东北大学秦皇岛分校本科课程教学大纲

一、课程基本信息

<table>
<tr><td>开课单位</td><td colspan="3">计算机与通信工程学院</td><td>课程代码</td><td colspan="5">3100112008</td></tr>
<tr><td>中文名称</td><td colspan="8">信号与系统分析</td></tr>
<tr><td>英文名称</td><td colspan="8">Analysis of Signals and Systems</td></tr>
<tr><td>总学时</td><td>56</td><td rowspan="2">理论学时</td><td rowspan="2">56</td><td rowspan="2">实验学时</td><td rowspan="2">0</td><td rowspan="2">上机学时</td><td rowspan="2">0</td><td rowspan="2">设计学时</td><td rowspan="2">0</td><td rowspan="2">课外学时</td><td rowspan="2">0</td></tr>
<tr><td>学　分</td><td>3.5</td></tr>
<tr><td>课程类型</td><td colspan="11">☑理论课程　☐理论（含实验）课程　☐实践类课程</td></tr>
<tr><td>课程类别</td><td colspan="11">☐通识类　☑学科基础类　☐专业方向类　☐实践类</td></tr>
<tr><td>适用专业</td><td colspan="11">通信工程</td></tr>
<tr><td>先修课程</td><td colspan="11">高等数学、线性代数、复变函数与积分变换、电路原理</td></tr>
<tr><td>建议开课学期</td><td colspan="11">☐1-1 ☐1-2☐2-1 ☑2-2 ☐3-1 ☐3-2
☐4-1 ☐4-2 ☐5-1 ☐5-2 ☐*（代表每学期都开设）</td></tr>
<tr><td>考核方式</td><td colspan="4">☑考试 ☐考查</td><td>成绩分制</td><td colspan="6">☑百分制 ☐五级制
☐二级制</td></tr>
<tr><td>使用教材</td><td colspan="11">1. （美） Alan V. Oppenheim, Alan S. Willsky, S. Hamid Nawab. Signals and Systems (Second Edition). 电子工业出版社, 2015 年.</td></tr>
<tr><td>参考书及教学资源</td><td colspan="11">1. 郑君里, 应启珩, 杨为理. 信号与系统(第三版, 上、下册). 高等教育出版社, 2011 年.</td></tr>
<tr><td>其他说明</td><td colspan="11">无</td></tr>
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二、课程简介

中文描述

信号与系统分析课程是通信工程专业重要的专业基础课程之一，同时作为数字信号处理课程的基础部分，是衔接基础课与专业课的桥梁。信号与系统分析课程是通信工程、电子信息工程、物联网工程等专业必修的核心课程。

本课程主要研究确定信号的特性与线性时不变系统的性质、信号通过线性系统的响应，以及由此引出的信号与线性系统理论中重要的概念和基本分析方法。通过对某些典型信号、系统及其响应进行深入讨论，使学生初步认识如何建立信号与系统的数学模型，如何正确地对信号与系统进行数学分析与求解，并对所得结果给以物理解释、赋予物理意义。

通过本门课程的学习为学生继续深造和就业过程奠定理论知识基础，能够建立起坚实的理论知识框架，这对提高学生分析、解决电子信息领域中诸如管理与维护、开发与设计等问题的能力至关重要。更重要的是，本课程培养学生勤学笃行意识和创新实践精神，厚植学生四个自信和家国情怀。通过学习信号与系统分析的相关知识，学生不仅能够获得实用的技能，还能够在学习过程中增强对中国特色社会主义文化自信及工匠精神的认同，树立起正确的世界观、人生观和价值观。

English Description

Signal and System Analysis is one of the important basic courses for the Communication Engineering major. As the foundation of the Digital Signal Processing course, it is a bridge between basic courses and professional courses. Signal and System Analysis is a required core course for majors such as Communication Engineering, Electronic Information Engineering, and Internet of Things Engineering.

This course mainly studies the characteristics of signals and the properties of linear time-invariant systems, the responses of signals through linear systems, and the important concepts and basic analysis methods in the theory of signals and linear systems derived from them. Through in-depth discussions on some typical signals, systems and their responses, students will have a preliminary understanding of how to establish mathematical models of signals and systems, how to correctly perform mathematical analysis and solutions on signals and systems, and give physical interpretations and physical meanings to the results obtained.

Through the study of this course, students can lay a theoretical knowledge foundation for further study and employment, and establish a solid theoretical knowledge framework, which is crucial to improving students' ability to analyze and solve problems such as management and maintenance, development, and design in the field of electronic information. More importantly, this course cultivates students' awareness of diligence and practice and innovative practice, and cultivates students' four confidences and patriotism. By learning the relevant knowledge of signal and system analysis, students can not only acquire practical skills, but also enhance their confidence in the socialist culture with Chinese characteristics and their recognition of the craftsman spirit in the learning process, and establish a correct world outlook, outlook on life and values.

三、课程目标

1、知识目标：

1-1：掌握信号与系统的基本概念、基本原理和基本分析方法。
1-2：掌握连续时间信号与系统的时域分析方法。
1-3：掌握连续时间信号与系统的频域分析方法。
1-4：掌握连续时间信号与系统的复频域分析方法。
1-5：掌握傅里叶变换应用于通信系统的分析方法。
1-6：掌握离散时间信号与系统的时域分析方法。
1-7：掌握离散时间信号与系统的 *z* 域分析方法。

2、能力目标：

2-1：掌握科学研究和工程应用中的分解原则。
2-2：掌握科学研究和工程应用中的等价原则。
2-3：掌握工程应用中滤波器的分析和设计。
2-4：掌握 MATLAB 仿真平台的使用，能够利用该平台模拟各种信号与系统。

3、德育/素养目标：

3-1：展示本专业在新时代中国特色社会主义建设中的成就和当前要解决的重大课题。
3-2：具有良好的团队协作意识和能力、较强的表达能力和人际交往能力。
3-3：具备一定科学思维、科学精神和科学素质，树立科学思想以及正确的世界观和方法论。
3-4：认知提升工程科技人才的创新创业能力、责任意识对提高中国在全球发展核心竞争力的作用。
3-5：认知大国工匠精神的内涵及时代意义，增强专业认同感、民族责任感。

表 1 课程目标与毕业要求的对应关系

毕业要求	指标点	课程目标	关联性（H/M/L）
1. 工程知识：能够将数学、自然科学、工程基础和专业知识用于解决复杂工程问题。	1.1 掌握数学、自然科学、工程基础和专业知识，并使用其建立正确的数学、物理学等模型以解释复杂工程问题。	1-1、2-1、3-1、3-5	H
	1.2 掌握通信原理、信号与信息处理、电子电路技术等专业知识，具备通信系统功能模块设计开发能力和通信与信息系统设计开发与维护能力。	1-2、2-2、2-3、3-4	H
2. 问题分析：能够应用数学、自然科学和工程科学的基本原理、方法和手段，识别、表达、并通过文献研究分析复杂工程问题，以获得有效结论。	2.1 能够应用数学、自然科学和工程科学的基本原理、方法和手段，分析、识别、表达本专业相关的复杂工程问题。	1-3、1-4、1-6、2-2、3-2	M
	2.2 能够应用数学、自然科学和工程科学的基本原理、方法和手段，针对实际复杂工程问题设计针对性的技术方案，并综合运用文献、科学理论和技术手段予以解决。	1-6、1-7、2-3、3-3、3-5	M

3. 设计/开发解决方案：能够设计针对复杂工程问题的解决方案，设计满足特定需求的系统、单元或流程，并能够在设计环节中体现创新意识，考虑社会、健康、安全、法律、文化以及环境等因素。	3.1 能够设计针对本专业相关复杂工程问题的解决方案，能够设计和开发实现特定功能、满足特定需求的信息传输、信号处理或网络通信系统。	1-5、2-4、3-3、3-4、3-5	L

四、主要教学内容

（一）理论教学

第 1 章：Introduction （支撑课程目标 1-1、2-1、3-1、3-2、3-3）

【1】知识点：

(1) Definition, description, classification, and typical examples of signals.
(2) Step signal and impulse signal.
(3) Calculation and decomposition of signals.
(4) Definition, model, and classification of systems.
(5) Linear time invariant system.

【2】学习目标：

理解：The definition and properties of linear time invariant system, and will apply these properties.

掌握：Description, characteristics, and properties of common basic signals (including ordinary signals and singular signals) in time domain, and will apply these properties. The method of signal decomposition, transformation, and operation in time domain.

【3】重点内容：

(1) Definition and classification of signals and systems.
(2) Time domain description, waveform transformation and operation rules of continuous-time signals.
(3) Definition, characteristics, and applications of typical signals.
(4) Basic properties and time domain description of linear time invariant systems.

【4】难点内容：

(1) Distinguishing and understanding the change of the independent variable and the change of the function value in the time domain operation.
(2) Understanding and application of limit models and characteristics of impulse signals and step signals.
(3) The understanding, judgment, and application of the basic characteristics of the system such as linearity, time invariance, causality, and stability.

【5】思政案例：

Based on the radar ranging principle and the spectrum of radar signals, the latest concept of lidar is introduced, and then a comparative analysis is made on the development of China and the United States in the field of autonomous driving technology to stimulate students' interest in learning, sense of responsibility and innovative spirit.

第 2 章：Time domain analysis of continuous time system （支撑课程目标 1-2、2-1、3-2、3-3）

【1】知识点：

(1) The system model described by differential equation. Solving differential equations using classical methods in the time domain. The solution of initial state, zero input response, zero state response, impulse response, and step response.

(2) Calculations and properties of convolution integral.

(3) Use operator symbols to express differential equations.

【2】学习目标：

理解：The meaning of the characteristic equation and characteristic roots of the system, and how to solve them. The complete response of the system and its decomposition, that is, the sum of the zero-state response and the zero-input response, the sum of the free response and the forced response, the sum of the transient response and the steady-state response, and how to solve them. The definition of the unit impulse response and its descriptive role in the system, and how to solve and apply it.

掌握：The establishment method of differential equation. Calculations and properties of convolution integral.

【3】重点内容：

(1) Methods for solving the differential equation.

(2) Applications of the convolution integral.

【4】难点内容：

(1) Description and calculation for the 0_- and 0_+ states.

(2) The differences for various response types and their solution methods.

(3) The calculation of convolution integral.

【5】思政案例：

Although the invention and application of radar ranging technology has a history of more than 70 years, the interest in this field is still strong and widespread. Many practical difficulties and new theories attract people to further study and practice, and the innovation potential is huge. For example, in order to solve practical problems such as searching for stealth targets, countering radiation missiles, responding to low-altitude penetration, and resisting electronic interference, it is urgent to study new concepts and theories such as radar optimization configuration and networking, information compression and transmission, information fusion and decision-making, large-scale comprehensive display of radar targets, and the application of artificial intelligence technology, and establish a new digital, software-based, and fully automated air defense radar network. Inspire students' national pride, the spirit of continuous innovation of craftsmanship, and the spirit of exploration of science.

第 3 章： Fourier transform（支撑课程目标 1-3、2-1、2-2、3-1、3-3、3-5）

【1】知识点：

(1) Fourier series analysis of periodic signals.

(2) Fourier series of typical periodic signals.

(3) Fourier transform.

(4) Fourier transform of typical aperiodic signals.

(5) Basic properties of Fourier transform.

(6) The convolution property.

(7) The Fourier transform of periodic signals.

(8) The Fourier transform of sampling signal.

(9) The sampling theorem.

【2】学习目标：

理解：The spectral characteristics of continuous-time periodic signals. The ability to use Fourier series and Fourier transform to solve the spectrum and bandwidth of periodic signals, and draw the spectrum graphs. The spectral characteristics of continuous-time non-periodic signals. The ability to use Fourier transform to solve the spectrum and

bandwidth of non-periodic signals, and draw the spectrum graphs.

掌握：The role of sampling, implementation methods and spectral characteristics of the sampled signal, and the solution of the sampling theorem.

【3】重点内容：

(1) Unilateral spectrum, bilateral spectrum, and their relationship.
(2) Spectrum characteristics of periodic and aperiodic signals.
(3) The correspondence between time domain and frequency domain in signal waveform, basic operation, energy (or average power) and symmetry.
(4) Spectrum and characteristics of typical signals.
(5) Frequency bandwidth.
(6) Spectrum relationship between periodic signal and non-periodic signal.
(7) The sampling theorem.

【4】难点内容：

(1) Understanding of Fourier series and Fourier transform.
(2) Understanding of signal spectrum and bandwidth.
(3) One-to-one correspondence of continuous-time signals in time domain and frequency domain.
(4) Description, characteristics, and relationship of the spectrum of periodic and non-periodic signals.
(5) The conversion between continuous-time signal and discrete-time signal and their spectral relationship.
(6) Inter-conversion and time-domain waveform relationship between continuous spectrum and discrete spectrum.
(7) The application of sampling theorem.

【5】思政案例：

A new technology called "ultra-wideband, short-pulse electromagnetics" is being widely used in the fields of radar, communication, and signal processing. For a pulse signal with a very short duration, its spectrum ranges from nearly DC to hundreds of gigahertz, with a large relative bandwidth. The radar system that constitutes the radiation source is called an ultra-wide bandwidth radar. Its outstanding advantages are: high-resolution ranging, deep search for invisible targets, penetration of leaves, ground and walls, suppression of clutter and interference, resistance to electronic countermeasures, etc. Inspire students' national pride, the spirit of continuous innovation of craftsmanship and the spirit of exploration of science.

第 4 章：Laplace transform, *s*-domain analysis of continuous time system（支撑课程目标 1-4、2-1、2-2、3-3、3-4、3-5）

【1】知识点：

(1) The definition and the region of convergence for Laplace transform. Laplace transform of some common functions.
(2) Basic properties of the Laplace transform.
(3) The inverse Laplace transform.
(4) Analyzing circuits using Laplace transforms: Steps in analyzing circuits using Laplace transforms, Laplace transforms of differential equations, analyzing circuits using *s*-domain models of components.
(5) System functions: definition, classification, solution, and application.
(6) Time domain characteristics are determined by zero and pole distribution of system functions.
(7) Frequency response characteristics are determined by zero and pole distribution of system functions.

(8) Zero and pole distribution of all-pass function and minimum phase shift function.
(9) Stability of linear system.
(10) Bilateral Laplace transform.
(11) Relationship between Laplace transform and Fourier transform.

【2】学习目标：

理解：Relationship between Laplace transform and Fourier transform. Bilateral Laplace transform.

掌握：Laplace transform of common functions. Circuit analysis using Laplace transform method and *s*-domain analysis method of continuous-time system. Solving system functions (time domain characteristics, frequency response characteristics, stability of linear system).

【3】重点内容：

(1) Definition and basic properties of Laplace transform.
(2) The time domain characteristics and frequency domain characteristics determined by the zero-pole distribution of the system function $H(s)$.
(3) System analysis by the *s*-domain method.

【4】难点内容：

(1) The region of convergence domain of Laplace transform.
(2) Plot the frequency response characteristic curve of the system by using the zero-pole method.

【5】思政案例：

Take the telecommunications network as an example to introduce the composition principle of communication methods. The core of communication revolves around the mutual adaptation between the spectrum analysis of signals and the transmission characteristics of the system. Emphasize that science and technology are the primary productive forces, and inspire students' sense of responsibility and self-confidence.

第 5 章：Fourier transform applied to communication systems--filtering, modulation and sampling（支撑课程目标 1-5、2-3、2-4、3-1、3-4、3-5）

【1】知识点：

(1) Responses are obtained using system function.
(2) No distortion transmission.
(3) Ideal low-pass filter.
(4) Physical realization、Perry -Wiener criterion of the system.
(5) Modulation and demodulation.
(6) Application of band-pass filtering system.
(7) Recovery of continuous-time signals from sampling signals.

【2】学习目标：

理解：The concept and significance of distortion-free transmission; the physical feasibility of the system; the significance and application of the Paley-Wiener criterion and Hilbert transform; the role of filters; the relationship and difference between actual filters and ideal filters; the basic method of measuring filter parameters using impulse response and step response; the implementation method, significance and spectrum transformation of modulation and demodulation.

掌握：The time domain and frequency domain conditions for distortion-free transmission, and the ability to judge and apply them; the frequency response and frequency response characteristic curve of the ideal filter.

【3】重点内容：

(1) Linear distortion and nonlinear distortion and their characteristics, the causes of linear distortion-amplitude distortion and phase distortion, conditions for distortion-free transmission (time domain, frequency domain).

(2) The frequency response characteristics of an ideal low-pass filter, the corresponding relationship between the impulse response and step response curves and the cut-off frequency of the filter.

(3) Frequency domain judgment of the physical feasibility of the system.

(4) The significance of modulation and demodulation, implementation methods and spectrum conversion.

(5) Recovery of continuous-time signals from sampling signals.

【4】难点内容：

(1) The classification, characteristics and causes of distortion, distortion-free transmission, and its role in communication systems.

(2) The role of ideal filters, frequency response characteristics, parameter measurement methods and their applications.

(3) The physical reliability of the system and its judgment method.

【5】思政案例：

Through the evolution process of communication technology, we will introduce China's Huawei's international leading position in communication technologies such as 5G, and inspire students' patriotic enthusiasm.

第 6 章： Time domain analysis of discrete time System（支撑课程目标 1-6、2-1、3-3、3-4）

【1】知识点：

(1) Discrete time signal-sequence.

(2) Mathematical model of discrete time system.

(3) Solving linear difference equations with constant coefficients.

(4) Unit impulse response of discrete time system.

(5) The convolution sum: definition, properties, calculation.

【2】学习目标：

理解： The type of discrete-time LTI system response and its time-domain solution method. The definition, significance, and application of unit impulse response.

掌握： The calculation of discrete sequences. Solving constant coefficient difference equations and the unit sample response. Application of convolution sum.

【3】重点内容：

(1) Descriptions for sequential and discrete-time systems.

(2) Solving Difference Equations with Constant Coefficients.

(3) The unit sample response.

(4) Description of the input-output relationship of the system through convolution sum.

(5) Basic properties and response types of discrete-time linear time-invariant systems.

【4】难点内容：

(1) The relationship and similarities and differences between discrete-time signals and continuous-time signals.

(2) Periodicity judgment of sinusoidal sequence, and its relationship and difference with continuous-time sinusoidal signal in periodicity and frequency domain parameters.

(3) The relation and difference between sequential operation and continuous time signal operation.

【5】思政案例：

The theory and technology of discrete time signal and system are developing at an alarming speed. In particular, the application of "digital signal processing" formed by it is becoming more and more extensive. In recent years, various high-speed digital signal processing chips have become a series of products and are widely used in various real-time signal processing. Chips are the key way to become a strong country in science and technology! Inspire students' sense of responsibility and national pride.

第 7 章： *z*-transform, *z*-domain analysis of discrete-time systems（支撑课程目标 1-7、2-1、3-3、3-4）

【1】知识点：

(1) Definition, properties, and the region of convergence for the *z*-transform. *Z*-transform for the typical sequence.
(2) Inverse *z*-transform.
(3) The relationship between *z*-transform and Laplace transform.
(4) Solving difference equations using the *z*-transform: steps, determination of the starting point of the response $Y(z)$, verification of the solution.
(5) Systems function of discrete system.
(6) Fourier transform of the sequence.
(7) Frequency response characteristics of discrete-time systems.

【2】学习目标：

理解： The definition, region of convergence and properties for *z*-transform. Definitions of system function of discrete-time LTI system.

掌握： Partial fraction expansion methods of inverse *z*-transform. *Z*-domain analysis of discrete-time LTI system. Relationship between system function and system stability. Frequency response characteristics of discrete-time LTI system.

【3】重点内容：

(1) The *z*-transform and its region of convergence.
(2) The corresponding relationship of sequences in time domain and *z* domain.
(3) The relationship between *z*-transform and Laplace transform.
(4) System function and frequency response characteristics of discrete-time LTI system.
(5) Stability determination of discrete-time LTI systems.

【4】难点内容：

(1) The region of convergence for *z*-transform.
(2) The inverse *z*-transform.

【5】思政案例：

The *z*-transform theory has important application value in digital signal processing technology. For example, the realization of digital filters and the analysis and synthesis of speech signals require the use of *z*-transform theory for research, analysis, and design, and it is widely used in many engineering fields. It emphasizes that science and technology are the primary productive forces and inspires students' sense of responsibility and self-confidence.

（二）实验教学

None.

五、教学安排与学时分配

This course is mainly classroom-based. Classroom teaching focuses on the basic concepts, basic theories, and basic principles of this course. The course focuses on the fundamental task of cultivating

morality and cultivating people, with the overall goal of cultivating socialist builders and successors with all-round development of morality, intelligence, physical fitness, aesthetics, and labor. It takes the basic problems of communication systems and control systems as the background, and comprehensively analyzes the two major research objects of signals and systems. In-depth explanation of the three major methods of time domain, frequency domain (Fourier transform) and complex frequency domain (Laplace transform/*z*-transform) to understand the general laws of signal transmission or processing through the system. The course makes full use of offline classrooms, online teaching resources and ideological and political cases to carry out teaching activities, give play to the role of theoretical knowledge imparting and value guidance, improve practical skills and innovative spirit, to establish a correct outlook on life, world outlook and values. The course hours are distributed as shown in Table 2.

表 2 学时分配表

讲　　课　　内　　容		学时				
		讲课	实验	上机	设计	课外
第 1 章	Introduction	4	0	0	0	0
第 2 章	Time domain analysis of continuous time system	4	0	0	0	0
第 3 章	Fourier transform	14	0	0	0	0
第 4 章	Laplace transform, *s*-domain analysis of continuous-time systems	12	0	0	0	0
第 5 章	Fourier transform applied to communication systems-filtering, modulation and sampling	6	0	0	0	0
第 6 章	Time domain analysis of discrete time system	6	0	0	0	0
第 7 章	*z*-transform, *z*-domain analysis of discrete-time systems	10	0	0	0	0
小计		56	0	0	0	0
总计	56					

六、教学方法

1、Teach basic principles, combine theory with practice, emphasize the principles of signal and system analysis, and cultivate students' innovative ability.

2、The teaching method combines multi-media courseware, online teaching, and traditional teaching to give the classroom vitality.

3、Release theoretical questions in advance to mobilize students' enthusiasm for learning and cultivate their self-study ability, teamwork ability and ability to solve practical problems.

七、成绩评定

1、This course is a closed-book exam, graded on a 100-point scale. The grade is based on attendance, regular homework, class questions, class discussions, and the final exam.

（1）Attendance and classroom communication account for 25%. Students are required to participate in all aspects of this course and are not allowed to be absent.

（2）Regular homework accounts for 25%, mainly including comprehensive assessments such as classroom communication, homework, and online material learning.

（3）The final grade accounts for 50%, mainly the examination score (closed-book test).

2、If the students' missed assignments exceed 1/3 of the required amount, or the students' missed class hours exceed 1/3 of the planned class hours, they will be disqualified from the course assessment.

八、评价及持续改进

1、Syllabus

Assessment cycle: 4 years, revision cycle: 4 years.

Improvement measures: The course leader organizes all teachers in the course team to discuss and put forward improvement suggestions, which will be reviewed by the head of the teaching and research department and approved by the dean of the school.

2、Performance Assessment

Assessment cycle: 1 academic year, evaluation basis: comprehensive analysis of students' final scores.

Improvement measures: According to the distribution of students' final scores, make corresponding content adjustments and optimizations, and improve teaching methods.

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