National Taiwan University
Graduate Institute of Communication Engineering Newsletter

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In this issue

Technology Developed in GICE

Principal Component Localization in Indoor WLAN Environments

from Communication and Signal Processing Group

The popularity of wireless infrastructure and mobile devices fulfills people's desire to access the required services ubiquitously. Indoor positioning is definitely one of the possibilities. Positioning in the wireless environments is highly desirable for many location-aware services such as visitor guidance and fraud detection. Since WLAN infrastructures are widespread and the received signal strength (RSS) sensor function is available in every 802.11 interface, the WLAN-RSS-based positioning is growing rapidly in importance. At present, the most viable solution for RSS-based indoor positioning is the fingerprinting architecture. The basic design of fingerprinting can be divided into two stages: offline and online. During the offline stage, RSS is collected at sampling locations to build the database called the radio map for the target environment. During the online stage, the physical (PHY) location of the client can be estimated by comparing the measured RSS with the stored RSS values in the database.

For resource-constrained handheld devices, accuracy is not the only aspect of the overall system. Factors such as the computational complexity, battery power, and the storage capacity need to be jointly considered. Choosing only a subset of detectable APs for the positioning is an intuitive way to reduce the computational burden on and storage requirement of the devices [1], [2]. However, such advantages usually come at the expense of performance. Only the information from selected APs is retained for the positioning, whereas those in unselected APs are totally discarded. Thus, our concept considered here is not individual information selection but rather information reorganization by combining RSSs. We squeeze the useful information into the relatively lower dimensions by a suitable transformation. The reduction of the data dimensions

(continued on page 2)

GICE Honors

- Professor Tzong-Lin Wu
  Honored 2013 IEEE Fellow

For contributions to noise mitigation technologies and EMC design on printed circuit board

- Chiu-Chih Chou
  Best Student Paper Award in 21st IEEE Conference on Electrical Performance on Electronic Packaging and Systems (EPEPS)
  (Advisor: Professor Tzong-Lin Wu)

- Tai-Hsiang Huang, Chen-Tai Kao
  2012 IEEE MMSP Workshop Top 10% Paper Award
  (Advisor: Homer H. Chen)

- Li-Yuan Fang, Shih-An Yang, Chin-Chia Chang, and Bing-Zhang Tsai
  1st Prize in the 2012 IEEE Antennas and Propagation Society Student Design Contest
  (Advisor: Prof. Shih-Yuan Chen)

Message from the Director

Tzong-Lin Wu

Professor& Director of GICE

2012 is a fruitful year for GICE. Several research outcome and developed technologies have been well recognized in international society. Three faculties of GICE, Prof. Homer Chen, Prof. Wanjiun Liao, and Prof. Kwang-Cheng Chen, are elected as IEEE Distinguished Lecturers. Our master program student, Chiu-Chih Chou, received the Best Student Paper Award in 21st IEEE Electrical Performance of Electronic Packaging and Systems (EPEPS). It is the fourth paper to be awarded as best paper award in IEEE prestigious conferences in past 3 years. The honors demonstrate again GICE's momentum in pursuit of academic excellence. Hopefully, you enjoy the reading of GICE Newsletter.
Happy New Year!

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leads to a decrease in the computational complexity. In addition, the performance can be further enhanced when the discarded information is in fact the redundant noise.

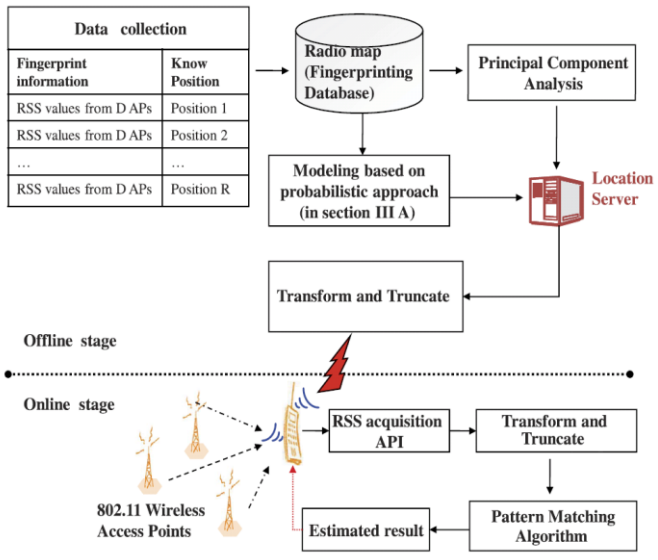

Figure. 1. The system architecture of the proposed positioning algorithm. First, the client downloads the transformed and truncated model parameters. Next, the online measured RSS is also transformed and truncated, so that the pattern matching algorithm can applied.

The proposed technique—based on Principal Component Analysis (PCA)—finds effective weightings that best present data in a least square sense. The technique can identify the redundancy behind multiple variables in order to obtain a compact description of it. This is achieved by transforming RSS to a new set of variables, namely principal components (PCs). As shown in Fig. 1, instead of choosing a subset of APs, our approach replaces the elements by a subset of PCs to avoid unnecessary calculations while ensuring the performance of accuracy. Moreover, our work presents an objective mechanism of determining the number of PCs, as the information quantification is feasible after the PCA transformation.

$$\begin{pmatrix} y_1 \\ \vdots \\ y_L \end{pmatrix}_{L*1} = \begin{pmatrix} a_{11} & a_{12} & \cdots & a_{1D} \\ a_{21} & a_{22} & \cdots & a_{2D} \\ \vdots & \vdots & \vdots & \\ a_{L1} & a_{L2} & \cdots & a_{LD} \end{pmatrix}_{L*D} \begin{pmatrix} x_1 \\ \vdots \\ x_D \end{pmatrix}_{D*1} \quad (1)$$

Our concept here is to reduce the dimensions by combining APs. In other words, we adopt information reorganization, rather than AP selection. As shown in (1), the principal components $[y_1,\ldots,y_L]^T$ are produced by a transformation with real numbers, and the vector, $X = [x_1, x_2,\ldots, x_D]^T \in R^{D*1}$, represents the measurement from available D APs, and the matrix, $A \in R^{L*D}$, $L \leq D$, represents transformation matrix containing the selective weighting describing which APs are chosen. With appropriate weightings, the information transmitted into Y from X can be maximized.

Our algorithm can be divided into two stages. The first stage illustrates how to produce location estimation from the derived PCs. Previous works show that in indoor environments, probabilistic approaches provide more accurate results than do deterministic approaches. Thus, our location system adopts a probabilistic approach. The second part illustrates PCA criterion. We report how to derive the transformation matrix such that the PCs can be obtained with quantified information [4].

In the experiments, our localization system was evaluated by collecting realistic RSS data in an indoor WLAN environment. The experiment was performed on the fifth floor of the electrical engineering building of National Taiwan University as shown in Fig. 2. Compared to the traditional approaches [1], [2], our algorithm shows both a considerable saving of computation and even better accuracy. As shown in Fig. 3, the numerical results show that the mean error is reduced by 33.75 percent and the complexity is decreased by 40 percent, respectively.

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Technology *(continued from page 2)*

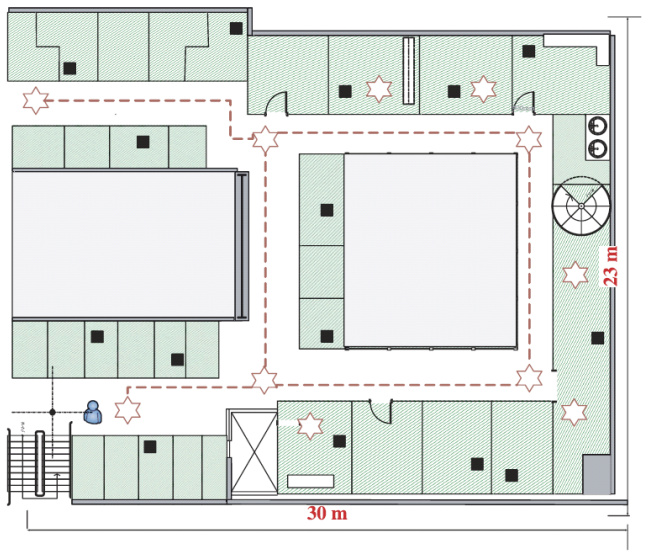

Fig. 2. Part of the fifth floor plane of NTU EE, where we have performed the experiments. The black dots show the locations of the APs.

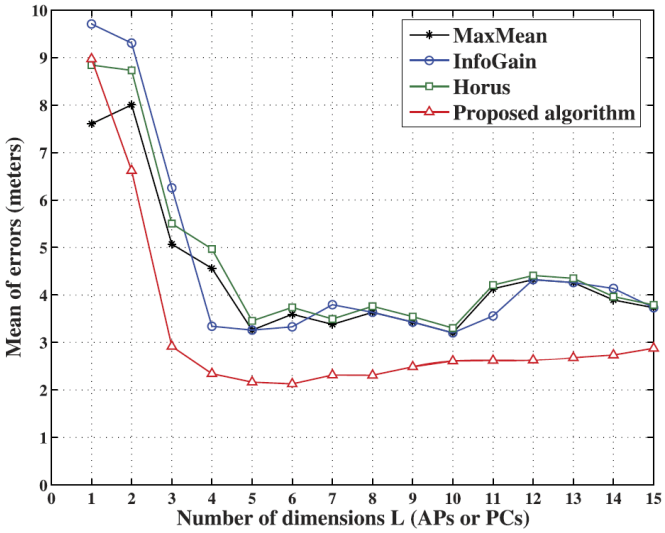

Fig. 3. Effect of the number of dimensions L versus the average error.

In [4], a novel, information-theoretic approach is presented to building a WLAN-based indoor positioning system. The proposed technique—based on principal component analysis—offers a more efficient mechanism to utilize information from all APs. Instead of choosing a small subset of available APs, our algorithm replaces the elements by a subset of PCs. The PCs are intelligently generated through a transformation such that the retained information is maximized to ensure the performance of accuracy. Moreover, an adequate number of PCs can be theoretically chosen to strike a graceful balance between positioning accuracy and system cost.

Due to the limitations of linear transformations, there may exist better approaches to extract the information and exclude the noises when the relationship of RSS contains a highly nonlinear effect. A possible future extension is to investigate some nonlinear approaches such as Isomap and the locally linear embedding techniques.

References

[1] M. Youssef, A. Agrawala, and A.U. Shankar, "WLAN Location Determination via Clustering and Probability Distributions," Proc. IEEE Int'l Conf. Pervasive Computing and Comm., pp. 143-150, 2003.

[2] Y. Chen, J. Yin, X. Chai, and Q. Yang, "Power-Efficient Access-Point Selection for Indoor Location Estimation," IEEE Trans. Knowledge and Data Eng., vol. 18, no. 7, pp. 877-888, July 2006.

[3] T. King, T. Haenselmann, and W. Effelsberg, "On-Demand Fingerprint Selection for 802.11-Based Positioning Systems," Proc.Int'l Symp.

[4] Shih-Hau Fang, and Tsungnan Lin, "Principal Component Localization in Indoor WLAN Environments," Mobile Computing, IEEE Transactions on , vol.11, no.1, pp.100-110, Jan. 2012

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Design and Analysis of A 77.3 % Locking Range Divide-by-4 Frequency Divider

from Electromagnetics Group

The microwave and millimeter wave frequency provide wide bandwidth which is suitable for wireless high-data-rate communication. Many applications such as the next generation 4G-LTE backhaul link and the short-range Cloud communications at 60 GHz utilize wide-band frequency resources for high data rate. Therefore, the wide-band high-speed local oscillator (LO) is an essential building block in today's wireless transceiver. However, the design of high-speed wide-band LO is not an easy task. The parasitic effect, large division ratio between output frequency and reference frequency, process variation makes the bandwidth and speed limited. These design bottlenecks need to be solved in frequency divider which is the key component on the feedback path of frequency synthesizer. For high-speed operation, the dynamic frequency divider such as injection-locked frequency divider (ILFD) and Miller divider can be used. The dynamic frequency divider has drawback of narrow bandwidth. Therefore, the bandwidth-enhanced techniques, which have been proposed in previously published work, achieve 42% and 28% bandwidth for ILFD and Miller divider, respectively.

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Technology (continued from page 3)

Due to the Federal Communication Commission (FCC) allocates the 22–29-GHz band for automotive radar systems, the application at 24-GHz frequency has become more attractive such as phase-array system, and frequency-modulated continuous wave (FMCW) radar. One of the key building blocks in these systems is the phase-locked loop (PLL). The PLL provides accurate local oscillation frequencies as shown in Fig. 1.

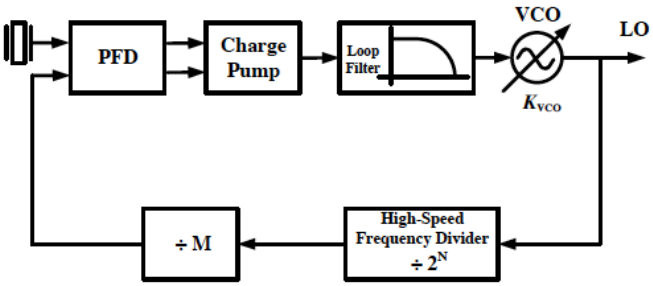

Fig. 1 The block diagram of the phase-locked loop (PLL).

Due to the frequency ratio of the voltage controlled oscillator (VCO) and the crystal oscillator is very large, PLL needs enormous frequency dividers (FDs) at its feedback path. The dividers need to provide large division number while consuming low dc power to enhance the battery lifetime. It is common to choose the current mode logic (CML) frequency divider at the feedback path of PLL which has the advantages of wide bandwidth and small area for the operating frequency below 20 GHz. However, when the operating frequency toward millimeter-wave (MMW) range, the CML divider increases its speed at the expense of high dc power consumption. As a result, the injection-locked frequency divider (ILFD) is usually adopted as the first-stage.

This article presents the design and analysis of an innovative divide-by-four frequency divider. To achieve wide bandwidth and low power consumption, the cascoded topology is selected to combine D2 ILFD and D2 CML dividers, which removes the buffer and transconductance stages between these two dividers. The cascoded topology of the proposed D4 FD has smaller parasitic capacitance which results in wider bandwidth. The CML is directly controlled by the current signal, I_x, of mixer output as shown in Fig. 2.

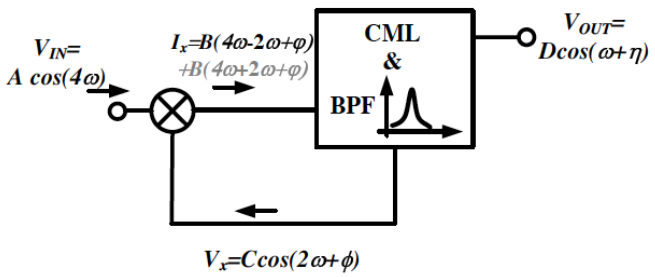

Fig. 2 The block diagram of the proposed divide-by-4 cascoded frequency divider.

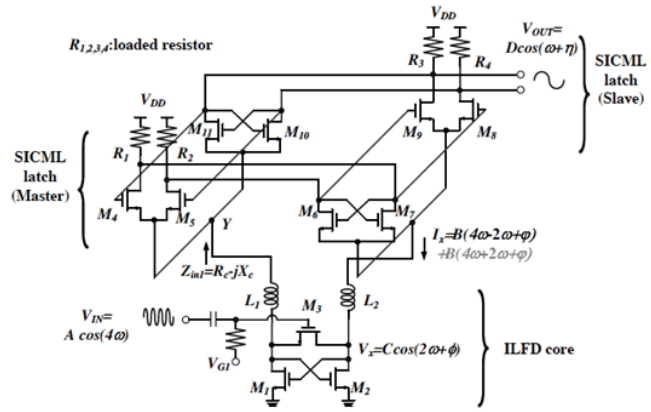

Fig. 3 The proposed divide-by-four frequency divider. The SICML is cascoded on the ILFD core.

The complete schematic of the proposed FD is shown in Fig. 3. The $M_{1–3, L1}$ and L_2 form the ILFD core which generates the controlled current to the SICML latches directly. The $M_{4–11}$ and $R_{1–4}$ form the SICML FD which provides another division number of two. The proposed cascoded topology requires 1.4 V bias voltage, which consists of 0.6V for SICML and 0.8V for ILFD respectively. Due to the cascoded combination of ILFD and CML dividers, the dc and ac current can be used effectively. The proposed topology has the widest locking range due to low parasitic capacitor. The topology also improves dc power consumption by eliminating the transconductance and buffer stages. The chip size is 0.33 mm2 as shown in the Fig. 4. The measured locking range is 13.5-to-30.5 GHz (77.3 %) at 0 dBm injection power as shown in the Fig. 5 and the dc power is 7.3 mW.

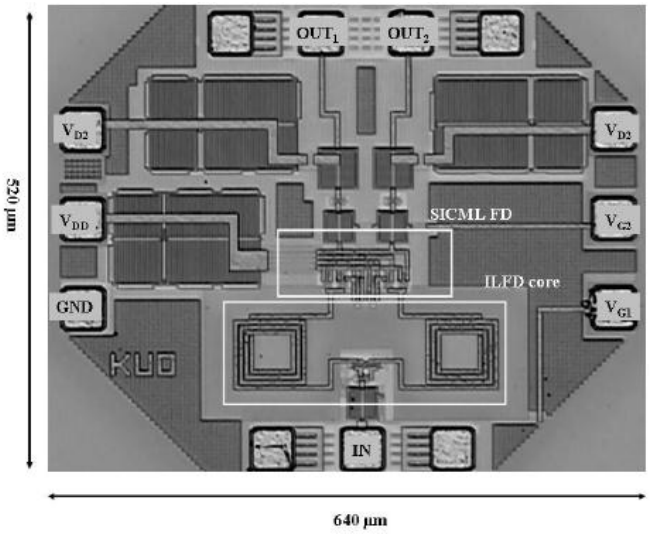

Fig. 4 Chip photograph of the proposed frequency divider. The chip size is 0.33 mm² including the testing pad.

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Technology

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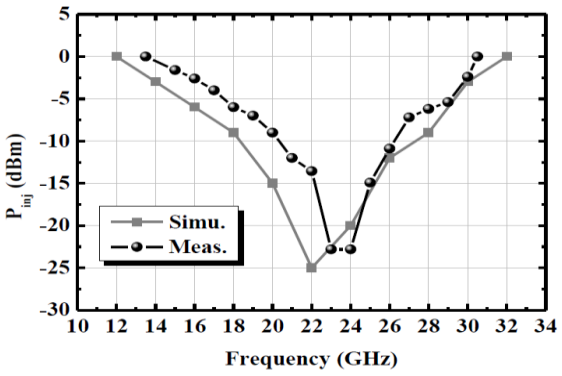

Fig. 5. The measurement of input sensitivity of the proposed frequency divider.

Reference:
[1] Yen-Hung Kuo, Jeng-Han Tsai, Hong-Yeh Chang, and Tian-Wei Huang, "Design and analysis of a 77.3 % locking range divide-by-4 frequency divider,"IEEE Trans. Microw. Theory Tech., vol. 59, pp. 2477–2485, Oct. 2011.

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Activities

International Symposium on Wireless Personal Multimedia Communications

International Symposium on Wireless Personal Multimedia Communications (WPMC) was held at the Howard International House, Taipei, on September 24 - 27, 2012, with a theme of "Autonomous Communication and Networking for Promoting Human Living" which embraces the global trend of connecting heterogeneous devices together to better the human living experience and productivity. WPMC was founded in 1998. Since then, it has been held in Asia, Europe and America, and has established itself as a unique global conference for promoting academic and industrial research collaboration on wireless information and multimedia communications. WPMC 2012, with ten prominent keynote speakers, two tutorials, two panel discussions and 30 technical sessions on Wireless Communications, Wireless Networks, Applications and Services, Systems, Standards and Regulations, and Internet of Things and M2M Communications, attracted 244 attendees from 19 countries.

In the opening of WPMC 2012, San-cheng Chang, the Minister without Portfolio of the Executive Yuan in charge of the ICT industry in Taiwan, gave a speech on the current status of the wireless data services in Taiwan. In the following days, ten outstanding keynote speeches were delivered by international academic or industrial leaders (including eight IEEE Fellows) such as Prof. H. Vincent Poor (who is the Dean of the School of Engineering and Applied Science, Princeton University, and a member of the U.S. National Academy of Engineering and of the U.S. National Academy of Sciences), Prof. Ezio Biglieri (who was the recipient of the IEEE Communications Society Edwin Howard Armstrong Achievement Award, and served as the Chairman of the IEEE Information Theory Society), Prof. Khaled Ben Letaief (Dean of Engineering, Hong Kong University of Science and Technology), Prof. Gordon Stüber(Georgia Institute of Technology), Prof Sherman Shen (University of Waterloo), Prof. Ryuji Kohno (Yokohama National University), Prof. Y.G. Michael Fang (University of Florida), Prof. Naohisa Ohta (Keio University), Prof. Lizhong Zheng (Massachusetts Institute of Technology) and Dr. Parag Pruthi (CEO and Founder of NIKSUN).

Other distinguished guests of WPMC 2012 included Yasuo Tawara (Director, Land Mobile Communications Division, Radio Department, Telecommunications Bureau, Ministry of Internal Affairs and Communications, Japan), Hiroshi Kumagai (VP, National Institute of Information and Communications Technology (NICT)), Mitsutoshi Hatori (Chairman, Yokosuka Research Park (YRP) R&D Promotion Committee), Shingo Ohmori (President, YRP International Alliance Institute), Prof. Hideki Imai (Chuo University), Prof. Fumiyuki Adachi and Prof. Nei Kato (Tohoku University).

2012 WPMC (from left to right)
Dr. Rasmus Hjorth Nielsen
Dr. Parag Pruthi
Prof. Ramjee Prasad
Prof. H. Vincent Poor

Activities

2012 IEEE Electrical Design of Advanced Packaging and Systems Symposium

2012 IEEE Electrical Design of Advanced Packaging and Systems Symposium (2012 IEEE EDAPS), chaired by Professor Ruei-Beey Wu, has been held in Taiwan from December 9 to 11, 2012. It is a great honor to invite Dr. Doug Yu, TSMC, Ricky Lee, Hong Kong University of Science & Technology to attend the opening ceremony. And Dr. Ho-ming Tong, General Manager of ASE Group, Professor Mitsumasa Koyanagi, Tohoku University, and Mr. Bob Sankman, Intel, were invited to give keynote speeches.

Group photo of steering committee and technical program committee members.

On December 9, there were 5 sessions in tutorial/workshop including to "Intel Summit", "Signal and Power Integrity in High Speed Interconnects", "High Speed Serial Link Design, Modeling, Simulation and Measurement", "RF Interference Control in Mixed Digital/RF Designs", and "Multi-physics Methods for 3-Dimensional Integrated Circuits (3-D ICs) and System-in-Packaging (SiP)". On December 10 and 11, there were one special session in 3D ICs, 22 oral presentations and 41 poster presentations in the symposium. The technical program not only addressed the current technical issues but also brought out the challenges on IC design, SiP/SoP packaging, EMI/EMC, EDA tools, and also the challenges in next generation 3DIC and packaging design. IEEE EDAPS 2012 recognizes the innovative and high quality research through the EDAPS Best Paper Award and EDAPS Best Poster Paper Award. The TPC and Award Committee selected one paper for the Best Paper Award and two papers for the Best Poster Paper Award, and the awardees received the prize and a certificate on Dec. 11, 2012.

Over 160 participants from 15 countries and areas, including to Japan, United States, Republic of Korea, China, Singapore, Hong Kong, India, Poland, Belgium, France, Canada, Germany, Malaysia, and Switzerland, attended the symposium, and 31 student volunteers from EE, NTU and EE, NTUST helped prepare for the conference. Their enthusiasm and support have made EDAPS 2012 a great success.

Taipei EMC chapter

On Oct. 12 and Nov. 7, 2012, the Taipei EMC chapter hosted two technical presentations at the National Taiwan University. The first presentation, titled "Physics and Modeling of Vias in Printed Circuit Boards," was delivered by Prof. Christian Schuster, IEEE EMC Society Distinguished Lecturer of the Hamburg University of Technology, Germany. This presentation provided an overview of the current understanding and simulation of electromagnetic fields around vias in printed circuit boards with a focus on the so-called physics-based via model. The presentation addressed the topics of the physics of parallel-plane modes and their impact on via behavior, the equivalent circuit model for signal vias, the effect of ground vias, and the impact of floating planes on signal transmission. About one month later, Mr. Ghery S. Pettit, President of the IEEE EMC Society and EMC Regulatory Compliance Manager in Intel, was invited to give the second presentation, "CISPR Standards for ITE," to the Taipei EMC chapter.

President Ghery S. Pettit (right) listened to a challenging question at the end of his presentation to the Taipei EMC Chapter on November 7, 2012.

Group photo of President Ghery S. Pettit and the attendees coming from various universities and institutions in Taiwan.

(continued on page 7)

Activities *(continued from page 6)*

This presentation described current standards in CISPR for Information Technology Equipment (ITE). A brief history of their development and requirements was also provided. The presentation specifically covered new standards that have been developed or are being developed in CISPR that ultimately will replace the corresponding existing standards.

At the end of the presentation, all the attendees, coming from academia, industry, and government, cheerfully participated in the question and answer session. This discussion continued and closed at a campus restaurant in a cordial atmosphere.

2012 IVF-Taiwan ICT Workshop

Standing on a joint agreement between the National Science Council of Taiwan and the International Visegrád Fund which was signed in July 2011, the IVF-Taiwan ICT workshop has been set to be one of the major cooperation forums between IVF and Taiwan.

ICT (Information and communication technologies) has been the most important, flourishing and successful industry in Taiwan. It has received numerous resources from both government and industry, and has become a distinctive and integrated force in the global industry supply chain. This is the result of many breakthroughs in innovative research techniques from the close cooperation among government, academia, industries and research fields. Many Taiwan ICT products not only have the highest value but the highest quantity in the world. Taiwan has played a decisive role worldwide.

The International Visegrad Fund is an international organization based in Bratislava founded by the governments of the Visegrad Group (V4) countries—the Czech Republic, the Republic of Hungary, the Republic of Poland, and the Slovak Republic in June, 2000.

The themes of this workshop are: Internet of Thing, Biophotonics, Research and Educational Networks and HPC (High-performance computing) and PRACE activities in Europe. This workshop covers the well-developed ICT technologies in V4 countries and Taiwan to promote closer cooperation between both sides.

By exchanging knowledge and experiences in the IVF-Taiwan ICT Workshop, we have developed great outcomes and more mutual scientific and business opportunities between V4 countries and Taiwan in the future.

IVF-Taiwan ICT National Contact Point
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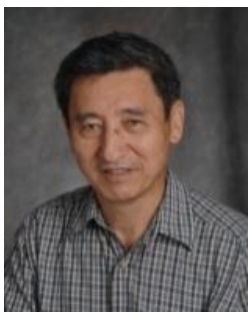
Invited Talk

Leaky Wave Antennas Based on Transmission Line Metamaterials

Lecturer: Professor Tatsuo Itoh



Professor Tatsuo Itoh is now a Distinguished Research Chair Professor in GICE, and also the distinguished professor and the holder of the Northrop Grumman Chair in Microwave and Millimeter Wave Electronics in UCLA. He earned a Ph.D. degree in electrical engineering from the UIUC in 1969. He is IEEE Life Fellow and a member of National Academy of Engineering.

Abstract

On Dec 3, 2012, recent advances on meta-material leaky wave antennas (LWA) were delivered by Professor Tatsuo Itoh based on Composite Right/Left Handed (CRLH) structure. CRLH LWA at THz range is also developed by combining the LWA with quantum cascade laser (QCL). The presentation is a report of recent advances in research on applications of metamaterial leaky wave antennas. After brief review of fundamentals of transmission

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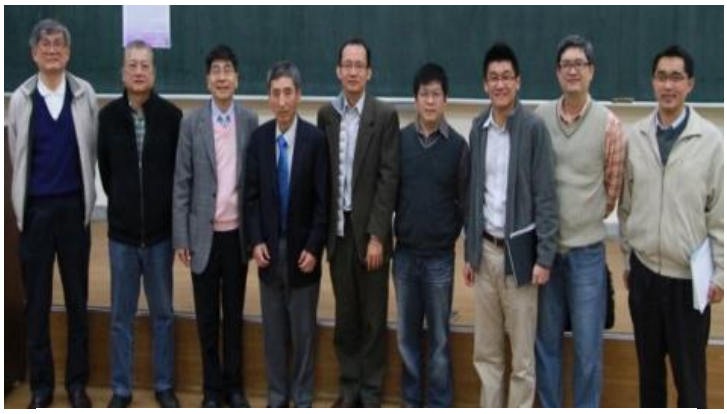

Group photo of Prof. Itoh and faculties of EM Wave Group of GICE.

line metamaterial called the composite right/left handed (CRLH) structure, the basis form of CRLH based leaky wave antenna (LWA) is described. To improve the gain of LWA, a distributed amplifier is combined with the LWA to realize a traveling wave active antenna. In order to improve the poor efficiency of the LWA, power recycle scheme have been implemented for the active LWA. More recently, Prof. Itoh has developed the CRLH LWA at THz range by combining the LWA with a quantum cascade laser QCL). Both passive version and active LWA have been actively demonstrated.

Corner of Student News

by Ko Ting-Yu

It is a surprise in my life that I had never expected—a wonderful semester spent in Japan as an exchange student to Osaka University. I applied for the Foreign Education Program of College of Electrical Engineering and Computer Science, and had a good fortune to be chosen as a representative to Osaka University. Joining FrontierLab Research Program at Osaka University, I took instructions from a respected professor and achieved some valuable experiment results for my research about image compression. Moreover, I have the chance to get a real understanding of Japanese people and Japanese culture.

The precious opportunity made me realize one thing: The only way I can build up a global vision is to experience it. When I am trapped in my own country, I take in information unilaterally. As a result, there are always misunderstandings of things and people in other countries. On the contrary, I had a lot of chances to communicate with the Japanese when I studied in Japan. I started to understand their thoughts, and after that I had the capacity to think from their angles. Only by that can I eradicate my misunderstandings of Japanese culture and society. In addition to my Japanese lab-mates, I have also made many friends from many other countries. These countries included Mainland China, Sweden, Mexico, America, India, and even Uzbekistan. By interacting with them, I gained more knowledge and perspectives about this dynamic and colorful world.

Indeed, Japan is a beautiful country. On weekends, I traveled around the Kansai Area, visiting world heritages and less visited secret spots. I have been to Kyoto, Kobe, Nara, Shikoku, savoring splendid cherry blossom, breath-taking night scenes, relaxing hot springs and delicate Japanese gourmets. All of these reminded me of the saying: Present is a present. If there is anything I want to do, I must do it now. The surprise I got was truly beyond my imagination. Studying, working, playing, traveling and making friends—what a meaningful life! I appreciate this horizon-widening opportunity very, very much.

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