27TH AES INTERNATIONAL CONFERENCE

Efficient Audio Power Amplification

Hillerød, Copenhagen, Denmark
September 2–4, 2005

Photograph of Frederiksborg Castle courtesy Danish Tourist Board; Photographer: Klaus Bentzen

The magnificent castle pictured above, Frederiksborg Slot, is only a short distance northwest of Copenhagen in the town of Hillerød, which (at the nearby Pharmakon conference center) will be the site of the AES 27th International Conference, *Efficient Audio Power Amplification*, September 2–4.

Linear (Class A/AB/B) amplification has been the standard for power amplification for many decades. During the last ten years, interest in higher efficiency power amplification has increased, particularly in the audio industry. The major driving force has been the need to provide fresh opportunities in audio design with the advantages that higher efficiency potentially offers: higher power with increased power density, savings in energy and battery life, potential cost savings, and even potential performance improvement in audio reproduction.

The interest in this new field is global and includes all major industrial segments, such as consumer electronics, automotive audio, pro audio, and mobile devices. A paradigm shift in power amplification seems to be underway.

Conference Chair Jan Abildgaard Pedersen and his committee have forged a conference program that will present an overview of the current state-of-the-art in a broad perspective and address many of the new scientific disciplines involved in this emerging field.

THE TECHNICAL PROGRAM

Michael Andersen and Thomas Frederiksen, papers cochairs, have coordinated a program of six sessions during the three days of the conference. Andersen will get things rolling on Friday afternoon with a keynote address in which he will discuss the challenges facing the companies and individuals developing efficient audio power amplification.

Following the keynote address Jens Christensen will present an invited paper, "The Industrial Dynamics of Open Innovation: Evidence from the Transformation of Sound Amplification from Linear Solid-State to Class D Technology."

The next and final papers session on Friday afternoon will be comprised of three papers on the topic of power stage topologies. Later in the evening after dinner there will be a table-top demo session in which participants will be able to display some of the innovative technologies they are developing.

The Saturday morning session will feature five papers delving into the topic of modulation and control. Skip Taylor will lead off this session with an invited paper, "Taking Advantage of Improved Digital Signal Processing Techniques to Reduce the Implementation Complexities of High-Performance, High-Efficiency Digital Amplifiers." The second session on Saturday morning, concentrating on errors and distortion, will open with another invited paper, "Design Criteria for Ultra Low Distortion Open Loop PWM Output Stages," by Brian Attwood. The papers in the afternoon session are on IC and integration

The final papers session, devoted to measurements and tests, will be on Sunday morning. The rest of the technical program on Sunday will be a workshop on measurement and instrumentation and a tutorial and workshop on EMI/EMC. The calendar, complete program with abstracts, and registration form follow.

SOCIAL EVENTS, DANISH HISTORY, COPENHAGEN

At press time, an excursion and banquet on Saturday evening were still in the planning stages. But they are sure to be memorable events. You certainly want to make sure you have time to visit Frederiksborg Castle. The National History Museum has been housed in the castle since 1878.

The Pharmakon conference center is situated on the southern outskirts of Hillerød about one kilometer from the train and bus terminal. It takes approximately 45 minutes to reach Pharmakon by train from Copenhagen City, which is a 15-minute train ride from Copenhagen Airport.

Before or after the conference be sure to spend a day or two in Copenhagen, one of the great capital cities of Europe. Its museums and concert halls are world-class. The spectacular new waterfront opera house has recently opened to rave reviews. Check for updates on the conference at http://www.aes.org/events/27. These new developments in power amplification will have a significant impact on future developments in the audio industry. Don't miss this important event. Join colleagues in Denmark September 2–4 at the AES 27th International Conference, *Efficient Audio Power Amplification.*

Technical Sessions*

*This preliminary program is accurate as of press time.

Friday, September 2 **14.10**

KEYNOTE ADDRESS

Efficient Audio Power Amplification—Challenges

Keynote Speaker **Michael A. E. Andersen**, 27th Conference Papers Chair

For more than a decade efficient audio power amplification has evolved and today switch-mode audio power amplification in various forms are the state-of-the-art. The technical steps that lead to this evolution are described and in addition many of the challenges still to be faced and where extensive research and development are needed is covered.

Friday, September 2 **15.00–16.00**

PAPER SESSION 1: INVITED PAPER

1-1 The Industrial Dynamics of Open Innovation: Evidence from the Transformation of Sound Amplification from Linear Solid-State to Class D Technology—*Jens Frøslev Christensen, Michael Holm Olesen, Jonas Sorth Kjær*, Copenhagen Business School, Frederiksberg, Denmark

This paper addresses how the open innovation concept, as recently coined by Henry Chesbrough, can be analyzed from an industrial dynamics perspective. The main proposition of the paper is that the specific modes in which different companies manage open innovation in regard to an emerging technology reflect their differential position within the innovation system in question and the stage of maturity of the technology. The proposition is analyzed through an in-depth study of the current transformation of sound amplification from linear solid-state technology to switched or digital technology within the consumer electronics system of innovation.

Friday, September 2 **16.30–18.00**

PAPER SESSION 2: POWER STAGE TOPOLOGIES

2-1 A 97 Percent Efficiency Power Stage Design for High Performance Class D Audio Amplification—*René Lambruschi, Nicola Lomuto, Frédérik Dezé*, CL3, Pontoise, France

An innovative solution of switching power conversion is introduced, and its benefits on class D audio amplifiers is demonstrated. The smart association of a high side N MOSFET and a low side P MOSFET in the power stage combines the dynamic parameters of the two MOSFETS, so that only one drive signal is used and the risk due to skew and unmatched thresholds is eliminated. No dead time is needed, therefore lowering distortion and allowing high efficiency (97 percent and more). Exceptional sound reproduction and scale integration in an enclosed environment are permitted. The proposed architecture is patent pending and will be referred to as Gemincore.

2-2 Digital Audio Power Amplifier Based on Multilevel Power Converters—*Victor M. E. Antunes*,[1] *Vitor Fernao Pires*,[2] *Jose Fernando Silva*[3]
[1]Instituto Politécnico de Setúbal, Portugal
[2]Instituto Superior Técnico (IST), UTL, Lisbon, Portugal
[3]Centro Automática Universidade Técnica Lisboa (CAUTL), Lisbon, Portugal

The concepts and design aspects of all-digital open-loop audio power amplifiers, based on multilevel power converters, are presented. Innovative modulation techniques to reduce harmonic distortion of this type of amplifiers are also presented. A prototype of a digital multilevel audio power amplifier has been developed, implemented, and tested. THD plus noise performance comparisons between some class A, AB, and D amplifiers are presented. Results show that the proposed digital audio power amplifier can be a promising solution for a high-quality digital audio power amplifier.

2-3 Self-Oscillating Modulators for Direct Energy Conversion Audio Power Amplifiers—*Petar Ljusev, Michael A. E. Andersen*, Technical University of Denmark, Lyngby, Denmark

Direct energy conversion of an audio power amplifier represents the total integration of a switching-mode power supply and class D audio power amplifier into one compact stage, achieving high efficiency, high level of integration, low component count, and eventually low cost. This paper presents how self-oscillating modulators can be used with the direct switching-mode audio power amplifier to improve its performance by providing fast hysteretic control with high power supply rejection ratio, open-loop stability, and high bandwidth. Its operation is thoroughly analyzed, and experimental results from a prototype amplifier are presented.

Friday, September 2 **20.00–22.00**

DEMONSTRATIONS

Table-Top Demonstrations

Technology demonstrations by participants/inventors.

Saturday, September 3 **09.00–12.00**

PAPER SESSION 3: MODULATION AND CONTROL

3-1 Taking Advantage of Improved Digital Signal Processing Techniques to Reduce the Implementation Complexities of High-Performance, High Efficiency Digital Amplifiers [Invited Paper]—*SkipTaylor*, D2Audio, Austin, TX, USA

With the recent move from the classical PWM amplifier approaches, which employ a hysteretic comparator technology to the newer emerging sigma-delta techniques, there is increased interest and motivation to revisit the strategic importance of high performance switching amplifiers. The new modulation techniques have found their way into the newer, low-profile, "lifestyle" systems in the home theater and whole house audio markets where single-chip and two-chip designs offer a manageable solution. However, the limited performance and power levels of the initial offerings have fallen short of the requirements of the more challenging high-end home theater applications and other market segments where a more audiophile quality is desired. Out of necessity, the requirements for these more demanding markets will dictate an ability to manage and tame discrete output drivers, output stages, and output

filters in a very scalable implementation. The trade-offs between seemingly contradictory design considerations (EMI, efficiency, performance, cost) force the need to take an innovative and more system-centric approach to the amplifier design. This paper addresses a unique and previously unrealized technique of using advanced adaptive digital signal processing technology and amplifier system modeling to assure not only the performance of the legacy linear analog solutions, but also a very cost-effective system realization. This technique is presented as it relates to the total system implementation and as it integrates into the graceful fault protection methods that have come to be expected in these applications. It includes descriptions of the critical circuit blocks, the software/firmware algorithms and techniques, and the final amplifier topology. Results are shown that illustrate both the performance improvements and the reduction in complexity of the total system design.

3-2 Real-Time Power Supply Feedback Reduces Power Conversion Requirements for Digital Class D Amplifiers— *Randy Boudreaux*, Cirrus Logic, Inc., Austin, TX, USA

The development of real-time power supply feedback for an all-digital class D PWM amplifier enables the use of many different power conversion techniques allowing a greater number of alternatives to meet system demand requirements. With a typical voltage ripple rejection of 40dB at 60Hz, an all-digital PWM amplifier with this PSR compensation can achieve better than 105dB system dynamic range and a total harmonic distortion plus noise measurement of 0.1 percent. The system performance of the real-time PSR feedback is discussed and evaluated for a half-bridge and full-bridge amplifier output stage powered from a low cost unregulated linear power supply.

3-3 Distortion and Error Reduction in a Class D Power Stage Using Feedback—*Michael Pate*,[1] *Lars Risbo*,[2] *Pietro Andreani*,[3] *Kwong Chao*[1]
[1]Texas Tech University, Lubbock, TX, USA
[2]Texas Instruments, Lyngby, Denmark
[3]Technical University of Denmark, Lyngby, Denmark

In this paper a method for minimizing the total harmonic distortion (THD) is presented for a class D output stage by optimizing a loop filter. A second-order filter is chosen to create large error suppression through the audio band while keeping the overall system complexity low. The stability of the optimized loop is examined to ensure proper operation. SIMULINK simulations are given to verify the theory introduced.

3-4 Derivation and Analysis of a Low-Cost, High-Performance Analog BPCM Control Scheme for Class D Audio Power Amplifiers—*Mikkel C. W. Høyerby, Michael A. E. Andersen*, Technical University of Denmark, Lingby, Denmark

This paper presents a low-cost analog control scheme for class D audio power amplifiers. The scheme is based around bandpass current-mode (BPCM) control and provides ample stability margins and low distortion over a wide range of operating conditions. Implementation is very simple and does not require the use of operational amplifiers. Small-signal behavior of the controller is accurately predicted, and design is carried out using standard transfer function based linear control methodology. Effectiveness of the approach is demonstrated via a 60-W/8-W single-ended switching amplifier with THD+N of typically 0.02 percent.

3-5 Discrete-Time Modeling of Continuous-Time Pulse Width Modulator Loops—*Lars Risbo*, Texas Instruments Denmark, Lingby, Denmark

Traditionally, the dynamics of continuous-time PWM loops are analyzed by using linearized continuous-time models where the comparator is modeled as a linear gain. However, this method fails to accurately explain several important characteristics such as noise aliasing, image components, and loop stability. This paper analyzes the sampling nature of the comparator and derives a general linear discrete-time loop small-signal model that can be applied to loops of any order—both driven (synchronized) and free running (self-oscillating).

Saturday, September 3 13.00–15:00

PAPER SESSION 4: ERRORS AND DISTORTION

4-1 Design Criteria for Ultra Low Distortion Open Loop PWM Output Stages [Invited Paper]—*Brian E. Attwood*, PWM Systems

A previous paper by the author (*JAES* November 1983) looked at various distortion mechanisms in switching amplifiers and discussed circuit topologies to overcome these limitations. While the basic content of this paper still applies today, advances in semiconductors and the developing area of fully digital amplifiers for DVD, SACD, and AV markets means that a fresh look should be taken at consistently achieving the lowest possible open loop system performance. Since digital amplifiers (those with no input A/D converters) are operating totally in the digital domain, overall feedback becomes a much more complex issue compared to conventional analog (Class D) pwm systems where 30 dB can be readily achieved. Some solutions have been proposed that look very promising at the moment; however, most currently available digital switching amplifiers are still operating under open loop conditions. Under these circumstances it becomes essential to achieve the best possible system linearity, and since most predominant distortion mechanisms will occur in the power output stage this is the area that will be fully considered. In order to help digital feedback systems techniques evolve, another factor will also become important, that of successfully operating at higher switching frequencies. This reduces phase shifts and will help extend feedback loop gains to the higher audio frequencies. The proposed paper thus seeks to define all the necessary steps to achieve good output stage linearity not only at 384 KHz, but also at 768 KHz and even higher, combined with high efficiency. This will then lay the groundwork for optimal performance both for open loop and feedback systems alike. Components and semiconductors need to be chosen very carefully, particularly when operating at the higher frequencies, and some parameters, which are of crucial importance are not usually quoted or even mentioned in most manufacturers data sheets. As an example, the intrinsic internal gate resistance Rg of Mosfets is rarely mentioned or quoted, yet this is very important to fully optimize circuit switching characteristics. So the criteria needed to ensure optimum selection of semiconductors for a particular application and supply rail will also feature prominently in the paper.

4-2 Harmonic Distortion Reduction with Output Capacitance in PWM Inverters—*Gael Pillonnet*,[1,2] *Nacer Abouchi*,[1] *Philippe Marguery*[2]
[1]CPE Lyon, Lyon, France
[2]ST Microelectronics, Grenoble, France

An audio class D converter has nonlinear distortion provided by power stage. In fact, the PWM inverter is influ-

enced by the switching dead time introduced by the power output control system. If output capacitance is added, the audio quality is improved. In this paper the interaction between the dead time effect and the output stage capacitance is investigated. At first, each effect is investigated separately. Then, the sum of the effects is analyzed to predict the improvement of audio quality. Finally, the calculated results are compared with low level simulation in order to confirm the validity of the analysis.

4-3 Time Domain Analysis of Open Loop Distortion in Class D Amplifier Output Stages—*Flemming Nyboe*,[1,2] *Lars Risbo*[1], Pietro Andreant[2]
[1]Texas Instruments, Lyngby, Denmark
[2]Technical University of Denmark, Lyngby, Denmark

During the long history of class AB amplifiers, many topology improvements have been developed with the aim of reducing open-loop THD. As class D amplifiers become widely used, a new learning of such improvements is needed, since the basic distortion mechanisms are very different from those of class AB amplifiers. This is even more important with class D designs because the very high feedback loop gains seen in class AB designs is not always achievable in class D designs. In some cases no feedback is used at all, because it cannot easily be applied to digital input systems at low cost. This paper analyzes the nature of different contributors to THD in class D output stages. It is shown how large-signal transfer characteristic analysis can be applied to individual parts of a PWM output signal, to help identify problems and optimize a design for minimum THD.

Saturday, September 3 15.00–16.30

PAPER SESSION 5: IC AND INTEGRATION

5-1 An Integrated 40-W Analog Input Class D Amplifier with Improved Clipping Recovery and Reduced Turn-on Transients—*Ronnie Bean, Ryan Lind*, Texas Instruments, Ridgeland, MS, USA

A 20-W per channel, analog input, class D amplifier is presented. This paper includes an overview of the design, stability equations and describes several innovations used to improve the performance of the device. Among these innovations is a novel Operational Transconductance Amplifier (OTA) input structure that greatly reduces pops and clicks at startup and a special clipping recovery circuit that reduces clipping distortion. The design tradeoffs and the silicon results are also presented.

5-2 Commercializing Class D Amplifier Technologies —*Paul Mathews, Philip R. Jeffs*, Rane Corporation, Mukilteo, WA, USA

The popularity of commercial audio systems having large numbers of channels has resulted in a growing demand for smaller, lighter, and less expensive multichannel power amplifier products. This paper describes how careful integration of power factor corrected switchmode power supplies, class D power amplifiers, and digital signal processors yields high power density and especially reliable and electromagnetically quiet products at a reasonable cost.

5-3 A High Performance 8x150-W Digital Audio System—*Kim Nordtorp Madsen, Thomas Morch, Lars Risbo*, Texas Instruments Denmark A/S, Copenhagen, Denmark

An eight-channel digital audio amplifier solution using pulse width modulation (PWM) and power stage providing superior dynamic range performance and a high level of system integration is presented. The typical dynamic range in a well-designed system is better than 110 dB and 115 dB is possible in a parallel coupling setup. Including the Power Supply Volume Control (PSVC) feature additional 24 dB dynamic range is possible at normal listening levels in a typical application.

Sunday, September 4 09.00–10:30

PAPER SESSION 6: MEASUREMENTS AND TESTS

6-1 Measuring Distortion in Switching Amplifiers—*Bruce Hofer*, Audio Precision, Inc., Beaverton, OR, USA

The distortion performance of switching amplifiers (a.k.a. “Class-D” amplifiers) has rapidly improved in recent years. Unfortunately they still exhibit a form of high-frequency nonlinearity that is not clearly revealed by traditional THD+N and SMPTE-IMD tests. The Twin-Tone IMD measurement technique provides an excellent way to measure this form of distortion.

6-2 Comparison Between Different IDDQ Measurement Techniques on Class D Audio Amplifiers—*Victor-Hugo Lopez de Nava*, Texas Instruments, Dallas, TX, USA

During the IDDQ test on class D audio amplifiers, it is very common to have a higher current measurement on the Automated Test Equipment (ATE) than on bench. This is an issue that is always present on the ATE-to-bench correlation process. In order to overcome this issue, test engineers have come up with several techniques or compensation methods to help reduce the measurement differences between ATE and bench. Some of these methods are discussed in the next sections.

6-3 Click and Pop Measuring Technique—*Tomas Bruunshuus Sørensen*, Texas Instruments Denmark A/S, Copenhagen, Denmark

During various occasions a digital amplifier can generate a click or a pop. The click is generated at changes of the operational modes of the amplifier, e.g., charging of capacitors or mute / unmute. For class D amplifier systems click is typically at PWM start and stop. The audibility of a click is very dependent on the system, amplifier, and speaker. Also, perception of the click is subjective. This makes it difficult to compare the results from two different systems. This paper specifies a measurement technique, which can be used for all systems and makes results comparable, and give limits to what is acceptable in an end application. The described measurement technique applies to all systems, which have a start up sequence of less than 1 ms. For Purepath systems this applies to TAS5026, TAS5036, TAS5066, TAS5076, TAS5028, TAS5508, and TAS5518. Measurements on 2 EVM’s TAS5066-5121K6EVM and TAS5508-5121K6EVM are shown for reference.

Sunday, September 4 10.30–12.30

WORKSHOP

Measurement and Instrumentation Workshop

Abstract Not Available at Press Time

Sunday, September 4 14.00–16.00

TUTORIAL AND WORKSHOP

EMI/EMC Tutorial and Workshop

Abstract Not Available at Press Time

Audio Engineering Society

MEMBERSHIP APPLICATION FORM

All applicants complete this page in English: Please print in CAPITALS.

1 Personal Information

Family Name

First Name(s)

Email

I desire

☐ ADMISSION AS
☐ ADVANCEMENT IN GRADE TO
☐ REINSTATEMENT AS

☐ MEMBER
☐ ASSOCIATE
☐ STUDENT

Address 1

Address 2

City | State/county/province

Zip/post code | Country

Phone | Fax

Date of birth (year/month/day) | Birthplace

Nationality

2 Professional Information

Company/Institute or college

Address 1

Address 2

City | State/county/province

Zip/post code | Country

Phone | Fax

Student Members

Year of graduation

Faculty advisor

Email or phone number

3 Payment

Amount: $_____

☐ Online Journal only — Member/Associate $65 — Student $22
☐ Online and printed — Member/Associate $105 — Student $62

☐ Check/Money Order ☐ American Express ☐ Visa ☐ MasterCard/Eurocard

Credit Card # | Expiration Date

Cardholder Name

Signature (all applicants) | Date

Please send my AES mail to address ☐ Home or ☐ Office

Nature of Business:

☐ Commercial Recording Studio
☐ Project Recording Studio
☐ Live Sound
☐ Broadcast Station/Studio
☐ Sound Reinforcement
☐ Mastering
☐ Internet Audio
☐ Duplication/Replication
☐ Manufacturer: Audio Equipment
☐ Manufacturer: Video Equipment
☐ Record Label
☐ Education/Government
☐ Consultant Audio Engineer
☐ Postproduction Facility
☐ Dealer/Distributor/Rep. Firm
☐ Film/Video Production House
☐ Sound Contractor/Installation
☐ Res. & Dev. Organization
☐ A/V Computer Soft/Hardware
☐ Venue/Auditorium
☐ Studying at University/College
☐ Other _____

Job Description:

☐ Owner/Director
☐ Studio/Corporate Manager
☐ Independent Engineer
☐ Engineer
☐ Technician
☐ Production Management
☐ Financial Management/Buyer
☐ Sales/Marketing
☐ Designer
☐ Producer
☐ Musician
☐ Editor
☐ Mixing Engineer
☐ Educator/Student
☐ A/V Computer Designer
☐ Sound Designer
☐ Student
☐ Other _____

Interest in AES Activities:

☐ Journal ☐ Conferences
☐ Publications ☐ Standards
☐ Conventions ☐ Technical Committees

Please return form to:

Audio Engineering Society, Inc.
60 East 42nd Street, Room 2520
New York, NY 10165-2520, USA
FAX: +1 212 682 0477

Join online at http://www.aes.org

ADDITIONAL INFORMATION REQUIRED FOR FULL MEMBERSHIP
B. Curriculum Vitae

4 Education: (use a separate sheet, if necessary)

Institution: _____ Place: _____

Major or Subject: _____ Attended from: _____ to: _____

Degree awarded: _____ Number of years credit if no degree: _____

Institution: _____ Place: _____

Major or Subject: _____ Attended from: _____ to: _____

Degree awarded: _____ Number of years credit if no degree: _____

Seminars, short courses related to audio: (Give approx. hours of study involved)

_____

_____

_____

5 Other Accomplishments: (list any papers, patents, etc., with appropriate dates)

_____

_____

Member of other societies: _____

Linguistic Abilities: _____

6 Past Experience: (use a separate sheet, if necessary)

From: _____ to: _____
Date Date Company name & location Position

Duties performed _____

From: _____ to: _____
Date Date Company name & location Position

Duties performed _____

From: _____ to: _____
Date Date Company name & location Position

Duties performed _____

7 References: (3 references, in total, required for full membership)

1. _____
Name Company name Position

_____
Email address or Phone number AES Member Number, if applicable

2. _____
Name Company name Position

_____
Email address or Phone number AES Member Number, if applicable

3. _____
Name Company name Position

_____
Email address or Phone number AES Member Number, if applicable

8 If completing this form after applying for membership online, please quote:

_____
Name AES member no. on online receipt

AES 27TH INTERNATIONAL CONFERENCE

Efficient Audio Power Amplification

September 2–4, 2005

	FRIDAY, SEPTEMBER 2	SATURDAY, SEPTEMBER 3	SUNDAY, SEPTEMBER 4
08:00			
08:30			
09:00			
09:30		Session 3 **Modulation and Control**	Session 6 **Measurements and Tests**
10:00			
10:30			
11:00	Registration		
11:30			Measurement and Instrumentation Workshop
12:00		Session 4 **Errors and Distortion**	
12:30			
13:00	Lunch	Lunch	Lunch
13:30			
14:00	**Opening Ceremony and Keynote Address**	Session 5 **IC and Integration**	EMI/EMC Tutorial and Workshop
14:30			
15:00			
15:30	Session 1 **Invited Paper**		
16:00			
16:30			
17:00			
17:30	Session 2 **Power Stage Topologies**	**Social Event—Excursion**	
18:00			
18:30			
19:00			
19:30			
20:00	Table-Top Demonstrations	**Banquet**	
20:30			
21:00			
22:00			
23:00			

This schedule reflects accurate information as of press time.

Photograph of Frederiksborg Castle courtesy Danish Tourist Board; Photographer: Klaus Bentzen

REGISTRATION FORM
AES 27th International Conference
Efficient Audio Power Amplification

Pharmakon a/s, Hillerød, Denmark

September 2–4, 2005

Mail or fax this form with payment information to

AES 27th International Conference
Treasurer, S. K. Pramanik
Sarpsborgvej 56, 7600 Struer. Denmark
Fax +45 97853105

or register on line at
www.aes.org/events/27/registration

1 Please print/type all information as you wish it to appear on your badge.

Family Name_____First Name_____

Company/organization_____Job Title _____

Street Address _____

City_____State_____Post Code_____Country _____

Tel:_____Fax:_____Email:_____

AES Membership No. _____ Name of Accompanying person_____

2 **Conference Registration.** Please check appropriate box (all figures in Danish Kroner DKK)
Registration fee includes meals and banquet.

☐**AES MEMBERS**	☐6500 (before July 2)	☐7000 (after July 2)
☐**NONMEMBERS**	☐7200 (before July 2)	☐7900 (after July 2)
☐**AUTHORS**	☐4200	
☐**AES STUDENT MEMBERS**	☐4200	
ACCOMPANYING PERSON	☐220 Sept. 2–4 including breakfast only Lunches, dinners, and banquet will be handled on site.	

Arrival date _____ Departure date _____

Extra Nights: ☐ 685 single room, per night including breakfast
☐ 905 double room, per night including breakfast

3 **Payment Modes** (check box) Total Amount DKK_____

☐ Giro / Bank Transfer to BG Bank, account No. 1199 7412282. Account holder - AES Denmark

on Date : _____

Please charge my credit card in US$:

☐ Amex ☐ Mastercard/Eurocard ☐ Visa

Card Number

Expiration Date

		/	
Month			Year

Name on card (print)_____Date:_____

Signature of Cardholder_____