รายการอ้างอิง

ประสิทธิ์ ประพิณมงคลการ. (2540). **หลักการระบบสื่อสาร.** บริษัทซีเอ็ดยูเคชั่น จำกัด(มหาชน).

ลัญฉกร วุฒิสิทธิกุลกิจ. (2546). **หลักการไฟฟ้าสื่อสาร.** สำนักพิมพ์แห่งจุฬาลงกรณ์มหาวิทยาลัย.

3rd Generation Partnership Project (3GPP), (2007). Spacial channel model for multiple input multiple output (MIMO) simulations (3gpp tr 125.996 version 7.0.0 release 7). **ETSI, Technical Report.** [On-line]. Available: http://www.3gpp.org/ftp/Specs/html-info/25996.htm.

Balanis, C. A. (1997). **Antenna Theory: Analysis and Design.** 2nd ed. John Wiley.

Cover, T. M., and Thomas, J. A. (1991). **Element of Information Theory.** New York: Wiley-Interscience Publication.

Foschini, G. J. (1996). Layered space-time architecture for wireless communication in a fading environment when using multi-element antennas. **Bell Labs Technical Journal.** 1(2): 41-59.

Foschini, G. J., and Gans, M. J. (1998). On limits of wireless communication in a fading environment when using multiple antennas **Wireless Personal Communication.** 6(3): 311-335.

Gesbert, D., Shafi, M., Shiu, D.-S., Smith, P. J., and Naguib, A. (2003). From theory to practice: an overview of MIMO space-time coded wireless systems. **IEEE Journal Select Areas Communication.** 21(3): 281–302.

Jensen, M. A., and Wallace, J. W. (2004). A review of antennas and propagation for MIMO wireless systems. **IEEE Transactions on Antennas and Propagation**. 52(11): 2810-2824.

Khalighi, M. A., Brossier, J., Jourdain, G., and Raoof, K. (2001). Water filling capacity of Rayleigh MIMO channels. **Proceeding IEEE 12th International Symposium on Personal, Indoor and Mobile Radio Communication.** 12(1): 155-158.

Patzold, M., and Hogstad, B. O. (2004). A space-time channel simulator for MIMO channels based on the geometrical one-ring scattering model. **Vehicular Technology Conference.** 1: 144-149.

Petrust, P., Reed, J. H., and Rappaport, T. S. (1996). Geometrically based statistical channel model for macro cellular mobile environments. **IEEE Global Telecommunications Conference.** 2: 1197-1210.

Rappaport, T. S. (2002). **Wireless Communications: Principles and Practice.** 2nd ed. Prentice Hall.

Shannon, C. (1948). A mathematical theory of communication. **Bell Labs Technical Journal.** 27 : 379-423, 623-656.

Shiu, D.-S., Foschini, G. J., Gans, M. J., and Kahn, J. M. (2000). Fading correlation and its effect on the capacity of multi-element antenna systems. **IEEE Transactions on Communication.** 48: 502-513.

Svantesson, T. (2002). Correlation and channel capacity of MIMO systems employing multimode antennas. **IEEE Transactions on Vehicular Technology.** 51(6): 1304-1312.

Svantesson, T., and Ranheim, A. (2001). Mutual coupling effects on the capacity of multiple antenna systems. **Proceeding IEEE Inernational Conference on Acoustics, Speech, and Signal Processing**. 4: 2485-2488.

Telatar, I. E. (1995). Capacity of multi-antenna gaussian channels. **European Transactions on Telecommunications**, 10(6): 585-595

Wallace, J. W., and Jensen, M. A., (2004). Mutual coupling in MIMO wireless systems: A rigorous network theory analysis. **IEEE Transactions Wireless Communication.** 3(4): 1317-1325.

Wyglinski, A. M., and Blostein, S. D. (2003). On uplink CDMA cell capacity: mutual coupling and scattering effects on beamforming, **IEEE Transactions on Vehicular Technology**. 52(2) : 289-304.

ภาคผนวก ก

บทความทางวิชาการที่ได้รับการตีพิมพ์เผยแพร่

รายชื่อบทความทางวิชาการที่ได้รับการตีพิมพ์เผยแพร่

Thongsopa C., Saetiaw C. and Intarapanich A. (2009). "**The Effect of 3D Antenna Radiation Pattern on Narrowband MIMO Capacity Simulation and Measurement**," 2009 International Symposium on Antennas and Propagation. : 540-543

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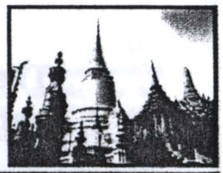
October 20-23, 2009

The Imperial Queen's Park Hotel, Bangkok, Thailand



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The Effect of 3D Antenna Radiation Pattern on Narrowband MIMO Capacity : Simulation and Measurement

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1. Introduction

G. J. Foschini and M. J. Gan have been shown that the use of multiple antennas in both transmitter and receiver, called multiple input multiple output system (MIMO), linearly increases the channel capacity with the number of antennas [1]. The channel model in [2] is based on the angle of arrival (AOA). This model, however, does allow including the radiation pattern into the capacity calculation. The effect of fading correlation without antenna pattern on the MIMO capacity has been studied in [3]. It has been shown that the capacity is reduced when the fading correlation exists [3]. In this paper, we generalize the channel model so that it is able to include 3-dimention (3D) antenna pattern effect on the capacity into consideration. Having the channel model, capacity measurements are performed for omni-direction and direction antennas.

The paper is organized as follows. In the next section, the proposed channel model with 3D antenna radiation pattern is discussed for both single and multiple antenna systems. Simulations of the MIMO capacity in various propagation environments are presented in section 3. Section 4 will show about field measurement and results by the MIMO test-bed. Finally, section 5 concludes the paper.

2. Proposed MIMO Model

In this section, a brief review of spatial correlation based on "one-ring" channel model is given. Then, the proposed model of the MIMO system with the effect of antenna pattern is discussed. We conclude this section with a technique for MIMO capacity calculation with effect of both spatial correlation and antenna pattern.

The "one-ring" channel model is used for fading correlation computation [3]. Let x and y be a transmitted and received signal respectively. The system model of a narrowband wireless system with single antenna at the both ends can be written as

$$y = hx + n \quad (1)$$

where h and n are the channel impulse response and additive noise respectively. The radiation pattern of the receive antenna will change the magnitude of the channel impulse response for each angle of arrival (AOA) as shown in Fig. 1.

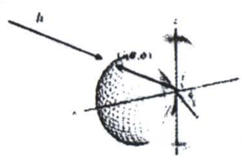


Figure 1: Schematic of the antenna pattern, incoming signal and received signal

The modified channel impulse response with the effect of the radiation pattern or antenna gain pattern for a narrowband wireless system can be then written as [4]

$$h_u = G(\theta,\phi)h \tag{2}$$

It can be seen that the modified channel impulse response consists of three random variables, i.e. θ, ϕ and h. The antenna gain pattern, $G(\theta,\phi)$, will transform the angle random variable, θ, ϕ, to a new random variable. Hence, the modified channel impulse response is a multiplication of two random variables. The narrowband MIMO capacity is a function of the channel matrix will given by [4]

$$C = \log\det\left(I_{n_T} + \frac{P}{\sigma_n^2}\mathbf{H}_u\mathbf{H}_u^T \right) \tag{3}$$

where P is the signal power and σ_n^2 is the noise power. To calculate the capacity with effect of antenna pattern, random matrices are generated by using realization of the channel matrix is obtained as in [4] where the AOA for each receive antenna is randomly generated.

3. 3D Radiation Pattern Simulations

The MIMO capacity in (3) is evaluated using Monte Carlo simulations. We generate 10,000 instances of channel and collect the statistics of MIMO channel capacity. In the simulations, we use 4 transmit and 4 receive antennas at the both ends. The signal to noise ratio (P/n) is 20 dB. The AOAs are generated using Laplacian distribution [1]. In all simulations, the antenna is pointed into the direction of the main lobe of antenna. Three types of antenna are used in the simulations. An isotropic antenna is used for simulating a reference scenario. A horizontal polarized dipole and a 5-element Yagi-Uda are used to investigate the effect of antenna radiation pattern to the channel capacity.

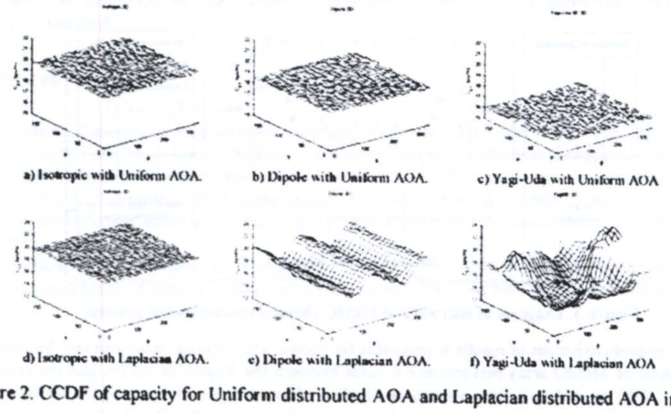
In this simulation, the 3D radiation patterns of all antennas are normalized, by average antenna radiation or antenna gain of all direction with normalize factor Z_z:

$$Z_z = \frac{\int_0^{\pi}\int_0^{2\pi} \left| G(\theta,\phi)_{Directional} \right| d\theta d\phi}{\int_0^{\pi}\int_0^{2\pi} \left| G(\theta,\phi)_{Isotropic} \right| d\theta d\phi} \tag{4}$$

Then, the normalize radiation pattern or gain for each angle will be

$$G(\theta,\phi)_{normalize} = \frac{G(\theta,\phi)_{Directional}}{Z_z} \tag{5}$$

The 3-dimentional radiation patterns of dipole and Yagi-Uda antennas are obtained from SuperNEC version 2.9. The 3D radiation pattern in linear scale and polar scale used in the simulations, for dipole and Yagi-Uda antennas. To compare the performance of each antenna type, we vary the angle spread values and observe the outage capacity. The channel capacity at a given outage probability q, denoted by C_q. For example, The 10% outage channel capacities will be writhen as $C_{0.1}$.



a) Isotropic with Uniform AOA. b) Dipole with Uniform AOA. c) Yagi-Uda with Uniform AOA

d) Isotropic with Laplacian AOA. e) Dipole with Laplacian AOA. f) Yagi-Uda with Laplacian AOA

Figure 2. CCDF of capacity for Uniform distributed AOA and Laplacian distributed AOA in 3D

In the simulations, the antenna is pointed into a 3-dimention with $0 \leq \theta_k \leq \pi$ and $0 \leq \phi_k \leq \pi$ in azimuth plane and elevation plane. Capacities of 10% outage with uniform distribution for Isotropic antenna, Dipole, and Yagi-Uda 5-element are shown in Fig.2a, 2b and 2c respectively. For Laplacian AOA distribution, 10% outage capacities are shown Fig.2d, Fig.2e and Fig.2f for Isotropic antenna, Dipole and Yagi-Uda 5-element respectively. For uniform distribution case, the average $C_{0.1}$ of the isotropic antenna is about 19.7 bps/Hz for all directions. The outage capacity for dipole antenna reduces from the ideal case by about 1.2 bps/Hz while Yagi-Uda antenna case, $C_{0.1}$ is about 3.7 bps/Hz less than the ideal case.

In Laplacian distribution case, the power spectrum is concentrated in the mean AOA and it can be observed that there is a relationship between mean AOA and capcacity. The capacity of direction antenna is greater than the isotropic case when the direction antenna is in the direction of mean AOA. If the antenna is in a wrong direction, the capacity will be less than the isotropic case. Hence, to gain the maximum capacity for the directional antenna, the antenna has to point into a proper direction. Otherwise, the advantage of using direction antenna will vanish due to signal attenuation by the antenna. The average capacity for all directions is less than the isotropic capacity, however. For example, the outage capacity of the isotropic case for uniform AOA is 19.69 bps/Hz which is higher than 18.50 bps/Hz and 16.11 bps/Hz for the dipole and Yagi-Uda antennas.

4. Capacity Measurements

In this section, the capacity of a directional antenna is measured for 2x2 MIMO system. A dipole antenna is used in the experiment for comparison with 5-element Yagi-Uda antenna. The 2-element dipole array is used in the experiment as a transmit array. At the receiver, either 2-element dipole or 2-element Yagi-Uda array is used. The measurement campaign is performed by using the SUT QPSK test-bed with 70 MHz IF signal which is modulated at 2.33 GHz. The transmitted signal from each antenna is captured at each receive antenna by using a switch. The channel's coherence bandwidth at this frequency is less than 16 MHz for typical indoor and outdoor environments. To ensure far-field radiation, the transmitter and receiver are at least three meters apart. A complete calibration of each radio's gain, phase noise and frequency offset was performed prior to field measurements. The block diagram of the capacity measurement system is shown in Fig. 3. Probing signal is loaded into the QPSK signal generator. The received IF signals are digitized and stored in the digital oscilloscope. The field measurements were performed in a laboratory with electronic equipment and office furniture and at a car parking yard that has a very large empty ground with a few electrical power line for an indoor and outdoor environment respectively.

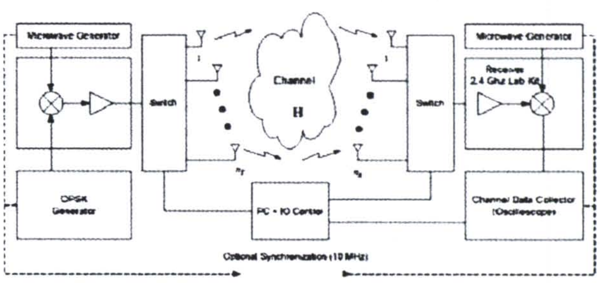
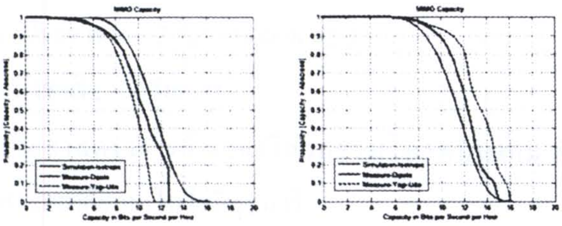


Figure 3. Diagram of narrowband MIMO channel measurement system.

A comprehensive set of results is presented for indoor and outdoor measurement locations. A fair comparison of MIMO array performance is made between the Yagi-Uda arrays and the reference dipole arrays with an isotropic from simulation result as show in figure 4a and figure 4b for indoor scenarios and outdoor scenarios respectively. It is observed in Fig. 4 that the directional antenna in indoor environment doesn't improve MIMO capacity whereas directional antenna improves MIMO capacity in outdoor environment.



a) indoor scenarios b) outdoor scenarios

Figure 4. Field measurement Yagi-Uda for indoor scenarios and outdoor scenarios with $\Delta d = 4\lambda$.

5. Conclusion

We have proposed the channel model with including 3-D radiation effect for MIMO capacity calculation. We have shown that the directional antennas can improve the MIMO capacity in outdoor scenarios when the directional antenna is in a proper direction. Capacity improvement can be achieved when the statistic of AOA has peaky characteristic. We have shown that directional antennas are not attractive for MIMO systems in a scenario where the randomness of AOA is high such as uniformly distributed AOA. In a scenario where AOA is concentrated on a single direction, the antenna position is crucial to the capacity. If the antenna is point into the mean AOA, then the capacity is increased. However, when the main antenna beam is off from the mean AOA, the capacity does not improve. The results from measurement verify that the AOA and antenna radiation pattern play an importance role in narrowband MIMO capacity. AOA is controlled by the propagation environment whereas the antenna radiation pattern depends on the antenna design. Hence, the antenna has to be design to match specific propagation environment so that the MIMO capacity is improved.

Acknowledgments

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References

[1] I. E. Telatar, *Capacity of multi-antenna Gaussian channels* AT&T Bell Labs, 1995, Tech. Rep.
[2] G. J. Foschini and M. J. Gan, "On limits of wireless communications in fading environment when using multiple antennas," Wireless Personal Communications, vol. 6, no. 3, pp. 311-335, March 1998.
[3] D.-S. Shiu, G. J. Foschini, M. J. Gans, and J. M. Kahn, "Fading correlation and its effect on the capacity of multielement antenna systems," IEEE Transactions on Communications, vol. 48, pp. 502-513, 2000.
[4] C. Saetiaw, A. Intarapanich, C. Thongsopa, "Relations Between 3-Dimensions Antenna Pattern and Narrowband MIMO Capacity", Microwave Conference, 2007. APMC 2007. Asia-Pacific pp. 1-4, 2007

ประวัติผู้วิจัย

ชื่อ-นามสกุล : ผู้ช่วยศาสตราจารย์ ดร. ชาญชัย ทองโสภา

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2539 วิศวกรรมศาสตรมหาบัณฑิต สาขาวิศวกรรมไฟฟ้า-สื่อสาร มหาวิทยาลัยเกษตรศาสตร์

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ความชำนาญเฉพาะด้าน

1) การออกแบบวงจรความถี่สูง
2) ระบบสายอากาศ และสายอากาศแบบแอคทีฟ (Active antenna)
3) การให้ความร้อนด้วยคลื่นความถี่สูง (Microwave Hypethermia)

รางวัลเกียรติคุณ

2533: โล่ห์เกียรติคุณ จากกรมสื่อสารทหารอากาศ **ในฐานะบุคคลดีเด่น**

2534: โล่ห์เกียรติคุณ จากกองทัพอากาศ **ในฐานะบุคคลดีเด่น**

2540: รางวัลวิทยานิพนธ์ มหาวิทยาลัยเกษตรศาสตร์

2546: รางวัลศิษย์เก่าดีเด่น โรงเรียนช่างฝีมือทหาร

2551: โล่ห์เกียรติคุณ จากมหาวิทยาลัยเทคโนโลยีสุรนารี**ในฐานะบุคคลดีเด่น**

สิทธิบัตร

1. การหลอมขึ้นรูปผลิตภัณฑ์โดยใช้วัตถุดิบรีไซเคิ้ลจากขยะชุมชนโดยขบวนการคลื่นแม่เหล็กและการบีบอัด เลขที่คำขอ 0501000290
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- การออกแบบระบบสื่อสาร หอบังคับการบินกับนักบิน
- การออกแบบวิทยุรับ-ส่ง VHF, UHF (AM) 25 วัตต์ (ระบบเปิดตลอด 24 ชั่วโมง)
- การออกแบบระบบวิทยุคลื่นสั้น HF (AM) 1kW (ระบบเปิดตลอด 24 ชั่วโมง)

พ.ศ. 2540-2543 ตำแหน่งนักวิจัย สังกัดหน่วยปฏิบัติการวิจัยเทคโนโลยีโทรคมนาคม ศูนย์เทคโนโลยีอิเล็กทรอนิกส์และคอมพิวเตอร์แห่งชาติ (NECTE)
- เป็นที่ปรึกษาองค์การโทรศัพท์แห่งประเทศไทยในโครงการ SDH
- ผลงานการออกแบบวงจรทางด้านความถี่สูง

ปัจจุบัน อาจารย์มหาวิทยาลัยเทคโนโลยี สำนักวิชาวิศวกรรมศาสตร์ สาขาวิชาวิศวกรรมโทรคมนาคม

บทความวิชาการทั้งในประเทศและต่างประเทศ

1) M.Krairiksh, **C.Thongsopa** and A.Mearnchu, "A Steerable Active Applicator," Proceedings of the 1998 Asia-Pacific Microwave Conference, Yokohama, vol. 2, pp.861-864, Dec. 1998.
2) M.Krairiksh, **C.Thongsopa** and C.Phongcharoenpanich, "A Steerable Active Spherical Slot Array Antenna," Proceedings of the 1999 Progress in Electromagnetics Research Symposium, Taipei, vol. 1, p.483, Mar. 1999.
3) M.Krairiksh, **C.Thongsopa**, D.Srimoon and A.Mearnchu, "Analysis of Steerable Active Slot Array Applicator," Proceedings of the 1999 Asia-Pacific Microwave Conference, Singapore, vol. 2, pp.489-492, Dec. 1999.
4) M.Krairiksh, **C.Thongsopa**, C.Phongcharoenpanich, E.Khoomwong andC.Leekpai,"A Steerable Spherical Slot Array Antenna," Journal Science Asia, vol. 25, no.4, pp.231-236,
5) **C.Thongsopa**, M.Krairiksh, N.Srirattana and A.Intarapanich, "A Single Patch Beam Steering Antenna," Proceedings of the 2000 Asia-Pacific Microwave Conference, Sydney, pp. 1510-1513, Dec. 2000.
6) **C.Thongsopa**, M.Krairiksh and A.Mearnchu, " Analysis and Design of a Steerable Active Array Applicator," The First National Meeting on Biomedical Engineering, Bangkok Thailand, Sep. 2001
7) **C.Thongsopa**, M.Krairiksh, A.Mearnchu and D.Srimoon, "Analysis and Design of Injection Locking Steerable Active Array Applicator," IEICE Trans. Communications, vol.E 85-B, no 10, pp. 2327-2337, Oct. 2002.
8) **C.Thongsopa**, C. Jumniensri, and J.Wongmethanukro, "Beam Steering Using Single Patch Active Antenna," Proceedings of the 26th Electrical Engineering Conference, Thailand, pp.1796-1800, Nov. 2003.
9) **C. Thongsopa**, P. Jarataku, and P. Sukpong, "Wide Band U-Shaped cross section Antenna with a strip on a U-Shaped ground plane," IEEE Transactions on Magnetics,Beijing,China, pp.458-461, Apr. 2005.
10) P. Sukpong, **C. Thongsopa**, and P. Jarataku, "Injection-Locked Active Antenna Using a Dual Gate MESFET," The 4th PSU-Engineering Conference (PEC4), Songkhla,Thailand, pp. 50-54, December 8-9, 2005.

11) C. Thongsopa, A. Intarapanich, and C. Saetiaw," Amplitude Modulation Using Injection Locking Oscillator Under Strong Envelop Variation Injection," Journal of Electromagnetic Waves and Applications, Tokyo, Japan, August 2006.

12) **C. Thongsopa**, "Array of A U-Shaped Element on A U-Shaped Ground Plane Wideband Antenna", 2006 Asia-Pacific Conference on Communication, Bussan, Republic of Korea, 31 August-1 September 2006, 5D-145.

13) P. Jarataku, and **C. Thongsopa**, "2.45 GHz Bi- Directional Amplifier for Wireless LAN," The 5th PSU-Engineering Conference (PEC5), Phuket, Thailand, pp.197-201,May 10-11. 2007.

14) **C. Thongsopa**, D.Srimoon,and P. Jarataku, "A U-Shaped Cross Sectional Antenna on a U-Shaped Ground Plane with an offset Parabolic Reflector for WLAN," IEEE AP-S International Symposium 2007, Honolulu, Hawaii. USA, pp 5159-5162, Jun 10-15, 2007.

15) C. Saetiaw, A. Intarapanich, and **C.Thongsopa**, "Effect of Spatial Correlation with Directional Antenna on MIMO capacity," 2007 International Symposium on Antenna and Propacation, Niigata, Japan, pp 1334-1337, August 20-24, 2007.

16) A. Intarapanich, **C.Thongsopa**, and C. Saetiaw, "Effect of Antenna Patterns on Narrowband MIMO capacity," IEEE 2007 International Symposium on Microwave, Antenna, Propacation, and EMC Technologies For Wireless Communications, Hangzhou,China, pp 160-163, August 14-16, 2007.

17) **C. Thongsopa**, and A. Intarapanich, " Double injection Locking Active Antenna," European Conference on Antennas and Propagation, (Eucap 2007) Edinburgh, UK, pp aa-bb, November 11-16, 2007.

18) P. Thosdee, and **C. Thongsopa**, "Quasi-Rhomboid Antenna for Ultra Wideband Wireless Communication System," Proceedings of the 30th Electrical Engineering Conference, Kanchanaburi, Thailand, pp. aa-bb, October 25-26. 2007.

19) C. Saetiaw, A. Intarapanich, and **C.Thongsopa**, "Relations between 3-Dimensions Antenna Pattern and Narrowband MIMO Capacity," Proceedings of the 2007 Asia-Pacific Microwave Conference, Bangkok, Thailand, pp. aa-bb, December 11-14, 2007.

20) Maungrat, M., **Thongsopa**,C., and Jarataku, P.,"Measurement of UHF Radio Wave Propagation in Parking," *The 7th PSU-Engineering Conference (PEC7)*, Songkhla,Thailand, pp. 97-100, May. 21-22, 2009.

21) Tangwachirapan, S., **Thongsopa**,C., "Numerical Simulation of Magnetic Fields Shield for Breast Cancer Hyperthermia," *The 7th PSU-Engineering Conference (PEC7)*, Songkhla,Thailand, pp. 102-105, May. 21-22, 2009.

22) Patummakasorn, C., and **Thongsopa, C.,** "Analysis and Design of Applicator System for Regional Induction Heating 2.45 GHz," WSEAS Transactions on Communications, Issue 9, Volume 8, September 2009.

23) **Thongsopa, C.**, and Thosdee, P., "Array of Quasi Rhomboid Shaped Element Bowtie Antenna with Reflector for Ultra Wideband Applications," *in proc.* The 2009 International Symposium on Antennes and Propagation (ISAP 2009), Thailand, October 20-23, 2009.

24) **Thongsopa, C.**, and Saetiaw, C., "The Effect of 3D Antenna Radiation Pattern on Narrowband MIMO Capacity: Simulation and Measurement," *in proc.* The 2009 International Symposium on Antennes and Propagation (ISAP 2009), Bangkok, Thailand, October 20-23, 2009.

25) Patummakasorn, C., and **Thongsopa, C.,** "Simulations and Experiment of Applicator System for Regional Induction Heating 2.45 GHz," WSEAS Conferences AIC '09, ISCGAV '09, ISTASC '09, HTE '09, FMA '09, BEBI'09 Moscow, Russia, August 20-22, 2009.

26) **Thongsopa, C.**, Intarapanich, A.and Maungrat, M., "Temporal Measurement of UHF Radio Wave in Presence of Vehicles" *in proc.* 2009 International Symposium on Electromagnetic Compatibility(EMC'09) Kyoto, Japan, July 20-24,2009.

27) **Thongsopa, C.**, Intarapanich, A.and Tangwachirapan, S.,"Shielding system for breast hyperthermia inductive heating"*in proc.* The XIVth International Symposium on Electromagnetic Fields in Mechatronics Electrical and Electronic Engineering, (ISEF'09) Arras, France, Sep 10-12, 2009.

28) **Thongsopa, C.**, and Thosdee, P., *"Development of Monocycle pulse* Generator Circuit for Ultra Wideband Applications," *in proc.* 32nd Electrical Engineering Conference (EECON-32), Tawaravadee Resort Hotel, Prachinburi, Thailand, October 20-23, 2009.

29) Maungrat, M., and **Thongsopa, C.**, "Measurement of ASK and FSK Wave Propagation in Parking," *in proc.* 32^{nd} Electrical Engineering Conference (EECON-32), Tawaravadee Resort Hotel, Prachinburi, Thailand, October 20-23, 2009.

30) Tangwachirapan, S., **Thongsopa, C.**, "Study Magnetic Fields Shield for Lossy Mediums Inductive Hyperthermia Heating," *in proc.* 32^{nd} Electrical Engineering Conference (EECON-32), Tawaravadee Resort Hotel, Prachinburi, Thailand, October 20-23, 2009. ***(The Best Paper Award in Biomedical Engineering).***

31) Santalunai, S., and **Thongsopa, C.**, "High Power Amplifier Design for RF Induction Heating" *in proc.* 32^{nd} Electrical Engineering Conference (EECON-32), Tawaravadee Resort Hotel, Prachinburi, Thailand, October 20-23, 2009.

32) Yaemsuan, P., and **Thongsopa, C.**, "Design and Construction of Induction Heating Boiler Machine with Full-Bridge Inverter"*in proc.* 32^{nd} Electrical Engineering Conference (EECON-32), Tawaravadee Resort Hotel, Prachinburi, Thailand, October 20-23, 2009.

33) Saetiaw, C., **Thongsopa, C.,** Intarapanich, A. and Chinanupakorn, M., "Effect of Directional Antennas to Narrowband MIMO Capacity", 2010 International Workshop on Information Communication Technology (ICT 2010) , August 24 - 25, 2010 KMITL, Bangkok, Thailand.