Washington State University
School of EECS
Electrical Engineering Course Assessment Report

Course Number  EE 464
Course Title  Digital Signal Processing
Semester Offered  Fall 2006
Instructor  T. R. Fischer
10th Day Enrollment  15  Number Completing Successfully (C grade or better)  13

I. Assessment Outcomes from the Course Syllabus

☒ (A) ABET Outcome: Ability to apply knowledge of mathematics, science and engineering. **Application to EE 464:** Understand the basic properties of discrete-time signals and systems. Ability to analyze discrete-time linear time-invariant systems in the time-domain. Ability to use effectively mathematical transforms for the analysis of systems. Understand the effect of sampling in the frequency-domain. Ability to solve linear difference equations in time- and transform-domains. Learn efficient implementations of discrete Fourier transform.

☐ (B) ABET Outcome: Ability to design and conduct experiments as well as analyze and interpret data.

☒ (C) ABET Outcome: Ability to design a system, component, or process to meet desired needs. **Application to EE 464:** Ability to realize discrete-time systems using basic components. Ability to use software tools for the design of discrete-time frequency selective filters.

☐ (D) ABET Outcome: Ability to function on multidisciplinary teams.

☒ (E) ABET Outcome: Ability to identify, formulate, and solve engineering problems. **Application to EE 464:** Ability to use software tools for the

☒ (G) ABET Outcome: Ability to communicate effectively in written and oral formats.

☐ (H) ABET Outcome: A broad education necessary to understand the impact of engineering solutions in global, economic, and societal context.

☐ (I) ABET Outcome: Recognize the need for, and have the ability to engage in lifelong learning.

☐ (J) ABET Outcome: Have a broad education and knowledge of contemporary issues.

☒ (K) ABET Outcome: Ability to use techniques, skills and modern engineering tools necessary for engineering practices.
design of discrete-time frequency selective filters.

☐ (F) ABET Outcome: An understanding of professional and ethical responsibility.

II. List of Course Topics from the Course Syllabus

1. Discrete-time systems. (4)
   b. Linear constant-coefficient difference equations.
   c. Fourier representation of sequences.
   d. Sampling.
2. Z-Transform. (6)
   a. Z-transform.
   b. Inverse Z-transform.
   c. Properties of Z-transform.
   d. Application to solving difference equations.
3. Network realizations. (2)
   a. Basic forms (DF-I, DF-II, cascade, parallel).
   b. Transposed forms.
   c. IIR network structures.
   d. FIR network structures.
   e. Quantization effects.
4. Discrete Fourier transform. (4)
   a. Discrete Fourier series and properties.
   b. Discrete Fourier transform and properties.
   c. Circular convolution.
5. Fast Fourier transform. (2)
   a. Decimation in time algorithm.
   b. Decimation in frequency algorithm.
   c. Computational aspects.
6. Review of analog filter properties. (1)
7. Design of IIR filters. (4)
   a. Solution to difference equation.
   b. Impulse invariance.
   c. Bilinear transformation.
8. Design of FIR filters. (4)
   a. Windows.
   b. Frequency sampling.
   c. Equiripple approximation.

III. Course Assessment Summary Table: one row of the table should be devoted to each of the checked outcomes in part I.

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Topics</th>
<th>Specific Measures (Samples should be available in the course materials file for inspection.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) ABET Outcome: Ability to apply knowledge of mathematics, science and engineering.</td>
<td>1-8</td>
<td>Homework exercises and computer exercises</td>
</tr>
</tbody>
</table>
### IV. Using the table as a guide, for each outcome summarize your evaluation of the students’ achievement of that outcome; cite student performance on the identified measures as evidence to support your conclusions.

(A) Ability to apply knowledge of mathematics, science and engineering.

The students completed numerous homework exercises, three computer exercises, and a project that requires application of knowledge of mathematics, science and engineering. Examples include: a) Finding the Fourier transform of an analog waveform, finding the discrete-time Fourier transform of the samples of an analog waveform, and relating the two; b) Relating the continuous-time and discrete-time Fourier transforms to the discrete Fourier transform (DFT) computed using Matlab; c) Calculating the Z-transform and inverse Z-transform, and using these to analyze linear, discrete-time systems.

(C) Ability to design a system, component, or process to meet desired needs.

The students completed several design problems, including design of frequency-selective digital filters to satisfy design specifications. The window design method and the Parks-McClellan linear-phase finite impulse response filter design methods were used and the designs compared.
The project required the students to design a graphic equalizer using an M-band linear-phase filter bank, implement the equalizer in Matlab, and demonstrate that the design would properly process an audio signal.

(E) Ability to identify, formulate, and solve engineering problems.

The students were required to design linear phase FIR filters to satisfy frequency response specifications. The students were required to design and implement (in Matlab) a graphic equalizer. The number of sub-bands and selection of filtering method(s) was left to be selected by each student. Each student was required to submit working Matlab code that implemented his or her respective design, with the Matlab code required to satisfy certain format requirements for use. Each student successfully completing the course produced a satisfactory design and implementation.

(K) Ability to use techniques, skills and modern engineering tools necessary for engineering practices.

The students demonstrated proper use of several techniques, skills, and modern engineering tools including a) use of the fast Fourier transform (FFT) as a tool for performing fast convolution, and as a tool for computing the discrete Fourier transform; b) use of band-pass sampling to efficiently sample a band-pass signal; c) the ability to use Matlab to design and test frequency-selective digital filters; and d) the ability to design frequency-selective digital filters, the ability to apply these filters as a filter bank in a graphic equalizer, and the ability to implement the graphic equalizer in Matlab to successfully process an audio signal.
V. Qualitative Assessment of Student Performance: using the arguments above and other data support the claim that students who completed this course with a grade of C or better have achieved each of the intended outcomes of this course.

Each student who completed the course with a grade of C or better demonstrated the ability to satisfy each of the ABET outcomes A, C, E, and K listed above. The students demonstrated achievement of these outcomes through a combination of a) successfully completing relevant assigned homework assignments; b) successfully completing relevant assigned computer exercises; c) successfully answering problems on exams; and d) successfully completing the course design project that required design of frequency-selective digital filters and design and implementation of a graphic equalizer.

VI. Concerns: state any concerns you may hold about this class – were the students adequately prepared coming into it? Are there topics or outcomes where (some) students were weak after completing the course? Other concerns? Were there any comments on students’ course evaluations that should be addressed in future instances of the course? This section is very important for improving our program: it provides critical input to the curriculum committee for identifying areas requiring attention.

I felt that the students who successfully completed the course demonstrated a sound understanding of the material. Their background was adequate and their work ethic was sufficient to complete the required assignments. Some of the students struggled initially with Matlab programming, and one dropped the course, in part because of poor programming skills. The recent curriculum change that requires each student to complete a programming course using Matlab (early in the schedule of studies) should help reduce background programming deficiencies. In general, I was very pleased with the students’ performance in the course.

Signature __________________________________________ Date: _______________________

Please email a copy of the completed form to Patricia Arnold, patricia@eecs.wsu.edu and deliver a signed hardcopy to her mailbox.