# TU Dortmund Germany – Report on the set of TIMS Systems

Report by the **Communication Technology Institute** (chair Prof. Dr. R. Kays) of **Technische Universität Dortmund**'s **Faculty of Electrical Engineering & Information Technology** (Germany) on the set of TIMS systems used in student's experiments

## 1) Use of the TIMS system

Our institute operates since 2009 five units of the TIMS system to train students in the field of analog and digital communications technology. This is done by supervised experiments that are timed closely with matching lectures. This way, students are well prepared for the experiments. In addition, there is a reinforcement of the learning success, as the students experience the abstract contents of the lecture in practice. The experimental program was partially inspired by documents coming with the TIMS system but was newly designed at our institute to match our lectures.

Our previous versions of the experiments were based on hardwired experimental boxes that were designed for a specific topic. Only switch and adjustment operations were required in the past. The decisive innovation when using the TIMS system was that students had to actually convert the formulas and block diagrams into physical components. To our surprise, it was found that the process of translating some theoretical knowledge in a practical system caused problems by the students. Two conclusions were drawn: First, that in the past this task obviously had not been addressed sufficiently in the training of students. It was therefore adequate to improve this shortcoming by migrating to the TIMS system. Secondly, for most parts of the experimental program wiring plans can optionally handed out by the supervisors. This is done as soon as the students have consumed a period of time without substantial progress. This way, the experiments are successfully finished within reasonable time.

Our department continuously performs evaluation procedures on the success of each element of tuition. The experiments are assessed by the students as somewhat time-consuming but also as highly beneficial.

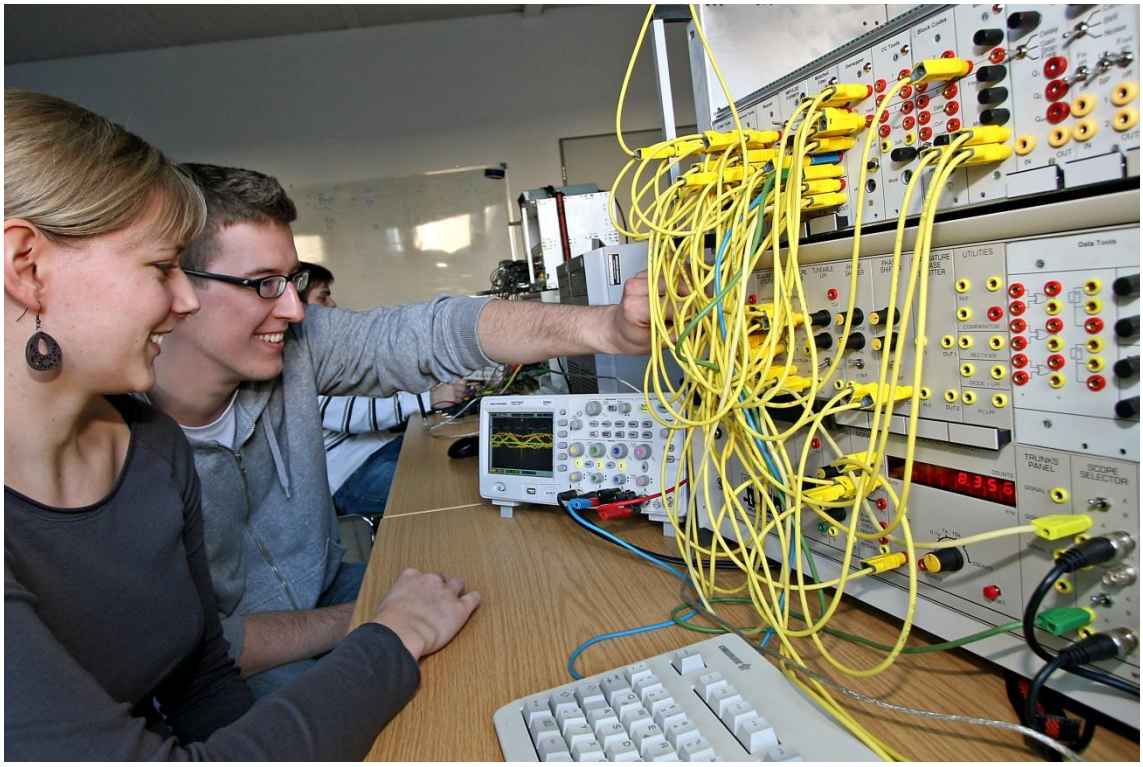
## 2) Setup of the TIMS system

Four units of the TIMS system are available in parallel for groups of each with two or three students. Though rarely needed, a fifth system serves as a backup. Each system owns a set of original modules from the TIMS system, which provides the basic functions. All measurements are done by standard 4-channel oscilloscopes. The oscilloscopes can be linked via USB to a PC. We run our own MATLAB based software on the PC for further analysis. These include spectrum analysis, histograms, power and SNR measurements, etc..

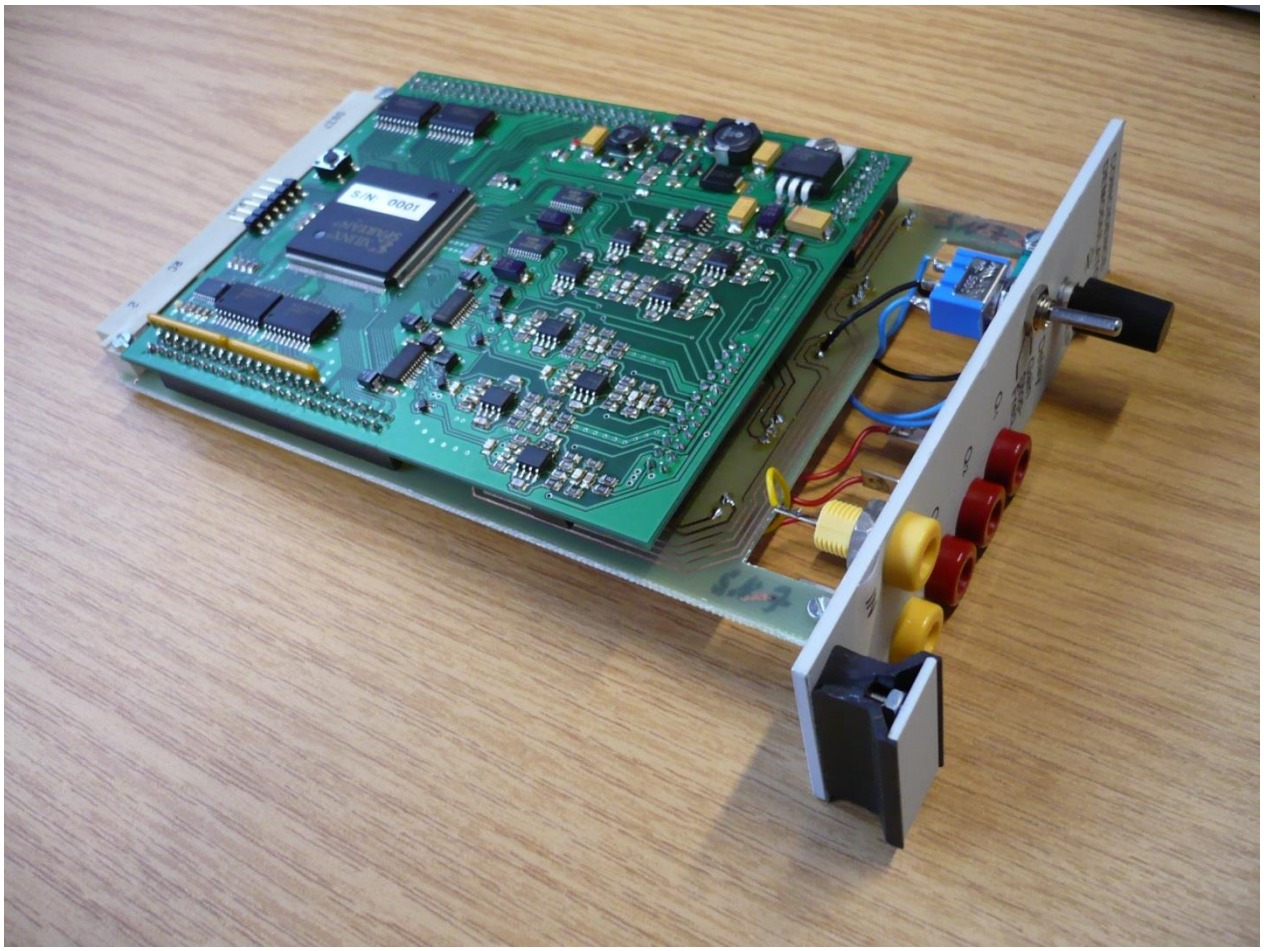
Moreover, we have supplemented the TIMS system by complex modules for experiments in digital transmission technology. To save development time, the hardware of the signal processing in all modules for all realized functions is absolutely identical. The hardware is build around a Spartan-3 FPGA. 4 ADC channels and 2 DAC channels with pre- and post-filters operating at selectable sampling frequencies in the MHz range are present. Digital I/O lines with protective level shifters serve as digital in- and outputs. These I/O lines are also used to scan switches and rotary encoders on the front panel. The otherwise identical modules differ only by the front panel elements located on an interconnector

board and the individual firmware of the FPGA. We have implemented complex functions such as DCOs with precision frequency offset, delay lines, impulse formers with selectable and exact shapes (e.g. RRCOS with adjustable rolloff), suitable matched filters, samplers, elements for CDMA, block codes like BCH codes, convolutional codes with selectable parameters, Hilbert transformers and low-pass / bandpass channels with adjustable parameters.

Using this FPGA board, students can build and examine a wide range of modern communication systems and their typical impairments. The FPGA boards used in the TIMS system can also be programmed by the students in VHDL. This makes it possible to give them an introduction into hardware based real time signal processing.




Title: Actual training of students




Title: FPGA-Board located on interconnecting board