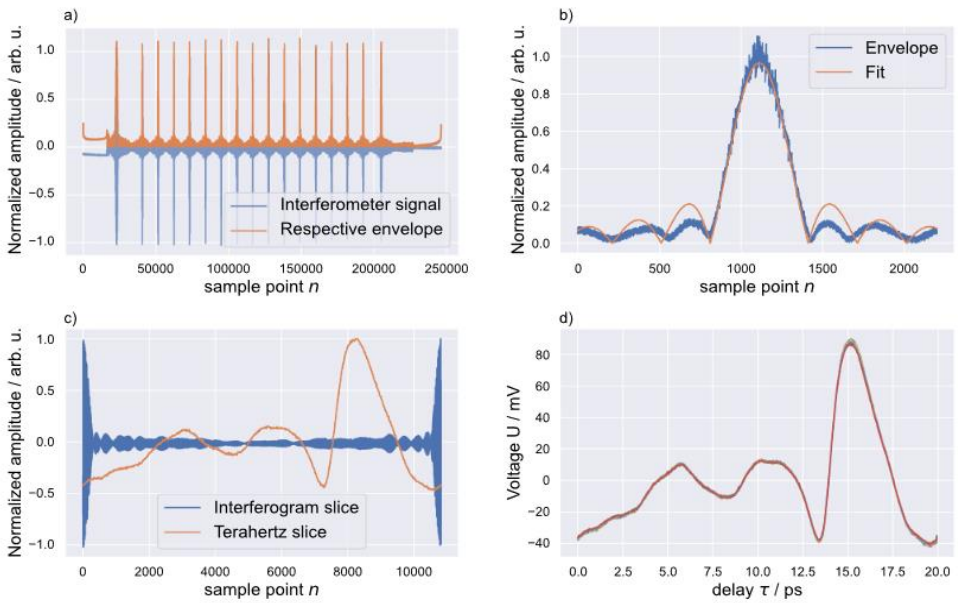
Master Thesis / Master Project

Implementation of Real-Time Synchronization and Resampling for Terahertz Time-Domain Spectroscopy on FPGA

UNIVERSITÄT DUISBURG ESSEN

Offen im Denken

Terahertz time domain spectroscopy (THz-TDS) relies on a relativ time delay between two identical optical pulses. One pulse generates the terahertz wave at a transmitting antenna, while the other pulse probes the electromagnetic field at the receiver antenna. By altering the relative delay, the terahertz pulse can be sampled. The quality of the THz-TDS system is determined by the precision with which it can determine the relative delay.



Cherniak, V., Kubiczek, T., Kolpatzeck, K. et al. *Laser diode based THz-TDS system with 133 dB peak signal-to-noise ratio at 100 GHz.* Sci Rep ***13****, 13476 (2023). https://doi.org/10.1038/s41598-023-40634-3*

In our self-built THz-TDS system, we utilize a mechanical optical delay unit (ODU) to control the relative delay. In a recent publication, we presented a method for monitoring the ODU's position during the measurements, achieving high accuracy in the reconstruction of the time axis. The proposed algorithm uses a low percentage of the optical pulse power as an interferometer for synchronization and resampling of the measurement points in offline processing.

To enhance the measurement speed and portability of the self-built THz-TDS system, the aim of this thesis is to implement the synchronization and resampling of the measurement data on an FPGA development board. The development board hosts an ARM-V7 dual-core processor with an onboard FPGA and two 14-bit ADC channels. Using the ADC, the terahertz signal and interferometer signal are sampled simultaneously. Based on the characteristics of the interferometer signal, the terahertz signal needs to be sliced, downsampled, and transferred to a PC for validation.

The task includes:

- the creation of a time and work plan,
- the familiarization with the concept THz-TDS and the interferometer observation,
- FPGA programming, simulation and implementation with Vivado,
- programming of a simple server / client, communication
- and the evaluation of the measurement results
- the documentation of the work,
- the regular participation in group seminars,
- the presentation of an interim report,
- the final presentation of the work,
- the submission of the documentation and the presentation in PDF format as well as the hand in of the printed documentation to the Prüfungsamt according to the regularisation in the Prüfungsordnung.

Helpful skills:	Experience in programming (Python or Matlab, C and Verilig or VHDL). Knowledge in signal processing.
Character of the project:	60% System level programming / 20% Simulation / 10% Measurements 10% Measurement validation
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