Preview Research project

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Contents

1 Abstract

This report briefly summarizes the research project and its results. A deeper insight as well as the interpretation of the results will take place in the actual report of the research project.

2 Introduction

The research project was carried out in cooperation with the company KSD Köthener Spezialdichtungen GmbH. The company deals with the production and trade of seals for valve and plant construction. The cooperation arose because the faulty pumps were examined and the grease used had turned dark. One assumption is that water and other dirt particles (metal abrasion or dirt from outside) are deposited in the grease and thus influence the functionality of the seal. This gave rise to the topic of the research project: "Moisture detection in grease".
There were two basic ideas to investigate the problem of moisture. On the one hand, the observation in the infrared spectrum or the capacitive observation in an analog or digital variant.

3 Methods

3.1 Analog

The measurement with the analog variant was done via an AC bridge. The circuit was designed and built by Mr. Adler. The first measurements seemed to be successful, however, a problem turned out quickly: The DC voltage at the output of the measuring circuit became an oscillating AC voltage signal. This meant that the DC signal fluctuated or oscillated by 500mV. Since a possible explanation for this was not found, it was decided to create a digital version.

3.2 Digital

In the digital version, the charging time of the capacitor was measured by means of ESP32. This microcontroller was taken because it has a very high clock frequency and thus the timers can also resolve very high. The measurement setup can be seen in the figure [3.1] and [3.2]. To slow down the charging time a resistor with $R = 1\text{M}\Omega$ was taken. Then a comparator compared the voltage of the capacitor with 0.63 of the total voltage. When this value was reached, the output of the comparator was set to HIGH and the ESP32 reacted with an interrupt and calculated the corresponding capacitance. The capacitor was a plate capacitor with a plastic tube containing the grease mixture [3.3]. The graphical evaluation of the measurement results can be seen in the figures [3.4] - [3.7]. The grease is the grease provided by Mr. Adler. The grease-water mixture contains 6.66% water. The measurements were always performed with the same water and the same grease-water mixture, since the dielectric constant is frequency-dependent. A striking feature is the measurement at a very low frequency (f=2Hz), where the measured capacitance of the water is lower than that of the grease, for which there is still no explanation. In this case, the measurements at higher frequencies show an expected result, where the grease-water mixture has a higher capacitance than the grease. The differences between the two capacitance became larger the higher the frequency of the measurement became.
With f=20Hz:

$$C_{\text{grease}} = 65.54378418879908\mu\text{F} \tag{3.1}$$

$$C_{\text{grease-water}} = 65.59469145327826\mu\text{F} \tag{3.2}$$

$$\Delta C = 0.05090726447917859\mu\text{F} \tag{3.3}$$

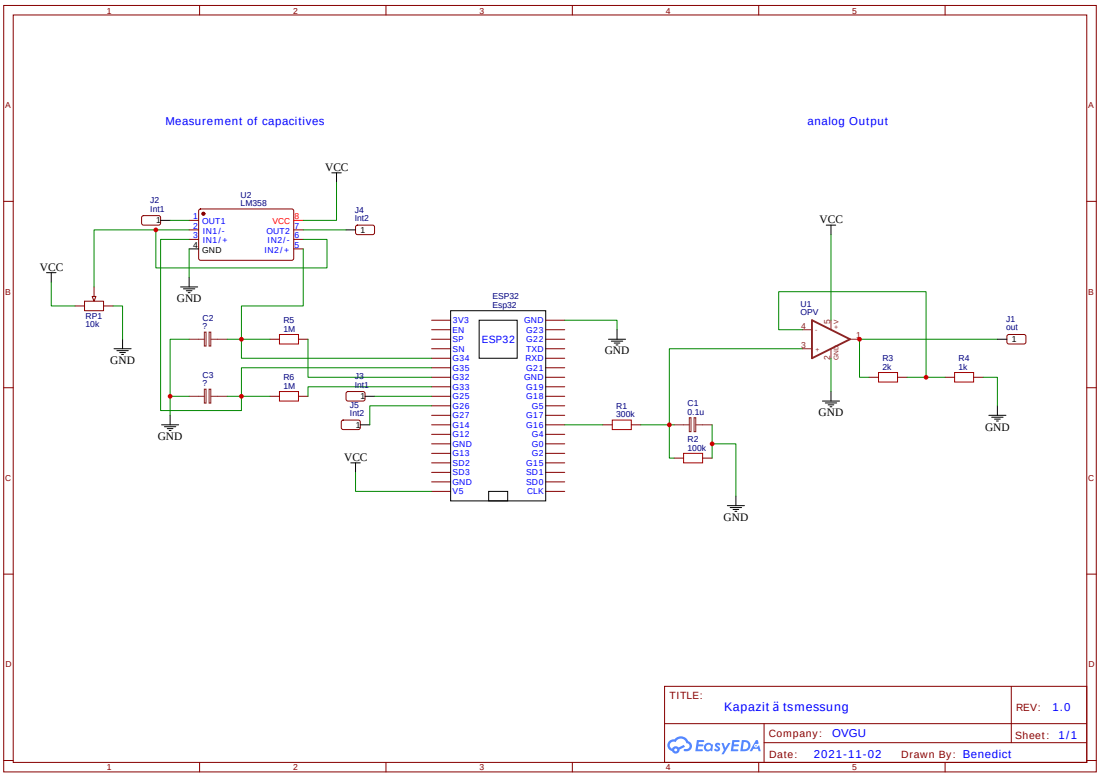

Figure 3.1: Overall design of the circuit

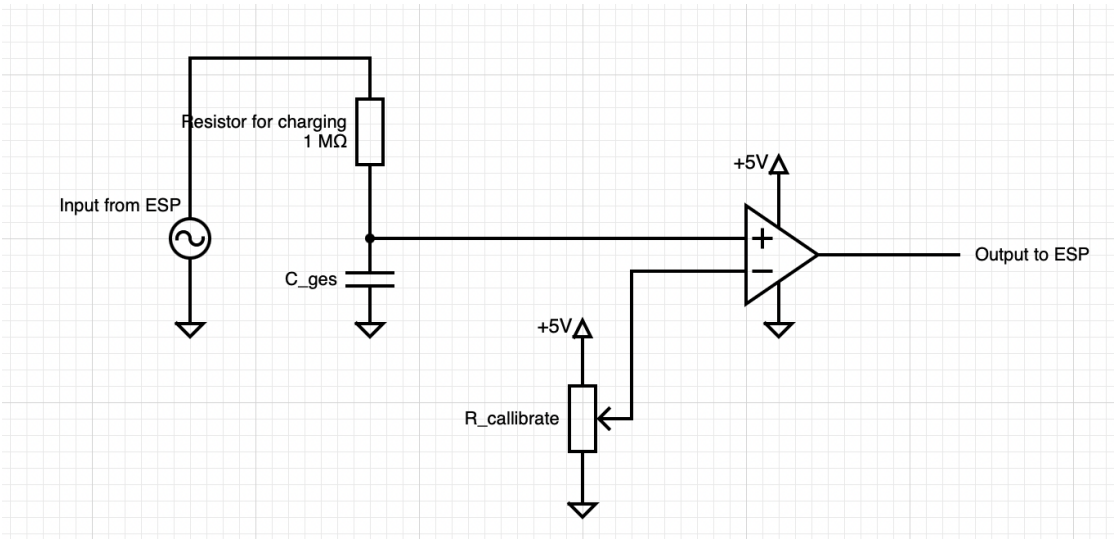

Figure 3.2: Simplified structure of the circuit

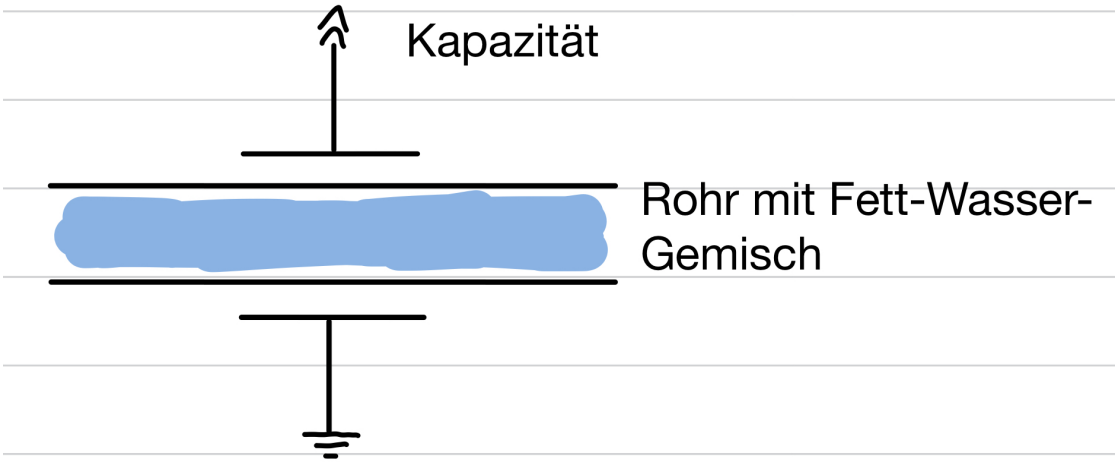

Figure 3.3: Schematic structure of the circuit

With f=200Hz:

$$C_{\text{grease}} = 63.32508218439551\mu\text{F} \tag{3.4}$$
$$C_{\text{grease-water}} = 63.39419065185354\mu\text{F} \tag{3.5}$$
$$\Delta C = 0.06910846745802957\mu\text{F} \tag{3.6}$$

With f=568Hz:

$$C_{\text{grease}} = 63.30306145021645\mu\text{F} \tag{3.7}$$
$$C_{\text{grease-water}} = 63.40192108738288\mu\text{F} \tag{3.8}$$
$$\Delta C = 0.09885963716643431\mu\text{F} \tag{3.9}$$

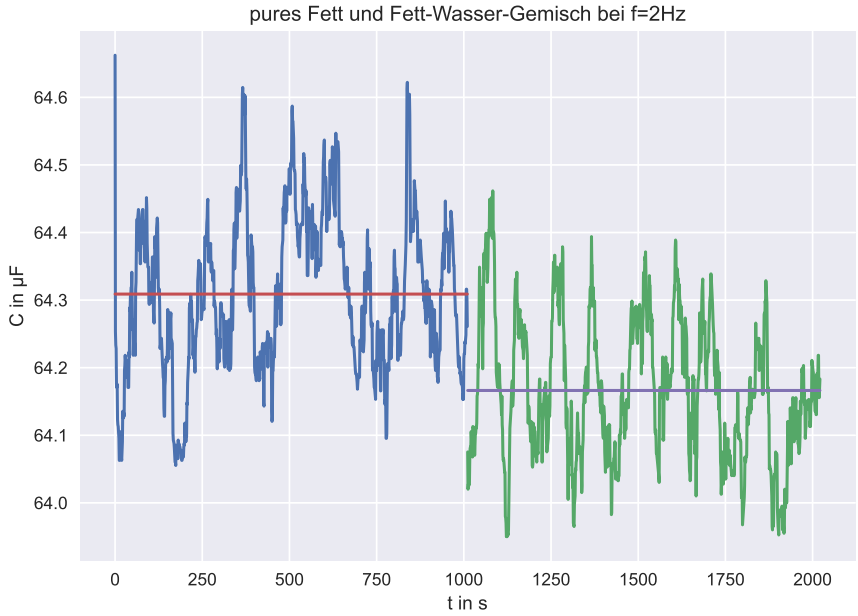

Figure 3.4: graphical representation of the grease (blue) and water (green) with the calculated mean values of the grease (red) and water (purple)

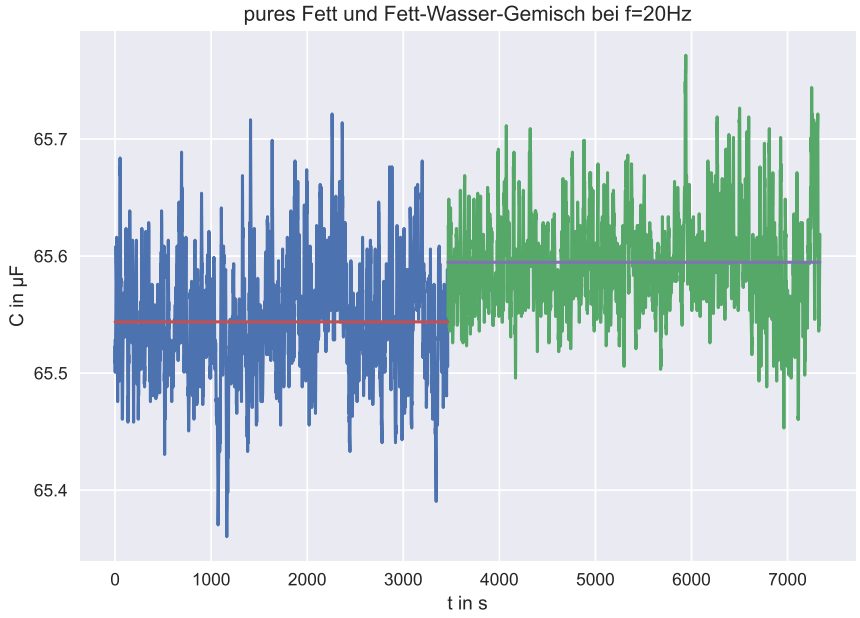

Figure 3.5: graphical representation of the grease (blue) and water (green) with the calculated mean values of the grease (red) and water (purple)

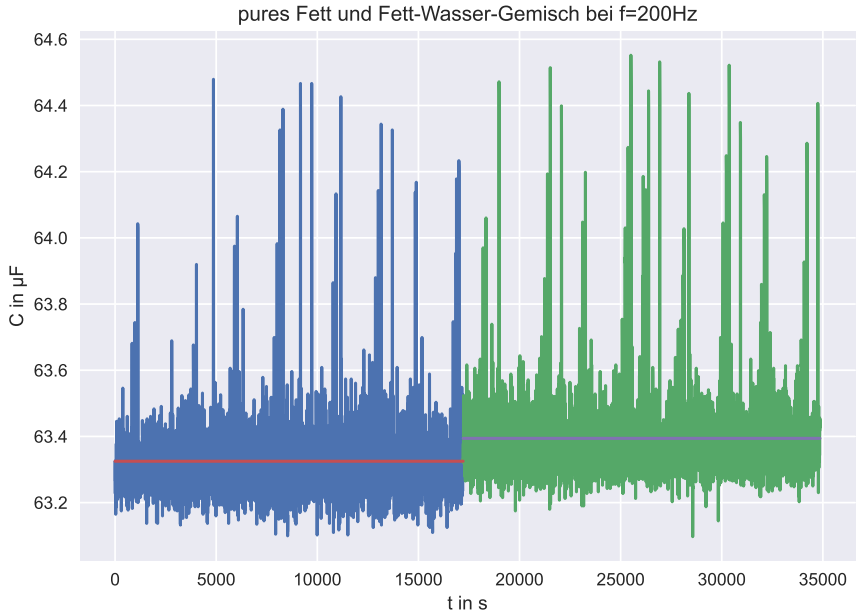

Figure 3.6: graphical representation of the grease (blue) and water (green) with the calculated mean values of the grease (red) and water (purple)

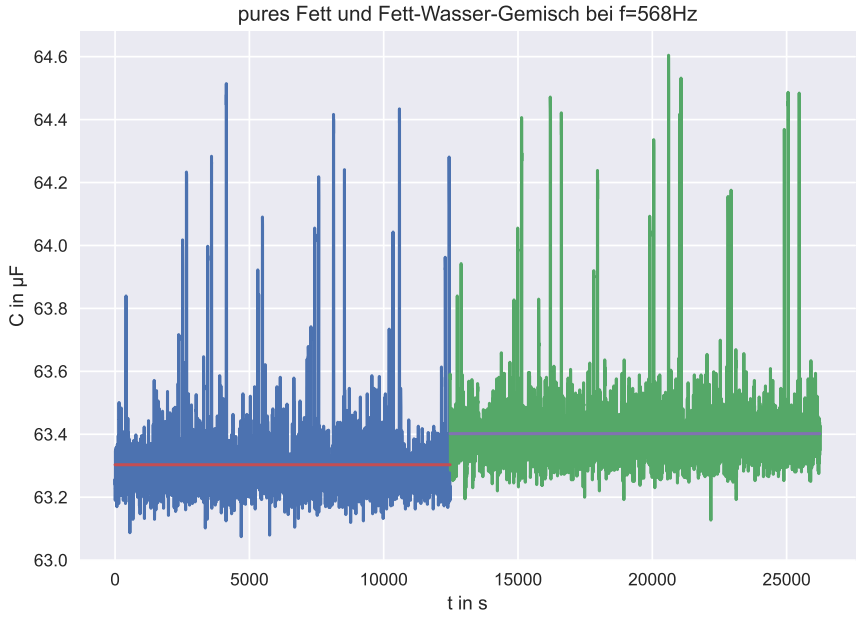

Figure 3.7: graphical representation of the grease (blue) and water (green) with the calculated mean values of the grease (red) and water (purple)

4 Conclusion

With the developed method it is possible to detect even small amounts of water (6.6%) in grease. The setup for this is relatively simple to implement in reality and with improvement of the algorithm and the use of a faster microcontroller, the results can be improved even further.