S701: A 3-Day Intensive Course on

"Advanced RF Power Amplifier Techniques for Modern Wireless and Microwave Systems"

Jointly Organized by
Institute of Microelectronics (IME),
IEEE Singapore MTT/AP Chapter, and
IEEE Singapore SSC Chapter

When: February 7- 9, 2007
Where: Institute of Microelectronics (IME), Singapore

In any system, the power amplifier (PA) is a critical component. It is typically the most costly single item and consumes most of the supply power. Knowledge of the possibilities for trading power per unit cost with efficiency and linearity often forms the basis for the entire system architecture design.

The increasing use of linearisation techniques, and especially the emergence of high speed digital processing as an enabling technology to implement predistortion on the PA input signal, represent an important paradigm shift in PA design. The PA component can now be designed with more emphasis on efficiency, without the traditional constraints of meeting stringent linearity specs simultaneously.

There is also a new subject area, which is the consideration of new and/or novel PA circuit and device technologies, which can maximise the utility of a lineariser in order to obtain optimum efficiency. This will undoubtedly change the rather traditional face of PA design in the coming era of 3G systems.

In addition to the obvious high volume applications for RF PAs in cellular and wireless communications systems, there are other requirements in more traditional areas, broadly categorised as "microwave systems". Satellite communications, microwave links and repeaters, and military ECM present different requirements and challenges for the RF PA designer.

This is an advanced level RF design course, dealing with the theory and design of RF power amplifiers for wireless, satcom, and microwave applications. The course features in-depth treatment of PA design, PA modes, envelope power management, and circuit level linearization techniques.

About the Instructor:

Dr Steve C. Cripps obtained his Ph.D. degree from Cambridge University, England. He worked for Plessey Research (now GECMM) on GaAsFET hybrid circuit development. Later he joined Watkins-Johnson's solid state division , Palo Alto, CA, and has held Engineering and Management positions at WJ, Loral, and Celeritek. During this period, he designed the industry's first 2-8 Ghz and 6-18 Ghz 1 watt solid state amplifiers, and in 1983 published a technique for microwave power amplifier design, which has become widely adopted in the industry. In 1990 he became an independent consultant and was active in a variety of commercial RF product developments, including the design of several cellular telephone power amplifier MMIC products. In 1996 he returned to England, where his consulting activities continue to be focused in the RF power amplifier area.
Dr Cripps has been a member of the CEI-Europe Faculty since 1995.

Benefits of this Course

Enhance your understanding of:

a. Power amplifier basic concepts like classes of operation, stability, linearity, bias technique
b. Impedance matching technique based on lumped elements and transmission lines
c. High-efficiency technique including well-know Classes F and E and newly developed their subclasses and Efficiency Enhancement Techniques
d. Power Amplifier Non-Linearity and Signal Environments
e. PA Architecture, Microwave PA Design and Linearization Techniques

Who Should Attend?

This course presents an overview, fundamentals, theory, practical and advanced power amplifier design which will be of interest to engineers and technical staff, managers and business development personnel who plan to pursue this technology, or compete with it.

Date: 7-9 February 2007, Wednesday to Friday, Time: 0900 – 1700 (Registration start at 8:30am)
Venue: 3F Training Room, Institute of Microelectronics (IME), Singapore
11 Science Park Road, Singapore Science Park II, Singapore 117685

Fees: **S$1500** for course materials and a book worth USD139, lunch and tea break
S$1300 without the book from Artech House
IEEE Member will enjoy S$200 discount from regular fee by providing Membership No.
S$500 for students
(Lunch and refreshments will be provided)
Registration Deadline: 22nd January 2007

Dr. Cripps' PA Course Outline

Day 1: Wednesday, 7-Feb-2007

Power Amplifier Basics and Signal Environments
Linear amplifier modes are described with quantitative analysis of power, efficiency and linearity tradeoffs in uncompensated form leading into a discussion of the device technologies currently available for PA design, including LDMOS, GaAs MESFET and HBT, SiC and GaN. Differences between bipolar and FET devices, and the effects of different kinds of parasitic effects will be discussed using circuit analysis and CAD models. Possibilities for tailoring the characteristics of devices for optimum efficiency and linearity will be presented. Particular emphasis is given to correct fundamental and harmonic matching. The impact of non-ideal harmonic terminations in practical Class AB designs will be analysed quantitatively. Various modulation systems (QPSK, EDGE, CDMA, OFDM) will be reviewed from the viewpoint of PA requirements.

- Introduction
- Classical PA Modes, Class A, Class AB, Class B, Class C
- PA Device Technology
- Optimum Device Characteristics for Class AB Operation
- Modulation Systems in Wireless Communications QPSK, GSM, EDGE, OFDM
- Effect of Signal Environment on RFPA Design

Class AB PA Design, Doherty PA
We will focus on practical issues in the design and manufacture of PAs for RF and MW Systems. Several design examples will be demonstrated, including a GaAs MESFET, a GaAs HBT, and a high power LDMOS device. The Doherty PA has become one of the most important emerging techniques in Pas for wireless communications, and will be given full treatment, from basic concept to a CAD design example.

- Class AB circuits
- Harmonic Terminations
- CAD Examples
- Doherty PA, Basic Theory, Variations, CAD example

Day 2: Thursday, 8-Feb-2007

Power Amplifier Non-Linearity and Signal Environments.
We will focus on the non-linear properties of RF PAs, their source, manifestation, and methods for their characterization and modeling. A topical issue of great impact in modern linearised multi-carrier PA (MCPA) applications is memory effects. This subject will be illustrated with device measurements, and physical causes and remedies will be discussed. This will include a full treatment of bias network design. The process of converting a measured PA gain compression and AM-PM characteristic into spectral and EVM distortion, and the issues involved, will be discussed using several different modulation environments, including GSM-EDGE and WCDMA.

- Non-Linear PA Characteristics, Gain Compression, AM-PM
- Physical Origins of AM-PM, Analysis
- Peak to Average Power Ratio Issues in Modern Signal Environments
- Spectral Regrowth and EVM
- Power Series, Volterra Series. Model Fitting using measured Data
- Envelope simulation using EDGE, CDMA signals
- Memory Effects
- Bias Network Design and Stability

Day 3: Friday, 9-Feb-2007

Efficiency Enhancement Techniques
We will focus on the key issue of power back-off (PBO) efficiency, and LINC (linear amplification using non-linear components). Envelope management methods and tracking techniques in PA design will be presented. These include classical techniques such as the Chireix out-phasing method, the Khan and the Polar Loop envelope reconstruction approaches. Other less well-known techniques will be discussed. Ultra high efficiency amplifier modes, Classes C, D, E, and F will be analyzed as possible candidates for LINC implementation and as stand-alone possibilities in systems using digital pre-distortion or feed forward linearization.

PA Architecture, Microwave PA Design and Linearization Techniques
PA architecture, including multistage effects, power combining techniques, and load pull design will be discussed. A discussion Microwave PA design at higher GHz frequencies will address the various issues such as efficiency and linearity in the context of higher frequency and broader bandwidth applications. The course will conclude with of a review of linearization techniques.

- Multistage PA Design
- Power Combining Techniques; Balanced and Push-Pull Operation
- Load-Pull Techniques
- Microwave PA Design
- Linearization Techniques (overview)

Registration Form

Name: _____(IEEE Member No.)_ Email: _____

Name: _____ Email: _____

Name: _____ Email: _____

Company: _____

Address: _____

_____

Tel: _____ Fax: _____

Email of contact person for group registration: _____

An invoice will be issued to your company upon successful registration.

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