A Design of Multi-harmonics Load Network for Class-S Power Amplifier

Girdhari Chaudhary[1], **Phirun Kim**[1], **Yongchae Jeong**[1], **and Chan-sei Yoo**[2]

[1]Chonbuk National University, Republic of Korea
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Abstract— Abstract Today's wireless communications systems require higher transmit and receive data rates in order to fulfill the demands of customers including features such as email, internet browsing, and video downloads with faster rates. This results in greater power consumption in power amplifiers. Therefore, minimizing the power consumption of wireless devices is a critical challenge for both system and circuit design. For this purpose, highly efficient switching-mode power amplifiers (PAs) such class-S are attractive solution because their high efficiency can potentially extend the battery life, lower cost of heat-sinking and increase the device reliability. In highly efficient switching mode PAs, the product of current and voltage should ideally zero at all frequencies except the fundamental frequency. Therefore, the load network for the voltage mode class-S PA is proposed in this paper. The load network for the voltage mode class-S PA requires infinite impedances at harmonic frequencies except the fundamental as shown in Fig. 1. For designing load network, the first shunt stub transmission line should be $\lambda/4$ at highest harmonic frequency which will be transferred to open by transmission line of electrical length $\theta_1 = \lambda/4$ at this harmonic frequency. Similarly, second shunt stub of $\lambda/4$ long at second highest harmonic frequency is added after line of electrical length θ_2. This line will help to make total electrical length of the series transmission line $\theta_1 + \theta_2 = \lambda/4$ at this frequency and will transfer impedance at open (Fig. 1). This process is repeated until lowest harmonic frequency. To verify design concept, the load network for $n = 3$ (2nd and 3rd harmonic suppression) at the fundamental frequency (f_0) of 0.955 GHz is designed and fabricated as shown in Fig. 2. From simulation and measurement results, it was found that load impedance at harmonic frequencies ($3f_0$ and $2f_0$) is almost infinite and is matched to 2 Ω at f_0 respectively, as shown in Figs. 3 and 4. Similarly, the attenuation characteristics are greater than 30 dB at harmonic frequencies as shown in Fig. 5. The proposed design method is applicable for multi-harmonics and will help in efficiency enhancement of the voltage-mode class-S PA.

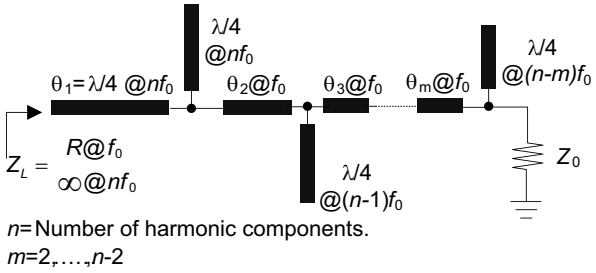

Figure 1.

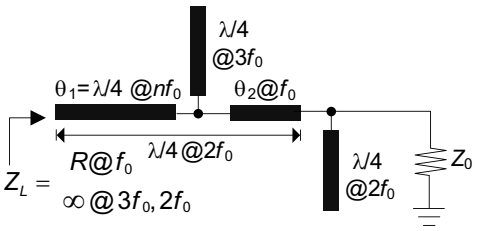

Figure 2.

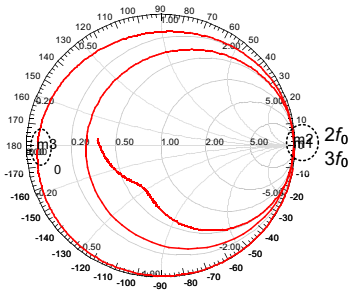

Figure 3.

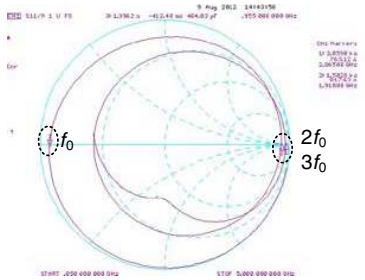

Figure 4.

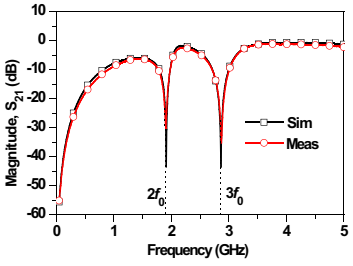

Figure 5.

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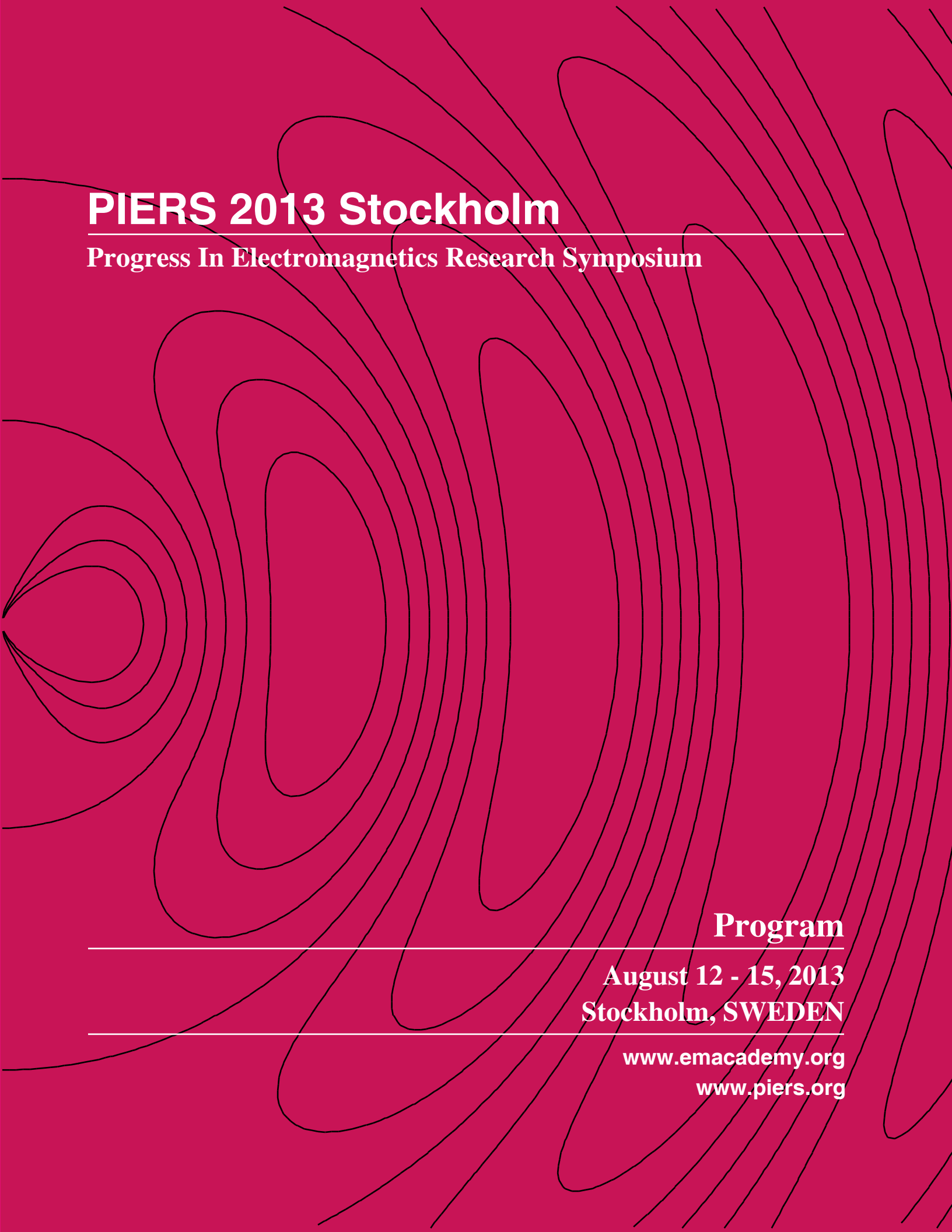

Program

August 12 - 15, 2013
Stockholm, SWEDEN

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16:40 Body-effect-adaptive Compact Wideband LTE MIMO Antenna Array with Quad Elements for Mobile Terminals
Shuai Zhang (*Royal Institute of Technology, Sweden*); *Kun Zhao* (*School of Electrical Engineering, KTH-Royal Institute of Technology, Sweden*); *Zhinong Ying* (*Sony Ericsson Mobile Communications AB, Sweden*); *Sailing He* (*Royal Institute of Technology, KTH-ZJU Joint Research Center of Photonics, Sweden*);

17:00 Multiple-feed Coupling Measurements for Luneburg Lens Antenna
Debora Franco-Vazquez (*Universidade de Vigo, Spain*); *María Vera-Isasa* (*Universidad de Vigo, Spain*); *M. Edita De Lorenzo Rodriguez* (*Universidad de Vigo, Spain*);

17:20 Planar MIMO Antenna System for Laptop Applications
Amira El-Tokhy Ali (*Modern Science and Arts University (MSA), Egypt*); *Deena A. Salem* (*Electronics Research Institute, Egypt*);

17:40 The Study of Loss Effect on the LTE MIMO Antenna in Mobile Handset
Kun Zhao (*KTH-Royal Institute of Technology, Sweden*); *Shuai Zhang* (*Royal Institute of Technology, Sweden*); *Zhinong Ying* (*Sony Ericsson Mobile Communications AB, Sweden*); *Erik Bengtsson* (*Sony Mobile Communications AB, Sweden*); *Sailing He* (*KTH-Royal Institute of Technology, Sweden*);

Session 4P7
Microwave and Millimeter Wave Circuits and Devices, CAD

Thursday PM, August 15, 2013

Room G

Chaired by Martin Norgren

13:20 Asymetrical Interdigital Dual-band Bandpass Filter Using Grounded inside Arms with via Holes
Ram Krishna Maharjan (*Kwangwoon University, South Korea*); *Nam-Young Kim* (*Kwangwoon University, Republic of Korea*);

13:40 Low Profile Planar Composite Inductor Design for High Power Applications
Abdullah Eroglu (*Indiana University-Purdue University, USA*);

14:00 A Design of Multi-harmonics Load Network for Class-S Power Amplifier
Girdhari Chaudhary (*Chonbuk National University, Republic of Korea*); *Phirun Kim* (*Chonbuk National University, Republic of Korea*); *Yongchae Jeong* (*Chonbuk National University, South Korea*); *Chan-Sei Yoo* (*Korea Electronics Technology Institute (KETI), Korea*);

14:20 Systematic Study of the Effective Permittivity in a Periodically Drilled Substrate Integrated Waveguide
Rodrigo Isidro (*Universidad Miguel Hernández de Elche, Spain*); *Angela Coves Soler* (*Universidad Miguel Hernández de Elche, Spain*); *Miguel Ángel Sanchez-Soriano* (*Universite Bretagne Occidentale, France*); *German Torregrosa-Penalva* (*Universidad Miguel Hernández de Elche, Spain*); *Enrique Bronchalo* (*Universidad Miguel Hernández de Elche, Spain*); *Maurizio Bozzi* (*University of Pavia, Italy*);

14:40 Design of a Single-board Two-port Analyzer for Microwave Dielectrometry
Roberto Olmi (*Institute of Applied Physics N. Carrara-CNR, Italy*); *Filippo Micheletti* (*Institute for Applied Physics — National Research Council IFAC-CNR, Italy*);

15:00 A 2.45 GHz High Figure-of-Merit Reflection Type Phase Shifter
François Burdin (*University of Grenoble, France*); *Zyad Iskandar* (*LAIR/DACLE, CEA/Léti, France*); *Florence Podevin* (*University of Grenoble, France*); *Philippe Ferrari* (*University of Grenoble, France*);

15:20 **Coffee Break**

15:40 A Compact Hybrid EBG Microstrip Bandstop Filter for Digital Clock Suppression in a Power Supply System
Raul Peña Rivero (*National Polytechnique Institute, Mexico*); *A. Mendoza-Tellez* (*National Polytechnique Institute, Mexico*); *Roberto Linares-Miranda* (*National Polytechnique Institute, Mexico*); *J. A. Tirado-Mendez* (*National Polytechnique Institute, Mexico*);

16:00 Switchable Band-stop to All Pass Filter Using Stepped Impedance Resonator
Amine Adoum Bakhit (*Universiti Teknologi PETRONAS, Malaysia*); *Peng Wen Wong* (*Universiti Teknologi PETRONAS, Malaysia*);

16:20 Study of Dynamic-periodic Transmission Lines
Jose Roberto Reyes Ayona (*Instituto Nacional de Astrofisica Optica y Electronica, Mexico*); *Peter Halevi* (*Instituto Nacional de Astrofisica, Optica y Electronica (INAOE), Mexico*);

16:40 A Length-reduced Microstrip Line with Inductive and Capacitive Perturbations
Jongsik Lim (*Soonchunhyang University, Republic of Korea*); *Kyunghoon Kwon* (*Soonchunhyang University, Republic of Korea*); *Kolet Mok* (*Chonbuk National University, Republic of Korea*); *Yongchae Jeong* (*Chonbuk National University, South Korea*); *Sang-Min Han* (*Soonchunhyang University, Korea*); *Dal Ahn* (*Soonchunhyang University, Korea*);

17:00 Effect of the Ionizing Radiation on the Harmonic and Intermodulation Performance of the CMOS Inverting Amplifier
Muhammad Taher Abuelma'atti (*King Fahd University of Petroleum and Minerals, Saudi Arabia*);

17:20 Design Optimization of Microstrip Matching Circuits Using a Honey Bee Mating Algorithm Subject to the Transistor's Potential Performance
Peyman Mahouti (*University Istanbul, Turkey*); *Salih Demirel* (*Yildiz Technical University, Turkey*); *Filiz Gunes* (*Yildiz Technical University, Turkey*);

Session 4P8a
Medical Electromagnetics, Biological Effects

Thursday PM, August 15, 2013

Room H

Chaired by Qiu Qiang Zhan

13:00 Electromagnetic Information Delivery as a New Perspsctive in Medicine
Alberto Foletti (*University of Applied Sciences of Southern Switzerland-SUPSI, Switzerland*); *Settimio Grimaldi* (*Institute of Neurobiology and Molecular Medicine (INMM), National Research Council (CNR), Italy*); *Mario Ledda* (*Istituto di Neurobiologia e Medicina Molecolare, C.N.R., Italy*); *Antonella Lisi* (*Istituto di Neurobiologia e Medicina Molecolare, CNR, Italy*);

13:20 A Novel Conformal Antenna for Ingestible Capsule Endoscopy in the MedRadio Band
Konstantinos A. Psathas (*National Technical University of Athens, Greece*); *Asimina Kiourti* (*National Technical University of Athens, Greece*); *Konstantina S. Nikita* (*National Technical University of Athens, Greece*);

13:40 Impact of Electromagnetic Field Generated by Mobile Phone on Prooxidant-antioxidant Balance in Selected Internal Organs of Rats
Pawel Sowa (*Silesian University of Technology, Poland*); *Karolina Sieron-Stoltny* (*Medical University of Silesia, Poland*); *Grzegorz Jan Cieslar* (*Medical University of Silesia, Poland*); *Aleksander Sieron* (*Medical University of Silesia, Poland*);

14:00 Electric and Magnetic Fields Due to the Operation of Roof Mounted Photovoltaic Systems
Anastasia S. Safigianni (*Democritus University Thrace, Greece*); *Aristotle M. Tsimtsios* (*Democritus University Thrace, Greece*);

14:20 Experimental Study about the Thermal Effects of EM Sources on Human Skin Tissue
A. Yasin Citkaya (*Bogazici University, Turkey*); *S. Selim Seker* (*Bogazici University, Turkey*); *Osman Cerezci* (*Sakarya University, Turkey*);

14:40 Optimized Nanocage for Cancer Photothermal Therapy and Comparison with Other Nanoparticles
Sameh Kessentini (*University of Technology of Troyes, France*); *Dominique Barchiesi* (*University of Technology of Troyes, France*);

Session 4P8b
SC3: Nonlinear Optics: Structured Materials, Functional Devices and Applications 2

Thursday PM, August 15, 2013

Room H

Organized by Chia Chen Hsu, Shiming Gao

Chaired by Roberto Caputo, Shiming Gao

15:00 invited Dynamic Frequency Conversion in an Ultrahigh-Q Fiber Grating Cavity
Zhangwei Yu (*Royal Institute of Technology (KTH), Sweden*); *Irina V. Kabakova* (*University of Sydney, Australia*); *Patrik Rugeland* (*Institute of Technology (KTH), Sweden*); *Pierre-Yves Fonjallaz* (*Acreo Swedish ICT AB, Sweden*); *Oleksandr Tarasenko* (*Acreo Swedish ICT AB, Sweden*); *C. Martijn de Sterke* (*University of Sydney, Australia*); *Walter Margulis* (*Royal Institute of Technology (KTH), Sweden*);

15:20 **Coffee Break**

15:40 Third Harmonic Generation by Optimized Hyperfine Aperiodic Optical Superlattice
Cheng-Wei Hsu (*National Tsing Hua University, Taiwan*); *Jui-Yu Lai* (*National Tsing Hua University, Taiwan*); *Shangda Yang* (*National Tsing Hua University, Taiwan*);

Session 4P7
Microwave and Millimeter Wave Circuits and Devices, CAD