



Annual Report 2008/2009

## DEPARTMENT OF ELECTRICAL ENGINEERING

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DEPARTMENT OF  
ELECTRICAL ENGINEERING

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Annual Report 2008/2009

## DEPARTMENT OF ELECTRICAL ENGINEERING

In the beginning of 2009, Information and Communication University (ICU) was merged into KAIST. Given that nearly half of the studies at ICU focused on electrical engineering, the major contribution of ICU joined our department, the Department of Electrical Engineering (EE) at KAIST.



## Message from the Department Head

In the beginning of 2009, Information and Communication University (ICU) was merged into KAIST. Given that nearly half of the studies at ICU focused on electrical engineering, the major contribution of ICU joined our department, the Department of Electrical Engineering (EE) at KAIST. At present, KAIST EE is the largest department in Korea, with 86 professors, more than 1,500 students (approximately 500 undergraduate and 1,000 graduate students), and 20 administrative and technical staff members.

I would like to revisit and update our mission and vision statements to adapt to recent changes and to lead the IT-related academic, research and industry fields more aggressively. Our unchanging mission is to foster global leaders who are equipped with fundamental knowledge, creativity, the ability to communicate effectively, and a sense of social responsibility over a wide range of electrical engineering fields. We also educate undergraduate students and instill in them fundamental knowledge, a foundation for a diverse career path, design and analysis capability, the ability to communicate effectively, and a sense of social responsibility. Our long-term vision is to become a world-leading EE department with world-class faculty and outstanding students. We hope to foster global leaders and provide break-through technologies for a better quality of life.

In order to achieve our long-term vision, we are continuously expanding our EE area to energy, biomedical engineering, network computing, and environmental issues so that we can contribute to improving the quality of life. Students will experience highly advanced classes including the breadth and depth of EE as well as design labs to improve their creativity and design capability. We all concentrate on high-impact research into fundamental and technology innovations, and we seek to participate in international collaborations that make important contributions to society, thereby improving our visibility.

This annual report highlights the various activities undertaken in 2008 and in first half of 2009 by our faculty members, students and staff. This year, we made great progress and produced outstanding research results. Our research centers worked closely with government and industry, we strengthened our national research laboratories and increased the number of IEEE fellows, and we gained a considerable amount of research funding. All of these achievements would not have been possible without the efforts of every member of KAIST EE. We know we have a lot of things to do to realize our vision of becoming the best EE department in the world. All of the members of the Department of Electrical Engineering at KAIST are ready to listen to

your voices with a warm welcome. I hope you will never hesitate to give us any comment that may improve the Department of Electrical Engineering. Hopefully, I would like you to keep your interest in the Department of Electrical Engineering at KAIST and watch us become one of the best such departments in the world.

June 2009

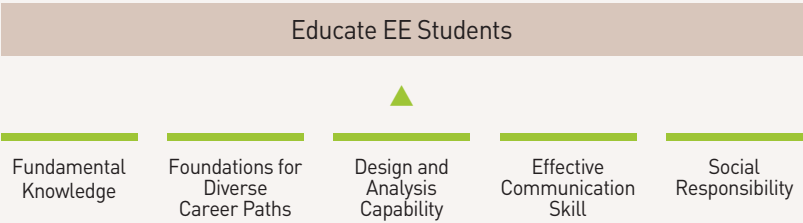
**HyunWook Park**

Professor and Department Head  
Department of Electrical Engineering



# EE Vision

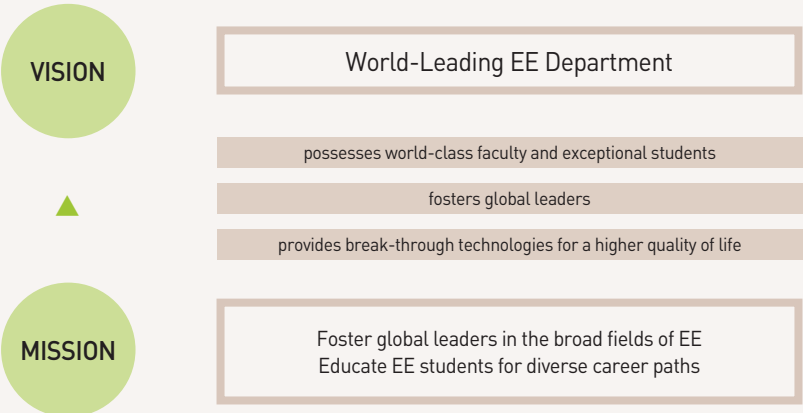
## Mission Statements (Undergraduate)



## Mission Statements (Graduate)

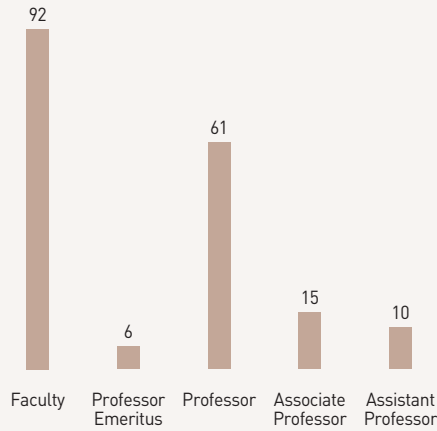


## Vision Statements

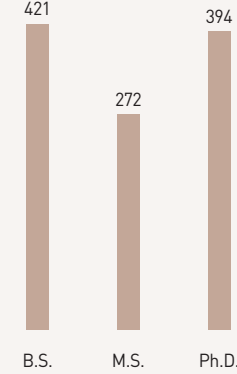


# Overview

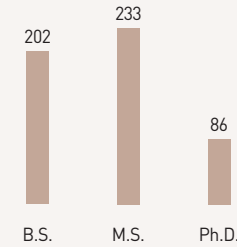
## Faculty (May 2009)



## Student Enrollment (Feb. 2009)



## Degrees Awarded (Feb. 2008 - Feb. 2009)



## FACILITIES

7 Buildings  
3 Research Groups  
86 Laboratories  
20 Research Centers

## RESEARCH FUND (2008)

\$ 30.5 Million

## DEPARTMENT SCHOLARSHIP

- Creative Activity Prize - donated by the families of EE graduate students
- Distinguished Thesis Prize - established by the trust fund of Prof. Song-Bae Park
- Hwang Yoon-Ho Scholarship - donated by Mr. Yoon-Ho Hwang
- Il-Soo Scholarship - donated by the father of Prof. Young-Se Kwon
- Kim Choong-Ki Scholarship - donated by Dr. Hyung-Kyu Lim
- Lee Min-Hwa Scholarship - donated by Dr. Min-Hwa Lee
- No Yop Scholarship - donated by No Yop Culture Foundation
- Sang-Ae Scholarship - donated by Sang-Ae Foundation
- So-Chun Scholarship - donated by the father of Prof. Myung Joong Youn
- Suk Rim Scholarship - donated by Suk Rim Academic Foundation
- Un Chong-Kwan Scholarship - donated by Prof. Chong-Kwan Un



# A Brief History

## 1970's

1971

- Establishment of Korea Advanced Institute of Science (KAIS) at Hongneung, Seoul
- Prof. J.-W. Ra was the first faculty of the Department

1973

- First entrance ceremony for the master program

1975

- First graduation ceremony for the master program
- First entrance ceremony for the PhD program

1976

- Prof. C.-K. Un won L. G. Abraham Award from the IEEE Communications Society

1978

- Development of adaptive delta modulation system for defense applications (Prof. C.-K. Un)
- Development of facsimile machine (Prof. J.-K. Kim)

1979

- Development of KAISEM, a 4 dof robot-arm manipulator (Prof. Z. Bien)



## 1980's

1980

- Establishment of Korea Advanced Institute of Science and Technology (KAIST), merged with Korea Institute of Science and Technology (KIST)
- Development of LPC vocoder (Prof. C.-K. Un)

1981

- First graduation ceremony for the PhD program
- Development of 512-bits mask-programmable ROM (Prof. C.-K. Kim)

1982

- Development of statistical time-division multiplexer (Prof. C.-K. Un)

1984

- Establishment of Korea Institute of Technology (KIT), starting the undergraduate program
- Development of turret servo drive system (Prof. M. J. Youn)

1985

- Development of 2-Tesla nuclear magnetic resonance imaging system (Prof. Z.-H. Cho)
- Development of packet switching equipment, KORNET (Prof. C.-K. Un)

1986

- First entrance ceremony for KIT
- Development of ultrasonic imaging system (Prof. S.-B. Park)

## 1990's

1990

- First graduation ceremony for the undergraduate program
- Detected the fourth infiltration tunnel excavated by North Korea (Prof. J.-W. Ra)

1992

- Launched KITSAT-1 into orbit (Prof. S. D. Choi)
- Development of HDTV encoder (Prof. J. B. Ra)

1993

- Launched KITSAT-2 into orbit (Prof. S. D. Choi)
- Prof. C.-K. Kim was awarded a Hoam Prize

1994

- Development of KAICUBE Hanbit-1, a 2-Gflops parallel computer (Prof. K. H. Park)
- Profs. S. D. Choi, C.-K. Kim, J.-K. Kim, and S.-B. Park were elected Members of Korean Academy of Science and Technology (KAST)

1995

- Development of digital adaptive equalizer ASIC (Prof. C.-M. Kyung)
- Development of wireless IR printer-sharing unit (Prof. S.-Y. Shin)
- Prof. C.-K. Kim was elected a Fellow of the Institute of Electrical and Electronics Engineers (IEEE)
- Prof. Z.-H. Cho was awarded a Korea Engineering Award

1996

- Establishment of Korea Institute of Advanced Study (KIAS)
- Prof. S.-B. Park was awarded an In-Chon Academic Award

1988

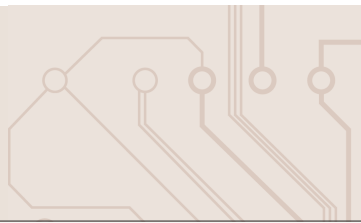
- Implementation of two-dimensional optical neural network (Prof. S.-Y. Shin)
- Development of 45-Mbps video codec (Prof. J.-K. Kim)
- Development of vertically integrated AlGaAs laser and JFET (Prof. Y.-S. Kwon)

1989

- KIST separated from KAIST
- KAIST merged with KIT and moved to Daejeon
- Development of 4-legged robot (Prof. Z. Bien)
- Development of KAICUBE-I, a parallel computer (Prof. M. H. Kim)







1997

- **Establishment of Information and Communications University (ICU)**
- Development of 50-MHz Pentium chip (Prof. C.-M. Kyung)
- Development of intelligent wheelchair (Prof. Z. Bien)
- Prof. J.-H. Kim founded the Federation of International Robot-Soccer Association
- Prof. C.-K. Kim was awarded an Order of Civil Merit (Mo-Ran)

1998

- **First entrance ceremony for the graduate program of ICU**
- Development of room-temperature IR sensor (Prof. S. Hong)
- Development of fiber back-haul network for wireless CDMA service (Prof. Y. C. Chung)
- Development of sign-language translation system (Prof. Z. Bien)
- Prof. Z. Bien was elected a Member of KAST
- Prof. S.-B. Park was elected a Member of the National Academy of Engineering of Korea (NAEK)
- Prof. J.-K. Kim was awarded an Order of Civil Merit (Suk-Ryu)

1999

- **First graduation ceremony for the graduate program of ICU**
- Launched KITSAT-3 into orbit (Prof. D. K. Sung)
- Development of 3-dimensional integrated inductor (Prof. C.-K. Kim)
- Profs. Y.-S. Kwon and S.-Y. Shin were elected Members of KAST
- Prof. J.-W. Ra was awarded an Order of Civil Merit (Mo-Ran)

2000's

2000

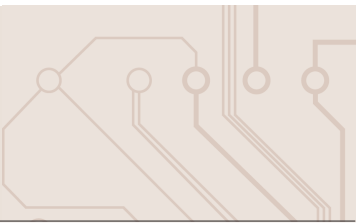
- Development of CMOS oscillator for cellular systems (Prof. B. S. Kim)
- Development of medical diagnosis simulator based on 3-dimensional virtual reality image (Prof. J. B. Ra)
- Development of all-optical WDM network testbed with 4 optical cross-connects (Prof. Y. C. Chung)
- Profs. S.-Y. Shin and M. J. Youn were elected Members of NAEK
- Prof. S.-B. Park was awarded a Korea Engineering and Technology Award
- Prof. C.-M. Kyung was awarded an Order of Civil Merit (Suk-Ryu)
- Prof. I. Song was awarded a Young Scientists Award from KAST

2001

- Development of 0.25-micron standard cell library (Prof. C.-M. Kyung)
- Development of bluetooth baseband chip (Prof. I.-C. Park)
- Demonstration of Tbps fiber-optic transmission (Prof. Y. C. Chung)
- Development of speech-recognition phone conversation recorder (Prof. K. Lee)
- Prof. H. J. Eom was elected a Member of KAST

2002

- **First entrance ceremony for the undergraduate program of ICU**
- Development of active robot vision camera system (Prof. M. J. Chung)
- Prof. J.-W. Ra was elected a Member of KAST



2003

- Launched STSAT-1 designed for astronomic studies into orbit (Prof. J.-T. Lim)
- Development of prototype radio in compliance with IEEE 802.15.4 standard for wireless personal area network (Prof. K. Lee)
- Prof. K. Lee was elected a Member of NAEK
- Prof. Z. Bien was awarded an Order of Science and Technology Merit (Hyeoksin Medal)

2004

- **Foundation of the National Nanofab Center**
- Development of low-noise CMOS-based 13-GHz distributed oscillator (Prof. E.-S. Yoon)
- Development of RITY, a robot with gene and chromosome (Prof. J.-H. Kim)
- Prof. C.-M. Kyung was elected a Member of KAST
- Profs. Y. C. Chung and C.-M. Kyung were elected Members of NAEK
- Prof. J.-K. Kim was awarded an Order of Service Merit (Ok-Jo Geun-Jung)
- Prof. J.-T. Lim was awarded an Order of Science and Technology Merit (Doyak Medal)

2005

- **1000th Ph.D. graduated from the Department**
- Development of tactile sensor imitating human skin (Prof. E.-S. Yoon)
- Prof. I. Song was elected a Member of KAST

2006

- Development of the world smallest 3-nm transistor (Prof. Y.-K. Choi)
- Development of system-in-chip RFID reader (Prof. J.-H. Kim)
- Demonstration of low-power communication through human body (Prof. H.-J. Yoo)
- Prof. Y. C. Chung was elected a Fellow of IEEE
- Prof. I. Song was awarded an Achievement Award from the Institution of Engineering and Technology (IET)

2007

- Development of 8-nm flash memory device (Prof. Y.-K. Choi)
- Development of prototype technologies for highly efficient PDP lighting (Prof. K. C. Choi)
- Prof. Y. C. Chung was elected a Member of KAST
- Prof. J.-W. Ra was elected a Member of NAEK
- Prof. Z. Bien was elected a Fellow of IEEE

2008

- Development of HanSaRam-VIII, a humanoid robot (Prof. J.-H. Kim)
- Development of quantum-effect based multiplexer IC (Prof. K. Yang)
- Prof. J.-W. Ra was elected a Member of the National Academy of Sciences (NAS)
- Profs. J.-J. Lee and H.-J. Yoo were elected Fellows of IEEE

2009

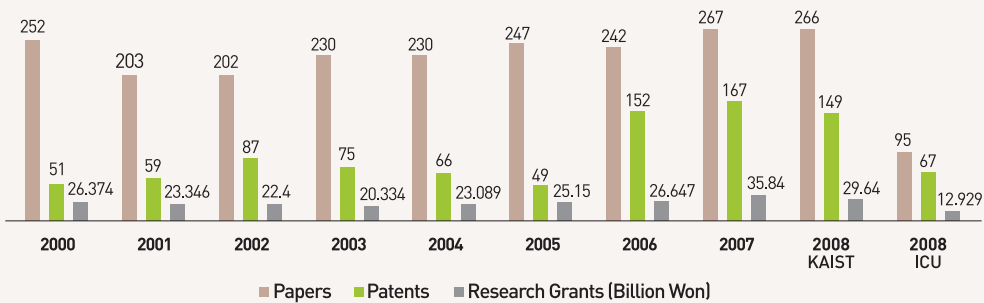
- **Merger of KAIST and ICU**
- Profs. Y. H. Lee and D. K. Sung were elected Members of NAEK
- Profs. J. H. Kim, C.-M. Kyung, and I. Song were elected Fellows of IEEE
- Prof. J.-W. Ra was awarded a Korea Engineering Award



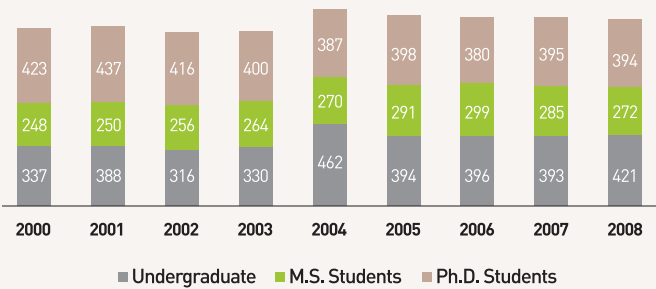


## Statistics 2008/2009

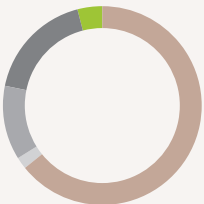
Papers, Patents, and Research Grants



Student Enrollment

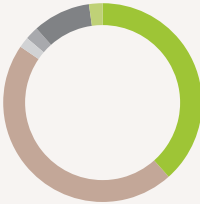


Ph.D. Students (Feb. 1981 - Feb. 2009)



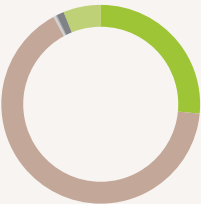
Industries 805  
Government Agencies 19  
Educational Institutes 155  
Research Institutes 230  
Others 49

M.S. Students (Aug. 1975 - Feb. 2009)



Industries 1110  
Advanced to Higher-Degree Programs 1318  
Government Agencies 51  
Educational Institutes 64  
Research Institutes 276  
Others 65

B.S. Students (Feb. 1994 - Feb. 2009)



Industries 495  
Advanced to Higher-Degree Programs 1199  
Government Agencies 5  
Educational Institutes 3  
Research Institutes 22  
Others 114

## Professor Emeritus



**Bien, Zeungnam** | Professor Emeritus  
Ph.D., University of Iowa (1975)  
Automation System, Intelligent Fuzzy Control, Service Robotics  
zbien@ee.kaist.ac.kr



**Choi, Soon Dal** | Professor Emeritus  
Ph.D., Stanford University (1969)  
Satellite Communication, Remote Sensing  
sdchoi@ee.kaist.ac.kr



**Kim, Choong-Ki** | Professor Emeritus and Distinguished Professor  
Ph.D., Columbia University (1970)  
Semiconductor Engineering, Infrared Detecting Device Development  
ckkim@ee.kaist.ac.kr



**Kim, Jae-Kyoon** | Professor Emeritus  
Ph.D., University of Southern California (1971)  
Video Coding, Visual Communication Systems  
kimjk@ee.kaist.ac.kr



**Park, Song-Bae** | Professor Emeritus  
Ph.D., University of Minnesota (1968)  
Ultrasonic Systems  
sbpark@ee.kaist.ac.kr



**Ra, Jung-Woong** | Professor Emeritus  
Ph.D., Polytechnic Institute of Brooklyn (1971)  
Scattering of EM Waves by Dielectric Wedge, Inverse Scattering, Underground Tomogram  
rawoong@ee.kaist.ac.kr









Bae, Hyeon-Min  
Assistant Professor

Ph.D., University of  
Illinois,Urbana-  
Champaign (2004)

hmbae@ee.kaist.ac.kr

## Integrated System Research Laboratory

The relentless scaling of feature sizes exemplified by Moore’s Law has enabled the application of sophisticated signal processing techniques to high speed broadband communication links employing mixed analog and digital architectures and circuits. The Integrated System Research Laboratory (ISRL) focuses on developing innovative solutions by jointly optimizing algorithm, architecture, and circuits for broadband systems. Recent IC developments include low power 100Gb/s Ethernet transceiver ICs. Adaptive digital phase rotator based clock and data recovery (CDR) scheme was developed to tolerate various interferences including thermal noise and substrate injections prevalent in high speed mixed mode system ICs. In addition, the designed CDR maintains low clock jitter while providing sufficient input jitter tolerance through adaptive bandwidth control.

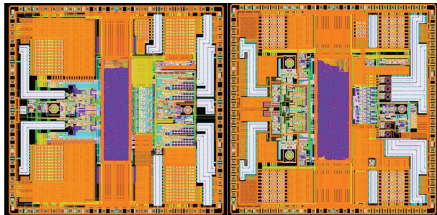


Fig. 1 100Gb/s Ethernet transceiver ICs

### KEY PUBLICATIONS (2008/2009)

[1] H.-M. Bae, J. Ashbrook, N. Shanbhag, and A. Singer, "A fast power transient management for WDM add/drop networks," *IEEE J. Solid State Circuits*, vol. 43, no. 12, pp. 2958-2966, Dec. 2008.

[2] A. Singer, N. Shanbhag, and H.-M. Bae, "Electronic dispersion compensation: Signal processing for fiber optical links," *IEEE Signal Process. Mag.*, vol. 25, no. 6,

pp. 110-130, Nov. 2008.

[3] E. Rosenbaum, H.-M Bae, K. S. Bhatia, and A. C. Faust, "Moving signals on and off chip," *Custom Integr. Circuit Conf.*, San Jose, USA, Sep. 2009.

[4] H.-M. Bae, J. Ashbrook, N. Shanbhag, and A. Singer, "10Gb/s MLSE based EDC IC with fast power transient management for WDM add/drop networks," *Int. Solid State Circuit Conf.*, San Francisco, USA, Mar. 2008.

## Communication Circuits and Systems Laboratory

Communication Circuits and Systems Group explores emerging technologies for various high-performance, low-power wired and wireless communication systems. Our main area of focus is in the design and implementation of analog and mixed-signal integrated circuits with multiple layers of system abstraction in mind, from communication protocols and system architectures to circuit techniques. Our recent research topics include low power communication circuits, digital transceiver and bio-sensor network. As a key building block of low power communication system, we demonstrated a state-of-the-art ultra low power frequency synthesizer, and also proposed a state-of-the-art digitally-controlled injection-locked frequency divider. For the implementation of digital receivers, we proposed a digital PLL (DPLL) architecture with novel sub-feedback loop which reduces the effect of quantization. We also proposed a low power time-based ADC architecture that can directly digitize the RF signal without any use of large passive devices such as inductors, which is attractive solution for direct RF sampling in deep-submicron processes. In addition, we have proposed a novel low-power digital-friendly transmitter architecture which does not use mixers or DACs. In the bio-sensor area, we are investigating a novel magnetic-stimulation-based bio-sensor and a novel bio-impedance measurement system.

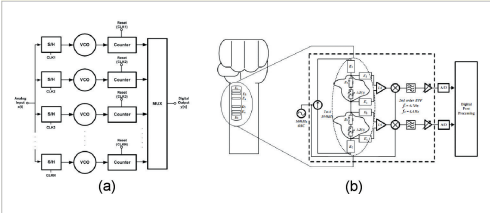


Fig. 1 (a) Time-based bandpass ADC  
(b) Bio-impedance measurement system

### KEY PUBLICATIONS (2008/2009)

[1] D. Park and S.-H. Cho, "Design tech. for a LV VCO with wide tuning range and low sensitivity to environmental variations," *IEEE Trans. Microw. Theory, Techn.*, vol. 57, no. 4, pp. 767-774, Apr. 2009.

[2] D. Park and S.-H. Cho, "A 1.8 V 900-uW 4.5 GHz VCO and prescaler in 0.18um CMOS using CR tech.," *IEEE Microw., Wireless Comp. Lett.*, vol. 19, no. 2, pp. 104-106, Feb. 2009.

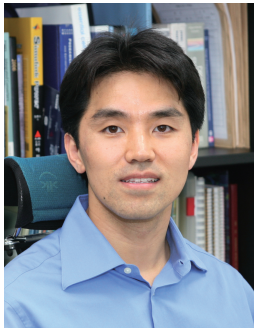
[3] Y. G. Yoon, J. Kim, T. Jang, and S.-H. Cho, "A time-based BP ADC using TI VCOs," *IEEE Trans. Circuits, Syst. I*, vol. 55, no. 11, pp. 3571-3581, Oct. 2008.

[4] Y. G. Yoon and S.-H. Cho, "A 1.5-GHz 63dB SNR 20mW DRF samp. BP VCO-ADC in 65nm CMOS," *IEEE Symp. VLSI Circuits*, Kyoto, Japan, June 2009.

[5] S. H. Park, C. W. Min, and S.-H. Cho, "A 95nW ring oscillator based temperature sensor for RFID tags in 0.13um CMOS," *IEEE Int. Symp. Circuit, Syst.*, Taipei, Taiwan, May 2009.

### OTHER ACCOMPLISHMENTS (2008/2009)

[1] 2 Awards



Cho, SeongHwan  
Associate Professor

Member, IEEE

Ph.D., Massachusetts  
Institute of Technology  
(2002)

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http://ccs.kaist.ac.kr





Chung, Myung Jin  
Professor

Senior Member, IEEE

Ph.D., University of  
Michigan (1983)  
  
mjchung@ee.kaist.ac.kr  
http://cheonji.kaist.ac.kr

## Robotics Research Laboratory

Robotics Research Laboratory (RRLAB) has mainly focused on developing robot systems for human-robot interaction, rehabilitation, and 3D world modeling. Biologically inspired active head-eye systems have been developed for human-robot interaction using visual information. Artificial models of human visual actions and facial expressions are established based on the biological models of humans. Several basic cognition abilities such as face detection, tracking, face recognition, and facial expression recognition from the visual information are implemented.

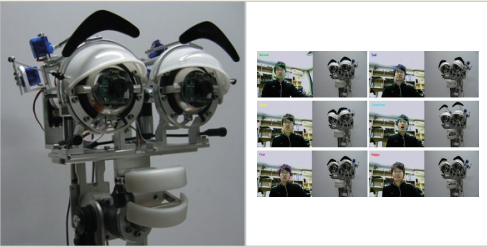


Fig. 1 KAVIS: KAIST Active Visual Interaction System  
Fig. 2 Recognition and imitation of face expressions

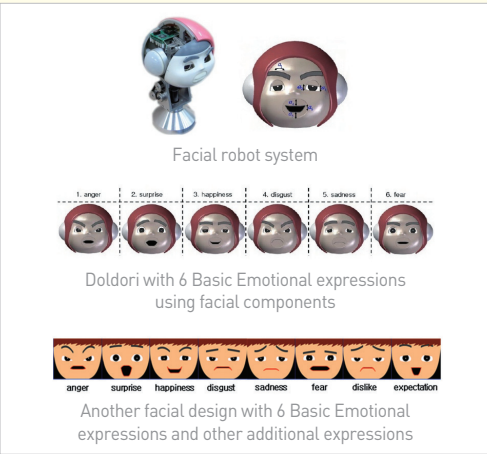


Fig. 3

The facial robot called 'Doldori' is focused on the relationship between facial expressions and emotions. A novel emotion expression model, Linear Dynamic Affect-Expression

Model, is introduced to implement facial expressions of robots. We have also developed 'FRESi', a simulator with another facial design, in order to express more abundant emotional state of robots.

### KEY PUBLICATIONS (2008/2009)

[1] D. H. Kim, S. U. Jung, and M. J. Chung, "Extension of cascaded simple feature based face detection to facial expression recognition," *Pattern Recogn. Lett.*, vol. 29, pp. 1621-1631, Apr. 2008.

[2] J. W. Kang, B. S. Kim, and M. J. Chung, "Assistive mobile robot systems helping the disabled workers in a factory environment," *Int. J. Assistive Robotics, Mechatronics*, vol. 9, no. 2, pp. 42-52, June 2008.

[3] J. H. Joung, K. H. An, J. W. Kang, W. H. Kim, and M. J. Chung, "3D terrain reconstruction using 2D laser range finder and camera based on cubic grid," *Int. Conf. Ubiquitous Robots, Ambient Intell.*, Seoul, Korea, Nov. 2008.

[4] K. H. An and M. J. Chung, "3D head tracking and pose-robust 2D texture map-based face recognition using a simple ellipsoid model," *IEEE/RSJ Int. Conf. Intell. Robots, Syst.*, Nice, France, Sep. 2008.

[5] J. W. Kang, B. S. Kim, and M. J. Chung, "Development of assistive mobile robots helping the disabled work in a factory environment," *IEEE/ASME Int. Conf. Mechatronic, Embedded Syst., Appl.*, Beijing, China, Oct. 12-15, 2008.

### OTHER ACCOMPLISHMENTS (2008/2009)

[1] 6 MS Graduates



Hahn, Minsoo  
Professor

Member, KSPSST

Ph.D., University of  
Florida (1989)  
  
mshahn@ee.kaist.ac.kr  
http://sail.kaist.ac.kr

## Speech and Audio Information Laboratory

The Speech and Audio Information Laboratory (SAIL) has primarily focused on developing speech and sound fields for human robot interface, car interface, text to speech (TTS) synthesis system, speech codec, audio codec, and so on.

Now days, we focused on the noise reduction using beamforming. There are already solutions which are Wiener filter and Kalman filter of good performance of stationary noise reduction. However, the solutions of nonstationary noise reduction are insufficient comparing it. Beamforming is introduced recently as a solution of nonstationary noise reduction. Beamforming is a spatial filtering with look direction information using multi-channel microphone array. The advantage of this method is robustness in nonstationary noise environment. The most typical adaptive beamforming algorithm is a GSC algorithm. Fig. 1 shows the block diagram of GSC algorithm.

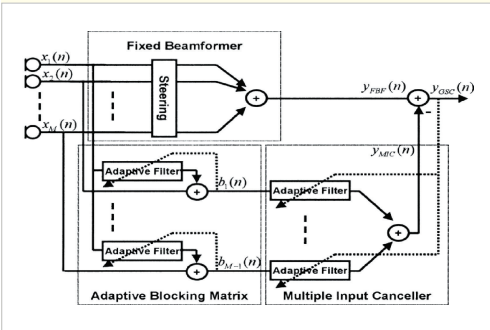


Fig. 1 Block diagram of GSC algorithm

### KEY PUBLICATIONS (2008/2009)

[1] S. Jeong, S. Lee, and M. Hahn, "Dual microphone-based speech enhancement by spectral classification and Wiener filtering," *Electron. Lett.*, vol. 44, no. 3, pp. 253-254, Jan. 2008.

[2] J. Kim, H. Lee, W. Ryu, S. Han, and M.

Hahn, "Improved noise reduction with packet loss recovery based on post-filtering over IP networks," *IEICE Trans. Comm.*, vol. E91-B, no. 3, pp. 975-979, Mar. 2008.

[3] J. Kim, T. Um, W. Ryu, B. Lee, and M. Hahn, "Heterogeneous network & terminals aware QoS/QoE guaranteed mobile IPTV Service," *IEEE Comm. Mag.*, vol. 46, no. 5, pp. 110-117, May 2008.

[4] S. Jeong, H. Yang, and M. Hahn, "Two-channel noise reduction for robust speech recognition in car environments," *Electron. Lett.*, vol. 44, no. 17, pp. 1042-1043, Aug. 2008.

### OTHER ACCOMPLISHMENTS (2008/2009)

[1] 4 Patents  
[2] 2 PhD Graduates





Kim, Byung Kook  
Professor

Member, IEEK  
Member, KIEE

Member, IEEE

Ph.D., Korea Advanced  
Institute of Science and  
Technology (1981)

bkkim@ee.kaist.ac.kr  
http://rtcl.kaist.ac.kr

## Real Time Control Laboratory

Research in Real-Time Control (RTC) Lab has been focused on the following: real-time control systems area including reliable process control system, real-time systems, and automotive control. Robot control system area includes mobile robot sensing, navigation, localization and manipulator control. We developed an intelligent powered wheelchair with ultrasonic distance measuring system to meet the needs of users. Also, the researches for unmanned NBC (Nuclear, Bio, and Chemical) reconnaissance system have been conducted. Hybrid real-time control architecture which allows SilverMate robots to synchronously control mobile platforms and manipulators to accomplish objectives is shown below.

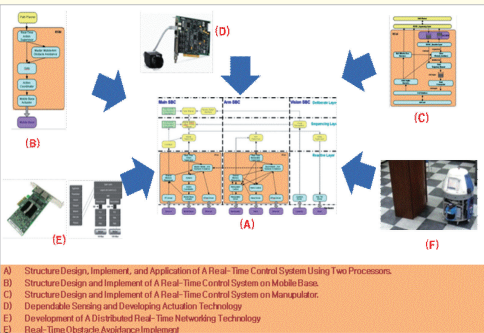


Fig. 1

### KEY PUBLICATIONS (2008/2009)

[1] H. J. Sohn and B. K. Kim, "An efficient localization algorithm based on vector matching for mobile robots using laser range finders," *J. Intell. Robotic Syst.*, vol. 51, no. 4, pp. 461-488, Apr. 2008.

[2] C. Y. Song and B. K. Kim, "Non-preemptible last section assignment for reducing feedback latency in real-time control systems," *Int. J. Syst. Science*, vol. 40, no. 5, pp. 479-495, May 2009.

[3] H. J. Kim and B. K. Kim, "Minimum-energy translational trajectory planning for battery-powered three-wheeled omni-directional mobile robots," *Int. Conf. Control, Automation, Robotics, Vision*, Hanoi, Vietnam, Dec. 2008.

[4] K. B. Kim and B. K. Kim, "Minimum-time straight-line trajectory for three-wheeled omni-directional mobile robots with voltage constraint," *Int. Symp. Robotics*, Seoul, Korea, Oct. 2008.

[5] B. K. Kim, "Control engineering education with experiments on real-time control system implementation," *IFAC World Congress*, Seoul, Korea, July 2008.

### OTHER ACCOMPLISHMENTS (2008/2009)

[1] 3 Patents

[2] 1 MS Graduate, 1 PhD Graduate



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## Computational Imaging Laboratory

The Computational Imaging Laboratory (CI Lab) has performed innovative research work in the areas of image understanding, intelligent schemes for mobile TV display, immersive and 3D video processing, medical imaging, and advanced video coding. One of the main issues being studied by CI Lab is human video understanding. Moving object detection and human/animal classification algorithms have been successfully developed, which is being followed by studying of various classification problems, such as gender classification, age classification, and so on. The integrated system is aimed at applying to silver robots, video surveillance, and ubiquitous computing systems.

### KEY PUBLICATIONS (2008/2009)

[1] W. Kim and C. Kim, "A new approach for overlay text detection and extraction from complex video scene," *IEEE Trans. Image Process.*, vol. 18, no. 2, pp. 401-411, Feb. 2009.

[2] I. Ahn, Y. Kim, and C. Kim, "Customizing ground color to deliver better viewing experience of soccer video," *ETRI J.*, vol. 30, no. 1, pp. 101-112, Feb. 2008.

[3] K. Seo, J. Ko, I. Ahn, and C. Kim, "An intelligent display scheme of soccer video for mobile devices," *IEEE Trans. Circuits, Syst. Video Techn.*, vol. 17, no. 10, pp. 1395-1401, Oct. 2007.

[4] B. Kim and C. Kim, "Automatic browsing of large image for small displays," *SPIE Appl. Digital Image Process.*, San Diego, USA, Aug. 2009.

[5] W. Kim and C. Kim, "An efficient correction method of wide-angle lens distortion for surveillance systems," *IEEE Symp. Circuits, Syst.*, Taipei, Taiwan, Mar. 2009.

### OTHER ACCOMPLISHMENTS (2008/2009)

[1] 3 Patents, 1 Book

[2] 1 MS Graduate

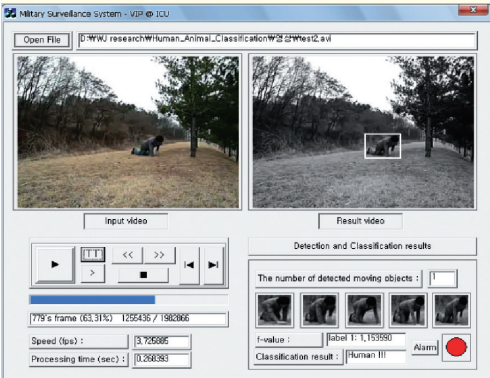


Fig. 1 Screenshots of the developed border surveillance system  
(a) Human in crawling position detected, (b) Animal detected





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## Speech Recognition Technology Laboratory

The Speech Recognition Technology Laboratory (SRT-LAB) has focused on developing speech and audio signal processing systems related to speech recognition, speaker identification & verification, keyword spotting, audio indexing & retrieval, music retrieval, and multi-modal interface. Speech recognition refers to the process of translating the input speech signal obtained from a microphone or telephone into a word or a sentence. The recognition results can be used to command or control a system, or they can be used as an input to a system which understands speech. As a result, speech recognition technology has enabled human beings to communicate more naturally with computers or machines. Recently, speech recognition as one of tools for advanced user interface has become a part of our lives such as mobile device user interface, speech controlled computers, various speech guidance systems, car navigation systems, robot interface, and home automation systems. In addition, audio indexing & retrieval is an emerging technology including music summarization, musical instrument identification, music recommendation, music genre classification, speech/music discrimination, mood classification, and many other audio information processing techniques.

The major achievements in the last year are as follows:

- A voice activity detection based on reliable bands of statistical models was proposed and applied to robust speaker recognition in adverse environments.
- Feature compensation and model adaptation methods based on histogram equalization were proposed for robust speech recognition.
- New utterance verification methods were

proposed for a very large vocabulary (more than  $3 \times 10^6$  words) speech recognition system which was designed for car navigation.

- Robust speaker recognition methods were proposed for the use in home robot systems, and the key idea is on how to combine the information from multiple channels.

### KEY PUBLICATIONS (2008/2009)

[1] M. K. Ji, S. T. Kim, H. R. Kim, and H. S. Yoon, "Text-independent speaker identification using soft channel selection in home robot environments," *IEEE Trans. Consumer Electron.*, vol. 54, no. 1, pp. 140-144, Feb. 2008.

[2] S. B. Kwon and H. R. Kim, "Utterance verification using word voiceprint models based on probabilistic distributions of phone-level log-likelihood ratio and phone duration," *IEICE Trans. Inform., Syst.*, vol. E91-D, no. 11, pp. 2746-2750, Nov. 2008.

[3] Y. Suh and H. Kim, "Environmental model adaptation based on histogram equalization," *IEEE Signal Process. Lett.*, vol. 16, no. 4, pp. 264-267, Apr. 2009.

[4] Y. J. Suh and H. R. Kim, "The effectiveness of histogram equalization on environmental model adaptation," *IEEE Int. Conf. Acoustics, Speech, Signal Process.*, Taipei, Taiwan, Apr. 2009.

### OTHER ACCOMPLISHMENTS (2008/2009)

- [1] 1 Patent  
[2] 1 MS Graduate, 2 PhD Graduates

## Robot Intelligence Technology Laboratory

Robot Intelligence Technology (RIT) Lab. has been focused on researches in Ubiquitous robot (Ubibot), Genetic robot (Genebot) and Multi-agent system (MAS) based on multi-layer architecture for Cyber-Physical Robot Systems (CPRS).

**Ubiquitous Robot (Ubibot):** Rity, Geney, DD, Mybot, HanSaRam (HSR)

Rity and Geney have its own motivation, homeostasis and emotion where the desired behavior is decided from these internal components. As a mobile robot, wheeled-type robot (Mybot) has been developed and Rity in software system can be transmitted to Mybot and control Mybot. Also, humanoid robot, HSR has been developed since 2000.

**Genetic Robot (Genebot):** Artificial Genome, Gomdoll

Evolutionary Generative Process for an Artificial Creature's Personality (EGPP) has been proposed to create an artificial genome for software robot. Bear-type intelligent robot (GomDoll), which endows hardware robot with the genome code, has been developed.

**Multi-agent System (MAS):** MiroSot, RoboSot, HuroCup

In the research for FIRA robot soccer, vector field navigation method using the position and velocity vectors of robot has been proposed. To achieve high mobility in RoboSot soccer game,

omni-directional platform with three omni-wheels has been developed. Note that HSR have been participating in the HuroCup.

### KEY PUBLICATIONS (2008/2009)

[1] J.-H. Kim, C.-H. Lee, and K.-H. Lee, "Evolutionary generative process for an artificial creature's personality," *IEEE Trans. Syst., Man, Cybern., -Pt. C*, vol. 39, no. 3, pp. 331-342, May 2009.

[2] J.-H. Kim, I.-B. Jeong, I.-W. Park, and K.-H. Lee, "Multi-layer architecture of ubiquitous robot system for integrated services," *Int. J. Social Robotics*, vol. 1, no. 1, pp. 19-28, Jan. 2009.

[3] J.-H. Kim, S.-H. Cho, Y.-H. Kim, and I.-W. Park, "Two-layered confabulation architecture for an artificial creature's behavior selection," *IEEE Trans. Syst., Man, Cybern., -Pt. C*, vol. 38, no. 6, pp. 834-840, Nov. 2008.

[4] J.-S. Jang and J.-H. Kim, "Fast and robust face detection using evolutionary pruning," *IEEE Trans. Evol. Comp.*, vol. 12, no. 5, pp. 562-571, Oct. 2008.

[5] B.-J. Lee, D. Stonier, Y.-D. Kim, J.-K. Yoo, and J.-H. Kim, "Modifiable walking pattern of a humanoid robot by using allowable ZMP variation," *IEEE Trans. Robotics*, vol. 24, no. 4, pp. 917-923, Aug. 2008.

### OTHER ACCOMPLISHMENTS (2008/2009)

- [1] 1 Patent, 1 Award  
[2] 4 MS Graduates



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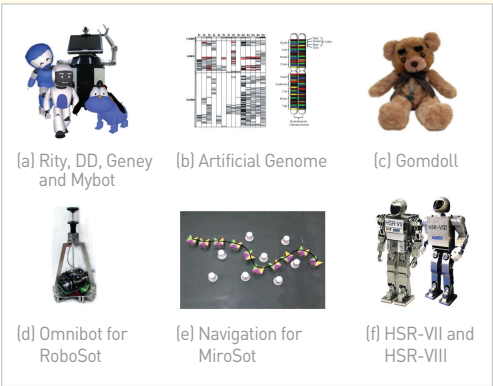
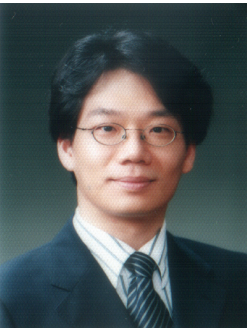


Fig. 1





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## Statistical Inference and Information Theory Laboratory

The researches of the Statistical Inference and Information Theory Laboratory focus on development of theoretical methods which can be applied to image processing, computer vision, pattern recognition, and machine learning. In particular, our research contributions are mostly based on Bayesian detection theory and more advanced methods such as nonparametric statistical methods. The recent research contributions are introduced below.

**Statistical Analysis of Shapes:** We have been working on the problem of statistical analysis of shapes. In particular, we proposed a framework to learn and model a prior distribution in a space of shapes based on available example shapes. This problem involves many challenging issues such as representation of the shape, analysis of resulting Riemannian structure of the shape space, and definition of probability density functions in the shape space. We proposed viable estimates of the probability density functions in the Riemannian space without having to compute the Riemannian metric, namely the geodesic distance. Based on these results, we developed a shape-based image segmentation technique, which outperforms traditional approaches based on principal component analysis of shape variations.

**Face Recognition:** Illumination variation is one of the main obstacles for face recognition as face images change significantly under illumination change. We proposed a method of preprocessing input images so that the output images are much less sensitive to illumination change. The bottom row in the figure shows the results of our preprocessing method compared to the histogram equalization (the second row).

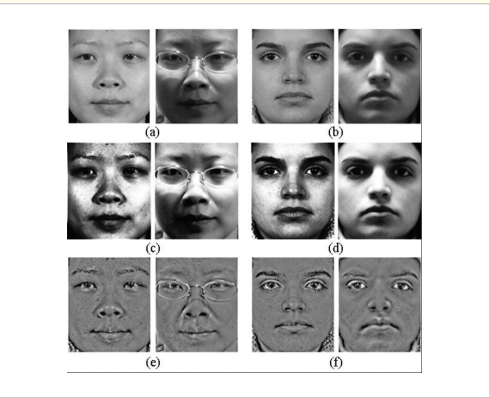


Fig. 1

We also proposed a classifier fusion method for constructing a stronger classifier out of multiple individual classifiers.

### KEY PUBLICATIONS (2008/2009)

[1] W. Hwang, H. Wang, H. Kim, S.-C. Kee, and J. Kim, "Face recognition system using multiple face model of hybrid Fourier feature under uncontrolled illumination variation," submitted to *IEEE Trans. Image Process.*  
[2] W. Hwang, H. Ren, H. Kim, S.-C. Kee, and J. Kim, "Face recognition using gender information," *IEEE Int. Conf. Image Process.*, Cairo, Egypt, Nov. 2009.

### OTHER ACCOMPLISHMENTS (2008/2009)

[1] 2 Patents, 1 Award



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## Multimedia VLSI Laboratory

Our research focuses on efficient multimedia contents processing widely based on algorithm design, hardware circuitry design, low-power memory, and the design of high performance CMOS serial link transceiver. Since the establishment in 1993, many brilliant results have been published by many international journals and conferences. Currently, we work in 2 teams; Multimedia SoC Design Team and SoC Circuit Design Team. Multimedia SoC design team focusing on 3D graphics acceleration engine design, computer vision, and augmented reality. Previous researches have focused on quality enhancement and simulation based on software. However, multimedia SoC design team has researched hardware architecture design for real time complex application as well as simulation based on software.

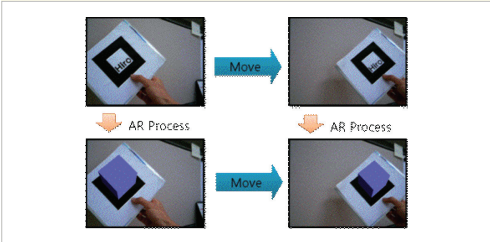


Fig. 1 Pose estimation engine for augmented reality processor

SoC circuit design team focusing on high performance CMOS serial link transceiver design such as a clock and data recovery, a spread spectrum clock generator, all-digital phase-locked loops/delay-locked loops, and

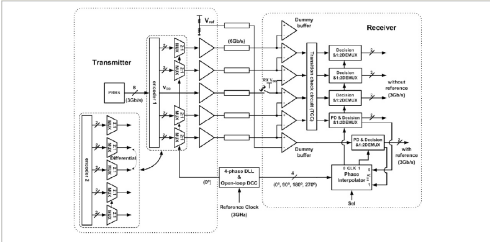


Fig. 2 Transceiver for DRAM interface in ISSCC 2009

signaling techniques. Recently, SoC circuit design team is interested in high speed memory applications and low power display applications.

### KEY PUBLICATIONS (2008/2009)

[1] B. G. Kim, L. S. Kim, K. I. Park, Y. H. Jun, and S. I. Cho, "DLL with jitter reduction techniques and quadrature phase generation for DRAM interfaces," *IEEE J. Solid-State Circuits*, vol. 44, no. 5, pp. 1522-1530, May 2009.  
[2] C. H. Yu, D. Kim, and L. S. Kim, "An area efficient early Z-test method for 3D graphics rendering hardware," *IEEE Trans. Circuits, Syst.*, vol. 55, no. 7, pp. 1929-1938, Aug. 2008.  
[3] D. Kim and L. S. Kim, "Area-efficient pixel rasterization and texture coordinate interpolation," *Comp. Graphics*, vol. 32, no. 6, pp. 669-681, Dec. 2008.  
[4] K. S. Ha, L. S. Kim, S. J. Bae, K. I. Park, J. S. Choi, Y. H. Jun, and K. Kim, "A 6Gb/s/pin pseudo-differential signaling using common-mode noise rejection techniques without reference signal for DRAM interfaces," *IEEE Int. Solid-State Circuit Conf.*, San Francisco, USA, Feb. 2009.  
[5] K. I. Oh, L. S. Kim, K. I. Park, Y. H. Jun, and K. Kim, "A 5-Gb/s/pin transceiver for DDR memory interface with a crosstalk suppression scheme," *IEEE Custom Integr. Circuits Conf.*, San Jose, USA, Sep. 2008.

### OTHER ACCOMPLISHMENTS (2008/2009)

[1] 1 Award





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# Multimedia Computing, Communications and Broadcasting Laboratory

The Lab for Multimedia Computing, Communications and Broadcasting (MCCB Lab) studies next-generation high-performance video coding (HVC) for ultra-high definition (UHD) TV, pattern recognition and video analysis for IPVT personalization and security camera applications. The MCCB Lab has been actively involved in video coding standardization activities of both ISO/IEC MPEG and ITU-T VCEG, especially by contributing high-efficiency coding tools for UHD video. The MCCB Lab has also studied fast processing of the recent H.264|MPEG-4 AVC (Advanced Video Coding) and H.264|MPEG-4 SVC (Scalable Video Coding) encoders/decoders for Advanced T-DMB applications. The developed SVC encoder with one spatial enhancement layer runs on PCs at more than 40 fps with little degradation of visual quality.

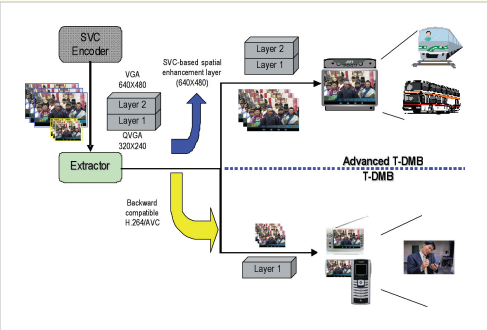


Fig. 1 Concept of an SVC based Advanced T-DMB

The MCCB Lab, on the other hand, studies intelligent multimedia applications such IPTV personalization and user modeling using pattern recognition, machine learning and data mining. With our intelligent recommendation system, personalized IPTV programs and schedulers are automatically recommended for users in context-aware senses to enhance the TV viewing environments.

## KEY PUBLICATIONS (2008/2009)

[1] J. Lim and M. Kim, "An optimal adaptation framework for streaming multiple video objects," *IEEE Trans. Circuits, Syst. Video Techn.*, vol. 18, no. 5, pp. 699-703, May 2008.

[2] J. Lim, M. Kim, B. Lee, M. Kim, H. Lee, and H.-K. Lee, "A target advertisement system based on TV viewer's profile reasoning," *Multimedia Tools Appl.*, vol. 36, no. 1, pp. 11-35, Jan. 2008.

[3] T. Na, Y. Lee, J. Lim, Y. Joo, K. Kim, J. Byun, and M. Kim, "A fast macroblock mode decision scheme using ROI-based coding of H264\_MPEG-4 for mobile video telephony applications," *SPIE Conf. Appl. Digital Image Process.*, San Diego, USA, Aug. 2008.

[4] B. Lee, M. Kim, S. Hahm, C. Park, and K. Park, "An efficient block mode decision for temporal scalability in scalable video coding," *Visual Comm. Image Process.*, San Jose, USA, Jan. 2008.

# Visual Communications Laboratory

Visual Communications Laboratory (VCL) was established in 1984. The research area of VCL covers image/video processing, 2D/3D computer vision, pattern recognition, and imag/video coding. In the past year, 2008, we achieved considerable results regarding the 3D based on signal processing, face detection dynamic range compression (DRC). Face detection, automatic white balance and DRC (Dynamic Range Compression) are developed for a digital camera system. We propose fast three-dimensional dilation and erosion methods using run-length encoding, derive the Fourier transform of a simplified 3D video signal and analyze how a 3D video is influenced by disparity and motion in terms of temporal aliasing. This approaches are useful for reducing undesirable visual artifacts in 3D video as well as for assisting the development of relevant technologies.

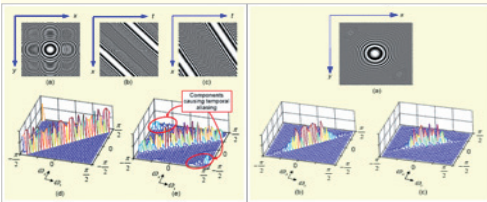


Fig. 1 Test image sequences and Fig. 2 Performance of the temporal anti-aliasing filter

In digital camera system, we proposed face detection using a novel scheme to construct a cascaded classification and DRC revealed the fine details without affecting already well-balanced region using space-varying dynamic range compression method.



Fig. 3 Face detection

Fig. 4 Dynamic range compression

## KEY PUBLICATIONS (2008/2009)

[1] W. J. Kim, S. D. Kim, and H. Radha, "3D binary morphological operations using run-length representation," *Signal Process.: Image Comm.*, vol. 23, no. 6, pp. 442-450, July 2008.

[2] W. J. Kim, S. D. Kim, N. Hur, and J. W. Kim, "Temporal anti-aliasing of a stereoscopic 3D video," *ETRI J.*, vol. 31, no. 1, pp. 1-9, Feb. 2009.

[3] W. J. Kim, S. D. Kim, J. W. Kim, and N. Hur, "Resizing of stereoscopic images for display adaptation," *Stereoscopic Displays, Appl.*, San Jose, USA, Jan. 2009.

## OTHER ACCOMPLISHMENTS (2008/2009)

[1] 1 Patent  
[2] 3 MS Graduates



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## Robotics and Computer Vision Laboratory

Research in Robotics and Computer Vision (RCV) Lab. has been focused on developing new theories concerning important computer vision problems: 3D structure recovery, image processing, object recognition and robotics research : (i) a novel method has been proposed to match feature points extracted from an image pair with significant deformation. (ii) a new theory has been proposed to model the sensor noise of CCD cameras and applied to edge and corner detection, background subtraction, and etc. (iii) various mobile robot (including UAV) localization and mapping technologies using general or catadioptric cameras and laser sensors have been proposed. (iv) an intelligent robot platform "ROCOVI", which is able to localize its position, map and recognize environments, interact with human, and manipulate objects, has been developed. (v) an optimization-based framework to extract semantic information from images (multi-labeling problem) has been proposed.



Fig. 1 "ROCOVI"



Fig. 2 Deformable feature matching and object detection

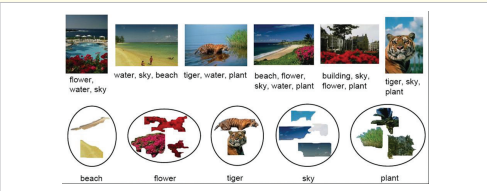


Fig. 3 Semantic image decomposition from multi-label context

### KEY PUBLICATIONS (2008/2009)

[1] S. H. Kim and I. S. Kweon, "Object recognition using a generalized robust invariant feature and Gestalt's law of proximity and similarity," *Pattern Recogn.*, vol. 41, no. 2, pp. 726-741, Feb. 2008.  
[2] S. H. Kim and I. S. Kweon, "Scalable representation for 3D object recognition using feature sharing and view clustering," *Pattern Recogn.*, vol. 41, no. 2, pp. 754-773, Feb. 2008.  
[3] O. Choi and I. S. Kweon, "Robust feature point matching by preserving local geometric consistency," *Computer Vision, Image Underst.*, vol. 113, no. 6, pp. 726-742, June 2009.  
[4] Y. K. Jeong and I. S. Kweon, "Relative scale estimation between two camera motions," *Int. Conf. Pattern Recogn.*, Tampa, USA, Dec. 2008.  
[5] T. Li, T. Mei, S. Yan, I. S. Kweon, and C. W. Lee. "Contextual decomposition of multi-label images." *IEEE Conf. Comp. Vision, Pattern Recogn.*, Miami, USA, June 2009.

### OTHER ACCOMPLISHMENTS (2008/2009)

[1] 3 Awards  
[2] 4 MS Graduates, 1 PhD Graduate

## VLSI Systems Laboratory

**Power-Rate-Distortion Optimization in H.264 Video CODEC:** Mode decision based on Rate-Distortion Optimization (RDO) is the critical part in Motion Estimation in H.264. We make various efforts to extend this toward CRDO(complexity-rate-power optimization), where C can be code size, gate count, or power. We proposed a fast rate estimator based on CABAC for H.264/AVC based on a simplified rate model. We also developed lossless embedded compression algorithms to reduce the bandwidth in transmission, data size in storage. The proposed algorithm uses hierarchical prediction and grouping based on spatial correlation between pixels and the Truncated Bit Packing (TBP) to reduce the redundancy of residual. The proposed algorithm achieves at least 60% data compression without loss of quality while meeting the real time requirement of the high definition video coding, i.e., 30cycles/macro-block.

**System-Level Low-Power Design for MP (Multi-Processor) SoC:** This topic is focused on developing algorithms for energy-efficient SoC in system-level design step. First, we developed a DVFS (dynamic voltage and frequency scaling) algorithm to minimize energy consumption in MPSoC (multi-processor SoC). We proposed an analytical DVFS method that judiciously exploits slack by considering the varying parallelism over each path in a task graph. Energy reduction over 25% was achieved with H.264 encoder and decoder. We also proposed a novel on-line DVFS method which exploits both phase behavior and runtime distribution during runtime in combined Vdd/Vbb scaling.

### KEY PUBLICATIONS (2008/2009)

[1] J. Hahm and C.-M. Kyung, "Efficient CABAC rate estimation for H.264/AVC

mode decision," *IEEE Trans. Circuits, Syst. Video Techn.* (to be published).  
[2] J. Kim, S. Oh, S. Yoo, and C.-M. Kyung, "An analytical dynamic scaling of supply voltage and body bias based on parallelism-aware workload and runtime distribution," *IEEE Trans. Computer-Aided Design Integr. Circuits, Syst.*, vol. 28, no. 4, pp. 568-581, Apr. 2009.  
[3] S. Jung, J. Kim, S. Na, and C.-M. Kyung, "Energy-aware instruction-set customization for real-time embedded multiprocessor systems," *Int. Symp. Low Power Electron., Design*, San Francisco, USA, Aug. 2009.  
[4] J. Kim, J. Kim, and C.-M. Kyung, "A lossless embedded compression algorithm for high definition video coding," *Int. Conf. Multimedia, Exposition*, New York, USA, June 2009.  
[5] J. Kim, S. Yoo and C.-M. Kyung, "Program phase and runtime distribution-aware online DVFS for combined Vdd/Vbb scaling," *Proc. Design Autom. Test Europe*, Nice, France, Apr. 2009

### OTHER ACCOMPLISHMENTS (2008/2009)

[1] 1 Award  
[2] 13 MS Graduates, 3 PhD Graduates



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## Future of Beyond Human Intelligence Laboratory



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Future Beyond Human Intelligence Laboratory has been focusing on development of intelligent control theories and their application to the real robotic systems as follows: (i) real-time welding gap/profile monitoring technology (ii) Unmanned Ground Vehicle (UGV) for the military application. In welding project, a 3D measurement system for robotic is developed. The system consists of a PC-based camera and a stripe-type laser diode. A mechanism adjusting the beam angle and the focus is devised, image processes are implemented, and a 3D shape is reconstructed for robot manipulation. In UGV project, we have developed the unified hierarchical path planning algorithm which consists of global and local path planner. For global path planning, we convert the given DEM/DSM and vector map to the mobility map and search the optimal path based on the generated map. For local path planning, we have newly developed Virtual Tangential vector (VTV) algorithm and Emergency Level Around (EMA) using LMS. VTV is similar to VFF, but it can generate mode smooth and short trajectories. ELA is a simple but powerful obstacle avoidance technique.

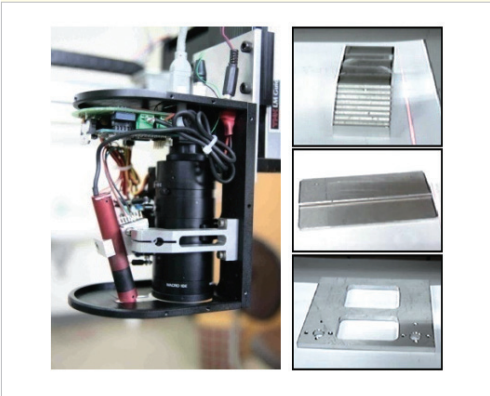


Fig. 1 Vision based scanner for laser welding

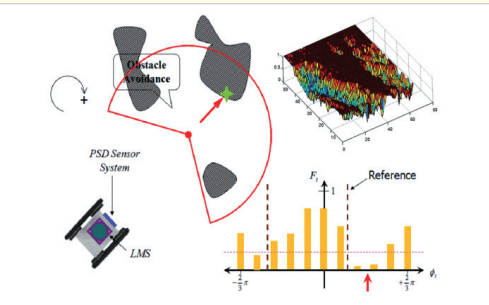


Fig. 2 Velocity map by DEM and obstacle avoidance by ELA

### KEY PUBLICATIONS (2008/2009)

- [1] Z. Li and J. J. Lee, "New approach to synchronization in asymmetrically coupled networks," *Phys. Lett. A*, vol. 372, no. 8, pp. 1228-1235, Feb. 2008.
- [2] K. H. Seo and J. J. Lee, "The development of two mobile gait rehabilitation systems," *IEEE Trans. Neural Syst., Rehabilitation Engin.*, vol. 17, no. 2, pp. 156-166, Apr. 2009.
- [3] J. J. Lee, B. G. Shin, and J. J. Kim, "Posture control of a free falling robotic cat for soft landing using reinforcement learning," *Int. Conf. Humanized Syst.*, Beijing, China, Oct. 2008.

### OTHER ACCOMPLISHMENTS (2008/2009)

- [1] 1 Patent, 3 Awards
- [2] 2 MS Graduates, 1 PhD Graduate

## System Theoretic Analysis and Control Laboratory

The aim of System Theoretic Analysis and Control Lab is to study the theoretical aspect of nonlinear control systems and communication systems, and to develop the application algorithms for airborne spotlight synthetic aperture radar (SAR) system and global positioning system (GPS). Study of nonlinear control systems has focused on analyzing the stability of nonlinear systems, and study of communication systems has focused on improving the throughput of each flow in wireless ad-hoc networks/wireless cellular networks and performance of channel estimation over time-varying channels.

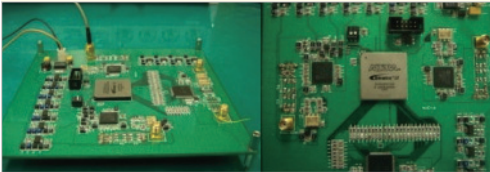


Fig. 1 Chirp pulse generator for SAR system

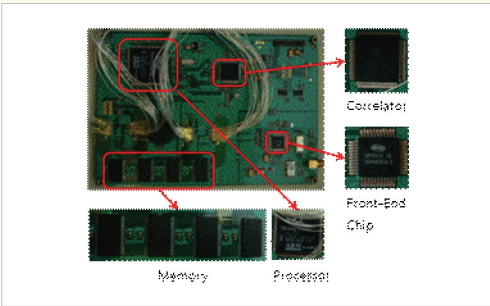


Fig. 2 GPSR test board for GPS

### KEY PUBLICATIONS (2008/2009)

- [1] J.-G. Kim and J.-T. Lim, "MAP based channel estimation for MIMO-OFDM over fast Rayleigh fading channels," *IEEE Trans. Vehic. Techn.*, vol. 57, no. 5, pp. 1963-1968, May 2008.
- [2] J.-W. Son and J.-T. Lim, "Stabilization of approximately feedback linearizable systems using singular perturbation," *IEEE*

- Trans. Automatic Control*, vol. 53, no. 6, pp. 1499-1503, July 2008.
- [3] H.-S. Shin and J.-T. Lim, "Omega-K algorithm for airborne spatial invariant bistatic spotlight SAR imaging," *IEEE Trans. Geosc. Remote Sensor*, vol. 2, no. 1, pp. 159-163, Jan. 2009.
  - [4] H.-J. Lee and J.-T. Lim, "On congestion control for streaming real-time application over wireless network with bandwidth variation," *Asia-Pacific Conf. Comm.*, Tokyo, Japan, Oct. 2008.
  - [5] H.-L. Choi and J.-T. Lim, "On robust position control of DC motors by e-PID controller and its application to humanoid robot arms," *IFAC World Congress*, Seoul, Korea, July 2008.

### OTHER ACCOMPLISHMENTS (2008/2009)

- [1] 1 Patent
- [2] 2 MS Graduates, 2 PhD Graduates



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Professor

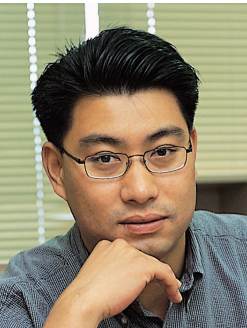
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## Display Power Circuit Laboratory

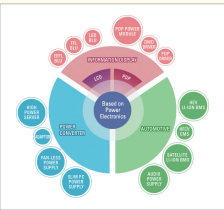


Fig. 1

following applications: information display system, automotive electronics, server power system, and IT computing devices.

**LED Driver System for LCD TV:** To reduce the power consumption and realize high efficiency and low cost LED Driver system, DPCL newly proposed a two dimensional channel driving employing X-Y channel driving technique for 46" LCD TVs.

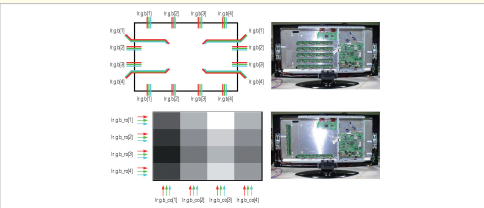


Fig. 2

**Li-Ion Battery Unit for STSAT-3:** To realize the power management system for lithium-ion battery, DPCL proposed and implemented the protection circuits and equalizer circuit for a satellite called STSAT-3.

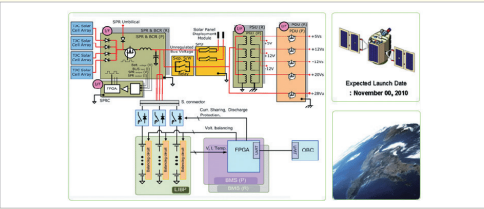


Fig. 3

**Sensor-less Automatic Charge Equalizer for Li-ion Batteries:** To ensure safety of lithium-ion battery as well as prolong the lifetime, DPCL proposed a new charge equalization

converter without the sensor of small size and high efficiency for HEV lithium-ion cells.

### KEY PUBLICATIONS (2008/2009)

- [1] K. H. Yi and G. W. Moon, "A novel two phase interleaved LLC series resonant converter using a phase of the resonant capacitor," *IEEE Trans. Indust. Electron.*, vol. 56, no. 5, pp. 1815-1819, May 2009.
- [2] H. S. Park, C. E. Kim, C. H. Kim, G. W. Moon, and J. H. Lee, "A modularized charge equalizer for an HEV lithium-ion battery string," *IEEE Trans. Indust. Electron.*, vol. 56, no. 5, pp. 1464-1476, May 2009.
- [3] K. H. Yi, S. W. Choi, and G. W. Moon, "Comparative study on a single sustaining driver (SSD) with single and dual energy recovery circuits for plasma display panels (PDPs)," *IEEE Trans. Power Electron.*, vol. 24, no. 2, pp. 540-547, Feb. 2009.
- [4] K. H. Yi and G. W. Moon, "New dual sustaining driver used two-different energy recovery circuits for large-sized plasma display panels (PDPs)," *IEEE Trans. Indust. Electron.*, vol. 56, no. 1, pp. 221-230, Jan. 2009.
- [5] W. S. Oh, D. Y. Cho, and G. W. Moon, "A novel two-dimensional adaptive dimming technique of X-Y channel drivers for LED backlight system in LCD TVs," *IEEE J. Display Techn.*, vol. 5, no. 1, pp. 20-26, Jan. 2009.

### OTHER ACCOMPLISHMENTS (2008/2009)

- [1] 4 Awards

## Neural Networks and Machine Intelligence Laboratory

Our research vision is to make intelligent systems. An intelligent system makes judgments on the unseen data based on the training data as human being does. Our human brain can be thought of as a biological intelligent system for information processing. We implement intelligent systems by imitating the behavior of human brain. Accordingly our main work is to develop upgraded machine intelligence by investigating phenomena and principles of human and present machine intelligence and by utilizing the human-related technologies such as neural networks, evolutionary algorithms, and fuzzy logic. The most popular system that mimics human brain is the neural network.

The neural network is a new technology that solves problems by modeling functions and structures of human brains. It is used in various fields such as signal processing, intelligent control, image/voice recognition, prediction, and data mining. We have so many areas to be explored using neural networks. Our laboratory focuses on four parts.

The first part is the feature extraction, a basic part in the data analysis. Extracting meaningful features from the raw data helps systems to solve the given problem easily. We try to develop the algorithm for extracting features efficiently to improve the accuracy of pattern recognition problems. The second part is the expert system. We can combine various experts (neural networks) to solve the problems that cannot be solved by a single network or to improve the performance. The expert system can be composed of local experts with a gating network or only global networks or mixture of them. We try to find the way to constitute the expert system which shows good performance. The third part is the optimization of neural

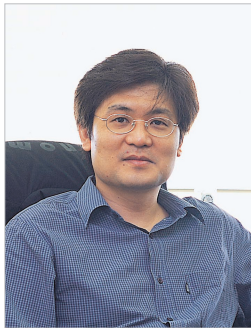
network structure. If the complexity of neural network is too low or too high, the network under-fits or over-fits the training data, which degrades the generalization performance. We are interested in how to control the complexity of neural networks automatically. The fourth part is the chaos system.

### KEY PUBLICATIONS (2008/2009)

- [1] H. Lee and C. H. Park, "Set-point regulation of LTI nonminimum phase systems with a single positive zero using two sliding lines," *IEICE Trans. Fund. Electron., Comm. Computer Sciences*, vol. E92-A, no. 3, pp. 862-870, Mar. 2009.
- [2] J.-S. Lee and C. H. Park, "Robust audio-visual speech recognition based on late integration," *IEEE Trans. Multimedia*, vol. 10, no. 5, pp. 767-779, Aug. 2008.
- [3] S. I. Lee, J.-S. Lee, H.-K. Min, and C. H. Park, "A pattern recognition method of fatigue crack growth on metal using acoustic emission," *J. Inst. Electron. Engin. Korea*, vol. 46-SP, no. 3, pp. 133-145, May 2009.
- [4] J.-S. Lee and C. H. Park, "A new temporal filtering method for improved automatic lipreading," *J. Korea Inform. Process. Soc.*, vol. 15-B, no. 2, pp. 123-130, Apr. 2008.
- [5] J.-S. Lee and C. H. Park, "Improved automatic lipreading by multiobjective optimization of hidden Markov models," *J. Korea Inform. Process. Soc.*, vol. 15-B, no. 1, pp. 53-60, Feb. 2008.

### OTHER ACCOMPLISHMENTS (2008/2009)

- [1] 1 Book
- [2] 2 MS Graduates



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## Image Computing Systems Laboratory

Research field of Image Computing Systems Laboratory (ICSL) has introduced medical imaging system, image processing, video compression, stereo image and pattern recognition.

Our medical imaging system area consists of brain functional studies, cellular MRI, parallel imaging, RF pulse design, and visualization of 3D brain images from the magnetic resonance imaging (MRI). Brain functional studies have been performed using functional MRI (fMRI) to analyze brain functional characteristics. Cellular MRI, which is a collaboration work with Dept. of Biological Sciences in KAIST, is also interesting research area. We have demonstrated that a proposed scheme has enabled in-vitro and in-vivo positive-contrast visualization without the use of complicated pulse sequence. Moreover, in order to acquire better spatial resolution MR images, we have developed a reconstruction algorithm combining parallel imaging and high-order generalized series method. Furthermore, acquisition method of diffusion weighted images, visualization of MR images with fMRI data and tractography, and brand-new RF pulse sequence have been proposed. In video compression parts, we have designed an encoder to improve computational complexity of the encoder by reducing residual signals and adaptive up-sampling method using DCT for SVC. Automatic target recognition is also our interesting research fields. Because it is difficult to trace the target in varying object's scale, we have proposed a template updating method, where a scale variance is estimated by finding movements of target. In order to apply the conventional superresolution methods to multi-viewpoint images, an accurate isoplane transformation is required. We propose a robust random

sample consensus (RANSAC) criterion and a weighted homography estimation, which were important for accurate geometric transformation.

Finally, we have participated in developing 3D display processor embedding a programmable 3D graphics rendering engine to generate interpolated image using two stereo images and depth information.

### KEY PUBLICATIONS (2008/2009)

[1] Y. Kim, K. Bae, S. Yoo, T. Park, and H. Park, "Positive contrast visualization for cellular magnetic resonance imaging using susceptibility-weighted echo-time encoding," *Magn. Reson. Image*, vol. 27, no. 5, pp. 601-610, June 2009.

[2] S. Yun, S. Oh, Y. Han, and H. Park, "High-resolution fMRI with higher-order generalized series imaging and parallel imaging techniques (HGS-parallel)," *J. Magn. Reson. Image*, vol. 29, no. 4, pp. 924-936, Mar. 2009.

[3] I. Shin and H. Park, "Adaptive up-sampling method using DCT for spatial scalability of scalable video coding," *IEEE Trans. Circuits, Syst. Video Techn.*, vol. 19, no. 2, pp. 206-214, Feb. 2009.

[4] S. Oh, S. Yun, and H. Park, "Compensation of the susceptibility artifact in temporal and orbitofrontal region in brain using the flat RF pulse," *Int. Soc. Magn. Reson. Medicine*, Hawaii, USA, Apr. 2009.

[5] Y. Kim, S. Yoo, K. Bae, T. Park, and H. Park, "Dual contrast method for cellular MRI using positive and negative contrast agents," *Int. Soc. Magn. Reson. Medicine*, Hawaii, USA, Apr. 2009.

### OTHER ACCOMPLISHMENTS (2008/2009)

- [1] 2 Patents  
[2] 1 PhD Graduate

## Integrated Computer Systems Laboratory

Integrated Computer Systems Lab is the leading group in the research about the advancement of practical implementation of VLSI systems, the application of circuit theoretic techniques to systems and signal processing, and design methodologies.

**Design of Microprocessors:** A high-performance microprocessor including on-chip bus suitable for developing embedded systems was developed together with its corresponding development environment such as compiler, assembler and debugger.

**VLSI Design for Communication Systems:** A high-throughput and small-area duo-binary turbo decoder was developed for the WiMAX standard. A new efficient synchronization method was proposed for an OFDM-based system, IEEE 802.16d. In addition, a simple-yet-efficient technique was proposed to improve the performance of distributed sorting based K-best detection.

**VLSI Design for Multimedia Signal Processing:** A scalable sound synthesis system was proposed for synthesizing the harmonic and non-harmonic sound of a musical instrument.

**Analog Circuit and Computer Aided Design:** A new capacitor array structure and its switch control method were proposed for binary weighted SAR analog-to-digital converters. A new FIR digital filter synthesis algorithm was also proposed to consider multiple adder graphs for a coefficient.

### KEY PUBLICATIONS (2008/2009)

[1] T. H. Kim, Y. J. Lee, and I. C. Park, "Design of a scalable and programmable sound synthesizer," *IEEE Trans. Very Large Scale Integr. Syst.*, 2009 (to be published).

[2] J. H. Kim and I. C. Park, "Bit-level extrinsic information exchange method for double-binary turbo codes," *IEEE Trans. Circuits*

*Syst. II*, vol. 56, no. 1, pp. 81-85, Jan. 2009.

[3] T. H. Kim and I. C. Park, "Low-power and high-accurate synchronization for IEEE 802.16d systems," *IEEE Trans. Very Large Scale Integr. Syst.*, vol. 16, no. 12, pp. 1620-1630, Dec. 2008.

[4] J. H. Han and I. C. Park, "FIR filter synthesis considering multiple adder graphs for a coefficient," *IEEE Trans. Computer-Aided Design Integr. Circuits Syst.*, vol. 27, no. 5, pp. 958-962, May 2008.

[5] J. S. Lee and I. C. Park, "Capacitor array structure and switch control for energy-efficient SAR analog-to-digital converters," *IEEE Int. Symp. Circuits, Syst.*, Washington, USA, May 2008.

### OTHER ACCOMPLISHMENTS (2008/2009)

- [1] 3 Awards  
[2] 5 MS Graduates



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## Image Systems Laboratory

Image Systems Laboratory (ISL) was founded in 1987. The research field includes image and video processing, medical image processing, and 3D systems. In order to solve multimodality image registration problem, an entropy-based objective function is proposed on the basis of a 3-D joint histogram incorporating intensity information and edge orientation information. Experimental results show that the proposed method provides more robust registration results than the existing approaches.



Fig. 1

We also proposed a novel method using an active tube model in order to quantify the geometric parameters of an abnormal vessel. The conventional centerline-based measurement often produces inaccurate clinical information of abnormal vessel due to local curvatures on the centerline around complex-structured abnormal regions. However, the proposed method overcomes the problem of incorrect local curvatures from the centerline via introduction of a region-based active tube model and provides good vessel quantification results.

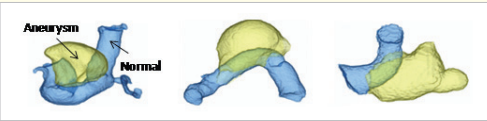


Fig. 2 Region classification result of an abnormal vessel

### KEY PUBLICATIONS (2008/2009)

[1] Y. S. Kim, J. H. Lee, and J. B. Ra, "Multi-sensor image registration based on

intensity and edge orientation information," *Pattern Recogn.*, vol. 41, no. 11, pp. 3356-3365, Nov. 2008.

[2] D. G. Kang, J. B. Ra, and D. C. Suh, "Three-dimensional blood vessel quantification via centerline deformation," *IEEE Trans. Medical Imaging*, vol. 28, no. 3, pp. 405-414, Mar. 2009.

[3] Y. G. Lee and J. B. Ra, "New image multiplexing scheme for compensating lens mismatch and viewing zone shifts in three-dimensional lenticular displays," *Optical Engin.*, vol. 48, no. 4, p. 044001, Apr. 2009.

[4] D. Lee, Y. S. Kim, J. H. Lee, and J. B. Ra, "Non-rigid registration of 3D ultrasound and CT images in the liver using intensity and gradient information," *Computer Assisted Radiol., Surgery*, Barcelona, Spain, June 2008.

[5] W. H. Nam, D. G. Kang, D. Lee, and J. B. Ra, "Anatomical feature extraction in 3D B-mode ultrasound liver images for CT-ultrasound image registration," *Computer Assisted Radiol., Surgery*, Barcelona, Spain, June 2008.

### OTHER ACCOMPLISHMENTS (2008/2009)

[1] 2 Patents  
[2] 1 MS Graduate, 1 PhD Graduate

## Image and Video System Laboratory

Image and Video Systems (IVY) Lab. conducts research on topics relating to image/video processing and communications, which is one of the most demanding technologies in modern society. IVY Lab. focuses on very interesting research topics and recently included research in multimedia processing in social media. The followings are (some of) the topics that IVY Lab has been focusing on:

**Semantic Image/Video Indexing, Retrieval, and Filtering in Social Media:** Recently, we have been researching a new tag recommendation technique that calculates visual similarity in the semantic space. The proposed semantic space is advantageous to represent true concepts present in images and videos. Also the increasing popularity of video contents gives rise to a strong need for precise search, retrieval, and effective management. To realize those needs, our research has been focused on semantic-based video analysis techniques. Further, we are dedicated to develop an effective face indexing/search method for social media by combining context- and content-based information. In the multimedia filtering, we have been focusing on classifying the malicious images/videos from non-malicious based on MPEG-7 visual descriptors and support vector machine (SVM).

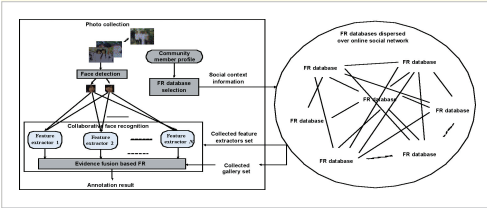


Fig. 1 Face annotation system in social media

**Color Face Recognition and Biometric Security:** Face recognition has been one of the most active research topics primarily due to its potential applications (including content

indexing in IPTV). The result obtained in IVY Lab. is interesting in that the developed color face recognition/detection is very robust to the degraded face images due to low-resolution, high compression, and blurring noise.



Fig. 2

For the usage of biometric data like face and fingerprint information in real-world applications, it is critically important to guarantee the security of biometric data for the purpose of privacy protection. IVY Lab. has been focusing on the protection of contents in social media using fuzzy vault.

### KEY PUBLICATIONS (2008/2009)

[1] J. Y. Choi, Y. M. Ro, and K. N. Plataniotis, "Color face recognition for degraded face images," *IEEE Trans. Syst., Man, Cybern., Pt. B*, vol. 39, no. 5, pp. 1217-1230, Mar. 2009.

[2] W. De Neve, D. V. Deursen, W. V. Lancker, Y. M. Ro, and R. V. Walle, "Improved BSDL-based content adaptation for JPEG 2000 and HD photo (JPEG XR)," *Signal Process.: Image Comm.*, vol. 24, no. 6, pp. 452-467, July 2009.

[3] S. H. Jin, J. H. Cho, and Y. M. Ro, "Real time filtering for live broadcasts in TV terminals," *Multimedia Tools, Appl.*, vol. 36, no. 3, pp. 285-301, Feb. 2008.

### OTHER ACCOMPLISHMENTS (2008/2009)

[1] 3 Awards  
[2] 3 MS Graduates, 1 PhD Graduate



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## VLSI Design Technology Laboratory



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VLSI Design Technology LAB focuses on a broad range of VLSI design technology (tools and methodologies) topics, strives to perform world class research, which at the same time has an industrial impact. Our recent research topics are in the area of low-power/low-leakage design methodology, sequential circuit analysis and optimization, high-level synthesis, statistical timing analysis, and structured ASIC.

Research in sequential logic optimization has been focused on applying leakage reduction methods using skewed flip-flops (SFF) and achieving high performance designs using pulsed latches. A set of SFFs, which are obtained by applying leakage reduction methods to a subset of the transistors in a conventional flip-flop, exhibit unequal characteristics in terms of leakage and delay. We present an algorithm that selectively substitutes SFFs for conventional flip-flops in sequential circuits, such that the timing constraint is still satisfied while the leakage from the flip-flops is reduced. Pulsed-latches are latches driven by a brief pulse, and thus inherits the benefit of both latches and flip-flops. We presented a method of allocating multiple pulse widths along with clock skew scheduling to minimize the clock period of pulsed-latch based circuits. Research in high-level synthesis has also been focused on reducing the leakage by considering power-gating and improving the performance of designs by using latches.

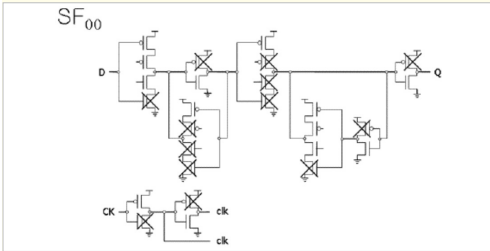


Fig. 1 Transistor-level implementation of SFF

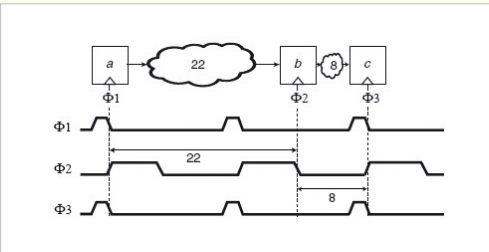


Fig. 2 Multiple pulse widths with clock skew

### KEY PUBLICATIONS (2008/2009)

[1] E. Choi, C. Shin, and Y. Shin, "HLS-pg: high-level synthesis of power-gated circuits," *IEEE Trans. Computer Aided Design Integr., Circuits, Syst.*, vol. 28, no. 3, pp. 451-456, Mar. 2009.

[2] Y. Shin, S. Paik, and H. Kim, "Semicustom design of zigzag power-gated circuits in standard cell elements," *IEEE Trans. Computer Aided Design Integr., Circuits, Syst.*, vol. 28, no. 3, pp. 327-339, Mar. 2009.

[3] J. Seomun, J. Kim, and Y. Shin, "Skewed flip-flop and mixed-Vt gates for minimizing leakage in sequential circuits," *IEEE Trans. Computer Aided Design Integr., Circuits, Syst.*, vol. 27, no. 11, pp. 1956-1968, Nov. 2008.

[4] S. Paik, I. Shin, and Y. Shin, "HLS-l: high-level synthesis of high performance latch-based circuits," *Design, Automation, Test Europe*, Nice, France, Apr. 2009.

[5] H. Lee, S. Paik, and Y. Shin, "Pulse width allocation with clock skew scheduling for optimizing pulsed latch-based sequential circuits," *Int. Conf. Computer-Aided Design*, San Jose, USA, Nov. 2008.

### OTHER ACCOMPLISHMENTS (2008/2009)

- [1] 2 Patents  
[2] 2 MS Graduates

## Multimedia Processing Laboratory

MultiMedia Processing Laboratory (MMPLAB) is interested in the application of digital signal processing and machine learning theories. MMPLAB has been trying to apply several state-of-the-art machine learning algorithms to multimedia signal processing. Using advanced machine learning theory and signal processing techniques, multimedia signals such as speech, audio and video are processed for various applications including an analysis, enhancement, recognition, processing, and security. MMPLAB proposed a novel almost alias free subband adaptive filtering with critical sampling for multimedia analysis and novel underdetermine blind source separation algorithm based on subspace representation, and developed a robust audio/video fingerprinting system, large vocabulary continuous speech recognition system, humming-based music retrieval system and simple free viewpoint video system.

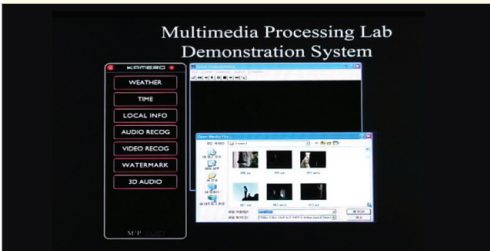


Fig. 1

### KEY PUBLICATIONS (2008/2009)

[1] S. Kim, C. D. Yoo, and T. Q. Nguyen, "Alias-free subband adaptive filtering with critical sampling," *IEEE Trans. Signal Process.*, vol. 56, no. 5, pp.1894-1904, May 2008.

[2] S. Lee and C. D. Yoo, "Robust video fingerprinting for content-based video identification," *IEEE Trans. Circuits, Syst. Video Techn.*, vol. 18, no. 7, pp. 983-988, July 2008.

[3] M. Jin and C. D. Yoo, "Quantum hashing for multimedia," *IEEE Trans. Inform. Forens., Security* (to be published).

[4] S. Yun and C. D. Yoo, "Speech emotion recognition via a max-margin framework incorporating a loss function based on the Watson and Tellegen's emotion model," *IEEE Int. Conf. Acoustics, Speech, Signal Process.*, Taipei, Taiwan, Apr. 2009.

[5] D. Jang and C. D. Yoo, "Fingerprint matching based on distance metric learning," *IEEE Int. Conf. Acoustics, Speech, Signal Process.*, Taipei, Taiwan, Apr. 2009.

### OTHER ACCOMPLISHMENTS (2008/2009)

- [1] 4 Patents



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## Semiconductor System Laboratory

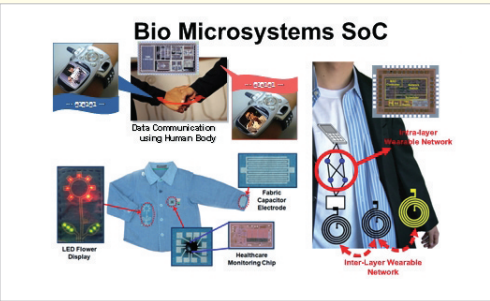


Fig. 1 Microsystems SoC

**Bio Microsystems SoC:** To meet the demands for ubiquitous era, SSL focuses on development of SoC that enables convergence of biology and electronics for well-being of human life. Our research fields span as: Body Channel Communication (BCC), Planar-Fashionable Circuit Board (P-FCB), and Wearable Network. BCC enables low energy-per-bit communication via body coupling, and P-FCB provides means to form a pervasive, wearable computer intro clothes. Wearable network conveniently connects devices and sensors around the body with low energy consumption.

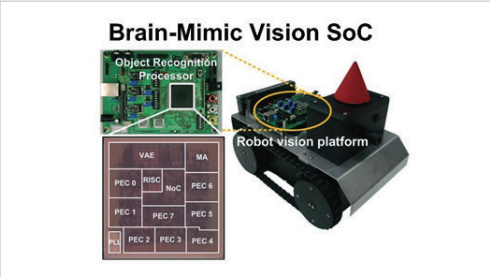


Fig. 2 Vision SoC for intelligent robot

**Brain-Mimic Vision SoC:** The network-on-chip (NoC) has been replacing the traditional bus-based on-chip interconnections to meet the huge bandwidth requirements of recent many-core chips. To realize NoC, SSL has developed specification and C-level simulator for NoC architecture and protocol explorations, and

multi-core vision SoC for image processing and object recognition applications. Real-time operation is achieved by silicon-brain architecture that compromises brain mimic visual attention, neural networks, and fuzzy logic with the conventional silicon based VLSI.

### KEY PUBLICATIONS (2008/2009)

[1] N. Cho, L. Yan, J. Bae, and H.-J. Yoo, "A 60kb/s-10Mb/s adaptive frequency hopping transceiver for interference-resilient body channel communication," *IEEE J. Solid-State Circuits*, vol. 44, no. 3, pp. 708-717, Mar. 2009.

[2] K. Kim, S. Lee, J.-Y. Kim, M. Kim, and H.-J. Yoo, "A 125 GOPS 583 mW network-on-chip based parallel processor with bio-inspired visual attention engine," *IEEE J. Solid-State Circuits*, vol. 44, no. 1, pp. 136-147, Jan. 2009.

[3] J.-H. Woo, J.-H. Sohn, H. Kim, and H.-J. Yoo, "A 195 mW, 9.1 Mverices/s fully programmable 3-D graphics processor for low-power mobile devices," *IEEE J. Solid-State Circuits*, vol. 43, no. 11, pp. 2370-2380, Nov. 2008.

[4] N. Cho, J. Bae, and H.-J. Yoo, "A 10.8mW body-channel-communication/MICS dual-band transceiver for a unified body-sensor-network controller," *IEEE Int. Solid-State Circuits Conf.*, San Francisco, USA, Feb. 2009.

[5] J.-Y. Kim, M. Kim, S. Lee, J. Oh, K. Kim, and H.-J. Yoo, "A 201.4GOPS 496mW real-time multi-object recognition processor with bio-inspired neural perception engine," *IEEE Int. Solid-State Circuits Conf.*, San Francisco, USA, Feb. 2009.

### OTHER ACCOMPLISHMENTS (2008/2009)

[1] 2 Patents, 1 Award, 1 Book  
[2] 2 PhD Graduates



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## Power Electronics Laboratory

Power Electronics (PE) LAB makes researches on developing new control algorithm and circuit of power systems: Motor Control System, Power Conversion System, Display Driver Circuit, and Battery management system. Recently, the digital power systems such as the LCD backlight unit, the LED lighting system, and the sever power system have been researched. The developed power circuits controlled digitally can reduce the cost, the weight, and the circuit complexity. The key researching areas are the control algorithm development and the digital platform development.

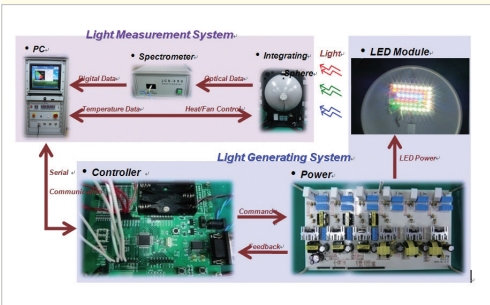


Fig. 1 Digital LED lighting system configurations

### KEY PUBLICATIONS (2008/2009)

[1] H. K. Yoon, S. K. Han, E. S. Choi, G. W. Moon, and M. J. Yoon, "Zero-voltage switching and soft-commutating two-transformer full-bridge PWM converter using the voltage-ripple," *IEEE Trans. Indust. Electron.*, vol. 55, no. 3, pp. 1478-1488, Mar. 2008.

[2] T. S. Kim, S. K. Han, G. W. Moon, and M. J. Yoon, "High efficiency active clamp forward converter for sustaining power module of plasma display panel," *IEEE Trans. Indust. Electron.*, vol. 55, no. 4, pp. 1874-1876, Apr. 2008.

[3] K. B. Park, C. E. Kim, G. W. Moon, and M. J.

Yoon, "A double-ended ZVS half-bridge zeta converter," *IEEE Trans. Power Electron.*, vol. 23, no. 6, pp. 2838-2846, Nov. 2008.

[4] S. M. Jung, J. S. Park, H. W. Kim, and M. J. Yoon, "Improved rotor position estimation employing voltage distortion compensation for sensorless PMSM drives at low speed," *IEEE Power Electron. Special. Conf.*, Rhodes, Greece, June 2008.

[5] J. S. Park, S. M. Jung, H. W. Kim, and M. J. Yoon, "A study on stable torque control in overmodulation region for high speed PMSM systems," *IEEE Power Electron. Special. Conf.*, Rhodes, Greece, June 2008.

### OTHER ACCOMPLISHMENTS (2008/2009)

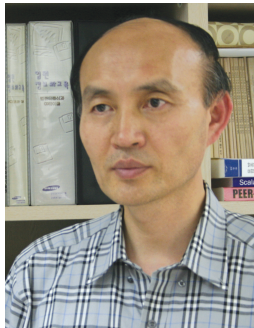
[1] 2 Awards  
[2] 2 MS Graduates, 1 PhD Graduate







## Communication and Information Systems Laboratory



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**Professor**

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Major research area of the Communication and Information Systems Laboratory (CISL) could be classified into five sub areas which consist of new IT convergence technology for smart building, indoor wireless communication system, cognition-based autonomous communication system, 4G mobile communication system, and 5G generation wireless communication system. Firstly, in the research area of new IT convergence technology for smart building, coverage extension and spectrum sensing for in-building area has been researched. Also, the fixed relay system for large scaled building which is constructed by the material shielding electromagnetic waves has been designed for the purpose of supporting qualified indoor communication. Secondly, in the research area of indoor wireless communication system, medium access control, data link control, and resource management in indoor WiBro system for home and enterprise environment have been researched. Moreover, the contribution documents to domestic and international standardization for indoor/outdoor WiBro system are being prepared. Thirdly, in the research area of cognitive-based communication system, key technologies related to cognition and flexibility for beyond 4th generation communication system have been researched. Fourthly, in the research area of 4G mobile communication system, media access control, and radio resource management in autonomy communication system including P2P/Ad-hoc, relay and moving network system have been researched. In addition, simulators have been designed and developed for evaluating the performance of P2P, femto cell handover, emergency call and moving network.

Fifthly, in the research area of 5G generation wireless communication system, resource allocation scheme for beam division multiple access (BDMA) system has been designed.

### KEY PUBLICATIONS (2008/2009)

- [1] S. Y. Pyun and D. H. Cho, "Power-saving scheduling for multiple-target coverage in wireless sensor networks," *IEEE Comm. Lett.*, vol. 13, no. 2, pp. 130-132, Jan. 2008.
- [2] O. H. Jo and D. H. Cho, "Efficient spectrum matching based on spectrum characteristics in cognitive radio system," *Wireless Telecomm. Symp.*, LA, USA, Apr. 2008.

### OTHER ACCOMPLISHMENTS (2008/2009)

- [1] 30 Patents

## Broadband Network Laboratory

The Broadband Networking Lab (BNLab) is tightly related with the IPTV and mobility research activities. We are contributing to make IPTV related standardization with much number of contributions in ITU-T and IETF. Some of our works on IPTV have been published as a recommendation for all vendors and users who are intended to use IPTV.



Fig. 1 ITU-T meeting in Geneva for IPTV

Professor Jun Kyun Choi received M.S (Eng.) and Ph.D. degrees in 1985 and 1988, respectively, in electronics engineering from Korea Advanced Institute of Science and Technology (KAIST). From June 1986 to December 1997, he was with the Electronics and Telecommunication Research Institute (ETRI). In January 1998 he joined the Information and Communications University (ICU), Korea as a professor. His research interests are concerned with broadband network architecture and technologies with particular emphasis on performance and protocol problems. He was an active member of ITU-T Study Group 13 as a Rapporteur and Editor from January 1993 on the ATM, MPLS, and NGN issues. He has also submitted more than 30 drafts in the IETF in the last few years. In addition to that he has a large number of publication in different renowned and conferences and journals.

### KEY PUBLICATIONS (2008/2009)

- [1] T. Um, H. Vu, J. Choi, and W. Ryu "Priority-based duplicated burst transmission

- mechanism in OBS Networks," *ETRI J.*, vol. 30, no. 1, pp. 164-166, Feb. 2008.
- [2] T. Um, J. Choi, J. Guo, W. Ryu, and B. Lee, "Soft-state bandwidth reservation mechanism for slotted optical burst switching networks," *ETRI J.*, vol. 30, no. 2, pp. 216-226, Apr. 2008.
- [3] J. Lee and H. Park, "Adaptive hybrid transmission mechanism for on-demand mobile IPTV over WIMAX," *IEEE Trans. Broadcast.*, vol. 55, no. 2, pp. 468-477, June 2009.
- [4] G. Lee and J. Choi, "Personalized IPTV services using web-based open platform in NGN," *IEEE Global Comm. Conf.*, New Orleans, USA, Nov. 2008.
- [5] H. Park, J. Yang, J. Lee, and J. Choi, "E.164 based global identification scheme for IPTV service portability," *Asia-Pacific Conf. Comm.*, Tokyo, Japan, Oct. 2008.

### OTHER ACCOMPLISHMENTS (2008/2009)

- [1] 14 Patents
- [2] 4 MS Graduates



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## Wireless Communication Systems Laboratory

We focus on communications theory and information theory, and their applications related to network MIMO, cooperative communications, cognitive radio and interference management for next generation wireless systems. Theoretical capacity limits and thereof rooms to improve are identified and advanced techniques for improving the performance are investigated. We also develop our proposed ideas and evaluate the performance upon practical wireless systems including WiMAX and Advanced LTE systems, aiming to patent identified key technologies. For example we develop new interference mitigation schemes and limited feedback strategies for next generation wireless cellular systems and new cooperation schemes for relay networks.

### KEY PUBLICATIONS (2008/2009)

[1] T. W. Ban, W. Choi, B. C. Jung, and D. K. Sung, "A cooperative phase steering scheme in multi relay node environments," *IEEE Trans. Wireless Comm.*, vol. 8, no. 1, pp. 72-77, Jan. 2009.

[2] T. W. Ban, W. Choi, B. C. Jung, and D. K. Sung, "Multiuser diversity in a spectrum sharing system," *IEEE Trans. Wireless Comm.*, vol. 8, no. 1, pp. 102-106, Jan. 2009.

[3] W. Choi and J. G. Andrews, "The capacity gain from intercell scheduling in multi-antenna systems," *IEEE Trans. Wireless Comm.*, vol. 7, no. 2, pp. 714-725, Feb. 2008.

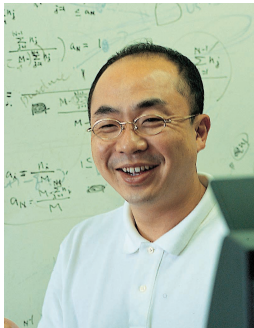
[4] W. Choi, J. Hong, D. I. Kim, and B. H. Kim, "An error detection aided GSC/MRC switching scheme in AF based relay communications," *IEEE Vehic. Techn. Conf.*, Barcelona, Spain, Apr. 2009.

[5] T. Ban, D. Sung, B. Jung, and W. Choi, "Capacity analysis of an opportunistic

scheduling system in a spectrum sharing environment," *IEEE Global Comm. Conf.*, New Orleans, USA, Nov. 2008.

### OTHER ACCOMPLISHMENTS (2008/2009)

[1] 1 MS Graduate



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## Network Systems Laboratory

Network Systems (NETSYS) Lab has been focusing on wireless network research based on broad knowledge gained from wired network research. There are three research groups: Cellular Network Group, Wireless Mesh Network Group, and Mobility Group. Cellular Network Group studies resource allocation algorithms to efficiently share scarce wireless resources in future mobile networks. Wireless Mesh Network Group develops new architecture and protocols for wireless mesh networks. We deployed a world-class wireless mesh network testbed in the undergraduate dormitory area of KAIST. It provides unique experimental experiences on large-scale multi-hop wireless networks and helps to verify the performance of our network protocols. We designed Common Code architecture which gives flexibility for protocol implementation on the mesh testbed. Mobility Group studies human mobility characteristics and their impact on wireless networks including Delay Tolerant Networks (DTN). We designed a novel mobility model called Self-similar Least Action Walk (SLAW) which captures the least action principle in human trip planning.

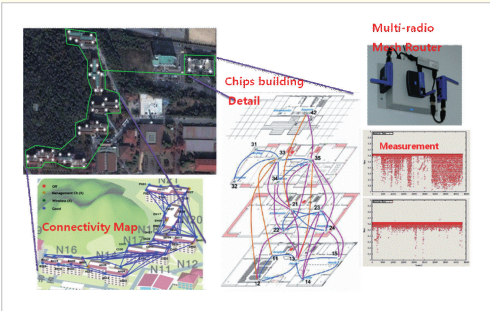


Fig. 1 Deployment map of KAIST wireless mesh network testbed

### KEY PUBLICATIONS (2008/2009)

[1] K. H. Son, S. Chong, and G. Veciana, "Dynamic association for load balancing

and interference avoidance in multi-cell networks," *IEEE Trans. Wireless Comm.* (to be published).

[2] K. H. Lee, S. I. Hong, S. J. Kim, I. J. Rhee, and S. Chong, "SLAW: A mobility model for human walks," *IEEE Conf. Comp. Comm.*, Rio de Janeiro, Brazil, Apr. 2009.

[3] J. H. Lee, K. H. Lee, J. S. Jung, and S. Chong, "Performance evaluation of a DTN as a city-wide infrastructure network," *Int. Conf. Future Internet Techn.*, Seoul, Korea, June 2009.

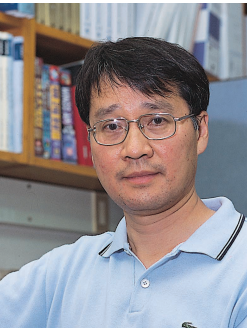
[4] K. H. Son, Y. Yi, and S. Chong, "Adaptive multi-pattern reuse in multi-cell networks," *Int. Symp. Modeling, Optimization Mobile, Ad Hoc, Wireless Networks*, Seoul, Korea, June 2009.

[5] J. H. Lee, K. H. Lee, J. S. Lee, J. S. Jung, and S. Chong, "A TCP starvation problem in combining TCP and max-weight scheduling of cross-layer algorithms in WMNs," *Int. Conf. Future Internet Techn.*, Seoul, Korea, June 2009.

### OTHER ACCOMPLISHMENTS (2008/2009)

[1] 1 Patent  
[2] 2 MS Graduates





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University (1989)

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## Scientific Computing Laboratory

### Signal Processing for Mobile Communication

- MIMO detection/transmit technique
- MIMO relay systems
- MIMO channel estimation/equalization
- 3.5G, 4G mobile communication systems

### Detection and Estimation

- Space Time Adaptive Processing (STAP) algorithm
- Distributed , multi-static radar system (MIMO Radar)
- Beamforming and sidelobe canceller for radar system
- Point Target Detection

### KEY PUBLICATIONS (2008/2009)

[1] S. Kim and J. Chun, "Capacity and perfromance of lattice reduction aided linear processing with lattice encoding and decoding in limited feedback systems," *IEEE J. Selet. Areas Comm.*, vol. 26, no. 8, pp. 1567-1577, Aug. 2008.

[2] V. Saveljev, J. Son, J. Chun, K. Kwack, and K. Cha, "About a Moire-less condition for non-square grids," *IEEE/OSA J. Display Techn.*, vol. 4, no. 3, pp. 332-339, Sep. 2008.

[3] J. Park and J. Chun, "Pilot-based non-adaptive equalizers using an array antenna for DTV receivers," *IEEE Trans. Consumer Electron.*, vol. 55, no. 1, pp. 42-48, Feb. 2009.

[4] H. Park and J. Chun "Alternate transmission relaying schemes for MIMO wireless networks," *IEEE Wireless Comm., Networking Conf.*, Las Vegas, USA, Apr. 2008.

[5] B. W. Jung, R. S. Adve, and J. Chun, "Distributed aperture OFDM radar," *IEEE Radar Conf.*, Pasadena, USA, May 2009.

### OTHER ACCOMPLISHMENTS (2008/2009)

- [1] 2 MS Graduates, 1 PhD Graduate



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## Wireless Communications Laboratory

Our research focuses on information theory and communication theory and their applications to wireless communications. Specifically, we characterize the fundamental limits of various wireless and wireline communication channels including the broadcast channel, relay channel, interference channel, wireless ad hoc networks, and flash memory channels. Based on this, we develop technologies that can either enhance the performance of the present wireless systems or enable new services. For example, we develop and patent key new technologies for next generation wireless standards including dirty paper coding, network coding, rateless coding, and new cooperation strategies for relay networks.

### OTHER ACCOMPLISHMENTS (2008/2009)

- [1] 2 Awards  
[2] 5 MS Graduates, 1 PhD Graduate

### KEY PUBLICATIONS (2008/2009)

[1] S. Y. Chung, "Multi-level dirty paper coding," *IEEE Comm. Lett.*, vol. 12, pp. 456-458, June 2008.

[2] W. Y. Shin, S. Y. Chung, and Y. H. Lee, "Diversity-multiplexing tradeoff and outage performance for Rician MIMO channels," *IEEE Trans. Inform. Theory*, vol. 54, no. 3, pp. 1186-1196, Mar. 2008.

[3] S. Y. Chung and P. A. Humblet, "An optimal soft handoff algorithm for Rayleigh fading channels," *IEEE Trans. Wireless Comm.*, vol. 7, no. 2, pp. 726-735, Feb. 2008.

[4] S. W. Jeon and S. Y Chung, "Capacity of a class of multi-source relay networks," *Inform. Theory, Appl. Workshop*, San Diego, USA, Feb. 2009.

[5] W. S. Nam and S. Y. Chung, "Relay networks with orthogonal components," *Allerton Conf. Comm., Control, Computing*, Monticello, USA, Sep. 2008.





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Fellow, OSA

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## Lightwave Systems Research Laboratory

In 2008, we have worked on various aspects of lightwave communication systems including 100G transmission systems, multi-level modulation techniques, performance monitoring techniques, WDM PONs, coherent receivers, and high-speed MMF systems.

### KEY PUBLICATIONS (2008/2009)

- [1] P. K. J. Park, C. H. Kim, and Y. C. Chung, "Performance analysis of low-frequency pilot-tone based monitoring techniques in amplified wavelength-division-multiplexed networks," *Optical Engin.*, vol. 47, no. 2, p. 025009, Feb. 2008.
- [2] H. C. Ji, J. H. Lee, H. Kim, P. K. J. Park, and Y. C. Chung, "Effect of PDL-induced coherent crosstalk on polarization-division-multiplexed direct-detection systems," *Optics Express*, vol. 17, no. 3, pp. 1169-1177, Jan. 2009.
- [3] Y. Takushima, H. Y. Choi, and Y. C. Chung, "Measurement of differential phasor diagram of multilevel DPSK signals by using an adjustment-free delay interferometer composed of a 3x3 optical coupler," *J. Lightw. Techn.*, vol. 27, no. 6, pp. 718-730, Mar. 2009.
- [4] Y. C. Chung, "A review of optical performance monitoring techniques," *Int. Conf. Photon. Switching*, Sapporo, Japan, Aug. 2008.
- [5] Y. C. Chung, "Optical performance monitoring techniques; current status and future challenges," *Europ. Conf. Optical Comm.*, Brussels, Belgium, Sep. 2008.

### OTHER ACCOMPLISHMENTS (2008/2009)

- [1] 5 Patents, 1 Award
- [2] 4 MS Graduates



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## Coding, Communications, and Information Theory Laboratory

The research interests of the CCIT Lab include the general areas of communications, error-control coding, and information theory. CCIT Lab has been working on challenging problems in physical layer security, distributed source coding (DSC), and error-control codes which are sponsored by ETRI, IITA, KOSEF, KRF, and etc.

**Physical Layer Security:** Due to the broadcast behavior of wireless mediums, it has become essential to address the inherent security issues in wireless environments. The physical layer security provides solutions in the physical layer and thus provides ways to optimize/strengthen the security measures across layers. This work is supported by KOSEF, KRF.

Secure network coding is also one of the hottest topics in network systems. Network environments are vulnerable to many different types of attacks, for example, eavesdropping, impersonation, and Byzantine modification. CCIT Lab has been studying the secure network coding to evade off such attacks which is supported by IITA.

**Distributed Source Coding (DSC):** DSC was founded by the fact that separate encoding is as efficient as joint encoding for compression. This is true when their compressed outputs are jointly decompressed at a decoder. The impressive potential of DSC is attractive in various practical applications such as sensor network, networked multimedia, and video coding. This work is supported by IITA.

**Stochastic Iterative Decoding of Low-Density Parity-Check (LDPC) codes:** LDPC codes, decoded with the sum-product (SP) algorithm can perform very close to channel capacity. However, hardware implementation of the SP algorithm is complex due to massive message exchanges in multi-bits. Stochastic computing gives an elegant solution by using bit stream

representations of messages and replaces the complex non-linear operations with primitive logic operations such as XOR. We study decoder/code structures that keep the simplicity of the circuitry and achieve a comparable performance as the SP algorithm.

### KEY PUBLICATIONS (2008/2009)

- [1] C. Jung, J. Choi, and J. Ha, "Power allocation to improve convergence rate of iterative receivers with soft cancellation," *IEEE Comm. Lett.*, Feb. 2009 (to be published).
- [2] J. Choi and J. Ha, "Rate optimization to minimize distortion for source-channel coded H-BLAST with SIC decoding," *IEEE Comm. Lett.*, vol. 13, no. 2, pp. 115-117, Feb. 2009.
- [3] H. Jeon, N. Kim, M. Kim, H. Lee, and J. Ha, "Secrecy capacity over correlated ergodic fading channel," *IEEE Mil. Comm. Conf.*, San Diego, USA, Nov. 2008.
- [4] J. Nam, S. Kim, and J. Ha, "A new design of iterative detection and decoding with soft interference cancellation," *IEEE Vehic. Techn. Conf.*, Calgary, Canada, Sep. 2008.
- [5] J. Nam, S. Kim, and J. Ha, "A modified turbo principle of iterative detection and decoding," *IEEE Int. Symp. Inform. Theory*, Toronto, Canada, June 2008.

### OTHER ACCOMPLISHMENTS (2008/2009)

- [1] 3 Patents
- [2] 1 MS Graduate





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## Wireless Innovative Technologies Laboratory

The Wireless Innovative Technologies LAB (Wit-LAB) has primarily focused on researching radio resource management (RRM) for next generation wireless communication systems. RRM is core technique to achieve efficient use of limited resources, such as power control, scheduling, frequency and time allocation, and maximize system capacity. OFDM has been a widely accepted technology in high rate and multimedia data service systems, such as 3G Long Term Evolution (3G LTE) system in the 3rd Generation Partnership Project (3GPP). In our research, we propose a new cell search scheme based on the frequency domain sequence hopping of synchronization channel symbols. The assigned hopping pattern provides frame boundary information as well as cell identification (cell ID) to a mobile station (MS). The proposed synchronization channel structure allows MS to acquire OFDM symbol/frame timing, cell ID and frequency offset estimates in the initial cell search stage.

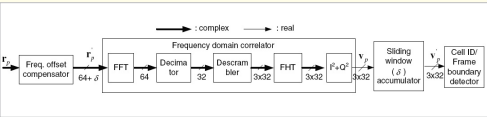


Fig. 1 ITU-T meeting in Geneva for IPTV

In scheduling, a user in B3G (Beyond 3rd Generation) mobile communications systems may choose to simultaneously launch various multimedia applications. In our research, we suggest that the mobile station (MS) shares its available resources among the user's applications, based on her/his preferences and the applications' quality of service (QoS) requirements. A utility maximization problem is formulated. In power control issue, we proposed a distributed utility maximization power control scheme in uplink DS-CDMA systems.

Maximizing a utility function is solved by Lagrangian dual decomposition, where the Lagrangian multiplier can be considered as a resource price charging to users. By adjusting the price in a distributed fashion, the proposed algorithm results in a bangbang type power control, 'maximum power transmission' or 'shutdown'. Numerical result shows that the proposed algorithm achieves around 95% of the optimal utility maximization with a modest computational burden.

### KEY PUBLICATIONS (2008/2009)

[1] I. Kim, Y. Han, Y. Kim, and S. Bang, "Sequence hopping cell search scheme for OFDM cellular system," *IEEE Trans. Wireless Comm.*, vol. 7, no. 5, pp. 1483-1489, May 2008.

[2] S. Han and Y. Han, "Utility maximization using a resource pricing power control in uplink DS-CDMA," *IEEE Comm. Lett.*, vol. 12, no. 4, pp. 286-288, Apr. 2008.

[3] K. M. Koumadi and Y. Han, "Bandwidth allocation for multimedia applications at mobile stations," *IEEE Comm. Lett.*, vol. 12, no. 5, pp. 359-361, May 2008.

[4] Y. J. Kim, S. Kim, T. Kim, and Y. Han "A mobility support and load reducing partner selection criterion in cooperative communication," *IEEE Global Conf. Comm.*, New Orleans, USA, Nov. 2008.

[5] S. Han , K. M. Koumadi, and Y. Han "SDP relaxation of sum-rate maximization for Gaussian cognitive multiple access channel," *IEEE Vehic. Techn. Conf.*, Calgary, Canada, Sep. 2008.



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## Advanced Radio Technology Laboratory

The Advanced Radio Technology Laboratory (ARTLab) has focused on developing digital signal processing techniques for advanced wireless communication systems. Orthogonal Frequency Division Multiplexing (OFDM), Cooperative Multiple-Input Multiple-Output (MIMO), and GPS-less Geo-location tracking algorithms have been researched for next generation wireless systems with localization capability. An orthogonal frequency-division multiplexing (OFDM) is widely used for high rate wireless communication systems. Though it is robust against frequency selectivity, the OFDM approach is known to be adversely affected by the time selectivity due to mobility of the terminal. We devised a novel OFDM system called Impulse Postfix OFDM (IP-OFDM) which is remarkably robust against the effect of the mobility. Multiple-input multiple-output (MIMO) techniques has received considerable attention since they increase link reliability and spectral efficiency over wireless fading channels without increased time and bandwidth. Recently, MIMO paradigm shift to multiuser MIMO (MU-MIMO) systems that achieves enhanced system capacity for supporting multiple users with interference cancellation among them. We made several contributions in topics related to MIMO and MU-MIMO systems: space-time code (STC) design, low complexity signal detection at receiver, and precoder design for BS cooperation system. Especially, BS cooperative system is considered as a candidate technology for LTE-Advanced system. In realistic cellular system, the DL capacity is limited by inter-cell interference and ideal MIMO capacity gains cannot be achieved. Cooperative MIMO system with multiple base-stations (BSs) supports the DL

transmission toward users collaboratively in their cell coverage. The well-known positioning system, namely, Enhanced 911 (E911) and Global Positioning System (GPS) have been used to provide relatively accurate positioning for the outdoor environment. However, these technologies, nonetheless accurate, could not provide relatively high accuracy when applied to indoor positioning system suffered from severe multipath radio propagation situation. Thus we have researched GPS-less Geo-location tracking algorithms based on time-of-arrival (TOA) and direction of arrival (DoA) method using various super-resolution techniques.

### KEY PUBLICATIONS (2008/2009)

[1] N. Kim, S. Kim, Y. Kim, and J. Kang, "A high precision ranging scheme for IEEE802.15.4a chirp spread spectrum system," *IEICE Trans. Comm.*, vol. E92-B, no. 3, pp. 1057-1061, Mar. 2009.

[2] N. Lee, H. Lee, J. Kang, and G. Gil, "Low-complexity equalizer for OFDM systems in doubly-selective fading channels," *IEICE Trans. Comm.*, vol. E92-B, no. 3, pp. 1031-1034, Mar. 2009.

[3] N. Chang, G. Yu, J. Kang, and G. Gil, "Adaptive switching technique for space-time, frequency coded OFDM systems," *IEICE Trans. Comm.*, vol. E91-B, no. 2, pp. 633-636, Feb. 2008.

[4] S. Hur, N. Kim, H. Park, and J. Kang, "Enhanced lattice-reduction precoding using list quantizer for multi-antenna multi-user communication," *IEICE Trans. Comm.*, vol. E91-B, no. 1, pp. 351-354, Jan. 2008.

### OTHER ACCOMPLISHMENTS (2008/2009)

[1] 4 Patents





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## Laboratory for Integrated Network Engineering

Lab. for Integrated Network Engineering (LINE) aims to be a global leader in the research for information network engineering area including inter-operation of various IP networks, intelligent optical internet, and wireless networks. Current research areas of LINE are optical Internet, traffic engineering & QoS support mechanism, FTTH networks, home network, broadband convergence networks, optical-wireless integration, and the next generation wireless network technology. We have executed the ERC Optical Internet Research Center (OIRC) project since 2000 in which the main goal is "Research on optical packet router architecture" and currently, we focus on the control plane architecture of next generation optical Internet in terms of organization of architecture and QoS mapping for seamless service. Moreover, we cover convergence of optical and wireless networks such as PON-Wibro on QoS mapping, enhanced mobility for converged networks, and power management area.

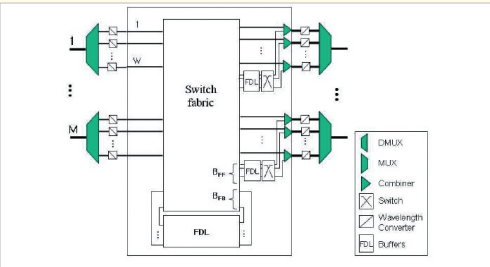


Fig. 1 A Hybrid shared optically buffered switching system

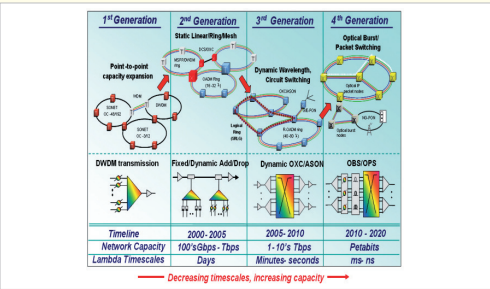


Fig. 2 Background of the ERC research goal set

### KEY PUBLICATIONS (2008/2009)

- [1] N. U. Kim, T. Y. Kim, S. J. Lee, and M. H. Kang, "Coordination of wavelength and time-window assignment in WDM-based TDM hybrid-PONs," *Photon. Network Comm.*, vol. 10, no. 10, pp. 139-147, Apr. 2008.
- [2] N. U. Kim, H. S. Lim, and M. H. Kang, "Fair bandwidth allocation using effective multicast traffic share in TDM-PONs," *J. Lightw. Techn.*, vol. 26, no. 7, pp. 756-767, Apr. 2008.
- [3] M. G. Kim, J. Y. Choi, and M. H. Kang, "Scheduled power-saving mechanism to minimize energy consumption in IEEE 802.16e systems," *IEEE Comm. Lett.*, vol. 12, no. 12, pp. 874-876, Dec. 2008.
- [4] Y. G. Lee, J. G. Kim, and M. H. Kang, "Feasibility analysis for service differentiation using an FDL bank in OBS networks," *Photon. Network Comm.*, vol. 15, no. 3, pp. 275-281, June 2008.
- [5] H. G. Jeong, J. Y. Choi, and M. H. Kang, "An adaptive load-aware burst assembly scheme to achieve optimal performance of FDL buffers in OBS networks," *Photon. Network Comm.*, vol. 17, no. 3, pp. 238-244, Aug. 2008.

### OTHER ACCOMPLISHMENTS (2008/2009)

- [1] 1 Patent, 1 Award
- [2] 2 PhD Graduates



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## Communication Signal Processing Laboratory

The Communications Signal Processing Laboratory (CSPLAB) has primarily focused on digital signal processing and wireless communication system. Major research interests include radio resource management, synchronization, wireless scheduling, frequency and phase offset estimation for OFDM systems, multiuser detection for MC-CDMA and MC-DS/SS, precoder design for MIMO systems, adaptive modulation and coding. In a CDMA communication system, the time synchronization between the pilot code and local generated code is the first step to set up a link between a mobile terminal and a base station. The performance of the code acquisition detector mainly depends on the mean code acquisition time, which is the probable elapse time to acquire the pilot code phase. Hence, it is very important to minimize mean code acquisition time in order to reduce the waiting time for call admission of each mobile user and to achieve high service quality. The throughput performance of orthogonal random beamforming (ORBF) with a finite number of users is limited due to the increasing amount of residual interference. We have found the optimal beam subset, the optimal user set, and the optimal number of random beams to maximize the sum throughput of the ORBF. We have considered very general code-division-multiple access (CDMA) systems, namely multiple-chip-rate CDMA systems, where signals can be transmitted at different chip rates, carrier frequencies, processing gains, and transmitted powers to satisfy the given quality of service (QoS) requirements. For these systems, a closed-form bit error rate (BER) expression is derived based on the simplified improved Gaussian approximation.

### KEY PUBLICATIONS (2008/2009)

- [1] W. G. Ahn and H. M. Kim, "An improved ranging algorithm for ad-hoc relay networks over IEEE 802.16 OFDMA systems," *IEEE Comm. Lett.*, vol. 13, no. 5, pp. 357-359, May 2009.
- [2] T. S. Kang and H. M. Kim, "Optimal beam subset and user selection for orthogonal random beamforming," *IEEE Comm. Lett.*, vol. 12, no. 9, pp. 636-638, Sep. 2008.
- [3] M. C. Ju, H. M. Kim, and I. M. Kim, "Closed-form BER results for multiple-chip-rate CDMA systems based on the simplified improved Gaussian approximation," *IEEE Trans. Comm.*, vol. 56, no. 1, pp. 14-20, Jan. 2008.
- [4] C. Jeong and H. M. Kim, "Radio resource allocation in OFDMA multihop cellular cooperative networks," *IEEE Int. Symp. Personal, Indoor, Mobile Radio Comm.*, Cannes, France, Sep. 2008.
- [5] W. G. Ahn and H. M. Kim, "Proportional fair scheduling in relay enhanced cellular OFDMA systems," *IEEE Int. Symp. Personal, Indoor, Mobile Radio Comm.*, Cannes, France, Sep. 2008.

### OTHER ACCOMPLISHMENTS (2008/2009)

- [1] 2 Patents
- [2] 3 MS Graduates, 3 PhD Graduates





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## Systems Modeling and Simulation Laboratory

Systems Modeling and Simulation (SMS) Lab is devoted to researching on theory and applications of modeling, simulation and analysis of discrete event systems. The modeling framework in our research is DEVS (Discrete Event Systems Specification) formalism which supports specification of discrete event models in a hierarchical modular manner. Research emphasis is given to two areas: methodology and tools for (1) systems analysis at a high level and for (2) simulators development and their interoperation .

The first area is to develop a new framework for the efficient analysis of complex systems, such as application-specific digital systems, using discrete event system M&S. The framework includes a DEVS specification language, realization of the DEVS formalism in MATLAB/Simulink, an operation and interconnection sharing algorithm for reconfiguration overhead reduction using static partial reconfiguration .

The second area is mainly aimed at the development of HLA-compliant military wargame simulators. Such simulators should be interoperable with other simulators through HLA (High Level Architecture) / RTI (Run Time Infrastructure). SMS lab has developed a set of tools for development of simulators which meet the standard: DEVSim++, KHLAAdaptor, and KComLib. The tools set has been used to develop 3 major military wargame simulators in Korea such as Navy's Chunghae Simulator, Air Force's Changkong Simulator and Marine's Chunjabong Simulator (shown in the figure above).

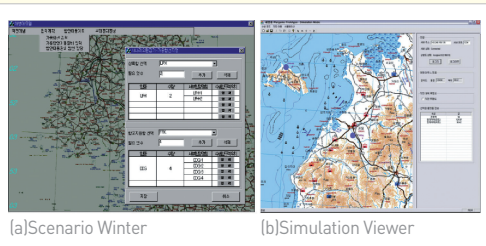


Fig. 1 Marine's Chunjabong simulator prototype

### KEY PUBLICATIONS (2008/2009)

[1] S. J. Oh and T. G. Kim, "Speculative loop pipelining in binary translation for hardware acceleration," *IEEE Trans. Computer Aided Design of Integr. Circuits, Syst.*, vol. 27, no. 3, pp. 409-422, Mar. 2008.

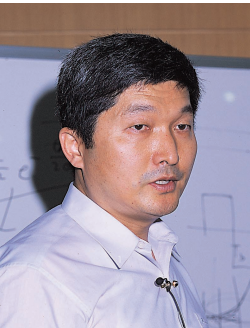
[2] S. J. Jung and T. G. Kim, "Configuration sharing to reduce reconfiguration overhead using static partial reconfiguration," *IEICE Trans. Inform., Syst.*, vol. E91-D, no. 11, pp. 2675-2684, Nov. 2008.

[3] S. J. Jung and T. G. Kim, "An operation and interconnection sharing algorithm for reconfiguration overhead reduction using static partial reconfiguration," *IEEE Trans. Very Large Scale Integration Syst.*, vol. 16, no. 12, pp. 1589-1596, Dec. 2008.

[4] K. M. Seo, C. H. Sung, and T. G. Kim, "Realization of the DEVS formalism in MATLAB/Simulink," *Grand Challenges, Modeling, Simul.*, Edinburg, Scotland, June 2008.

### OTHER ACCOMPLISHMENTS (2008/2009)

- [1] 1 Award  
[2] 1 MS Graduate



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## Mobile Communications Laboratory

Our research covers two major areas: mobile communications and networks. In the mobile communication area, we are doing research on the development of Digital Multimedia Broadcasting Systems and Mobile WiMAX. For mobile networks area, significant research achievements have been made on tactical communication systems based on wireless mesh and wireless sensor networks.

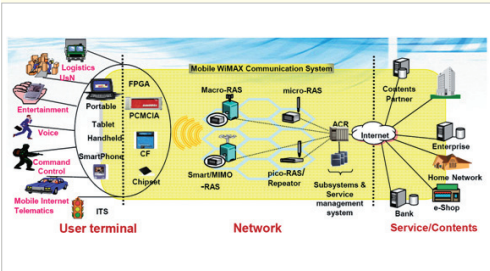


Fig. 1

### KEY PUBLICATIONS (2008/2009)

[1] J. Y. Lee and H. S. Lee, "A performance analysis model for IEEE 802.11e EDCA under saturation condition," *IEEE Trans. Comm.*, vol. 57, no. 1, pp. 56-63, Jan. 2009.

[2] M. Lee, B. Keum, J. H. Jeong, Y. S. Shim, and H. S. Lee, "A software-based receiver running on a single DSP for terrestrial digital multimedia broadcasting," *IEEE Trans. Consumer Electron.*, vol. 54, no. 4, pp. 1894-1902, Nov. 2008.

[3] Y. Son, C. H. Nam, and H. S. Lee, "An approach for PAPR reduction based on tone reservation method," *Consumer Comm., Networking Conf.*, Las Vegas, USA, Jan. 2009.

[4] B. C. Kim, Y. Bang, Y. Kim, J. Y. Lee, D. G. Kwak, H. S. Lee, and J. S. Ma, "A QoS framework design based on DiffServ and SNMP for tactical networks," *IEEE Mil. Comm. Conf.*, San Diego, USA, Nov. 2008.

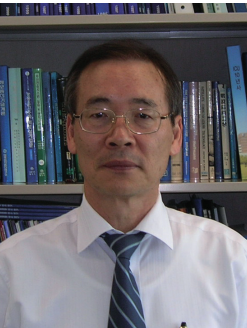
[5] B. C. Kim, D. G. Kwak, H. Song, H. S. Lee,

and J. S. Ma, "An adaptive holdoff algorithm based on node state for IEEE 802.16 mesh mode with coordinated distributed scheduling," *IEEE Symp. Personal, Indoor, Mobile Radio Comm.*, Cannes, France, Sep. 2008.

### OTHER ACCOMPLISHMENTS (2008/2009)

- [1] 2 MS Graduates, 1 PhD Graduate





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## Radio and Communications Laboratory

Research interests in Radio and Communications Laboratory (RCLab) include fundamentals of wireless communications and 4G related communication systems such as Dynamic Spectrum Access (DSA), Wireless Channel Modeling, and Radio Frequency Identification (RFID).

**Dynamic Spectrum Access (DSA):** While demand for the limited spectrum resource is causing the spectrum scarcity, DSA has recently received a great attention due to the ability to improve spectrum utilization. RCLab is working on political and engineering issues related to DSA such as cognitive radio, modern spectrum management.

**Wireless Channel Modeling:** To guarantee reliable performance measurement of next generation wireless communication systems, practical observation and modeling about wireless channel need to be established. We aim at developing a novel wireless channel modeling of cooperative communications based on IMT-Advanced system.

**Radio Frequency Identification (RFID):** RFID is one of the key technologies for ubiquitous communications, which use RF waves to identify, track, or categorize object. We are researching the protocol related with the arrangement of efficient RFID system, especially which considers the anti-collision protocol among various types of readers.

### KEY PUBLICATIONS (2008/2009)

[1] J. Cha, H. Jeon, and H. Lee, "Low complexity Fano-based detection algorithm with iterative structure for V-BLAST systems," *IEICE Trans. Comm.*, vol. E91-B, no. 1, pp. 347-350, Jan. 2008.

[2] H. Jung, J. Cha, and H. Lee, "Efficient transmit power allocation with partial feedback for closed-loop SQRD based V-BLAST systems," *IEICE Trans. Comm.*, vol.

E91-B, no. 4, pp. 1219-1222, Apr. 2008.

[3] H. Kim, S. Park, J. Seo, H. Eum, Y. Lee, S. Lee, and H. Lee, "Modulation and pre-equalization method to minimize time delay in equalization digital on-channel Repeater," *IEEE Trans. Broadcast.*, vol. 54, no. 2, pp. 249-256, June 2008.

[4] A. Kang, S. Lee, S. Jo, W. Choi, and H. Lee, "An opportunistic relay selection algorithm for hybrid-ARQ in wireless networks," *IEEE Int. Conf. Inform. Networking*, Chiang Mai, Thailand, Jan. 2009.

[5] S. Kim, Y. Yoon, H. Jeon, M. Kim, and H. Lee, "Selective discrete wavelet packet transform-based energy detector for cognitive radios," *IEEE Mil. Comm. Conf.*, San Diego, USA, Nov. 2008.

### OTHER ACCOMPLISHMENTS (2008/2009)

[1] 4 Patents

## Digital Communications Laboratory

Research activities in Digital Communications (DC) LAB are in the area of wireless physical layer design and communication signal processing, which includes synchronization, estimation, detection, interference management, and signal processing for RF devices and multiple-input multiple-output (MIMO)/orthogonal frequency division multiplexing (OFDM) systems. Current research interests lay in the following areas-Cognitive radio system design and analysis (opportunistic transmit/receive scheme for cognitive radio system and superposition data transmission scheme of secondary node), interference management techniques (low complexity interference alignment scheme), digital signal processing techniques (low complexity predistortion technique for power amplifier linearization and an efficient cell identification method for cellular OFDM system), resource allocation and transmission scheme over amplify-and-forward (AF) relay (low complexity two step power allocation scheme for two-way relay system, multi-user scheduling scheme over AF relay, and optimal receiver structure with whitening filter for frequency selective AF relay channel).

### KEY PUBLICATIONS (2008/2009)

[1] S. Choi, E.-R. Jeong, and Y. H. Lee, "Adaptive predistortion with direct learning based on piecewise linear approximation of amplifier nonlinearity," *IEEE J. Select. Topics Signal Process.*, vol. 3, no. 3, pp. 397-404, June 2009.

[2] W. Nam and Y. H. Lee, "Preamble-based cell identification for cellular OFDM systems," *IEEE Trans. Wireless Comm.*, vol. 7, no. 12, pp. 5263-5267, Dec. 2008.

[3] H. Yu, J. Park, Y. Sung, and Y. H. Lee, "A least squares approach to joint beam

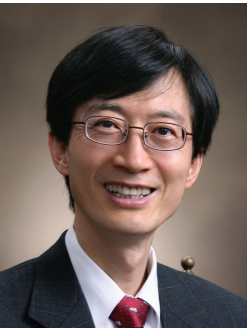
design for interference alignment in multiuser interference channels," *Signal Process. Adv. Wireless Comm.*, Perugia, Italy, June 2009.

[4] H. Kim, S. Choi, Y. Sung, and Y. H. Lee, "Amplify-forward relays with superimposed pilot signals for frequency-selective fading channels," *IEEE Vehic. Techn. Conf.*, Barcelona, Spain, Apr. 2009.

[5] H. Yu, Y. Sung, and Y. H. Lee, "Superposition data transmission for cognitive radios: performance and algorithms," *IEEE Mil. Comm. Conf.*, San Diego, USA, Nov. 2008.

### OTHER ACCOMPLISHMENTS (2008/2009)

[1] 3 Patents, 2 Awards  
[2] 2 MS Graduates, 1 PhD Graduate



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## Mobile Multimedia Laboratory



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The Mobile Multimedia Laboratory (MMLAB) has focused on designing wireless communications network architectures, protocols, and evaluating network performance. Currently, we are developing communication protocols and algorithms to service a large number of real-time traffic flows efficiently in a multi-hop wireless mesh network. Our target real-time traffic includes voice, video, and sensed data. Our particular emphasis is placed on developing expandable multi-channel multi-radio medium access and routing protocols that easily adjust to geographically differing traffic densities. We are also developing congestion and admission control policies that produce a high capacity while satisfying a given quality of service. We are building simulation programs and prototype systems to verify the performance and the ultimate usability.

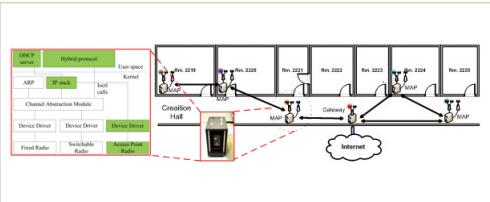


Fig. 1 Multi-channel multi-radio wireless mesh network architecture and testbed

### KEY PUBLICATIONS (2008/2009)

- [1] M. Seo and J. Ma, "Dynamic channel selection with snooping for multi-channel multi-hop wireless networks," *IEICE Trans. Comm.*, vol. E91-B, no. 8, pp. 2752-2756, Aug. 2008.
- [2] C. Kim, K. Kang, and J. Ma, "Adaptive interference cancellation: cancellation performance vs. computational overhead," *Int. Conf. Computer Comm., Networks*, Virgin Islands, USA, Aug. 2008.
- [3] S. Kim, J. Cha, and J. Ma, "Spatial reuse

- DCF for enhancing throughput and performance analysis," *IEEE Vehic. Techn. Conf.*, Calgary, Canada, Sep. 2008.
- [4] M. Seo, Y. Kim, and J. Ma, "A multi-channel MAC protocol with snooping for multi-hop wireless networks," *IEEE Int. Symp. Wireless Comm. Syst.*, Reykjavik, Iceland, Oct. 2008.
  - [5] M. Seo, Y. Kim, and J. Ma, "Multi-channel MAC protocol for multi-hop wireless networks: handling multi-channel hidden node problem using snooping," *IEEE Mil. Comm. Conf.*, San Diego, USA, Nov. 2008.

### OTHER ACCOMPLISHMENTS (2008/2009)

- [1] 6 Patents
- [2] 3 MS Graduates, 1 PhD Graduate

## Communications and Storage Laboratory

Our research in the Communications and Storage Lab deals with signal processing and coding for various communication and storage channels. We cover a broad range of issues - from highly theoretical performance and capacity studies to more practically-oriented low-complexity algorithm developments - on equalization, detection, interference cancelation, error correction coding, channel-matched coding, timing recovery and parameter estimation. The application areas of interest include: wireless MIMO communication, chip-to-chip high-speed interconnect buses, high density disk drives, advanced signal processing for solid state and flash memory devices and interference-dominated wireline communications. As an example of our ongoing research efforts in the CSL, we are investigating capacity and coding issues in intersymbol interference (ISI) channels. ISI arises in a wide variety of communications channels. Wireless multi-path channels, high density data storage and band-limited wireline channels are good examples of communication channels where ISI is a major source of transmission errors. In many such channels, the characteristics of ISI are well understood and are known a priori at the receiver. Our research aims at 1) developing computationally efficient error correction and equalization methods for input-constrained ISI channels and 2) clearing a path to approaching theoretical limits of error correction for such channels with fundamentally improved complexity/performance tradeoffs. The main research objective is to find efficient ways to match error correction coding to the known channel characteristics. Specifically we design codes that target at dominant error cluster patterns inherent at the ISI channel output, as the structure of the ISI typically gives rises to a

dominance of a relatively small number of distinct error cluster patterns.

### KEY PUBLICATIONS (2008/2009)

- [1] J. Park and J. Moon, "Error-pattern-correcting cyclic codes tailored to a prescribed set of error cluster patterns," *IEEE Trans. Inform. Theory*, vol. 55, no. 4, pp. 1747-1765, Apr. 2009.
- [2] N. Xie, W. Xu, T. Zhang, E. F. Haratsch, and J. Moon, "Concatenated LDPC and BCH coding system for magnetic recording read channel with 4K-byte sector format," *IEEE Trans. Mag.*, vol. 44, no. 12, pp. 4784-4789, Dec. 2008.
- [3] J. Moon and L. Lee, "Timing recovery in conjunction with maximum likelihood sequence detection in the presence of intersymbol interference," *IEEE Trans. Circuits, Syst. I*, vol. 55, no. 10, pp. 1-14, Oct. 2008.
- [4] M. Ahmadi, J. Moon, and R. Harjani, "Constrained partial response receivers for high-speed links," *IEEE Trans. Circuits, Syst. II*, vol. 55, no.10, pp. 1006-1010, Oct. 2008.
- [5] Y. Li and J. Moon, "Reduced-complexity soft MIMO detection based on causal and noncausal decision feedback," *IEEE Trans. Signal Process.*, vol. 56, no. 3, pp. 1178-1187, Mar. 2008.

### OTHER ACCOMPLISHMENTS (2008/2009)

- [1] 1 Patent, 1 Award

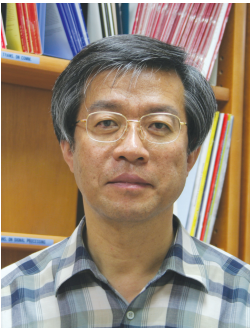


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## Information Processing Systems Laboratory

Information processing and systems laboratory (IPSL) is focusing on two major parts: wireless communication systems and multimedia information processing. Researches and projects are also categorized into such two topics. Students are enthusiastically involved in researches and projects.

The wireless communication system part is about a physical layer for modern and future communication systems such as: synchronization, channel estimation, channel coding, precoding, and detection schemes for OFDM, MIMO, and relaying systems.

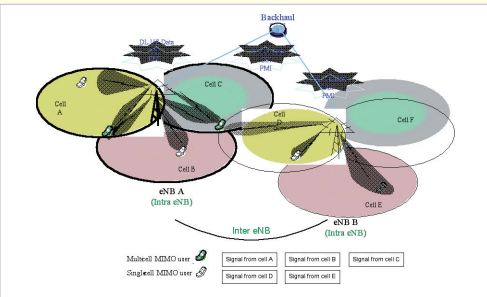


Fig. 1 CoMP for LTE-advanced systems

One of the promising candidates for the 4G wireless communication system is LTE-advanced organized by 3GPP. LTE-advanced systems can improve spectral efficiency of whole cell users and especially for cell-edge users by coordinate multiple transmission/reception as shown in Fig. 1. In one of our lab projects, we are proposing patents for LTE-advanced systems to increase throughput of the systems.

The multimedia information processing part puts an emphasis on several subtopics: wireless multimedia sensor network, image coding, and video analytics (VA). In the VA project, we are developing several algorithms for automatic detection, tracking, and classification of moving objects. Examples of

video analytics applications include: counting the number of pedestrians entering a door of buildings or a certain geographic region, determining the location, speed and direction of travel, and identifying suspicious movement of people or assets.

### KEY PUBLICATIONS (2008/2009)

- [1] M. K. Oh, H. M. Kwon, D. J. Park, and Y. H. Lee, "Iterative channel estimation and LDPC decoding with encoded pilots," *IEEE Trans. Vehic. Techn.*, vol. 57, no. 1, pp. 273-285, Jan. 2008.
- [2] Y. H. Kwon, M. K. Oh, and D. J. Park, "Optimal erasure selection of m-ary PAM signalling for errors and erasures decoding algorithm," *IEEE Trans. Comm.*, vol. 56, no. 12, pp. 938-950, Dec. 2008.
- [4] H. S. Lee, S. Kim, D. J. Park, J. Kim, and C. Park, "Robust method for detecting an infrared small moving target based on the facet-based model," *SPIE, USA*, Mar. 2008.
- [5] Y. H. Cho and D. J. Park, "A new preamble design for synchronization and cell searching algorithms in OFDM cellular systems," *IEEE Vehic. Techn. Conf.*, Singapore, May 2008.

### OTHER ACCOMPLISHMENTS (2008/2009)

- [1] 2 Patents, 2 Awards

## Multimedia Traffic Engineering Laboratory

The Multimedia Traffic Engineering Laboratory (MTELAB) has primarily focused on researching traffic management technology for Next Generation Network (NGN) such as QoS provisioning, traffic and congestion control, resource management, traffic measurement, network reliability, and protocol engineering for open. MTELAB is actively contributing to the international standardization works of NGN especially to the study group 13 and IPTV-GSI of ITU-T. In addition, MTELAB is interested in the new future network paradigms issues such as the network coding and the bio-inspired network technologies.

### KEY PUBLICATIONS (2008/2009)

- [1] N. S. Ko, S. B. Hong, K. H. Lee, H. S. Park, and N. Kim, "Quality-of-service mechanisms for flow-based routers," *ETRI J.*, vol. 30, no. 2, pp. 183-193, Apr. 2008.
- [2] Y. M. Kim, M. S. Ryu, and H. S. Park, "Performance comparisons of restoration techniques in optical burst switching networks," *Photon. Network Comm.*, vol. 17, no. 2, pp. 171-181, Aug. 2008.
- [3] H. Lim, M. Kim, S. Ahn, and H. S. Park, "Dynamic resource sharing protection using label stacking and burst multiplexing in optical burst switched networks," *IET Comm.*, vol. 3, no. 3, pp. 363-371, Mar. 2009.
- [4] M. S. Ryu, Y. M. Kim, and H. S. Park, "Systematic QoS class mapping framework over multiple heterogeneous networks," *Int. Conf. Next Gener. Teletraffic, Wired/wireless Adv. Networking*, St. Petersburg, Russia, Sep. 2008.
- [5] Y. T. Han, W. Sun, and H. S. Park, "Service differentiation based on packet size and flow length in best-effort networks," *Int.*

*Conf. Inform. Networking*, Chiang Mai, Thailand, Jan. 2009.

### OTHER ACCOMPLISHMENTS (2008/2009)

- [1] 4 Patents
- [2] 1 MS Graduate, 1 PhD Graduate



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## Laboratory for Information Transmission

The Laboratory for Information Transmission (LIT) activities include basic and applied researches on the design and analysis of modern digital communications especially wireless communications systems. The main research areas are: broadband wireless optical/radio communication, signal processing for MIMO wireless communications, multicarrier modulation, and error correcting codes.

**MIMO Systems:** Multi antenna (MIMO) schemes are essential in modern wireless communication systems for high capacity, increased diversity, and interference suppression. Several algorithms related to antenna selection, MIMO detection and pre-coding have been investigated to improve the system performance and to reduce the system complexity. In addition, multi-user MIMO system schemes are studied to gain high capacity using space-division multiple accesses. Theoretical bound on capacities, user and cell interferences cancellation algorithms have been developed. Moreover, distributed MIMO scheme using relay network is also investigated.

**OFDM ICI Cancellation:** IMT-advanced system based on OFDM is required to service in high mobile environment. Therefore, it is important to develop the channel estimation algorithms and the suppression of inter-carrier interference (ICI). For these purpose, low complexity LMMSE channel estimation scheme, enhanced DFT-based channel estimation scheme, and optimum pilot structure are proposed. Also, a robust pre-coding technique and a low complexity equalizer for ICI cancellation are developed.

**Network Coding:** Network coding has been proposed to maximize the flow of information in a network by linearly combining nodes. It has various applications such as wireless

networks, sensor networks, file downloads, network security. We focus our study on network coding to mitigate interference and to enhance network throughput in multi-user environments.

### KEY PUBLICATIONS (2008/2009)

- [1] N. Kim, Y. Lee, and H. Park, "Performance analysis of MIMO system with linear MMSE receiver," *IEEE Trans. Wireless Comm.*, vol. 7, no. 11, pp. 4474-4478, Nov. 2008.
- [2] Y. Lee and H. Park, "A rake receiver with and ICI/ISI equalizer for a CCK modem," *IEEE Trans. Vehic. Techn.*, vol. 58, no. 1, pp. 198-206, Jan. 2009.
- [3] N. Kim and H. Park, "Bit error performance of convolutional coded MIMO system with linear MMSE receiver," *IEEE Trans. Wireless Comm.*, vol. 8, no. 7, pp. 3420-3424, July 2009.
- [4] K. Kim, H. Park, and H. R. You, "Parameters optimization of multiuser OFDM on doubly selective fading channels," *IEEE Vehic. Techn. Conf.*, Singapore, May 2008.
- [5] K. Kim and H. Park, "Modified successive interference cancellation for MIMO OFDM doubly selective channels," *IEEE Vehic. Techn. Conf.*, Barcelona, 2009.

### OTHER ACCOMPLISHMENTS (2008/2009)

- [1] 6 Patents
- [2] 4 MS Graduates, 4 PhD Graduates

## Computer Engineering Research Laboratory

Computer Engineering Research (CORE) Laboratory has been contributed to (1) Embedded Systems, (2) Ubiquitous Computing Environment, and (3) the Hardware/Software Architecture of Storage Systems. We have developed several techniques (Prediction-Based Micro-scheduler, Interrupt Handler Migration, etc.) for embedded operating systems and several flash file systems (CFFS, HFFS and PFFS) exploiting emerging memory technologies such as PRAM. We also developed an energy-efficient MAC protocol (LAS-MAC) for the ubiquitous wireless sensor network and its testing environment. Our PKASSO infrastructure solves the security problem of the ubiquitous computing environment. In addition, we have studied various user interfaces for a wearable computer, future museum, etc. Finally, the hardware/software architecture of storage systems includes novel techniques such as contiguity transform and adaptive strip prefetching for software RAID systems.

### KEY PUBLICATIONS (2008/2009)

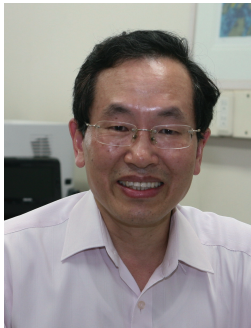
- [1] J. Lee and K. H. Park, "Prediction-based micro-scheduler: toward responsive scheduling of general-purpose operating systems," *IEEE Trans. Comp.*, vol. 58, no. 5, pp. 648-661, May 2009.
- [2] K. W. Park, S. S. Lim, and K. H. Park, "Computationally efficient PKI-based single sign-on protocol, PKASSO, for mobile devices," *IEEE Trans. Comp.*, vol. 57, no. 6, pp. 821-834, June 2008.
- [3] C. Lee, S. H. Baek, and K. H. Park, "A hybrid flash file system based on NOR and NAND flash memories for embedded devices," *IEEE Trans. Comp.*, vol. 57, no. 7, pp. 1002-1008, Jan. 2008.
- [4] J. Kim and K. H. Park, "Design and implementation of a look-ahead

scheduling MAC protocol for wireless sensor networks," *ACM Int. Wireless Comm.*, Leipzig, Germany, June 2009.

- [5] S. H. Baek and K. H. Park, "Prefetching with adaptive cache culling for striped disk arrays," *USENIX Annual Techn. Conf.*, Boston, USA, June 2008.

### OTHER ACCOMPLISHMENTS (2008/2009)

- [1] 16 Patents, 5 Awards
- [2] 1 MS Graduate, 3 PhD Graduates



Park, Kyu Ho  
Professor

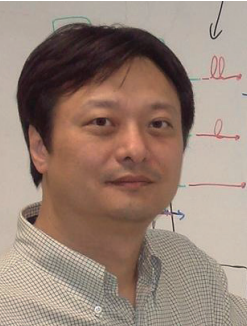
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## Convergence and Advanced Network Engineering Laboratory

Convergence and Advanced Network Engineering Lab (CANE Lab) focuses on developing key technologies for the next generation networks such as ubiquitous wireless networks and broadband convergence networks. In the area of wireless networking researches, CANE Lab. develops frontiering novel concepts in wireless networks including potential-field-based mesh network routing and network coding technologies. Inspired from physics, a breakthrough in the field of field-based routing has been proposed and developed, for the first time enabling practical implementations. This autonomous load-balancing field-based routing (ALFA) outperforms other routing protocols in load balancing, path efficiency, fast recovery, and low control overheads. A campus-scale testbed for wireless mesh networking is being constructed for various experiments. Network coding is also another frontiering research at the CANE Lab, with a 5-year term funding from MKE. In most network topology, there exists disjoint-path routing in the space or in the time. When multicast is utilized over such disjoint paths with coding as simples as XOR operations, network coding increases the wireless link capacity and packet transmission reliability substantially. CANE Lab is currently leading the network coding implementation

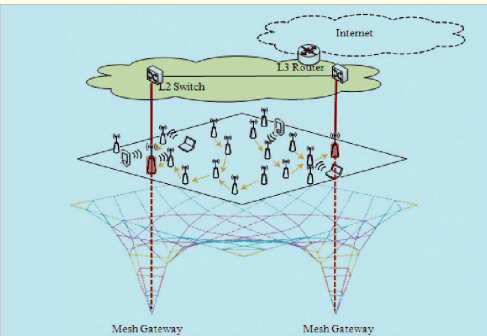


Fig. 1 Electrostatic field based routing

standardization effort for reliable multicast transmissions at IEEE 802.11aa TG. In the area of optical networks, CANE Lab investigates Ethernet networks and packet-optical networks. Especially, CANE Lab is recognized as one of the world leaders in developing Ethernet ring protection technology at the ITU-T, providing key solutions for the framework design, switching behavior, and multi-ring protections.

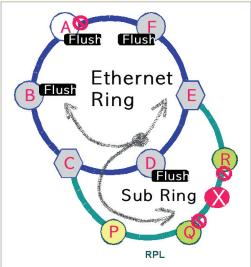


Fig. 2 Ethernet ring protection

### KEY PUBLICATIONS (2008/2009)

[1] S. Jung, M. Kserawi, D. Lee, and J.-K. Rhee, "Distributed potential field based routing and autonomous load balancing for wireless mesh networks," *IEEE Comm. Lett.*, vol. 13, no. 6, pp. 429-431, June 2009.

[2] J.-K. Rhee, J. Im, and J.-D. Ryoo, "Ethernet ring protection using filtering database flip scheme for minimum capacity requirement," *ETRI J.*, vol. 30, no. 6, pp. 874-876, Dec. 2008.

[3] J.-D. Ryoo, H. Long, Y. Yang, M. Holness, Z. Ahmad, and J.-K. Rhee, "Ethernet ring protection for carrier ethernet networks," *IEEE Comm. Mag.*, vol. 46, no. 9, pp. 136-143, Sep. 2008.

[4] K. Lee, T. Chan, and J.-K. Rhee, "All optical discrete Fourier transform processor for 100 Gbps OFDM transmission," *Optics Express*, vol. 16, no. 5, pp. 4023-4028, Mar. 2008.

### OTHER ACCOMPLISHMENTS (2008/2009)

[1] 6 Patents, 2 Awards



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## Statistical Signal Processing Laboratory

Research in the Statistical Signal Processing Laboratory has mainly been on the fundamental theory and applications of various communication/signal processing techniques. Recently, we have investigated the following quintessential techniques for next-generation communication: (1) theoretical approach for the detection of weak known random signals and (2) decoding schemes for multiple-input multiple-output (MIMO) system.

### Detection of Weak Known and Random

**Signals:** We have addressed the problem of detecting weak known and random signals in observations corrupted by multiplicative and first-order Markov additive noises. The asymptotic and finite sample-size performance of several detectors are obtained and compared theoretically.

### Decoding Schemes for MIMO Systems:

We have proposed decoding schemes that exhibit substantially lower computational complexity than conventional decoders while maintaining the bit error performance for MIMO systems. We are now focusing our efforts on efficient transmission signal processing and communication techniques for low-power ultra high-speed mobile communications and fundamentals of future 4G mobile communications.

The research result has been recognized in its significance and originality, having been published in an internationally reputable journal. The result is theoretically interesting, and at the same time, practically applicable in many areas. We have also produced interesting results in other research areas.

### KEY PUBLICATIONS (2008/2009)

[1] J. Lee, I. Song, H. Kwon, and H. J. Kim, "Locally optimum detection of signals in multiplicative and first-order Markov additive noise," *IEEE Trans. Inform. Theory*,

vol. 54, no. 1, pp. 219-234, Jan. 2008.

[2] S. R. Park, J. Bae, H. G. Kang, and I. Song, "On the polynomial representation for the number of partitions with fixed length," *Math. Comp.*, vol. 77, no. 262, pp. 1135-1151, Apr. 2008.

[3] H. G. Kang, I. Song, J. Oh, J. Lee, and S. Yoon, "Breadth-first signal decoder: a novel maximum-likelihood scheme for multi-input multi-output systems," *IEEE Trans. Vehic. Techn.*, vol. 57, no. 3, pp. 1576-1584, May 2008.

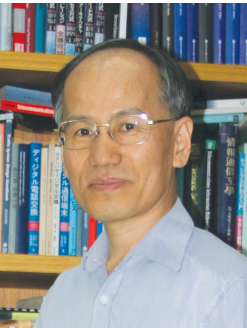
[4] T. An, I. Song, J. Oh, H. G. Kang, and S. R. Park, "A near ML decoding scheme based on the metric-first search for multiple input multiple output systems," *IASTED Int. Conf. Signal, Image Process.*, Kailua-Kona, USA, Aug. 2008.

[5] J. Oh, I. Song, J. Park, M. A. Jeong, and M. S. Choi, "A hybrid ML decoding scheme for multiple input multiple output signals on partitioned tree," *IEEE Vehic. Techn. Conf.*, Calgary, Canada, Sep. 2008.

### OTHER ACCOMPLISHMENTS (2008/2009)

[1] 3 Patents, 2 Books





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## Communication Networks Research Laboratory

The research activities at Communication Networks Research (CNR) Lab. have focused on radio resource management for next generation mobile communication networks, multi-hop transmission schemes for relay-deployed multi-hop networks, interference mitigation schemes for wireless networks, and quality of service (QoS) guarantee for communication networks.

We have proposed an Orthogonal Resource Hopping Multiplexing (ORHM) scheme in downlink and an Orthogonal Resource Hopping Multiple Access (ORHMA) scheme in uplink. The ORHM scheme yields a statistical multiplexing gain in downlink and the ORHMA scheme provides a new multiple access technique to improve the uplink capacity of mobile communication networks. Furthermore, a novel Hybrid Multiple Access (HMA) scheme, which combines ORHMA and scheduling-based multiple access schemes, have been proposed for next-generation mobile communication networks and presented as a contribution in IEEE 802.16m standardization meeting which was held in Jan. 2008.

We have carried out several research projects such as beyond 4G mobile communication systems, hybrid radio resource management for relay-based cellular networks, airborne communication protocols for tactical information communication networks (TICN), development of a simulator for military ad-hoc networks, and Mobile WiMAX system design.

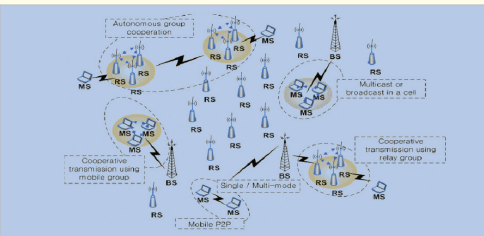


Fig. 1 KAIST beyond 4G system

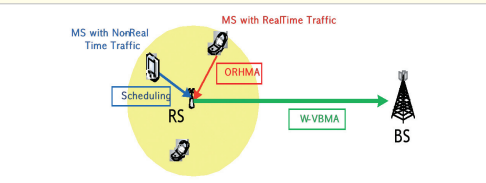


Fig. 2 Hybrid radio resource management scheme

### KEY PUBLICATIONS (2008/2009)

- [1] B. C. Jung and D. K. Sung, "Performance analysis of orthogonal code hopping multiplexing systems with repetition, convolutional, and turbo coding schemes," *IEEE Trans. Vehic. Techn.*, vol. 57, no. 3, pp. 932-944, Mar. 2008.
- [2] S. Y. Nam, S. Kim, and D. K. Sung, "Measurement based admission control at edge routers," *IEEE/ACM Trans. Networking*, vol. 16, no. 2, pp. 410-423, Apr. 2008.
- [3] T. W. Ban, W. Choi, B. C. Jung, and D. K. Sung, "Multi-user diversity in a spectrum sharing system," *IEEE Trans. Wireless Comm.*, vol. 8, no. 1, pp. 102-106, Jan. 2009.
- [4] H. Jin, B. C. Jung, H. Y. Hwang, and D. K. Sung, "Performance comparison of uplink WLANs with single-user and multi-user MIMO schemes," *IEEE Wireless Comm. Networking Conf.*, Las Vegas, USA, Mar. 2008.
- [5] J. W. Chong, Y. Sung, and D. K. Sung, "Cross-layer performance analysis for CSMA/CA system: impact of imperfect sensing," *IEEE Workshop Signal Process. Adv. Wireless Comm.*, Recife, Brazil, July 2008.

### OTHER ACCOMPLISHMENTS (2008/2009)

- [1] 28 Patents, 1 Award
- [2] 7 MS Graduates, 6 PhD Graduates

## Wireless Information Systems Research Laboratory

The research of Wireless Information Systems Research Lab. (WISRL) focuses on wireless communication and networking. The research topics include signal processing, statistical inference and communication theory with applications to next generation wireless networks, sensor networks, and related fields. The research direction of WISRL is two-fold.

First, WISRL is trying to advance the fundamental understanding of large networks that will be the main issue of the system area in the future. Second, WISRL is conducting research to improve the performance and devise innovative methods for current and next wireless communication systems.

Theory for Large Networks: One of the most important and long-standing open problems in the field of communications and networking is the lack of general theory of large networks. This open problem is closely related to design and commercialization of many types of important wireless networks. In this area, we investigate the possibility of the development of new abstractions and general theory capturing the essence of multi-node large networks, which may not be the Shannon framework. Recently, Youngchul Sung and his colleagues investigated large ad hoc sensor networks deployed for statistical inference under 2D stochastic field model using large deviations principle, and obtained the fundamental trade-offs among information, energy and density for such networks. The results provide guidelines for sensor network design for statistical inference about 2-D correlated random fields.

Next Generation Wireless Networks: In this area, WISRL is conducting research on wireless communication systems and networks from the perspective of commercial applications such as 3G, 3G LTE/4G and Beyond 4G. We are trying to come up with new

wireless communication methods or architectures with significant performance improvement. Currently, we are working on challenging problems in cognitive radio and femto-cell communication systems, i.e., optimal policy design for multiple secondary users and interference alignment schemes, respectively.

### KEY PUBLICATIONS (2008/2009)

- [1] Y. Sung, H. V. Poor, and H. Yu, "How much information can one get from a wireless ad hoc sensor network over a correlated random field," *IEEE Trans. Inform. Theory*, vol. 55, no. 6, pp. 2827-2847, June 2009.
- [2] Y. Sung, Y. Lim, L. Tong, and A. J. van der Veen, "Signal processing advances for 3G WCDMA: from rake receivers to blind techniques," *IEEE Comm. Mag.*, no. 1, pp. 48 - 54, Jan. 2009.
- [3] Y. Sung, X. Zhang, L. Tong, and H. V. Poor, "Sensor configuration and activation for field detection in large sensor arrays," *IEEE Trans. Signal Process.*, vol. 56, no. 2, pp. 447-463, Feb. 2008.
- [4] Y. Sung, H. V. Poor, and H. Yu, "Information, energy and density for ad hoc sensor networks over correlated random fields: large deviations analysis," *IEEE Int. Symp. Inform. Theory*, Toronto, Canada, July 2008.
- [5] Y. Sung, H. V. Poor, and H. Yu, "Optimal node density for two-dimensional sensor arrays," *IEEE Workshop Sensor Array, Multi-Channel Signal Process.*, Darmstadt, Germany, July 2008.

### OTHER ACCOMPLISHMENTS (2008/2009)

- [1] 2 Patents



Sung, Youngchul  
Assistant Professor

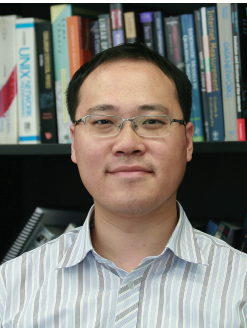
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## Laboratory of Network Architecture, Design, and Analysis

The Laboratory of Network Architecture, Design, and Analysis (LANADA in short) has made research on futuristic communication networking systems. Nowadays the communication networking systems have been changed vertically and horizontally at an alarming scale and speed. Horizontally, various network infrastructures such as broadband access networks, wireless cellular/ad-hoc networks, wired core networks, and overlay networks have been evolved and combined together, and also vertically, the division of each layer has become more ambiguous and cross-layer network designs are becoming more and more preferable. LANADA has focused on developing algorithmic and practical solutions of important networking problems, their performance evaluation and analysis over various communication networking systems with a theme of "Architecture First". We try to start to look at many problems fundamentally from theories and transfer them to practice by developing theory-driven algorithms and protocols.

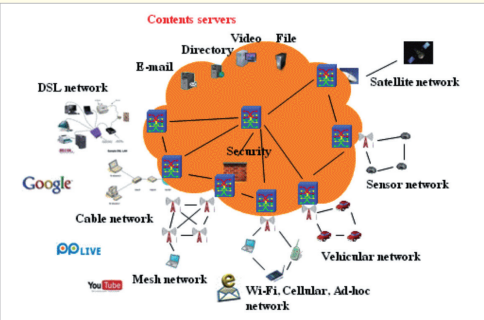


Fig. 1

Recently, our lab increases interest in economic aspects in communication networking systems that starts to receive significant attentions these days, and are challenging due to its necessity to view

problems from various angles and tools such as stochastic theory, control theory, economic theory, optimization theory, and even biological theory. LANADA has established strong collaboration with other research groups inside and outside Korea, such as ETRI, Samsung, North Carolina University, Princeton University, University of Texas at Austin, Microsoft Research lab, and Chinese University of Hong Kong, and strongly recommends the students in our group to visit and jointly research with them.

### KEY PUBLICATIONS (2008/2009)

- [1] Y. Yi and S. Shakkottai, "On the elasticity of marking functions in an integrated network," *IEEE Trans. Automatic Control*, vol. 54, no. 2, pp. 323-336, Feb. 2009.
- [2] Y. Yi, J. Zhang, and M. Chiang, "Delay and effective throughput of wireless scheduling in heavy traffic regimes: vacation model for complexity," *ACM Mobihoc*, New Orleans, USA, May 2009.

### OTHER ACCOMPLISHMENTS (2008/2009)

- [1] 2 Patents

## Advanced Network and Computing Laboratory

Advanced Network and Computing Laboratory (ANCL) as a founder of Grid Middleware Research Center has primarily focused on developing advanced computing middleware for advanced applications. Especially, PQRM (Policy Quorum-based Resource Management), which had been developed in our ANCL for the past 4 years, was selected and evaluated as the best research project, Physio-Grid development, by the government, Ministry of Education, Science and Technology in 2008.

The Physio-Grid service platform (depicted in Fig. 1) controls and manages both processing of several medical applications and data transference among applications. The local and historical data of measured ECG are offered to medical doctors (or patients) and Virtual Heart Simulation Module via medical database system at the same time. Virtual Heart Simulation Module provides more accurate results through pattern matching with real ECG data. Finally we can obtain integrated diagnosis results through knowledge-based medical decision support system.

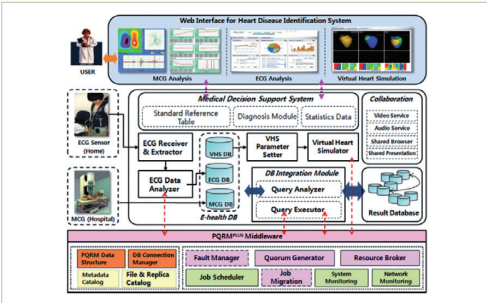


Fig. 1 Layered architecture of physio-grid system

Moreover, we are developing Nano-sensor integrated micro-computing applicable for healthcare system and advanced e-Organ simulated collaborative computing system to identify new drugs effectively from metadata of

chemical compounds. This system provides high performance computing for experiments of drug discovery with coordination and efficient execution management of geographically distributed complex applications. Furthermore, this system allows researchers to share high-resolution collaborative visualization for simulation results among multiple sites at the same time.

### KEY PUBLICATIONS (2008/2009)

- [1] Y. Han and C.-H. Youn, "A new grid resource management mechanism with resource-aware policy administrator for SLA constrained applications," *Future Gener. Comp. Syst.*, vol. 25, no. 7, pp. 768-778, July 2009.
- [2] Y. Han, H. Song, B. Kim, and C.-H. Youn, "SLA-constrained policy-based scheduling mechanism in grid," *IEICE Trans. Comm.*, vol. E91-B, no. 12, pp. 4009-4012, Dec. 2008.
- [3] U. Im, S. Kwon, K. Kim, Y. Lee, Y. Park, C.-H. Youn, and E. Shim, "Theoretical analysis of the magnetocardiographic pattern for reentry wave propagation in a three-dimensional human heart model," *Progress Biophysics, Molecular Biology*, vol. 96, pp. 339-356, Jan. 2008.
- [4] C.-H. Youn, J. Kim, D. Kim, W. Jung, D. Kim, and S. Yoo, "Geometry poincare plot analysis for cardiac disease estimation," *IEEE Int. Conf. e-Health Networking, Appl. Services*, Singapore, July 2008.
- [5] C.-H. Youn, C. Han, Y. Han, S. Kwon, and E. Shim, "Physio-Grid system for advanced identification of heart disease," *IEEE Int. Conf. e-Health Networking, Appl. Services*, Singapore, July 2008.

### OTHER ACCOMPLISHMENTS (2008/2009)

- [1] 1 Patent, 1 Award
- [2] 3 MS Graduates



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## Nano IC Technology Laboratory

Nano IC Technology (NIT) Laboratory has been launched in 2007 by Prof. BJ Cho. NIT Lab is tackling the main stream of IC technology, which is one of the backbone industries of Korea. Research focus of NIT lab includes near term solutions for memory IC technology as well as long term solutions for future nano-IC devices.

NIT lab is closely working with National Nano Fab Center, together with Hynix Semiconductor, Jusung Engineering, and UP chemicals to develop new high-K materials and process for 30 nm and beyond technology DRAM and Flash memory devices. To achieve its goal, new high-K materials and process developments will be needed and have a significant impact on semiconductor industry.

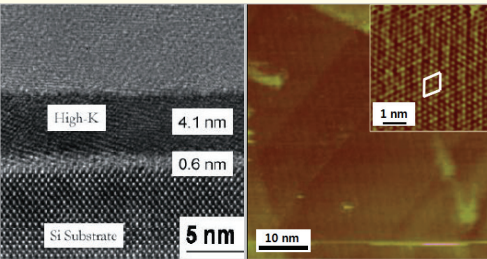


Fig. 1 (Left) TEM image of High-K film, (Right) STM image of 2-D Graphene

NIT Lab is closely collaborating with KRISS (Korea Research Institute of Standards and Science) for graphene technology development which is now considered to be the strongest candidate for post-silicon era. Graphene is a one-atom thick sheet of carbon that stacks with other such sheets to form graphite. Graphene exhibits remarkably high quality resulting from a combination of the purity of its carbon content and the orderliness of the lattice into which its carbon atoms are arranged. Especially, the mobility of graphene reaches up to  $2 \times 10^5 \text{ cm}^2/\text{V.s}$  at room temperature, which can open the door for the

regime of Tera Hz electronic devices and ultra-low power devices.

### KEY PUBLICATIONS (2008/2009)

- [1] W. S. Hwang, D. S. H. Chan, and B. J. Cho, "Metal carbides for band-edge work function metal gate CMOS devices," *IEEE Trans. Electron Dev.*, vol. 55, no. 9, pp. 2469-2474, Sep. 2008.
- [2] W. He, D. S. H. Chan, S. J. Kim, Y. S. Kim, S. T. Kim, and B. J. Cho, "Process and material properties of HfLaOx prepared by atomic layer deposition," *J. Electrochem. Soc.*, vol. 155, no. 10, pp. G189-G193, Aug. 2008.
- [3] B. J. Kang, S. K. Lim, and B. J. Cho, "Surface passivation using silane for epitaxial growth of graphene on SiC substrate," *Electrochem. Soc. Meeting*, San Francisco, USA, May 2009.
- [4] B. J. Cho, W. He, and J. Pu, "High-K dielectrics for charge trap-type flash memory application," *Asia-Pacific Workshop Fund., Appl. Adv. Semicond. Dev.*, Sapporo, Japan, July 2008.

### OTHER ACCOMPLISHMENTS (2008/2009)

- [1] 1 Patent
- [2] 4 MS Graduates

## Circuit Design and System Application Laboratory

Circuit Design and System Application Laboratory is established at the department of EECS (Electrical Engineering and Computer Science) in KAIST in 1984. The research and administrative members in our laboratory are led by professor Gyu-Hyeong Cho. Major research areas are focused in designing PMIC, Display driver IC and Bio-Chip.

### Power Management IC (DC-DC Converter):

Power management IC is important in portable electronic devices. Power management technology can generate various controlled voltages from a battery which are required for the sub-circuits in the device. SIMO can generate multiple controlled voltages from a single battery with single inductor, which can reduce the size and cost of the IC.

### Class-D Audio Amplifier & Envelop Modulator for polar RF transmitter:

Class-D audio amplifier has significant advantages in many applications. Moreover, the combination of class-D, which is the extension of DC/DC converter, and class-AB has been successfully implemented in envelope modulator for polar RF transmitter suitable for EDGE communicational standard by extending the operation speed.

### Data Drivers for LCD and AMOLED Displays:

Our researches in data driver ICs for displays are mainly focused on high resolution and low power-consumption in driving schemes. Another special interest in our research is aiming at AMOLED displays. Innovative driving schemes and dedicated circuits for AMOLED drivers have been developed for fast and accurate AMOLED data driver ICs.

### Bio-Chip for a Biological Molecule:

Current processes which analyze a bio-molecule require much time and cost, large size of equipments and work places. Thus our researches are focused on design Diagnosis

chip using antigen-antibody reaction, impedance detection chip.

### KEY PUBLICATIONS (2008/2009)

- [1] C.-S. Chae, H.-P. Le, K.-C. Lee, G.-H. Cho, and G.-H. Cho, "A single-inductor step-up DC-DC switching converter with bipolar outputs for active matrix OLED mobile display panels," *IEEE J. Solid-State Circuits*, vol. 44, no. 2, pp. 509-524, Feb. 2009.
- [2] K.-S. Seol, Y.-J. Woo, G.-H. Cho, G.-H. Cho, and J.-W. Lee, "A synchronous multioutput step-up/down DC-DC converter with return current control," *IEEE Trans. Circuits, Syst. II*, vol. 56, no. 3, pp. 210-214, Mar. 2009.
- [3] Y.-J. Jeon, H.-M. Lee, S.-W. Lee, G.-H. Cho, H. R. Kim, Y.-K. Choi, and M. Lee, "A piecewise-linear 10b DAC architecture with drain current modulation for compact AMLCD driver ICs," *IEEE Solid-State Circuits Conf.*, San Francisco, USA, Feb. 2009.
- [4] K.-S. Seol, Y.-J. Woo, G.-H. Cho, G.-H. Cho, J.-W. Lee, and S.-I. Kim, "Multiple-output step-up/down switching DC-DC converter with vestigial current control," *IEEE Solid-State Circuits Conf.*, San Francisco, USA, Feb. 2009.

### OTHER ACCOMPLISHMENTS (2008/2009)

- [1] 2 Patents, 2 Awards
- [2] 2 MS Graduates



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## System VLSI Laboratory

Main research interests of the System VLSI Lab (SVL) are, first, On-Chip Network (OCN) based Multi-Processor System-on-Chip (MPSoC) design for Communication / Multi-media Applications and its Core IPs (Intellectual Properties) implementation including Microprocessor and DSP, second, Digital Radio Frequency Transceiver like All-Digital PLL (ADPLL). At the System VLSI Lab, we have researched on design of video/audio source codec as a part of implementation of 3GPP WCDMA system. Also, a Bluetooth-based well-being terminal, IBRC (Intelligent Bi-directional Remote Controller), has been designed as a project of industrial-educational cooperation. Now, we are doing researches on current and futuristic hot topic, On-Chip Network based MPSoC and ADPLL. More specifically, an exquisite harmony of computation and communication will be realized via exploration of model of computation and its optimal mapping on OCN nodes. For this purpose, 65nm FPGA based MPSoC emulator will be prototyped to accelerate the ESL (Electronic System Level) exploration for multi-media and communication system development. As for Core IP design, an advanced constant multiplier for 128-point 4-path pipelined FFT in UWB applications was developed and published and a reconfigurable 64/128/256/512/1024/2048-point FFT/IFFT optimized for Gsamples/s OFDM wireless applications is under design. Regarding digital radio frequency (DRF) transceiver design, two ADPLL related circuits were devised: a meta-stability free retiming logic for ADPLL and a fast locking time ADPLL using look-up table (LUT). We are planning more futuristic interdisciplinary projects such as 'Intelligent green ICT building or U-space' and 'Environment management system using real-

time plants information' for leading IT convergence trend.

## Information Display and Micro-Plasma Laboratory

The Information Display & Micro Plasma Laboratory (IDMP Lab) has focused on information display devices, especially flexible and transparent photoluminescent display devices and plasmonic applications for display and energy devices. The Center for Advanced Flexible Display Convergence (CAFDC) directed by IDMP Lab. was chosen as an Engineering Research Center (ERC) by the Korea Science and Engineering Foundation (KOSEF), which is funded by the Ministry of Education, Science and Technology (MEST). In the impending society, the paradigm for information display devices is moving from conventional displays to novel display devices such as flexible displays and transparent displays. In the near future, there will likely be a huge demand for new display applications. Prototype flexible and transparent displays have been proposed, and the development of novel low-power display devices is underway.

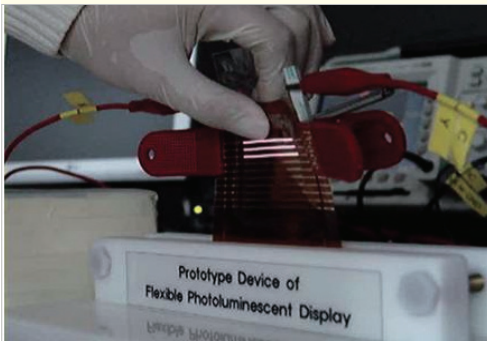


Fig. 1 Prototype of a flexible plasma display

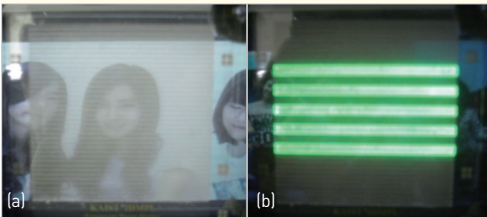


Fig. 2 Prototype of a transparent plasma display:  
(a) off-state, (b) on-state

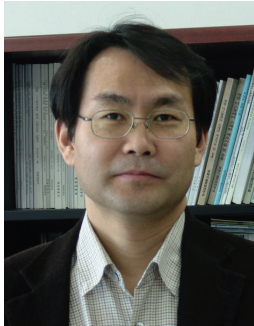
Surface plasmon-enhanced spontaneous emission rate phenomena were applied in order to improve the efficiency of OLEDs and PDP phosphors in research that utilized Ag cluster-incorporated nano-structures. Ag cluster-deposited cathode structures and solution-based coated Ag nano-particles were studied in an effort to improve the efficiency of the OLEDs and PDP phosphors, respectively.

### KEY PUBLICATIONS (2008/2009)

- [1] K. Y. Yang, K. C. Choi, and C. W. Ahn, "Surface plasmon-enhanced energy transfer in an organic light-emitting device structure," *Optics Express*, vol. 17, no. 14, pp. 11495-11504, July 2009.
- [2] K. Y. Yang, K. C. Choi, and C. W. Ahn, "Surface plasmon-enhanced spontaneous emission rate in an organic light-emitting device structure: cathode structure for plasmonic application," *Appl. Phys. Lett.*, vol. 94, no. 17, p. 173301, Apr. 2009.
- [3] S. H. Kim, J. H. Mun, and K. C. Choi, "Study on the discharge modes of the microplasma generated in a plasma display with an auxiliary electrode," *IEEE Trans. Plasma Science*, vol. 37, no. 2, pp. 327-333, Feb. 2009.
- [4] K. C. Choi, S. H. Kim, C. Jang, K. J. Kim, and S. I. Ahn, "Application of microplasma for flexible display devices," *Fund., Appl. Microplasmas*, San Diego, USA, Mar. 2009.
- [5] K. C. Choi, S. H. Kim, C. Jang, K. J. Kim, and S. I. Ahn, "Photoluminescent flexible displays," *Asia Optical Fiber Comm., Optoelect. Exposition, Conf.*, Shanghai, China, Oct. 2008.

### OTHER ACCOMPLISHMENTS (2008/2009)

- [1] 16 Patents
- [2] 2 MS Graduates, 1 PhD Graduate



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## Nano-Oriented Bio-Electronic Laboratory

Nano-Oriented Bio-Electronics Laboratory (NOBEL) explores novel device structures with new material and silicon-based nanotechnologies for biological/electrical applications. Ultimately, NOBEL pursues a second phase of Shockley device functioning at human body, bio-electronic system, etc. In the field of bio-related research, superhydrophobic structure was formed on a substrate of large area by using semiconductor process technology. Preexisting fabrication process for realizing superhydrophobic surface was a bottom-up method and hence suffered from large-area patterning as well as the uniformity, whereas the fabrication process proposed in our laboratory uses lithography process which enables the large-area patterning and guarantees high uniformity. Fig. 1 and 2 show the fabricated nanostructure and the contact angle change with respect to the aspect ratio of the structure.

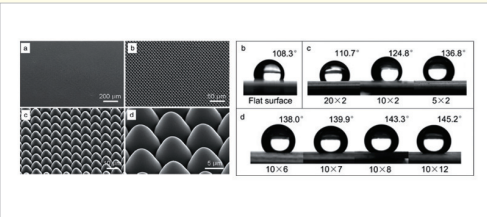


Fig. 1 Fabricated nanostructure  
Fig. 2 Contact angle for various aspect ratio

NOBEL also has focused on the paradigm shift in the silicon memory technology. A high-speed DRAM and non-volatile flash memory are integrated in a single memory transistor, named as Unified-Random Access Memory (URAM). This fusion allows users to adjust memory capacity and speed; they can optimize specifications of memory to fit their products. In addition to the conventional SOI substrate, NOBEL developed three novel substrates, silicon on silicon-carbide (SOC), silicon on n-

well (SON), and silicon on silicon-germanide (SOG) substrate.

### KEY PUBLICATIONS (2008/2009)

[1] X. J. Huang, J. H. Lee, J. W. Lee, J. B. Yoon, and Y.-K. Choi, "A one-step route to a perfectly ordered wafer-scale microbowl array for size-dependent superhydrophobicity," *Small*, vol. 4, no. 2, pp. 211-216, Apr. 2008.

[2] S. J. Choi, J. W. Han, S. H. Kim, M. G. Jang, J. S. Kim, K. H. Kim, G. S. Lee, J. S. Oh, M. H. Song, Y. C. Park, J. W. Kim, and Y.-K. Choi, "Enhancement of program speed in dopant-segregated-schottky-barrier (DSSB) FinFET SONOS for NAND-type flash memory," *IEEE Electron. Dev. Lett.*, vol. 30, no. 1, pp. 78-81, Jan. 2009.

[3] J. W. Han, S. W. Ryu, S. H. Kim, C. G. Kim, J. H. Ann, S. J. Choi, K. J. Choi, B. J. Cho, J. S. Kim, K. H. Kim, G. S. Lee, J. S. Oh, M. H. Song, Y. C. Park, J. W. Kim, and Y.-K. Choi, "Band offset FinFET-based URAM (Unified-RAM) built on SiC for multi-functioning NVM and capacitorless 1T-DRAM," *IEEE Symp. VLSI Techn.*, Hawaii, USA, June 2008.

[4] M. Im, D. H. Kim, X. J. Huang, J. H. Lee, J. B. Yoon, and Y.-K. Choi, "A highly flexible superhydrophobic microlens array with small contact angle hysteresis for droplet-based microfluidics," *IEEE Int. Conf. Micro Electro Mechanical Syst.*, Sorrento, Italy, Jan. 2009.

### OTHER ACCOMPLISHMENTS (2008/2009)

[1] 13 Patents  
[2] 7 MS Graduates

## Electromagnetic Wave Laboratory

The Electromagnetic Wave Laboratory performs research on antennas and electromagnetic theory, covering a wide range of electromagnetics and microwave engineering. The relevant applications find in high-frequency electromagnetic wave phenomena, antennas, EMI/EMC (electromagnetic interference and compatibility), etc. We are mainly interested in the study of electromagnetic scattering, diffraction, and radiation problems, using various analytic methods such as the Fourier transform and mode-matching. The use of analytic methods allows us to obtain very efficient solutions to many theoretical and practical problems often encountered in the area of antenna engineering and high-frequency circuit analysis. We have so far developed novel analytical tools using rigorous mathematical techniques, and have successfully applied to various high-frequency problems. We have performed various projects supported by governmental organizations and private sectors. We analyzed, designed, and tested various types of leaky wave antennas that utilize planar and cylindrical slotted structures. Our recent projects focus on theoretical modeling of slotted array antennas, canonical waveguiding and cavity structures.

### KEY PUBLICATIONS (2008/2009)

[1] M. Y. Park and H. J. Eom, "Two coaxial lines cross-coupled to a rectangular waveguide," *IET Proc. Microw. Ant. Prop.*, vol. 2, no. 1, pp. 10-14, Feb. 2008.

[2] Y. H. Kim, H. J. Eom, and J. W. Zeong, "Radiation from transversely slotted waveguide," *Microw. Optical Techn. Lett.*, vol. 50, no. 6, pp. 1547-1549, Apr. 2008.

[3] J. S. Ock, H. J. Eom, and J. Y. Park,

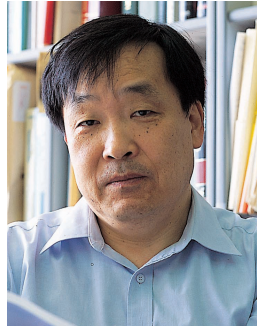
"Electromagnetic scattering from multiple slant strips," *IEEE Ant. Wireless Prop. Lett.*, vol. 8, pp. 40-43, Apr. 2009.

[4] H. J. Eom, M. J. Kim, and J. S. Ock, "Mode-matching model for electromagnetically coupled coaxial dipole array antenna," *IEICE Trans. Comm.*, vol. E92-B, no. 4, pp. 1406-1409, Apr. 2009.

[5] J. K. Paek and H. J. Eom, "Radiation of Hertzian dipole in cylindrical cavity with narrow slots," *IEICE Trans. Comm.*, vol. E92-B, no. 4, pp. 1410-1413, Apr. 2009.

### OTHER ACCOMPLISHMENTS (2008/2009)

[1] 2 MS Graduates, 1 PhD Graduate



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## Wave Embedded Integrated System Laboratory

Research area of WEIS (Wave Embedded Integrated Systems) Laboratory covers RF transmitter and RADAR systems. There are two groups that dedicate to each research topic: FT (Future Transmitter) and SOAC (System-On-A-Chip). The main topics of FT group are a CMOS power amplifier and digital transmitter, which are the most important issues that determine the performance of various mobile applications. Recently, many efforts are made to improve the efficiency of a power amplifier for the long life time of battery, which is one of the most significant issues among the cellular phone makers. Digital transmitter is the new research area of FT group which will lead to the increased flexibility, programmability and better tolerance against PVT variation.

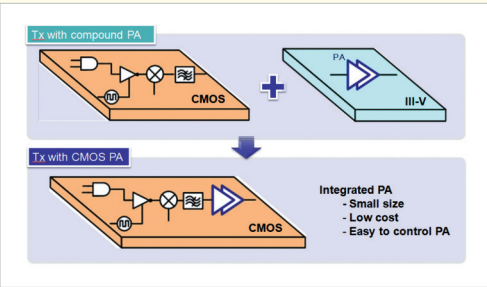


Fig. 1

Another research group, SOAC, focuses on sensor system using miniaturized RADAR. This group has pursued studies of RADAR systems, which can be applied to various industries, based on the Si semiconductor design technology. SOAC group is mainly interested in RF front-end of miniaturized RADAR. RADAR sensor system detects an object and sends the signal. We should process the signal to get data of range or velocity. Recent topics of this group are remote bio-sensor which extracts heart-beat and respiration signals and image sensor which can get the information of distance and

shape of an object for the application of the robot vision. Automotive RADAR for anti-collision and insurance of a field of vision is also researched for core technology.

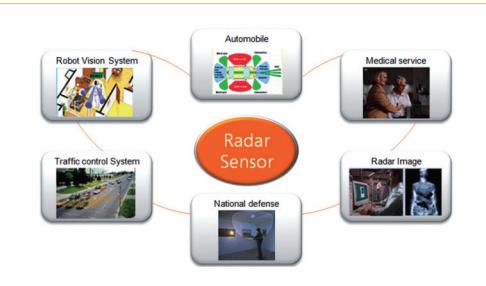


Fig. 2

### KEY PUBLICATIONS (2008/2009)

[1] H. Lee, C. Park, and S. Hong, "A quasi-four-pair class-E CMOS RF power amplifier with an integrated passive device transformer," *IEEE Trans. Microw. Theory, Techn.*, vol. 57, no. 4, pp. 752-759, Apr. 2009.

[2] C. Y. Kim, J. G. Kim, D. Baek, and S. Hong, "A circularly polarized balanced radar front-end with a single antenna for 24-GHz radar applications," *IEEE Trans. Microw. Theory, Techn.*, vol. 57, no. 2, pp. 293-298, Feb. 2009.

[3] S. Shim and S. Hong, "A 1-W, 800-MHz, switch-mode CMOS RF power amplifier using an on-chip transformer with double-primary sides," *IEEE Radio, Wireless Symp.*, San Diego, USA, Jan. 2009.

### OTHER ACCOMPLISHMENTS (2008/2009)

[1] 1 Patent, 1 Award  
[2] 3 PhD Graduates

## Biomedical Engineering Laboratory

In the Biomedical Engineering Lab (BMELab), we have advanced signal processing methods for electrocardiogram and developed numerous applications focusing on cellular and clinical imaging. In one of our recent applications, we have found that Lorentz plotting of heartbeat intervals helped to visualize dynamic changes during the transition from normal to abnormal cardiac episodes, namely, atrial fibrillation. These plots were analyzed by image analysis techniques to decide whether atrial fibrillation could be predicted. In addition, we recently developed radiograph analysis software to help dentists to evaluate the effectiveness of dental treatments. Since subtle differences in complicated bone structures may not be appreciated with naked eyes, imaging software tools should segment dental bones accurately. Our new on multi-scale segmentation techniques performed accurately and reliably enough to provide quantitative data critical to make a clinical decision. These tools will be eventually integrated into healthcare systems for better management of human diseases.

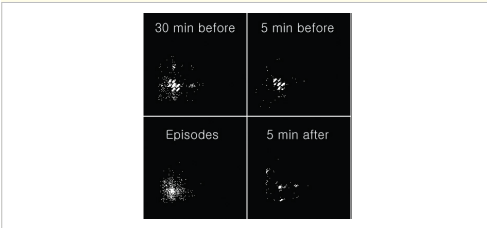


Fig. 1 Lorentz plot analysis for cardiac episodes

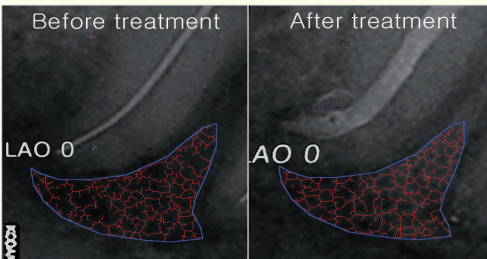


Fig. 2 Dental radiograph analysis

### KEY PUBLICATIONS (2008/2009)

[1] T. Lee, H. Jeong, B. Lee, and D. Kim, "Quantitative analysis of endodontic treatment for periapical lesions in intraoral radiographs," *IEEE Int. Conf. Bioinformatics, Bioengin.*, Taichung, Taiwan, June 2009.

[2] N. D. Duong, Y. Seo, and D. Kim, "Heterogeneous temporal changes of Poincare plot shapes during the transition to atrial fibrillation onsets," *U-Healthcare*, Busan, Korea, Oct. 2008.

[3] D. Kim, Y. Seo, and C. H. Youn, "Detection of atrial fibrillation episodes using multiple heart rate variability features in different time periods," *IEEE Engin. Medicine, Biology Conf.*, Vancouver, Canada, Aug. 2008.

[4] D. Kim, Y. S. Chae, and S. J. Kim, "High content cellular analysis for functional screening of novel cell cycle regulatory genes," *IEEE Biomed. Engin., Informatics*, Sanya, China, May 2008.

[5] D. Kim, Y. Seo, and L. Salahuddin, "Decreased long term variations of heart rate variability in subjects with higher self reporting stress scores," *Perv. Computing Techn. Healthcare*, Tampere, Finland, Jan. 2008.



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## Terahertz Interconnection and Package Laboratory

At present, to satisfy the demands for an integrated semiconductor with high-speed and high-density characteristics, the SoC (System-on-Chip) and SiP (System-in-Package) approaches have been actively researched. However, performance-degradation issues such as high-frequency noise coupling between digital and analog blocks, simultaneous switching noise (SSN) generation in digital switching blocks, and jitter and skew problems in high-speed channels have become critical design challenges to chip, package, and PCB designers. Research by the Terahertz Interconnection and Package Laboratory (TERA Lab.) has focused on devising unique modeling methodologies and design approaches to solve these problems, especially for the 3-D (three-dimensional) SiPs and 3-D ICs.

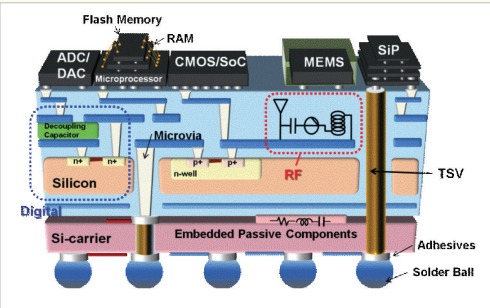


Fig. 1 3-D stacked SiP with silicon-BGA package

The most outstanding achievements of the TERA Lab. in 2008 were the development of novel 3-D stacked SiP design methodologies that can significantly increase the integration density. As shown in Figure 1, SiP is a semiconductor package solution that can integrate various passive components and several semiconductor dies with different processes (RF, analog, digital) to perform complex functions. TERA Lab. has applied its unique methodology to cope with SI/PI/EMI

issues related to a 3-D stacked SiP with novel co-designing and modeling methodologies.

### KEY PUBLICATIONS (2008/2009)

[1] D. G. Kam and J. Kim, "40-Gbps package design using wire-bonded plastic ball grid array," *IEEE Trans. Adv. Packaging*, vol. 31, no. 2, pp. 258-266, May 2008.

[2] J. Kim, Y. Jeong, J. Kim, J. Lee, C. Ryu, J. Shim, M. Shin, and J. Kim, "Modeling and measurement of inter-level electromagnetic coupling and fringing effect in a hierarchical power distribution network using segmentation method with resonant cavity model," *IEEE Trans. Packaging*, vol. 31, no. 3, pp. 544-557, Aug. 2008.

[3] G. Kim, D. G. Kam, S. J. Lee, J. Kim, M. Ha, K. Koo, J. S. Pak, and J. Kim, "Modeling of eye-diagram distortion and data dependent jitter in meander delay line on high-speed PCB based on a time domain even-mode and odd-mode analysis," *IEEE Trans. Microw. Theory, Techn.*, vol. 56, no. 8, pp. 1962-1972, Aug. 2008.

### OTHER ACCOMPLISHMENTS (2008/2009)

[1] 1 Award  
[2] 4 MS Graduates

## Opto-Electronics Laboratory

Opto-Electronics Laboratory was founded in 1979 and has been interested in demonstration of high speed optical and wireless communication systems using technology integration based on optical device (LD, LED, PD) technology, electronic device (HBT, MESFET, FECFET) technology, and package technology (SiOB, SOPS). Since foundation of Opto-Electronics Laboratory, we have tried to pursue a unique and creative evolution on our research topics. We propose the microwave package consists of selectively anodized aluminum substrate for high power package modules. Using a selectively anodized aluminum substrate, high power bare MMICs are mounted on aluminum to dissipate easily heat from bare chips and high quality passive devices are made on the thick alumina (anodized aluminum) region.

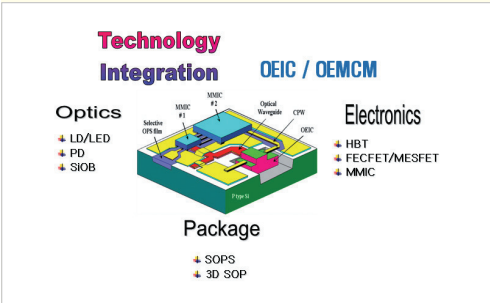


Fig. 1

The requirement for electronic devices and systems with small size, light weight, high integration and performance demands that electronic package and substrate companies develop substrates with low cost, excellent thermal properties and electrical properties. Low-cost, ultra-thin and compact package technology is proposed using selective anodized aluminum substrate. Fig. 1 shows the proposed structure of the package with the tolerance of size variation. Using the process of anodization, a thick selectively anodized

aluminum oxide (Al<sub>2</sub>O<sub>3</sub>) with high dielectric properties is formed on an aluminum substrate. High-performance passive circuits are integrated on the thick Al<sub>2</sub>O<sub>3</sub> film. Active bare chips or MMIC dies are usually mounted on the aluminum substrate which works as a path for thermal dissipation and the signal lines are interconnected using bonding wires. A more advanced technology named a 'pocket embedding package (PEP)' was developed to achieve a size reduction and electrical performance improvements. Using the PEP technology, the active dies are embedded inside the package to dissipate heat effectively from chips and to reduce the dimensions and height of the package.

### KEY PUBLICATIONS (2008/2009)

[1] K. M. Kim, S. H. Shin, Y. K. Lee, S. M. Choi, and Y. S. Kwon, "Aluminum based packaging platform for LED using selectively anodizing method," *IET Electron. Lett.*, vol. 44, no. 1, pp. 24-25, Jan. 2008.

[2] K. M. Kim, Y. K. Lee, S. H. Shin, S. M. Choi, and Y. S. Kwon, "Aluminum packaging for light-emitting diode using selectively anodizing method," *Japan. J. Appl. Phys.*, vol. 47, Special Issue, pp. 2850-2953, Apr. 2008.

[3] J. J. Jo, J. M. Yook, and M. J. Kim, "Anodic alumina substrate using via in pad for memory package applications," *Solid State Dev., Materials*, Tsukuba, Japan, Sep. 2008.



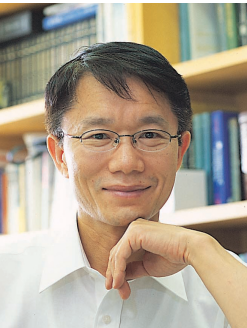
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## Photonic Networks Research Laboratory

Quadruple play services, converged service of voice, data, wireless, and video, will play a key role in the future access networks. This will in turn simplify network management and billing systems. Further simplification of the network will be accomplished by employing fiber-to-the home (FTTH) based on a passive optical network (PON). A WDM (Wavelength Division Multiplexing)-PON is considered to be the ultimate goal of the access networks since it can deliver almost unlimited dedicated bandwidth with protocol transparency. Photonic Networks Research Laboratory (PNRL) has been focusing on investigating enabling technologies for optical access network such as, WDM-PON architectures including high-speed WDM-PONs based on wavelength-locked Fabry-Perot Laser Diodes (F-P LDs). To make WDM-PON reliable and field deployable, protection methods and the low noise BLS based on mutually injected F-P LDs with RF modulation were investigated. We also proposed an evolution scenario from the existing TDM-PON to WDM-PON with video overlay and a remotely reconfigurable remote node (RN) to provide next generation services (WDM-PON) from legacy services (TDM-PON). Moreover, we derived analytic expression for relative intensity noise (RIN) and theoretical model of wavelength-locked F-P LD to understand physical mechanism clearly. PNRL is one of the National Research Laboratories supported by the government and has an infrastructure for research on breaking through technologies for photonic networks. We demonstrated improved performance of a low noise broadband light (BLS) based on mutually injected F-P LDs for a large capacity and high bit-rate WDM-PON. The 3-dB linewidth and RIN of each mode of the low-noise BLS are improved by RF modulation. A

WDM-PON with a 622 Mb/s was demonstrated. We demonstrated 40 Gb/s (32x1.25 Gb/s) WDM-PON based on wavelength-locked F-P LDs with an automatic decision threshold control circuit. A color-free transmission of 1.25 Gb/s per subscriber was achieved with flat-top pass band AWG (channel spacing: 100-GHz) and a laser diode with low reflectivity after 15 km transmission.

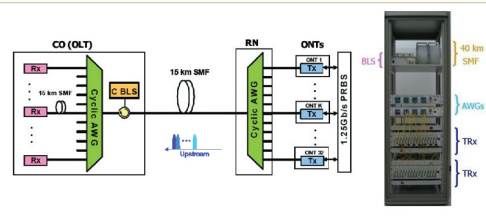


Fig. 1 32x1.25Gb/s WDM-PON configuration and implemented test-bed

### KEY PUBLICATIONS (2008/2009)

[1] S.-G. Mun, S.-M. Lee, K. Okamoto, and C.-H. Lee, "A multiple star WDM-PON using a band splitting WDM filter," *Optics Express*, vol. 16, no. 9, pp. 1260-1266, Apr. 2008.

[2] J. H. Lee, K.-M. Choi, and C.-H. Lee, "A remotely reconfigurable remote node for next-generation access networks," *IEEE Photon. Techn. Lett.*, vol. 20, no. 11, pp. 915-917, June 2008.

[3] K.-Y. Park and C.-H. Lee, "Noise characteristics of a wavelength-locked Fabry-Perot laser diode," *IEEE J. Quantum Electron.*, vol. 44, no. 11, pp. 995-1002, Nov. 2008.

### OTHER ACCOMPLISHMENTS (2008/2009)

[1] 4 Patents, 1 Award

## Infrared Image Sensor Laboratory

Infrared Detector is the main research theme of IRIS (InfraRed Image Sensor) LAB. We focused on the cooled type infrared sensor before 2005, and transition to the uncooled type has been made after then. Our research result has led to the beginning of an infrared camera venture company, I3system, whose CEO is the 1st PhD alumni of IRIS LAB. Now, we are focusing on the uncooled infrared detectors which are expected to be used more widely than cooled ones for their low price and reasonable performance. IRIS LAB also research polymer based non volatile RAM. Currently, the infrared sensor team in our laboratory is studying about the novel bolometer material and the micro-cantilever type capacitive IR sensor which uses bi-material effect (fig.1). The former is under brisk researches whereas the latter is at the finishing step.

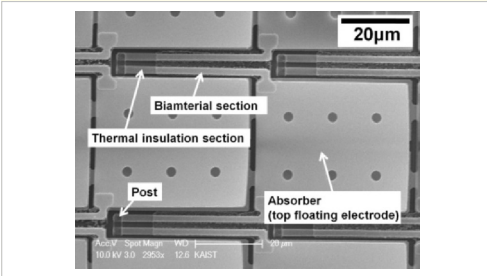


Fig. 1 IRIS capacitive IR sensor

Now we are focusing on a new ROIC structure, which lowers the power consumption. This circuit uses counters to perform pixel level ADC. The required numbers of counter operation for ADC can be decided by the micro-bolometer current variation. These counting numbers exactly mean how much the infrared flux is absorbed. For this performance, normally a 14bit counter is used. By adapting current skimming scheme, however, the total bits for counter can be reduced up to 10bits. That is because DC

offsets caused by the device non-uniformity generated from ROIC fabrication can be subtracted by the current skimming. Therefore, only 10 bit counter is required for pixel level ADC. Due to this mechanism, the overall power consumption in the counter will be reduced up to 1/64 compared to the conventional structure. This low power approach deserves welcome in the pixel level ADC for micro-bolometer.

### KEY PUBLICATIONS (2008/2009)

[1] C. B. Kim, C. H. Hwang, B. H. Kim, Y. S. Lee, and H. C. Lee, "CMOS TDI readout circuit that improves SNR for satellite IR applications," *Electron. Lett.*, vol. 44, no. 5, pp. 346-347, Feb. 2008.

[2] C. H. Hwang, C. B. Kim, Y. S. Lee, and H. C. Lee, "Pixelwise readout circuit with a current mirroring injection for microbolometer FPAs," *Electron. Lett.*, vol. 44, no. 12, June 2008.

[3] I. W. Kwon, J. E. Kim, C. H. Hwang, Y. S. Lee, and H. C. Lee, "Design and fabrication of a capacitive infrared detector with a floating electrode and thermally isolatable bimorph legs," *Sensors, Actuators A: Physical*, vol. 147, no. 2, pp. 391-400, Oct. 2008.

[4] I. W. Kwon, H. J. Son, D. S. Kim, C. H. Hwang, Y. S. Lee, B. G. Yu, and H. C. Lee, "A cantilever-type uncooled infrared detector with high fill-factor and low-noise characteristic," *IEEE Electron Dev. Lett.*, Jan. 2009. (to be published)

[5] W. Y. Kim, D. Y. Ka, B. O. Cho, S. Y. Kim, Y. S. Lee, and H. C. Lee, "Retention performance of ferroelectric polymer film for nonvolatile memory devices," *IEEE Electron Dev. Lett.*, May 2009.



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## Wireless PHYCOM Laboratory

Main research focus is the development of multi-band programmable CMOS radio receivers for SDR (software defined radio) as well as wakeup and cognitive radios. Modern cellular phone is supposed to have more than 15 radios, composed of several cellular's, several mobile TV's, and I/O radio's such as WLAN, Bluetooth, RF-ID, etc. It is a great challenge to implement this in CMOS with acceptable performance with smallest form factors and cost.

The recent R&D topic is SAW-less RF transceiver circuit design for multi-band / multi-mode radio applications. Wideband RF CMOS chip has been designed for ATSC/DVB-T terrestrial TV receivers. The design challenges are broadband matching, wide band selectivity/sensitivity, a sufficient gain with wide bandwidth, a high linearity, a small noise, and so forth. We developed several CMOS IP's specifically for highly linear ultra wide band LNA, harmonic rejection mixer, SD ADC, and oversampling mixer using 0.18um CMOS technology. Single chip ATSC tuner adopting these IP's will be commercialized in 2009 by LG Electronics.

Recent search includes user interface technology based on touch, haptic as well as bend sensing for organic user interface. Various sensors, sensing algorithms and modeling, gesture language development, and feedback techniques are the main issues.

During '05-'07 for 3 years, Professor Kwiro Lee worked as an Executive Vice President of LG Electronics Inc. His responsibility was to direct LG Electronics Institute of Technology as the President. LG Elite is the LG Electronics cooperate-wide central basic research center, consisted of Device and Material, Information Technology, and Communication Technology Research Labs.

### KEY PUBLICATIONS (2008/2009)

- [1] D. Im, I. Nam, H. Kim, and K. Lee, "A wideband CMOS low noise amplifier employing noise and IM2 distortion cancellation for a digital TV tuner," *IEEE J. Solid-State Circuits*, vol. 44, no. 3, pp. 686-698, Mar. 2009.
- [2] Y. Lim, I. Nam, H. Kim, and K. Lee, "A highly linear wideband up-conversion differential CMOS micromixer using IMD3 cancellation for a digital TV tuner IC," *IEEE Microw., Wireless Comp. Lett.*, vol. 19, no. 2, pp. 89-91, Feb. 2009.
- [3] K. Kwon, H. Kim, and K. Lee, "A 50-300MHz highly linear and low-noise CMOS Gm-C filter adopting multiple gated transistors for digital TV tuner ICs," *IEEE Trans. Microw. Theory, Techn.*, vol. 57, no. 2, pp. 306-313, Feb. 2009.
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- [5] J. Jang, M. Kwon, E. Tjandranegara, K. Lee, and B. Jung, "A digital driving technique for an 8b QVGA AMOLED display using  $\Delta\Sigma$  modulation," *Int. Solid State Circuit Conf.*, San Francisco, USA, Feb. 2009.

### OTHER ACCOMPLISHMENTS (2008/2009)

- [1] 1 Patent
- [2] 3 MS Graduates, 2 PhD Graduates



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## Photonics Application Laboratory

The Photonics Application Laboratory (PALAB) has primarily focused on research and developing technologies in the field of laser applications, especially ultra-short pulsed laser applications, and optical communications. An ultra-short pulsed laser with its high power can be applied to study material surface treatments, micromachining, microfabrication of bio-devices and optical devices such as biosensors, optical gratings, optical waveguide devices, optical memory, and so on.

Material surface treatments, which imply to modify or create specific features or structures on surface of the material to obtain new material properties, can be use a variety of applications for reduction of friction, for self-cleaning surface by super hydrophobic property. It also can be used for increasing the absorption ratio of light in solar cell applications. We performed surface treatment of polydimethylsiloxane (PDMS) by Ti: Sapphire femtosecond laser irradiation to fabricate morphology of submicro/microstructures that led to new surface properties. We also proposed a new idea of fast cutting of display glass plates using a femtosecond laser, which was able to micromachine strips in rear-surface and internal void arrays simultaneously. Single shot void morphology was investigated varying input pulse energy, focusing depth, and scanning speed.

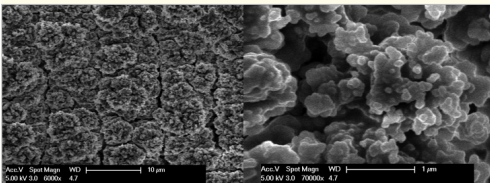


Fig. 1 Modified structures on the surface of PDMS

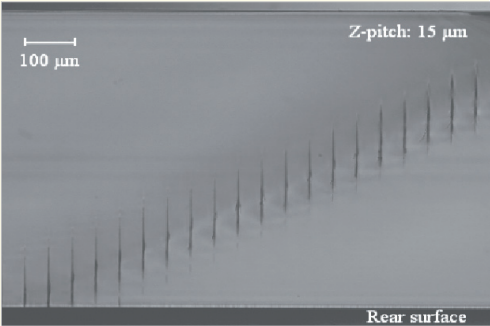


Fig. 2 Void arrays inside display glass

### KEY PUBLICATIONS (2008/2009)

- [1] F. Ahemd, M. Lee, H. Sekita, T. Sumiyoshi, and M. Kamata, "Display glass cutting by femtosecond laser induced single shot periodic void array," *Appl. Phys. A-Materials Science, Process.*, vol. 93, no. 1, pp. 189-192, Oct. 2008.
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- [3] C. Min and M. Lee, "Surface structure changes induced by femtosecond laser irradiation for surface treatment with PolyDiMethylSiloxane (PDMS)," *Triangle Symp. Adv. ICT*, Daejeon, Korea, Oct. 2008.
- [4] F. Ahmed, C. Min, and M. Lee, "Far rear surface focusing of femtosecond laser pulses for dicing display glass plates," *Photon. West*, San Jose, USA, Jan. 2008.

### OTHER ACCOMPLISHMENTS (2008/2009)

- [1] 2 Patents
- [2] 1 MS Graduate, 1 PhD Graduate





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Micro Radio Laboratory

Micro-Radio Laboratory ( $\mu$ -Radio LAB) has focused on CMOS Integrated Circuit design since 1998.  $\mu$ -Radio Lab's research area consists of RF front-end, Baseband analog, Mixed-mode (Synthesizer, ADC/DAC), High speed optical circuits and Digital calibration techniques. 21 Ph.D and 7 master degree students are currently supervised by Professor Sang-Gug Lee. The Lab's recent research topics include DTV tuner, Impulse-Radio UWB (IR-UWB) radar, Wake-up receiver, Digital RF system, Display semiconductor, FM receiver, Advanced transceiver system modeling, etc. Some of the research details are as follows.

**Digital TV Tuner:** In line with digital convergence on video and TV technology,  $\mu$ -Radio laboratory has made persistent effort in DTV tuner IC development and developed DVB-T/DVB-H dual band tuner and ISDB-T tuner. Now the research phase moves to multi-standard DTV tuner development which covers ATSC, DVB-T, DVB-C, and Open-Cable.

**Impulse Radio UWB Application:** Impulse Radio UWB (IR-UWB) rises as a core scheme in RFID/USN applications due to its advantages of high security, efficiency in low-speed data transmission, and high-accuracy distance measurement.  $\mu$ -Radio laboratory developed low-power IR-UWB transceiver for IEEE 802.15.4a standard and low-power, low-cost, and low-complexity IR-UWB radar for movement detection.

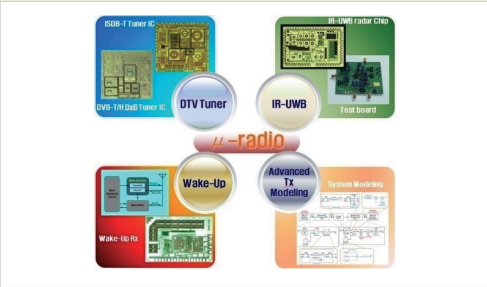


Fig. 1

KEY PUBLICATIONS (2008/2009)

[1] I.-Y. Lee, S.-J. Yun, S.-M. Oh, and S.-G. Lee, "A low-parasitic and common-centroid cross-coupled CMOS transistor structure for high-frequency VCO design," *IEEE Electron Dev. Lett.*, vol. 30, no. 5, pp. 532-534, May 2009.

[2] T. A. Phan, J.-S. Lee, V. Krizhanovskii, L. Quan, S.-K. Han, and S.-G. Lee, "Energy-efficient low-complexity CMOS pulse generator for multiband UWB impulse radio," *IEEE Trans. Circuits, Syst. I*, vol. 55, no. 11, pp. 3552-3653, Dec. 2008.

[3] S.-J. Yun, D. B. Y. Nguyen, I.-Y. Lee, J.-T. Lee, and S.-G. Lee, "A differentially-tuned voltage controlled oscillator using symmetric transformer," *IEEE Microw. Wireless Comp. Lett.*, vol. 18, no. 7, pp. 464-466, July 2008.

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OTHER ACCOMPLISHMENTS (2008/2009)

[1] 2 Patents

[2] 3 MS Graduates, 2 PhD Graduates

Semiconductor Energy Laboratory

Research in Semiconductor Energy Lab (SEL) has been focused on the developing and analyzing new and efficient photo-voltaic devices, low cost solar cell module fabrication methods, transparent conductive oxide, new texturing method and its application. Transparent resistive random access memory (TRRAM) is also investigated.

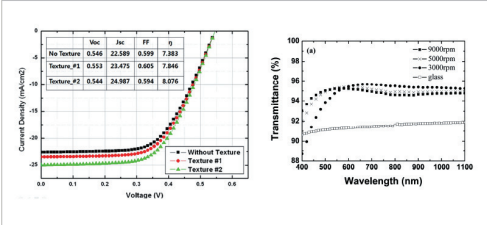


Fig. 1 (a) Solar cell characteristics with various textures made by the PDLC 3D-lithography and ICP etching (b) Transmittance of glass spin-coated with PMMA solution (0.009 g/cm3) in chloroform with 1.5 vol % of nonane

A new texturing method and its application were investigated. Using a PDLC film, we could make some textures having various shapes. Using these textures, we made crystalline silicon solar cells and it showed about 10% of current increase. PMMA coatings also show quantum efficiency improvement.

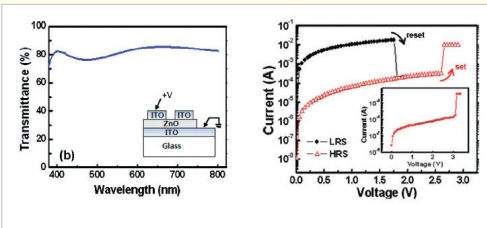


Fig. 2 (a) Transmittance in the visible region. The inset shows a schematic diagram of the structure (b) Typical I-V characteristics of a TRRAM device. The inset shows the initial electroforming

The fabrication of a fully transparent resistive random access memory (TRRAM) device based on an ITO (indium tin oxide)/ZnO/ITO capacitor structure and its resistive switching characteristics are investigated. The

fabricated TRRAM has a transmittance of 81% (including the substrate) in the visible region and an excellent switching behavior under 3 V.

KEY PUBLICATIONS (2008/2009)

[1] J. Seo, J. Park, K. Lim, J. Yang, and S. Kang, "Transparent resistive random access memory and its characteristics for nonvolatile resistive switching," *Appl. Phys. Lett.*, vol. 93, no. 22, pp. 1-3, Dec. 2008.

[2] E. Lee, D. Moon, J. Yang, K. Lim, and Y. Choi, "Transparent zinc oxide gate metal-oxide-semiconductor field-effect transistor for high-responsivity photodetector," *IEEE Electron Dev. Lett.*, vol. 30, no. 5, pp. 493-495, May 2009.

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[4] L. Fang, J. Im, S. Park, and K. Lim, "Improvement of quantum efficiency of amorphous silicon thin film solar cells by using nanoporous PMMA antireflection coating," *Materials Research Soc. Symp.*, San Francisco, USA, Apr. 2009.



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## Electromagnetic Theory and Technology Laboratory

ETT laboratory's main research activities are divided into two groups, electromagnetic wave theory and RF system development. In the electromagnetic wave theory research group, research topics include development of wave propagation prediction model for next generation mobile system and DTV broadcasting, hybrid analysis technique for wave scattering by inlet geometries, RCS modeling and analysis, target recognition inclusive of radar signal processing. Analysis of electromagnetic signal interference and jamming effect is also one of the main topics in this group. In the RF system development group, research activities are development of the dual polarized array antenna, active phased array antenna without phase shifter, oscillator design using EBG (electromagnetic band gap), new type of RFID tag antennas, meta-material issues and high integrity wideband SAR front-end.

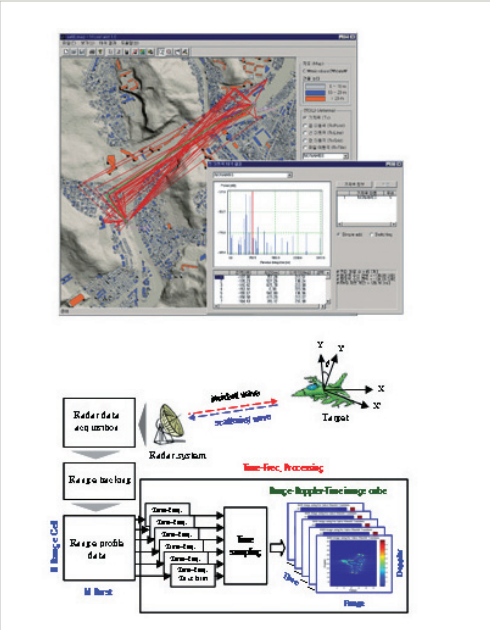


Fig. 1 DRT simulator for 3D ray tracing  
Fig. 2 Motion compensation method for ISAR image

### KEY PUBLICATIONS (2008/2009)

- [1] J. S. Jang and N. H. Myung, "Downlink coverage and capacity of a distributed repeater system in a WCDMA multicell environment," *IEICE Trans. Comm.*, vol. E91-B, no. 4, pp. 1211-1214, Apr. 2008.
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- [3] S. Y. Shin and N. H. Myung, "The efficient technique for extraction two-dimensional SCs of a target using the SSOC and the MSSP," *Asia-Pacific Microw. Conf.*, Hongkong, China, Dec. 2008.
- [4] D. W. Seo and N. H. Myung, "The RCS of wire-type scattering structures," *Asia-Pacific Microw. Conf.*, Hong Kong, China, Dec. 2008.

### OTHER ACCOMPLISHMENTS (2008/2009)

- [1] 1 Patent
- [2] 1 PhD Graduate

## Microwave Microsystems Laboratory

The Microwave and Microsystems Laboratory (MICROLAB) has focused on researching radio circuits and systems to cope with demands of the coming next generation mobile communications. The primary studies being undertaken by the laboratory are the design of RFICs for intelligent radio and millimeter-wave circuits for Gbps high data rate wireless communications, and their implementation to radio systems. These are also the major research objectives of the IREC (Intelligent Radio Engineering Center), which is supported as an ERC (engineering research center), a center-of-excellence program, by MOEST (Ministry of Education, Science, and Technology) and KOSEF (Korea Science and Engineering Foundation) since 2005. An intelligent radio can change its frequency, band-width, and modulation autonomously according to the communication environment, a core solution for the software defined radio and cognitive radio. The ultimate aim of MICROLAB's current line of research is to arrive at a the "Universal Radio Solution with Unlimited Connectivity" in a form of a CMOS single chip, to cope with convergence among mobile, WLAN, WPAN, broadcasting, and sensor networks. In 2008, a single path reconfigurable CMOS RF was investigated for an intelligent solution for 800MHz ~ 6GHz multi-band multi-mode communication and is currently under design with 180 nm CMOS. At the same time, power amplifiers RFICs are being studied for the intelligent radio. Furthermore, 60 GHz radio SoC and Sop have been studied for high data rate WPAN/WLAN and full HD video transmission applications. A very low power single chip 60 GHz receiver integrating a low noise amplifier (LNA), a mixer, a driver amplifier, a frequency doubler, and a voltage controlled oscillator (VCO) has been developed with 130 nm CMOS

technology. Currently, transmitters and an enhanced version of the receiver are under design with 65 and 90 nm CMOS technology. System packaging of the 60 GHz transmitter and receiver has been implemented monolithically together with antennas for high data rate video transmission. A high data rate transmission of up to 3Gbps has been demonstrated, and a HD video transmission test was successfully accomplished with the SoP radios.

### KEY PUBLICATIONS (2008/2009)

- [1] D. Y. Jung, J. J. Lee, and C. S. Park, "Low-power and low NF V-band down-converter in 0.13um CMOS," *Electron. Lett.*, vol. 45, no. 10, pp. 509-510, May 2009.
- [2] J. J. Lee, K. C. Eun, D. Y. Jung, and C. S. Park, "A novel GCPW to rectangular waveguide transition for 60 GHz applications," *IEEE Microw., Wireless Compon. Lett.*, vol. 19, no. 2, pp. 80-82, Feb. 2009.
- [3] J. H. Kim, K. Y. Kim, and C. S. Park, "Linearity improvement of a power amplifier with a series LC resonant circuit," *IEEE Microw., Wireless Compon. Lett.*, vol. 18, no. 5, pp. 332-334, May 2008.
- [4] D. Y. Jung and C. S. Park, "A low-power, high-suppression V-band frequency doubler in 0.13um CMOS," *IEEE Microw., Wireless Compon. Lett.*, vol. 18, no. 8, pp. 551-553, Aug. 2008.
- [5] D. Y. Jung and C. S. Park, "A power efficient Ka-band low phase noise VCO in 0.13um CMOS," *Electron. Lett.*, vol. 44, no. 10, pp. 630-631, May 2008.



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## Photonic Computer Systems Laboratory

The current issue of the Photonic Computer Systems Laboratory (PCS Lab) is to achieve a high-speed operation of computers by photonic data-transmission through optical interconnection lines between chips and systems. The optical interconnection can provide a lot of advantages such as higher band width, lower power consumption, EMI free, reduction of impedance matching problem, larger pin density, etc. To achieve the photonic computer systems, we have initiated new architectures of computer systems where MPU and memory chips are data-linked through optical lines which are embedded in the PCB (printed-circuit board). In 2009 year, we demonstrated an optical interconnection platform for video image processing through optically-linked microprocessors, as seen below. For this system, low-loss optical PCBs, compact optical transmitter/receiver array modules, and mass-producible packaging schemes were developed.

As a next demonstration system, we are challenging to build a fully-optical-linked computer system where the optical interconnection is applied for the link between advanced MPU and memory chips and also for the link to peripheral equipments. As intermediate products, integration schemes of the several hundred optical lines at the interface of MPU/chipset/memory chips and structures of optically-interfaced PCI express were designed. Also, many interface ICs were developed, such chips as for the synchronization of optical and electrical signals in multiple lines, for the serialization of signals to convert into a high-speed optical transmission, and for the clock recovery from optical signals. This study is proceeding in cooperation with many institutions, including ETRI Server Platform Research Team and LG micron, since it requires broad developments

from components to systems and fusion of electronic and photonic technologies.

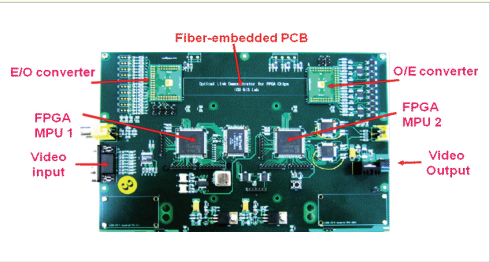


Fig. 1 Demonstration platform for image processing by optical interconnection between FPGA microprocessors

### KEY PUBLICATIONS (2008/2009)

- [1] T.-H. Ngo, N. T. H. Nguyen, T.-W. Lee, and H.-H. Park, "Bidirectional CMOS transceiver with automatic mode control for chip-to-chip optical interconnects," *IEEE Photon. Techn. Lett.* (to be published).
- [2] D.-W. Kim, S. H. Ahn, I.-K. Cho, D.-M. Im, S. M. S. Muslim, and H.-H. Park, "Fabrication of thermally stable and cost-effective polymeric waveguide for optical printed-circuit board," *Optics Express*, vol. 16, no. 21, pp. 16798-168005, Oct. 2008.
- [3] S. H. Hwang, M. H. Cho, S.-K. Kang, H. S. Cho, T.-W. Lee, and H.-H. Park, "Optical interconnection platform composed of fiber-embedded board, 90o-bent fiber block and 10 Gb/s optical module," *IEEE J. Lightw. Techn.*, vol. 26, no. 11, pp.1479-1485, June 2008.
- [4] D.-W. Kim, S. Md. S. Muslim, A. I. Ukaegbu, T.-W. Lee, M. H. Cho, S. J. Kim, B.-S. Yoo, and H.-H. Park, "Comparison of long- and short-wavelength optical transmitters for optical PCB applications," *SPIE Photon. West*, San Jose, USA, Jan. 2009.

### OTHER ACCOMPLISHMENTS (2008/2009)

- [1] 1 PhD Graduate

## Microwave and Antenna Research Laboratory

Microwave and Antenna Laboratory research activities cover a wide range of next generation communication antenna including the LTE MIMO handset antennas, reconfigurable antenna, handset intelligent antenna, microwave communication system, and precision antenna measurement techniques.

**Research on the Intelligent Handset Antenna:** With the rapid progress in new communication standards, ultra-slim profile and miniature multi-band/multiple internal antennas are needed for modern and in the near future mobile handsets. More innovative intelligent antenna techniques applied in new multi-radio system simultaneously are needed to reduce the size of these multiple antennas in space-limited mobile devices and pattern reconfigurable antenna smartly while retaining good multi-band characteristics and without scarifying antenna electrical performance.

### Measurement system and development of LTE (Long Term Evolution) MIMO Antennas:

The main purposes of LTE MIMO Handset antenna research are focusing to new innovative multiple-element antenna design and measurement techniques of interdisciplinary nature for new material, antenna measurements involving new radio standards, and proper antenna spatial configurations of each service band constraints of space-limited mobile handset. In the near future mobile devices, they can accommodate at least the seven or more different wireless devices in operation at the same time. In order to support the simultaneous operation in limited space, there are many technical challenges to be solved in multiband and multiple antenna concerning mutual interference between radios and involving system definition, antenna structure, the isolation and correlation problems

between antennas, antenna allocation, new antenna measurement techniques for LTE MIMO handset, and etc.

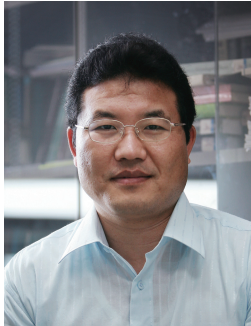
**Development of a Portable Multi-function X-band Radar for Surveillance:** This research is developing on surveillance X-band radar system with the multi-function of Doppler, chirp pulse LFM, and FMCW. We are concentrating to implement very hypersensitive new radar system. This system is applied to find the non-invasive vital signal sensing and surveillance.

### KEY PUBLICATIONS (2008/2009)

- [1] V. A. Nguyen and S. O. Park, "A compact tunable internal antenna for personal communication handsets," *IEEE Ant., Wireless Prop. Lett.*, vol. 7, pp. 569-572, July 2008.
- [2] R. A. Bhatti, Y. T. Im, J. H. Choi, D. M. Tuan, and S. O. Park, "Ultrathin planar inverted-F antenna for multi-standard handsets," *Microw., Optical Techn. Lett.*, vol. 50, no. 11, pp. 2894-2897, Nov. 2008.
- [3] J. H. Choi, Y. S. Shin, and S. O. Park, "Performance evaluation of 2x2 MIMO handset antenna arrays for mobile WiMAX applications," *Microw., Optical Techn. Lett.*, vol. 51, no. 6, pp.1558-1561, Mar. 2009.
- [4] R. A. Bhatti, M. G. Choi, J. H. Choi, and S. O. Park, "Design and evaluation of a PIFA array for MIMO-enabled portable wireless communication devices," *IEEE Ant. Prop. Soc.*, San Diego, USA, July 2008.

### OTHER ACCOMPLISHMENTS (2008/2009)

- [1] 2 Patents
- [2] 3 MS Graduates



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## Bit Engineering Laboratory

Bit Engineering Laboratory (BitE Lab) focuses on wireless communication system development from algorithm to implementation level. BitE Lab covers Wireless Video/Personal/Body Area Network (WWAN/WPAN/WBAN) up to Wireless Local Area Network (WLAN). Latest research activities have expanded to include MAC PHY cross-layer optimization, power aware design technology, and reconfigurable digital transceiver.

In 2008, the next generation WLAN medium access control (MAC) system has been developed and demonstrated on FPGA platform. The system provides at least 100Mbps of link throughput and supports Wi-Fi Multimedia (WMM) for real time services such as voice over IP (VoIP) and video. Next, the cross-layer simulator for IEEE 802.11n draft 7.0 has also been developed based on SystemC. Most recent technologies with MIMO-OFDM and frame aggregations can be evaluated to obtain the link spectral efficiency. The simulator can also be extended to network simulator because of unified interfaces provided by SystemC. In addition, BitE Lab is involved in research endeavor to generate efficient architectures of digital transceiver for WLAN system.



Fig. 1 The Next Generation WLAN Development Platform and Verification Environments

### KEY PUBLICATIONS (2008/2009)

- [1] T. Kim, J. Lee, and S.-C. Park, "Performance evaluation of RTLS based on active RFID power measurement for dense moving objects," *IEICE Trans. Comm.*, vol.

- E92-B, no. 4, pp. 1422-1425, Apr. 2009.
- [2] S. Park, K. K. Parhi, and S.-C. Park, "Probabilistic spherical detection for multiple antenna systems," *IEEE Trans. Circuits, Syst. I*, vol. 56, no. 3, pp. 685-698, Mar. 2009.
- [3] J. Lee and S.-C. Park, "MIMO detector based on trellis structure," *IEICE Trans. Comm.*, vol. E91-B, no. 4, pp. 951-954, Mar. 2008.
- [4] S. Seo and S.-C. Park, "Efficient RFID anti-collision scheme with multi-collision reflected frame request," *IEEE Consumer Comm., Networking Conf.*, Las Vegas, USA, Jan. 2009.
- [5] T. Kim, S. Lee, and S.-C. Park, "Effect of collision on movement tracking using active RFID power measurement," *IEEE Consumer Comm., Networking Conf.*, Las Vegas, USA, Jan. 2009.

### OTHER ACCOMPLISHMENTS (2008/2009)

- [1] 3 MS Graduates, 2 PhD Graduates

## Mixed Signal Integrated Circuits Laboratory

The Mixed-Signal Integrated Circuits Laboratory (MSICL) is working on CMOS analog and mixed-mode circuit designs including data converters, amplifiers, filters, display drivers, and etc. Especially, performance enhancing design techniques for data converters have mainly been researched as follows: energy efficient A/D conversion algorithm, low-power high-speed data converter architecture and related peripheral building blocks such as reference drivers and regulators, and switching noise tolerant design methods.

A simple digital error correction technique for high-speed binary weighted SAR ADCs with no hardware overhead has been developed. Inspired by the pipelined ADCs, decision error by the incomplete DAC settling in coarse conversion step is corrected in digital domain owing to the comparator offset and the proposed redundant decision cycles. This relaxes the requirement of the reference voltage settling accuracy and, therefore, enhances the conversion speed (1.4 times faster compared with the conventional SAR conversion for 10bit design). Time-domain noise isolation technique has been proposed for mixed-signal circuits in which a single power/ground port must be shared by analog and digital circuits. The proposed method removes supply regulator and makes low voltage design easier. The technique has been implemented in a sigma-delta ADC for digital microphone application, and its significant effectiveness has been proved by both circuit simulation and chip measurement.

In addition, new high conversion-rate ADC architectures such as time-interleaved flash-SAR architecture and time-domain interpolating flash ADC are currently being investigated in MSICL.

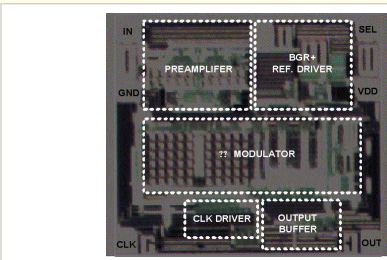


Fig. 1 Sigma-delta ADC for digital microphone

### KEY PUBLICATIONS (2008/2009)

- [1] S. H. Cho, C. K. Lee, B. R. S. Sung and S. T. Ryu, "Digital error correction technique for binary decision successive approximation ADCs," *Electron. Lett.*, vol. 45, no. 8, pp. 395-397, Apr. 2009.
- [2] H. B. Le, J. W. Nam, S. T. Ryu, and S. G. Lee, "Single-chip A/D Converter for digital microphones with on-chip preamplifier and time-domain noise isolation," *Electron. Lett.*, vol. 45, no. 3, pp. 151-152, Jan. 2009.
- [3] H. B. Le, S. T. Ryu, and S. G. Lee, "A fully on-chip Gm-opamp-RC based preamplifier and time-domain noise isolation," *IEICE Trans. Electron.*, vol. E82-C, no. 4, pp. 587-588, Apr. 2009.
- [4] B. R. S. Sung, S. H. Cho, C. K. Lee, J. I. Kim, and S. T. Ryu, "A time-interleaved flash-SAR architecture for high speed A/D conversion," *IEEE Int. Symp. Circuits, Systems*, Taipei, Taiwan, May 2009.
- [5] H. N. Nguyen, Y. S. Jang, Y. S. Son, S. T. Ryu, and S. G. Lee, "A multi-bit/cycle 12-bit cyclic DAC for TFT-LCD column drivers," *Int. Display Workshop*, Niigata, Japan, Dec. 2008.

### OTHER ACCOMPLISHMENTS (2008/2009)

- [1] 1 Patent



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## Computational Nanotechnology Laboratory

In the Computational Nanotechnology Lab (CNL), our main research activity lies in developing in-house nano-electronic device simulators based on the quantum mechanical principles. Our developed tools are aimed to be deployed in Web-based simulation portals such as nanoHUB for public access. Recently, we have developed a nanowire field effect simulator based on the eight-band k.p Hamiltonian, so that the hole transport in silicon-based devices and band-to-band tunneling in III-V based devices can be simulated respectively. The Schrodinger equation with open-boundaries were solved using the non-equilibrium Green's function approach and the self-consistent calculations were performed by solving the transport equation together with the three-dimensional Poisson's equation. The key points in our approach are: 1) we have successfully constructed the mode-space Hamiltonian for efficient simulation, 2) we have devised an approximate but highly accurate method to solve the nanowire cross-sectional eigenvalue problems, thereby overcoming the numerical bottleneck of the mode-space approach. We have therefore been able to develop a highly efficient simulator, which is comparable to the tight-binding simulators in quality but much faster and much more resource-saving so that larger-sized devices can be simulated. Fig. 1 shows the device structure, I-V characteristics of [100], [110], and [111] Si nanowire pMOSFETs, and the charge density profiles for different orientations. We have also developed a simulator for carbon nanotube field effect transistors based on the tight-binding method. In the nano-Grid research activities, we have developed various front/back-end tools and middleware to integrate our simulators to the Grid environment.

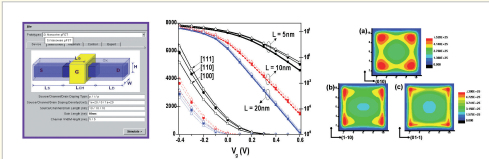


Fig. 1 (Left) k.p device simulator, (Center) I-V characteristics of 5x5 Si nanowire pFETs, (Right) the charge density profiles for [100], [110], and [111] directions for 10x10, 40nm Si nanowire pFETs

### KEY PUBLICATIONS (2008/2009)

- [1] M. C. Shin, "Computational study on the performance of multiple-gate nanowire Schottky-Barrier MOSFETs," *IEEE Trans. Electron Dev.*, vol. 55, no. 2, pp. 737-742, Mar. 2008.
- [2] M. C. Shin, J. H. Lee, and C. Y. Ahn "Simulation study of the scaling behavior of top-gated carbon nanotube field effect transistors," *J. Nanosc. Nanotechnol.*, vol. 8, no. 10, pp. 5389-5392, Oct. 2008.
- [3] M. C. Shin, "Non-equilibrium Green's function approach to three-dimensional carbon nanotube field effect transistor simulations," *J. Korean Physical Soc.*, vol. 52, no. 4, pp. 1287-1291, Apr. 2008.
- [4] M. C. Shin "NEGF simulation of nanowire field effect transistors using the eight-band k · p method," *Int. Workshop, Comp. Electron.*, Beijing, China, May 2009.

### OTHER ACCOMPLISHMENTS (2008/2009)

- [1] 1 MS Graduate

## Electro-Optics Laboratory

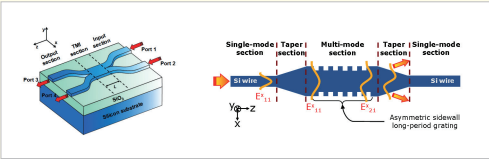


Fig. 1 Schematic diagram of the proposed ZGDC based PS (a) and LPG filter (b)

### KEY PUBLICATIONS (2008/2009)

- [1] Y. B. Cho, B. K. Yang, J. H. Lee, J. B. Yoon, and S. Y. Shin, "Silicon photonic wire filter using asymmetric sidewall long-period waveguide grating in a two-mode waveguide," *IEEE Photon. Techn. Lett.*, vol. 20, no. 7, pp. 520-522, Apr. 2008.
- [2] B. K. Yang, S. Y. Shin, and D. Zhang, "Ultrashort polarization splitter using two-mode interference in silicon photonic wires," *IEEE Photon. Techn. Lett.*, vol. 21, no. 7, pp. 432-434, Apr. 2009.
- [3] M. S. Kwon and S. Y. Shin, "Influence of the parameters of a heater array inducing a thermo-optic long-period grating on its power consumption," *J. Lightw. Technol.*, vol. 27, no. 9, pp. 1108-1113, May 2009.
- [4] Y. B. Cho, G. J. Oh, D. M. Yeo, and S. Y. Shin, "Polarization splitter using asymmetric sidewall long-period waveguide gratings in a two-mode silicon waveguide," *Optoelect., Comm. Conf.*, Seoul, Korea, Aug. 2008.
- [5] B. K. Yang, S. Y. Shin, and D. Zhang, "Ultrashort polarization splitter using silicon photonic wires," *Integr. Photon., Nanophot. Research, Appl.*, Boston, USA, July 2008.

### OTHER ACCOMPLISHMENTS (2008/2009)

- [1] 1 PhD Graduate



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## Advanced Sensors and Optical Network Laboratory

The Advanced Sensors and Optical Network (ASON) Laboratory has primarily focused on developing key optical modules and systems for ultra-high speed internet and sensor devices for biological and environmental applications. The main research topics are optical ID and image sensors for the sensor-related research, and optical burst switching, ultra-low power consuming green internet, and nonlinear optical modules using injection-locked Fabry Perot laser diodes (FP-LDs) for the optical network-related research. The optical ID called by the next generation bar-code was firstly invented in this lab and is now developing using the technology of printing hologram pattern with information data and retrieving the original data from the pattern by laser diode beam. The optical ID has strong potential for many killer applications due to capability to deliver huge amount of data information with robust security. The next research topic is to develop a high sensitive nano-rod photodetector which is capable of capturing high quality images even under ultra-low light environments. This photodetector is developing using nano-rod growth technology which is expected to expose much superior quality than conventional CCD or CMOS image sensors (CIS). A conventional multimode FP-LD was firstly transformed to a single mode laser diode using additional injection locking structure. This structure has been accepted as innovative concept and introduced in the world magazine "Photonics Spectra". The single mode FP-LD has very simple and cost-effective structure, which has been applied in this lab to generate novel optical modules for the optical network like as optical wavelength conversion, optical flip-flop memory, etc. The optical burst ADM test-bed system has been firstly demonstrated in this lab which is supposed to use in optical ring

network for ultra-high speed internet.

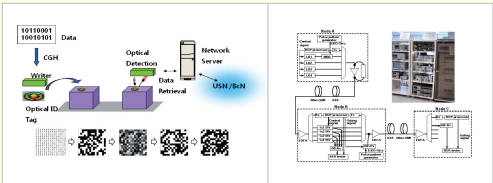


Fig. 1 Optical ID with hologram pattern  
Fig. 2 Optical burst ADM test-bed system

### KEY PUBLICATIONS (2008/2009)

[1] M. R. Uddin, J. S. Cho, and Y. H. Won, "All-optical wavelength conversion with multicasting at 4X10 Gbits/s up and down using a Fabry-Perot laser diode," *IEICE Electron. Express*, vol. 6, no. 9, pp. 566-571, May 2009.

[2] M. R. Uddin, J. S. Cho, and Y. H. Won, "All-optical multicasting NOT and NOR logic gates using gain modulation in an FP-LD," *IEICE Electron. Express*, vol. 6, no. 2, pp. 104-110, Jan. 2009.

[3] M. R. Uddin, J. S. Cho, and Y. H. Won, "Single to multi-wavelength conversion using gain modulation in an FP-LD," *IEICE Electron. Express*, vol. 5, no. 23, pp. 1024-1029, Dec. 2008.

[4] M. R. Uddin, J. S. Cho, and Y. H. Won, "All-optical NOR and NOT gates at 10 Gb/s based on gain modulation in Fabry-Perot laser diode," *Asia-Pacific Comm. Conf.*, Akihabara, Tokyo, Japan, Oct. 2008.

[5] T. Q. Hoai, J. S. Cho, Y. D. Jeong, and Y. H. Won, "Utilization of absorption modulation of an injection-locked Fabry-Perot laser diode to demonstrate all-optical multi-wavelength conversion," *Int. Conf. Comm., Electron.*, Hoian, Vietnam, June 2008.

### OTHER ACCOMPLISHMENTS (2008/2009)

- [1] 2 Patents  
[2] 1 MS Graduate, 1 PhD Graduate

## High Speed Nanoelectronics Laboratory

High Speed Nanoelectronics Lab (HSNL) conducts research in next-generation devices and ICs with focus on high speed and high functional applications. The lab is currently involved in three research categories:

(i) In research based on the Quantum/Nano device, such as an RTD (Resonant Tunneling Diode), it has been possible to design and fabricate numerous revolutionary ICs based on new topology using the RTD technology which has shown ultimate efficiency and potential that can possibly replace the previous conventional circuits

(ii) A broadband compact 3D-MMIC technology has been developed by using multi-layer processes for high frequency InP-based Microwave/Millimeter-wave Monolithic IC applications.

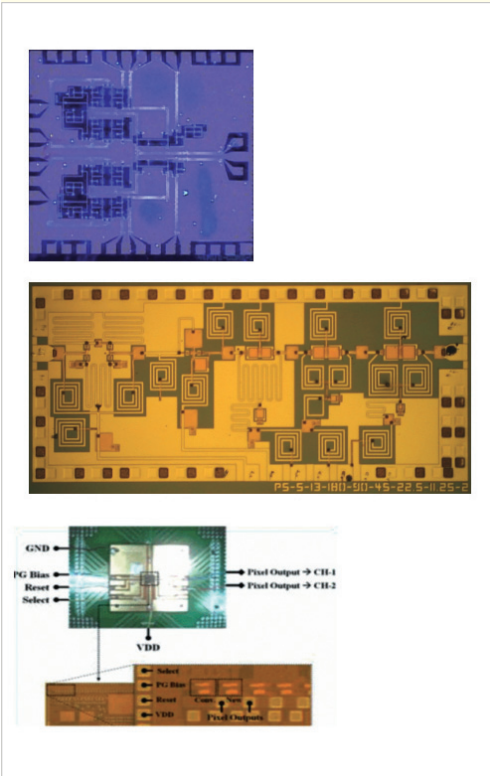


Fig. 1 (i) RTD-based 4:1 multiplexing circuit (left), (ii) InP-based PIN phase shifter MMIC (center), (iii) CMOS Image Sensor (right)

(iii) A new optoelectronic sensor of a 3TR photogate pixel based on self-adaptive operation has been proposed and investigated. Further research on new methods and sensor operation for the 3-D imaging system is in progress.

### KEY PUBLICATIONS (2008/2009)

[1] T. Kim, Y. Jeong, and K. Yang, "Low-power high-speed performance of current-mode logic D flip-flop topology using negative-differential-resistance devices," *IET Circuits Dev. Syst.*, vol. 2, no. 2, pp. 281-287, Apr. 2008.

[2] S. Choi, Y. Jeong, J. Lee, and K. Yang, "A novel high-speed multiplexing IC based on resonant tunneling diodes," *IEEE Trans. Nanotechn.* (to be published).

[3] S. Choi, Y. Jeong, J. Lee, and K. Yang, "Implementation of a new functional digital IC for multiplexing operation based on RTDs," *IEEE Int. Conf. Nanotechn.*, Arlington, USA, Aug. 2008.

[4] J. Lee, S. Choi, and K. Yang, "Temperature dependent characteristics of InP RTD based CML-MOBILE D-flip flop IC," *IEEE Int. Conf. InP, Related Materials*, Newport Beach, USA, May 2009.

### OTHER ACCOMPLISHMENTS (2008/2009)

- [1] 6 Patents



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## Communication and Device System Laboratory

CoDeS(Communication Device and System) Lab. has researched on RF (Radio Frequency) technology for next generation wireless communication. As the various wireless communication standards proliferate, demands for multistandard transceiver are increased. Multistandard transceiver should satisfy the wide range of requirements such as frequency band, dynamic range and bandwidth etc. Also, since multistandards transceiver should be comparable with a single standard transceiver in size, power consumption and other performances, designing it is faced with many challenges. For implementation of efficient multistandard transceiver with the high flexibility, we have been trying to process as many functions with digital circuitry as possible instead of minimizing the RF parts. Digitalization of RF function can make high efficiency system in terms of integration, noise, cost and power consumption. Recently, our researches focus on direct digital RF processing and high IF (Intermediate Frequency) digitizing processing because it is advantage to implement the multistand transceiver. Digital to RF converter, digital polar transmitter, compensation of amplitude phase mismatch, digital down converter and digital filtering are our mainly interesting topics.

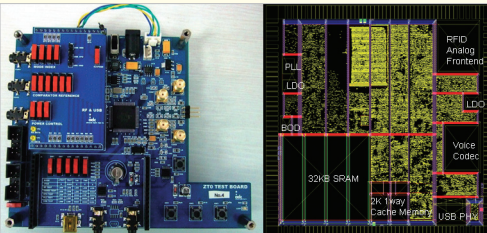


Fig. 1

### KEY PUBLICATIONS (2008/2009)

[1] E.-P. Hong, Y.-S. Hwang, and H.-J. Yoo,

"Direct conversion RF front-end with low power consumption technique for 2.4 GHz ISM band," *IET Microw. Ant., Prop.*, vol. 2, no. 8, pp. 898-903, Dec. 2008.  
[2] M. L. Huang, H.-J Yoo, and S.-C. Park, "Reconfigurable multi-band class E power amplifier using CMOS technology," *IEICE Trans. Comm.*, vol. E92-B, no. 7, pp. 2488-2491, July 2009.  
[3] M.-W. Seo, Y.-C. Choi, Y.-H. Kim, and H.-J. Yoo, "A 13.56MHz RFID transceiver SoC for multi-standard reader," *IEEE Radio, Wireless Symp.*, San Diego, USA, Jan. 2009.  
[4] C.-H. Kim, S.-H. Shin, and H.-J. Yoo, "A low phase noise and low power series coupled quadrature VCO using reconfigurable LC tank," *IEEE Radio, Wireless Symp.*, Orlando, USA, Jan. 2008.  
[5] M.-W. Seo, Y.-C. Choi, Y.-H. Kim, and H.-J. Yoo, "A 13.56MHz receiver SoC for multi-standard RFID," *IEEE Int. Conf. Electron. Dev., Solid-State Circuits*, Hong Kong, China, Dec. 2008.

### OTHER ACCOMPLISHMENTS (2008/2009)

[1] 3 Patents  
[2] 2 MS Graduates

## Integrated Organic Electronics Laboratory

Integrated Organic Electronics Lab (IOEL), established on August, 2006, focuses on developing novel device architectures and integrated systems based on organic semiconductors and conductors in the three major areas: display & lighting, energy, and flexible low-cost electronics. Research on organic light-emitting diodes (OLEDs) for displays & lighting applications constitute one of IOEL's top-priority research efforts and is being pursued mostly in device-level innovation that reflects the application-specific needs from the practical or system-level perspectives. Such efforts include a development of (i) flexible/transparent OLEDs for ultraportable displays and smart windows; (ii) inverted OLEDs for AMOLEDs with n-type TFTs; and (iii) organic dry jet printing as a novel, scalable deposition technique that can lead to reliable large-area organic displays and lighting. Energy-related research is mainly focused on development of organic solar cells for future use of this innately low-cost organic technology in photovoltaic energy generation. Key efforts are being made in achieving reliable and scalable OPV technologies that are balanced with continual improvement of power conversion efficiencies. Another integral part of IOEL's research efforts is to develop reliable, high-performance electronic devices and integrated circuits based on organic field-effect transistors (OFETs), metal oxide thin-film transistors (MOxTFTs), and memory devices for low-cost and flexible alternatives to existing technologies.

### KEY PUBLICATIONS (2008/2009)

[1] J. Park and S. Yoo, "New n-type TiO<sub>2</sub> transparent active channel TFTs fabricated with a solution process," *IEEE Electron. Dev. Lett.* vol. 29, no. 7, pp. 724-727, July

2008.

[2] D. Gupta, N. Jeon, and S. Yoo, "Modeling the electrical characteristics of TIPS-Pentacene thin-film transistors: effect of contact barriers, field-dependent mobility, and traps," *Org. Electron.* vol. 9, no. 6, pp. 1026-1031, Aug. 2008.

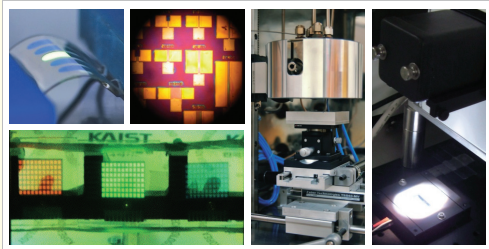


Fig. 1 Photos of various devices and systems under development by IOEL: flexible OLEDs, organic/oxide TFTs, transparent OLEDs, organic dry jet printing, and organic solar cells

[3] S. Kim, H. Moon, D. Gupta, S. Yoo, and Y. Choi, "Resistive switching characteristics of sol-gel zinc oxide films for flexible memory applications," *IEEE Trans. Electron Dev.*, vol. 56, no. 4, pp. 696-699, Apr. 2009.  
[4] C. Yun, H. Cho, and S. Yoo, "Hybrid multilayer transparent electrodes for ultra flexible OLED displays," *Flexible Electron., Displays Conf.*, Phoenix, USA, Feb. 2009.  
[5] S. Han, W. Shin, M. Seo, D. Gupta, and S. Yoo, "Enhanced performance in organic solar cells using thermally-evaporated Tungsten Oxide interlayer and its Application to ITO-free organic solar cells," *Spring Material Research Soc. Meeting*, San Francisco, USA, Apr. 2009.

### OTHER ACCOMPLISHMENTS (2008/2009)

[1] 4 Patents



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## Communication Electronics Laboratory

Communication Electronics Laboratory explores a vision of multi-functional and intelligent devices, systems and algorithms to provide more efficient and seamless information communications. Our research areas of interest include solid-state nano-scale devices, ultra-small intelligent RF devices & systems, and also smart systems & algorithms for future wireless applications.

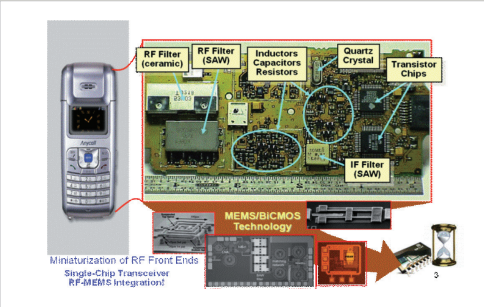


Fig. 1 Miniaturization of RF systems

Recently, our research efforts have been mainly focused on communication hardware and software technologies involving ultra-small RF devices and MIMO (Multi-input multi-output) algorithms. More efforts are expected to be made to develop nano-scale solid-state devices based on the modeling, design and fabrication of novel structures. In addition, we have a keen interest in and are also working on the semiconductor technology-based RF devices and intelligent algorithms for smart wireless communications.

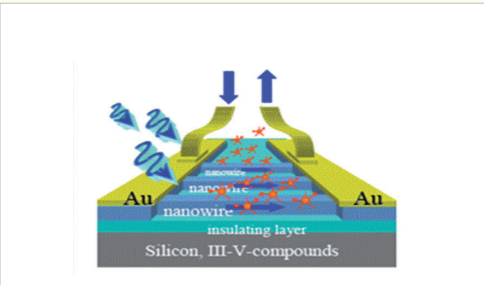


Fig. 2 Nano-scale Devices

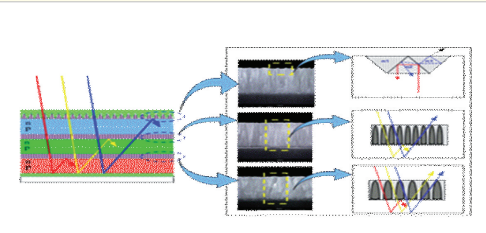


Fig. 3 Nano-Rods Structures

### KEY PUBLICATIONS (2008/2009)

- [1] L. Mai, V. Pham, and G. Yoon, "ZnO-based film bulk acoustic resonator devices on a specially designed Bragg reflector," *Appl. Phys. A*, vol. 95, pp. 667-671, Mar. 2009.
- [2] M. Le, V. Pham, L. Mai, and G. Yoon, "A low complexity branch-and-bound-based decoder for V-BLAST systems with PSK signals," *Signal Process.*, vol. 89, pp. 197-205, Feb. 2009.
- [3] L. Mai, V. Pham, and G. Yoon, "Second-order resonant ZnO-based film bulk acoustic resonator devices and thermal techniques to improve their resonant characteristics," *J. Vacuum Science, Techn.-A*, vol. 27, no. 1, pp. 67-72, Dec. 2008.
- [4] K. Humayun, V. Pham, and G. Yoon, "On the closed-form ergodic capacity of MIMO rayleigh channels," *IEEE Int. Conf. Adv. Comm. Techn.*, Phoenix Park, Korea, Feb. 2009.
- [5] L. Mai, J. Lee, V. Pham, and G. Yoon, "A new fabrication technique for 2.75 GHz ZnO-based FBAR Devices," *IEEE Int. Symp. Appl. Ferroelect.*, New Mexico, USA, Feb. 2008.

### OTHER ACCOMPLISHMENTS (2008/2009)

- [1] 1 Award
- [2] 1 PhD Graduate

## 3D Micro-Nano Structures Laboratory

3D Micro-Nano Structures Lab. has been focusing on micromachining technologies for 3D structures with micro to nano size and has applied these in Korea-strong fields such as display, memory and wireless telecommunication.

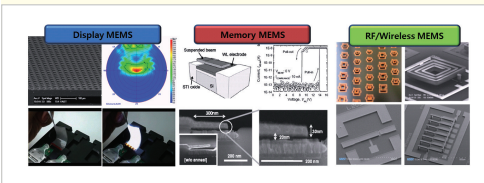


Fig. 1 Korea-strong MEMS/NEMS: Display, Memory and RF/Wireless MEMS

In the Display MEMS, we have researched novel backlight unit (BLU) and flexible front light guide (FLU) unit for liquid crystal display (LCD) or reflective type display. We also have demonstrated see-through LCDs using transparent light-guide and a novel method of using MEMS switches in Driving AMOLED in 2008.

In the Memory MEMS, we proposed the mechanical memory which was produced using MEMS/NEMS technology. Our laboratory has proposed original DRAM-like mechanical memory. We developed the 'smallest' NEMS switch with 30 nm-thick beam and 15 nm-thick air-gap for high density non-volatile memory applications in 2008. In RF/Microwave MEMS, passive components such as RF inductor, variable capacitor, and microwave antenna have been researched. Specially, we have gone deeper into study about modeling, design, and fabrication of MEMS inductors for a long time.

### KEY PUBLICATIONS (2008/2009)

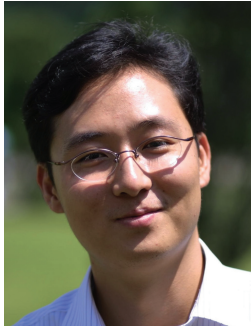
- [1] W. W. Jang, J.-O. Lee, H. H. Yang, and J.-B. Yoon, "Mechanically operated random access memory (MORAM) based on an electrostatic microswitch for nonvolatile

memory applications," *IEEE Trans. Electron Dev.*, vol. 55, no. 10, pp. 2785-2789, Oct. 2008.

- [2] W. W. Jang, J.-O. Lee, H. H. Yang, J.-B. Yoon, M.-S. Kim, J.-M. Lee, S.-M. Kim, K.-H. Cho, D.-W. Kim, D. Park, and W.-S. Lee, "Fabrication and characterization of a nanoelectromechanical switch with 15nm-thick suspension air-gap," *Appl. Phys. Lett.* vol. 92, no. 10, pp. 103110-1-103110-3, Jan. 2008.
- [3] J.-O. Lee, H.-H. Yang, and J.-B. Yoon, "A new method of driving an AMOLED with MEMS switches," *IEEE MEMS Conf.*, Tucson, USA, Feb. 2008.
- [4] H. S. Lee, Y. J. Yoon, D.-H. Choi, and J.-B. Yoon, "High-Q, tunable-gap MEMS variable capacitor actuated with an electrically floating plate," *IEEE MEMS Conf.*, Tucson, USA, Jan. 2008.

### OTHER ACCOMPLISHMENTS (2008/2009)

- [1] 1 Patent, 2 Awards
- [2] 2 MS Graduates



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## RF System Solution Laboratory

The Radio Frequency System Solution Lab (RFSS Lab) primarily focuses on making RF systems more optimal, reliable and efficient for the future wireless environment. Currently, main research areas include hybrid and integrated RF system, minimized and multiband antenna, applications using electromagnetic analysis, etc.

In the system area, six-port applications for RF system architecture which enables wide bandwidth, low cost and low power are actively studied. We also investigate a simulation environment similar to a real condition for which the parameters of digital and RF components are controllable in tag-to-reader or reader-to-tag communication in the UHF band. In the antenna area, researches in quadrifilar antenna which consists of four antennas winding up along the same direction, and minimized and multi-band antenna are ongoing.

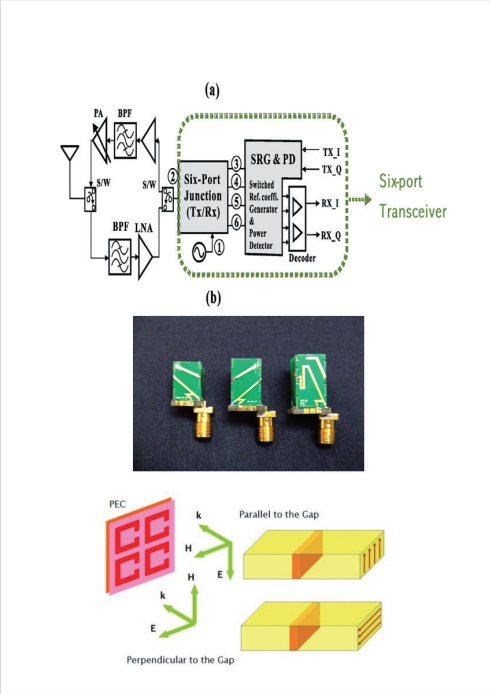


Fig. 1

In the field of electromagnetic analysis, electromagnetic imaging for breast cancer, and security applications based on electromagnetic characteristic such as RFID are studied.

### KEY PUBLICATIONS (2008/2009)

- [1] W. G. Lim, S. Y. Park, W. I. Son, M. Q. Lee, and J. W. Yu, "RFID reader front-end having robust Tx leakage canceller for load variation," *IEEE Trans. Microw. Theory, Techn.*, vol. 57, no. 5, pp. 1348-1355, May 2009.
- [2] D. Z. Kim and J. W. Yu, "Wide-band planar monopole antenna with triple band-notched slots," *J. Electromagn. Waves, Appl.*, vol. 23, no. 1, pp. 117-128, Jan. 2009.
- [3] W. G. Lim, W. I. Son, K. S. Oh, W. K. Lim, and J. W. Yu, "Compact integrated antenna with circulator for UHF RFID system," *IEEE Ant., Wireless Prop. Lett.*, vol. 7, pp. 673-675, 2008.
- [4] W. I. Son, W. G. Lim, M. Q. Lee, S. B. Min, and J. W. Yu "Printed square quadrifilar helix antenna (QHA) for GPS receiver," *Europ. Microw. Conf.*, Amsterdam, Netherlands, Oct. 2008.
- [5] W. S. Jeong, S. Y. Lee, W. G. Lim, H. Lim, and J. W. Yu, "Tunable band-notched ultra wideband (UWB) planar monopole antennas using varactor," *Europ. Microw. Conf.*, Amsterdam, Netherlands, Oct. 2008.

### OTHER ACCOMPLISHMENTS (2008/2009)

- [1] 3 Patents, 3 Awards

Research Centers



# Research Centers

- Center for Advanced Flexible Display Convergence (CAFDC)**  
Director: Prof. Kyung Cheol Choi  
Sponsor: National Research Foundation

  - CAFDC conducts interdisciplinary convergence of basic research related to next generation flexible display devices, materials, and driving methods. CAFDC has set its aim high to develop display devices in the spirit of Anywhere, Any Size, and Anytime for the approaching ubiquitous era.
- Center for Robot Intelligence Technology (RIT)**  
Director: Prof. Jong-Hwan Kim  
Sponsor: Institute for Information Technology Advancement

  - RIT center guides the leadership of technical innovation from ‘information technology’ to ‘intelligence technology’. The center proposes 6 types of robot intelligence (CI, SI, BI, AI, GI, SI) and realizes each of them through 5 core technologies (EC, FL, NN, DES, ML) and 5 detail technologies (Cognitive Architecture, Voice Recognition, HRI, Task Scheduling, Learning).
- Center for Robot Vision and Perception (CRVP)**  
Director: Prof. Myung Jin Chung  
Sponsor: Ministry of Knowledge Economy

  - CRVP consists of 4 professors and 42 students. CRVP is currently focusing on the development of 3D sensing and vision based human/object perception for intelligent robots.
- Display Research Center (DRC)**  
Director: Prof. Gun-Woo Moon  
Sponsor: Samsung Electronics

  - DRC consists of 12 professors and 80 students who conduct research in the field of LCD and displays.
- Human-Friendly Welfare Robot System Research Center (HWRS)**  
Director: Prof. Zeungnam Bien  
Sponsor: National Research Foundation

  - HWRS consists of 21 professors and 66 students. HWRS is currently focusing on the development of both a human-oriented robot system as well as a variety of related core technologies with an emphasis on human-friendly welfare.

- IC Design Education Center (IDEC)**  
Director: Prof. Chong-Min Kyung  
Sponsor: Ministry of Commerce, Industry and Energy

  - IDEC was founded by the Ministry of Commerce, Industry and Energy to cultivate design experts in the field of non-memory IC. IDEC provides each working group in each university with CAD tools, computing platforms and related technologies. IDEC offers the lectures, CAD tool training classes and CD-ROMs of the open lectures and books relevant to IC design.
- Image Information Research Center (IIRC)**  
Director: Prof. Jong Beom Ra  
Sponsor: Agency for Defense Development

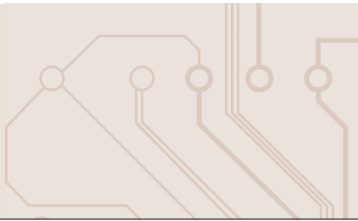
  - IIRC consists of 20 professors and 19 students conducting research in the field of image information.
- Intelligent Radio Engineering Center (IREC)**  
Director: Prof. Chul Soon Park  
Sponsor: National Research Foundation

  - The mission of the IREC is to acquire the “Universal Radio Solution with Unlimited Connectivity” to cope with convergence among the mobile, WLAN, WPAN, broadcasting, and sensor networks. 14 Professors and more than 100 students are engaged in the IREC.
- Intelligent Robot Vision Systems Research Center (IRVS)**  
Director: Prof. In So Kweon  
Sponsor: Samsung Techwin

  - The center is working to develop intelligent robot vision systems using multiple sensors and mobile robots.
- Mobile Media Platform Center (MMPC)**  
Director: Prof. Hwang Soo Lee  
Sponsor: Texas Instruments, Korea Institute for Advancement of Technology

  - MMPC consists of 9 professors and 50 students. MMPC was established to develop mobile multimedia platform technology.





**Mobile Multimedia Research Center (MMRC)**

Director: Prof. Joongsoo Ma

Sponsor: Ministry of Knowledge Economy

- MMRC consists of 9 professors and 60 students. MMRC is developing fundamental technologies and prototypes for Mobile Tactical Communication System and Ad Hoc Mesh Network.



**Next Image Systems Research Center (NIS)**

Director: Prof. In So Kweon

Sponsor: Samsung Electronics

- NIS consists of eight professors and more than 20 students. NIS is trying to investigate the new concept of image systems in the next generation. Accordingly the core technology in both hardware and software systems will be developed.



**Optical Internet Research Center (OIRC)**

Director: Prof. Minho Kang

Sponsor: National Research Foundation

- OIRC consists of 12 professors and 80 students. OIRC is first aimed to put the invention practice use and get core patents for GMPLS over AOBS. Second, it purpose to investigate for the metro-access architectures and applications in AOBS, and finally conduct researches in the blue ocean of the optical internet.



**Power Electronics Research Center (PERC)**

Director: Prof. Gun-Woo Moon

Sponsor: Samsung Electro-Mechanics

- PERC consists of one professor and 18 students. PREC is working to develop the best products in the world in the terms of both servers and adapters while collaborating with 12 experts from Samsung Electro-Mechanics.

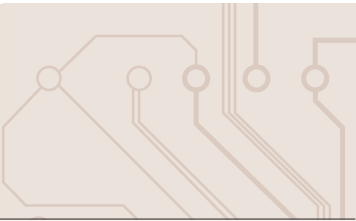


**Radio Education and Research Center (RERC)**

Director: Prof. Hyuckjae Lee

Sponsor: Korea Communications Commission

- Funded by the Korea Communications Commission, the RERC has been established to be a major educational center to cultivate students and professionals in the radio technology field and to boost the global competitiveness of radio technology industry through systematic development of new educational materials both online and offline.



**Radiowave Detection Research Center (RDRC)**

Director: Prof. Noh-Hoon Myung

Sponsor: Agency for Defense Development

- RDRC consists of 13 professors and 11 students. RDRC works to develop next generation mobile systems and digital television broadcasting systems using the uniform geometric theory of diffraction, finite difference time domain analysis and the design of a RF headlcoil for 3T MRI, EMI/EMC and related technologies.



**Samsung Research Center (SRC)**

Director: Prof. Youngnam Han

Sponsor: Samsung Electronics

- SRC consisted of 7 professors and 40 students who conduct research in the field of uHealth and 4G wireless communication systems. Currently, 2 professors and 6students are invloved in Samsung sponsored research.



**SoC Initiative for Ubiquity and Mobility (SoCium)**

Director: Prof. Chong-Min Kyung

Sponsor: Samsung Electronics, LG Electronics, Core-Logic, Enter-Tech

- SoCium consists of 14 professors and 100 students. SoCium produces experts in the field of SoC design and industry.



**System Design Innovation and Application Research Center (SDIA)**

Director: Prof. Hoi-Jun Yoo

Sponsor: Institute for Information Technology Advancement

- SDIA focus on the research, development of some platforms and application of intelligent robots, wearable computers and bio systems.



**Wireless Technology Center (WTC)**

Director: Prof. Songcheol Hong

Sponsor: Samsung Electro-Mechanics

- WTC, consisting of 4 professors and 37 students, is working to develop next generation wireless technology. The center does research on the front-end module and future transmitter system.



Undergraduate Courses

Classification	Subject No.	Subject Name	Lecture:Lab.: Credit (Homework)	Semester	Remark
Mandatory Major Course	EE305	Analog Electronics Design Lab	1:6:3 (6)	Spring	
	EE306	Digital Electronics Design Lab	1:6:3 (6)	Fall	
	EE405	Electronics Design Lab.	1:6:3 (6)	Spring	
Elective Major Course (Select 4 or more out of 8)	EE201	Circuit Theory	3:0:3 (6)	Spring	*CS211
	EE202	Signals and Systems	3:0:3 (6)	Fall	
	EE203	Digital System Design	3:0:3 (6)	Spring	
	EE204	Electromagnetics	3:0:3 (6)	Fall	
	EE206	Electronic Circuits	3:0:3 (6)	Fall	
	EE209	Programming for Electrical Engineering	3:0:3 (6)	Spring	
	EE211	Introduction to Physical Electronics	3:0:3 (6)	Spring	
	EE301	Analog Circuits	3:0:3 (6)	Spring	
Elective Major Course	EE205	Data Organization for Engineering Application	3:1:3 (6)	Spring	*CS311
	EE210	Probability and Introductory Random Processes	3:0:3 (6)	Fall	
	EE308	Applied Electronics Lab.	1:6:3 (6)	Fall	
	EE312	Introduction to Computer Architecture	3:1:3 (6)	Fall	
	EE321	Communication Engineering	3:0:3 (6)	Spring	
	EE341	Electromagnetic Waves and Antennas	3:0:3 (6)	Spring	
	EE342	Radio Engineering	3:1:3 (6)	Fall	
	EE372	Integrated Circuits Design	3:0:3 (6)	Fall	
	EE381	Control System Engineering	3:0:3 (6)	Spring	
	EE391	Electronic Control of Electric Machines	3:0:3 (6)	Spring	
	EE401	Communication Skills	2:0:2 (4)	Spring	
	EE402	Future Society and Electrical Engineering	2:0:2 (4)	Fall	
	EE406	Project Lab	1:6:3 (6)	Fall	
	EE411	Switching and Automata Theory	3:0:3 (6)	Spring	
	EE413	Networking Design and Programming	3:1:3 (6)	Spring	
	EE414	Embedded Systems	3:1:3 (6)	Fall	
	EE421	Communication Systems	3:0:3(6)	Spring	
	EE432	Digital Signal Processing	3:0:3 (6)	Fall	
	EE441	Introduction to Fiber Optic Communication Systems	3:0:3 (6)	Spring	
	EE461	Semiconductor Devices	3:0:3 (6)	Fall	
Research	EE481	Intelligent Systems	3:0:3 (6)	Spring	
	EE484	Special Topics in Electrical Engineering	3:0:3 (6)	Spring·Fall	
	EE485	Special Topics in Electronics Engineering I	1:0:1	Spring·Fall	
	EE486	Special Topics in Electronics Engineering II	2:0:2	Spring·Fall	
	EE490	B.S. Thesis Research	0:6:3		
	EE495	Individual Study	0:6:1		
	EE496	Seminar	1:0:1	Spring	

Notes. i) 400 level course credits except EE405, EE406 can be counted as master course credits.  
ii) “\*” mark represents a substitutive subject.

Graduate Courses

Classification	Subject No.	Subject Name	Lecture:Lab.: Credit (Homework)	Semester	Remark
General Course (Select 1 out of 7)	CC010	Special Lecture on Leadership	1:0:0	Fall	*EE528
	CC020	Ethics and Safety I	1AU	Spring·Fall	
	CC500	Scientific Writing	3:0:3 (4)	Spring·Fall	
	CC510	Introduction to Computer Application	2:3:3 (10)	Spring·Fall	
	CC511	Probability and Statistics	2:3:3 (6)	Spring·Fall	
	CC512	Introduction to Materials and Engineering	3:0:3 (3)	Spring·Fall	
	CC513	Engineering Economy and Cost Analysis	3:0:3 (6)	Fall	
	CC530	Enterpreneurship and Business Strategies	3:0:3 (6)	Fall	
	CC531	Patent Analysis and Invention Disclosure	3:0:3 (6)	Spring·Fall	
	CC532	Collaborative System Design and Engineering	4:0:4	Spring	
Mandatory Major Course	EE505	Electronics design Lab.	1:6:3 (6)	Spring	
Elective Major Course	EE511	Computer Architecture	3:0:3 (6)	Spring	*CS655
	EE512	System Programming	3:0:3 (6)	Fall	
	EE516	Embedded Software	1:6:3 (6)	Fall	
	EE520	Telecommunication Networks	3:0:3 (6)	Spring	
	EE522	Advanced Communication Systems	3:0:3 (6)	Fall	
	EE524	Telecommunication Software Design	3:1:3 (6)	Fall	
	EE525	Networking Technology and Applications	1:6:3 (6)	Spring	
	EE526	Telephone and Internet Telephony Networks	3:0:3 (6)	Fall	
	EE527	Data Communication	3:0:3 (6)	Spring	
	EE528	Engineering Random Processes	3:0:3 (6)	Spring	
	EE531	Statistical Learning Theory	3:0:3 (6)	Fall	
	EE533	Digital Speech Processing	3:0:3 (6)	Spring	
	EE535	Digital Image Processing	3:0:3 (6)	Spring	
	EE538	Neural Networks	3:0:3 (6)	Fall	
	EE539	Nonlinear Statistical Signal Processing	3:0:3 (6)	Spring	
	EE541	Electromagnetic Theory	3:0:3 (6)	Spring	
	EE542	Microwave Engineering	3:1:3 (6)	Fall	
	EE546	Fields and Waves	3:0:3 (6)	Fall	
	EE555	Optical Electronics	3:0:3 (6)	Spring	
	EE561	Introduction to VLSI Devices	3:0:3 (6)	Spring	
	EE563	Display Engineering	3:0:3 (6)	Spring	
	EE565	Modern Physics for Engineers	3:0:3 (6)	Spring	
	EE566	MEMS in EE Perspective	3:0:3 (6)	Fall	
	EE567	Photovoltaic Power Generation	3:0:3 (6)	Fall	
	EE568	Introduction to Organic Electronics	3:0:3 (6)	Fall	
	EE571	Advanced Electronic Circuits	3:0:3 (6)	Spring	
	EE573	Introduction to VLSI Systems	3:0:3 (6)	Spring	
	EE574	Computer Aided Design of VLSI Circuits and Systems	3:0:3 (6)	Fall	
	EE581	Linear Systems	3:0:3 (6)	Spring	
	EE582	Digital Control	3:1:3 (6)	Spring	
	EE594	Power Electronics Systems	3:0:3 (6)	Fall	
	EE612	Discrete Event System Modeling and Simulation	3:0:3 (6)	Fall	
	EE621	Coding Theory	3:0:3 (6)	Spring	
	EE622	Signal Detection Theory	3:0:3 (6)	Fall	
	EE623	Information Theory	3:0:3 (6)	Spring	
	EE624	Mobile Communication Systems	3:0:3 (6)	Fall	
	EE625	Applied Detection and Estimation	3:0:3 (6)	Spring	
	EE627	Performance Analysis of Communication Networks	3:0:3 (6)	Spring	
	EE628	Visual Communication Systems	3:0:3 (6)	Fall	
	EE631	Advanced Digital Signal Processing	3:0:3 (6)	Spring	



Classification	Subject No.	Subject Name	Lecture:Lab.: Credit (Homework)	Semester	Remark
Elective Major Course	EE634	Pattern Recognition	3:0:3 (6)	Fall	*CS676
	EE641	Monolithic Microwave Integrated Circuits	3:0:3 (6)	Fall	
	EE652	Optical Communication	3:0:3 (6)	Fall	
	EE661	Solid State Physics	3:0:3 (6)	Spring	
	EE663	High Frequency Electronic Devices	3:0:3 (6)	Spring	
	EE665	CMOS Front-End Process Technology	3:0:3 (6)	Spring	
	EE676	Analog Integrated Circuits	3:0:3 (6)	Fall	
	EE678	Digital Integrated Circuits	3:0:3 (6)	Fall	
	EE681	Nonlinear Control	3:0:3 (6)	Fall	
	EE682	Intelligent Control Theory	3:0:3 (6)	Fall	
	EE683	Robot Control	3:0:3 (6)	Fall	
	EE684	Evolutionary Computation	3:0:3 (6)	Fall	
	EE686	Optimization Theory	3:0:3 (6)	Fall	
	EE687	Real-Time Control	3:0:3 (6)	Spring	
	EE722	Advanced Signal Detection	3:0:3 (6)	Fall	
	EE724	Parallel and Distributed Computation	3:0:3 (6)	Fall	
	EE726	Optimization in Communication Networks	3:0:3 (6)	Fall	
	EE731	Adaptive Signal Processing	3:0:3 (6)	Spring	
	EE733	Multirate Signal Processing	3:0:3 (6)	Spring	
	EE735	Computer Vision	3:0:3 (6)	Spring	
	EE737	Imaging Systems	3:0:3 (6)	Spring	
	EE741	Radiation and Diffraction of Waves	3:0:3 (6)	Spring	
	EE742	Ray Analysis for Electromagnetic Scattering Problems	3:0:3 (6)	Fall	
	EE745	EMI/EMC Design and Analysis	3:0:3 (6)	Spring	
	EE757	Nonlinear Fiber Optics	3:0:3 (6)	Spring	
	EE762	Advanced MOS Device Physics	3:0:3 (6)	Fall	
	EE783	Adaptive Control Theory	3:0:3 (6)	Spring	
	EE785	Robust Control Theory	3:0:3 (6)	Spring	
	EE786	Optimal Control Theory	3:0:3 (6)	Fall	
	EE788	Robot Cognition and Planning	3:0:3 (6)	Fall	
	EE791	Power Conversion Circuits and Systems	3:0:3 (6)	Spring	
	EE807	Special Topics in Electrical Engineering	3:0:3 (6)	Spring	
	EE808	Special Topics in Electronics Engineering I	1:0:1	Spring, Fall	
	EE809	Special Topics in Electronics Engineering II	2:0:2	Spring, Fall	
	EE817	Special Topics in Computer Engineering	3:0:3 (6)	Spring	
	EE827	Special Topics in Communication	3:0:3 (6)	Spring	
	EE837	Special Topics in Signal Processing	3:0:3 (6)	Spring, Fall	
	EE838	Special Topics in Image Engineering	3:0:3 (6)	Fall	
	EE847	Special Topics in Electromagnetics	3:0:3 (6)	Spring, Fall	
	EE857	Special Topics in Optical Engineering	3:0:3 (6)	Spring	
	EE867	Special Topics in Physical Electronics	3:0:3 (6)	Spring, Fall	
	EE868	Special Topics in Solid-State Physics	3:0:3 (6)	Fall	
	EE877	Special Topics in Integrated Circuits	3:0:3 (6)	Spring, Fall	
	EE878	Special Topics in VLSI	3:0:3 (6)	Fall	
	EE887	Special Topics in Robotics	3:0:3 (6)	Spring	
	EE888	Special Topics in Control Theory	3:0:3 (6)	Spring, Fall	
	EE897	Special Topics in Power Electronics	3:0:3 (6)	Spring	
	EE898	Special Topics in Intelligent Information Processing	3:0:3 (6)	Fall	
Research	EE960	M.S. Thesis			
	EE966	M.S. Seminar	1:0:1	Spring	
	EE980	Ph.D. Thesis			
	EE966	Ph.D. Seminar	1:0:1	Spring	
	EE990	Technical Writing	1:0:1(2)	Fall	

Notes. i) 500 level course credits except EE505, EE525 can be counted as bachelor course credits.  
ii) "\*" mark represents a substitutive subject

## Global Advisory Committee



●  
Professor  
**Yongmin Kim**  
University of Washington



●  
Professor  
**Karen Maex**  
Katholieke Universiteit Leuven



●  
Professor  
**Jasprit Singh**  
University of Michigan



# Special Programs

## Government-Sponsored Program

### Brain Korea 21 (BK21)

BK 21 School of Information Technology (IT) of KAIST aims to develop a world-class research-oriented graduate program. Specifically, our goal is to improve the graduate program so that its quality reaches a level comparable to that of the top level universities in the world. IT is widely expected to play an essential role in the information-oriented society of the 21st century, and the School of IT is committed to playing a pioneering role in conducting research and educating students who will become leaders in Korea. The School of IT is consists of 9 groups with 74 professors, 30 researchers and 800 graduate students. The average annual budget for the school of IT is about 28 million dollars which comes from the government, industry, and KAIST.



## Industry-Sponsored Programs

### Cooperative Telecommunication Education Program (CTEP)

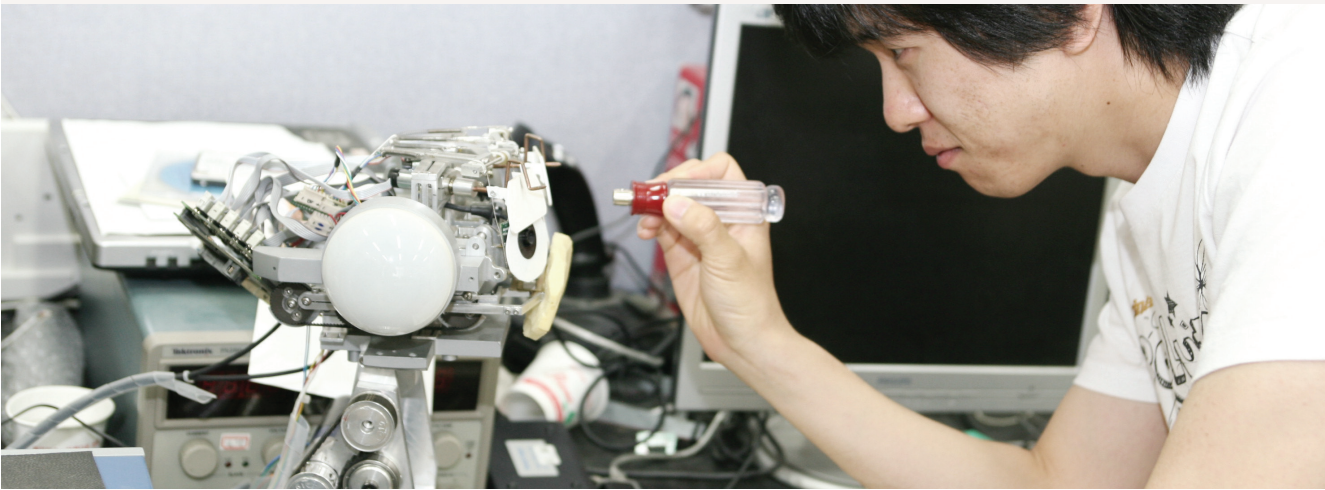
CTEP was established to promote education in date transmission, networking and network application. This program provides the participating students with a scholarship and appropriate facilities for IT education. CTEP students are industry-university cooperative scholarship students supported by the companies participating in CTEP such as Dacom, KTF, LG Electronics, and Hanaro Telecom. This program has been started in 1998 as a cooperative educational program in collaboration with the four departments/divisions; Electrical Engineering, Computer Science, Industrial Engineering and Applied Mathematics. Homepage: <http://ktep.kaist.ac.kr>

### Educational Program for Samsung Semiconductor (EPSS)

EPSS at KAIST was founded in August, 2005 to cultivate human resources that will become the pioneers in the semiconductor technology through the world in the 21st century with joint efforts of the five departments (Electrical Engineering, Physics, Biological & Chemical Engineering, Material Engineering, Chemistry) at KAIST and the sponsor of Samsung Electronics. This program makes an effort to produce high quality and multidisciplinary human resources by offering the customized programs and to set a successfully collaborative model with both industry and university. Homepage: <http://epss.kaist.ac.kr>

### KAIST Education Program for Semiconductor Industry (KEPSI)

KEPSI was established in 1996 as a response to the demand of semiconductor industries to foster high qualified semiconductor engineers who can play a leading role in the area of semiconductors and integrated circuits for information technologies. This program is supported by the participating companies, especially Hynix Semiconductor. Homepage: <http://kepsi.kaist.ac.kr>





## Admission to Graduate Program

### 1. Scholarships for Graduate Students

Every graduate student at KAIST is eligible for one of the following scholarships:

- A. Government Scholarship (sponsored by the government)
- B. KAIST Scholarship (sponsored by the research fund of a faculty member or such industry-funded education programs as CTEP, KEPSI, EPSS, etc.)
- C. General Scholarship (sponsored by outside organizations)

### 2. Advisor Assignment

- A. A student with Government Scholarship shall be assigned a faculty member in the Department by the Head.
- B. A student with KAIST Scholarship shall be assigned a faculty member who has in advance requested students under the special education programs. The field of the student's research may have been pre-determined if the student is supported by the research fund of a faculty member.
- C. A student with General Scholarship shall be assigned a faculty member in the field of research specified by the sponsoring organization.

### 3. Admissions Process

Once an applicant submits the academic information together with English score (TOEFL, TOEIC, TEPS, IEPS), the Admissions Committee will review the application material and then interview qualified applicants as necessary. For more information, please visit <http://admission.kaist.ac.kr>



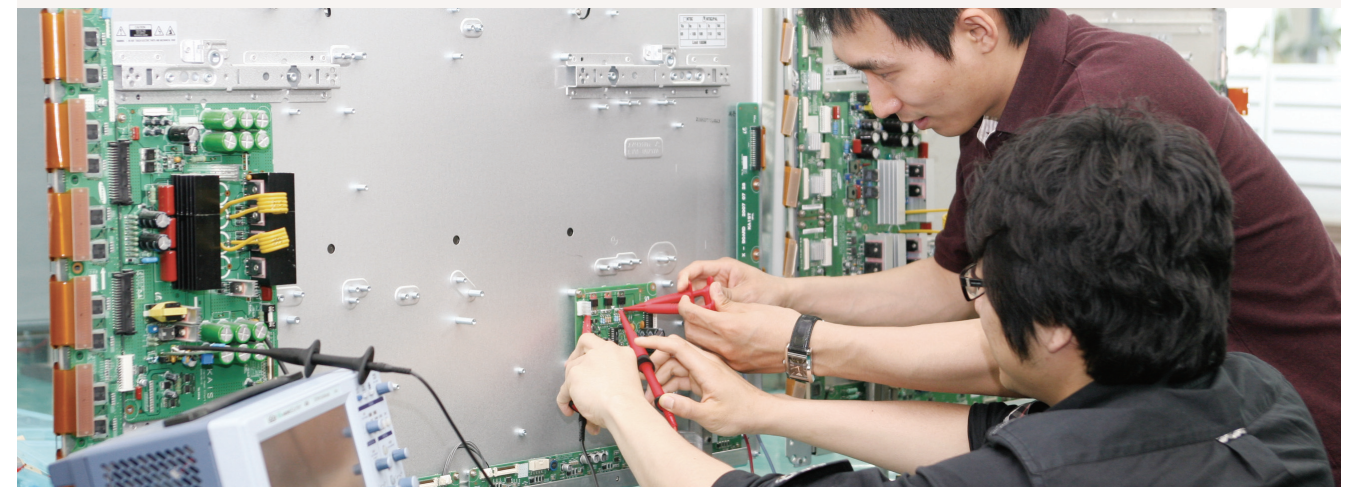
## 대학원 입학 안내

### 1. 학생구분

- ① 국비 장학생: 교육경비의 일부를 한국과학기술원이 확보한 정부예산으로 지원 받는 학생.
- ② 과학기술원 장학생: 교육경비의 일부를 교육 프로그램 (CTEP, KEPSI, EPSS), 한국과학기술원에서 조성한 장학금, 외부출연금, 교수 수탁과제 연구비, 연구센터 운영비에서 지원 받는 학생 (교수 수탁과제 연구비에서 지원받는 과학기술원 장학생은 해당 과제에 따라 연구 분야가 제한될 수 있음).
- ③ 일반 장학생: 교육경비의 전부 또는 일부를 입학추천기관에서 지원 받는 학생.
- ④ 지원자는 입학 원서에 학생구분을 3지망까지 순위를 매겨 적어 낼 수 있습니다. 그 순위를 바탕으로 한국과학기술원이 학생구분을 정해 최종 합격자를 발표하며, 따라서 2지망이나 3지망으로 합격될 수도 있음을 참고하시기 바랍니다.

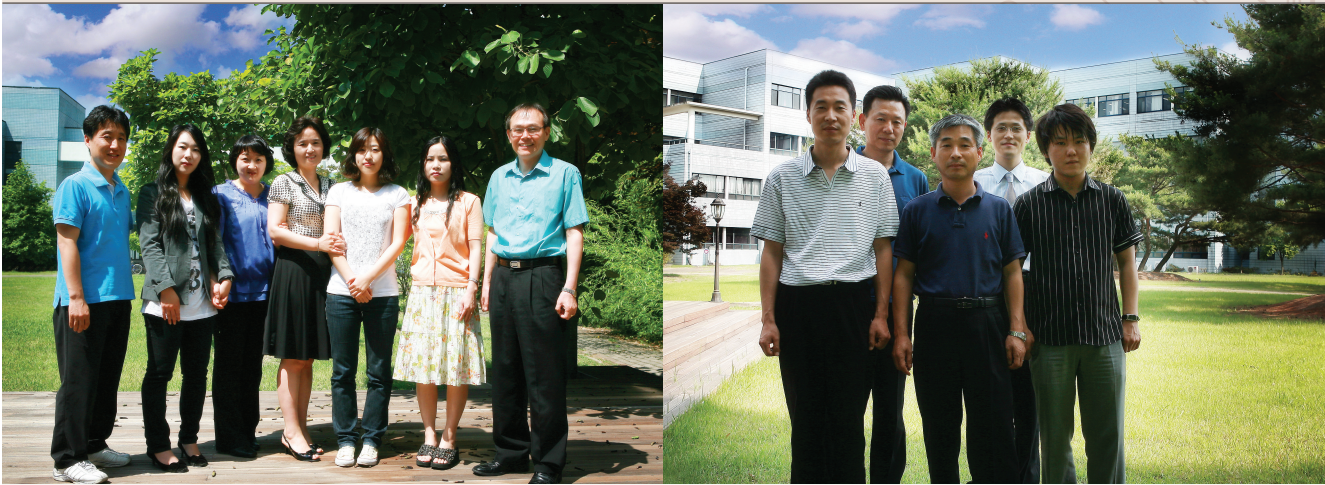
### 2. 전형방법

- ① 1차 전형: 서류심사 (영어성적 포함)
  - ② 2차 전형: 면접시험
- ※자세한 사항은 학교 누리집 <http://admission.kaist.ac.kr>에서 보실 수 있습니다.





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The Location



- East Campus Map**

E1 • Main Gate  
E2 • Industrial Engineering and Management  
E3 • Information and Electronics  
    ① Division of Computer Science  
    ② Division of Electrical Engineering  
    ③ Image Processing  
    ④ Semiconductor  
E4 • Stadium  
E5 • Faculty Hall  
E6 • Natural Science  
E7 • Biomedical Research Center  
E8 • East Dormitory  
E9 • Digital Science Library  
E10 • Storehouse  
E11 • Creative Learning  
E12 • Energy Plant
- E13 • Satellite Technology Research Center  
E14 • Main Administration  
E15 • Auditorium  
E16 • ChungMoonsoul  
E18 • Bio Model System Park  
E19 • Nano  
    ① Socium Research Center  
    ② National Nano Feb Center  
E20 • Kye Ryoung Hall

**West Campus Map**

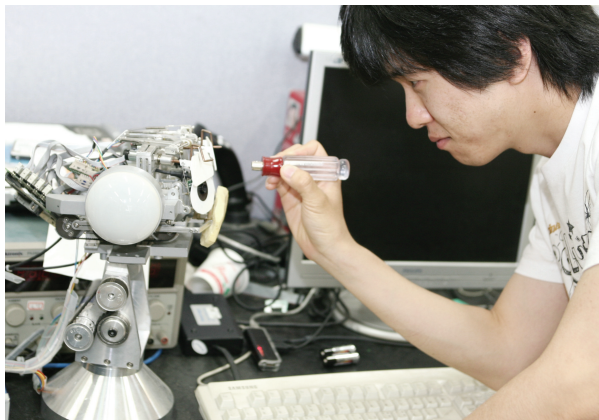
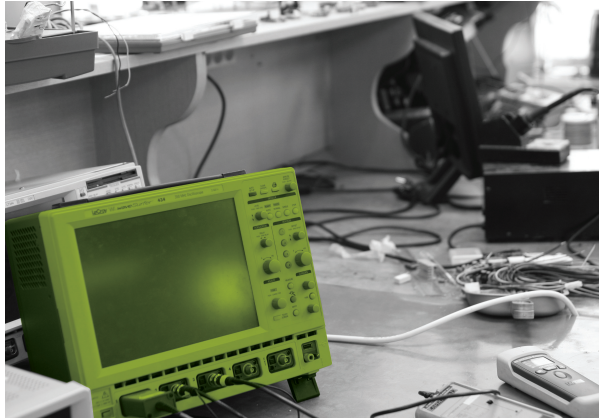
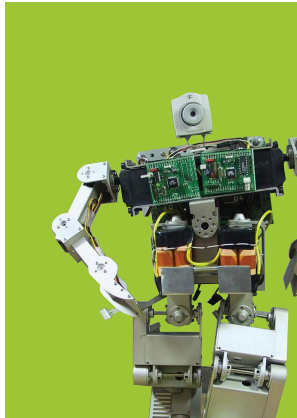
W1 • Applied Engineering  
W2 • Student Center-1  
W3 • West Dormitory  
W4 • Dasom Hall  
W5 • Married Students Housing  
W6 • West Energy Plant
- E13 • Nanum Hall  
W8 • Educational Support  
W9 • Outdoor Theater  
W10 • Wind Tunnel Laboratory  
W11 • Tear Gate

**North Campus Map**

N1 • East Gate  
N2 • Branch Administration  
N3 • Gymnasium  
N4 • School of Humanities and Social Science  
N5 • Basic Experieiment and Research  
N6 • Faculty Club  
N7 • Mechanical Engineering  
N8 • Department of Industrial Design  
N9 • Practice  
N10 • Unedrgraduate Library
- N11 • Cafeteria  
N12 • Student Center-2  
N13 • Tea Wul Gwan  
N14 • Sarang Hall  
N15 • Bachelors Housing-2  
N16 • Somang Hall  
N17 • Seongsil Hall  
N18 • Jilti Hall  
N19 • Areum Hall  
N20 • Silloe Hall  
N21 • Jihye Hall  
N22 • Alumni Venture Hall  
N23 • fMRI Center  
N24 • LG Semicon Hall  
N25 • Energy and Environment Research Center  
N26 • CHIPS  
N27 • Hi-Tech Venture Hall



DEPARTMENT OF  
ELECTRICAL ENGINEERING



한국과학기술원  
전기 및 전자공학과  
연차보고서 2008/2009

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펴낸때: 2009년 8월