Proposal for New Certificate
in

Digital Signal Processing Applications

in
the Graduate Engineering Program
at
Santa Clara University

submitted by the Electrical Engineering Department
29 February 2012

From: Godfrey Mungal
To: Sally Wood
CC: Aleksandar Zecevic
Date: 2/29/2012 1:52 PM
Subject: Re: certificate approval

Sally,

I have verified with Alex, and we are happy with the proposal.

Godfrey

>>> On 2/29/2012 at 11:44 AM, in message < 4F4E0F94.B046.00C6.1@scu.edu >, Sally Wood < SWood@scu.edu > wrote:
Godfrey,

Did you have a chance to talk to Alex about the certificate? I'd like to send it on its way to the next level after I include any changes you and he request.

Thanks,

Sally

To: Godfrey Mungal, Dean of Engineering
From: Sally Wood, Chair, Electrical Engineering
Re: Proposal for new EE certificate in Digital Signal Processing Applications
Date: 17 February 2012

The attached proposal for the new certificate was written following the guidelines in the "Approval of Academic Program Changes, Santa Clara University, Academic Affairs Committee" document. This certificate was originally approved by the EE faculty several years ago, but it was removed from the catalog revisions when new procedures for certificate approvals were established. The current proposal was reviewed by the EE faculty at a faculty meeting on 15 February 2012. The faculty recommended the addition of one more elective course and then approved the proposal. The next step in the approval process is review and approval by the Dean of Engineering. Please send us your recommendations so that we can make any needed changes and continue the approval process by submitting this proposal to the Academic Affairs Committee.

As noted in the executive summary of the proposal, this certificate provides a benefit for our students at no additional cost to the university. No new courses, instructors, or operational changes are needed for this certificate.

Proposal for New Certificate in Digital Signal Processing Applications

Executive Summary

The proposed certificate in Digital Signal Processing (DSP) Applications complements the other five certificate programs in Electrical Engineering (EE). It provides a credential in DSP applications that would be of value to students working in a wide variety of companies with a focus on areas such as networking, communications, bioengineering, image and video processing, robotics, applications for mobile devices, and persistent monitoring for safety and sustainability. In recent years advances in microelectronics have produced dramatic increases in computational capability and mobile applications. These advances have moved DSP from a theoretical EE area with a relatively narrow application space to a fundamental tool used in a very broad array of applications where the educational experience of the professional workers may not have been focused on DSP.

The proposed certificate is appropriate for entry level graduate students and does not assume prerequisite coursework beyond an undergraduate degree. It is also appropriate for students with graduate education in related fields such as biomedical, computer or mechanical engineering, who find themselves working in an area where understanding of DSP is needed. Like most other certificates, this certificate is a structured program requiring 16 units of graduate work.

The proposed certificate is based on graduate courses that are already offered on a regular basis, and it would require no additional resources. It would require no operational changes in course delivery or admissions. No new classes or instructors would be needed and no schedule changes would be necessary. Since the certificate courses are part of the current M.S.E.E. curriculum, evaluations and assessments for courses in the M.S.E.E. program would already include certificate courses.

The certificate will support the professional growth of students completing the certificate and would also provide an opportunity for students to explore further graduate study. The proposed certificate may lead to a modest increase in graduate student enrollment. This increase would lead to increased enrollment in existing classes rather than requiring additional classes.

Purpose and Centrality

The DSP component of the Electrical Engineering graduate program includes a number of introductory and advanced courses in theory, applications, and implementations. In most areas several courses with a hierarchical prerequisite structure have been offered for many years. The more advanced DSP courses require sophisticated knowledge of related areas of mathematics such as probability, stochastic processes, and Fourier transforms. The proposed certificate requires that students take the basic DSP theory course and three supporting courses in an application area, a modern implementation architecture, and foundational mathematics. The proposed certificate was designed to complement a DSP Theory Certificate that provides a credential for students who already have taken advanced graduate mathematics prerequisite courses.

Certificate programs provide the benefit of a focused professional credential to both students who already have an advanced degree and wish to acquire knowledge in a specific new area and students who do not yet want to commit to a full M.S. program but desire graduate education in a narrowly defined area. However, as discussed in the enrollment section below, many students who start in a certificate program decide to continue in the M.S.E.E. program. The purpose and structure of the certificate program is described in the engineering graduate bulletin. The following summary can be found on page 38 of the bulletin:

> "Certificate programs are designed to provide intensive background in a narrow area at the graduate level. At approximately one-third of the units required for a master's degree, the certificate is designed to be completed in a much shorter period of time. These certificate programs are appropriate for students working in industry who wish to update their skills or for those interested in changing their career path."

A more detailed description of all certificate programs is taken from pages 7 and 8 of the current graduate engineering bulletin.

> "Certificate programs are designed to provide intensive background in a focused area at the graduate level. With 16-20 required units for completion, each certificate is designed to be completed in a much shorter period of time than an advanced degree. Santa Clara's certificate programs are appropriate for students working in industry who wish to update their skills or for those interested in changing their career path.
>
> All Santa Clara University courses applied toward the completion of a certificate program earn graduate credit that may also be applied toward a graduate degree, subject to the requirements of the degree program. Students who wish to continue for such a degree must submit a separate application and satisfy all normal admission requirements. The general Graduate Record Examination (GRE) test

requirement for graduate admission to the master's degree will be waived for students who have been formally admitted to and who have completed a certificate program with a GPA of 3.5 or better.

Certificate programs are offered in software engineering, information assurance, networking, ASIC design and test, analog circuit design, digital signal processing, microwave and antennas, fundamentals of electrical engineering, technology jump-start, materials, mechanical design analysis, mechatronics systems engineering, dynamics, controls, and thermofluids."

Program Requirements

Digital Signal Processing Applications
Advisors: Dr. Tokunbo Ogunfunmi, Dr. Sally Wood

This certificate program provides a basic understanding of digital signal processing theory and modern implementation methods as well as advanced knowledge of at least one specific application area. Digital signal processing has become a significant cost-effective component of many areas of engineering including communication, robotics, bioengineering, mobile applications, and monitoring for safety and sustainability. This certificate prepares students with a variety of academic backgrounds for traditional or novel applications of DSP. The certificate requires 16 units of coursework as specified below.

Required Courses (10 to 12 units)

- ELEN 233E or ELEN 233 and 234 Digital Signal Processing I, II (4 units)
- ELEN 223 Digital Signal Processing System Development (4 units) or ELEN 226 DSP Design in FPGA (2 units)
- ELEN 421 Speech Coding I or ELEN 640 Digital Image Processing I (2 units)
- AMTH 210 probability I or AMTH 245 Linear Algebra I (2 units)

Elective Courses (4 to 6 units to make a total of 16 units) may be selected from the list below. Any courses from the required list above that were not selected to meet the requirements may be included in the elective options.

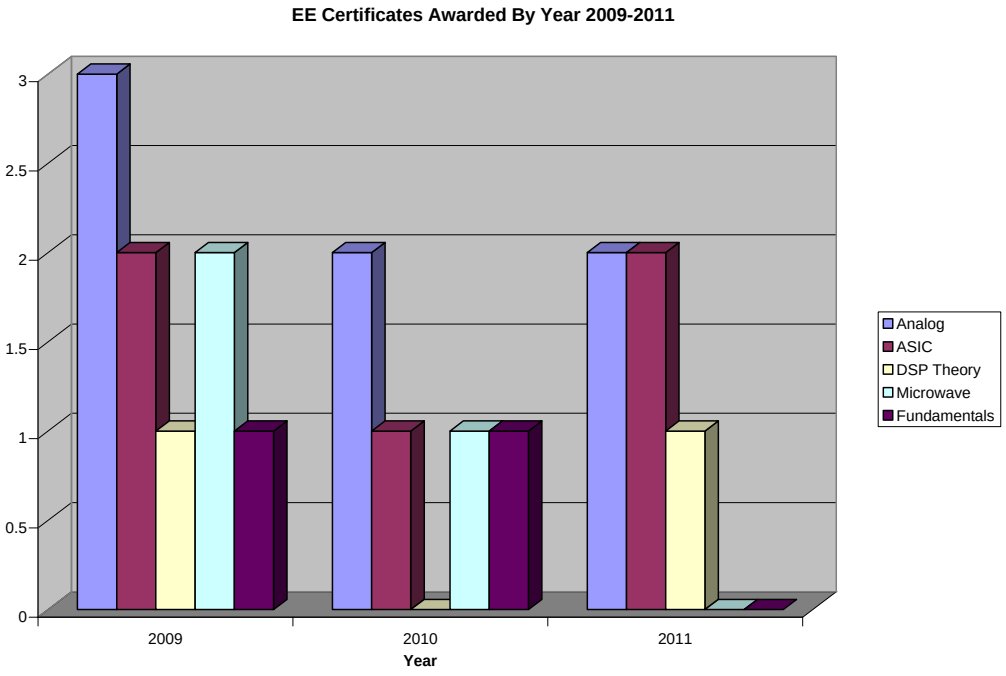
- ELEN 241 Introduction to Communications (2 units)
- ELEN 243 Digital Communications Systems (2 units)
- ELEN 244 Information Theory (2 units)
- ELEN 334 Introduction to Statistical Signal Processing (2 units)
- ELEN 422 Speech Coding II (2 units)
- ELEN 431 Adaptive Signal Processing I (2 units)
- ELEN 643 Digital Image Processing II (2 units)
- AMTH 308 Theory of Wavelets (2 units)
- AMTH 358 Fourier Transforms (2 units)

Evidence of Interest

A number of students have expressed interest in a DSP certificate that would focus on basic DSP and modern application areas. Usually these students are BSEE students or students with some graduate work in a related field such as biomedical, computer, or mechanical engineering. In recent years about 25% of the students enrolled in the 4-unit first level DSP course have been students with computer engineering backgrounds who are working in the communications industry and need to develop an understanding of DSP and DSP applications for professional advancement. It is expected that interest in the certificate will grow since DSP has become a significant cost-effective component of many diverse areas of emerging technology as discussed earlier. Since the certificate requires no new courses or instructors, it does not demand a specific rate of student growth to support it.

Enrollment Projection

Over the past three years 19 certificates have been awarded in Electrical Engineering as detailed by certificate title and year in the chart below. Of those certificate recipients, 15 (approximately 75%) continued into the M.S.E.E. program and 6 of those 15 students have already received the M.S.E.E. degree. Thus, out of the 101 currently active MSEE students, approximately 9% entered our program after receiving a certificate through the certificate program. There is anecdotal evidence that this estimate understates the importance of the certificate programs because many students who enroll in a certificate program decide to change to the M.S.E.E. program before the certificate is completed.



Impact on Other programs

This certificate will have no impact on other programs. It is possible that it will lead to a modest increase in enrollment in the M.S.E.E. program, but this is expected to increase enrollment in existing courses rather than requiring new course offerings.

Resource Requirements and Implications

This certificate requires no new resources and no operational changes. Courses needed for the certificate are already in place and have been offered on a regular basis for many years. No new courses or instructors are needed. Evaluation and assessment procedures used for the M.S.E.E. program as a whole would include the certificate courses.

Promise of Quality

The quality of the courses and instructors is consistent with our M.S.E.E. program. The courses needed for the certificate, which are already in place and have been offered on a regular basis for many years, are part of the M.S.E.E. program. Evaluation and assessment procedures used for the M.S.E.E. program as a whole would include the certificate courses.

Plans for Program Review

The certificate program has potential benefit to individual students and to the M.S.E.E. program, and the certificate can be offered at no additional cost to the university. The certificate program will be reviewed regularly by the faculty of the Electrical Engineering Department for participation levels and the possible inclusion of appropriate new courses as courses are added to the M.S.E.E. curriculum.

Assessment Plan:

The evaluation and assessment plan for all graduate courses will include courses in the certificate program. No evaluation or assessment procedures unique to the certificate program are needed.

Timetable:

The new certificate can start immediately. All courses required for the certificate are already established and most are offered on an annual basis. A few are offered every second year.

List of Faculty:

No new instructors are needed. The certificate will be managed by the Systems Group within the Electrical Engineering Department: Tokunbo Ogunfunmi, Sally Wood, and Aleksandar Zecevic. Professors Ogunfunmi and Wood will be the advisors for the DSP Applications certificate. They teach the courses in basic DSP, speech, and image processing. The modern implementation courses and mathematics courses, which have been offered for many years, are taught by quarterly appointed faculty who are selected by the same procedures used to select all quarterly appointed faculty for the M.S.E.E. program. Most of these instructors have been teaching in the Electrical Engineering graduate program for many years. For example, Dr. Christopher Dick from Xilinx, Inc., who had previous university teaching experience in Australia, has been teaching the FPGA DSP course since 2002.

Draft text for Bulletin

The text included in “Program Description” is written in the format for the bulletin.

Appendix A

Descriptions of required courses from the current engineering graduate bulletin

Required Courses (10 to 12 units)

- ELEN 233E or ELEN 233 and 234 Digital Signal Processing I, II (4 units)

ELEN 233E. Digital Signal Processing I and II
Same description as ELEN 233 and ELEN 234. Credit not allowed for both 133 and 233E. (4 units)

ELEN 233. Digital Signal Processing I
Description of discrete signals and systems. Z-transform. Convolution and transfer functions. System response and stability. Fourier transform. Sampling theorem. Digital filtering. State-space representations. Also listed as COEN 201. *Prerequisite: ELEN 210 or its undergraduate equivalent of ELEN 110.* (2 units)

ELEN 234. Digital Signal Processing II
Continuation of ELEN 233. Discrete Fourier transform. Digital filter design techniques. Fast Fourier transform. Quantization effects. Estimation. Also listed as COEN 202. *Prerequisite: ELEN 233.* (2 units)

- ELEN 223 Digital Signal Processing System Development (4 units) or ELEN 226 DSP Design in FPGA (2 units)

ELEN 223. Digital Signal Processing System Development
Hands-on experience with hardware and software development for real-time DSP applications. Students design, program, and build a DSP application from start to finish. Such applications include image processing, speech/audio/video compression, multimedia, etc. The development environment includes Texas Instruments TMS320C6X development systems. *Prerequisites: DSP I and II (ELEN 233, 234, or 233E). Knowledge of "C" programming language.* (4 units)

ELEN 226. DSP Design in FPGA
Introduction to current state-of-the-art design and implementation of FPGA signal processing systems with emphasis on digital communications applications. Overview of current generation FPGAs; FPGA architecture and data path design for digital filters, multirate filters, canonic signed digit arithmetic, and spectrum channelization using digital down converters (DOCs). Implementation of FPGA DSP design using VHDL and visual dataflow methodologies. *Prerequisites: ELEN 133 or 234, and ELEN 127 or the equivalent.* (2 units)

- ELEN 421 Speech Coding I or ELEN 640 Digital Image Processing I (2 units)

ELEN 421. Speech Coding I
Review of sampling and quantization. Introduction to Digital Speech Processing. Elementary principals and applications of speech analysis, synthesis, and coding. Speech signal analysis and modeling. The LPC Model. LPC Parameter quantization using Line Spectrum Pairs (LSPs). Digital coding techniques: Quantization, Waveform coding. Predictive coding, Transform coding, Hybrid coding, and Sub-band coding. Applications of speech coding in various systems. Standards for speech and audio coding. Also listed as COEN 348. *Prerequisite: ELEN 334 or equivalent.* (2 units)

ELEN 640. Digital Image Processing I
Digital image representation and acquisition; Fourier, cosine, and wavelet transforms; linear and nonlinear filtering; image enhancement; morphological filtering. Also listed as COEN 340. *Prerequisite: ELEN 234.* (2 units)

- AMTH 210 or AMTH 245 (2 units)

AMTH 210. Probability I
Definitions, sets, conditional and total probability, binomial distribution approximations, random variables, important probability distributions, functions of random variables, moments, characteristic functions, joint probability distributions, marginal distributions, sums of random variables, convolutions, correlation, sequences of random variables, limit theorems. The emphasis is on discrete random variables. (2 units)

AMTH 245. Linear Algebra I
Vector spaces, transformations, matrices, characteristic value problems, canonical forms, and quadratic forms. (2 units)

Elective Courses (4 to 6 units to make a total of 16 units) may be selected from the list below. Any courses from required list above that was not selected to meet the requirements may be included in the elective options.

- ELEN 241 Introduction to Communications (2 units)
- ELEN 243 Digital Communications Systems (2 units)
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