Malte Seldschopf

Development of a phasor measurement unit

Practical project

Technical High school cologne,

Cologne Institute for Renewable Energy,

07. 01. 2019

Supervisor: Prof. Dr. Eberhard Waffenschmidt

Cologne Institute for Renewable Energy

Technology
Arts Sciences
TH Köln

1. Table of Contents

1. Table of Contents 2
2. Abridged version 3
3. Hardware 3
   3.1. ChipKIT-Wi-Fire 3
   3.2. PIC32MZ2048EFG100 3
   3.3. GNSS 5 Click 4
   3.4. NEO-M8N 4
4. Software 5
   4.1. Main program 5
5. Conclusion 6
   5.1. Summary 6
   5.2. Future tasks 6
6. List of references 7
7. List of sources 7

2. Abridged version

This practical work deals with the development off a Phasor measurement Unit and serves as a preliminary work for the following bachelor thesis. The programming and the determination of the specifications for such a device are described in detail. The Phasor measurement Unit is used to measure and compare the phase shift of two voltages. With the help of this measurement, power losses are to be determined, which occur e.g. between consumer and generator. A development board from Digilent was used for this purpose. This development board contains a microcontroller from Microchip, the PIC32MZ2048EFG100.

3. Hardware

3.1. ChipKIT-Wi-Fire

Illustration 1: Development board – ChipKIT – Wi-FIRE

Source: Datasheet - ChipKIT Wi-FIRE [1]

The microcontroller "ChipKIT Wi-Fire" was used as the basic structure. The "ChipKIT Wi-Fire" has a large number of application possibilities, which work together with the microprocessor PIC32MZ2048EFG100 from the company "Microchip". For a number of different applications, the development board provides a considerable number of components [1].

3.2. PIC32MZ2048EFG100

The PIC32MZ2048EFG100 is a powerful 32-bit MCU with 512KB RAM, 2MB flash memory and a 200MHz clock. It has a large number of possible interfaces, which can be controlled via the peripheral buses. It also offers a large number of setting options, e.g. varying the system clock or regulating the voltage [2].

3.3. GNSS 5 Click

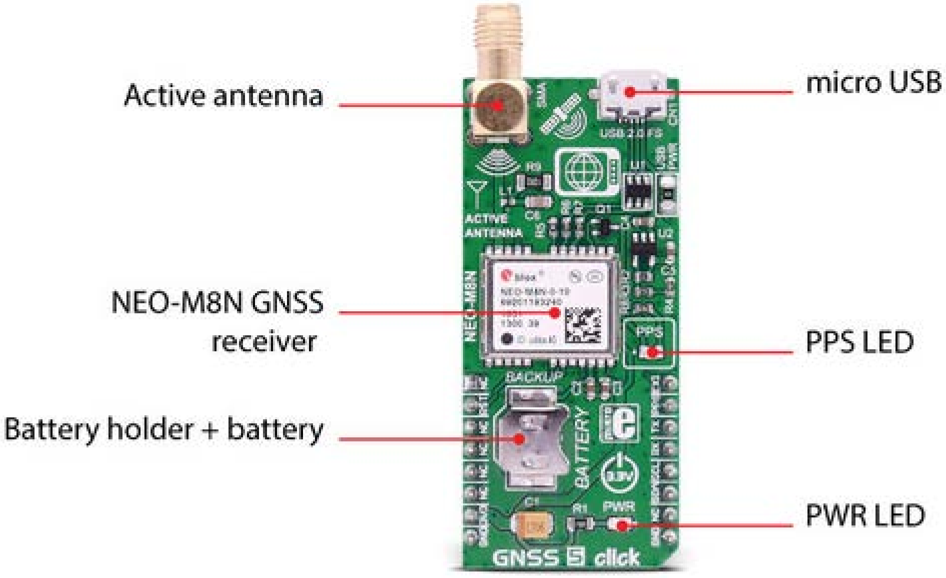

Illustration 2: GNSS Receiver – GNSS 5 Click

Source: GNSS 5 Click [3]

The GNSS 5 click carries the NEO-M8N receiver module from the company u-blox. GNSS 5 click is designed to run on a 3.3V power supply. The click communicates with the target microcontroller over I2C or UART interface [3].

3.4. NEO-M8N

The NEO-M8N utilizes concurrent reception of up to three GNSS systems (GPS, Galileo and GLONASS), recognizes multiple constellations simultaneously and provides outstanding positioning accuracy in scenarios where urban canyon or weak signals are involved [3].

4. Software

4.1. Main program

```
/* This is the main program */
void main(){

    SYSTEM_Init();
    // Initialize system settings - e.g. clock frequency of the peripheral bus

    INTERRUPT_Init();
    // Initialize interrupts - UART4&ADC0&ADC1

    TIMER_Init();
    // Initialize timers - To the clock frequency of ADC0&ADC1

    SD_Init();
    // Initialize SD card - SPI3

    UART_Init();
    // Initialize GNSS module - UART4

    ADC_Init();
    // Initialize voltage measurement - ADC0&ADC1


/* Endless loop - Is executed permanently */
    while (1){

        UART_Read();
// Reads the incoming GNSS time signal and compares it with the predefined
values

        SD_DataSave();
// Stores the data on the SD card as soon as the working memory is 90% full.
      }

}
```

In the main program, the functions are called which are only needed once. This includes the initialization processes, which configure the corresponding hardware and interfaces. It starts with the initialization of the system settings, where the clock frequencies of the peripheral bus and the general registers of the interrupts are configured. The next function initializes the interrupt configurations, where the used interrupts are configured accordingly. The counter (timer) initializations follows, here the sampling frequencies of the A/D converters are configured and started. Next, the SPI, UART and ADC registers are configured. As soon as the initialization processes are completed, the endless loop is started. The initialization process is completed after a few seconds, and then the program starts the endless loop, which can only be interrupted if either the SD card is full or the power supply goes out.

The endless loop of the main program contains the functions that are called regularly. This includes the functions UART_Read and SD_DataSave. These functions must be called regularly, because they do not react to an interrupt and it would take too much processor power to call them interrupt controlled. In the functions conditions are set, which are related to the interrupts, so that in the end most of the time it is queried whether the condition for the start of the function is fulfilled or not.

5. Conclusion

5.1. Summary

A phasor measurement unit give us a feedback about the grid stability, by measuring from current and voltage. With these values, we are able to represent the phase angle.
The selected development board has chosen because of a strong 32-bit and 200MHz fast processor. The ability to wear an on-board SD-card module is a welcome advantage. There are many interfaces, which are enough to get a connection with the Time receiver.
The main program is about the setting configurations and the query in the endless loop.

5.2. Future tasks

To start a measurement and getting the phase angel over a distance, it is necessary to build a voltage converter to assume the grid voltage to the microcontroller voltage. There have to be a voltage converter that is converting the voltage from the grid to the input voltage of the microcontroller that is between 0 and 3.3 Volts. Now it is important to buy the same microcontroller and to run the same software on him. The next step is to decide some places where I can start the measurements. After this practical work, I will be able to analyze the measurement and will be able to write about it in my bachelor thesis.

6. List of references

[1] Digilent, "Datenblatt - ChipKIT Wi-FIRE," 12 Juli 2016. [Online]. Available: https://reference.digilentinc.com/_media/chipkit_wifire/chipkit_wi-fire_rm_revc.pdf.

[2] Microchip, "Datenblatt - PIC32MZ," 23 Juni 2016. [Online]. Available: http://ww1.microchip.com/downloads/en/DeviceDoc/60001320E.pdf.

[3] MikroElektronika, "GNSS 5 Click," 2018. [Online]. Available: https://www.mikroe.com/gnss-5-click.

[4] Gude Analog- und Digitalsysteme GmbH, "Gude," 2018. [Online]. Available: https://www.gude.info/.

[5] Microchip, "Microchip - Developer Help," 2018. [Online]. Available: http://microchipdeveloper.com/mplabx:requirements.

[6] Microhip, "Datenblatt - PICKit 3," 1 Mai 2010. [Online]. Available: https://ww1.microchip.com/downloads/en/DeviceDoc/51795B.pdf.

[7] All about circuits, "The Universal Asynchronous Receiver/Transmitter," 20 Dezember 2016. [Online]. Available: https://www.allaboutcircuits.com/technical-articles/back-to-basics-the-universal-asynchronous-receiver-transmitter-uart/.

[8] Wikipedia, "Serial Peripheral Interface," 22 Oktober 2018. [Online]. Available: https://de.wikipedia.org/wiki/Serial_Peripheral_Interface.

[9] Microchip, "Developer Help - Oszillator Konfiguration," 2018. [Online]. Available: http://microchipdeveloper.com/32bit:mz-osc.

7. List of sources

Illustration 1: Development board – ChipKIT – Wi-FIRE 3
Illustration 2: GNSS Receiver – GNSS 5 Click 4