Power frequency website

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Abstract - The following research project focuses on developing of hardware, creating a database as well as programming a website to provide the download of the frequency of the union for the coordination of transmission of electricity (UCTE) for free and also for a dynamic representation. The concept to realize the project will be introduced in a total of four submissions. In this paper, the concept and the hardware will be presented. The other group members describe their activities in this project.

1 Introduction

For the realization of this project, a concept is first processed by a detailed research. In this case, the following concept has been developed.

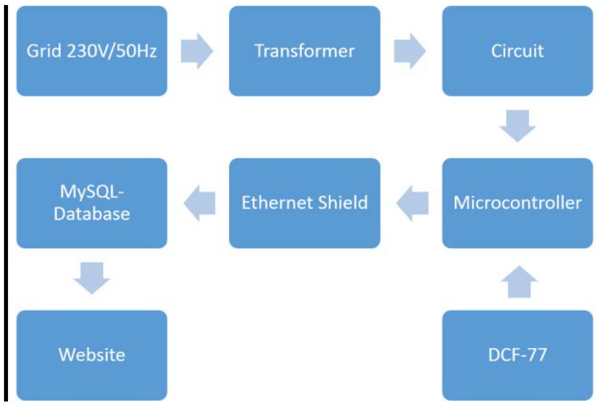

FIGURE 1: Concept 1

The structure is constructed as follows. First, to an electrical outlet a transformer is connected, which transforms the sine wave voltage from 230V to 9V. This 9V sine wave voltage is converted in the circuit to a square wave voltage. The task of the microcontroller is to count the edges and to measure the time, because the formula for the frequency is

$$f = \frac{1}{T}$$

The measured data were finally provided with a time stamp of a DCF-77. The DCF-77 is a small atomic clock, which provides each measured data with date and time. [1] Through an Ethernet shield, which was connected to the Arduino microcontroller sends these data to a MySQL-database. The web page accesses on this database. On the website a dynamic representation of the network frequency, representation of the last hour, presentation of the last three hour and the download will be offered.

The cause for the development of a new concept is that the Ethernet Shield is crashed after 5 minutes because it was overwhelmed to transfer the measurement data every second to the database. This semester, a new search was performed again, thus the problem could be fixed. From the research, the following solution resulted. [2] Through the implementation of a Raspberry Pi`s it was possible to dispense with the Ethernet shield and the MySQL-database would therefore be directly integrated into the Raspberry. In addition, the DCF-77 is no longer required, because the time stamp of the Internet is integrated.

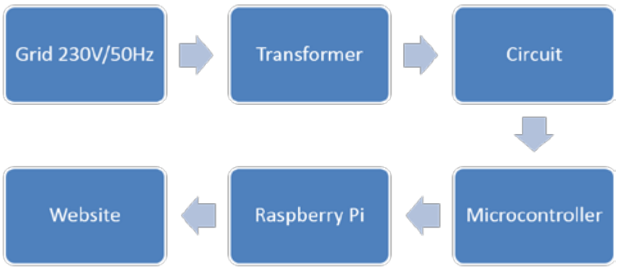

FIGURE 2: Concept 2

On the website **netzfrequenz.web.fh-koeln.de** the data of the mains frequency can be either downloaded for free or the course of the mains frequency can be observed.

2 CIRCUIT

[3] The basic consideration for the measurement of the frequency is to convert a sinus signal to a square wave signal. The square wave signal is generated by the hardware, which consists of a transformer, voltage limiter, the low-pass, half-wave rectifier, voltage-limiting device and a Schmitt trigger. The output of the Schmitt trigger is connected to the microcontroller. Before the circuit is constructed is a simulation program called LTSpice IV simulating the circuit. In the following figure the circuit diagram is shown.

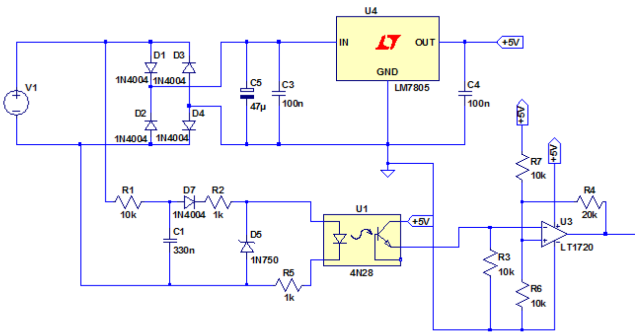

FIGURE 3: Circuit diagram

2.1 *Voltage conversion*

From the socket comes a voltage of 230V. In order to transform this voltage to safer and better evaluated values a commercially available AC/AC power supply will be used. The transformer converts the 230V voltage from the power outlet in 13V. Later, the power required for the actual frequency measurements is reduced to about 5V with the voltage transformer (LM7805). The supply of the circuit carried out via the power supply, thus the voltage for the voltage transformer has to be slightly higher. If the voltage is too high, the voltage transformer has to dissipate a lot of heat.

The power supply transforms the voltage down, but does not change the chronological course and the disturbances of the power supply will pass through.

2.2 *Filtering the disturbances of the power supply*

[4] The sine curve of the AC voltage is greatly disturbed including by other connected devices in the home. Therefore, the voltage is filtered by a passive low-pass for smoothing the sinusoidal curve. The low pass is realized as an RC element 1st order with a cut-off frequency of

$$f_G = 50Hz.$$

[5] The calculation of the low-pass filter is made by the formula

$$f_G = \frac{1}{2\pi \cdot R \cdot C}$$

Changed to C results

$$C = \frac{1}{2\pi \cdot R \cdot f_G}$$

The resistance is set with 10kΩ and the result for the value of the capacitor

$$\frac{1}{2\pi \cdot 10000\Omega \cdot 50Hz} = 318nF$$

[6] The next value in the E6-series is 330nF, thus resulting in a cut-off frequency of 48,2Hz, which is sufficiently accurate.
By this filtering, for example, short voltage spikes can be filtered out.

2.3 *Adjusting the voltage*

In the further course of the circuit is carried out with positive voltages, so the negative half-wave is removed by a diode (Figure 4). In the further course of the circuit is carried out with positive voltages, so the negative half-wave is removed by a diode. The rectify the negative voltage is also possible, but there are twice as many edges present to evaluate but it is omitted.

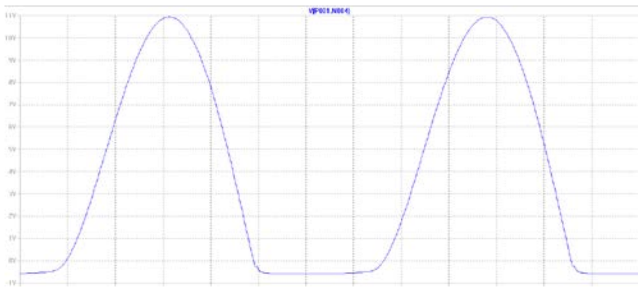

FIGURE 4: Removal of the negative half-wave

The voltage is limited by a subsequent in reverse direction settled zener diode (Figure 5). The zener diode behaves in the forward direction like a normal diode. In the reverse direction the zener diode become low resistance by a certain reverse voltage. The value of the breakdown voltage is 4,7V.

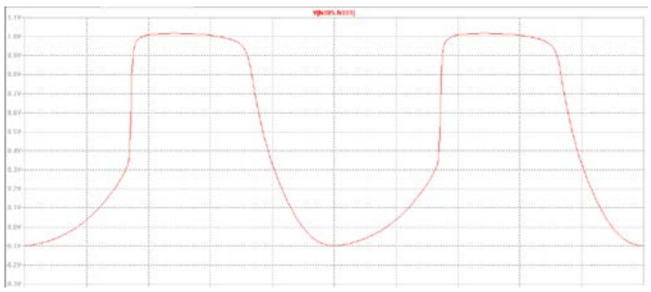

FIGURE 5: Limiting the voltage

2.4 *Adjustment of the waveform*

The voltage is limited to about 5V. In order to ensure a good detection of the flanks by the microcontroller the flanks should be very steep. To reach this and also to separate the AC voltage part from the circuit of the DC part an optocoupler is deployed. [7] An optocoupler is integrated to transmit an electrical signal between two separate circuits. It consists of a transmitter, for example a light emitting diode and a phototransistor as optical receiver. These are both housed in a light blocking housing. The type of the optocoupler is 4N28. It offers a bandwidth of 300 kHz and it is sufficiently fast.

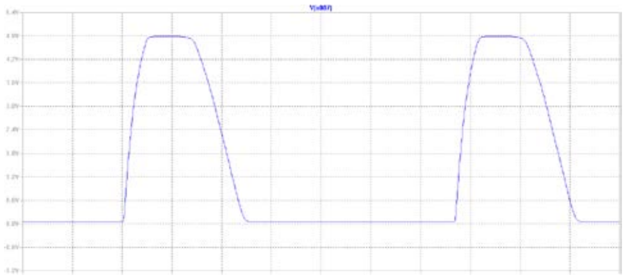

FIGURE 6: Stress diagram after optocoupler

The steepness of the edges is not enough to ensure reliable detection by the microcontroller. Therefore, a Schmitt trigger is still used to obtain a steep edges.

2.4.1 The Schmitt trigger

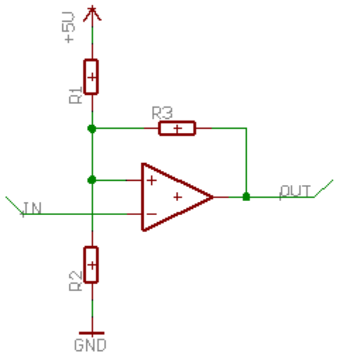

FIGURE 7: Schmitt trigger

[8] A Schmitt trigger can be set up with an operational amplifier or comparator. Across a voltage divider the switching point can be adjusted. On the relationship between R_3 and $R_1//R_2$, the hysteresis is set. The hysteresis of the Schmitt trigger is insensitive to voltage fluctuations for example line disturbances. Thus, if U_H is exceeded at the input operational amplifier changes into the negative saturation and if U_L is reached, it switchover to the positive saturation.

U_H: At the output HIGH is present when the Input signal exceeds a voltage U_H.

U_L: At the output LOW is present when the level falls below a voltage U_L at the entrance.
The resistance R_1 and the voltage U_H and U_L are set to the following values.

$$R_1 = 10k\Omega$$
$$U_H = 3V$$
$$U_L = 2V$$
$$V_{CC} = 5V$$

Characterized the resistors R_2 and R_3 can be determined by the following formulas, while V_{CC} is 5V.

$$R_2 = \frac{R_1 \cdot U_L}{V_{CC} - U_H} = 10k\Omega$$

$$R_3 = \frac{R_1 \cdot U_L}{U_H - U_L} = 20k\Omega$$

Now the Schmitt trigger generate very steep edges.

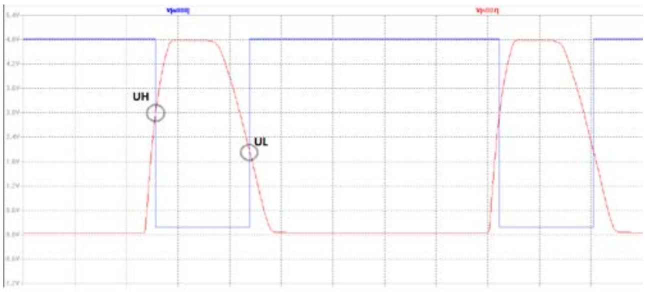

FIGURE 8: The output (blue) and the operating points of (red) the Schmitt trigger

3 LAYOUT

[9] For the creation of the board layout the software NI Multisim is used from the company Electronics Workbench. With the NI Multisim the circuit diagram is drawn and an export function transmitted the circuit diagram on NI Ultiboard. Now the components are placed.

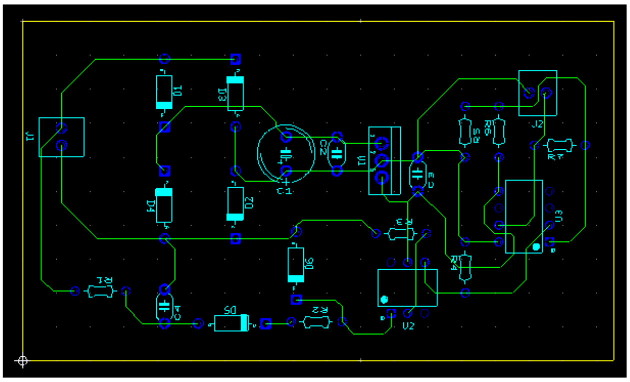

FIGURE 9: Layout of the circuit diagram

Figure 10 represents a 3D view there.

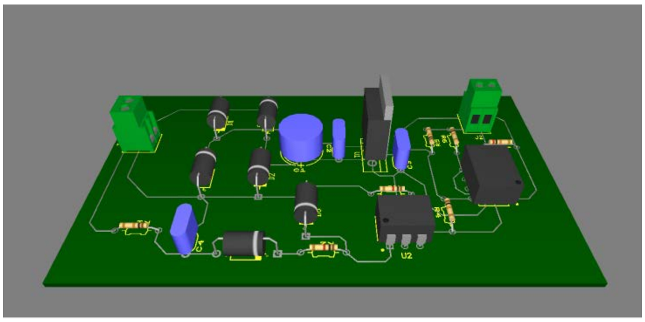

FIGURE 10: The output (blue) and the operating points of (red) the Schmitt trigger

4 CONCLUSION

The task in this project was to design a circuit that convert a sine wave into a square wave voltage, due to the microcontroller. With LTSpice IV is a simulation has been simulated. Finally, the components were ordered and soldered together. Therefore the task was successfully fulfilled.

5 REFERENCES

[1] Arduino Ethernet Shield, http://www.arduino.cc/en/Main/ArduinoEthernetShield, 15.03.2015

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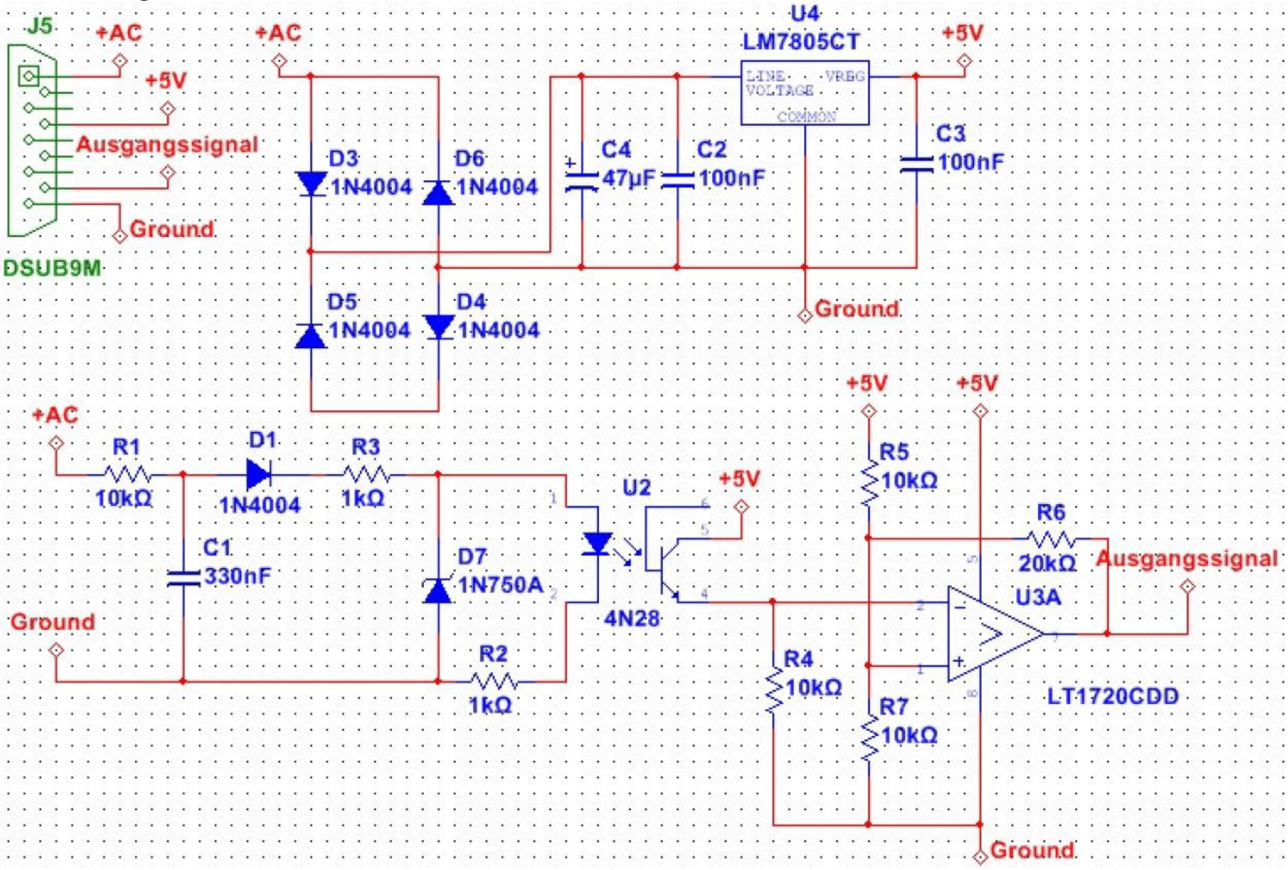
Appendix:

Circuit diagram of the measurement circuit



Proposal for a wire layout: