Department of Electronic and Information Engineering
The Hong Kong Polytechnic University

Subject Title	:	**Advanced Telecommunication Systems**
Subject Code	:	EIE579
Credit Value	:	3
Responsible staff and department	:	Prof. Geza Kolumban (visiting Professor), EIE
Pre-requisite	:	None
Recommended background knowledge	:	Digital communications and networking
Mutual exclusions	:	None
Learning approach	:	Lectures: 24 hours Laboratory/Case study/Presentation: 18 hours
Assessment	:	Continuous assessment: 100% Continuous assessment consists of assignments, laboratory report, a case study together with presentation and written report

Objectives:

The subject aims to introduce

(i) Operation principle of Wireless Local Area (WLAN) and Wireless Personal Area (WPAN) Networks where the date communications is organized according to the layered (OSI) model

(ii) Characteristics of indoor and mobile radio channels, implementation and performance testing issues of WLAN and WPAN physical layers, that is, radio transceiver

(iii) IEEE Standard 802.15.4 to explain both the hardware and software aspects of data communications in sensor networks, embedded systems and computer networks

(iv) Knowledge that is required to understand the operation of a WiFi, Bluetooth, ZigBee or ultra-wideband (UWB) radio system

At the completion of the subject, the student is equipped with the tools and ideas of selecting, designing, installing, testing and maintaining a WPAN or WLAN system providing the data communication in a sensor network, embedded system or computer network. Examples and case studies will help the students to learn not only the theoretical material but also to understand the practical issues. The IEEE Standard 802.15.4 applied by the ZigBee Alliance to implement the Physical (PHY) and Medium Access Control (MAC) layers is used as an example to discuss all details of the operation of the layered data communication systems. The survey and comparison of WiFi, Bluetooth, ZigBee and UWB radio systems equip the student with the knowledge required to choose the best solution to a data communication problem.
A laboratory experiment is also available where the data sheets and circuit blocks of the Texas TRF6900A FSK transceiver are evaluated in detail and its system level parameters are measured.

The TRF6900A implements the physical layer on a single chip and it operates in the 915-MHz ISM band. The laboratory experiment provides a deeper understanding of PHY layer operation and application.

References:

[1] S. Haykin, *Communication Systems,* 4^{th} ed., John Wiley & Sons, 2001.

[2] B. Razavi, *RF Microelectronics,* Prentice Hall, 1998.

[3] J. A. Gutiérrez, E. H. Callaway and R. L. Barrett, *Low-Rate Wireless Personal Area Networks,* IEEE Press, 2003.

[4] K. Siwiak and D. McKeown, *Ultra-Wideband Technology*, John Wiley & Sons, Chichester, UK, 2004.

[5] Homepages of related IEEE Working Groups: http://grouper.ieee.org/groups/802/11/
http://grouper.ieee.org/groups/802/15/

Detailed Subject Contents:

1. Basic concepts in application of Wireless Local Area (WLAN) and Wireless Personal Area (WPAN) Networks
   - 1.1 Typical WLAN and WPAN applications
     Sensor networks, smart dust, manufacturing lines and other embedded systems, home automation and networking
   - 1.2 Layered structure of WLAN and WPAN data communication systems
   - 1.3 Channel conditions in indoor and mobile radio communications
   - 1.4 Theory of WLAN and WPAN data communication systems
     Modulation and demodulation, intersymbol-interference, modulation schemes with constant envelope, effect of nonlinearity, spectra and eye diagram, spread spectrum techniques
2. Implementation issues and performance testing
   - 2.1 Receiver architectures
     Superheterodyne, image-reject, low-IF and zero-IF receivers. Digital-IF and subsampling receiver configurations
   - 2.2 Transmitter architectures
     Direct-conversion and heterodyne transmitters
   - 2.3 Antennas
   - 2.4 Special techniques used in WLAN and WPAN applications to reduce power consumption and complexity
   - 2.5 Transceiver performance testing
     Emission mask and unwanted emission, selectivity, third-order intercept point, 1-dB compression point, receiver blocking, sensitivity, dynamic range, intersymbol interference
3. Low-Rate Wireless Personal Area Network (LR-WPAN), the IEEE Standard 802.15.4
   - 3.1 Structure of IEEE Standard 802, the relationship between ZigBee Alliance and IEEE Standard 802.15.4
   - 3.2 Technical overview of IEEE Standard 802.15.4
   - 3.3 Parts of IEEE Standard 802.15.4
     - 3.3.1 Physical (PHY) layer
     - 3.3.2 Medium Access Control (MAC) layer
     - 3.3.3 Networking issues
     - 3.3.4 Application of IEEE Standard 802.15.4: The ZigBee Alliance
4. Survey and comparison of wireless IEEE 802 standards
   - 4.1 An alternative PHY layer: The Ultra-Wideband (UWB) radio (IEEE 802.15.4a)
   - 4.2 Implementation of IEEE Standard 802.15.1: The Bluetooth Special Interest Group
   - 4.3 Implementation of IEEE Standard 802.11: WiFi Alliance
5. Application oriented issues
   - 5.1 Calculation of the link budget
   - 5.2 Co-existence of different systems
   - 5.3 Case studies

Prof. Géza Kolumbán's Short Biography

Géza Kolumbán (Fellow, IEEE) received his M.Sc., Ph.D. and Dr.habil degrees from the Technical University of Budapest in 1976, 1990 and 2005, respectively, and his C.Sc. and D.Sc. degrees from the Hungarian Academy of Sciences in 1990 and 2004, respectively.

He was employed from 1976 to 1980 as a research engineer by the Fine Mechanical Enterprise, Hungary, where he developed local oscillators, microwave transistor power amplifiers and VCO circuits for high-capacity microwave analog radio relay systems.

He joined the Research Institute for Telecommunications, Hungary, in 1980, where he was involved in many system engineering projects such as SCPC-type satellite telecommunications system, microwave satellite up- and down-converters, low-capacity microwave digital radio system, etc. He headed a group of engineers, whose duty was to develop frequency synthesizers and local generators for frequency hopping spread spectrum and satellite systems. He spent one year with Bilkent University in Turkey (1991-92) and another year with the Eastern Mediterranean University in Cyprus (1992-93) as an associate professor. He returned to the Budapest University of Technology and Economics in 1993, where he is employed as a professor of system engineering at the Department of Measurement and Information Systems. He has been visiting professor and researcher to the Electronics Research Laboratory, UC Berkeley, University College Dublin, The Hong Kong Polytechnic University, City University of Hong Kong, Swiss Federal Institute of Technology Lausanne, University College Cork and Technical University of Dresden.

Two of his papers, co-authored with Profs. M.P. Kennedy and L.O. Chua, have been ranked in top-cited IEEE Trans.-I articles.

His current research and professional interests include nonlinear dynamics of different-type phase-locked loops, frequency synthesis, mixed signal processing, computer simulation of complex systems, chaos communications, and applications of chaotic signals in measurement engineering.

For further information visit the instructor's homepage at:

http://www.mit.bme.hu/∼kolumban