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Technology Developed in GICE

Digital Terrestrial Television Switchover in Taiwan – An Engineering Professor's Perspective

from Communication and Signal Processing Group

Since the beginning of July 1st, 2012, Terrestrial Television (TTV) signals all over Taiwan have been all digital. Analog TTV signals that served Taiwanese people for almost 50 years completely went into history. The switchover freed spectrum in the bands of 76-88MHz, 174-210MHz and 608-710MHz as parts of "digital dividends" and laid the foundation of High Definition TV broadcasting. I, an engineering professor-turned commissioner of National Communications Commission (NCC), had the privilege to participate in the last two years of switchover preparations and to eyewitness this milestone event in TV history of Taiwan.

NCC took over the mission of DTTV switchover (DSO) at the end of 2009 from the Government Information Office and I accepted the challenges of DSO tasks at the first day into the commissioner's office. DTTV signals have been on air in Taiwan since 2003 and there had been more than 2.5 million standard definition (SD) digital TVs or set top boxes sold. As cable TVs had penetrated to more than 80% of households and the main TTV channels are must-carries by cable TV, the DSO mission seemed to be simply "turning the analog TTV signals off and releasing the corresponding spectrum" at the policy level. In execution, there involved many challenges.

Maintaining the viewing rights of the analog TTV viewers is the fundamental requirement for DSO. How to raise DTTV signal coverage to the whole country, either in the distant rural areas or in the shadowed corners of metropolitan areas, poses the first challenge. To speed up the construction of gap fillers or boosters, NCC team needed to coordinate with local governments at either city, county, town or village level, TV broadcasters, and even telecommunication operators, especially in solution selection and in locating and acquiring the site for radio towers. During 2010 to mid 2012, NCC raised DTTV coverage to more than 96% of population by

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GICE Honors

Prof. Ruey-Beei Wu
The Outstanding Research Award of Pan Wen Yuan Foundation

Prof. Lin-shan Lee
The Outstanding In-school Service Award for Teachers of National Taiwan University

Message from the Director

Tzong-Lin Wu

Professor & GICE Director

Dear Colleagues and Friends,

This issue reports several interesting topics. Prof. Shi-Chung Chang in GICE has served as the Commissioner of National Communications Commission (NCC) in Taiwan during 2009 – 2012. He reviews the whole process in government policy and execution level for the digital terrestrial television switchover in Taiwan, which is successfully completed in June 30, 2012 and is a milestone in TV history of Taiwan. Prof. Chang shares the difficulties and lessons learned in this process. Another interesting technology proposed by Prof. Tah-Hsiung Chu is a novel microwave power-combined amplifier based on metamaterials. A prototype with excellent performance is also demonstrated in this report. In addition, several GICE activities with international interactions with academia and industries also appear in this issue.

Hopefully, you enjoy the reading of GICE Newsletter.

My Best wishes,
Tzona-Lin Wu

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jointly completing 53 gap fillers/boosters with HD modules with local governments. In conjunction with the use of satellite TV broadcasting, digital TV signals cover the whole country (Fig. 1& Fig.2).

Fig. 1 Gap filler construction (a site in Peng Hu County)

Fig. 2 DTTV and satellite TV for aborigine's households in rural areas

What would be government's household assistance scheme for DSO? Who is eligible? After the Executive Yuan. set the policy of free installation of a set top box per low income household, how should it be carried out effectively? How about many none low-income households that had analog TTV as the only source of TV programs but could not afford the set top box and/or antenna? All these posed the second challenge. The NCC team designed the procurement specifications that a set top box must have the new features of compliance to DVB-T H.264 (HD) standard, parental control and less than 1 W standby power consumption and that a remote controller should be easy to use for the senior citizens. Based on the low income household list provided by the Ministry of the Interior, NCC contracted and managed three regional contractors to provide 100,000+ low income households nation-wide with DSO assistance from August 2011 to June 2012 (Fig. 3).

Fig.3 Set top box and antenna installation assistance to low income household

Promotion to and education (P&E) of the general public about DSO had been critical to successful policy implementation but is what I was unfamiliar and inexperienced with. In principle, GIO was in charge of P&E at the concept level while NCC was responsible for technical assistance. In practice, there needed many coordination efforts between the two organizations. Besides government

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sponsored advertisements over major media, promotions in large-scale events and 3C chain stores and distribution of flyers, posters and banners by local governments, NCC had hundreds of workshops at townships or villages to explain what DTTV is about and demonstrate to both the public servants and the general public about the preparation and DIY for DSO(Fig. 4). Ministry of Economic Affairs helped informed set top box suppliers of manufacturing or importing DVB-T H.264 (HD) set top box only starting from year 2011. Furthermore, based on the design and experience of viewer service centers of the 5 TTV broadcasters, NCC set up a call center to answer DSO related questions and provided installation assistance to the home when needed. The center served over 100 thousands of call requests since July 1st, 2011.

Fig.4 Promotion of DTTV and switchover

The final switchover was by stage and by region according to regional readiness, which started with the central region on May 7, 2012, then eastern, southern, and finally the northern region at noon, June 30, 2012. To notify the unprepared, full-screen and signal-off notifications of regional DSO had been broadcasted in each region over all the analog channels 4 weeks before the regional switchover date. As a result, unprepared viewer call-in rate within 24 hours of analog signal switch off is approximately 0.08% in the central region (1603 out of 2.1 million households), which is well compatible with those of Demark (0.14%) and Japan (0.36%). Similar to other countries using by-stage-and-by-region strategies such as Austria and Czech Republic, the switchover of remaining regions went the later, the smoother.

There are many lessons learned from DSO. In specific, I would like to share a few as conclusions from an engineering professor perspective:

1. When the target switchover date was moved, in mid 2011, from December 31 to June 30, 2012, the adjustment of budget plan did not closely align with the task plan and caused many challenges to later implementation.
2. Pilot experiments and dynamic feedback are key to effective execution control and management. Pilot experiments such as the one in Pinglin township, summer 2010, and then the ones in Da-Chia district, I-Lan county, Chia-Yi county, etc., allowed NCC team to clearly identify the needs by the TTV viewers, the concerns of local governments and how to plan the collaboration for large-scale switchover. NCC workshops, visit to local governments, viewer phone surveys and call center services, and comments from the media had provided very valuable feedbacks to adjust the detailed execution.
3. Effective identification of the households that have analog TV channels as the sole source of TV programs is an interesting research problem because of the rareness of such viewers.
4. Rationality assumption by classical game theory may not fit very well in modeling individuals but fits quite well in modeling organizations or companies. The contract design for management of household assistance contractors is a real example. There are many cases that can be abstracted into my teaching materials for the course on "Information, Control and Games."

In conducting DSO tasks, I had been to many beautiful places in Taiwan and talked to and got help from many kind people, which is a very enjoyable experience. I appreciated very much this opportunity to contribute as a member of the NCC DSO team to the people and the land.

For more information please contact:
Professor Shi-Chung Chang
Email: *scchang@cc.ee.ntu.edu.tw*

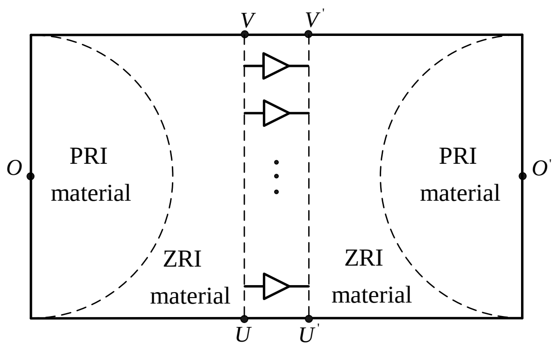
Technology

A Planar Microwave Power-combined Amplifier Using Metamaterials

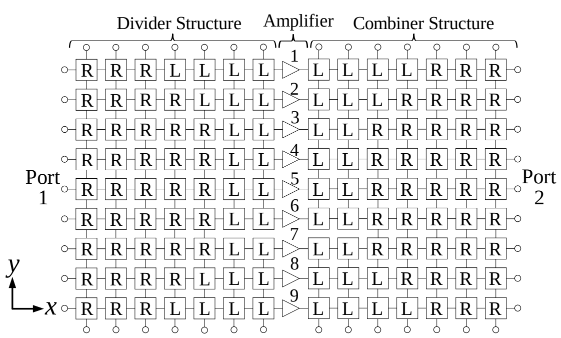
from Electromagnetics Group

Due to the power capacity of solid-state devices, power combining of multiple devices becomes necessary as a higher output power level is required. Therefore, development of microwave power dividing/combining techniques [1] of solid-state devices to achieve low loss and high combining efficiency is desirable. As the number of active devices increases, *N*-way power dividing/combining structures, such as Wilkinson [2] and radial [3] structures in a parallel configuration, are usually used due to compactness. These structures do not have the disadvantage of increasing loss with the number of active devices existed in chain and tree configurations. However, their main problem is having non-collinearly aligned multiple ports to make their integration with active devices in a planar structure difficult.

Recently, metamaterials with negative refractive index having left-handed (LH) propagation behavior are extensively applied to microwave devices [4]. They are mainly composed of one-dimensional right-handed (RH) and LH transmission lines called composite right/left-handed (CRLH) transmission lines. By properly operating CRLH transmission lines at the infinite wavelength frequency, metamaterials can have a zero-phase shift characteristic along the structure to give an equal magnitude and phase distribution.



(a)



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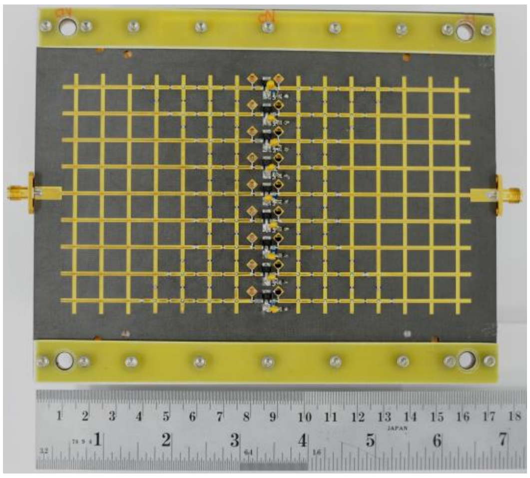

(c)

Fig. 1 (a) Structure, (b) schematic, and (c) circuit of a planar nine-way power-combined amplifier with R representing RH cell and L representing L cell.

This article presents a planar nine-way metamaterial power-combined amplifier based on this characteristic. The planar metamaterial power dividers contain positive refractive index (PRI) material and zero refractive index (ZRI) material. The PRI material is composed of two-dimensional (2-D) RH unit cells, while the ZRI material is realized by using LH unit cells operated at the infinite wavelength frequency to give the zero-phase shift characteristic. Due to its uniform isolation characteristics of the metamaterial power dividing/combining structure, its graceful degradation performance is independent of the amplifier failure sequence.

Fig. 1 shows the structure, schematic, and circuit of a planar nine-way metamaterial power-combined amplifier. As shown in Fig. 1(a), the input port is at focal point *O*. A cylindrical wave to planar wave conversion occurs at the left-side PRI-ZRI interface and attains an equal magnitude and phase distribution in the ZRI material to the collinearly aligned amplifiers along the dashed line UV. The amplification is obtained at the dashed line $U'V'$ then converted to a cylindrical wave through the right-side ZRI-PRI interface to the output port at focal point O'. Specifically, a planar PRI-ZRI-PRI lens with power dividing and combining characteristics is integrated with nine amplifiers as a planar metamaterial power-combined amplifier.

As shown in Fig. 1(b), the semi-circular interface

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between PRI and ZRI materials is approximated in a staircase manner. Each of the power divider and combiner includes 9 × 7 cells. Ports 1 and 2 located at the central RH unit cells of two PRI materials are the input and output ports, respectively. The remaining ports which are not indexed are open circuits. Nine amplifiers are directly connected to the divider output ports and the combiner input ports.

A nine-way power divider/combiner is designed on a 1.575-mm-thick RT/Duroid 5880 substrate with $\varepsilon_r = 2.2$ and $\tan\delta = 0.0009$. The operating frequency is 1 GHz. The size of RH and LH unit cells is given by 10 mm × 10 mm. The characteristic impedance of transmission line used in RH and LH cells is $Z_{oR} = Z_{oL} = 100\ \Omega$. By considering the parasitic effects of surface mounted device (SMD), shunt MuRata 0603 36 nH SMD inductors and series 0402 5.6 pF SMD capacitors are used to realize LH unit cells with zero-phase shift characteristics. The amplifiers are Hittite HMC452ST89E 1 Watt power amplifiers. The nine-way power-combined amplifier circuit is shown in Fig. 1(c).

Fig. 2(a) shows the measured results of output power, power gain, and PAE of the nine-way power-combined amplifier. The output power of 38.83 dBm at 1 dB gain compression point is obtained as the input power is 26.83 dBm, and the corresponding DC bias voltage and current are 5 V and 3.586 A to give a PAE about 40%. The power combining efficiency is 85%.

Fig. 2(b) shows the active probe measured results of S_{21} at the central node of each cell. The excitation source at the 5th row and the 1st column gives $|S_{21}| = -1.1\ \mathrm{dB}$, and $|S_{21}|$ values along the 5th row for the 7th, 8th, and 14th columns are −6 dB, 0 dB, and 7.1 dB, respectively. This indicates that a similar magnitude dividing and combining characteristics for power divider and combiner is obtained, and the amplification of $|S_{21}|$ from the 7th column to the 8th column is clearly observed.

Note the $|S_{21}|$ measured results show that the gain values of the amplifier only and the power combined amplifier are 6 dB and 8.2 dB, respectively, which do not quantitatively agree with the results of 14.45 dB for a single amplifier and 13 dB for the power-combined amplifier from *S*-parameter measurements. This is due to that the measured results given in Fig. 2(b) are the probed fringing fields radiated from the circuit near the central node of each RH and LH unit cells. They are affected by the probe characteristics, circuit components and environments. However, the probe measurement can clearly reveal the performance of the nine-way metamaterial power divider and combiner and the nine amplifiers.

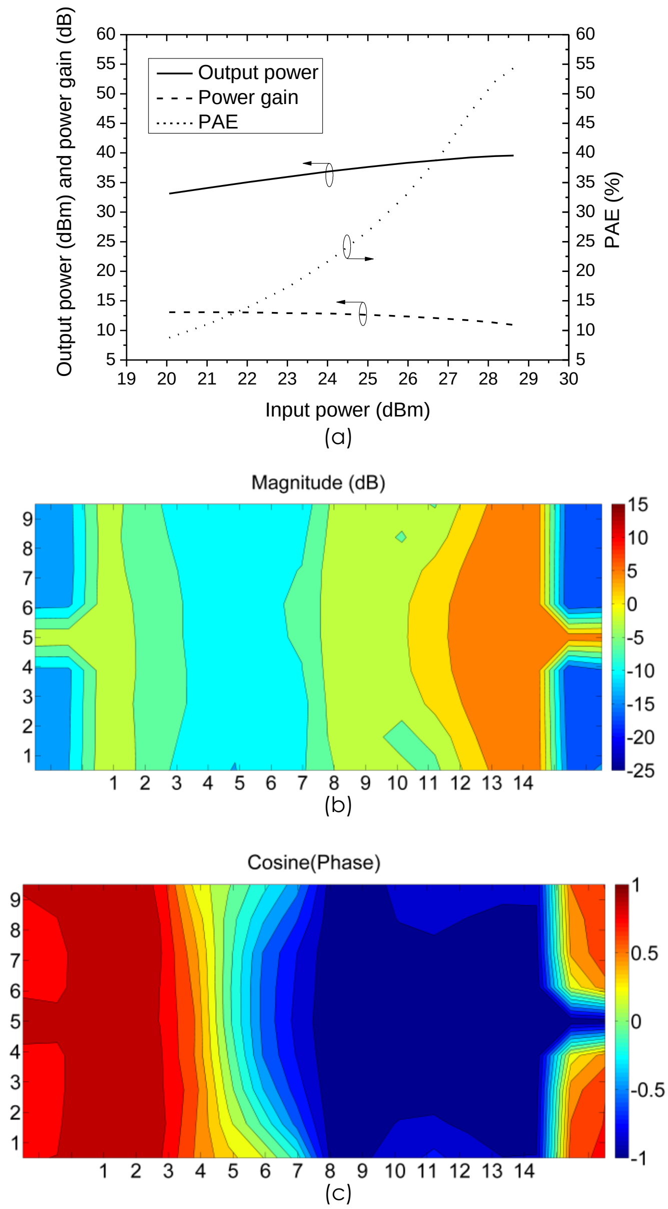

Fig. 2 Measured results of (a) the output power, power gain, and PAE, (b) magnitude of S_{21} in dB with respect to the input port and (c) cosine(phase).

Due to the infinite wavelength phenomenon, constant bution at the 7th and the 8th columns is obtained from the 4th row to the 7th row, and $|S_{21}|$ at these four rows is shown higher than that of the other rows. It may result from the non-uniformity of nine amplifiers. Furthermore, the graceful degradation characteristic of this nine-way power-combined amplifier is experimentally demonstrated and shown differently as those of using radial and planar power dividers and combiners.

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For more information please contact:
PHD Student: Wei-Chiang Lee
Adviser: Professor Tah-Hsiung Chu
Email: thc@ntu.ee.edu.tw

Apply to GICE

Invited Talk

Some Recent Developments in the Finite Difference Time Domain Method for Efficient Solution of Radiation and Scattering Problems

Lecturer : Prof. Raj Mittra

With the advent of sub-micron technologies and increasing awareness of Electromagnetic Interference and Compatibility (EMI/EMC) issues, engineers are often interested in full-wave solutions of the complete system, that takes in to account a variety of environments in which an antenna or a scatterer may be located. However, deriving full wave solutions of such complex problems is challenging, especially when dealing with problems that involve multi-scale geometries with very fine

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features. Even the well-established methods, such as the time domain technique FDTD (Finite Difference Time Domain Method), and the frequency domain methods FEM and MoM, are often pushed to the limits of their capabilities when attempting to solve such problems. In an attempt to meet such challenges, we present some novel techniques, which hybridize the the Dipole Moment (DM) Approach and Recursive Update in Frequency Domain (RUFD) with the FDTD. In addition, we address the so-called "low-frequency" problem, which presents a formidable challenge to the not only to the FDTD, but to FEM and MoM algorithms as well.

Activities

TEMIAC Technical Forum- New Radar Technology for Civil Applications

Owing to the progress of semiconductor process and a variety of emerging wireless services, the radar technology for civil applications has prevailed in the public mind and drawn extensive attention in recent years. This season seminar is organized by Taiwan Electromagnetic Industry-Academia Consortium (TEMIAC), Graduate Institute of Communication Engineering (GICE) of National Taiwan University, and Communication Research Center (CRC) of National Taiwan University together. The enthusiastic attendees from various fields are more than one hundred. The organizers are honored to invite many experts from industry and academy to give inspiring speeches about radar applications to safety surveillance, process automation, homeland security, automotive safety, vital-sign monitoring, and smart home appliances. The technical background, economic value and future prospect of the addressed topics are extensively illustrated. In addition to the speeches, a panel discussion is provided for the invited experts and audiences to share their perspective on the challenges and opportunities of radar technology and look forward to future cooperation over the coming years. Through the current system integration and DSP techniques, radar can be embedded in an electronic product more easily to develop potential killer applications. We wish the abundant information shared in this season seminar will benefit upgrading the domestic electronic industries to promote their international competitiveness.

Panel discussion- Five experts from industries and academia are invited to share opinions on the challenges and opportunities of radar technology.

Over 130 participants from industries and academia attended this seminar.

2013 A visit to Panasonic Taiwan

2013 May 10, the delegation led by director Tzong-Ling Wu called on the president of Panasonic Taiwan, Mr. Hong-Min Hong, and general manager Mr. Akihiro Nakatani. The delegation visited the factory in Da-Yuan, Taoyuan, which produces Any Layer Interstitial Via Hole (ALIVH) for Hi-tech mobile device such as smartphones, and interchanged

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ideas.

In 1996, Panasonic developed ALIVH, which was a breakthrough for mobile device that stress on space efficiency. It was a great opportunity to have the sight of ALIVH's automatized production and to get to know its technical aspect. Meanwhile, seven professors, whose expertise cover from chip/package design, antenna design, microwave and millimeter wave IC design etc., shared their researches with management and technique team of Panasonic Taiwan. Hoping this chance will lead to a long-term corporation of technique development, personnel training and industry promotion between GICE NTU and Panasonic Taiwan.

Corner of Student News

by Hung-Chuan Chen

Thanks for the great support from National Science Council. A wonderful chance to be an intern at the world-organized and over-100-year company, IBM in the US, is coming to my life. With the terrific opportunity, I can understand how the prestigious and worldwide company operates. Besides, many extraordinary first experiences occurred during the internship.

At IBM, the site area is really large and it is hard to believe that it takes long walk over 15 minutes from office to lab for taking experiments. In addition to the gigantic size of the site area, it is also amazing to collaborate with people around the world. I had experiences in working with people in India and Italy as well as getting assistance from Dublin in Ireland. This is the situation I have never thought when I study in Taiwan. Moreover, I can have several opinions about the work from different point of view based on the culture difference and personal experience. Here, it is prevalent to have conference call or meeting with people from different states in the US, and even people from various countries including Japan, Russia, and England, to discuss the same topic. Furthermore, people work here can choose any place where they can feel comfortable and do work efficiently. They can work in the company, at home, even in a coffee shop. This is totally opposite to the work style we have in our country.

The different culture and life style here bring me many first experiences and surprising moment. One of them is to breathtakingly see the snow in the winter. Even though it was really cold outside, the exciting emotion warmed up my body. House and road were covered with the white snow and it was very sparkling. However, it is pretty dangerous to drive on a snow day. The bad weather let the car frozen and the sleet covered the windshield to shield my view. Sometimes, I can only peek through it to drive on the slippery road, so I have to drive very slowly, even on the highway. Without the developed mass transportation system here, it usually needs long driving over 4 or 5 hours by car to travel from cities to cities. Among the trips, I have attended some sports games and enjoyed the atmosphere of watching the triple-A championship baseball game. Indeed, it is really fascinating to support the player (Che-Hsuan Lin) who also comes from Taiwan in person during the game. Therefore, I sincerely appreciate this great opportunity and deeply cherish the wonderful experience here.

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
gice_newsletter@cc.ee.ntu.edu.tw

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

Editor in Chief
Prof. Hung-Yu Wei

Editors
Joyce Jou
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