Middlebrook's New Structured Analog Design Course, June 2006

3 Days

WHO SHOULD TAKE THIS COURSE

This course is aimed primarily towards **analog, mixed-signal, and power supply design engineers**, although they are not the only ones to benefit from Dr. Middlebrook's course. A strong point has always been made that those who review and verify designs of others also need to know how design-oriented results of analysis should be presented. Only with this knowledge can they contribute meaningfully to design review discussions, instead of just saying to the presenting designer "Well, it looks as though it's coming along all right; carry on!"

Therefore, **system integration engineers, reliability and test engineers, and their managers** who evaluate vendors' products, a function similar to that of design review committee members, also can significantly increase their effectiveness by taking Dr. Middlebrook's course. In fact, they can improve the effectiveness of the whole project by requiring that design engineers present their results according to Dr. Middlebrook's Principles of Design-Oriented Analysis.

This Technical Therapy course affords your company a unique opportunity to reinvigorate your analog engineers, and empower them to increase their productivity by selecting, from many strategies, methods to achieve more useful results with less work.

For further information, contact Val at (909) 592-0317, val@ardem.com.

WHY THE ORIGINAL COURSE WAS DEVELOPED

Analog circuit design has long been thought to be more difficult than digital design, and students have found the analytical methods they were taught not well-suited to real-world design.

When Dr. Middlebrook was consulting with companies in the 1960's and '70's he found that when graduate engineers came out of universities, they were intelligent and well-educated but had no knowledge of design. As he puts it, "When entry level engineers are handed a design problem by their new manager, they feel as though they have 'fallen off a cliff' because they have no idea where to start."

Dr. Middlebrook developed design-oriented analysis techniques to teach his students at Caltech how to do their designs with practically no math.

Likewise, many companies have found that new-hire analog engineers are not prepared to do design work, so Dr. Middlebrook then developed his Design-Oriented Analysis approach in a "Technical Therapy" format to help bridge the gap between academic analysis and real-world design. His original 3-day course (Part 1) has enabled design engineers to significantly improve their productivity, and has been received with great acclaim throughout the USA, Canada and Europe.

The overwhelming response has been: **"Why wasn't I taught this in school?"**

Dr. Middlebrook discontinued his original course after 1999 in order to prepare a permanent record of his Design-Oriented Analysis approach, which is now available as *Technical Therapy for Analog Circuit Designers* on a 20-hour DVD ROM (TT DVD ROM).

While he was preparing the TT DVD ROM, Dr. Middlebrook produced some new work, *The GFT: A Final Solution for Feedback Analysis* which is now available on a 3-hour CD ROM (GFT CD ROM). The General Feedback Theorem (GFT) is the culmination of the previous work on the TT DVD ROM, and includes all the nonidealities of a feedback system without approximations. The GFT is implemented in the Intusoft ICAP/4 Circuit Simulator software http://www.intusoft.com/gft.htm.

WHY THE COURSE IS BEING RESUMED

With more and more analog design moving offshore, there is an increasing need for system integration and test engineers. These engineers need to be just as cognizant of Dr. Middlebrook's Design-Oriented Analysis techniques as if they were doing the design themselves.

Because he feels strongly that this much broader range of engineers needs to know how powerful and useful these techniques are, Dr. Middlebrook is resuming teaching his course under the title Middlebrook's New Structured Analog Design Course.

The new course differs from the original in two significant ways:

First, the motivation for the development of the techniques is as much from the perspective of an engineer who is going to evaluate or review someone else's design, as it is from the perspective of an engineer who is going to create the design himself.

Second, the GFT is fully integrated into the development and many examples of the ICAP/4 Circuit Simulator results are shown.

NEW DEVELOPMENTS

The course is “technical therapy” in that it replaces the conventional analog teaching approach with methods of Design-Oriented Analysis (D-OA) that can greatly improve the productivity of your analog, mixed-signal, and system integration engineers. The “New” version was presented six times in 2005 and eight times in 2006, at companies such as Raytheon and National Semiconductor.

In January 2006, a group of three professors at different universities submitted a Proposal to the National Science Foundation for support of a program to adopt the D-OA paradigm at the outset of a first-level university course. The Proposal includes Letters of Support from several engineers in industry who are familiar with D-OA, including two from Raytheon and National Semiconductor.

Here are some excerpts:

“I have hired graduate students with and without D-OA training, and have observed the difference the D-OA paradigm makes in how they adjust to the complexity of real-world engineering designs. The D-OA trained engineer immediately sees opportunity in the uncertainties and moves forward with a well thought out approach that meets all the stated requirements and anticipates the unstated requirements. The D-OA engineer understands that real designs are an almost continuous set of trade-offs and compromises that take into account all the stakeholders in a product and produce a design that is acceptable to all, including the accountants. In addition, the D-OA trained engineer has a much better intuitive grasp of the design trade-offs that have taken place and so is in a much better position to argue the merits of a design to co-workers, senior management and customers.”

“D-OA techniques are widely used by me and all the other engineers here to do circuit analysis and design. We have hired more than ten D-OA trained graduates who were able to get up the learning curve very quickly because of the skills they learned and the techniques they had been exposed to. Such skills include analytical techniques whose results explicitly indicate the effects of component changes and understanding how to move forward in a complicated problem by making reasonable, simple assumptions. They also have a better understanding of the trade-offs and compromises required to get to a robust, manufacturable design from a marketing specification.”

For 2007, Raytheon is planning a third presentation, and National Semiconductor has scheduled fifth, six, and seventh presentations of “Middlebrook’s New Structured Analog Design Course.”

It will be a long time before the majority of graduates will be D-OA trained. In the meantime, your analog engineers will benefit greatly from the “technical therapy” course.

COURSE DESCRIPTION

This course shows you how the value of the methods you learned in college can be multiplied manyfold by translating them into Design-Oriented Analysis techniques that *really work* to speed up your everyday design or evaluation projects by teaching you how to do your analysis while using little math.

Since Design is the Reverse of Analysis, it is essential that every analysis result be expressed in a low entropy form, in which its terms are grouped so that insight is preserved into the relative contributions of the circuit elements. Such a paradigm is **Design-Oriented Analysis or D-OA** (don't forget the hyphen!).

Design-Oriented Analysis in terms of Low Entropy Expressions enables you to solve "real life" analysis problems by keeping the algebra under control. Instead of simultaneous solutions of multiple loop or node equations, which automatically leads to the familiar (and useless) "High-Entropy" result, you get a useful **"Low-Entropy"** result in sequential, simple, circuit reduction steps: **"Divide and Conquer."**

Experienced engineers have tried it the "hard way," and they know that doesn't work!

Design-Oriented Analysis is the only kind of analysis worth doing!

D-OA is not merely a slogan: specific strategies and tools empower you to be the master of the analysis, not its slave.

TOOLS COVERED INCLUDE:

Low Entropy Expressions
The Key to Design-Oriented Analysis

Normal and Inverted Poles and Zeros
How to choose the gain at any frequency as the Reference Gain

An Improved Formula for Quadratic Roots
The conventional formula suffers from two congenital defects

Approximations and Assumptions
How to build Low Entropy Expressions with minimum work

Products and Sums of Factored Pole-Zero Expressions
Doing the algebra on the graph

The Input/Output Impedance Theorem
How to find them directly from the gain, thereby saving almost two-thirds of the conventional work

Null Double Injection (NDI) and the Extra Element Theorem (EET)
How to find the contribution of a particular element to a transfer function

The Dissection Theorem and the Chain Theorem
How to find the gain of a multistage amplifier as the product of separately calculated low entropy factors

Basic Feedback:
An Improved Formula expresses the closed-loop gain in terms of only two quantities, the specification G_∞ *and the loop gain T*

The Two Extra Element Theorem (2EET)
A short and easy way to find the poles and zeros of a circuit containing two reactances

The General Feedback Theorem (GFT):
How to identify and include nonidealities in a third quantity, the null loop gain T_n

Examples:
A two-stage feedback amplifier
A realistic IC amplifier
A design solution to Darlington Follower instability
The Input Filter Problem of a switching power supply
A current-programmed switched-mode regulator

A Circuit Simulator incorporating the GFT is also used to implement the Dissection Theorem and the Extra Element Theorem.

Dr. Middlebrook's original course was given many times in North America and Europe, the most recent being more than six years ago, and has now been updated to include Dr. Middlebrook's latest work on the General Feedback Theorem (GFT).

In 2005 and 2006, the New Structured Analog Design Course has been conducted in-house at Raytheon Santa Barbara and El Segundo CA, Xerox Rochester NY, National Semiconductor Santa Clara CA and Greenock Scotland, Intel Dupont WA, Northrop Grumman Redondo Beach CA, Lockheed Martin Moorestown NJ, Ball Aerospace Boulder CO, and publicly in Denver CO (sponsored by the IEEE), Kellogg West Pomona CA, and Plymouth England.

Each attendee will receive a copy of the 20-hour DVD ROM "Technical Therapy for Analog Circuit Designers," which is described in detail on the Ardem Associates website http://www.ardem.com.

Each attendee will also receive a second disk containing the PowerPoint files for the new 3-day course.

UPON COMPLETION OF THIS COURSE YOU WILL BE ABLE TO:

Save **Design Time, Improve Design Quality**, and get more useful answers with less work.

You achieve these goals by avoiding algebraic paralysis through a Divide and Conquer approach: you select appropriate strategies to achieve analysis results in low entropy forms, in which circuit elements are grouped so as to preserve their physical origin. In this way you can confirm that your design, or someone else's, meets specifications. If it doesn't, you can work the analysis backwards to determine which elements to change in which direction.

You will use a circuit simulator not merely to solve for the overall performance, but as part of the D-OA process to check approximations and assumptions, and to verify internal properties such as loop gain and phase margin.

WHO SHOULD ATTEND?

Analog, Mixed-Signal, and Power Supply analysts and designers at all experience levels.

System Integration Engineers, Test and Reliability Engineers.

Managers and Design Review Committee Members.

PREREQUISITES

A BSEE Degree, or at least a first-level course in analog devices and circuits.

LENGTH: 3 days

INSTRUCTOR

A distinguished international lecturer, Dr. R. David Middlebrook is Professor Emeritus of Electrical Engineering at the California Institute of Technology, and is particularly noted for presenting complex material in a simple, interesting, effective, and often entertaining manner, for which the Caltech student body has recognized him as an Outstanding Teacher.

In 1970 he founded the Power Electronics Group at Caltech, and was its Director until 1994. He is especially interested in design-oriented circuit analysis and measurement techniques, and his Structured Analog Design course in "technical therapy," now available on DVD ROM, has been attended by many hundreds of design engineers and managers in the U.S., Canada, and Europe.

Dr. Middlebrook is a Fellow of the IET, and a Life Fellow of the IEEE. He is a recipient of an I*R Award, the IEEE William E. Newell Power Electronics Award, the IEEE Centennial and Millennium Medals, and the Edward Longstreth Medal of the Franklin Institute. In 1997, he received the Richard P. Feynman Prize for Excellence in Teaching, Caltech's highest teaching award.