NTU GICE

Newsletter

Graduate Institute of Communication Engineering, National Taiwan University

Vol. 13, No. 2 Jun. 2022 http://www.comm.ntu.edu.tw gicenewsletter@ntu.edu.tw

GICE Honors

Prof. Lin-Shan Lee

ISCA Medal for Scientific Achievement

Prof. Wanjiun Liao

The Ministry of Education's 25th Annual National Professorship Awards

Prof. Ming-Syan Chen

110 Outstanding Special Researcher
Ministry of Science and Technology

Prof. Ai-Chun Pang

110 Outstanding Research Award
Ministry of Science and Technology

Prof. Hsi-Tseng Chou

110 Outstanding Research Award
Ministry of Science and Technology

Prof. Jian-Jiun Ding

110 Outstanding Instructor
National Taiwan University

Prof. Ai-Chun Pang

Far Eastern Y. Z. Hsu Science and Technology Memorial Foundation-
The 20th Paper Award (ICT)

Prof. Yu-Chiang Frank Wang

Far Eastern Y. Z. Hsu Science and Technology Memorial Foundation-
The 20th Paper Award (AI)

GICE Honors

Frequency diversity transmitting array for stable power reception under rotation in 2D far-field wireless power transmission

Prof. Hsin-Chia Lu

Associate Professor, Dept. Electrical Engineering &
Graduate Inst. Communication Engineering,
National Taiwan University

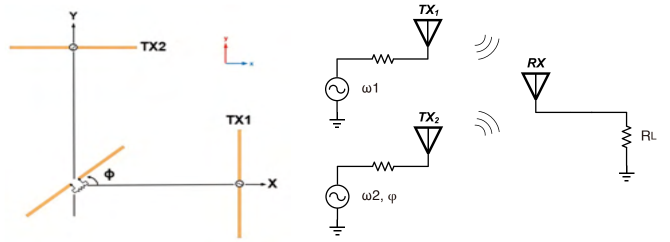
I. INTRODUCTION

Wireless power transmission can deliver power to small receiver nodes such as IoT devices and allow them to function without batteries. However, the area that a single transmitter antenna can serve is limited. A transmitter array with different frequencies to avoid interference between transmitters is proposed at [1]. The rotation of the receiver may cause polarization and antenna pattern mismatch, thus reduce the received power. Receivers with multiple receiving antennas to receive energy from different directions to mitigate power variation under rotation are proposed at [2-4]. However, this approach will inevitably increase the cost and size of the receiver.

Transmitter array using time switch modulation is proposed at [5] to realize stable received power under rotation of receiver. At each time instance, only one transmitter is turned on to eliminate the interference between TX antennas. As only one transmitter is turned on each time, the maximum power is limited by the power amplifier at each TX antenna. In the paper, we propose a frequency diversity transmitting array to increase the delivered power. Each TX antenna uses a distinct TX frequency. They are all turned on at the same time. Frequency beating will occur due to the coexistence of two signals with different frequencies. Beating will cause the periodical amplitude variation over time. However, if we integrate the received power over sufficient long time, this periodical variation can be eliminated to get stable received power. The received power will be the sum of the power from two transmitting antennas. As all transmitters can be turned on at the same time, the total power is increased. We already showed in [5] that the total power from two time-switched transmitters with 90° separation is a constant under rotation. Therefore, in frequency diversity modulation, we can also get stable received power under rotation. We will first give the formulation for the frequency diversity modulation, then, we will show the average of received power over a sufficiently long integration time is just the sum of power from each TX antennas, which is the same as no interference occurs. The measurement setup and results at 915MHz will also be given.

II. FORMULATION AND SIMULATION

A. Received power under rotation



(a.) (b.)

Fig. 1. (a) Antenna arrangement and (b) block diagram for wireless power transfer for 2D case with 2 TX and one RX antennas.

Fig. 1 shows the arrangement of two transmitting (TX) antennas and one receiving (RX) antenna in 2D case, which are all short dipole antennas. The receiving antenna is placed at the origin of the xy-plane, rotated by an angle ϕ. The receiving antenna is kept on the xy-plane when rotating. When ϕ = 0°, RX is parallel to TX2 and perpendicular to TX1. The transmitting power of TX1 and TX2 are P_{TX1} and P_{TX2} respectively. The antenna pattern of a short dipole is given as,

$$g(\phi) = g_0 \sin(\phi)\,. \qquad (1)$$

The received power contributed by TX1 and TX2 are expressed as,

$$P'_{RX1} = \sin^2\phi \times P_{RX1} \text{ and } P_{RX1} = \frac{P_{TX1} \times g_t \times g_r \times \lambda^2}{(4\pi r)^2}\,. \qquad (2)$$

$$P'_{RX2} = \cos^2\phi \times P_{RX2} \text{ and } P_{RX2} = \frac{P_{TX2} \times g_t \times g_r \times \lambda^2}{(4\pi r)^2}\,. \qquad (3)$$

where P_{RX1} and P_{RX2} are the maximum possible received power from TX1 and TX2 according to Friis equation. In (2)~(3), r is the distance between the TX and RX. g_t, and g_r are the gains of the TX and RX respectively. Note that there is no polarization mismatch, so the reduction of received power is only caused by antenna pattern mismatch. From (2)~(3), we can see the power from TX1 or TX2 is changing periodically under different rotation angles.

B. Received power under frequency diversity transmitter array

The carrier frequencies for two TX antennas are ω_1 and ω_2, respectively, with a phase difference φ between them. The received current can then be expressed as,

$$\begin{aligned} i_{RX}(t) = \; & \sqrt{2P_{RX1}/R_L}\,\sin\phi \times \cos(\omega_1 t) + \\ & \sqrt{2P_{RX2}/R_L}\,\cos\phi \times \cos(\omega_2 t + \varphi) \end{aligned} \qquad (4)$$

Assume $P_{TX}=P_{TX1}=P_{TX2}$, the instantaneous power when driving a load of R_L is

$$\begin{aligned} P_{INS} &= i_{RX}^2(t) R_L \\ &= 2P_{RX1}\begin{bmatrix} \sin^2\phi\cos^2(\omega_1 T) + \cos^2\phi\cos^2(\omega_2 T + \varphi) \\ +\sin\phi\cos\phi\left[\cos(\omega_2 T + \varphi + \omega_1 T) + \cos(\omega_2 T + \varphi - \omega_1 T)\right] \end{bmatrix} \end{aligned} \qquad (5)$$

The long-term average received power can be found by integrating over some period T as,

$$\begin{aligned} P_{RX} &= \frac{1}{T}\int_0^T i_{RX}^2(t) R_L\, dt \\ &= P_{RX1}\left(1 - \frac{2\sin\phi\cos\phi\left\{\sin\left[(\omega_2-\omega_1)T + \varphi\right] - \sin\varphi\right\}}{(\omega_2-\omega_1)T}\right) \end{aligned} \qquad (6)$$

The long-term here means the integration is much longer than the period of the carrier signals. The third term in (5) with frequency summation will vanish in the integration due to its much higher frequency. The second term in (6) denotes the beat frequency signal, which is the frequency difference between two TX antennas. The long-term average output power under different integration time T is shown in Fig. 2. If T is sufficiently long, the contribution to the average power from the second term will approach zero. To get less than 5% ripple, we only need about 3.24T0. T0 is the inverse of the beat frequency. We can therefore get a stable output power equal to PRX1 after a sufficiently long time. The value of φ is not critical as its contribution in (6) is divided by a large integration time T.

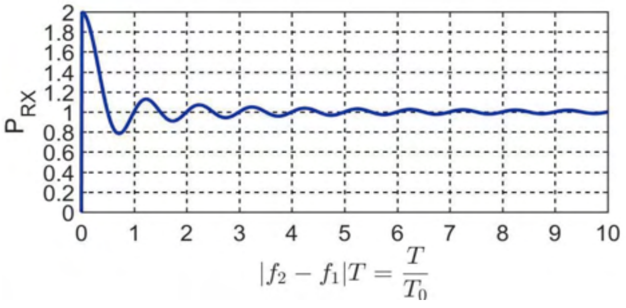


Fig. 2. Average output power under different integration time T when ϕ=45° and φ=0°.

III. MEASUREMENT RESULTS

A. Measurement setup

Two HP 8648C RF signal generators are used to generate two CW signals at 915MHz and 915.02MHz. A 10MHz signal synchronizes both signal generators. The measurement setup is shown in Fig. 3. A dipole antenna with model 3121 DB4 from EMCO is used to receive the RF signal at different rotation angles. The size of both TX antennas are about 15cm x 15cm. The distance between the receiving dipole and the two transmitting antennas are both 1m, which is greater than the far-field distance given by $2\lambda_0=0.656$m or $2D^2/\lambda_0=0.55$m. Received RF power is converted to DC voltage by the power detector ZX47-50LN+ from Mini-Circuits and measured by an oscilloscope.

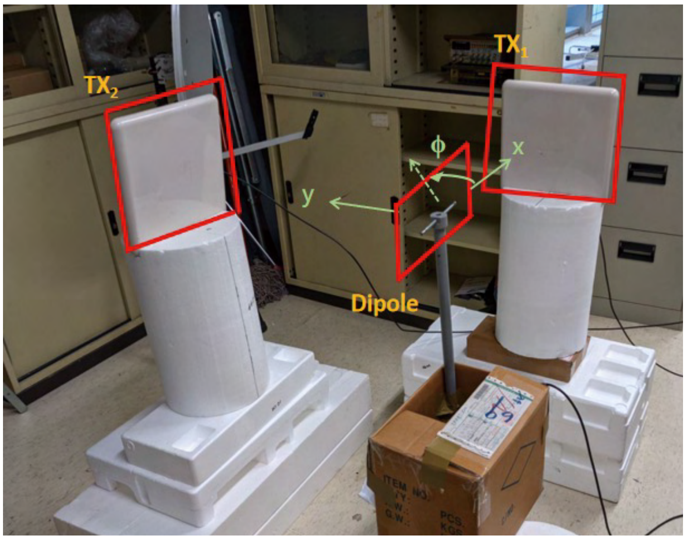


Fig. 3. Photo of measurement setup.

II. FORMULATION AND SIMULATION

B. Measurement results under rotation

The measured average power for different rotation angles are shown in Fig. 4. The received power for turning on only TX1 and TX2 are also added for comparison. TX1 has maximum received power at ϕ=90° while TX2 at ϕ=0° . Psum denotes the sum of power by numerically adding up power from TX1 and TX2 at that rotation angle. Pmax and Pmin are the measured maximum and minimum power at each rotation angle when both TX antennas are turned on. When ϕ=0° or 90° , the receiving antenna received signal only from one TX antenna, therefore, there is no interference. Pmax is close to Pmin. For ϕ=45° or 135° , the receiving antenna will receive siganls from both TX antennas with almost same amplitude. Therefore, Pmax is the largest while Pmin is close to zero. P_{RX} is calculated as the average of Pmax and Pmin. We can clearly see that receiver power when only TX1 or TX2 is turned on changes for different rotation angles, while P_{RX} is quite stable as two antennas are turned on. P_{RX} is also close to Psum. This means even the oscillators of two antennas are synchronized, the ripple due to interference can be removed by integration over time.

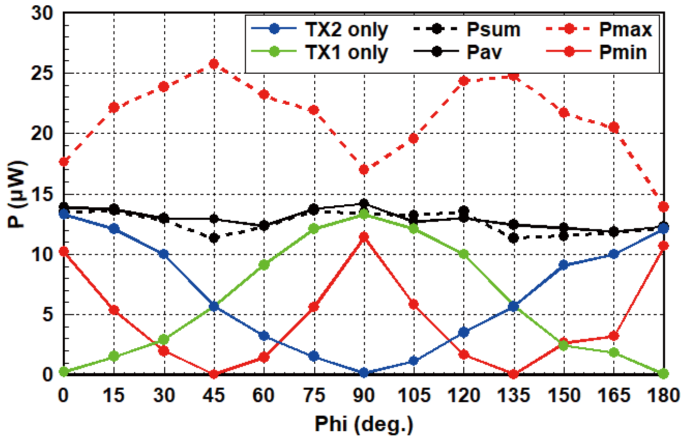


Fig. 4. Measured received power at different rotation angles.

IV. CONCLUSION

The frequency diversity modulation scheme allows all transmitters to turn on simultaneously to deliver more power to the receiver. In the meantime, it still can provide stable power under rotation after time integration. Measurement results show that we can get stable received power under rotation and the received power is just the sum of power from each TX antenna.

Reference

[1] Daiki Maehara, Gia Khanh Tran, Kei Sakaguchi, Kiyomichi. Araki, “Experimental study on battery-less sensor network activated by multi-point wireless energy transmission.” IEICE Transactions on Communications. Vol.E99-B, No.4, pp. 905-916, Apr. 2016. 10.1587/transcom.2015EBP3318

[2] M. Fantuzzi, M. Del Prete, D. Masotti and A. Costanzo, "Quasi-isotropic RF energy harvester for autonomous long distance IoT operations," 2017 IEEE MTT-S International Microwave Symposium (IMS), Honolulu, HI, 2017, pp. 1345-1348, doi: 10.1109/MWSYM.2017.8058861.

[3] F. Fezai, C. Menudier, M. Thevenot, T. Monediere and N. Chevalier, "Multidirectional receiving system for RF to dc conversion signal: application to home automation devices.," in IEEE Antennas and Propagation Magazine, vol. 58, no. 3, pp. 22-30, June 2016, doi: 10.1109/MAP.2016.2541649.

[4] Y. Chen and J. You, "A scalable and multidirectional rectenna system for RF energy harvesting," in IEEE Transactions on Components, Packaging and Manufacturing Technology, vol. 8, no. 12, pp. 2060-2072, Dec. 2018, doi: 10.1109/TCPMT.2018.2878927.

[5] Yu-Chia Chang, Chung-Hung Hong, Kae-An Liu and Hsin-Chia Lu, “Phase and time switching modulations for multi-point wireless power grid to realize stable power reception under rotational misalignment,” in 2015 Asia-Pacific Microwave Conference, (APMC), Nanjing, China, Dec. 2015.

Visual Analysis Across Unseen Data Domains

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Graduate Inst. Communication Engineering,
National Taiwan University

I. INTRODUCTION

Deep neural networks have achieved promising performance in a wide variety of areas such as computer vision, machine learning, speech recognition, and natural language understanding. However, these networks assume the training and testing samples fall in the same data distribution. Such a strong assumption would limit the applicability of the learned models in real-world scenarios (e.g., cross-city autonomous driving or multi-site medical imaging tasks), in which the training and testing data are typically observed under different conditions. In other words, the models may not be able to generalize to unseen target domains due to unexpected domain shifts. To tackle the domain discrepancy problem, domain generalization (DG) was proposed and has drawn increasing attention.

As depicted in Fig. 1, DG aims to train models using data observed from single or multiple source domains, and the models are expected to generalize to unseen target domains. Most existing DG approaches focus on deriving domain-invariant features among multiple source domains or adopting meta-learning techniques [1], which simulate domain shifts during the meta-training stage. However, the learned representations of the above methods are only guaranteed to be invariant to the seen source domains, and may not possess the ability to describe unseen domain data. To overcome the limitation, some works (e.g., [2]) turn to leverage data generation techniques to diversify the source distributions, thus avoiding overfitting on source domains, and improving the generalization ability of models. While the above methods perform well, designing an objective for generating samples with DG guarantees remains a challenging and open problem.

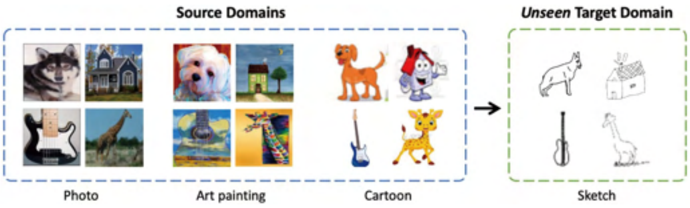


Fig. 1: Illustration of Domain Generalization (DG). DG aims to train a model on multiple source domains and then directly test on unseen target domains without accessing target-domain data during model training.

II. Adversarial Teacher-Student Representation Learning for Domain Generalization

In this paper, we propose a unique Adversarial Teacher-Student Representation Learning framework for tackling domain generalized visual classification (as illustrated in Fig. 2). Based on the recent success of contrastive learning, we advance the concept of multi-view learning into the DG regime for augmenting source instances to out-of-source styles and diversifying training distributions.

To be more precise, with the goal of learning representations robust to unseen domain shift, we jointly perform Domain Generalized Representation Learning and Novel Domain Augmentation in an adversarial learning manner. Based on Teacher-Student learning schemes, our framework utilizes original images as inputs to the teacher network and takes stylized augmentations as input to the student network.

To ensure both learning stages produce domain generalized representation, we adopt the Teacher-Student co-training scheme, which progressively refines Teacher by the distilled knowledge learned from Student which observes augmented novel-domain data, enabling Teacher to be generalizable to data with out-of-source distributions. On the other hand, Adversarial Novel Domain Augmentation aims at augmenting unseen-domain data using source-domain training instances. The objective is to maximize the discrepancy between the input and augmented data. To be specific, the discrepancy is calculated using the features derived by the teacher and student modules, respectively. By iteratively training the above two stages in an adversarial learning fashion, the resulting model (Teacher) would be able to derive domain generalizable representations.

Extensive image classification experiments on benchmark datasets in multiple-source (i.e., 85.3% on PACS and 66.7% on Office-Home datasets) and single-source (i.e., 46.0% on PACS and 34.1% on DomainNet datasets) DG settings confirm that, our model exhibits sufficient generalization ability and performs favorably against state-of-the-art DG methods (e.g., [1, 2, 3, 4]).

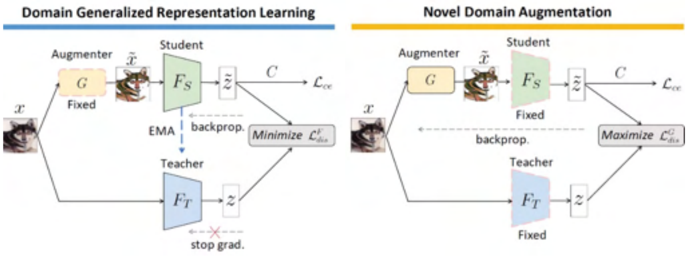


Fig. 2: Overview of our Adversarial Teacher-Student Representation Learning scheme, which includes the teacher network F_T, student network F_S, classifier C, and novel-domain augmenter G. Note that we alternate between the stages of domain generalized representation learning and novel-domain augmentation in a mutually beneficial manner, resulting in discriminative yet domain generalized representations.

*Work published at the 35th Conference on Neural Information Processing Systems (NeurIPS 2021) as top 3% papers for spotlight presentation.

Reference

[1] Da Li, Yongxin Yang, Yi-Zhe Song, and Timothy Hospedales. Learning to generalize: Meta-learning for domain generalization. In Proceedings of the AAAI Conference on Artificial Intelligence, 2018.
[2] Kaiyang Zhou, Yongxin Yang, Timothy Hospedales, and Tao Xiang. Deep domain-adversarial image generation for domain generalisation. In Proceedings of the AAAI Conference on Artificial Intelligence, 2020.
[3] Zeyi Huang, Haohan Wang, Eric P Xing, and Dong Huang. Self-challenging improves crossdomain generalization. In Proceedings of the European Conference on Computer Vision, 2020.
[4] Kaiyang Zhou, Yongxin Yang, Timothy Hospedales, and Tao Xiang. Learning to generate novel domains for domain generalization. In Proceedings of the European Conference on Computer Vision, 2020.

Advanced Constructed Electromagnetic Application

Taiwan Electromagnetic Industry-Academic Consortium

The 2022 1st Semiannual Report of TEMIAC
Advanced Constructed Electromagnetic Application

May 18, 2022

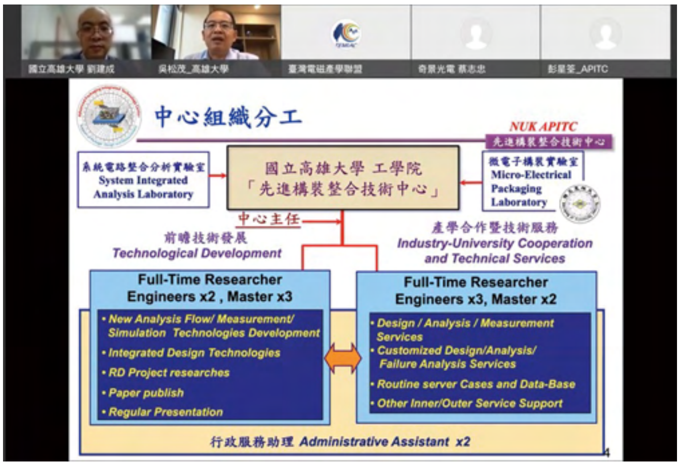
Organizers:
Taiwan Electromagnetic Industry-Academic Consortium
Advanced Packaging Integrated Technology Center, NUK
Co-organizers:
Department of Electrical Engineering, NTU
Graduate Institute of Communication Engineering, NTU

Fig. 1. Professor Ruey-Beei Wu, Chairman of TEMIAC, gave a welcome speech to the attendees.

Organizer：
Prof. Sung-Mao Wu, Chairman of Advanced Packaging Integrated Technology Center (APITC)

Host：
Mr. Chien-Cheng Liu, Project Manager of Industry Academia Incubation Center, NUK

The first R&D semi-annual report of the Taiwan Electromagnetic Industry-Academic Consortium (TEMIAC) was held in May 18, 2022, with the theme of "Advanced Constructed Electromagnetic Application". Following the current 5G development trend, we invited industry leaders to share the applications of electromagnetics to various industries and propose future prospects. In addition, a number of electromagnetic industry-academia alliances were also invited to conduct talent recruitment activities during the intermission. This semi-annual report was originally scheduled to be held at National Kaohsiung University. Due to the impact of the COVID-19 epidemic, it was held online instead. The semi-annual report was organized by Professor Sung-Mao Wu, Chairman of Advanced Packaging Integrated Technology Center (APITC).



中心組織分工

NUK APITC
先進構裝整合技術中心

系統電路整合分析實驗室
System Integrated Analysis Laboratory

國立高雄大學 工學院
「先進構裝整合技術中心」

微電子構裝實驗室
Micro-Electrical Packaging Laboratory

中心主任

前瞻技術發展
Technological Development

產學合作暨技術服務
Industry-University Cooperation and Technical Services

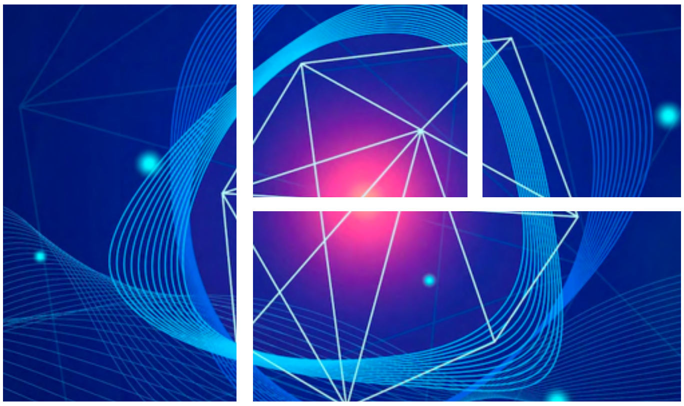
Full-Time Researcher
Engineers x2 , Master x3
- New Analysis Flow/ Measurement/ Simulation Technologies Development
- Integrated Design Technologies
- RD Project researches
- Paper publish
- Regular Presentation

Full-Time Researcher
Engineers x3, Master x2
- Design / Analysis / Measurement Services
- Customized Design/Analysis/ Failure Analysis Services
- Routine server Cases and Data-Base
- Other Inner/Outer Service Support

行政服務助理 Administrative Assistant x2

4

Fig. 2. Professor Sung-Mao Wu, Chairman of APITC, gave an introduction to APITC.



The event started with the opening speech by Professor Ruey-Beei Wu, Chairperson of TEMIAC and the Department of Electrical Engineering of National Taiwan University. He mentioned the impact and layout of the epidemic and the Ukrainian-Russian war on the future industrial development, and also explained that electromagnetics will be the next step for the industry. Next, Professor Sung-Mao Wu, Chairman of APITC, introduced the existing and developing technologies of APITC at this stage including:

1. Automatic needle placement.
2. Near-field measurement equipment.
3. Electromagnetic analog energy.
4. Double-sided calibration measurement probe station.
5. Near Field measurement SSN/ESD/EMI/EMS detection and analysis capabilities.
6. Intelligent automation and EMS integrated development and finally hope to cooperate with enterprises and academia to assist industry development.

Fig. 3. Before meeting , everyone takes USIE.


Drive for better vision

Himax

車載與TV顯示驅動晶片
電磁相容概況

May 18, 2022

Himax Technologies, Inc.
奇景光電股份有限公司


下世代毫米波系統
級封裝技術與發展

Alex C. C. Wang
ASE Group Kaohsiung, Taiwan

(Left) Fig. 4. R.J Liu, Director of Himax Technology Company delivered a talk on The Progress of EMC for Automotive and TV Display Driver IC.

(Right) Fig. 5. Alex Wang, Director of ASE Technology Company delivered a talk on Next Generation SiP Technology for mmWave.

In the workshop, five 1-hour presentations were delivered, listed as follows:

1. The Progress of EMC for Automotive and TV Display Driver IC, by R.J Liu, Director of Himax Technology Company;

2. Next Generation SiP Technology for mmWave, by Alex Wang, Director of ASE Technology Company;

3. System in Package/Integration-From Data Center Perspective, by Jerry Hsu, Technical director of Wistron Corporation Company;

4. Introduction of Modem Wire and Wireless Communication System and Signal Integrity, by Pei-Wei Chen, CEO of Grace Connection Microelectronics Limited;

5. High Frequency/High Speed Applications Development Trend of Flexible Circuit Board Materials, by Geli Hong, Senior Manager of ThinFlex Technology Company.

Ansys模擬技術於先進
構裝與電磁之應用

Benson Wei
2022/5/18

Ansys

Fig. 6. Benson Wei, Director of Ansys, delivered a talk on High frequency simmulation on Ansys.


系統構裝與整合於新世代資料中心的應用
System in Package/System Integration in Next-Generation Data Center

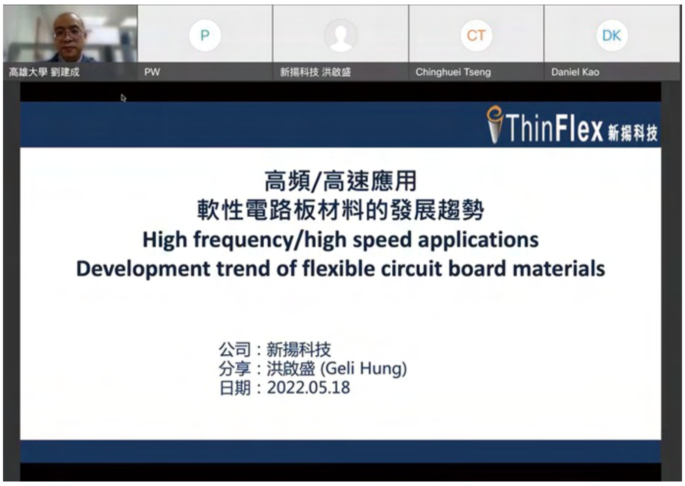
- 網通開發中心
- 訊號品質設計部
- 許仁芳 (Jerry Hsu)
- May, 2022

Wistron Technologies

wistron

Fig. 7. Jerry Hsu, Technical director of Wistron Corporation Company, delivered a talk on System in Package/Integration-From Data Center Perspective.

This semi-annual report also arranged for members of TEMIAC, Unimicron Technology Corporation, and ASUS Computer to show their recruitment videos during the intermission, and comprehensively explained their policy, development technology, talent demand and salary overview. The participants and students had an opportunity to the current industry needs. Due to the impact of the epidemic, everyone could only communicate online, but more than 200 people signed up for this event. The industry, academia, and students in electromagnetics participated in the grand event. The event ended successfully!



ThinFlex 新揚科技

高頻/高速應用
軟性電路板材料的發展趨勢
High frequency/high speed applications
Development trend of flexible circuit board materials

公司：新揚科技
分享：洪啟盛 (Geli Hung)
日期：2022.05.18

Fig. 9. Geli Hong, Senior Manager of ThinFlex Technology Company delivered a talk on High frequency/high speed applications Development trend of flexible circuit board materials.

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