



# MODULE HANDBOOK

## FUNDAMENTALS OF SIGNAL PROCESSING







BACHELOR DEGREE PROGRAM  
DEPARTMENT OF BIOMEDICAL ENGINEERING  
FACULTY OF INTELLIGENT ELECTRICAL AND INFORMATICS  
TECHNOLOGY

INSTITUT TEKNOLOGI SEPULUH NOPEMBER

## ENDORSEMENT PAGE



**MODULE HANDBOOK**  
**Fundamentals of Signal Processing**  
**DEPARTMENT OF BIOMEDICAL ENGINEERING**  
 INSTITUT TEKNOLOGI SEPULUH NOPEMBER  
 Number : 6853/IT2.IX.5.1.2/B/PP.03.00.00/2023

<b>Proses Process</b>	<b>Penanggung Jawab Person in Charge</b>			<b>Tanggal Date</b>
	<b>Nama Name</b>	<b>Jabatan Position</b>	<b>Tandatangan Signature</b>	
Perumus <i>Preparation</i>	Nada Fitriyatul Hikmah, S.T., M.T.	Dosen <i>Lecturer</i>		<b>November 18, 2022</b>
Pemeriksa dan Pengendalian <i>Review and Control</i>	Eko Agus Suprayitno, S.Si., M.T.	Tim kurikulum <i>Curriculum team</i>		<b>November 20, 2022</b>
Persetujuan <i>Approval</i>	Dr. Rachmad Setiawan, S.T., M.T.	Koordinator RMK <i>Course Cluster Coordinator</i>		<b>April 13, 2023</b>
Penetapan <i>Determination</i>	Dr. Achmad Arifin, S.T., M.Eng.	Kepala Departemen <i>Head of Department</i>		<b>April 17, 2023</b>


## MODULE HANDBOOK

### FUNDAMENTALS OF SIGNAL PROCESSING

Module name	<b>Fundamentals of Signal Processing</b>	
Module level	Undergraduate	
Code	EB234304	
Course (if applicable)	Fundamentals of Signal Processing	
Semester	First Semester (Odd)	
Lecturer	Nada F. H., S.T., M.T. M. Yazid, B.Eng., M.Eng.	
Language	Bahasa Indonesia and English	
Relation to curriculum	Undergraduate degree program, <b>mandatory</b> , 3 <sup>th</sup> semester.	
Type of teaching, contact hours	Lectures, <60 students Tuesdays, 11.00-12.50 (GMT+7)	
Workload	<ol style="list-style-type: none"> <li>1. Lectures : 4 x 50 = 200 minutes per week.</li> <li>2. Exercises and Assignments : 4 x 60 = 240 minutes (4 hours) per week.</li> <li>3. Private learning : 4 x 60 = 240 minutes (4 hours) per week.</li> </ol>	
Credit points	4 credit points (sks)	
Requirements according to the examination regulations	A student must have attended at least 75% of the lectures to sit in the exams.	
Mandatory prerequisites	Calculus 2	
Learning outcomes and their corresponding PLOs	<p>Course Learning Outcome (CLO) after completing this module</p> <p>CLO 1: Students understand fundamental signal and system analysis</p> <p>CLO 2: Students understand and are able to analyze Linear Time Invariant Systems in several domains</p> <p>CLO 3: Students understand and are able to analyze continuous-time signal such as: singularity function, exponential and geometrical complex, Fourier transform and representation</p> <p>CLO 4: Students understand and are able to analyze discrete-time signal such as: singularity function, exponential and geometrical complex, Fourier transform and representation, sampling and signal reconstruction</p> <p>CLO 5: Students are able to design simple digital filters</p>	
Content	This course consists of fundamentals of signal and system analysis, with focus upon representation of continuous	

	and discrete time signals (singularity function, exponential and geometrical complex, Fourier representation, Laplace and Z transformation, signal sampling and reconstruction) and Linear Time Invariant system representation (differential equation, block diagram, system function, pole and zero, convolution, step and impulse response, frequency response), and basic digital filter design.	
Study and examination requirements and forms of examination	<ul style="list-style-type: none"> <li>• In-class exercises</li> <li>• Assignment 1, 2, 3, 4, 5, 6</li> <li>• Quiz 1, 2</li> <li>• Mid-term examination</li> <li>• Final examination</li> </ul>	
Media employed	LCD, whiteboard, websites (myITS Classroom), zoom.	
Reading list	<p>Main:</p> <ol style="list-style-type: none"> <li>1. Alan V. Oppenheim and Alan Wilsky, "Signals and Systems," 2<sup>nd</sup> Ed., Prentice Hall.</li> <li>2. L. C. Ludeman, "Fundamentals of Digital Signal Processing", Harper and Row, 1986.</li> <li>3. John G. Proakis, Dimitris G. Manolakis, "Digital Signal Processing: Principles, Algorithms, Applications," Prentice Hall, 1996.</li> </ol> <p>Supporting:</p> <ol style="list-style-type: none"> <li>1. Paulo S.R. Diniz, Eduardo A.B. da Silva, dan Sergio L. Netto, "Digital Signal Processing: System Analysis and Design," Cambridge University Press, 2002.</li> <li>2. Monson H. Hayes, "Digital Signal Processing," Schaum's Outlines Series, McGraw Hill, 1999.</li> <li>3. Andre Quinquins, "Digital Signal Processing with MATLAB," John Wiley, 2007.</li> </ol>	

**I. Rencana Pembelajaran Semester / Semester Learning Plan**

		<b>INSTITUT TEKNOLOGI SEPULUH NOPEMBER (ITS)</b> <b>FACULTY OF INTELLIGENT ELECTRICAL AND INFORMATICS TECHNOLOGY</b> <b>DEPARTMENT OF BIOMEDICAL ENGINEERING</b>				<b>Document Code</b>
<b>SEMESTER LEARNING PLAN</b>						
<b>MATA KULIAH (MK)</b> <b>COURSE</b>	<b>KODE</b> <b>CODE</b>	<b>Rumpun MK</b> <b>Course Cluster</b>	<b>BOBOT (sks)</b> <b>Credits</b>		<b>SEMESTER</b>	<b>Tgl</b> <b>Penyusunan</b> <b>Compilation</b> <b>Date</b>
<b>Dasar Pengolahan Sinyal</b> <b>Fundamentals of Signal Processing</b>	EB234304	<b>Ilmu Dasar Teknik</b> <b>Basic Engineering</b>	T=4	P=0	III	27 Oktober 2023
<b>OTORISASI / PENGESAHAN</b> <b>AUTHORIZATION / ENDORSEMENT</b>		<b>Dosen Pengembang RPS</b> <b>Developer Lecturer of Semester Learning Plan</b>	<b>Koordinator RMK</b> <b>Course Cluster Coordinator</b>		<b>Ka DEPARTEMEN</b> <b>Head of Department</b>	
		(Eko Agus Suprayitno, S.Si, M.T.)	(Dr. Norma Hermawan, S.T., M.T., M.Sc.)		(Dr. Achmad Arifin, S.T., M.Eng.)	
<b>Capaian Pembelajaran</b>	<b>CPL-PRODI yang dibebankan pada MK</b> <b>PLO Program Charged to the Course</b>					
<b>Learning Outcomes</b>	<b>CPL-01</b> <b>PLO-01</b>	Mampu <b>menerapkan</b> Ilmu Pengetahuan Alam dan Matematika pada bidang Teknik Biomedika <i>Able to apply Natural Sciences and Mathematics in the field of Biomedical Engineering</i>				
	<b>CPL-02</b> <b>PLO-02</b>	Mampu <b>menemukan, memahami, menjelaskan, merumuskan, dan menyelesaikan</b> permasalahan umum pada bidang Teknik dan permasalahan khusus pada bidang Teknik Biomedika yang meliputi instrumentasi biomedika cerdas, teknik rehabilitasi medika, pencitraan dan pengolahan citra medika, serta informatika medika <i>Able to find, understand, explain, formulate, and solve general problems in the field of Engineering and special problems in the field of Biomedical Engineering which includes intelligent biomedical instrumentation, medical rehabilitation techniques, imaging and processing of medical images, and medical informatics</i>				

	<b>CPL-06</b> <b>PLO-06</b>	Mampu <b>menerapkan</b> ilmu pengetahuan, keterampilan, dan metode terkini dalam menyelesaikan permasalahan di bidang Teknik Biomedika <i>Able to apply the latest knowledge, skills and methods in solving problems in the field of Biomedical Engineering</i>																																																																														
<b>Capaian Pembelajaran Mata Kuliah (CPMK) – Bila CP MK sebagai kemampuan pada tiap tahap pembelajaran CP MK = Sub CP MK</b>																																																																																
	<b>CP MK 1</b> <b>CLO 1</b>	Mahasiswa memahami dasar analisis sinyal dan sistem <i>Students understand fundamental signal and system analysis</i>																																																																														
	<b>CP MK 2</b> <b>CLO 2</b>	Mahasiswa memahami dan mampu melakukan analisis terhadap sistem linear dan tidak berubah terhadap waktu (LTI) di beberapa domain <i>Students understand and able to analyze Linear Time Invariant System in several domain</i>																																																																														
	<b>CP MK 3</b> <b>CLO 3</b>	Mahasiswa memahami dan mampu melakukan analisis sinyal waktu kontinu seperti fungsi singular, eksponensial dan geometri kompleks, representasi dan transformasi Fourier <i>Students understand and are able to analyze continuous-time signal such as: singularity function, exponential and geometrical complex, Fourier transform and representation</i>																																																																														
	<b>CP MK 4</b> <b>CLO 4</b>	Mahasiswa memahami dan mampu melakukan analisa sinyal waktu diskrit: Fungsi singular, Eksponensial dan geometri kompleks, representasi dan transformasi Fourier, sampling dan rekonstruksi sinyal <i>Students understand and are able to analyze discrete-time signal such as: singularity function, exponential and geometrical complex, Fourier transform and representation, sampling and signal reconstruction</i>																																																																														
	<b>CP MK 5</b> <b>CLO 5</b>	Mahasiswa mampu merancang filter digital sederhana <i>Students are able to design simple digital filters</i>																																																																														
<b>Peta CPL – CP MK</b>  <b>Map of PLO - CLO</b>		<table border="1" data-bbox="369 999 2107 1398"> <thead> <tr> <th></th> <th>CPL-01</th> <th>CPL-02</th> <th>CPL-03</th> <th>CPL-04</th> <th>CPL-05</th> <th>CPL-06</th> <th>CPL-07</th> <th>CPL-08</th> <th>CPL-09</th> <th>CPL-10</th> <th>CPL-11</th> <th>CPL-12</th> </tr> </thead> <tbody> <tr> <td>CPMK 1 / SUB CPMK 1 CLO 1 / LLO 1</td> <td></td> <td>√</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>CPMK 2 / SUB CPMK 2 CLO 2 / LLO 2</td> <td></td> <td>√</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>CPMK 3 / SUB CPMK 3 CLO 3 / LLO 3</td> <td></td> <td>√</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>CPMK 4 / SUB CPMK 4 CLO 4 / LLO 4</td> <td></td> <td>√</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>CPMK 5 / SUB CPMK 5 CLO 5 / LLO 5</td> <td>√</td> <td></td> <td></td> <td></td> <td></td> <td>√</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </tbody> </table>		CPL-01	CPL-02	CPL-03	CPL-04	CPL-05	CPL-06	CPL-07	CPL-08	CPL-09	CPL-10	CPL-11	CPL-12	CPMK 1 / SUB CPMK 1 CLO 1 / LLO 1		√											CPMK 2 / SUB CPMK 2 CLO 2 / LLO 2		√											CPMK 3 / SUB CPMK 3 CLO 3 / LLO 3		√											CPMK 4 / SUB CPMK 4 CLO 4 / LLO 4		√											CPMK 5 / SUB CPMK 5 CLO 5 / LLO 5	√					√						
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<b>Diskripsi Singkat MK</b>  <b>Short Description of Course</b>	<p>Mata kuliah ini mempelajari tentang dasar analisa sinyal dan system, dengan fokus terhadap representasi sinyal waktu kontinyu dan diskrit (fungsi singularitas, kompleks eksponensial dan geometri, representasi Fourier, transformasi Laplace and Z, sampling dan rekonstruksi sinyal) dan representasi sistem LTI (persamaan diferensial, blok diagram, fungsi sistem, pole dan zero, konvolusi, respon step dan impuls, respon frekuensi), dan dasar perancangan filter digital.</p> <p><i>This course consists of fundamentals of signal and system analysis, with focus upon representation of continuous and discrete time signals (singularity function, exponential and geometrical complex, Fourier representation, Laplace and Z transformation, signal sampling and reconstruction) and Linear Time Invariant system representation (differential equation, block diagram, system function, pole and zero, convolution, step and impulse response, frequency response), and basic digital filter design.</i></p>	
<b>Bahan Kajian:</b> Materi pembelajaran  <b>Course Materials:</b>	<ol style="list-style-type: none"> <li>1. Pengenalan sinyal dan sistem / <i>Signal and System Introduction</i></li> <li>2. Sistem Linear Time Invariant (LTI) / <i>Linear Time Invariant System</i></li> <li>3. Representasi Fourier waktu kontinu dari sinyal periodik / <i>Fourier Representation of Continuous-Time Periodical Signal</i></li> <li>4. Transformasi Fourier waktu kontinu / <i>Fourier Transform of Continuous Time Signal</i></li> <li>5. Transformasi Laplace / <i>Laplace Transform</i></li> <li>6. Proses sampling dan rekonstruksi sinyal: Proses sampling sinyal kontinyu, Teorema Nyquist, Rekonstruksi Sinyal, Up-sampling, Down-sampling, sampling and hold / <i>Signal sampling and reconstruction process: Continuous signal sampling process, Nyquist Theorem, Signal Reconstruction, Up-sampling, Down-sampling, hold and sampling</i></li> <li>7. Representasi Fourier waktu diskrit dari sinyal periodik / <i>Fourier Representation of Discrete-Time Periodical Signal</i></li> <li>8. Transformasi Fourier Diskrit dan Fast Fourier Transform (FFT) / <i>Discrete Fourier Transform and Fast Fourier Transform (FFT)</i></li> <li>9. Transformasi Z / <i>Z Transform</i></li> <li>10. Perancangan filter digital: LPF, HPF, BPF, BSF, FIR, IIR / <i>Designing Digital Filter: LPF, HPF, BPF, BSF, FIR, IIR</i></li> </ol>	
<b>Pustaka</b>  <b>References</b>	<b>Utama / Main:</b>	<ol style="list-style-type: none"> <li>1. Alan V. Oppenheim and Alan Wilsky, "Signals and Systems," 2nd Ed., Prentice Hall.</li> <li>2. L. C. Ludeman, "Fundamentals of Digital Signal Processing", Harper and Row, 1986.</li> <li>3. John G. Proakis, Dimitris G. Manolakis, "Digital Signal Processing: Principles, Algorithms, Applications," Prentice Hall, 1996.</li> </ol>
	<b>Pendukung / Supporting:</b>	

	<ol style="list-style-type: none"> <li>1. Paulo S.R. Diniz, Eduardo A.B. da Silva, dan Sergio L. Netto, "Digital Signal Processing: System Analysis and Design," Cambridge University Press, 2002.</li> <li>2. Monson H. Hayes, "Digital Signal Processing," Schaum's Outlines Series, McGraw Hill, 1999.</li> <li>3. Andre Quinquins, "Digital Signal Processing with MATLAB," John Wiley, 2007.</li> </ol>						
<b>Dosen Pengampu Lecturer</b>	Nada F. H., S.T., M.T. M. Yazid, B.Eng., M.Eng.						
<b>Matakuliah syarat Prerequisite</b>	Calculus 2						
Mg ke/ Week	Kemampuan akhir tiap tahapan belajar (Sub-CPMK) / <i>Final ability of each learning stage (LLO)</i>	Penilaian / <i>Assessment</i>		Bantuk Pembelajaran; Metode Pembelajaran; Penugasan Mahasiswa; <i>[ Estimasi Waktu ] / Form of Learning; Learning Method; Student Assignment; [ Estimated Time]</i>		Materi Pembelajaran <i>[Pustaka] / Learning Material [Reference]</i>	Bobot Penilaian / <i>Assessment Load (%)</i>
		Indikator / <i>Indicator</i>	Kriteria & Teknik / <i>Criteria &amp; Techniques</i>	Tatap Muka / <i>In-class (5)</i>	Daring / <i>Online (6)</i>		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	Mahasiswa memahami dasar analisa sinyal dan sistem  <i>Students understand fundamental signal and system analysis</i>	<ul style="list-style-type: none"> <li>• Mampu menentukan klasifikasi sebuah sinyal berdasarkan karakteristiknya</li> <li>• Mampu melakukan analisa terhadap suatu sinyal</li> </ul>	<ul style="list-style-type: none"> <li>• Tugas Tertulis 1 Melakukan analisa dasar terhadap sinyal Menentukan karakteristik sebuah sistem</li> </ul>	<ul style="list-style-type: none"> <li>• Kuliah dan brainstorming, tanya jawab. [TM : 4 x 50"] [BM : 4 x 60"] [PT : 4 x 50"]</li> <li>• <i>Presentation and brainstorming, ask and answer.</i></li> </ul>	<ul style="list-style-type: none"> <li>• Chatting dan diskusi dalam forum platform ITS.</li> <li>• <i>Chat and discussion in ITS platform forum.</i></li> </ul>	<ul style="list-style-type: none"> <li>• Pengertian Sinyal dan Sistem</li> <li>• Klasifikasi Sinyal</li> <li>• Macam-macam sinyal</li> <li>• Karakteristik sistem</li> </ul>	7.5



		<ul style="list-style-type: none"> <li>• Mampu menentukan karakteristik dari sebuah sistem</li> <li>• <i>Able to classify signal based on its characteristics</i></li> <li>• <i>Able to analyze certain signal</i></li> <li>• <i>Able to determine characteristics of a system</i></li> </ul>	<ul style="list-style-type: none"> <li>• <i>Written Task 1 Basic analysis of signal, determining system characteristics</i></li> </ul>	<p>[FF : 4 x 50"] [SA : 4 x 60"] [SS : 4 x 50"]</p>		<ul style="list-style-type: none"> <li>• <i>Understanding Signal and System</i></li> <li>• <i>Signal Classification</i></li> <li>• <i>Types of Signal</i></li> <li>• <i>System Characteristics</i></li> </ul>	
2	<p>Mahasiswa memahami dan mampu melakukan analisa terhadap sistem linear dan tidak berubah terhadap waktu (LTI) pada domain waktu</p> <p><i>Students understand and able to analyze Linear Time Invariant System in time domain</i></p>	<ul style="list-style-type: none"> <li>• Mampu menentukan respon sebuah sistem dengan menggunakan konvolusi</li> <li>• Mampu menentukan respon terhadap unit impuls dan step berdasarkan persamaan beda dan diferensial</li> <li>• Mampu menentukan karakterstik sebuah sistem LTI</li> <li>• <i>Able to determine system's response using convolution</i></li> <li>• <i>Able to determine the response of impulse</i></li> </ul>	<ul style="list-style-type: none"> <li>• Tugas Tertulis 2 Menghitung respon sistem dengan menggunakan konvolusi; Menentukan karakteristik sistem LTI berdasarkan respon terhadap unit impuls; Menghitung respon terhadap unit impuls dan</li> </ul>	<ul style="list-style-type: none"> <li>• Kuliah dan brainstorming, tanya jawab. [TM : 4 x 50"] [BM : 4 x 60"] [PT : 4 x 50"]</li> <li>• <i>Presentation and brainstorming, ask and answer.</i> [FF : 4 x 50"] [SA : 4 x 60"] [SS : 4 x 50"]</li> </ul>	<ul style="list-style-type: none"> <li>• Chatting dan diskusi dalam forum platform ITS.</li> <li>• <i>Chat and discussion in ITS platform forum.</i></li> </ul>	<ul style="list-style-type: none"> <li>• Sistem LTI</li> <li>• Respon terhadap unit Impuls</li> <li>• Konvolusi waktu kontinu dan diskrit</li> <li>• Karekteristik sistem LTI berdasarkan respon terhadap unit impuls</li> <li>• Respon terhadap unit impuls dan step dengan menggunakan persamaan differensial dan beda</li> <li>• <i>LTI System</i></li> </ul>	5

		<p><i>unit and step based on differential equation</i></p> <ul style="list-style-type: none"> <li>• <i>Able to determine LTI System characteristics</i></li> <li>•</li> </ul>	<p>step dengan menggunakan persamaan diferensial dan beda</p> <ul style="list-style-type: none"> <li>• <i>Written Task 2 Calculate system's response using convolution; determining LTI System's characteristics based on respons of unit impulse and step using differential equation</i></li> <li>•</li> </ul>			<ul style="list-style-type: none"> <li>• <i>Response of unit impulse</i></li> <li>• <i>Continuous and Discrete Time convolution</i></li> <li>• <i>LTI System Characteristics based on response of unit impulse</i></li> <li>• <i>Response of impulse and step units using differential equations</i></li> </ul>	
<b>3,4,5</b>	<p>Mahasiswa memahami dan mampu melakukan analisa sinyal waktu kontinu seperti fungsi singular, eksponensial dan geometri kompleks, representasi dan transformasi Fourier</p>	<ul style="list-style-type: none"> <li>• Mampu merepresentasikan sinyal dalam bentuk Representasi atau Transformasi Fourier sesuai dengan karakteristiknya</li> </ul>	<ul style="list-style-type: none"> <li>• Tugas Tertulis 3 Merepresentasikan sinyal periodik dalam bentuk Representasi Fourier</li> </ul>	<ul style="list-style-type: none"> <li>• Kuliah dan brainstorming, tanya jawab. [TM : 2 x 4 x 50"] [BM : 2 x 4 x 60"] [PT : 2 x 4 x 50"]</li> <li>• <i>Presentation and brainstorming, ask and answer.</i></li> </ul>	<ul style="list-style-type: none"> <li>• Chatting dan diskusi dalam forum platform ITS.</li> <li>• <i>Chat and discussion in ITS platform forum.</i></li> </ul>	<ul style="list-style-type: none"> <li>• Representasi Fourier dalam bentuk Trigonometri</li> <li>• Representasi Fourier dalam bentuk kompleks eksponensial</li> </ul>	<b>12.5</b>

	<p><i>Students understand and are able to analyze continuous-time signal such as: singularity function, exponential and geometrical complex, Fourier transform and representation</i></p>	<ul style="list-style-type: none"> <li>• Mampu melakukan analisa sinyal dan sistem dalam domain frekuensi dan mentransformasi balik ke domain waktu</li> <li>• Mampu melakukan analisa sinyal dalam domain frekuensi dengan menggunakan MATLAB</li> <li>• <i>Able to represent signal according to the representation or Fourier's transformation according to the characteristics</i></li> <li>• <i>Able to analyze signal and system in frequency domain and transform it back to time domain</i></li> <li>• <i>Able to analyze signal in frequency</i></li> </ul>	<p>Menentukan transformasi sinyal menggunakan karakteristik Representasi Fourier</p> <p>Merepresentasikan sinyal waktu kontinu dalam bentuk Transformasi Fourier</p> <p>Menentukan respon frekuensi sebuah sistem berdasarkan karakteristik Transformasi Fourier</p> <ul style="list-style-type: none"> <li>• Tugas Pemrograman 3</li> </ul> <p>Membuat program untuk merepresentasikan sinyal dalam domain frekuensi</p>	<p><i>[FF : 2 x 4 x 50"]</i>  <i>[SA : 2 x 4 x 60"]</i>  <i>[SS : 2 x 4 x 50"]</i></p>		<ul style="list-style-type: none"> <li>• Karakteristik Representasi Fourier</li> <li>• Tranformasi Fourier</li> <li>• Karakteristik Transformasi Fourier</li> <li>• <i>Representing Fourier through Trigonometry</i></li> <li>• <i>Fourier representation using exponential complex</i></li> <li>• <i>Fourier representation characteristics</i></li> <li>• <i>Fourier Transformation</i></li> <li>• <i>Fourier transformartion characteristics</i></li> </ul>	
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		<p><i>domain using MATLAB</i></p>	<ul style="list-style-type: none"> <li>• <i>Written Task 3 Representing periodic signals in Fourier representation , determining signal transformation using Fourier's representation characteristics, Representing continuous-time signals by Fourier Transformation, Determining frequency response of system based on Fourier's transformation characteristics</i></li> <li>• <i>Programming Task 3 Create a program to</i></li> </ul>				
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			<i>represent signal in frequency domain</i>				
<b>6,7</b>	<p>Mahasiswa memahami dan mampu melakukan analisa terhadap sistem linear dan tidak berubah terhadap waktu (LTI) pada domain Laplace.</p> <p><i>Students understand and able to analyze Linear Time Invariant System in Laplace domain</i></p>	<ul style="list-style-type: none"> <li>• Mampu merepresentasikan sinyal dan sistem pada domain Laplace</li> <li>• Mampu menentukan respon sistem LTI pada domain Laplace dan mentransformasikan kembali pada domain waktu</li> <li>• Mampu menganalisa kestabilan sistem berdasarkan diagram pole dan zero</li> <li>• <i>Able to represent signal and system on Laplace domain</i></li> <li>• <i>Able to determine LTI System response on Laplace domain and transform back to time domain</i></li> <li>• <i>Able to analyze system stability</i></li> </ul>	<ul style="list-style-type: none"> <li>• Tugas Tertulis 4 Merepresentasikan sinyal dan sistem LTI pada domain Laplace Melakukan analisa terhadap sinyal dan sistem LTI pada domain Laplace</li> <li>• Quiz 1</li> <li>• <i>Written Task 4 Represent LTI signal and system on Laplace domain Analyze signal and LTI system on Laplace domain</i></li> </ul>	<ul style="list-style-type: none"> <li>• Kuliah dan brainstorming, tanya jawab. [TM : 4 x 50"] [BM : 4 x 60"] [PT : 4 x 60"]</li> <li>• <i>Presentation and brainstorming, ask and answer.</i> [FF : 4 x 50"] [SA : 4 x 60"] [SS : 4 x 60"]</li> </ul>	<ul style="list-style-type: none"> <li>• Chatting dan diskusi dalam forum platform ITS.</li> <li>• <i>Chat and discussion in ITS platform forum.</i></li> </ul>	<ul style="list-style-type: none"> <li>• Transformasi Laplace</li> <li>• Analisa Sistem LTI pada domain Laplace: Fungsi Transfer, Diagram Pole dan Zero</li> <li>• <i>Laplace Transformation</i></li> <li>• <i>LTI System Analysis on Laplace domain: Transfer Function, Pole and Zero Diagram</i></li> </ul>	<b>12.5</b>

		<i>based on pole and zero diagram</i>	<ul style="list-style-type: none"> <li>• Quiz 1</li> </ul>				
	<p>Mahasiswa mampu melakukan proses sampling dan rekonstruksi sinyal</p> <p><i>Students able to do signal sampling and signal reconstruction process</i></p>	<ul style="list-style-type: none"> <li>• Mampu melakukan sampling sinyal menjadi sinyal diskrit</li> <li>• Mampu merekonstruksi ulang sinyal diskrit menjadi sinyal kontinu</li> <li>• <i>Able to sample signal into a discrete signal</i></li> <li>• <i>Able to reconstruct discrete signal into continuous signal</i></li> </ul>	<ul style="list-style-type: none"> <li>• Tugas Pemrograman 4 Membuat program untuk melakukan sampling sinyal kontinu dan merekonstruksinya kembali</li> <li>• <i>Programming Task 4 Creating a program to sample continuous signal and reconstruct it back</i></li> </ul>	<ul style="list-style-type: none"> <li>• Kuliah dan brainstorming, tanya jawab. [TM : 2 x 4 x 50"] [BM : 2 x 4 x 60"] [PT : 2 x 4 x 60"]</li> <li>• <i>Presentation and brainstorming, ask and answer.</i> [FF : 2 x 4 x 50"] [SA : 2 x 4 x 60"] [SS : 2 x 4 x 60"]</li> </ul>	<ul style="list-style-type: none"> <li>• Chatting dan diskusi dalam forum platform ITS.</li> <li>• <i>Chat and discussion in ITS platform forum.</i></li> </ul>	<ul style="list-style-type: none"> <li>• Sampling and Hold</li> <li>• Rekonstruksi sinyal diskrit menjadi sinyal kontinu</li> <li>• <i>Sampling and Hold</i></li> <li>• <i>Discrete signal reconstruction into continuous signal</i></li> </ul>	<b>2.5</b>
<b>8</b>	<b>EVALUASI TENGAH SEMESTER MID-SEMESTER EXAM</b>						<b>15</b>
<b>9-10</b>	<p>Mahasiswa mampu melakukan proses sampling dan rekonstruksi sinyal, dan menganalisis sinyal pada domain frekuensi</p> <p><i>Students able to do signal sampling and signal reconstruction process,</i></p>	<ul style="list-style-type: none"> <li>• Mampu melakukan sampling sinyal menjadi sinyal diskrit</li> <li>• Mampu merekonstruksi ulang sinyal diskrit menjadi sinyal kontinu</li> <li>• Mampu menganalisis sinyal pada domain frekuensi</li> </ul>	<ul style="list-style-type: none"> <li>• Tugas Pemrograman 4 Membuat program untuk melakukan sampling sinyal kontinu dan menganalisis di domain frekuensi</li> </ul>	<ul style="list-style-type: none"> <li>• Kuliah dan brainstorming, tanya jawab. [TM : 2 x 4 x 50"] [BM : 2 x 4 x 60"] [PT : 2 x 4 x 60"]</li> <li>• <i>Presentation and brainstorming, ask and answer.</i> [FF : 2 x 4 x 50"]</li> </ul>	<ul style="list-style-type: none"> <li>• Chatting dan diskusi dalam forum platform ITS.</li> <li>• <i>Chat and discussion in ITS platform forum.</i></li> </ul>	<ul style="list-style-type: none"> <li>• Sampling and Hold</li> <li>• Rekonstruksi sinyal diskrit menjadi sinyal kontinu</li> <li>• Discrete Fourier Transform</li> <li>• <i>Sampling and Hold</i></li> <li>• <i>Discrete signal reconstruction</i></li> </ul>	<b>10</b>


	<i>and analyze the signal in frequency domain.</i>	<ul style="list-style-type: none"> <li>• <i>Able to sample signal into a discrete signal</i></li> <li>• <i>Able to reconstruct discrete signal into continuous signal</i></li> <li>• <i>Able to analyze signal in the frequency domain</i></li> </ul>	<ul style="list-style-type: none"> <li>• <i>Programming Task 4</i> <i>Creating a program to sample continuous signal and reconstruct it back and analyze in the frequency domain</i></li> </ul>	<p><i>[SA : 2 x 4 x 60"]</i> <i>[SS : 2 x 4 x 60"]</i></p>		<i>into continuous signal</i>	
<b>11</b>	<p>Mahasiswa memahami dan mampu melakukan analisa terhadap sistem linear dan tidak berubah terhadap waktu (LTI) pada domain Z</p> <p><i>Students understand and able to analyze Linear Time Invariant System in Z domain</i></p>	<ul style="list-style-type: none"> <li>• Mampu merepresentasikan sinyal dan sistem pada domain Laplace</li> <li>• Mampu menentukan respon sistem LTI pada domain Laplace dan mentransformasikan kembali pada domain waktu</li> <li>• <i>Able to represent signal and system in Laplace domain</i></li> <li>• <i>Able to determine LTI System response in Laplace domain and transform it back to time domain</i></li> </ul>	<ul style="list-style-type: none"> <li>• Tugas Tertulis 6 Merepresentasikan sinyal dan sistem LTI pada domain Z Melakukan analisa terhadap sinyal dan sistem LTI pada domain Z</li> <li>• <i>Written Task 6</i> <i>Represent signal and LTI system in Z domain, able to analyze signal and LTI</i></li> </ul>	<ul style="list-style-type: none"> <li>• Kuliah dan brainstorming, tanya jawab. [TM : 4 x 50"] [BM : 4 x 60"] [PT : 4 x 60"]</li> <li>• <i>Presentation and brainstorming, ask and answer.</i> [FF : 4 x 50"] [SA : 4 x 60"] [SS : 4 x 60"]</li> </ul>	<ul style="list-style-type: none"> <li>• Chatting dan diskusi dalam forum platform ITS.</li> <li>• <i>Chat and discussion in ITS platform forum.</i></li> </ul>	<ul style="list-style-type: none"> <li>• Transformasi Z</li> <li>• Karakteristik Transformasi Z</li> <li>• Analisa sistem LTI dengan Transformasi Z</li> <li>• <i>Z Transformation</i></li> <li>• <i>Z Transformation characteristics</i></li> <li>• <i>LTI System analysis using Z Transformation</i></li> </ul>	2.5

			<i>Systems in Z domain</i>				
<b>12,13, 14</b>	<p>Mahasiswa mampu merancang filter digital dengan metode FIR dan IIR</p> <p><i>Students are able to design digital filters using FIR and IIR methods</i></p>	<ul style="list-style-type: none"> <li>• Mampu mendesain filter digital sesuai dengan ketentuan</li> <li>• <i>Able to design digital filter as required</i></li> </ul>	<ul style="list-style-type: none"> <li>• Tugas Pemrograman 6 Membuat program filter digital sederhana</li> <li>• Quiz 2</li> <li>• <i>Programming Task 6 Creating simple digital filter</i></li> <li>• Quiz 2</li> </ul>	<ul style="list-style-type: none"> <li>• Kuliah dan brainstorming, tanya jawab. [TM : 3 x 4 x 50"] [BM : 3 x 4 x 60"] [PT : 3 x 4 x 60"]</li> <li>• <i>Presentation and brainstorming, ask and answer.</i> [FF : 3 x 4 x 50"] [SA : 3 x 4 x 60"] [SS : 3 x 4 x 60"]</li> </ul>	<ul style="list-style-type: none"> <li>• Chatting dan diskusi dalam forum platform ITS.</li> <li>• <i>Chat and discussion in ITS platform forum.</i></li> </ul>	<ul style="list-style-type: none"> <li>• LPF (Low Pass Filter)</li> <li>• HPF (High Pass Filter)</li> <li>• BPF (Band Pass Filter)</li> <li>• FIR (Finite Impulse Response)</li> <li>• IIR (Infinite Impulse Response)</li> </ul>	15
<b>15-16</b>	<b>EVALUASI AKHIR SEMESTER FINAL-SEMESTER EXAM</b>						20

TM=Tatap Muka, PT=Penugasan Terstruktur, BM=Belajar Mandiri.  
FF = Face to Face, SA = Structured Assignment, SS = Self Study.



## II. Rencana Asesmen & Evaluasi (RAE)/ *Assessment & Evaluation Plan*

	<b>ASSESSMENT &amp; EVALUATION PLAN</b> <b>BACHELOR DEGREE PROGRAM OF BIOMEDICAL ENGINEERING - FTEIC ITS</b> <b>Course : Fundamentals of Signal Processing</b>		<b>RA&amp;E</b>
			Write Doc Code
<b>Kode/code:</b> <b>EB234304</b>	<b>Bobot sks/credits (T/P): 4/0</b>	<b>Rumpun MK: Ilmu Dasar Teknik</b> <b>Course Cluster: Basic Engineering</b>	<b>Smt: III</b>
<b>OTORISASI</b> <b>AUTHORIZATION</b>	<b>Penyusun RA &amp; E</b> <b>Compiler A&amp;EP</b>  <b>Nada Fitriyatul H, S.T, M.T</b>	<b>Koordinator RMK</b> <b>Course Cluster Coordinator</b>  <b>Dr. Norma Hermawan, S.T., M.T., M.Sc.</b>	<b>Ka DEP</b> <b>Head of DEP</b>  <b>Dr. Achmad Arifin, S.T., M.Eng.</b>

Mg ke/ Week (1)	Sub CP-MK / Lesson Learning Outcomes (LLO) (2)	Bentuk Asesmen (Penilaian) Form of Assessment (3)	Bobot / Load (%) (4)
1	<b>Sub CP-MK 1:</b> Mahasiswa memahami dasar analisa sinyal dan sistem  <b>LLO 1:</b> <i>Students understand fundamental signal and system analysis</i>	<ul style="list-style-type: none"> <li>• Tugas Tertulis 1 Melakukan analisa dasar terhadap sinyal Menentukan karakteristik sebuah sistem</li> <li>• Tugas Pemrograman 1 Merepresentasikan sinyal dengan menggunakan MATLAB</li> <li>• <i>Written Task 1</i> <i>Basic analysis of signal, determining system characteristics</i></li> <li>• <i>Programming Task 1</i> <i>Representing signal using Matlab</i></li> <li>• <i>1 soal pada Quiz 1 (1 Question in Quiz 1)</i></li> <li>• <i>1 soal pada ETS (1 Question in Midterm Exam)</i></li> </ul>	7.5
2	<b>Sub CP-MK 2:</b> Mahasiswa memahami dan mampu melakukan analisa terhadap sistem linear dan tidak berubah terhadap waktu (LTI) pada domain waktu  <b>LLO 2:</b>	<ul style="list-style-type: none"> <li>• Tugas Tertulis 2 Menghitung respon sistem dengan menggunakan konvolusi; Menentukan karakteristik sistem LTI berdasarkan respon terhadap unit impuls; Menghitung respon terhadap unit impuls dan step dengan menggunakan persamaan diferensial dan beda</li> <li>• Tugas Pemrograman 2 Membuat program untuk menghitung konvolusi dengan menggunakan MATLAB</li> </ul>	5

Mg ke/ Week (1)	Sub CP-MK / Lesson Learning Outcomes (LLO) (2)	Bentuk Asesmen (Penilaian) Form of Assessment (3)	Bobot / Load (%) (4)
	<i>Students understand and able to analyze Linear Time Invariant System in time domain</i>	<ul style="list-style-type: none"> <li>• <i>Written Task 2</i> <i>Calculate system's response using convolution; determining LTI System's characteristics based on respons of unit impulse and step using differential equation</i></li> <li>• <i>Programming Task 2</i> <i>Creating a program to calculate convolution using MATLAB</i></li> <li>• <i>1 soal pada Quiz 1 (1 Question in Quiz 1)</i></li> <li>• <i>2 soal pada ETS (2 Questions in Midterm Exam)</i></li> <li>• <i>1 soal pada EAS (2 Questions in Final Exam)</i></li> </ul>	
3-4	<p><b>Sub CP-MK 3:</b> Mahasiswa memahami dan mampu melakukan analisa sinyal waktu kontinu seperti fungsi singular, eksponensial dan geometri kompleks, representasi dan transformasi Fourier</p> <p><b>LLO 3:</b> <i>Students understand and are able to analyze continuous-time signal such as: singularity function, exponential and geometrical complex, Fourier transform and representation</i></p>	<ul style="list-style-type: none"> <li>• <i>Tugas Tertulis 3</i> <i>Merepresentasikan sinyal periodik dalam bentuk Representasi Fourier</i> <i>Menentukan transformasi sinyal menggunakan karakteristik Representasi Fourier</i> <i>Merepresentasikan sinyal waktu kontinu dalam bentuk Transformasi Fourier</i> <i>Menentukan respon frekuensi sebuah sistem berdasarkan karakteristik Transformasi Fourier</i></li> <li>• <i>Tugas Pemrograman 3</i> <i>Membuat program untuk merepresentasikan sinyal dalam domain frekuensi</i></li> <li>• <i>Written Task 3</i> <i>Representing periodic signals in Fourier representation, determining signal transformation using Fourier's representation characteristics, Representing continuous-time signals by Fourier Transformation, Determining frequency response of system based on Fourier's transformation characteristics</i></li> <li>• <i>Programming Task 3</i> <i>Create a program to represent signal in frequency domain</i></li> <li>• <i>1 soal pada Quiz 1 (1 Question in Quiz 1)</i></li> <li>• <i>2 soal pada ETS (2 Questions in Midterm Exam)</i></li> <li>• <i>1 soal pada EAS (2 Questions in Final Exam)</i></li> </ul>	10
5	<b>Sub CP-MK 4:</b> Mahasiswa memahami dan	<ul style="list-style-type: none"> <li>• <i>Tugas Tertulis 4</i> <i>Merepresentasikan sinyal dan sistem LTI pada domain Laplace</i></li> </ul>	12.5

Mg ke/ Week (1)	Sub CP-MK / Lesson Learning Outcomes (LLO) (2)	Bentuk Asesmen (Penilaian) Form of Assessment (3)	Bobot / Load (%) (4)
	<p>mampu melakukan analisa sinyal waktu kontinu seperti fungsi singular, eksponensial dan geometri kompleks, representasi dan transformasi Fourier</p> <p><b>LLO 4:</b> <i>Students understand and are able to analyze continuous-time signal such as: singularity function, exponential and geometrical complex, Fourier transform and representation</i></p>	<p>Melakukan analisa terhadap sinyal dan sistem LTI pada domain Laplace</p> <ul style="list-style-type: none"> <li>• Quiz 1</li> <li>• <i>Written Task 4</i> <i>Represent LTI signal and system on Laplace domain</i> <i>Analyze signal and LTI system on Laplace domain</i></li> <li>• Quiz 1</li> <li>• <i>2 soal pada ETS (2 Questions in Midterm Exam)</i></li> <li>• <i>1 soal pada EAS (1 Questions in Final Exam)</i></li> </ul>	
6-7	<p><b>Sub CP-MK 5:</b> Mahasiswa mampu melakukan proses sampling dan rekonstruksi sinyal</p> <p><b>LLO 5:</b> <i>Students able to do signal sampling and signal reconstruction process</i></p>	<ul style="list-style-type: none"> <li>• Tugas Pemrograman 4 Membuat program untuk melakukan sampling sinyal kontinu dan merekonstruksi nya kembali</li> <li>• <i>Programming Task 4</i> <i>Creating a program to sample continuous signal and reconstruct it back</i></li> <li>• <i>1 soal pada EAS (1 Questions in Final Exam)</i></li> </ul>	2.5
8	<p><b>Evaluasi Tengah Semester</b></p> <p><b>Midterm Exam</b></p>	<p><b>Tes:</b> Ujian Tulis/Ujian Daring</p> <p><b>Test:</b> <i>Writing Exams / Online Exams</i></p>	15
9-10	<p><b>Sub CP-MK 6:</b> Mahasiswa memahami dan mampu melakukan analisa sinyal waktu diskrit seperti fungsi singular, eksponensial dan geometri kompleks, representasi dan transformasi Fourier</p>	<ul style="list-style-type: none"> <li>• Tugas Tertulis 5 Merepresentasikan sinyal periodik dalam bentuk Representasi Fourier Menentukan transformasi sinyal menggunakan karakteristik Representasi Fourier Merepresentasikan sinyal waktu kontinu dalam bentuk Transformasi Fourier Menentukan respon frekuensi sebuah sistem berdasarkan karakteristik Transformasi Fourier</li> </ul>	10

Mg ke/ Week (1)	Sub CP-MK / Lesson Learning Outcomes (LLO) (2)	Bentuk Asesmen (Penilaian) Form of Assessment (3)	Bobot / Load (%) (4)
	<p><b>LLO 6:</b> Students understand and are able to analyze discrete-time signal such as: singularity function, exponential and geometrical complex, Fourier transform and representation</p>	<ul style="list-style-type: none"> <li>• <i>Written Task 5</i> Represent periodic signals with Fourier representation, determining signal transformation using Fourier Representation characteristics, Representing continuous-time signal with Fourier Transformation, determining frequency response using Fourier</li> <li>• 1 soal pada Quiz 2 (1 Question in Quiz 2)</li> <li>• 2 soal pada EAS (2 Questions in Final Exam)</li> </ul>	
11	<p><b>Sub CP-MK 7:</b> Mahasiswa memahami dan mampu melakukan analisa terhadap sistem linear dan tidak berubah terhadap waktu (LTI) pada domain Z</p> <p><b>LLO 7:</b> Students understand and able to analyze Linear Time Invariant System in Z domain</p>	<ul style="list-style-type: none"> <li>• Tugas Tertulis 6 Merepresentasikan sinyal dan sistem LTI pada domain Z Melakukan analisa terhadap sinyal dan sistem LTI pada domain Z</li> <li>• <i>Written Task 6</i> Represent signal and LTI system in Z domain, able to analyze signal and LTI Systems in Z domain</li> <li>• 1 soal pada Quiz 2 (1 Question in Quiz 2)</li> <li>• 1 soal pada EAS (1 Question in Final Exam)</li> </ul>	2.5
12-14	<p><b>Sub CP-MK 8:</b> Mahasiswa mampu merancang filter digital sederhana</p> <p><b>LLO 8:</b> Students are able to design simple digital filters</p>	<ul style="list-style-type: none"> <li>• Tugas Pemrograman 6 Membuat program filter digital sederhana</li> <li>• Quiz 2</li> <li>• <i>Programming Task 6</i> Creating simple digital filter</li> <li>• Quiz 2</li> <li>• 1 soal pada EAS (1 Question in Final Exam)</li> </ul>	5
16	<p><b>Evaluasi Akhir</b></p> <p><b>Final Exam</b></p>	<p><b>Tes:</b> Ujian Tulis/Ujian Daring</p> <p><b>Test:</b> Writing Exams / Online Exams</p>	20
<b>Total bobot penilaian Total assessment load</b>			<b>100%</b>

● **Indikator Pencapaian CPL Pada MK / Indicator of PLO achievement charged to the course**

<b>CPL yang dibebankan pada MK / PLO charged to the course</b>	<b>CPMK / Course Learning Outcome (CLO)</b>	<b>Minggu ke / Week</b>	<b>Bentuk Asesmen / Form of Assessment</b>	<b>Bobot / Load (%)</b>
CPL-01 / PLO-01	CPMK 2 / CLO 2	Week-2	Task 2 + Demo 2	5
		Week-5	Quiz 1 Question 2	
		Week-8	Mid Exam Question 1 and 2	
		Week-16	Final Exam Question 1	
CPL-02 / PLO-02	CPMK 1 / CLO 1	Week-1	Task 1 + Demo 1	7.5
		Week-5	Quiz 1 Question 1	
	Week-8	Mid Exam Question 1		
	CPMK 3 / CLO 3	Week-3	Task 3 + Demo 3	
Week-5		Quiz 1 Question 2		
Week-8		Mid Exam Question 1 and 2		
Week-16		Final Exam Question 2		
CPMK 4 / CLO 4	CPMK 4 / CLO 4	Week-4	Task 4	12.5
		Week-8	Mid Exam Question 1 and 2	
		Week-16	Final Exam Question 3	
		CPMK 6 / CLO 6	Week-9,10	
Week-12,13,14	Quiz 2 Question 1			
Week-16	Final Exam Question 5			
CPMK 7 / CLO 7	CPMK 7 / CLO 7		Week-11	Task 6
		Week-12,13,14	Quiz 2 Question 2	
		Week-16	Final Exam Question 6	
		CPL-06 / PLO-06	CPMK 5 / CLO 5	Week-6,7
Week-16	Final Exam Question 4			
CPMK 8 / CLO 8	Week-12,13,14		Demo 6	5
	Week-16	Final Exam Question 7		
				<b>Σ = 100%</b>

No	Form of Assessment	PLO-01	PLO-02	PLO-03	PLO-04	PLO-05	PLO-06	PLO-07	PLO-08	PLO-09	PLO-10	PLO-11	PLO-12	Total
1	Task 1		0.075											0.075
2	Task 2	0.05												0.05
3	Task 3		0.1											0.1
4	Task 4 (W)		0.025											0.025
5	Task 4 (P)						0.025							0.025
6	Task 5		0.1											0.1
7	Task 6 (W)		0.025											0.025
8	Task 6 (P)						0.05							0.05
9	Quiz 1	0.1												0.1
10	Quiz 2	0.1												0.1
11	Mid Exam	0.15												0.15
12	Final Exam	0.2												0.2
	<i>Total</i>	0.60	0.325				0.075							1

