Declaration of authorship

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I declare that this piece of work which is the basis for recognition of achieving learning outcomes in the (Microprocessor Systems) EMISY course was completed on my own

EMISY Project 21 Portable Compass

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1 Analysis of the project

1.1 Discussion of project requirements

We need to create a simple portable compass circuit
It should:

- Use energy-saving power modes of microcontroller
- Be battery powered
- Be portable (cellphone/wrist watch)
- Communicate using graphical OLED display and two buttons keyboard

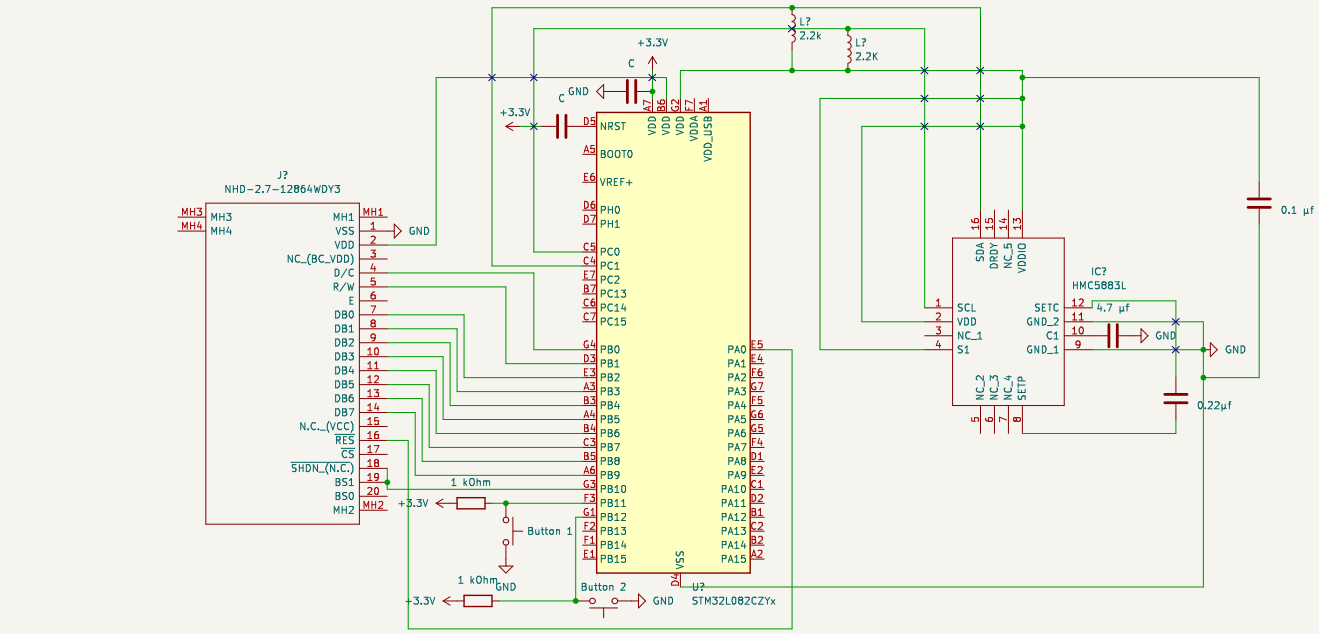
1.2 Discussion of solution

In my solution I focused on picking components based on firstly low power consumption, then size, then simplicity, whenever I could I tried to do everything as proposed in the component data sheet.
For the schematic itself I needed power saving microcontroller, oled display, battery, voltage regulator that works well with batteries and digital compass.

2 Detailed circuit diagram

2.1 Diagram itself

(Diagram is in pdf format so feel free to zoom in if something is not clearly visible)


L?
2.2k
L?
2.2K
+3.3V
C
GND
C
+3.3V
J?
NHD-2.7-12864WDY3
MH3
MH4
MH1
VSS
VDD
NC_(BC_VDD)
D/C
R/W
E
DB0
DB1
DB2
DB3
DB4
DB5
DB6
DB7
N.C._(VCC)
RES
CS
SHDN_(N.C.)
BS1
BS0
MH2
GND
1 kOhm
+3.3V
Button 1
1 kOhm
GND
+3.3V
Button 2
GND
U?
STM32L082CZYx
NRST
BOOT0
VREF+
PH0
PH1
PC0
PC1
PC2
PC13
PC14
PC15
PB0
PB1
PB2
PB3
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PA11
PA12
PA13
PA14
PA15
VDD
VSS
VDDA
VDD_USB
IC?
HMC5883L
SCL
VDD
NC_1
S1
SDA
DRDY
NC_5
VDDIO
SETC
GND_2
C1
GND_1
NC_2
NC_3
NC_4
SETP
4.7 µf
GND
0.1 µf
0.22µf
10µH
voltageRegulator
LTC3525-3.3
3 V
LR44R
Battery_Cell
LR44R
Battery_Cell
1 µF
SHDN
VIN
SW
GND
VOUT
+3.3V
10 µF
GND

2.2 Diagram description

Voltage regulator schematic is done one to one on how it was done in voltage regulator schematic in case of two battery cells
Digital compass also was connected exactly as specified in datasheet
For OLED I based on the pin descriptions from datasheet and on common patterns of connecting peripherals
Microcontroller itself was pretty straightforward with classic VDD, VSS and Reset pin conections
For buttons I used pull up resistors

2.3 Components

2.3.1 Microcontroller

I decided to use STM32L082CZ from STM32L0 line

Relatively small Up to 10 mm $\times$ 10 mm dimensions, compared to apple watch display of 34 mm by 40 mm for smaller version. [1] 111th page

Square It is shaped in a square which also simplifies portability [1] 111th page

Power saving STM32L0 line was designed specifically for low power consumption with power consumption as low as 0.29 μ A in Standby mode [1] 1st page

Consumer devices This microcontroller comes from STM32LOx2 line prepared to be used in consumer devices [2]

Ease of use USB compatible microcontroller and dedicaded debug port allows for swift code creation. [1] 1st page

2.3.2 All other components

Oled display For OLED display I decided to go with NHD-2.7-12864WDY3. It was an OLED display found on mouser webpage with lowest operating supply current of 180 uA, supply voltage compatible wit microcontroller (3.3 V) and datasheet not in japanese. [3]

Digital compass For the compass I used HMC5883L with compatible voltage, low power consumption of 100 μ A, compatiblity with battery powered applications according to datasheet and small size

Battery For the battery I choose 2x LR44R series battery, with output voltage of 1.5 V compatible with voltage regulator (3 V in series), compatible battery chemistry of Alkaline, 150 mAh capacity for single battery and compact coin cell shape. [5]

Voltage Regulator For voltage regulator I choose LTC3525-3.3 with high 95 % efficiency, desirable output voltage of 3.3 V, low profile and tiny package, it is also available in kicad by default [6]

3 Draft of the microcontroller firmware

3.1 Block diagram

Figure 1: Start algorithm

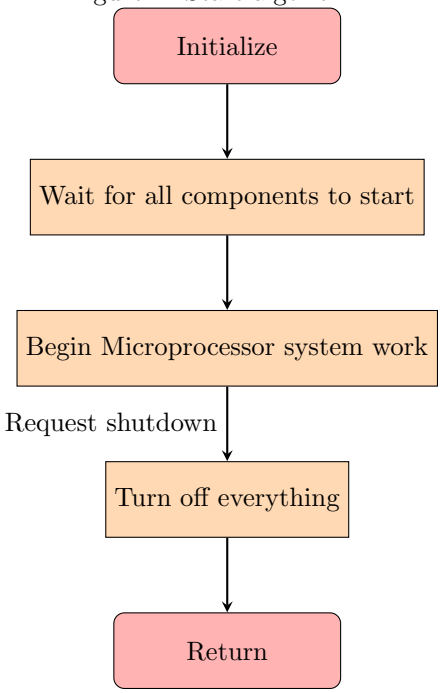


Figure 2: Main loop

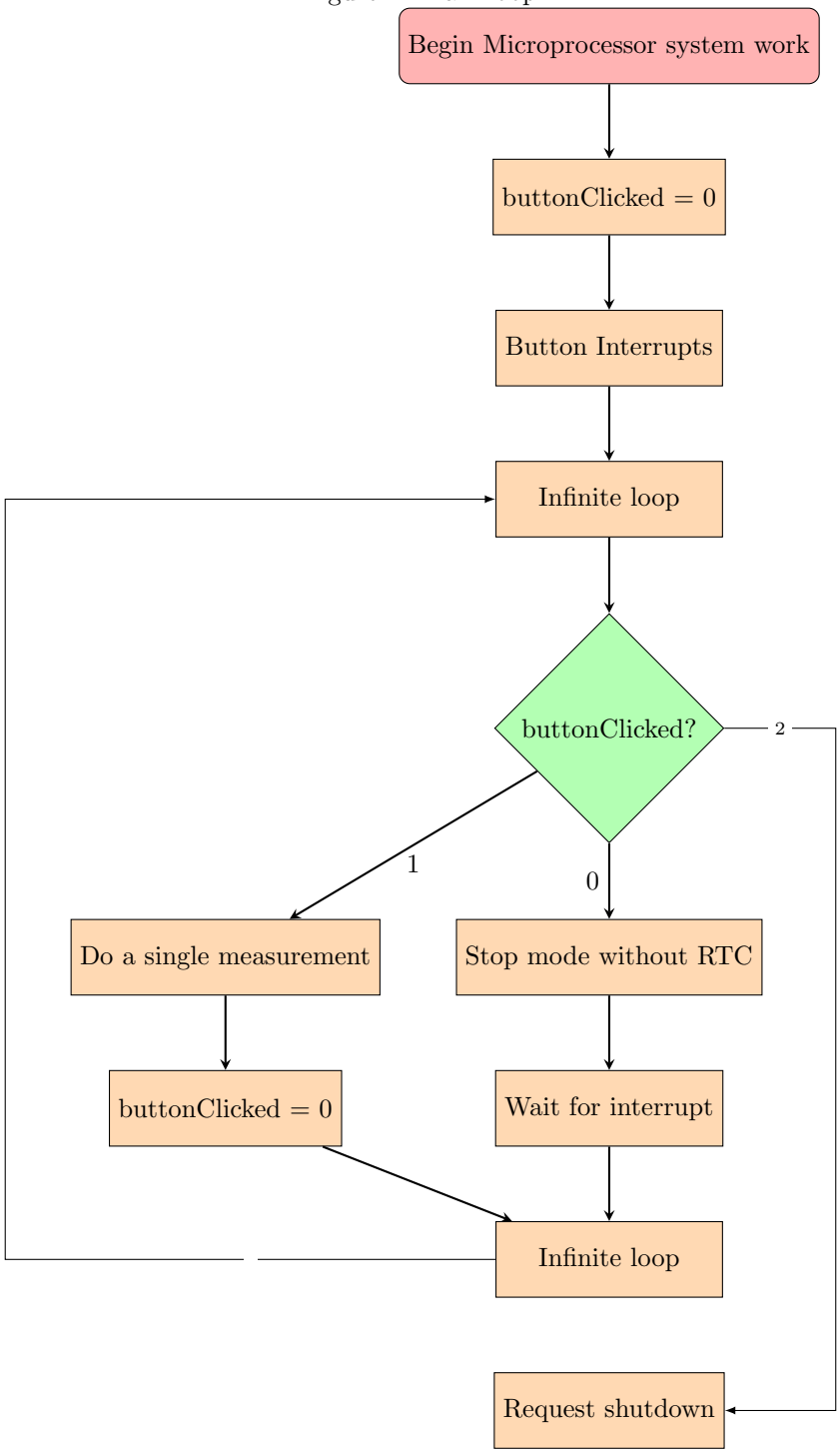
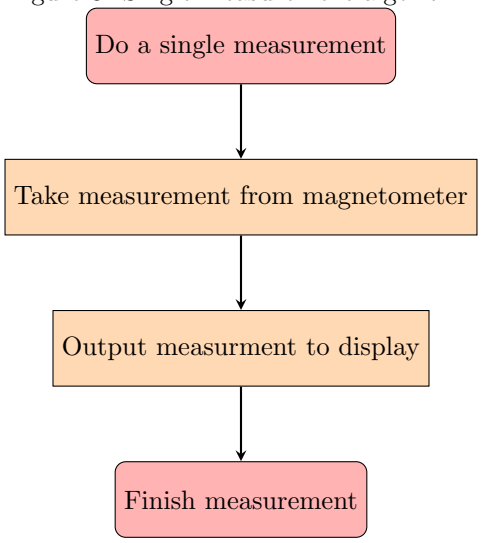


Figure 3: Single measurement algorithm



3.2 Description of the algorithm

There are 3 main diagrams, start algorithm at the very beginning of the microcontroller, then main loop containing most of the code and another one for single measurement from magnetometer.

1. Start algorithm - we initialize all of the components to be ready for the microcontroller to fork, we wait for the components to start and go into the main loop, once we get the shutdown interrupt we turn off all components and exit from the firmware.

2. Main loop - Once all the components are initialized we start the main loop, we set the variable which tells us which button was clicked to default value of 0, we set up button interrupts to get information what button we clicked and we enter the infinite loop. In infinite loop depending on button clicked we either do a single measurement, shutdown the whole microprocessor or enter stop mode without RTC (lowest power consumption while still working with interrupts)

3. Single measurement consists of taking data from magnetometer and outputing it on the display

References

[1] STM32LO82CZ datasheet

[2] Consumer Device STM32LOx2 Line

[3] OLED datasheet

[4] Magnetometer datasheet

[5] Battery

[6] Voltage regulator