters: `Vmax:800 L`,
- Actual volume of water in the tank in liters: `Vact:441 L`,
- Actual volume of water in the tank in percentage: `Vact:55 %`,
- Actual volume of water represented by a up-time graphic icon,
- System status message: `OK`, `ERROR`, `OVERFLOW`.



5. Relay module is set to interact with pressing installed button. **Do not** hesitate to use your creativity and relay module (modules) on your own by simply editing the code.

Possible Stages

After powering on, test screen procedure runs (represented by `DE2 Water System` screen and `graphic tank icon` filling up). System is ready to operate!

System OK

Level of water in tank is between **0** and **100%**, *capacitive sensor* is not activated by water reaching its level; system working correctly.

System ERROR

Rises when unexpected data is measured.

- Bad *ultrasonic calibration*, too close *(<4 cm)* or too far *(>400 cm)*,
- Bad tank dimensions,
- Capacitor used with relay module and button not connected properly,
- Apocalypse.

System OVERFLOW

Ultrasonic sensor occurred **problem**. Water reaches *capacitive sensor*. Different data received from two sensors leads to system `Overflow` stage message.

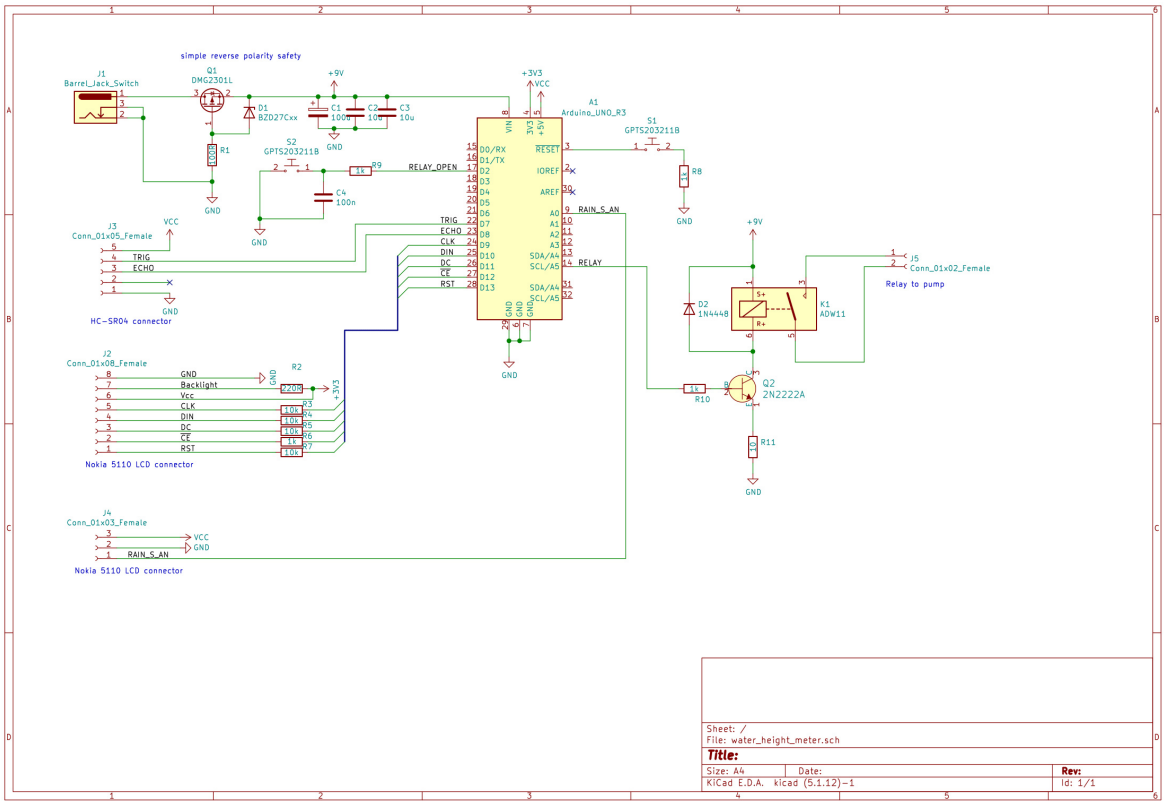
Video and Documentation

Video available here:
Link to YouTube

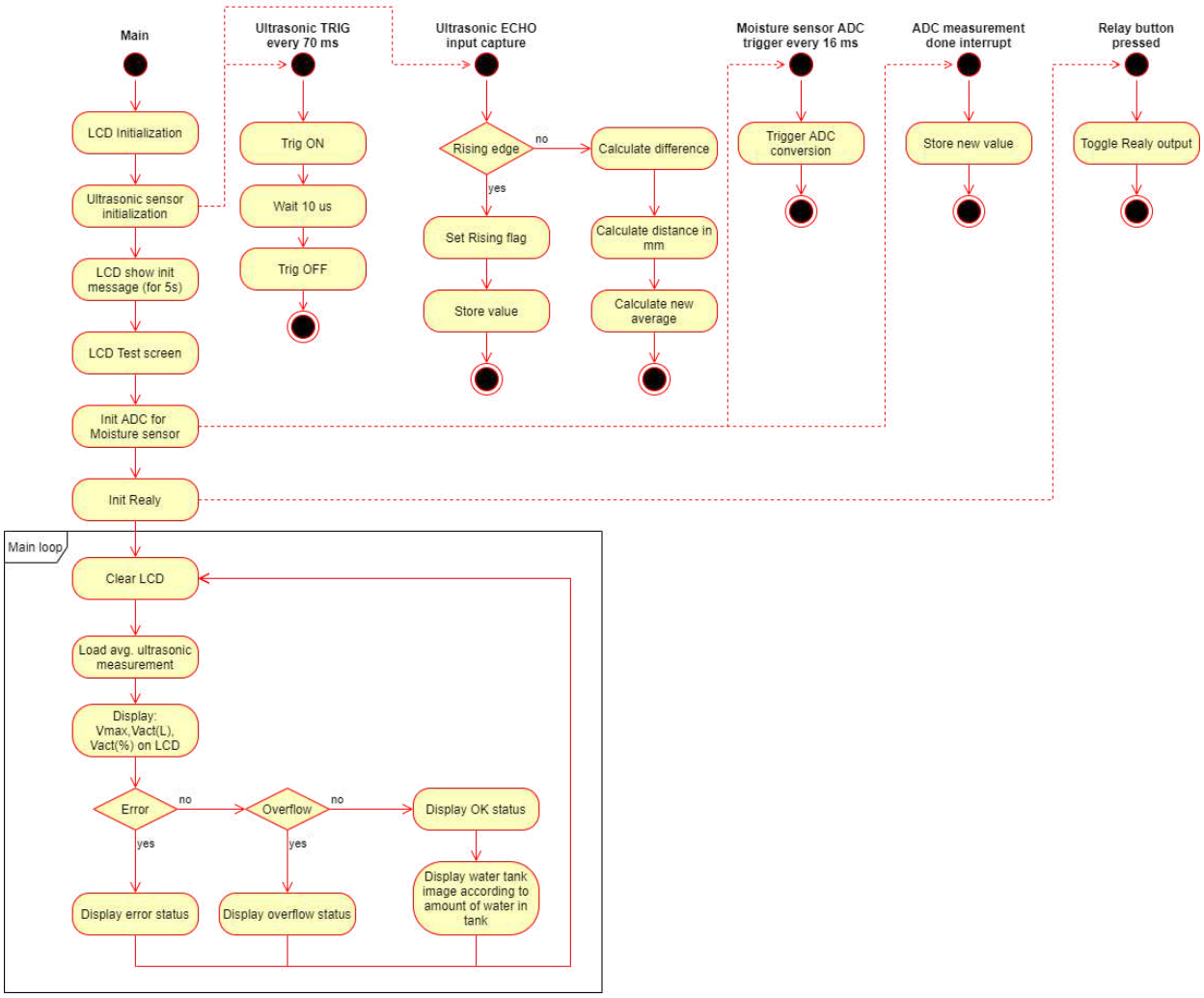
HEX file available here:
HEX file

Documentation available here:
As PDF file or as doxygen generated website (download required, open index.html)

Schematic



FSM



References

Used materials:

- Theoretical knowledge from Digital-Electronics-2, 2021 > Link
- Lab classes **DE2** > Link
- Byte Arrays Generator > Link
- LaTeX equation editor > Link

Used programs and its links:

- MicroChip Studio
- SimulIDE
- GitHub
- GitHub Desktop
- Git Bash
- KiCAD

All pictures have been taken in DE2 Laboratories!

Index komentářů

9.1 Vo Vasom pripade to nie je pravda. Vasa aplikacia iba zobrazuje objem kvapaliny v nadrzi. Aby bolo nieco automatizovane, musi tam byt riadiaca slucka. To vo vasej aplikacii nie je...

9.2 Tu ste mohli aspon zamedzit zaplnutiu rele v pripade max hladiny/emergency hladiny...