Syllabus	Motivation Examples Cont	rol Engineering	Plant Modeling	Block Diagram		
		tomatic (`ontrol	1		
	ECE 400 - Au		lontroi			
	Basics and Plant Modeling					
	Assistant Prof. Dr. Klaus Schmidt					
	Department of Mechatronics Engineering – Çankaya University					
	Compulsory Course in Elec Engin Credits	ctronic and o leering (3/0/3)	Communication			
	Course Webpage: http:/	//ECE488.ca	ankaya.edu.tr			
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Syllabus	Motivation Examples Cont	rol Engineering	Plant Modeling	Block Diagram		
Con	tant and Structura					
	tent and Structure					
Con	tent					
•	Modeling Dynamic Systems					
•	Linear State Space and Transfer	r Function N	/lodels			
•	Model Analysis					
•	Basic Control Concepts					
•	Control Loop Analysis					
•	Control Loop Design					
•	Matlab/Simulink Examples					
Stru	icture					
•	3 lecture hours: Thursday 15:40	– 17:30; Fr	iday 13:40			
•	Office hours: Friday 12:40 - 13:3	30				
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Collabus	Mativation	E comentae	Control Engineering	Diant Madaling	Dis als Dis group
Syllabus	Motivation	Examples	Control Engineering	Plant Modeling	Block Diagram
Grad	ding and Lite	erature			
Grad	ding				
•	10 Quizzes (10	%)			
•	12 Homeworks	(25%)			
•	1 Midterm Exa	m (25%)			
•	1 Final Exam (40 %)			
Lite	erature				
•	Goodwin, Graham	ı, Graebe Stei	fan, Salgado, Mario:	"Control System	Design" ,
	Prentice-Hall, Inc.	., 2001 (ISBN	I: 0-13-958653-9) (M	lain Textbook)	
٠	Ogata, Katsuhiko Inc., 2009 (ISBN:	: "Modern Co 0-13-615673	ontrol Engineering (5t -8)	h Edition)", Prer	ntice-Hall,
•	Astrom, Karl and Scientists and Eng 0-691-13576-2)	Murray, Rich gineers", Prin	ard: "Feedback Syste ceton University Pres	ms: An Introduct s, 2008 (ISBN:	ion for
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Klaus Sc ECE488 Syllabus Mot	- Automatic Control Motivation	Examples	Control Engineering	Plant Modeling	Department Block Diagram
Klaus Sc ECE488 Syllabus Mot	Automatic Control Motivation Civation: Basi Control is a manij	Examples iCS discipline the pulation of	Control Engineering hat is concerned w a <u>dynamic system</u>	Plant Modeling vith the <u>autom</u>	Department Block Diagram
Klaus Sc ECE488 Syllabus Mot Cont	Motivation Motivation Erol Control is a manij	Examples iCS discipline tl pulation of	Control Engineering hat is concerned w a <u>dynamic system</u>	Plant Modeling with the <u>autom</u>	Department Block Diagram
Klaus Sc ECE488 Syllabus Mot Cont Dyn Syst	Automatic Control Motivation Civation: Basi Control is a manif Mamic System	Examples iCS discipline the pulation of dynamic de	Control Engineering hat is concerned w a <u>dynamic system</u> pendency between	Plant Modeling with the <u>autom</u> 's behavior	Block Diagram
Klaus Sc ECE488 Syllabus Mot Cont Dyn Syst	Automatic Control Motivation Control is a Control is a manif Mamic System tem that shows of Signal is a time temperature, ve	Examples iCS discipline the pulation of dynamic de e-varying phe oltage, curr	Control Engineering hat is concerned w a <u>dynamic system</u> pendency between nysical quantity (e ent,)	Plant Modeling Vith the <u>automa</u> 's behavior input and out .g. position, ve	Department Block Diagram atic sput signals elocity,

• Dynamic systems are for example modeled by differential equations, difference equations, transfer functions

Syllabus	Motivation	Examples	Control Engineering	Plant Modeling	Block Diagram
Motiva	tion: Dyr	namic Sys	stem in Contro	ol	
Detaile	d Graphica	I Represen	tation		
					Gap 1
Manin	ulation of a	Dynamic	System		
wanipu	nation of a	Dynamic	System		
Appl	ication of a	opropriate in	nputs such that th	he system state	/output
	behaves as	s desired ev	en in the presence	e of disturbance	25
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Syllabus	Motivation	Examples	Control Engineering	Plant Modeling	Block Diagram
Evama	lac: Doon	Tompor	atura Suctom		
схатр	ies. Roon	i remper	ature System		
Schema	tic		Graphical	Representatio	on
	∽ Out∂	loor influence			Gap 2
			7		
	roo tempe	m 🌡 rature			
	······ P ·				
valve					
	ra	diator perature			
Control	Task				
• Des	ired (specifie	ed) behavio	r: keep room tem	perature consta	nt
		, 			

• Manipulation: automatically adjust valve position

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Syllabus	Motivation	Examples	Control Engineering	Plant Modeling	Block Diagram
Exam	ples: Vehi	cle Speed			
Schem	atic		Graphical	Representation	on
	speed	gas pedal			Gap 3
Contro	l Task				
• De	sired (specifi	ed) behavior	r: keep vehicle sp	eed constant	
• Ma	anipulation: a	automatically	/ adjust pedal po	sition	
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Syllabus	Motivation	Examples	Control Engineering	Plant Modeling	Block Diagram
Exam	ples: Mag	netic Susp	pension		
Schem	atic		<u> </u>		
	alle		Graphical	Representation	on
	train train	p x et suspension	Graphical	Representatio	Gap 4
Contro	train train rail magn	ap x et suspension	Graphical	Representatio	Gap 4
Contro • De	train train rail magn rail	ap x et suspension ed) behavior	r: Move to/keep s	Representation	Gap 4

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Examples: Movies
Inverted Pendulum
 Desired (specified) behavior: Keep pendulum upright
 Manipulation: horizontally move cart
\Rightarrow http://www.rt.eei.uni-erlangen.de/FGnls/video/inverted_pendulum.wmv
Automatic Parking
 Desired (specified) behavior: Reach parking position (without collision)
 Manipulation: automatically adjust speed and steering angle
\Rightarrow http://www.rt.eei.uni-erlangen.de/FGnls/video/automatic_parking.wmv
Ball on Plate
 Desired (specified) behavior: follow path/keep position
 Manipulation: automatically change orientation of plate
\Rightarrow http://www.rt.eei.uni-erlangen.de/FGnls/video/ball_on_plate.wmv
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Syllabus Motivation Examples Control Engineering Plant Modeling Block Diagram
Control Engineering: Basic Task
Control Eligineering. Dasic Task
Main Task of Control Engineering
Design and realize technical appliance – controller – that enforces the desired output behavior of the plant when connected to the plant
Feedforward Control
Gap 5
Gap 5 Gap 5 ⇒ Feedforward controller provides appropriate input such that the plant
$\stackrel{\text{Gap 5}}{\Rightarrow}$ Feedforward controller provides appropriate input such that the plant follows a given reference signal

Syllabus

Motivation

Examples

Control Engineering

Plant Modeling

Block Diagram

Syllabus	Motivation	Examples	Control Engineering	Plant Modeling	Block Diagram
Contr	ol Enginee	ring: Bas	ic Principles		
Feedba	ck Control				
					Gap 6
				· cc 1 .	
\Rightarrow Feed reference	back control	the measure	compensate the d ed output signal	ifference betwee	en a
Remarl	<s< td=""><td></td><td></td><td></td><td></td></s<>				
• Co	ntrol problem	ns occur in I	many subject area	as 	
• Exa net	amples: proce works auton	ess engineer notive appli	ing, electrical eng cations medicine	gineering, comm chemistry biol	unication
\Rightarrow	Mathematica	al abstractio	on of control prob	lems to enable	-8),
int Klaus Schmid	erdisciplinary ¹¹	application			Department
ECE488 – Aı	utomatic Control				·
Syllabus	Motivation	Fxamples	Control Engineering	Plant Modeling	Block Diagram
Contr	ol Enginee	ring: Ger	eral Solution	Procedure	
Proced	ure				
 Ma 	athematical n	nodeling of	plant		
\Rightarrow	Abstraction	from the ph	ysical problem		
2 An	alysis of the Determine b	plant behav	ior	nd their implica	tions on
	e design	asic propert	les of the plant a		
3 Co	ntroller desig	n			
\Rightarrow	Achieve desi	red plant be	ehavior		
● Sin⇒	Nulation and Verify if desi	test on the gn goals are	real system e achieved		
	The main sub with a single	ojects of thi e input sign	s lecture are item al and a single ou	s 1 to 3 for syst tput signal (SIS	tems 50)
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Plant Modeling: Basic Idea
A <u>plant model</u> is a <u>mathematical description</u> of the <u>cause-effect</u> relationship between the plant <u>signals</u> that are <u>relevant</u> for the design task
Remarks
 Different design tasks for the same system can lead to different plant models
 We focus on models for control tasks
• We consider as relevant signals
 Input signals (signals that we can directly influence) Output signals (signals that we want to manipulate) Disturbance signals (signals that cannot be directly influenced and that
can have a negative effect on the system)
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Syllabus Motivation Examples Control Engineering Plant Modeling Block Diagram
Plant Modeling: Example
RC-Circuit
Gap 7
• Input: $u = i$
• Output: $y = v$
Differential Equation $C \cdot \frac{dy}{dt} + \frac{1}{R} \cdot y = u$
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Syllabus

Motivation

Examples

Control Engineering

Plant Modeling

Block Diagram



Plant Modeling: Basic Dynamic Behavior in this Lecture

Linear Time-invariant Ordinary Differential Equation (LTI ODE)

$$a_n y^{(n)} + a_{n-1} y^{(n-1)} + \dots + a_1 \dot{y} + a_0 y =$$

 $b_m u^{(m)} + b_{m-1} u^{(m-1)} + \dots + b_1 \dot{u} + b_0 u$

Notation

- y: output signal (in the time domain)
- *u*: input signal (in the time domain)
- $y^{(i)}(u^{(i)})$: *i*-th time derivative of y(u)
- a_i , b_i : coefficients in \mathbb{R}
- *n*: highest derivative of *y*
- m: highest derivative of u

Block Diagram: Description	
Characteristics of the Block Diagram	
A block diagram is a graphical representation of the cause-effect relationship between signals by blocks and direct	ted lines
\Rightarrow Visualization of direction of action and interdependencies Block Diagram Components	
 Directed Lines: System signals and their direction of action Circles: Summation of signals 	1
	Gap 9
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Syllabus Motivation Examples Control Engineering Plant Modeling	Block Diagram
Block Diagram: Description	Block Diagram
Block Diagram: Description	Block Diagram Gap 10
Block Diagram: Description	Block Diagram Gap 10
Block Diagram: Description	Block Diagram Gap 10
Block Diagram: Description	Block Diagram Gap 10
Block Diagram Components	Block Diagram Gap 10
Synabus Motivation Examples Control Engineering Plant Modeling Block Diagram: Description	Block Diagram Gap 10 mapping
Syllabus Motivation Examples Control Engineering Plant Modeling Block Diagram: Description	Block Diagram Gap 10 mapping Gap 11
Block Diagram Components Block Diagram Components • Rectangles: Dynamic relationship between signals: unique r	Gap 10 mapping Gap 11
Block Diagram Components • Rectangles: Dynamic relationship between signals: unique of from input signal to output signal	Gap 10 Gap 11 Gap 11
Solution Examples Control Engineering Plant Modeling Block Diagram Components Rectangles: Dynamic relationship between signals: unique n from input signal to output signal Rectangles and circles are transfer blocks	Gap 10 mapping Gap 11
Block Diagram Components Block Diagram Components • Rectangles: Dynamic relationship between signals: unique of from input signal to output signal → Rectangles and circles are transfer blocks Klaus Schmidt	Block Diagram Gap 10 mapping Gap 11 Department



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Plant	Modeling:	System	Equations		
Comp	utation				
•					Gap 13
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Plant	Modeling	Block D)iagram		
i iant	mouching.	DIOCK L	agram		
Graph	ical Represe	entation			C 14
					Gap 14
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