NTU GICE Newsletter
Graduate Institute of Communication Engineering, National Taiwan University

Vol. 8, No.2 May. 2017 http://www.comm.ntu.edu.tw gicenewsletter@ntu.edu.tw

In this issue



# Technology Developed in GICE

## Multi-point Wireless Power Grid to Realize Stable Power Reception Under Any Rotation Angle

*from Electromagnetics Group*

**I. INTRODUCTION**

Battery replacement can be a huge burden for wireless sensor nodes. Wireless power transmission can eliminate the need of battery. [1] proposes a wireless grid to realize battery-less sensor networks in indoor environments. Internet of things (IoT) and capsule camera also provides a possible application of wireless power transmission.

While wireless transmission has been extensively investigated, the wireless sensor network about transmitters and receivers under different rotation angle is relatively unexplored. [2-3] use 3 concentric loops at orthogonal planes to realize stable reception on different directions. However, loops are 3D structure and size is too big. If we want to power up sea of sensors at arbitrary orientations, we can use multiple transmitting antennas at different locations and polarizations. By properly selecting phase, amplitude and/or polarization, we can realize stable reception for sensors using simple dipole antenna to receive power. Stable reception can be achieved when phase difference between two orthogonal transmitting antennas is 90°. However, this cannot be extended to 3D case. On the other hand, time switching among transmitting antennas can also achieve stable reception in both 2D and 3D cases. The efficiency in 2D case is 1/2, and 1/3 in 3D case. Section II will describe the formulation and simulation. Section III shows measurement results by using RFID techniques. Finally, the conclusion is in section IV.

(Continued on page 2)

# GICE Honors

### *Communication Excellence Cultivation Project Awardees*

- **MODE A**
  SHEN, WEN-DI
  LIN, YU-HSIN
  CHUANG, SHUN-PO
  CHEN, YU-YAU
  LIU, HE-HSUAN
  LO, I-CHAN
- **MODE B**
  CHEN, JIAN-HUNG
  CHEN, SIANG
  LIU, CHUNG-YUAN
  JEANTY ROBIN

※The aim of the schoarship is to encourage distinguished student candidates to pursue a Ph.D. degree.

• TWD 2.5 millions will be awarded to Mode A recipients for 5-year MS-PhD study
• TWD 1.5 millions will be awarded to Mode B recipients for 4-year PhD study

# Message from the Director

**Tzong-Lin Wu**

*Professor & GICE Director*

In Taiwan, May-June is the time Royal Poinciana blooming; they bloom bright and brilliant at NTU campus in the early summer, during the graduation season, full of vibrant. Here are my hopes for all GICE graduates; you are the future groundbreakers, innovators and leaders. Don't turn away from what's painful. Challenge it.

Your future must be full of blessings and expectations which as the Royal Poinciana are about to bloom in your life.

In this issue, we report two types of technology research from Professor Mao-Chao Lin and Professor Hsin-Chia Lu.

Please enjoy the article and give us a feedback if there is any.

# Technology

*(Continued from page 1)*

**II. FORMULATION AND SIMULATION**

A. Phase modulation

Reception power is reduced due to polarization and antenna pattern mismatch. Antenna pattern mismatch means the receiving antenna is not oriented to transmitting antenna with maximum gain. In order to solve the orientation problem, we propose the multiple transmitters structure in the 2-D case and 3-D case.

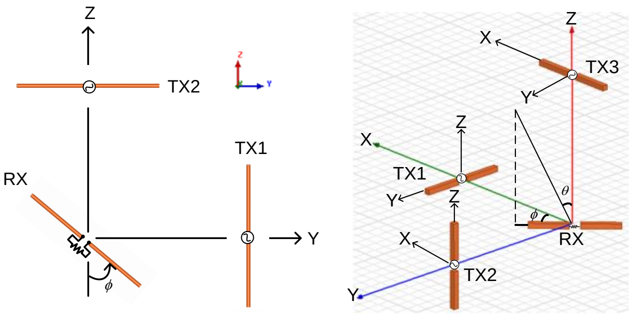



*Fig. 1 Antenna arrangement for (a)2D and (b)3D case with TX and RX antennas.*

Fig. 1(a) shows location arrangement of wireless power transmission using 2 transmitting and one receiving antennas. All antennas are dipole antennas. Receiving antenna (RX) is placed at origin of YZ plane with rotation angle ϕ. When ϕ =0°, RX is parallel with TX1 and perpendicular to TX2. PTX1, and PTX2 are the transmitting power. The power from TX1 at RX can be expressed as,

$$P_{RX1} = \frac{P_{TX1} \times g_t \times g_r \times \lambda^2}{(4\pi \mathrm{r})^2} \tag{1}$$

Where PRX1 is the maximum recevied power without antenna pattern mismatch based on Friis equation. θ is the phase difference between two TX antennas. r is the distance between TX and RX antennas. gt and gr are gains of transmitting and receiving antennas, respectively.

Assume PTX=PTX1=PTX2, then received power PRX can be expressed as

$$P_{RX} = P_{RX1}\left(1+2\cos\phi\times\sin\phi\times\cos\theta\right) \tag{2}$$

By taking $\theta = 90°$ in (2), the received power is independent of rotation angle. PRX is then equal to PRX1. We can define efficiency $\eta$ as received power to maximum possible received power. As now we have two transmitters now, so $\eta$ =1/2.

B. Time switching

Another approach to modulate TX signal is time switching mode. As capacitor will be placed between DC output and rectifier, the time variation from time switching can be averaged to a stable DC output.

Antenna location is the same as in phase modulation method. One signal source is switched between two TX antennas. Received current, $i_{RX}$ can be expressed as,

$$i_{RX} = \begin{cases} \sqrt{2P_{RX1} \times \cos^2\phi / R_L} \times \cos(\omega t) & at \quad 0 < t < kT, \\ \sqrt{2P_{RX2} \times \sin^2\phi / R_L} \times \cos(\omega t) & at \quad kT < t < T, \end{cases} \tag{3}$$

where T is the switching period. The switching duty cycle *k* is between 0 and 1. $P_{RX}$ can also be solved by integrating over the whole interval T. If T is much larger than period time of a single carrier cycle, we can get average power that is independent of T as $P_{RX}$=*k* $P_{RX1}$ $\cos^2(\phi)$+(1- *k*)$P_{RX2}$ $\sin^2(\phi)$. By taking *k*=1/2 and $P_{RX1}$=$P_{RX2}$, $P_{RX}$ is stable and equals to $P_{RX}$/2. This is half of received power in phase modulation. However, only one source is turned on in this case. So, the overall efficiency is the same as in phase modulation.

In 3-D case, we have three TXs in orthogonal directions and one RX as shown in Fig. 1(b). Switching is rotated around three TX antennas.

*(Continued on page 3)*

# Technology *(Continued from page 2)*

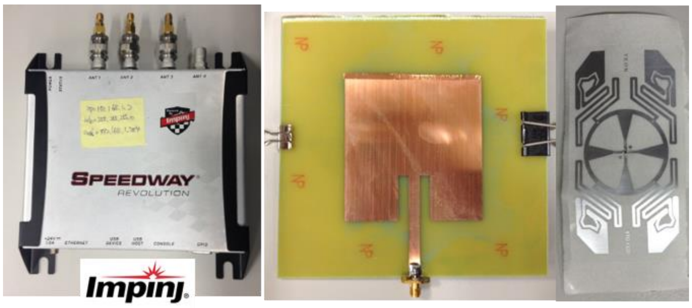
The received current can be expressed as,

$$i_{RX} = \begin{cases} \sqrt{2P_{RX1}\times\sin^2\phi\times\sin^2\theta/R_L}\times\cos(\omega t) & at \quad 0<t<kT \\ \sqrt{2P_{RX2}\times\cos^2\theta/R_L}\times\cos(\omega t) & at \quad kT<t<2kT, \\ \sqrt{2P_{RX3}\times\cos^2\phi\times\sin^2\theta/R_L}\times\cos(\omega t) & at \quad 2kT<t<T. \end{cases} \qquad (4)$$

If $k$=1/3 and $P_{TX1}=P_{TX2}=P_{TX3}$, we can get $P_{RX}=P_{RX1}/3$.

### III. EXPERIMENT RESULTS

Fig. 2 shows the equipment of the wireless power transfer experiment using RFID reader and tag. Linear polarization patch antenna is used to radiate power in UHF band. Passive tag with linear polarization is used as RX to receive power and generate the backscatter signal to TXs. The reader can give radio strength signal indicator (RSSI) for the strength of reflected signal. We will use this as a measure of the field strength at tag location.




(a) (b) (c)

*Fig. 2 RFID experiment equipment (a)reader, (b)reader antenna and (c)tag.*

Under one TX, maximum RSSI with -61dBm occurs when TX antenna and tag are parallel. Under two TXs, TX and tag are placed in the same plane as in Fig.1. Tag is rotated in this plane to measure RSSI in some directions. The distance between TX and RX is 1m and the height of TX and RX is 1m above floor in an anechoic chamber. 90° phase difference is generated by a coupler. The measured RSSI under difference rotation angle is shown in Fig. 3 in black line. It is stable at about -64dBm. Time switching method under two TX antennas is also performed under same total transmitted power. Fig. 3 shows the measurement result. Red line and blue line represent the received backscatter signal from TX1 and TX2. Green line represents the average power which defined as the average of $P_{TX1}$ and $P_{TX2}$. RSSI (green line) is -64 dBm, so η=0.5.

Finally, for 3 transmitting antennas, time switching arrangement and measurement environment are shown in Fig. 4. Tag is placed on a Styrofoam rod and TX3 is just under to rod in red square in Fig. 4(b). The measurement results of time switching method are shown in Fig. 5. Under any rotation angle, RSSI is about -66 dBm that is stable and 5dB down from -61dBm. This corresponds to 1/3 of efficiency.

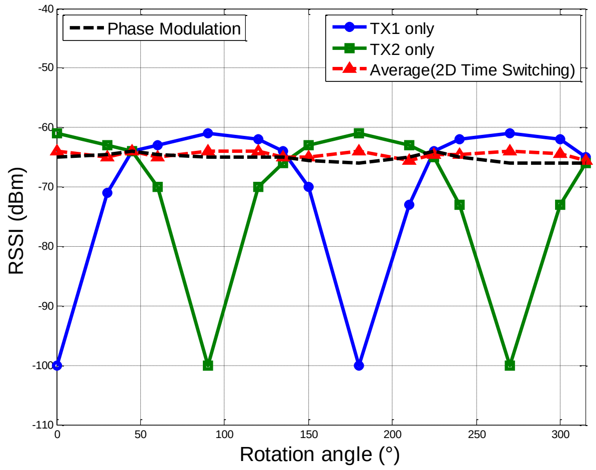
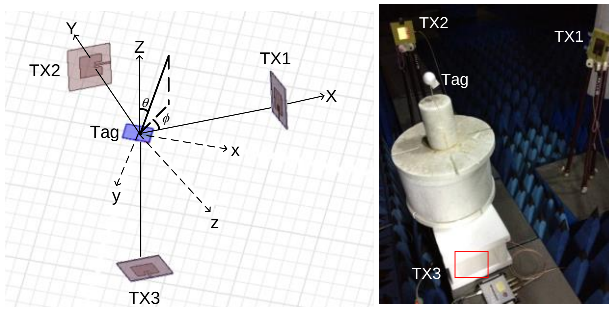



*Fig. 3 RSSI measurement results at 2D time switching and phase modulation.*




(a) (b)

*Fig. 4 Experiment setup for three TXs in (a) schematic and (b) photo.*

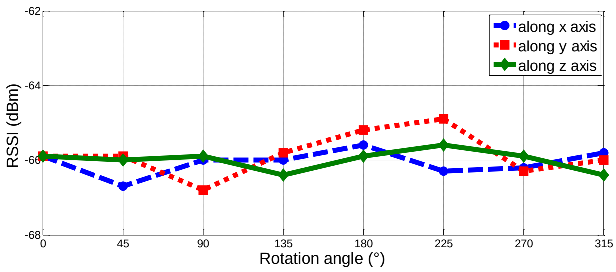



*Fig. 5 RSSI measurement results at 3D time switching.*

### IV. CONCLUSION

This work proposes phase and time switching modulations in multiple orthogonal transmitters to make the received power more stable under any rotation angle. Under 2D case, efficiency is 1/2, while it is 1/3 for 3D case. Experiment using RFID shows good

*(Continued on page 4)*

# Technology *(Continued from page 3)*

agreement with theoretical analysis. These methods can be used to power up wireless sensors in arbitrary angles. Capsule camera inside human body can be another application of this technique.

**REFERENCES**

[1] Gento Matsushita, Daiki Maehara, Yusuke Kuki, Kei Sakaguchi, Seiichi Sampei, and Kiyomichi Araki, “Wireless grid to realize battery-less sensor networks in indoor environments,” in 2014 Asia-Pacific Microwave Conference Proceedings (APMC), Nov. 2014, pp. 690-692.

[2] D. Daerhan, O. Jonah, Hao Hu, Stavros V. Georgakopoulos, and Manos M. Tentzeris, "Novel highly-efficient and misalignment insensitive wireless powertransfer systems utilizing strongly coupled magnetic resonance principles," in Electronic Components and Technology Conference (ECTC), May 2014, pp.759-762.

[3] D. Daerhan, Hao Hu and Stavros V. Georgakopoulos, "Novel topologies of misalignment insensitive SCMR wireless power transfer systems," in 2014 IEEE Antenna and Propagation Symposium(AP-S). July 2014, pp.1341-1342.

*For more information please contact:*
*Adviser: Professor Hsin-Chia Lu*
*Email: leonardo.hc.lu@gmail.com*

## Decoding Of Short Linear Block Codes Based On Tree Search

*from Communication and Signal Processing Group*

Since the introduction of turbo codes [1], many error-correcting codes with near-capacity performances have been proposed or rediscovered. Usually, iterative belief propagation (BP) is needed to achieve suboptimal error performances. Turbo codes, low-density parity check (LDPC) codes, repeat-accumulate (RA) codes belong to this class. The recently introduced polar codes [2] employs successive cancellation or list successive cancellation (SC) decoding. All these capacity approaching codes employ decoding techniques which are effective only if code lengths are very long. In some applications, such as the error-correction coding for the control channel of mobile communications, short error-correcting codes are needed. For short block codes, the BP decoding and the SC decoding are not efficient.

Currently, there are some well-known decoding algorithms for short linear block codes [1] including Generalized minimum distance decoding (GMD), Chase decoding algorithm, Ordered statistics decoding (OSD) algorithm, A* decoding algorithm . This article shows the performances of various versions of the A* algorithm.

For the A* decoding algorithm, a code tree with MRI (most reliable and independent) property is constructed firstly and then a priority-first search is applied to the code tree, where .the MRI property is obtained by permuting the received symbols so that the hard decision values of the most reliable symbols can be used as the message part for generating a codeword. The tree paths in the code tree are used to represent all the codewords. Suppose that C is an (n,k) linear block code with systematic generator matrix G, in which the 0th to the (k-1)th column is a k x k identity matrix. The tree structure expanded from a root node at level 0. For the first k levels, there are two branches emanated from each node representing 0 and 1 respectively. For the next n-k levels, there is only one branch emanated from each node representing a parity check bit. A node at level j representing a partial path (c0, c1, …, cj-1 ). At level n, we have a complete path, i.e., a codeowrd (c0, c1, …, cn-1). In the tree search, a stack of finite size is needed to store the searched nodes together with the associated metrics of partial code paths.

$$G = \begin{pmatrix} 1 & 0 & 0 & 0 & 1 & 0 & 1 & 1 \\ 0 & 1 & 0 & 0 & 1 & 1 & 1 & 0 \\ 0 & 0 & 1 & 0 & 1 & 1 & 0 & 1 \\ 0 & 0 & 0 & 1 & 0 & 1 & 1 & 1 \end{pmatrix}$$

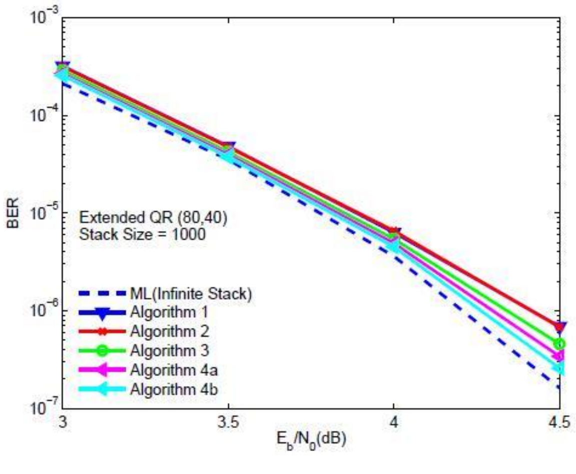
Figure 1

*(Continued on page 5)*

# Technology *(Continued from page 4)*

Consider an (n,k) = (8,4) extended Hamming code as example. Its generator matrix is shown in Figure 1. There are 16 code paths in the code tree. The basic A* decoding using the priority first search is referred as Algorithm 1 [3] here. In [4], the minimum distance of code C is employed to obtain a tree decoding with improves efficiency. We note that column 4 of G in Figure 1 is the sum of columns 0, 1 and 2. This implies that in the tree search, the bit c4 can be determined by c0, c1, and c2.. This information for c4 can be used to improve the efficiency of tree decoding. The algorithm employing this technique is denoted as Algorithm 3. We further note that the sum of columns 5 and 7 is equal to the sum of columns 0 and 1. This implies that in the tree search, the sum of bit c5 and c7 can be determined by c0 and c1. Then, we are able to obtain more information to improve the efficiency of tree decoding. The algorithm employing this technique is denoted as Algorithm 4a. There is a slightly different version of Algorithm 4a, which is denoted as Algorithm 4b [5].

Simulation results for decoding the (80,40) extended quadratic residue (QR) code with stack size of 1000 are shown in Figure 2. We see that using Algorithms 3, 4a, and 4b which employ the information of parity bits have the advantage of both lower bit error rates (BER) and lower complexity (average number of tree searches).



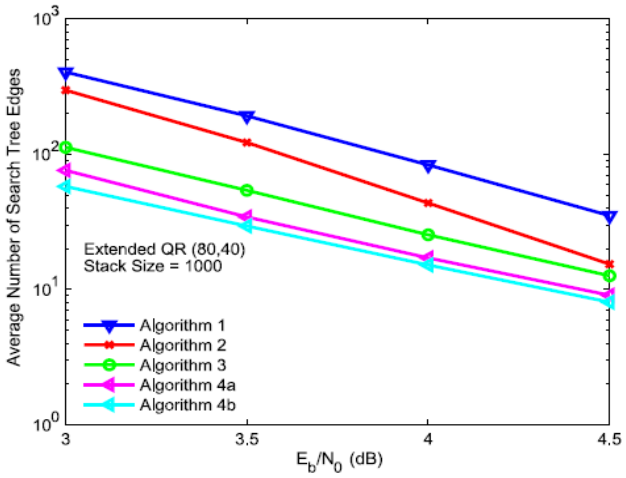




*Fig. 2*

References

[1] S. Lin and D. J. Costello, Error Control Coding, 2nd ed., NJ, USA: Prentice-Hall, Inc., 2004.

[2] . E. Arıkan, "Channel polarization: A method for constructing capacityachieving codes for symmetric binary-input memoryless channels," IEEE *Trans. Inform. Theory*, vol. 55, no. 7, pp. 3051–3073, 2009.

L. Ekroot and S. Dolinar, "A* decoding of block codes",. IEEE Trans. Comm., vol. 44, no. 9, pp. 1052.1056, Sep. 1996.

Y. S. Han, C. R. P. Hartmann., and Chih-Chieh Chen, "Efficient priority- first search maximum-likelihood soft-decision decoding of linear block codes," IEEE Trans. Inform. Theory, vol. 39, pp. 1514- 1523, September 1993.

T.-H. Chen, K.-C. Chen, M.-C. Lin, and C.-F. Chang, "On A∗ Algorithms for Decoding Short Linear Block Codes, IEEE Trans. Comm., Vol. 63, No. 10, pp. 3471-3481, October 2015.

*For more information please contact:*
*Professor: Mao-Chao Lin*
*Email: mclin@ntu.edu.tw*

# Activities

## GICE Delegates Visited Cathay Financial Holdings to Explore Industry-university Research Collaboration

On December 23th 2016, NTU GICE professors in the group of Data Science and Smart Networking (hereafter referred to as "DS group") were invited to visit Cathay Financial Holdings to discuss the possibility of cooperation between Financial and Technology. The NTU delegates include Professor Ming-Syan Chen, Dean of EECS College, Professor Tzong-Lin Wu, Director of NTU GICE, Professor Soo-Chang Pei, Tsung-Nan Lin, Hung-Yu Wei, I-Hsiang Wang and Hung-yi Lee.

The research of DS group includes Deep Learning, Data Privacy and Information Retrieval, Cognitive Neurorobotics, Internet of Things (IoT), Software Define Network (SDN), Network Function Virtualization, Machine Learning for Data Security, which highly meets the need of Cathay Financial Holdings.

Networks have taken an important place in our society. Almost everybody nowadays has already used it in one way or another. This means that the influence of networks is so boundless that we almost can't live without it.
Networks and software can do more than just digitized the banks' functions, they can also bring other applications into the financial industry like AI, the block chain, insurance tech, robot advising and more, which develop a new business model-Fintech. Fintech is revolutionizing the way we manage our finances, it will give customers advice, deal with transaction information and manage the product portfolio, which help them make better choices.


This new model will greatly affect people's economic activities and lifestyle.
In the past, we need to go to the bank to do most of the financial business, such as deposit money, payment, remittance and financial management etc…; in the future of Fintech, most of the financial services will be completed on our mobile device. Fintech not only reduce the costs effectively but also improve the quality and service efficiency.
We are very optimistic about the talks that GICE and Cathay Financial Holdings conduct a cooperative research program. Let us wait and see how much can Fintech bring to Taiwan.

*Group Photo*

# Corner of Student News

Article by Chao, Fang-Yi who is studying ESECA program at INP-ENSEEIHT via a dual degree agreement between NTU and ENSEEIHT.

Studying in France this year is doubtless the biggest adventure in my life. Although studying aboard is one of my dreams since I was little, the lack of financial support made me about to give it up. Thanks to the program of dual degree diploma between GICE NTU and INP-Enseeiht, I could have the opportunity to experience student life in France, even though I don't speak French.

INP-Enseeiht is an engineering school which aims to educate the professional engineer for industries in the future. The courses provided are very diverse and competitive. I was always exhausted after school since the classes are from 8 a.m. to 6 p.m. almost every week-day. In class, professors teach in English and they are willing to help foreign students. There are also many practical exercises which should be completed by collaborating with classmates. My knowledge of signal and Image processing, my specialty in GICE NTU, was improved further.

Besides the life in school, of course it is important to go travel on vacations. The beauty of France is well-known all over the world. There are countless magnificent castles, palaces and museums in every French city. I was overwhelmed by the spectacular of architecture when I visited Paris. It is also convenient to visit different countries in Europe. The trips to London and Poland with friends are my invaluable memories.

*Paris in the evening. 2016/9*

After studying in school for 6 months, a 5-month-internship in companies or laboratories is required for each student. I joined a tech company which utilizes satellite images and remote sensing techniques to provide solutions to manage environmental resources sustainably. The subjects are very international. They include maritime localization on Pacific Ocean or rice monitoring and intertidal zone detection in South Asia. It is fresh and interesting for me to explore a new domain of image processing.

It is my first time to go aboard alone for a long time. I faced some frustrated difficulties because of poor French and unfamiliar culture. But it made me stronger, braver and let me know there are still a lot of friendly people who are glad to help me. I appreciate them so much. Thank again to the faculties in GICE NTU and INP-Enseeiht. This priceless experience widened my horizon of the world and encouraged me to embrace the unpredictable future fearlessly.

*Poland trip with friends in Enseeiht. 2016/11*

# Corner of Student News

Article by TENG,CHIH-HENG who is studying ESECA program at INP-ENSEEIHT via a dual degree agreement between NTU and ENSEEIHT.

The INP-ENSEEIHT is a top ranking French public engineering school, under the trust of the Ministry of National Education, Higher Education and Research and in an agreement with the prestigious Ecole polytechnique. INP-ENSEEIHT is one of the seven components of the National Polytechnic Institute of Toulouse.

The standard curriculum is a three-year program resulting in the French Diplôme d'Ingénieur, considered by European universities (Bologna declaration) as a Master's degree of the European Higher Education Area. The ENSEEIHT is part of Institut National Polytechnique de Toulouse (INP Toulouse) which is itself part of the University of Toulouse. The school is also an associated school of the Institut Mines-Télécom.

The school life in France is different from Taiwan. The school arranges the courses from 8 am to 6 pm according to your major. There are more practical projects in ENSEEIHT. Fortunately, we just study for one semester then need to do a full time intern for the second semester. For the daily life, you need to cook by yourself every day because the cheapest menu in France is “Kebab”, it is an Arabic style food, which cost 5.5 euro at least (~180NTD). The price in supermarket is cheaper than it. The entertainments in night are going to the movie or bar. There is a bar in ENSEEIHT which have party every night. It is a good place to meet more friends. Or you can go to the bar out of the school and have a crazy night.

There is lot of vacations in France. Since we stay in Toulouse, we can visit the city of south France, Span and Italy easily. The travel time and distance are very long. Usually, the long distance bus is cheap and maneuvering transportation.

Above all, the culture such as the architecture, the people, daily life styles are very charming part in Europe.

*Ski in Andorra.*

**National Taiwan University Graduate Institute of Communication Engineering**

No.1, Sec.4, Roosevelt Road, Taipei 10617, Taiwan

**Phone**
+886-2-3366-3075

**Fax**
+886-2-2368-3824

**E-mail**
gicenewsletter@ntu.edu.tw

**Visit us at:**
http://www.comm.ntu.edu.tw

**Editor in Chief**
Prof. Hung-Yu Wei

**Editor**
Chiao Yun Kang