16. SOFTWARE DEFINED ELECTRONICS AND VIRTUAL INSTRUMENTATION

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ACTIVITY OF THE SDE-VI LAB, A BRIEF DESCRIPTION

The lab works on two hot research topics: 1) Software Defined Electronics (SDE) and 2) automated test beds implemented on Virtual Instrumentation (VI) platform

Topic #1: Software Defined Electronics. Advent of universal RF hardware devices has triggered a revolutionary change in the design paradigm of RF and microwave information processing systems including both telecommunications and testing. In SDE approach, the hardware (HW) and software (SW) components are completely separated and the system to be built is implemented entirely on a SW platform. Software defined radio, universal software radio peripheral and virtual instrumentation all mean that the information processing is performed in baseband exploiting all advantages of digital signal processing. SDE approach relies on complex envelopes and equivalent baseband models that ensure the use of theoretically attainable minimum sampling rate.

Because the different applications are implemented in SW, the implementation of a new application requires only changing the software. The SW implementation also makes the parallel information processing possible, for example, an SDE radio receiver can demodulate the received signal and evaluate the propagation conditions in the radio channel simultaneously. The flexibility and capability of parallel signal processing offered by SDE are must in cognitive and collaborative radio communications. The SDE approach also makes the implementation of adaptive information processing systems possible.

Topic #2: Automated Test Beds Exploiting Virtual Instrumentation. The main challenge in mass production of up-to-date and high quality products is the calibration and testing. Components used in automotive industry or the constituting elements of telecommunications and computer systems are so complex that their production, calibration and testing cannot be done manually anymore, instead, computer controlled automated production, calibration and test systems have to be used.

The SDE approach considers the universal HW device as a part of a computer system. The SDE together with the host computer form an embedded system. The SDE, the theoretical basis of virtual instrumentation, together with the remote controlled test equipment and production lines are used to form a fully automated production line or calibration/test bed where every step of manufacturing, calibration and testing is done automatically without any human interaction. This process provides the traceability required today in the production of safety critical and high-end products. Since the entire production, calibration and testing process is performed in an embedded system, not only the manufacturing but even the documentation and logistic of the entire manufacturing and distribution process can be arranged easily.

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Most Important International Collaborations:

Prof. C.K. Tse, Chair Prof., Head, Fellow of IEEE and Prof. F.C.M. Lau, Assoc. Head. EIE Dept., The Hong Kong Polytechnic University, Hong Kong SAR, China
Prof. R. Chen, Chair Prof., Director of Centre of Chaos and Complex Networks, Fellow of IEEE. EE Dept., City University of Hong Kong, Hong Kong SAR, China

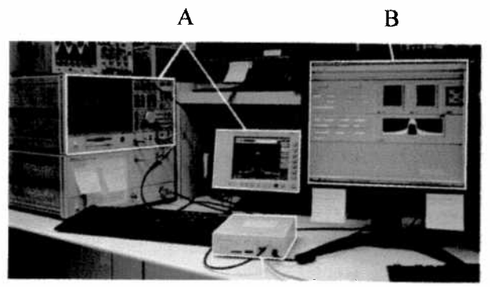

Figure 1 *Picture taken at an SDE experiment. A: stand-alone microwave equipment, B: GUI of SW implementation in BB, C: USRP, the universal HW device.Testing of a QPSK transmitter implemented on LabVIEW platform. Note the identity of the spectra and constellation diagrams calculated by SW in baseband (BB) and measured by stand-alone test equipment*

Our SDE-VI Lab has been playing a leading role worldwide in the research of software defined electronics. This leading role had been recognized by IEEE CAS Society and we were asked to write a tutorial on SDE for the IEEE CAS Magazine in 2012. See item [2] below.

PUBLICATIONS

[1] G. Kolumbán, T. Krébesz, C.K. Tse and F.C.M. Lau. Basics of Communications Using Chaos, In *Chaotic Signals in Digital Communications*, (M. Eisencraft, R. Attux and R. Suyama, Eds.), *in press, to appear* at CRC Press, 2013

[2] G. Kolumbán, T. Krébesz and F.C.M. Lau. Theory and Application of Software Defined Electronics: Design Concepts for the Next Generation of Telecommunications and Measurement Systems, invited tutorial in *IEEE Circuits and Systems Magazine*, vol. 12, no. 2, Second Quarter, pp. 8-34, 2012

[3] W.K. Xu, L. Wang and G. Kolumbán. A Novel Differential Chaos Shift Keying Modulation Scheme, *International Journal of Bifurcation and Chaos*, vol. 21, no. 3, pp. 799–811, 2011

[4] G. Kolumbán, F. C. M. Lau and C. K Tse. UWB Radio: From an Idea to Implementations, invited tutorial at *2010 IEEE International Conference on Ultra-Wideband, in Proc. of ICUWB'10* Tutorial Session, Nanjing, China, September 20–23, 2010

[5] G. Kolumbán. Feasibility of UWB radio: Dreams, facts and solutions, invited speech at *IEEE International Symposium on Communications and Information Technologies*, in Proc. ISCIT'09, Incheon, Korea, September 28–30, 2009