National Taiwan University
Graduate Institute of Communication Engineering Newsletter

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In this issue

Dr. Charles K. Kao Revisit

The Nobel Prize Laureate in Physics 2009 Dr. Charles K. Kao, who was also GICE's Distinguished Research Chair Professor during 2003-2004, revisited NTU on Dec. 2, 2010.

In honor of Dr. Kao's visit, GICE and College of EECS, GIPO, EE Dept., and NSC co-hosted a speech dedicated to the Father of Fiber Optic Communication to honor his achievements and dedication. Prof. Chinlon Lin, the former Professor and Director of Center for Advanced Research in Photonics of Chinese University of Hong Kong, introduced Dr. Kao's research and career during the presentation.

(upper left) *Dean L. S. Lee (upper right) and GICE Director K. C. Chen (upper left) photographed with Dr. Kao and Mrs. Kao.*

(bottom left) *Group photo: (from left to right) GIPO Director* Ching-Fuh Lin, Prof. Jingshown Wu, Dr. Kao, Dean Lee, Mrs. Kao, Prof. Chinlon Lin, GICE Director Chen.

(bottom right) *Dr. Kao during the presentation*

GICE Honors

Congratulations on GICE Professor Named ISCA 2010 Fellow

Professor Lin-Shan Lee
2010 ISCA (International Speech Communication Association) Fellow

Professor Lin-Shan Lee was elected for his contributions to Chinese spoken language processing and speech information retrieval, and his service to the speech language community.

Congratulations on GICE Professor Awarded 2010 IEEE MGA Innovation Award

Professor Ruei-Beei Wu
2010 IEEE MGA (Member and Geographic Activities) Innovation Awards

Professor Ruei-Beei Wu has been awarded this honor for his outstanding efforts in promoting IEEE membership, Chapters consolidation, and talents cultivation, especially initiating the Electromagnetics Education Initiative - Summer Camp Program.

Upcoming Events:

Dec 20-21
Dr. Shuo-Yen Robert Li Visit
The Chinese University of Hong Kong

Technology Developed in GICE

MMW Passive Components Design and SOP Applications by LTCC

from Electromagnetics Group

LTCC is a matured packaging technology for the electronic industry in Taiwan. Basically, it is a multilayered structure, capable of high-resolution signal traces and three-dimensional stack-ups. It has been used to construct the laminated waveguides, also called substrate integrated waveguide (SIW), for microwave and millimeter-wave applications. Taking advantages of its salient features, including multilayered capability, layout flexibility, low loss, low cost, and high integration, a series of researches navigated by Prof. Ruey-Beei Wu at GICE has exploited the various superior performance made possible to the passive components.

The multi-layered nature of LTCC technology enables three-dimensional arrangements of filter cavities, thereby developing the miniaturization techniques for band-pass filters design. Not only cavities are vertically stacked to reduce the footprint area [1] but also the folded cavities are proposed to further reduce the filter size [2]. The most challenging ones accomplished by these researches are to propose several novel coupling mechanisms for realizing both electrical and magnetic couplings with strong or low coupling strengths. Desired filter responses and specifications can be accomplished by properly choosing the proposed coupling structures. Successful demonstrations have been presented including a 4th order quasi-elliptic filter at 30GHz by fully stacked resonators to exhibit 8X reduction in size as compared to a planar version with traditional metallic cavities [1] and as shown in Fig. 1, a 30GHz three-pole Chebyshev filter with 8.5X size reduction by fully stacked double folded resonators [2] and a 30GHz four-pole Chebyshev filter with 12X size reduction by vertically stacked quadruple folded resonators [3], etc.

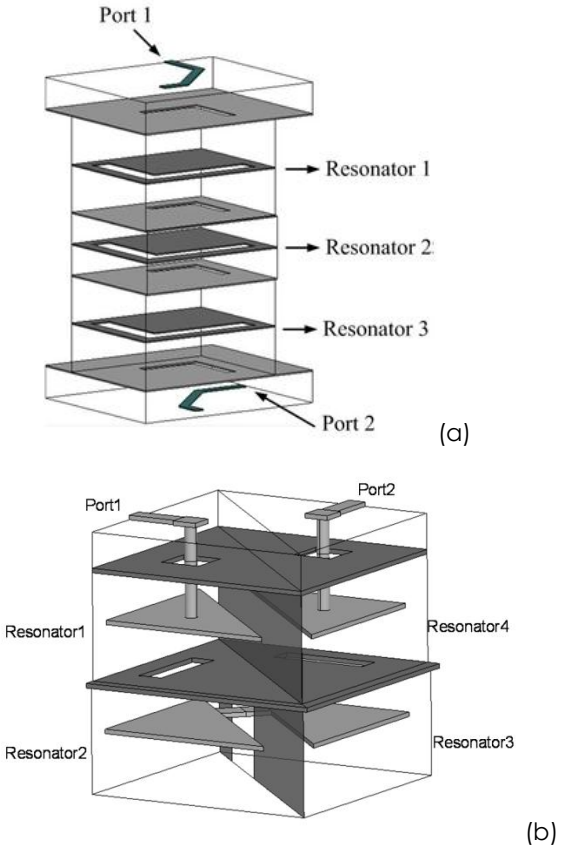

Fig. 1. Vertically stacked folded cavity bandpass filters in LTCC. (a) Three-pole Chebyshev filter by fully stacked double folded resonators. (b) Four-pole Chebyshev filter by vertically stacked quadruple folded resonators.

(continued on page 3)

GICE Honors

Congratulations on winning GOLD Best Paper Award of IEEE GLOBECOM 2010

Pin-Yu Chen
Co-author: Kwang-Cheng Chen
Topic: Information Epidemics in Complex Networks with Opportunistic Links and Dynamic Topology

Pin-Yu Chen (left) and IEEE ComSoc President Byeong Gi Lee

Message from the Director

Kwang-Cheng Chen

Professor &
GICE Director

The GICE Newsletter is getting into one year old now. We keep sharing good news and exciting research with our GICE friends. In the mean time, 2009 Nobel Laureate and former GICE distinguished research chair professor, Dr. Kao, visited GICE on Dec. 2. Full house of audience learned great experience to bring optical fiber communications into everyone's daily life, with introduction of Dr. Chinlon Lin. Please enjoy this issue.

Merry Christmas and Happy New Year!

Technology *(continued from page 2)*

Being in essence a metallic waveguide which exhibits well known modal pattern and polarization, the SIW implemented by LTCC can be smartly employed to design other passive components with special performance features. One is the design of dual-band filters by taking advantage of the existence of multiple cavity modes [4], as shown in Fig. 2. The major design concept is adequately choosing geometric shape of laminated waveguide resonators to control the frequency bands, and positions of open slots and feeding probes to realize the desired coupling coefficients and external quality factors at both bands simultaneously. Two design examples with third-order and quasi-elliptic filter responses are given and verified by experiments. By LTCC, the laminated waveguide resonators are vertically stacked, and the filter size can be miniaturized. Another one is shown in Fig. 3, the design of planar laminated waveguide magic-T with broad band performance [5]. By LTCC, two orthogonal slots are used to excite even- and odd-symmetric field patterns, respectively, resulting in a good isolation between each other. The great technical originality is the setup of equivalent circuit model with semi-analytical estimation of its input admittance, which facilitates the structure design for wideband performance and validated by the measurement results.

It has become evident from such efforts that the laminated SIW structure based on multi-layered LTCC is a promising solution for the MMW passive components, which can exhibit great advantages of mass production, high resolution, low cost, high quality factor, low interference, and special features. Furthermore, it also sheds light on the system on package for microwave or millimeter-wave radar and wireless communications applications.

A novel system on package (SoP) RF frontend module for X-band frequency-modulated continuous wave (FMCW) sensor has been developed [6] for short distance moving object detection, as shown in Fig. 4. A multi- function RFIC chip realized by typical 1P6M 0.18 μm deep n-well CMOS technology, a multi-layer 180° hybrid and two embedded ring filters, two sets of antenna arrays, and all other necessary components are all integrated into a miniaturized module no larger than 35mm×35mm LTCC substrates. The multi-layer 180° hybrid is based on conventional rat-race coupler, with the layout area reduced by 32% using the multi-layer capability of the LTCC. The ring filter is mainly composed of an embedded ring as resonator, but carefully designed to exhibit low insertion loss without sacrificing frequency selectivity. In addition to the 3.5dBm transmitter

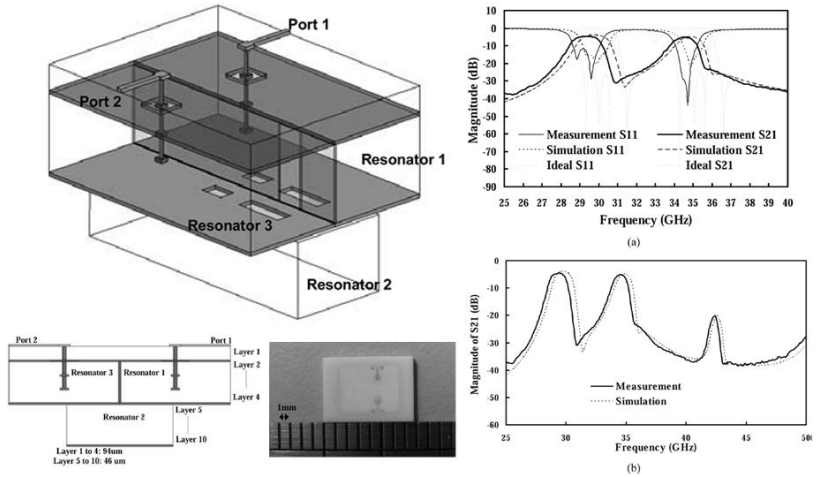

Fig. 2. Dualband LTCC filter by taking advantage of the existence of multiple cavity modes.

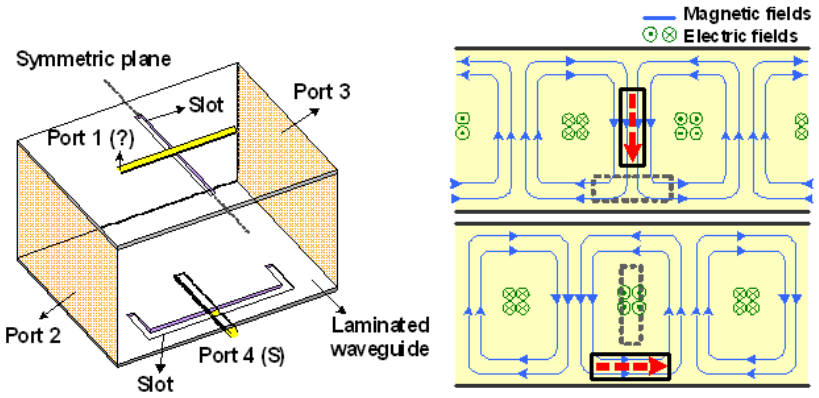

Fig. 3. Broadband planar laminated waveguide magic-T by orthogonally exciting cavity modes.

Technology (continued from page 3)

output and 6dB receiver conversion gain of the RFIC block, a 7.5dB-gain single-arm fractional spiral antenna element is backed with an electromagnetic bandgap (EBG) structure for maximizing the detection range within the volume limit of the module. Besides the basic functionality of distance detection, angle detection is also accomplished by comparing the sum and difference patterns of an antenna element pair at receiving end. Each building block has been tested individually for verifying the functionality of the whole module. Good agreements between simulations and measurements have been obtained.

Another SoP of the 60GHz front-end phase array is developed for wireless communications applications. In the SoP structure, the MMIC chip is flip-chip connected to a LTCC module in which the passive components and antennas are designed and integrated. A wide-band microstrip- to-microstrip via transition proposed for connecting an integrated circuit chip and an antenna array on the opposite sides of a multi-layered LTCC is investigated [7]. The physical mechanisms which result in the insertion loss are explored in detail and the effects of via diameter are also investigated for the reduction of insertion loss. Although with the relative thick substrate of up to about $0.5\lambda_g$, it is demonstrated that the overall return loss is better than 20 dB and insertion loss better than 0.48dB over a band from dc up to 67GHz. The SoP also includes transmitting and receiving antenna arrays which are formed by miniature broadband cavity backed planar antenna elements, achieving high efficient broadband antenna with compact antenna size, high isolation between adjacent elements and wide scanning angle in an array antenna configuration. It demonstrated an impedance bandwidth of 25%, peak gain of higher than 6dB, isolation of more than 15dB for element spacing smaller than 0.6λ.

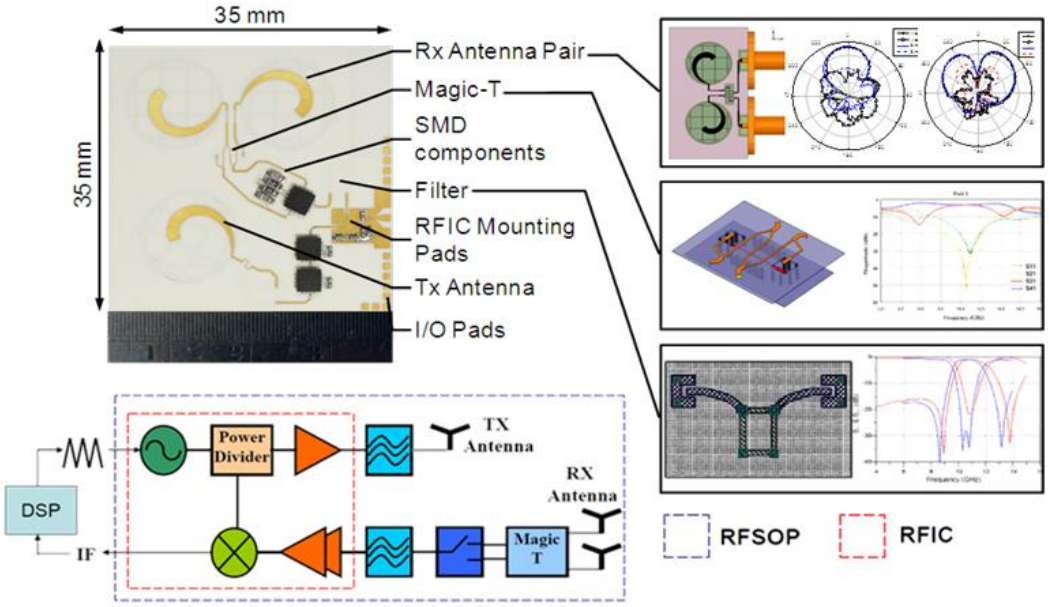

Fig. 4. SoP RF frontend module for X-band FMCW sensor.

References

[1] T.-M. Shen, C.-F. Chen, T.-Y. Huang, and R.-B. Wu,"Design of vertically stacked waveguide filters in LTCC," *IEEE Trans. Microw. Theory Tech.,* vol. 55, pp. 1771-1779, Aug. 2007.

[2] H.-Y. Chien, T.-M. Shen, T.-Y. Huang, and R.-B. Wu,"Miniaturized bandpass filters with double-folded substrate integrated waveguide resonators in LTCC,"*IEEE Trans. Microw. Theory Tech.,* vol. 57, pp. 1774-1782, July 2009.

[3] T.-Y. Huang, T.-M. Shen, H.-Y. Chien, and R.-B. Wu,"Design of miniaturized vertically stacked SIW filters in LTCC,"*2009 European Microw. Conf.,* EuMC22-2, Rome, Italy, Sept. 2009.

[4] B.-J. Chen, T.-M. Shen, and R.-B. Wu,"Dual band vertically stacked laminated waveguide filter design in LTCC technology,"*IEEE Trans. Microw. Theory Tech.,* vol. 57, pp. 1554-1562, June 2009.

[5] T.-M. Shen, T.-Y. Huang, and R.-B. Wu,"A laminated waveguide magic-T in multilayer LTCC,"*2009 IEEE MTT-S Int. Microw. Symp.,* Boston, USA, June 2009.

[6] T.-Y. Huang, T.-M. Shen, K.-F. Hung, C.-C. Chang, J.-W. Chen, H.-S. Wu, S. Wang, C.-K. C. Tzuang, H.-C. Lu, Y.-C. Lin, and R.-B. Wu,"An system-on-package integration of X-Band FMCW sensor RF frontend module," *Proc. 2009 Asia-Pacific Microw. Conf*., Singapore, Dec. 7-10, 2009, pp. 147-150.

[7] C. C. Tsai, Y. S. Cheng, T.-Y. Huwnag, A. Hsu, and R.-B. Wu, "Design of microstrip-to-microstrip via transition in multi-layered LTCC for frequencies up to 67GHz," accepted to appear on *IEEE Trans. Adv. Packag.*, 2011.

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Technology

Wireless Sensor Network for Behavioral Modeling in NTU Hospital's Elder Care Center

from Communication and Signal Processing Group

Global growth of the elder population has led to the increasing demand of long-term elder-care facilities. Most elders living in such facilities are usually with various chronic illnesses. Accompanying these illnesses are slow declines of the elders' physical and mental health. Continuous tracking of the elders' daily activities is required to detect the declines early. To facilitate long-term mobility tracking of the elders, we investigate, in this work, the potential of a wireless sensor network (WSN)-based real-time location system (RTLS) for automated tracking of the elders' daily mobility as support for the already-overloaded nursing staff.

In contrast to most studies whose experimentations are either in a laboratory setting or conducted within a short period of time, our installation lasts for 8 months which enables modeling of the elders' behavior and early detection of the chronic health decline. Working with the university hospital, i.e., National Taiwan University Hospital, we deploy a 45-node WSN-RTLS system in its elder care center, a.k.a, the Bei-Hu Branch (NTUH-BH). During the period of December 2008 to July 2009, we collect location traces and investigate the daily and long-term mobility of 4 volunteering elders. Preliminary results indicate that: (1) each elder's daily mobility shows a reoccurring pattern. The pattern, however, differs from individual to individual. (2) The mobility level shows a significant variability, i.e., not all elders show reoccurring patterns in mobility levels. These suggest that mere quantity of how much the elders move around the facility will not be a suitable target for behavioral modeling. Exact location of the elders' presence, rather, is more relevant. In-situ WSN-RTLSs would be an enabler towards early detection of the elders' physical or mental decline. In this overview article, we emphasize the experimental setting and system implementation.

The facility, NTUH-BH, under investigation is a part of the university hospital specializing in gynecology and pediatrics since 1960s. Its elder care center started operation in 1996. To accommodate the elders moving in, ward rooms on the 4th and the 5th floor of the building are transformed into bedrooms, living rooms, and rooms of other functionality for elders' daily needs. Our study is conducted on the 5th floor and Figure 1 depicts the spatial distribution and the functionality of individual rooms on the 5th floor.

Approved by the Ethics Committee of NTUH, we recruited four residents for the study. The sample consists of three females and one male. The age spans from 51 to 92. All of them have hypertension and heart disease. Many of them suffer from additional health conditions commonly seen in elders, e.g., the Parkinson's disease and dementia. All of the volunteers rely on wheelchairs to move. Three of them have stronger limbs and can move freely between the wheelchairs and their beds. The four residents live in bedroom No. 5, 7, and 8. To track how the space is used, we installed a WSN-based location system in NTUH-BH. The system can report locations of the moving targets in real time.

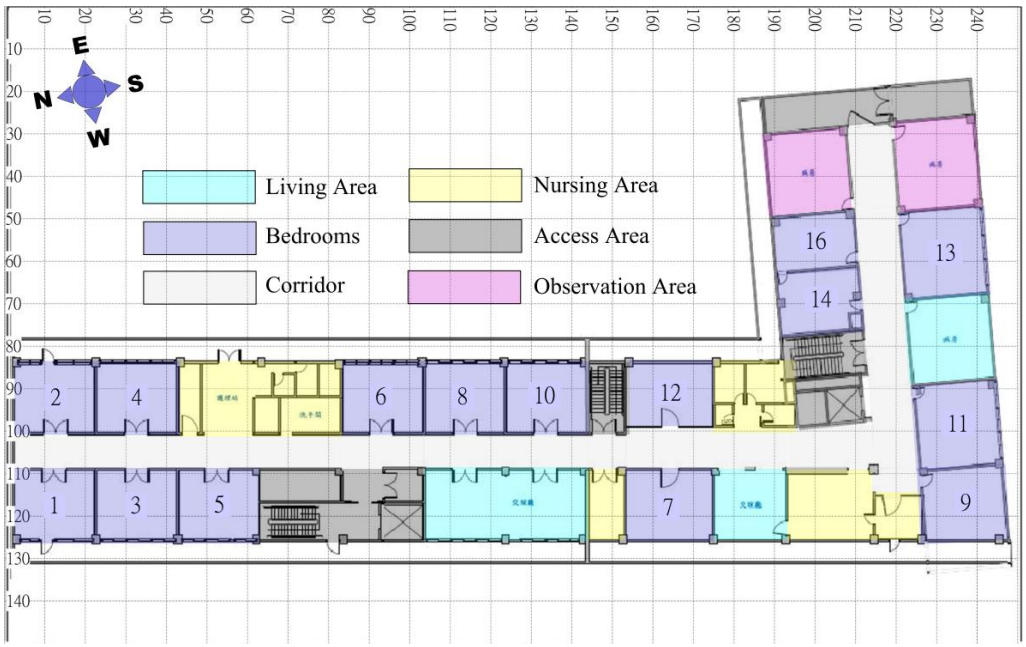

Figure 1: Floor Plan of NTUH-BH 5th Floor

(Continued on page 6)

Technology *(continued from page 5)*

To facilitate long-term data analysis, we log also all the location data in a databank.

The system is implemented in three parts: user module, infrastructure, and remote server. The user module implements the receiving tag in the system. It receives packets from beacons and transmits measured RSSI values to a back-end server. The exterior and interior of the user module is as shown in Figure 2. A commonly-used wireless sensor node platform is adopted. In that, processing is handled by an MSP430 microcontroller and wireless communication is done by a CC2420 RF radio that complies with the IEEE 802.15.4 standard. The platform is extended to draw energy from a rechargeable lithium battery.

Figure 2: The User Module

As for the infrastructure, WSN nodes, drawing energy from the power outlets in the building, are used to implement the beacons in the system. A number of relay nodes are added to relay packets from the tags to the back-end server due to the fact that the CC2420 RF chips transmit in short range and multi-hop communication is needed for the space under investigation. For the entire 5th floor of NTUH-BH, 45 WSN nodes are used in total, of which 36 are beacon nodes and 9 are relay nodes. Placement of the beacon nodes and relay nodes are shown in Figure 3. In particular, the relay nodes forward the RSSI vectors hop-by-hop to a pre-configured sink node via a mechanism named Magnetic Diffusion. The sink node is directly connected to one of the gateways which are connected to the Internet, from which the remote server can access the measured RSSIs easily. The remote server is essentially a PC working as the back-end server. This PC is installed in one of the nursing stations to collect RSSI data from the gateway and analyze RSSI data to produce location estimates. It is also used as a display for the nursing staff to monitor the locations of the residents as shown in Figure 4. One can also log in to the remote server to examine the location history of the residents.

In addition to viewing the locations in real time right on the monitor, the historical data can be viewed in formats as shown in Figure 5. The figure shows the movement of resident #6 in a typical day, 2008/12/27. Each dot represents the resident's presence on a location. As can be observed,

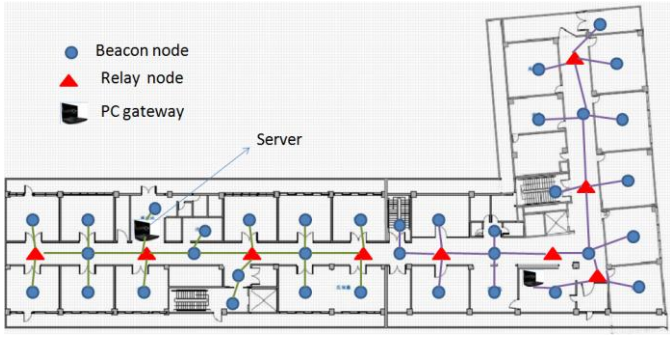

Figure 3: Deployment of the Location System

Figure 4: Display in the Nursing Station

resident #6 mainly moves in between his bedroom and the two living rooms. The area the resident spends the most time at is the bedroom and the hallway nearby. Over the two living rooms, the resident's preference is, observably, the smaller one. By examining plots such as this, one can conveniently derive the usage of the space and study living behavior of the residents.

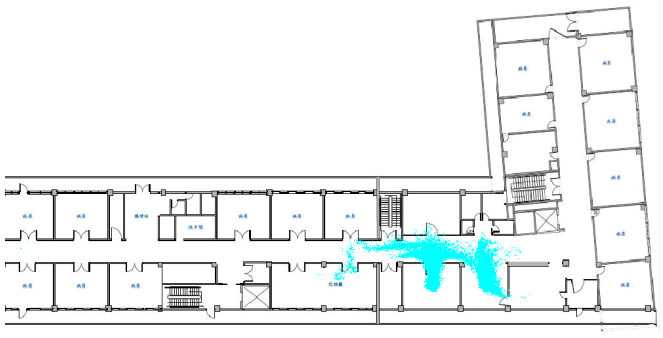

Figure 5: Spatial Moving Habit of Resident #6, 2008/12/27

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Communication Research Center

ICT NCP Taiwan participated in the ICT 2010 Event in Brussels on 27-29 September 2010

On 27-29 September 2010, ICT NCP Taiwan participated in the ICT 2010 Event in Brussels, Belgium. "ICT 2010—Digitally Driven" has been one of the European's most visible forums and showcased the latest trends and achievements in research and innovation in ICTs. ICT 2010 focuses on the policy priorities such as Europe's Digital Agenda and the next financial programme of the EU for funding research and innovation in ICT. This biennial event attracted thousands of researchers, business people, investors and high level policy makers in the field of digital innovation.

【Booth at International Village】
Taiwan this time had the opportunity to set up an international booth which introduced Taiwan's National technology achievements in ICTs, such as National Science and Technology Programs and also the Green-ICT demonstration from Taiwan's famous companies—Realtek Semiconductor Corp. and Epistar Corp.

【Networking Session】
Except the booth for Exhibition, Networking Session of Taiwan was composed of different ICT main research areas in Taiwan, such as Internet, Photonics, Robotics, IC Design and ICT for Healthcare, etc. We gathered the professors from Taiwan's top universities and the research institute making presentations which contains the future research directions and current status of Taiwan's ICT research in each field.

【Taiwan Technical Session - Taiwan Night】
Beyond the activities on the conference of ICT Event, we hold a Taiwan Technical Session on the second day of ICT Event. In order to build a communication platform for Taiwan researchers and international researchers who may interested in the international cooperation with Taiwan, we offered a place with some snacks and relaxed atmosphere for people to discuss further. In Taiwan night, almost 60 guests from different countries showed up and it was a real success for every participants.

2010 TI Educators Conference & Taiwan-Mainland University TI DSP Invitational Contest

With the cooperation by NTU Communication Research Center and Texas Instrument (USA), "2010 TI Educators Conference & Taiwan-Mainland University TI DSP Invitational Contest" was held on 31th Oct-4th Nov, 2010.

Evaluating the demonstration by Professors from Taiwan and Mainland China

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Communication Research Center *(continued from page 7)*

For the first time, this contest moved to Taiwan from mainland China in order to make China participants closer to Taiwan DSP (Digital Signal Processing) research environment for experiencing the people and culture of Taiwan, and further to in-depth exchange purposes. This year has entered the third year and already become one of the largest and best DSP performance activities which has caught much attention by Taiwan and China's academic institutions.

In addition to competition, "2010 Meeting of Educators from Mainland China and Taiwan" was held at the same time. More than 40 DSP teaching and research professors from universities in Taiwan and Mainland China such as Tsinghua University, Peking University, Fudan University, University of Electronic Science and Technology, National Taiwan University, Jiaotong University, National Cheng Kung University, Donghua University were participated in the meeting.

The event has inspired students to fully achieve the ability to create DSP, and to promote cross-strait teachers and students in research and teaching on the DSP system of communication, in order to bring a new boost cross-strait DSP Education and Promotion. This offered teachers and students the opportunities to establish good interaction for the development of future cooperation.

Demonstrations by the participants

Awards Ceremony

Workshop on Health Effects of EMFs

In order to correctly promote the health effects of EMFs, Communication Research Center, Taiwan Telecommunication Industry Development Association and IEICE Taipei Section have jointly hosted this workshop on 23th of November, 2010. The workshop invited important guest from National Communication Commission, Taiwan and also speakers from Nagoya Institute Technology (Japan), International Committee on Electromagnetic Safety, IEEE and Science & Technology Advisory Group of the Executive Yuan of Taiwan. The important issues such as "Radio Frequency Exposure Safety Concerns", "Dosimetry Evaluation of Children for GHz-Band Far-Field Exposure" and "EMF Risk" were discussed lively in the workshop.

Group photo in front of BL Building, NTU—speakers and guests of "Workshop on Health Effects of EMFs"

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