NTU GICE

Newsletter

Graduate Institute of Communication Engineering, National Taiwan University

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GICE Honors

Macronix Chair Professorship

Macronix International Co., Ltd..

Prof. Ruey-Beei Wu

To improve NTU's teaching proficiencies and facilitate its talent cultivation efforts, Macronix pledged an endowment in 2011 for NTU to establish "Macronix Chair Professorship," through which corresponding education talents can be recruited and rewarded. Candidates for the Chair Professorship shall be full-time NTU professors with over 10 years of teaching or research experience in the field of electronics, electrical engineering, computer science, and applied physics (criteria includes being awarded in an internationally-renowned conference or assuming a leadership role in a teaching or research program).

Garmin Scholar Fellowships

Kao Family Foundation (KFF)

Associate Prof. Chung-Tse Michael Wu

Garmin Scholar Fellowships are awarded to individuals who have achieved international prominence or demonstrate significant research and development potential and have been newly recruited to a teaching or research position at the University for a minimum of one year.

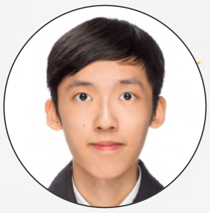
GICE Honors

Ph.D. graduate student : **XU, RUI-FU** | Advisor : **Prof. Shih-Yuan Chen**

2024 Hon Hai (Foxconn) Technology Award

Hon Hai Education Foundation

The Hon Hai Education Foundation's Technology Award supports tech research and talent with NT$250,000 grants in nine specific research areas each year. Recipients may also intern at the Hon Hai Research Institute for industry experience. In 2024, only 21 out of 147 applicants received this honor.



M.S. degree program student : **LIU, I-JIEH** | Advisor : **Prof. Yu-Chiang Frank Wang**

Merit Master Thesis Award at 17th Master's and Doctoral Thesis Award from The Chinese Image Processing and Pattern Recognition Society (IPPR)

Master's thesis title

Language-Guided Transformer for Federated Multi-Label Classification

M.S. degree program student : **CHOU, ZI TING** | Advisor : **Prof. Yu-Chiang Frank Wang**

Excellent Master Thesis Award at 17th Master's and Doctoral Thesis Award from The Chinese Image Processing and Pattern Recognition Society (IPPR)

Master's thesis title

GSNeRF: Enhancing 3D Scene Understanding with Generalizable Semantic Neural Radiance Fields

TEMIAC Collaboration Propels MTI to Historic IEEE Milestone Award : A Triumph for Taiwan's Tech Industry

Microelectronics Technology Inc. (MTI), a leading Taiwanese RF supplier, has been awarded the prestigious IEEE Milestone for its groundbreaking portable satellite communication terminal equipment developed between 1987 and 1995. This marks the first time a Taiwanese company has received this distinguished recognition, highlighting Taiwan's significant contributions to global technological advancement.

A key factor in MTI's success in securing this award was the pivotal role played by Professor Ruey-Beei Wu, the coordinator of the Taiwan Electromagnetic Industry-Academia Consortium (TEMIAC). As a member of TEMIAC, MTI benefited from the strong industry-academia collaboration fostered by the consortium. Professor Wu, serving as the award's proposer, invested considerable effort in ensuring MTI's application met the rigorous criteria for the IEEE Milestone award.

Figure 2: Minister Tsung-Tsong Wu of the National Science and Technology Council speaking at the award ceremony

Figure 1: Professor Ruey-Beei Wu delivering a speech at the award ceremony

MTI's innovation stemmed from the need for reliable communication in extreme conditions, as evidenced by the 1985 Mexico City earthquake. The company's research at its Hsinchu headquarters led to the development of the world's first portable satellite communication terminal (TCS) product series, which provided global voice, telegraph, and data connectivity in a compact, easily transportable form suitable for harsh environments.

The impact of MTI's technology was profound and far-reaching. During the 1991 Gulf War, MTI's TCS-9120 system enabled CNN to broadcast live from Iraq, revolutionizing war coverage and giving rise to the "CNN Effect" in global television news. The equipment also proved invaluable in various scenarios, including facilitating President Teng-hui Lee's speech transmission from Cornell University in 1995, supporting communication during the 1999 Jiji earthquake in Taiwan, and enabling communications for global expeditions in extreme locations like Mount Everest and the Taklamakan Desert.

The IEEE Milestone award recognizes not only MTI's technological prowess but also its significant impact on society. As emphasized in Professor Wu's award ceremony speech on December 6th, 2023 at the Taipei International Convention Center (TICC), this achievement underscores the importance of valuing long-term societal contributions over short-term profits or academic rankings. It aligns with Einstein's wisdom to "become a person of value" rather than merely successful.

Figure 3: IEEE President Professor K. J. Ray Liu giving a speech at the award ceremony

Figure 4: IEEE Milestone Award plaque unveiling ceremony with MTI executives (Left row from center: IEEE President Professor K. J. Ray Liu, Minister Tsung-Tsong Wu, Professor Nuno Borges Carvalho, Professor Stefano Maci, Professor Ruey-Beei Wu, Professor Pei-Wen Li; Right row from center: MTI Chairman Chi-Chia Hsieh, President Eugene Wu, VP Hunter Huang, VP Vivian Chiu, and VP Dunga Wu)

The rigorous evaluation process for the IEEE Milestone involved collaboration between academia and industry. Professor K. J. Ray Liu, IEEE global president, initiated the push for Taiwan's representation in this prestigious award. Professor Wu's expertise and dedication were instrumental in guiding the application process, revealing lesser-known but significant contributions of MTI's technology and showcasing Taiwan's capabilities in cutting-edge fields.

Figure 5: Group photo of guests attending the award ceremony

This recognition is seen as a catalyst for further acknowledgment of Taiwan's technological achievements on the world stage. It encourages the sharing of inspiring stories to motivate young minds towards research and innovation, ultimately contributing to social welfare and making a lasting impact.

The IEEE Milestone program, part of IEEE's mission to preserve the legacy and heritage of engineering professions, has recognized 241 milestones worldwide, with MTI's award being the first for Taiwan. This achievement not only celebrates past innovations but also inspires future advancements in the field of communications technology.

MTI's pioneering work has significantly propelled the satellite industry forward, with the goal of establishing a seamless global communication network. As Taiwan celebrates this milestone, it marks a new chapter in the global recognition of its technological contributions, paving the way for more stories of innovation and excellence to emerge from this island nation.

Figure 6: MTI receiving the IEEE Milestone Award plaque

The IEEE History Committee
recognizes and commends the efforts and contributions to the
Milestone Program of IEEE made by

Ruey-Beei Wu

in researching and proposing the Milestone:

MTI Portable Satellite Communication Terminals, 1987-1995

which has increased the recognition by the general public of technical achievements in IEEE's fields, and enhanced the appreciation of those achievements and their contributions to humanity.

Antonio Savini, Chair, IEEE History Committee

IEEE
Advancing Technology for Humanity

Figure 7: IEEE History Committee presenting a certificate of appreciation to Professor Wu Ruey-Beei

Design and Analysis of Power Delivery Network Noise Absorbers for High-Speed Circuits

Li-Ching Huang

Li-Ching received the Ph.D. degree from Graduate Institute of Communication Engineering, National Taiwan University in 2023. She is currently a Senior Engineer with MediaTek, Inc., Hsinchu, Taiwan.

Introduction

Recently, due to the increasing switching speeds of digital circuits, gigahertz (GHz) ranges of power noises can no longer be neglected on a package or printed circuit board (PCB). Several publications have indicated that high-frequency power noises cause more significant degradation in eye margins and RFI issues in modern wireless communication systems than low-frequency power noises. Especially, even though conventional reflective filters can effectively prevent high-frequency power noises from transmitting, a millimeter distance between an integrated circuit (IC) and these reflective filters may cause resonances at the noise source end [1]. Therefore, to stabilize the power systems and to avoid the consequent SI and RFI issues, this dissertation proposes a novel absorptive approach, utilizing PDN noise absorbers to the PDN, for the first time.

II. PROPOSED CIRCUITS for POWER PLANE SYSTEM

Fig. 1 shows a typical package mounted on a PCB. When power pins of an IC draw currents from the power/ground planes, or when via transitions of the signal traces pass from one layer to another layer for a multilayer stack-up, power noises will be induced and coupled throughout the parallel plates. In this scenario, a ring of PDN noise absorbers can be placed around the IC to prevent power noises from both reflecting and transmitting. To accomplish this objective, a PDN noise absorber comprising a lossless resonant stage and a lossy resonant stage is proposed. The circuit model is shown in Fig. 2 [2].

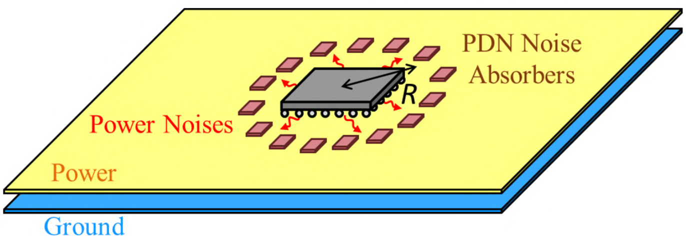


Fig. 1 Typical BGA package mounted on a PCB.

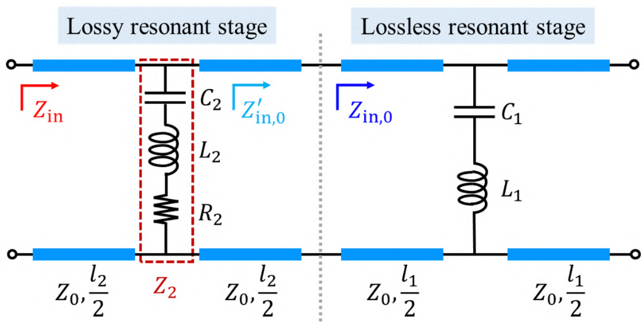


Fig. 2 Circuit model of the proposed PDN noise absorber.

For the design procedure, a lossless resonant stage with low $|S_{21}|$ is first designed to prohibit power noise transmission. Then, a lossy resonant stage continues to match the radial port impedance of the incident cylindrical wave at two frequencies and thus can prevent broadband power noise reflection [2]. The S-parameters and corresponding absorption rate are shown in Figs. 3 and 4, respectively.

Observing Fig. 3, the transmission zero is located at 5.5 GHz. $|S_{11}|$ goes to zero at 4.35 GHz and 6.75 GHz, thus forming a broadband -15-dB $|S_{11}|$ from 4 GHz to 7.3 GHz. The absorption rate of the proposed PDN noise absorber in Fig. 4 is almost 100% at 4.35 GHz and 6.75 GHz, and the 90%-absorption bandwidth ranges from 4 to 8 GHz. In contrast, a very low absorption rate of the conventional reflective filter is also shown in Fig. 4.

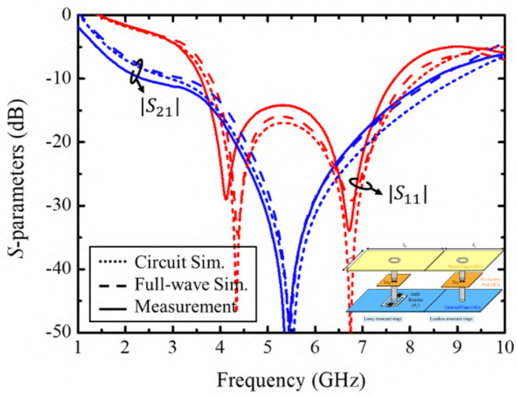


Fig. 3 Simulated and measured S-parameters of the proposed PDN noise absorber.

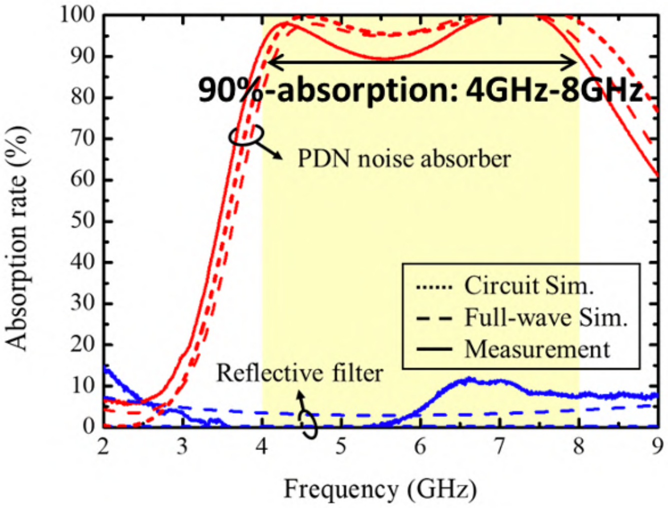


Fig. 4 Comparison of the absorption rates between a reflective filter and the proposed PDN noise absorber.

III. RESULTS

Here, the description of four parallel-plate test boards are listed in Table I. The advantage of applying PDN noise absorbers to power/ground planes will be introduced in frequency domain and time domain.

No.	Description
Case 1	1-μF capacitor
Case 2	1-μF capacitor + a ring of reflective filters
Case 3	1-μF capacitor + two rings of reflective filters
Case 4	1-μF capacitor + a ring of PDN noise absorbers

Table I Descriptions of four cases.

First, the self impedance $|Z_{11}|$ between four cases are shown in Fig. 5. It can be observed that there are $|Z_{11}|$ peaks for cases 2 and 3 around 6 GHz while $|Z_{11}|$ for case 4 is almost flat. The $|Z_{11}|$ peaks for cases 2 and 3 around 6 GHz result from the cavity resonances formed by the surrounding reflective filters. The $|Z_{11}|$ peak even increases by 25.3% when a ring of reflective filters are replaced with two rings of reflective filters. On the contrary, a $|Z_{11}|$ decrease by 80.8% and 85.6% can be achieved by the usage of the proposed PDN noise absorbers when compared with cases 2 and 3, respectively.

Furthermore, Fig. 6 shows the $|S_{21}|$ comparison. There are several cavity parallel-plate resonance modes at frequencies of (1.85, 2.94, 3.51, 4.73, 5.44, 5.86, 6.22, 6.95, 7.38, 8, 8.71, and 9.61 GHz) for case 1. It can be observed that $|S_{21}|$ becomes lower from 4 to 8 GHz regardless of applying reflective filters or PDN noise absorbers since those resonances are eliminated either by reflective filters or absorbers. However, with only a ring of reflective filters, $|S_{21}|$ for case 2 increases significantly around 6 GHz. The cavity resonance near the noise source also causes leaky power noises at the transmitted end. Then, by adding another ring of 15 reflective filters, $|S_{21}|$ for case 3 is expected with higher isolation level. Nevertheless, due to severe cavity resonance effects at the noise source end, $|S_{21}|$ becomes worse from 5.5 to 8 GHz so that our proposed PDN noise absorbers for case 4 can compete with case 3 over this band.

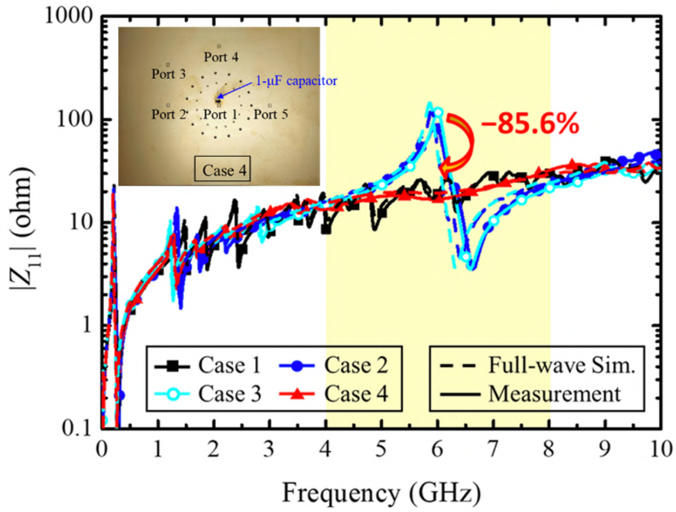


Fig. 5 $|Z_{11}|$ comparison between four cases.

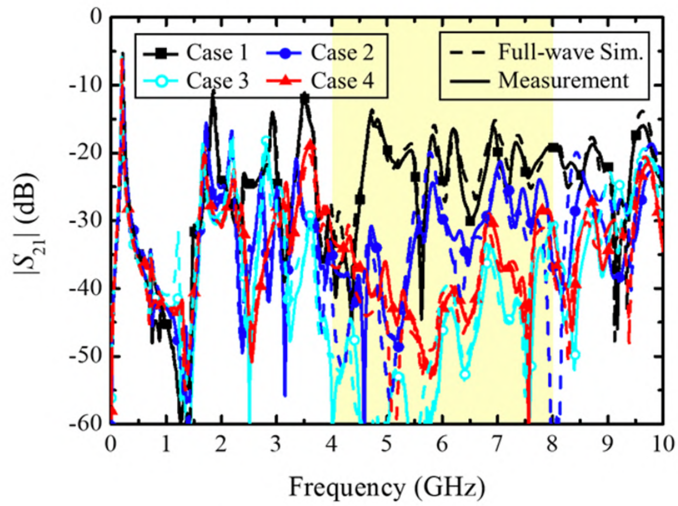


Fig. 6 $|S_{21}|$ comparison between four cases.

Next, Fig. 7 depicts the schematic for eye diagram comparison. The second and third layers are four kinds of power/ground planes, and a signal trace starts from layer 1 to layer 4 and returns back to layer 1 with two through-hole vias. These via transitions will induce power noises spreading throughout the power/ground planes, and these power noises will also couple back to the original signal through these vias. A 10-Gbps pattern source is launched at port 1 to observe the eye diagram at port 2. The simulated eye diagrams for four cases are shown in Fig. 8.

After adding one ring and two rings of reflective filters to prevent power noise transmission for cases 2 and 3, minimum eye heights can be slightly increased by 2.3% and 7.3%, respectively. However, minimum eye widths for cases 2 and 3 are both decreased by 4.7%. On the contrary, if the PDN noise absorbers are substituted for reflective filters to further reduce the cavity resonances for case 4, the minimum eye height and minimum eye width can be increased by 28.5% and 2.1%, respectively, when compared with the case 1. The percentage difference of minimum eye height and minimum eye width between cases 3 and 4 are 21.2% and 6.8%, respectively.

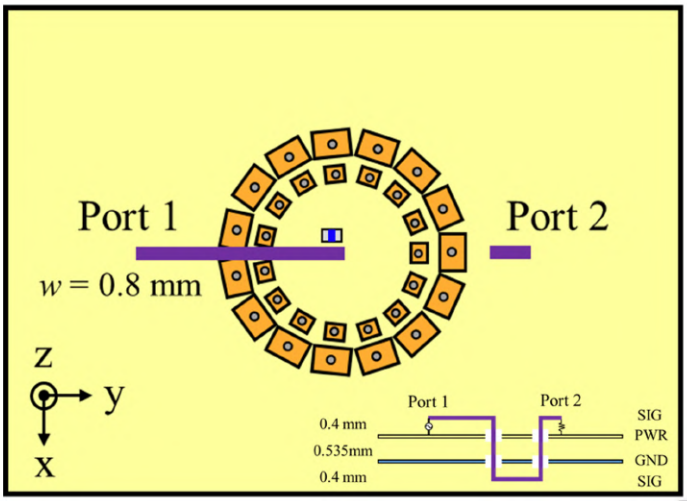


Fig. 7 Schematic for eye diagram comparison.

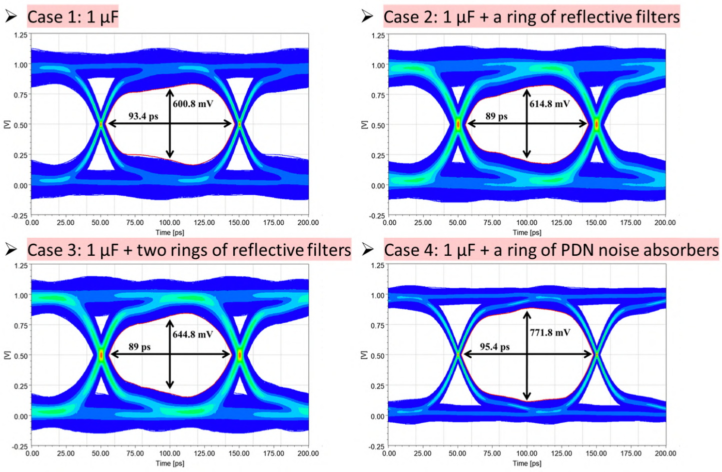


Fig. 8 Comparison of the simulated eye diagrams.

Reference

[1] L. -C. Huang, C. -H. Cheng, S. Chen and T. -L. Wu, "A Novel Absorptive Power Delivery Network for Power Noise Mitigation," in IEEE Trans. Electromagn. Compat., vol. 64, no. 2, pp. 536-542, April 2022, doi: 10.1109/TEMC.2021.3133926.
[2] L. -C. Huang and T. -L. Wu, "Design and Analysis of Broadband Power Delivery Network Noise Absorber for Parallel-Plate Mode Suppression," in IEEE Trans. Microw. Theory Techn., vol. 71, no. 4, pp. 1677-1686, April 2023, doi: 10.1109/TMTT.2022.3220802.

Broadcast Erasure Channels with Partial Single-User Feedback

Yen-Cheng Chu

Graduate Institute of Communication Engineering CSP group, National Taiwan University

Delayed channel state information (CSI) feedback was shown to be very helpful in enlarging the capacity region of the two-user broadcast packet erasure channel (PEC), even with single-user feedback. However, feedback link itself requires additional resources and may also cause additional delay to data transmission. For 5G low-latency communication, which has a stringent delay constraint, reducing the feedback delay by limiting the number of feedback bits is also important.

In this work, we aim to study how to optimally tradeoff the number of feedback bits and the reliable forward communication rate. In our model, one receiver does not provide its CSI while the other one can partially feeds back its observation of channel state to other nodes. This model includes three different feedback schemes: alternating single-user feedback, intermittent single-user feedback and rate-limited single-user feedback. Our achievability is an extension of previous opportunistic network coding such that the network coding gain can still be enjoyed even when the single-user feedback is not always available. Interestingly, rate regions of our modified schemes for partial single-user delayed CSI partially matches the capacity region of single-user delayed CSI. The matched-bound is in favor of no-feedback user, since it can benefits from the retransmission phase. Our results also reveal that even when the single-user feedback is partially provided, strictly positive capacity benefits can be attained over the no-feedback capacity.

Here we only present one of our contributions: alternating single-user feedback scheme, and show that this scheme can partially matches single-user feedback outer bound under the partial single-user feedback model.

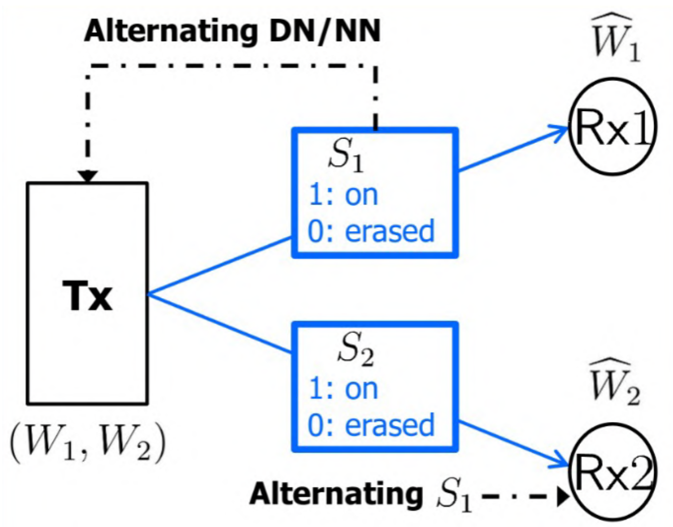


Fig. 1

As depicted in Fig. 1, there are two possible feedback states from Rx1 and Rx2 at a certain time index: "DN" and "NN". When feedback is in state "DN", Rx1 can feeds back its CSI to transmitter and Rx2 such that they know S1 with unit delay ; when the feedback is in state "NN", both receivers cannot feedback their CSI to other nodes. And the feedback state is alternating between "DN" and "NN".

Our main contribution is the achievable inner bound, we generalized the two-phase network coding in [6] with two new ingredients as shown in Fig. 2 . The first ingredient is that the feedback probability is controlled by two different Bernoulli process S_{F11} and S_{F12} in Phase I and Phase II respectively. We can optimize the distribution between S_{F11} and S_{F12} to get our partially matched inner bound. The second ingredient is that we modify the retransmission for W_1 in Phase II in [6], Only when $\overline{S_1}$= 1 will the transmitter knows that a bit is successfully delivered to Rx1 and proceeds to the next message bit of W_1.

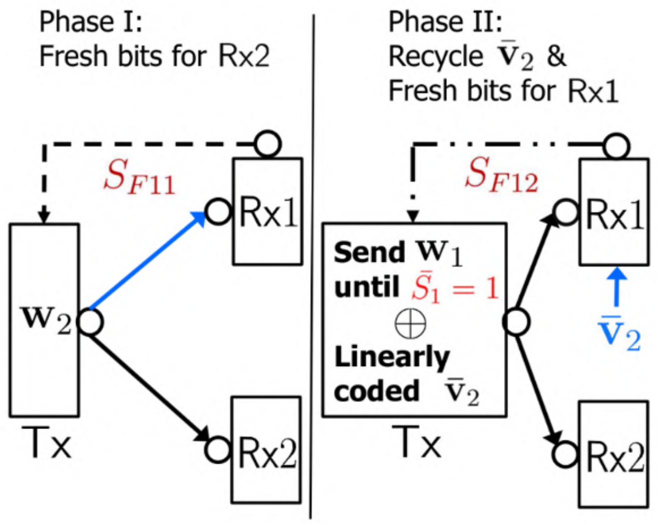


Fig. 2

Here we provide some numerical examples for our alternating achievability in Fig. 3. We naturally choose the capacity region of single-user always feedback in [6] as our alternating single-user feedback outer bound.

From Fig. 3, we can see that our achievable inner bound partially matches capacity outer bound. And our achievability has higher rate for Rx2 as the matched bound in the figure. This is because that we adopt a rather conservative ARQ control for Rx1 which only stops retransmission at time t only when both the feedback link and the link to Rx1 is on. Though the retransmission time for Rx1 is long, Rx2 can still benefits from the interference alignment to get useful equations for decoding. This is why our scheme is optimal for Rx2.

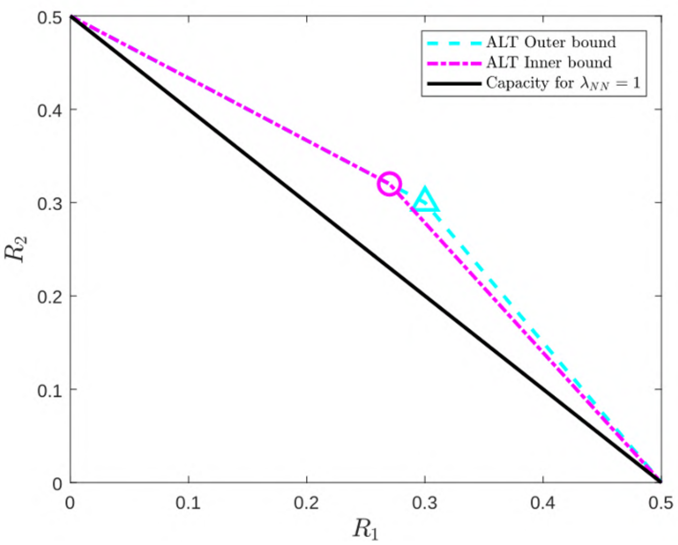


Fig. 3

Yen-Cheng Chu

Graduate Institute of Communication Engineering
National Taiwan University

Yen-Cheng Chu graduated from the NTU GICE CSP group. He is currently working as a DSP Algorithm Engineer at TronFuture Tech, where he focuses on the design and simulation of radar-related algorithms. During his time at the Graduate Institute, his research topics included information theory and network coding. He presented his work at the 2023 IEEE International Symposium on Information Theory and received the IEEE Taipei Section 2023 Thesis Award for his master's thesis.

The 2024 1st Semi-annual Workshop of Taiwan Electromagnetic Industry-Academia Consortium: Design and Testing of Millimeter Wave Reconfigurable Smart Surfaces and Active Antenna Devices and Prospects for 6G Key Technologies

The recent 2024 1st Semi-annual Workshop of Taiwan Electromagnetic Industry-Academia Consortium, held on May 29, 2024, brought together experts from industry and academia to discuss cutting-edge developments in wireless communication technology. The event, jointly organized by the National Taiwan University of Science and Technology (NTUST) and the Taiwan Electromagnetic Industry-Academia Consortium (TEMIAC), focused on the design and testing of millimeter wave reconfigurable smart surfaces and active antenna devices, as well as prospects for 6G key technologies.

Millimeter wave (mm-Wave) technology, a critical component of both 5G and 6G communications, promises to deliver higher data rates and lower latency. Reconfigurable Intelligent Surfaces (RIS) and Active Electronically Scanned Array (AESA) are seen as pivotal in overcoming issues related to attenuation and penetration in mm-Wave communications, thus significantly enhancing the performance and efficiency of communication systems.

Millimeter wave technology, operating within the 30 to 300 GHz range, offers unprecedented bandwidth and data transmission capabilities. However, to fully exploit mm-Wave technology, challenges such as signal attenuation, path loss, and interference must be addressed. Reconfigurable Intelligent Surfaces (RIS) come into play here, offering advanced signal processing capabilities powered by AI algorithms to optimize the propagation of electromagnetic waves. By dynamically adjusting the phase and amplitude of individual elements like reflectors or antennas, RIS can precisely control signal propagation, thereby mitigating attenuation effects and enhancing coverage in complex environments like urban canyons and indoor spaces.

Several key points emerged from the symposium:

• 5G advanced (B5G) aims to enhance existing 5G infrastructure by improving speed, capacity, and reliability through technologies like advanced MIMO, network slicing, and millimeter-wave spectrum utilization.
• 6G is envisioned as a transformative technology beyond 5G, providing unprecedented speed, ultra-low latency, and ubiquitous connectivity through technologies like terahertz frequencies, AI/ML for network management, holographic communications, quantum communications, and the Tactile Internet.
• RIS technology can effectively address signal attenuation, multipath interference, and coverage issues in communication systems by intelligently reconfiguring passive elements to control electromagnetic wave propagation.
• Taiwan's National Chung Cheng University has developed static and dynamic RIS under the leadership of Professor Chang.
• 6G technology trends include ultra-high frequencies and beamforming, AI-driven networks, and quantum communications for enhanced security.
• Package solutions for 6G involve hardware technology supporting higher frequencies, software-defined networking (SDN), network functions virtualization (NFV), AI and big data analytics platforms, and quantum security solutions.
• Millimeter-wave and satellite communications face challenges such as signal attenuation, limited range, high costs, and latency, which need further innovation and policy support.
• Ultra-Wideband (UWB) technology, known for its high data rates, low power consumption, high precision positioning, and strong penetration capabilities, has promising applications in areas like IoT, smart homes, Industry 4.0, and intelligent transportation.
• Terahertz technology and Raman material testing techniques were also discussed, with potential applications in medical imaging, security screening, material analysis, and performance evaluation of communication systems.

The transition from 5G advanced to 6G represents a significant leap in wireless communications, promising unprecedented speeds, ultra-low latency, and advanced features that could reshape our digital landscape. However, realizing this vision requires continued research, innovation, and supportive policies.

As researchers and industry leaders continue to push the boundaries of what's possible in wireless communication, events like the Taiwan Electromagnetic Industry-Academia Consortium workshop play a crucial role in fostering collaboration and driving progress. The future of wireless communication is bright, and the journey to 6G promises to be an exciting one, full of challenges and opportunities for those at the forefront of technological innovation.

Fig. 3. TEMIAC held a workshop at National Taiwan University of Sciense and Technology

Fig. 1. Professor Ruey-Beei Wu gave a welcome speech

Fig. 4. Guests from industry, academia, and research institutes

Fig. 2. Associate Dean Tzong-Lin Wu gave a welcome speech

Fig. 5. Guests from industry, academia, and research institutes

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