UNIVERSAL SYSTEM OF MODULAR LAB EQUIPMENT DESIGNED WITH VACUUM ELECTRONICS IN MIND

Michał Zychla, Jan Sobków

Wrocław University of Science and Technology, Faculty of Electronics, Photonics and Microsystems, Department of Microsystems

268597@student.pwr.edu.pl

Wrocław University of Science and Technology

Introduction

When our team was tasked with designing instrumentation for a quadrupole mass spectrometer, it became apparent that a considerable amount of custom electronics was to be designed. As this posed a significant expenditure of time, a decision was made to design all devices to be highly universal, allowing for their use in future projects.

Secondly, previous experience with automated measurement utilizing a collection of off-the-shelf instruments from different manufacturers proved unsatisfactory. Completely different across devices, often poorly implemented communication protocols and control schemes resulted in inefficient, slow, and unreliable measurement.

It was decided that the two considerations: versatility and ease of integration would best be fulfilled by a unified modular system. This brings easy reconfiguration into future measurement setups, as well as a unified control and readout scheme.

What resulted was a custom modular system, nicknamed *EuroMeasure*.

Overview

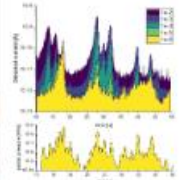
Example system with multiple different modules installed

The system's mechanical design was inspired by the Eurocard standard and uses I2C as the main communication bus between cards. Each module in the system communicates with the main controller card, which in turn is responsible with the communication with the PC. To improve user safety, a hardware lockout line was implemented, making it possible to reliably switch off all dangerous voltages within the experiment.

Software remains a crucial part of all automated measurement setups. A software package has been developed to quickly configure measurement routines and plot results. For more demanding tasks a python library has also been developed, enabling full control of the system. This enables users to quickly carry out simple measurements, and configure more complicated ones with relative ease.

Miniature quadrupole mass spectrometer fully controlled by presented system

Jendryka J. (2024). Development and characterization of portable quadrupole mass spectrometer [unpublished master's thesis]. WUST.



Example mass spectra acquired using the system

Unpublished, courtesy of Piotr Szyszka

Future development

A new version of the system is being designed at the moment, improving mechanical construction and communication protocols. It will be entirely based on ethernet communication, eliminating the need for a separate controller card for interfacing with the PC. Full compatibility with SCPI is also anticipated.

Example modules

4-channel 5.5-digit voltmeter

- ±1 V and ±10 V ranges
- Up to 10 µV resolution
- Max sample rate: 64 kS/s
- Analog bandwidth: 10 kHz

4-channel precision ±200 V power supply

- Accuracy: 0.055 % + 20 mV
- Output current: ±1 mA
- Overcurrent protection
- Load regulation: <1 mV
- Setting time: <1 ms
- Digitally controlled

High voltage CC-CV power supply

- Output voltage up to 6 kV
- Constant voltage and constant current operation
- Digitally controlled

2-channel DDS generator

- Frequency range: 2 kHz - 10 MHz
- In-band flatness: < 1dB
- Undistorted amplitude: 9 Vpp
- Amplitude control resolution up to 60 µV

RF Power amplifier

- Frequency range: 3 MHz - 10 MHz
- Output power: 5 W

Acknowledgments

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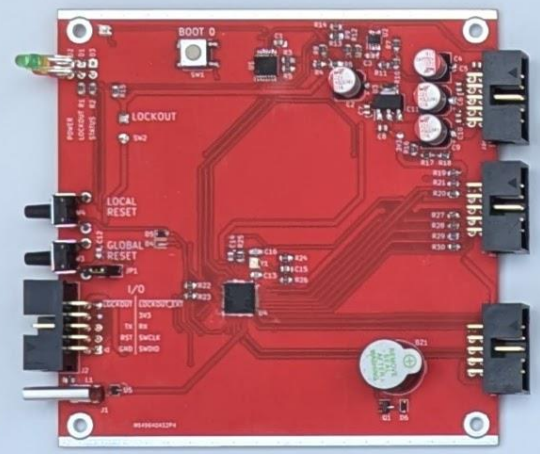
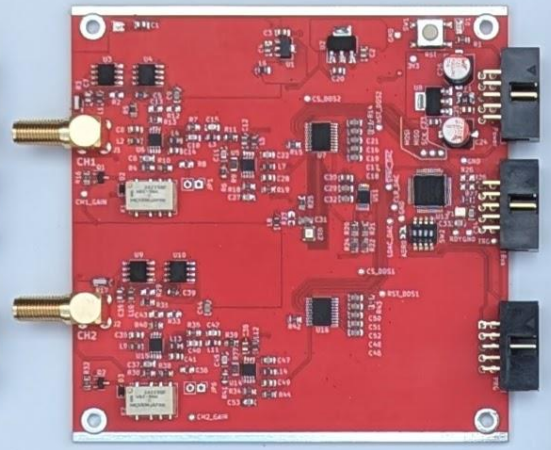
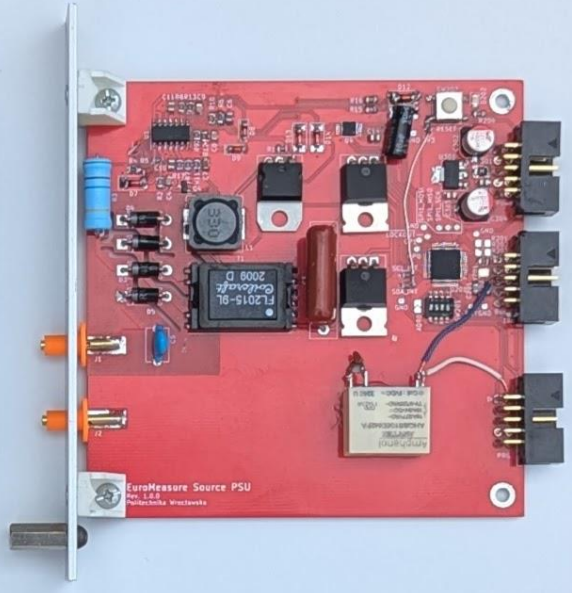
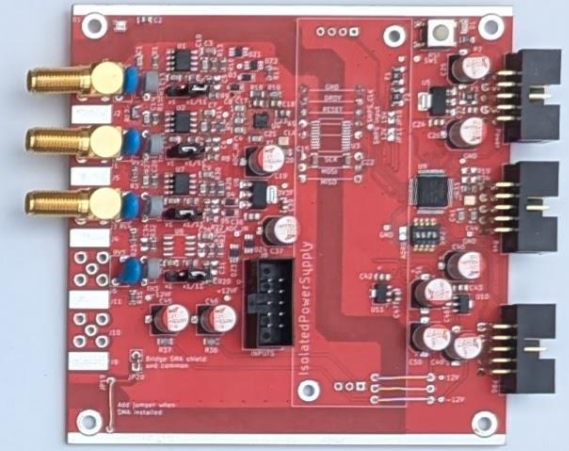
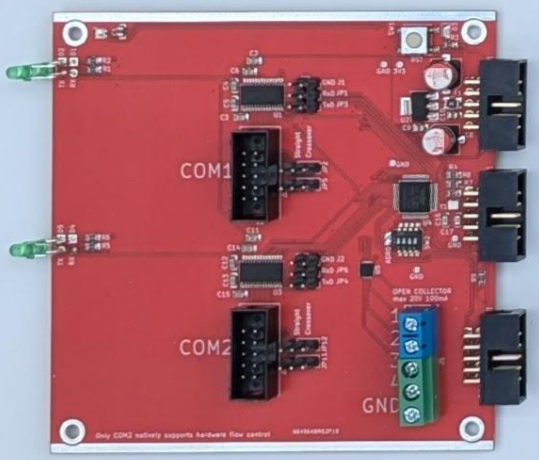
Hardware and software designed by: Jakub Jendryka, Krzysztof Nowak, Marcin Białas, Łukasz Swiszcz and authors

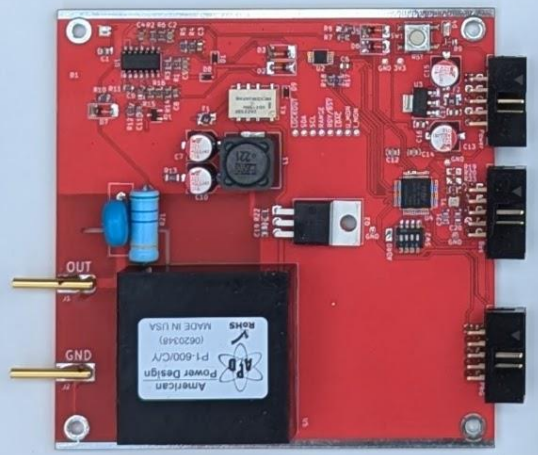

BOOT 0
LOCKOUT
LOCAL RESET
GLOBAL RESET
I/O


CH1
CH2

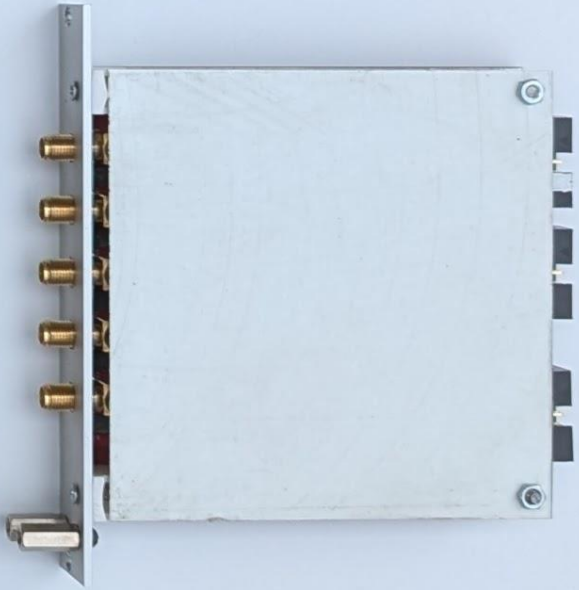

EuroMeasure Source PSU

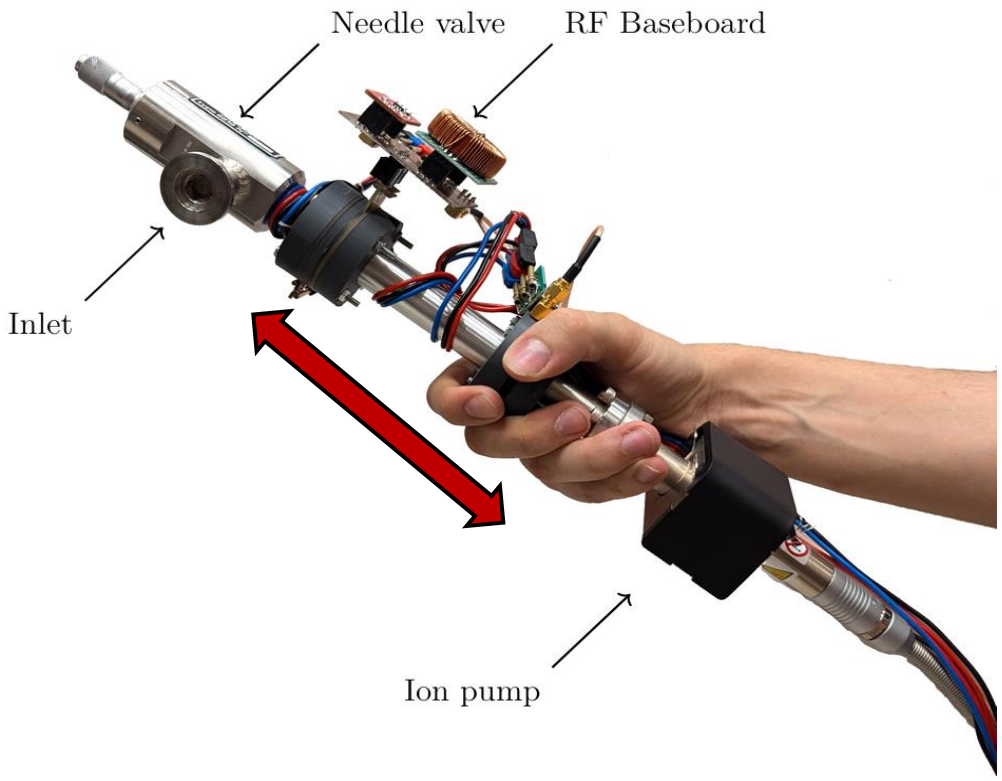

IsolatedPowerSupply

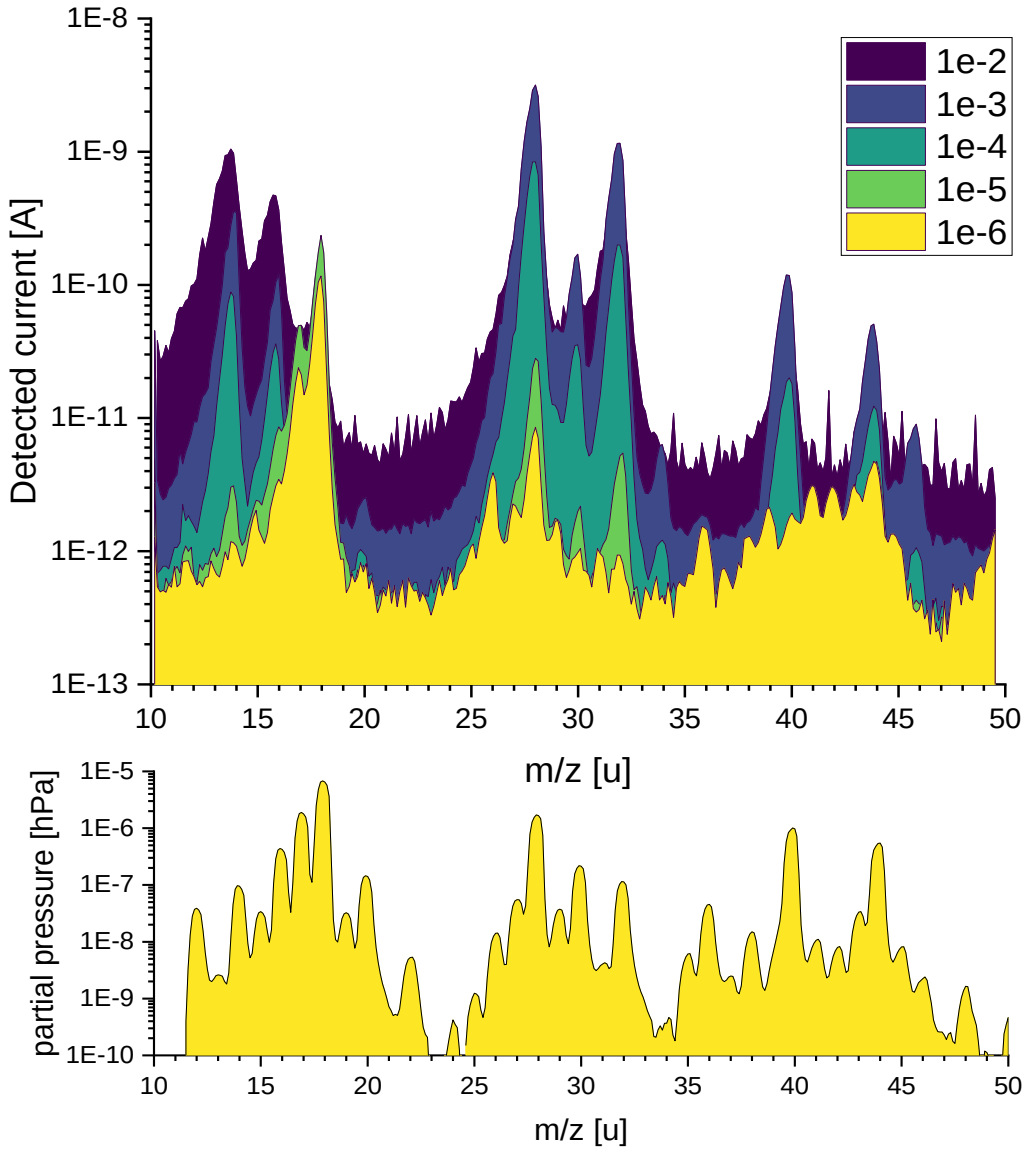

COM1
COM2
GND


OUT
GND
American Power Design
P1-600/C/Y
MADE IN USA


EuroMeasure-RFPA




Needle valve
RF Baseboard
Inlet
Ion pump


1E-8
1E-9
1E-10
1E-11
1E-12
1E-13
Detected current [A]
1e-2
1e-3
1e-4
1e-5
1e-6
10
15
20
25
30
35
40
45
50
m/z [u]
1E-5
1E-6
1E-7
1E-8
1E-9
1E-10
partial pressure [hPa]
10
15
20
25
30
35
40
45
50
m/z [u]