POLITECHNIKA RZESZOWSKA im. IGNACEGO ŁUKASIEWICZA

THE FACULTY OF ELECTRICAL AND COMPUTER ENGINEERING
RZESZOW UNIVERSITY OF TECHNOLOGY

BURY

Measurement system

Team members:
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1. Introduction

The project was executed on behalf of Bury Mielec company. This company is a leading producer and supplier of advanced information-communication systems and connectivity solutions for the automotive industry.

Our objective was to develop an application for measuring the efficiency of DC/DC converters as a function of load current values utilizing the existing equipment with an automated reading procedure via RS232, USB. The calculation results were to be presented in reports. The aim of this application is to automate a real issue within Bury Mielec company, ultimately leading to faster task execution and reduced workload for employees.

2. Section Project description

a) Connection with devices,

b) UI/system,

c) Raport.

2.1. Team members

Description of team members and their assumed responsibilities, owned tasks

1. Michał Mielonka – team leader
2. Konrad Zegar – programmer of connecting multimeters, help with system logic, debugging errors, author of part of documentation, tester,
3. Marcin Wiśniowski – programmer of connection DC Load, debugging errors, author of part of documentation, tester,
4. Daniel Szumski – programmer of connecting power supply, tester,
5. Alicja Wysocka - Calculation and analysis of data collected from experiments conducted on equipment from Bury Mielec. Preparation of the final report in Excel using the Python programming language.

3. Section Business plan

3.1. Analysis of competitive solutions/analysis of market (mandatory)

In analyzing the market for DC/DC converter efficiency calculation programs, we have identified several prominent international companies offering sophisticated solutions:

1. **Rohde & Schwarz**
   Verifying DC/DC Converter Efficiency [1]
2. **National Instruments**
   Power Conversion Solutions [2]
3. **Keysight Technologies**
   Application Note on Power Supply Measurement [3]
4. **Tektronix**
   Power Efficiency and Power Supply Measurement Analysis [4]
5. **Yokogawa Electronic Corporation**
   Power Measurement Application Software [5]
6. **Chroma ATE Inc.**
   OBC/DC-DC Converter Power HIL Testbed [6]

All of these companies are based internationally and offer robust programs for calculating the efficiency of DC/DC converters. However, our project, developed for the local company Bury Mielec, has distinct advantages over these foreign competitors.

Firstly, our solution is specifically tailored to meet the unique requirements of Bury Mielec. Unlike the standardized offerings of larger international companies, our project has been customized to address the specific needs and operational conditions of our client. This includes not only the software capabilities but also ensuring compatibility and optimal performance with Bury Mielec's existing equipment.

Secondly, we had the opportunity to test our program directly on the equipment provided by Bury Mielec. This hands-on approach allowed us to fine-tune the software in real-world conditions, ensuring greater accuracy and reliability.

Lastly, as a local provider, we offer unmatched post-implementation support. Our proximity to Bury Mielec means we can respond swiftly to any issues that may arise, providing timely and efficient solutions. Our local presence ensures that we are always available to assist with troubleshooting, maintenance, and any further customization needs.

In conclusion, while international companies like Rohde & Schwarz, National Instruments, Keysight Technologies, Tektronix, Yokogawa, and Chroma ATE Inc. offer comprehensive DC/DC converter efficiency calculation programs, our project for Bury Mielec stands out due to its customization, hands-on testing, and local support. These factors make our solution highly responsive and tailored to the specific needs of our client.

3.2. Risk analysis

Category	Thread	Vulnerability	Performed actions	Risk	Probability
Technical	Generating inaccurate data in certain cases.	Insufficient software testing duration on client devices.	Before fully automating the process and deploying the application, comprehensive tests should be conducted, including challenging scenarios such as a large volume of data collection.	High	Low
Human resources	Users may input incorrect data, resulting in inaccurate output.	The application allows users significant flexibility.	Conducting training sessions for Bury Mielec staff and providing thorough documentation.	Medium	Low
Human resoures	Connecting an incorrect device.	Lack of device verification before connection.	Conducting training sessions for Bury Mielec staff and providing thorough documentation	Medium	Low

4. Details of proposed solution

To measure the efficiency of the DC/DC converter, you need to assemble the circuit as shown in figure 4.1. The devices include: 2x ammeter, 2x voltmeter, power supply, dc load. They are all connected to one computer from which all activities are performed , setting and automatic adjustments are performed. The collected data is saved in files. After the measurement is completed, a report with graphs is generated.

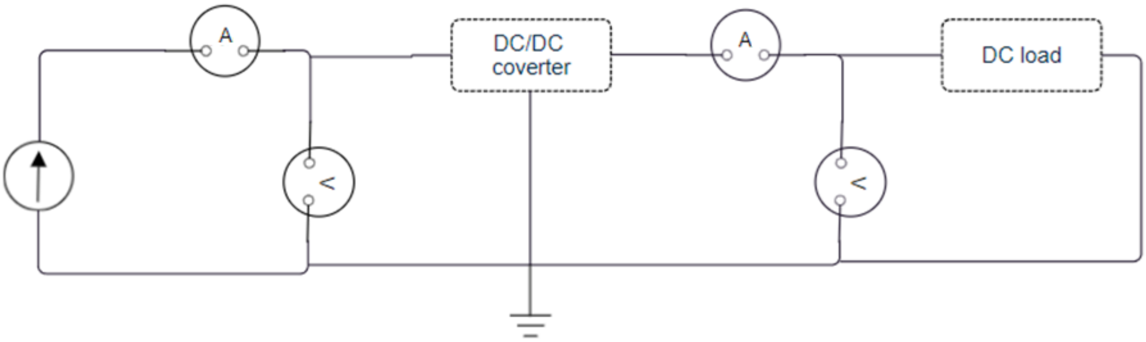

Fig. 4.1. Electrical circuit scheme

4.1. Connection with devices

We use open source library PyVISA to connect to all devices. It has the ability to communicate via the following protocols: RS232, USB, GPIB. But it also connects via the Internet, which is useful when expanding the system with a thermal chamber.
We have created our standard function so that the functions are universal for all types of devices (for example it_is() – function for asking what device we are connected, returns the name and model).

4.1.1. Multimeter

We dealt with FLUKE multimeters models: 8808A and 8846A because the company uses them. Thanks to the manufacturer's documentation, we knew what commands to use.

```
'''A method that returns what device you are'''
  def it_is(self):
    answer = ""
    self.instr.clear()
    try:
      answer = self.instr.query("*IDN?")
    except Exception as err:
      news = sm.Small_window()
      news.show_error(f"ERROR {self.port} Fluke8808A Unexpected {err=}, {type(err)=}")
    return answer
```

Fig. 4.1.1 – example of multimeter's method

4.1.2. Power supply

We dealt with the Power Supply model: TTI CPX400DP, because the company uses them. After reading the manufacturer's documentation, we were able to configure our devices properly.

Using these functions we can configure our device. Firstly we can initialize our device after connecting it to our PC. Secondly we can turn ON or OFF the output on the device and we can change output voltage too. To conclude these all functions are used in pre configure and also during the test to change output values.

```
def __init__(self, port):
    try:
        self.instr = pyvisa.ResourceManager().open_resource(port)
    except pyvisa.Error as e:
        print("Device initialization error: ", e)
```

Fig. 4.1.2.1 – function to connect into device

```
def output_on(self):
    self.instr.write("OP1 1")
    time.sleep(1)
```

```
def output_off(self):
    self.instr.write("OP1 0")
    time.sleep(1)
```

Fig. 4.1.2.2 – functions to set up output ON and output OFF

```
def set_output_voltage(self, voltage):
    self.instr.write("V1 " + str(voltage))
```

Fig. 4.1.2.2 – function to set up output voltage value

4.1.3. DC load

We dealt with DC Load model: BK Precision 8601, because the company uses them. After reading manufacturer's documentation, we know what command use in the configuration.

```
def __init__(self, port):
    try:
        self.instr = pyvisa.ResourceManager().open_resource(port)
    except pyvisa.Error as e:
        print("Device initialization error: ", e)
```

Fig. 4.1.3.1 – function to connect into device

```
def set_mode(self, mode):
    self.instr.write("FUNC " + mode)
    time.sleep(1)
```

Fig. 4.1.3.2 – function to set up mode in DC Load

```
def set_current(self, current):
    self.instr.write("CURR " + str(current) + "\n")
    time.sleep(1)
```

```
def set_voltage(self, voltage):
    self.instr.write("VOLT " + str(voltage) + "\n")
    time.sleep(1)
```

Fig. 4.1.3.3 – functions to set up current or voltage

```
def power_on(self):
    self.instr.write("INP 1")
    time.sleep(1)
```

```
def power_off(self):
    self.instr.write("INP 0")
    time.sleep(1)
```

Fig. 4.1.3.4 – functions to set up output on and off

This functions are used to configurate DC Load, first up we need to connect the device with right port with desktop. After that we change mode and current or voltage in some periods of time when test is up, last two functions is used to turn on or off the output. This all functions is used to pre configure and also during the test to make changes in output.

4.2. Collecting data

Each recorded result is the average of N measurements. N is set by the user. The measurement error decreases but the testing time increases. After one set cycle, the devices are automatically switched to the next test values.

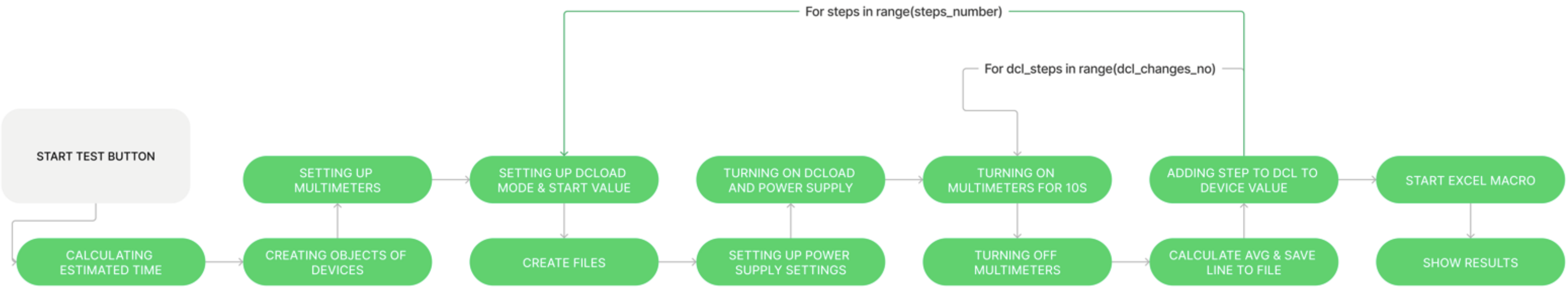

Fig. 4.2 – part of Flow Diagram

4.2.1. Data storage

We use plain text files with appropriate names to collect data from multimeters and transfer them to the report section.
By selecting the appropriate option, the user can delete "raw-files" after examination. This recording can also be made in a place designated by the user.
The data is recorded in the file as well as the appropriate notation of values - scientific notation.

4.2.2. Threads, concurrent environment

To avoid fluctuations in measurement error, we used threads to collect data from all devices at once. Each device returning data during a measurement cycle is a separate thread. In this solution we use the built-in Python library – asyncio.

4.3. UI

User interface made in a minimalist style using PyQt5 technology.
We set precise test parameters on each tab. First, we meticulously connect to the devices. When everything goes well, we will receive information in the form of a pop-up window, as well as any errors.
The UI is tailored to the required test sequences and device models.

4.3.1. App appearance

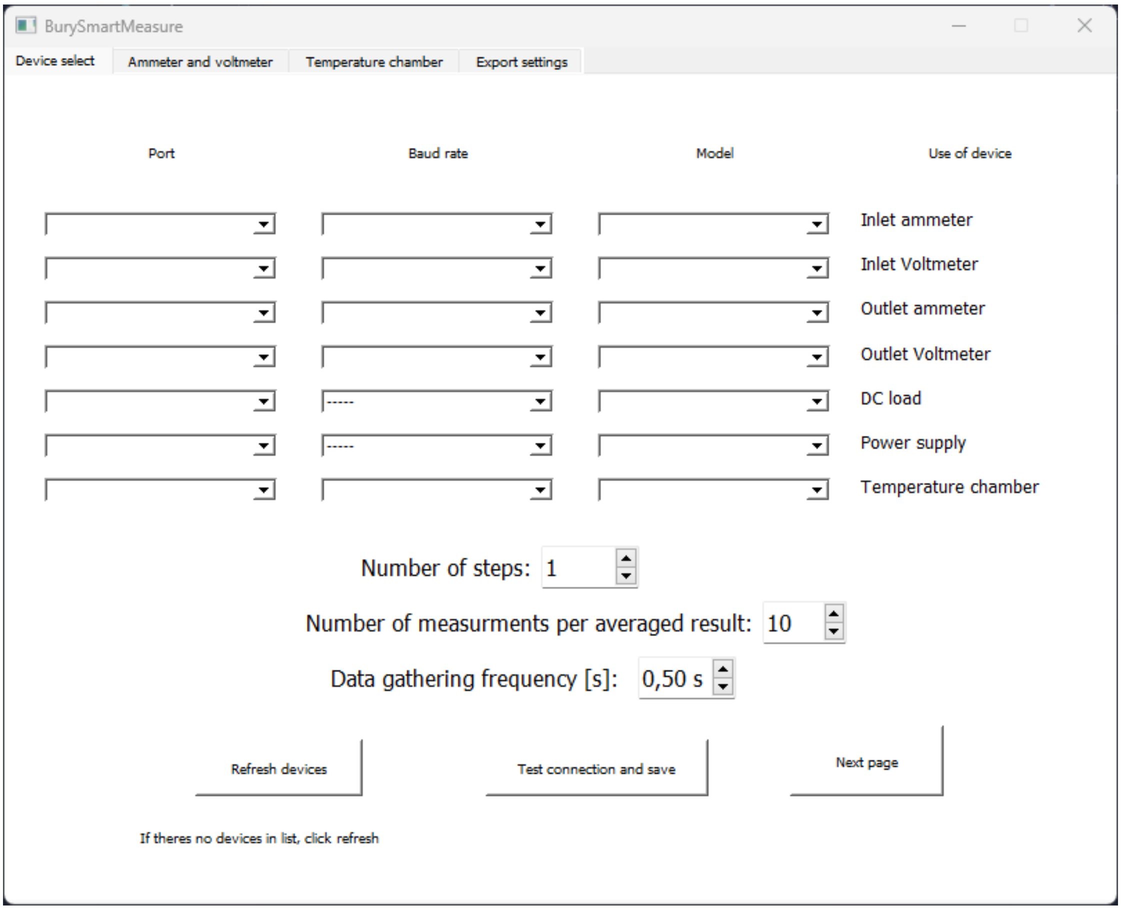

Fig.4.3.1 – window “device select”

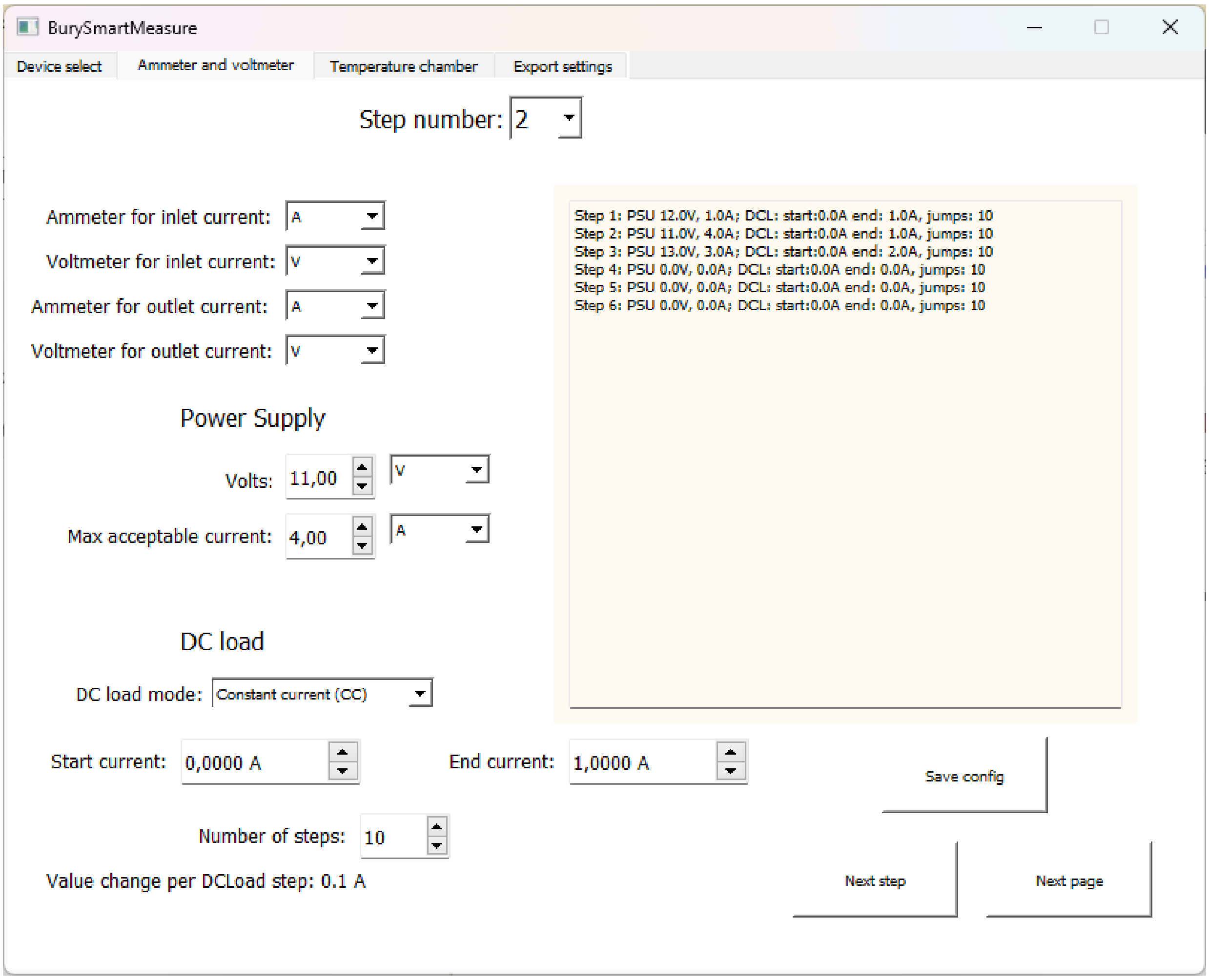

Fig.4.3.2 – window with step’s parameters

4.4. Raport

We draw performance charts from the saved data and add them to the report template. The graphs are standardized and show efficiency for various user-defined voltages depending on the current load. We are using this year's version of the openpyxl library and template from Bury company.

4.4.1. Rapport appearance

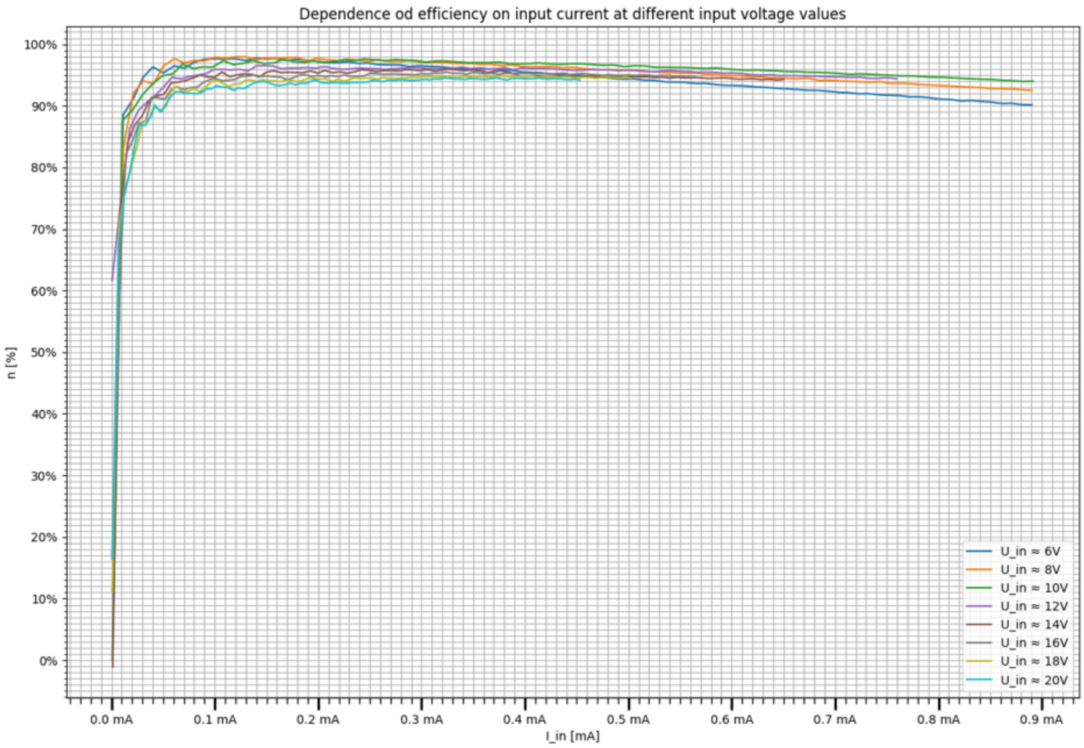

Fig.4.4.1 – graph of the efficiency of the DC/DC converter

5. Summary and conclusions

- Met problem and solution

From the very beginning, the problem was the asynchronization of data collection, which we solved with synchronous threads.

We had a problem with long data collection times - one relatively short test took 1.5 hours. By correcting the code, we obtained a satisfactory result. We have reached a data collection frequency of every 0.25 seconds. Time optimization is very important in this type of projects.

During testing, we discovered that the communication of one of the multimeters was not correct (the multimeter was giving wrong results to the computer). Replacing the device with another one resulted in proper operation. We efficiently determined what the problem was because error handling is implemented in the system.

- Unsolved issues

There were plans for a function that automatically searches for connected devices and connects to them. Determining the port and baud rate is quite difficult - possibly impossible.

- Things to be done in the future

In the future, a temperature chamber can be connected and the tests will be performed as a function of temperature.

- Possibilities to further develop proposed solution

We can create alternative systems for other companies. The system must be rebuilt for other devices and measurement sequences used.

- Members contribution

References

[1] https://www.rohde-schwarz.com/ae/applications/verifying-dc-dc-converter-efficiency-application-card_56279-836096.html Dostęp 06.2024.

[2] https://www.ni.com/en/solutions/energy/power-conversion.html - NI Dostęp 06.2024.

[3] https://www.keysight.com/us/en/assets/7018-05723/application-notes/5992-2278.pdf Dostęp 06.2024.

[4] https://www.tek.com/en/solutions/application/power-efficiency/power-supply-measurement-analysis Dostęp 06.2024.

[5] https://tmi.yokogawa.com/solutions/products/power-analyzers/power-measurement-application-software/ Dostęp 06.2024.

[6] https://www.chromaate.com/en/product/OBC_DC_DC_Converter_Power_HIL_Testbed_8620_342 Dostęp 06.2024.

[7] FLUKE 8808A Users Manual July 2007

[8] FLUKE 8845A/8846A Programmers Manual September 2006

[9] TTI CPX400DP Instruction Manual

[10] BK Precision Programmable DC Electronic Loads Programming Manual 2016

[11] https://forbot.pl/blog/kurs-elektroniki-ii-przetwornice-impulsowe-id9923 Dostęp 06.2024.

[12] https://pyvisa.readthedocs.io/en/latest/ Dostęp 06.2024.