INSTRUMENTATION AND CONTROL TECHNOLOGY

Systems for Training Technicians and Engineers

MATLAB & SIMULINK

2nd Edition

CONTENTS

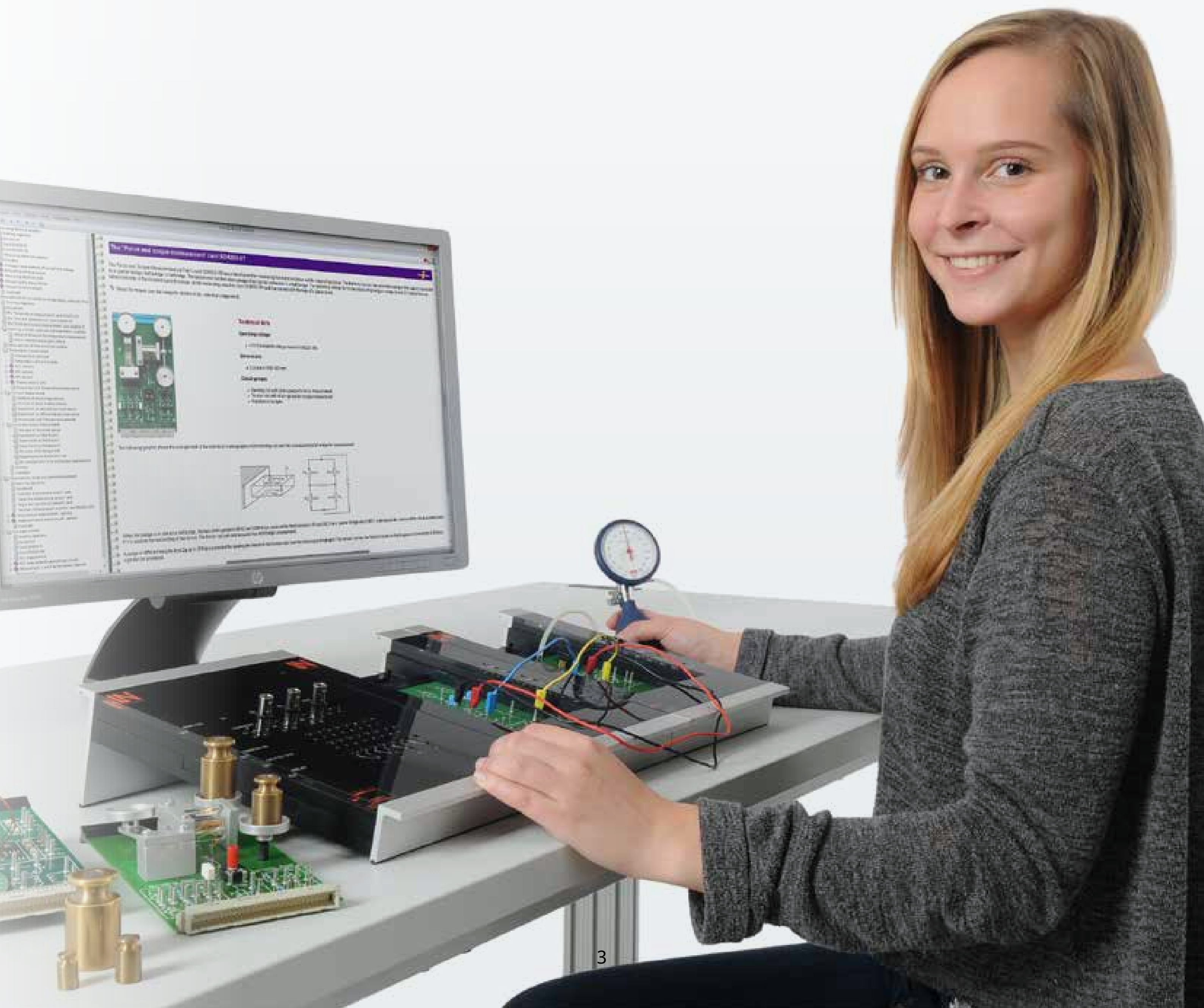
QUALITY TRAINING FOR QUALITY QUALIFICATIONS

Training Systems for Instrumentation and Control Technology

Technical progress...
Modern smart factories involve the meshing of production processes with the latest information and communications technology. This makes it possible to manufacture tailor-made products that match the customers' needs at inexpensive prices but in high quality. This concept is predicated on data acquisition pertaining to the status of the production system and the closed-loop control of process variables. This is accomplished using a wide variety of sensors that operate according to different physical principles. Knowledge of sensor systems is therefore essential for anyone dealing with automation or closed-loop control technology as well as for mechatronics technicians.

... has a major impact on education and training
Changing demands call for new, modern, practice-oriented training systems. These systems instruct trainees on the most up-to-date technology and provide them with the requisite skills.

Go to our website at www.lucas-nuelle.com where you can get inspired by watching some videos of our training systems



MORE THAN A LABORATORY

Complex educational content is presented
in vivid fashion using modern training media

Investigate instrumentation and control technology
in process engineering production systems

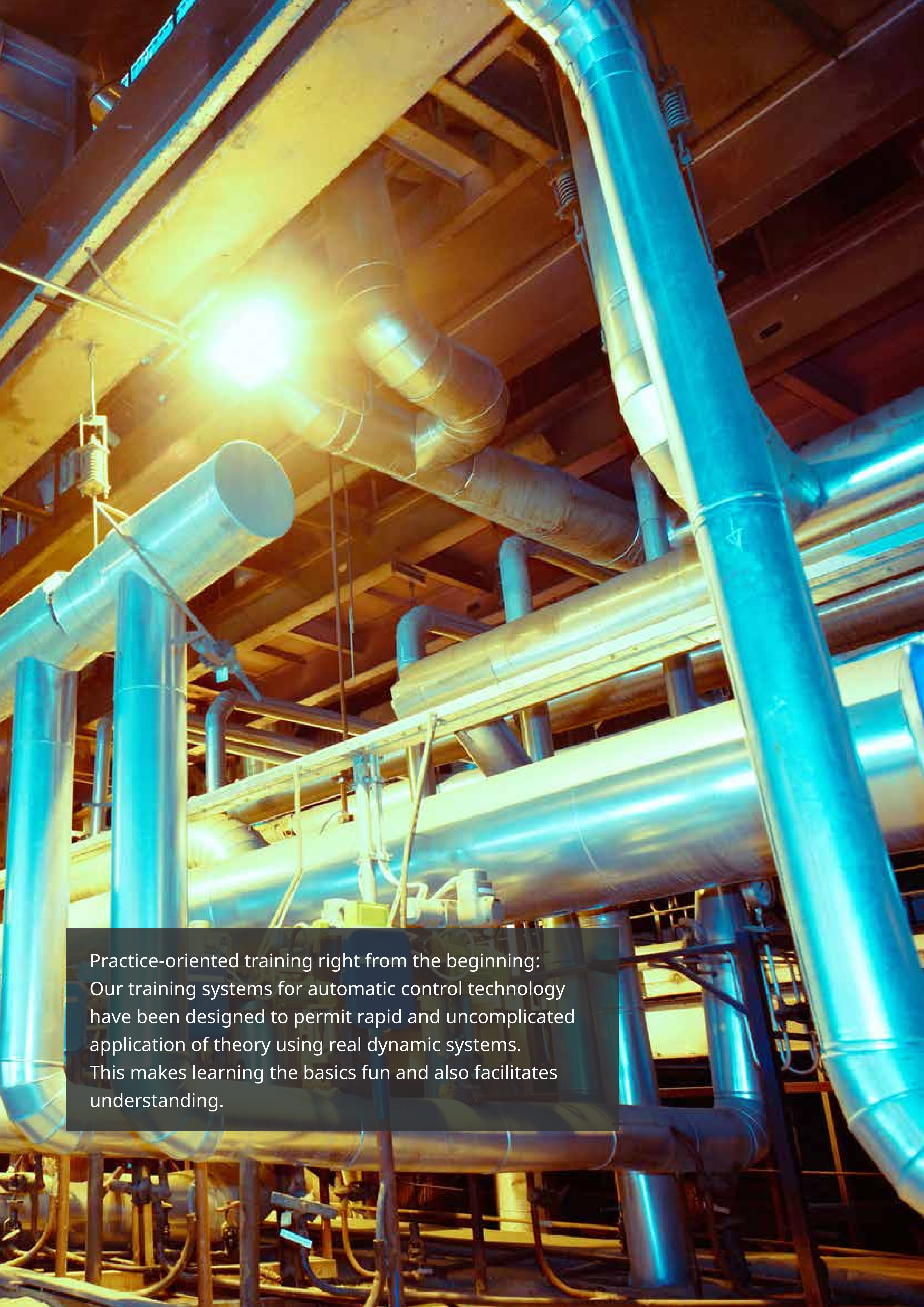
A variety of applications in closed-loop control
bring you up to speed to do your job professionally

Keep an eye on everything at all times
With the help of Classroom Manager, you can manage your trainees, adapt the training material for each trainee accordingly and monitor current learning progress

A comprehensive solution for instrumentation and control technology
Typical industrial models, controllers, PLC systems, drives and sensors

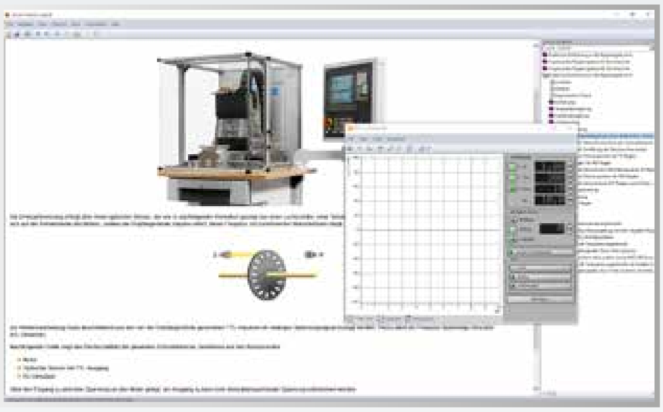
Multimedia-based teaching of knowledge via UniTrain
E-learning and experiments for solid and sustained learning

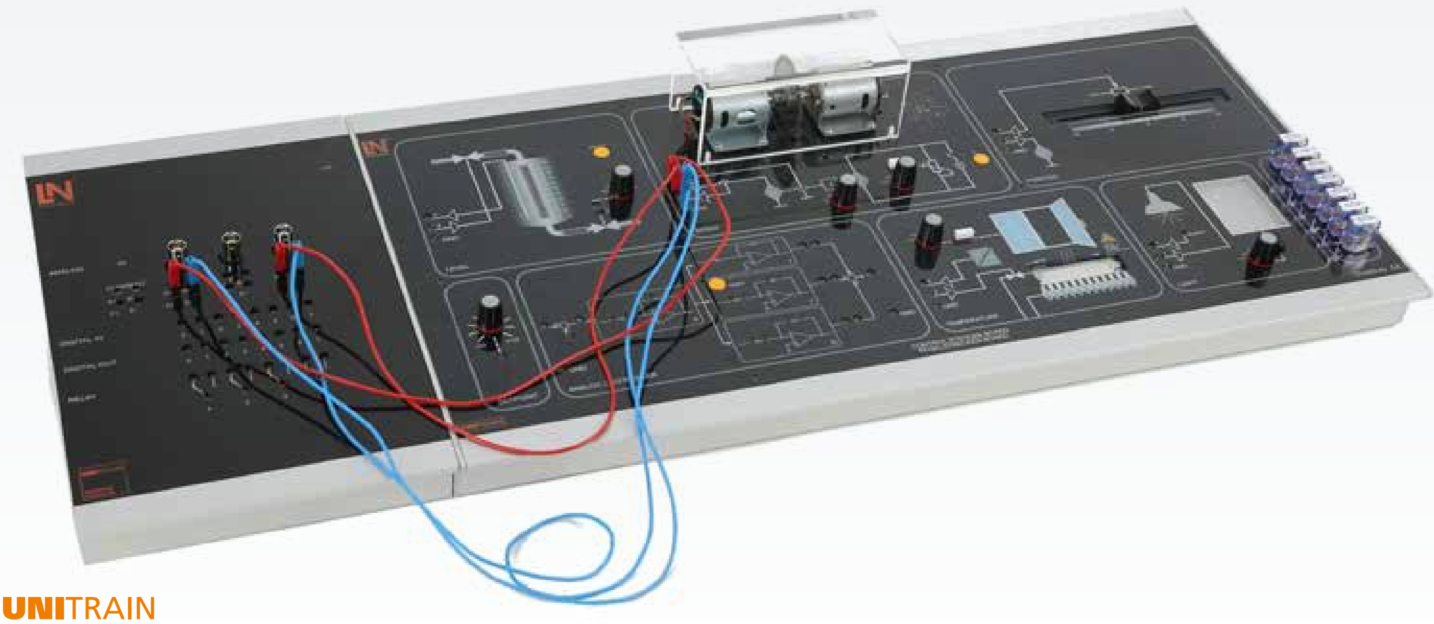
FUNDAMENTALS OF CONTROL TECHNOLOGY



Practice-oriented training right from the beginning: Our training systems for automatic control technology have been designed to permit rapid and uncomplicated application of theory using real dynamic systems. This makes learning the basics fun and also facilitates understanding.

CLOSED-LOOP CONTROL OF TEMPERATURE – SPEED – LIGHT – LEVEL – POSITION





UNITRAIN
SYSTEM

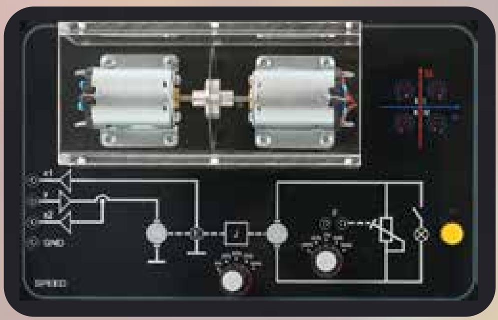
In the age of automation, automatic closed-loop control technology is of the utmost importance for technical systems. A fundamental understanding of how various types of controllers and controlled systems respond in the time and frequency domains is vital for choosing the right controllers and for ensuring that the control loop operates safely.

Training contents

- Operating principles for open- and closed-loop control
- Design and function of continuous and discontinuous controllers
- Practice-oriented investigation of control loops with continuous controllers in time and frequency domains
- Optimisation of a closed-loop room temperature control system
- Design and optimisation of an electrical drive system in 4 quadrants
- Investigation of a lighting controlled system for room lighting
- Design of a closed-loop filling level control system for a tank installation
- Investigation of a servo position control system as used in actual practice
- Analog controller with variable parameters for a vivid demonstration of closed control loop design

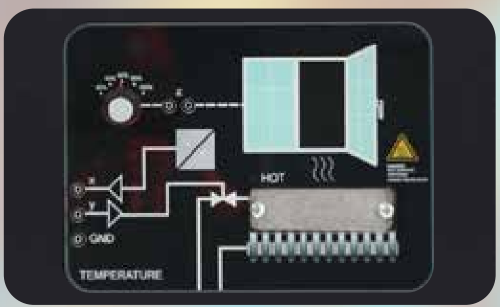
Order no. CO4204-8J

COMPACT AUTOMATIC CONTROL TECHNOLOGY – 5 DIFFERENT CONTROLLED SYSTEMS ON ONE BOARD

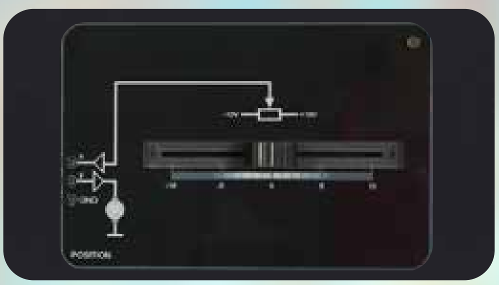


Speed controlled system
- Coupled drive system with two DC motors
- Operation in 4 quadrants
- Measurement of speed using incremental encoder
- Adjustable load and flywheel emulation
- Current detection for secondary current control loop

Filling level controlled system
- Digital model of a filling level controlled system
- Adjustable inlet feed
- Adjustable outlet feed as disturbance variable
- Visualization of filling level as well as inlet and outlet feed via LED display



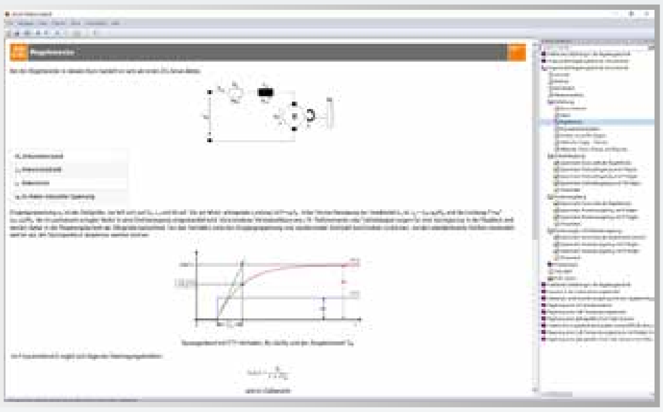
Temperature controlled system
- High-speed temperature controlled system with built-in power amplifier
- Built-in temperature sensor
- Pre-setting of disturbance variables



Position controlled system
- Drive with spindle
- Position feedback via potentiometer
- Automatic shut-off at end positions

Light controlled system
- Controlled system is unaffected by ambient light
- Built-in LED light source and sensor
- Presetting of interference light to explore control system

SERVO TECHNOLOGY –
PRECISION CONTROL OF ANGLE AND SPEED



UNITRAIN
SYSTEM

The DC servo-training system lets you automatically control both angle and speed with precision. Position and speed of a DC servo-motor are accurately detected by an incremental encoder with the data then passed on to a PC for further processing. This makes it possible to record step responses and determine time constants. Practical exercises convey the knowledge necessary to set parameters for P, I, PID and cascade controllers correctly, to deploy them and to understand their various effects on the system. Project work involves implementation of a time-dependent positioning sequence for a rotating platform.

Training contents

- Analysis of open- and closed-loop control implications for a DC servo-motor
- Closed-loop control of angle and speed
- Detection of position and speed of a DC servo by means of an incremental encoder
- Determination of control characteristic, lag time, transient response, system deviation and control oscillation
- Recording step responses
- Determining time constants
- Operation with various types of controller
- Investigation of servo-drive response to changes in load

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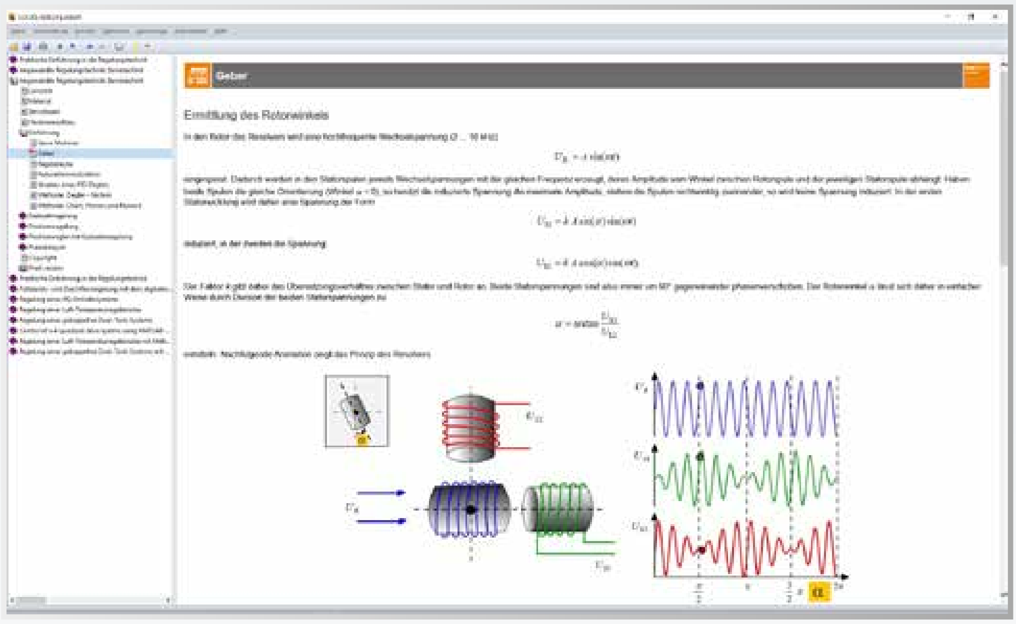
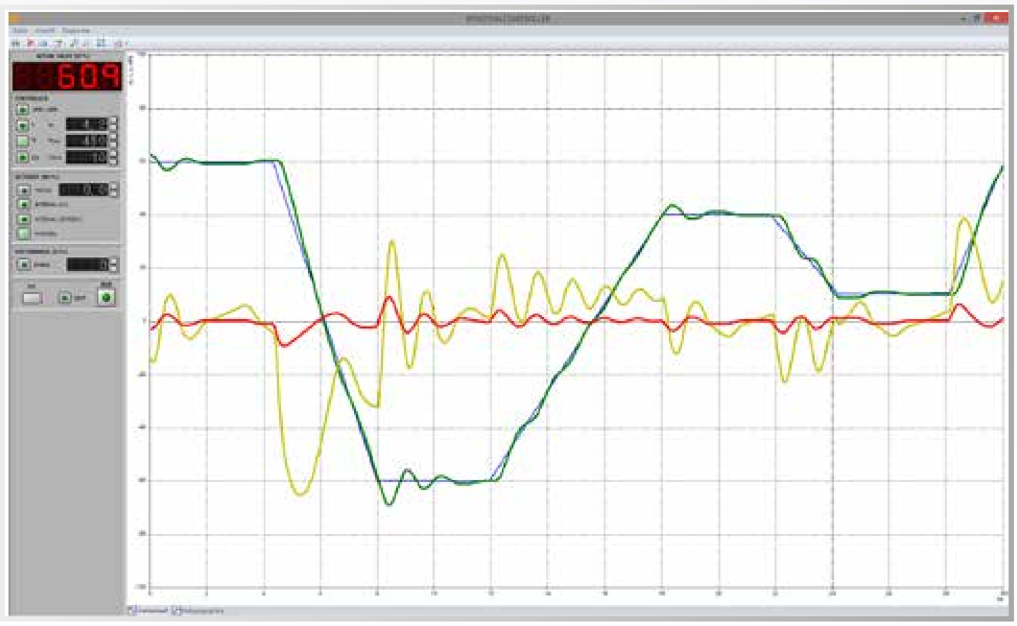
INTERACTIVE LEARNING PLATFORM



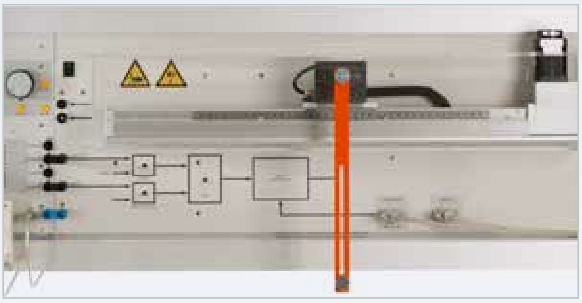
How does servo-control work?
In practice, it is often important to use a motor to move a tool to certain positions, e.g. the kinetic movements of a robot, or to maintain certain speeds. In most cases, digital controllers are used for this.

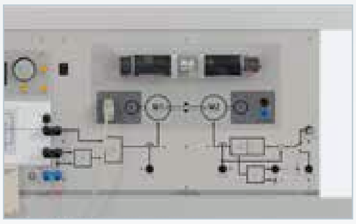
This ILA course shows step by step how the controller is calculated and optimised.

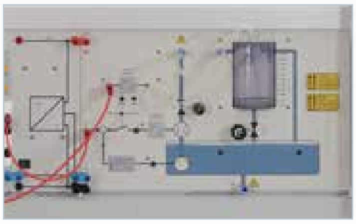


Position, speed and cascade controllers
The ILA course provides three different instruments for automatic position and speed control. Learn how various control parameters affect the drive system. Optimise the controllers and analyze how speed, position and system deviation change over time with the help of the relevant tools. Determine measures for optimising the controller for various load states.

ONE CONTROLLER FOR ALL CONTROLLED SYSTEMS







To make it possible for your students to achieve rapid success, the universal digital controller has been designed specifically for the needs of education and training. The controller can easily be combined with a variety of different controlled systems.

Benefits

- A compact, easy-to-operate and intrinsically safe system
- Can be combined with all controlled systems
- Measurement and display of controlled variables
- Output reference and disturbance variables
- Permits creation of complex control algorithms using Matlab®/ Simulink® and real-time implementation

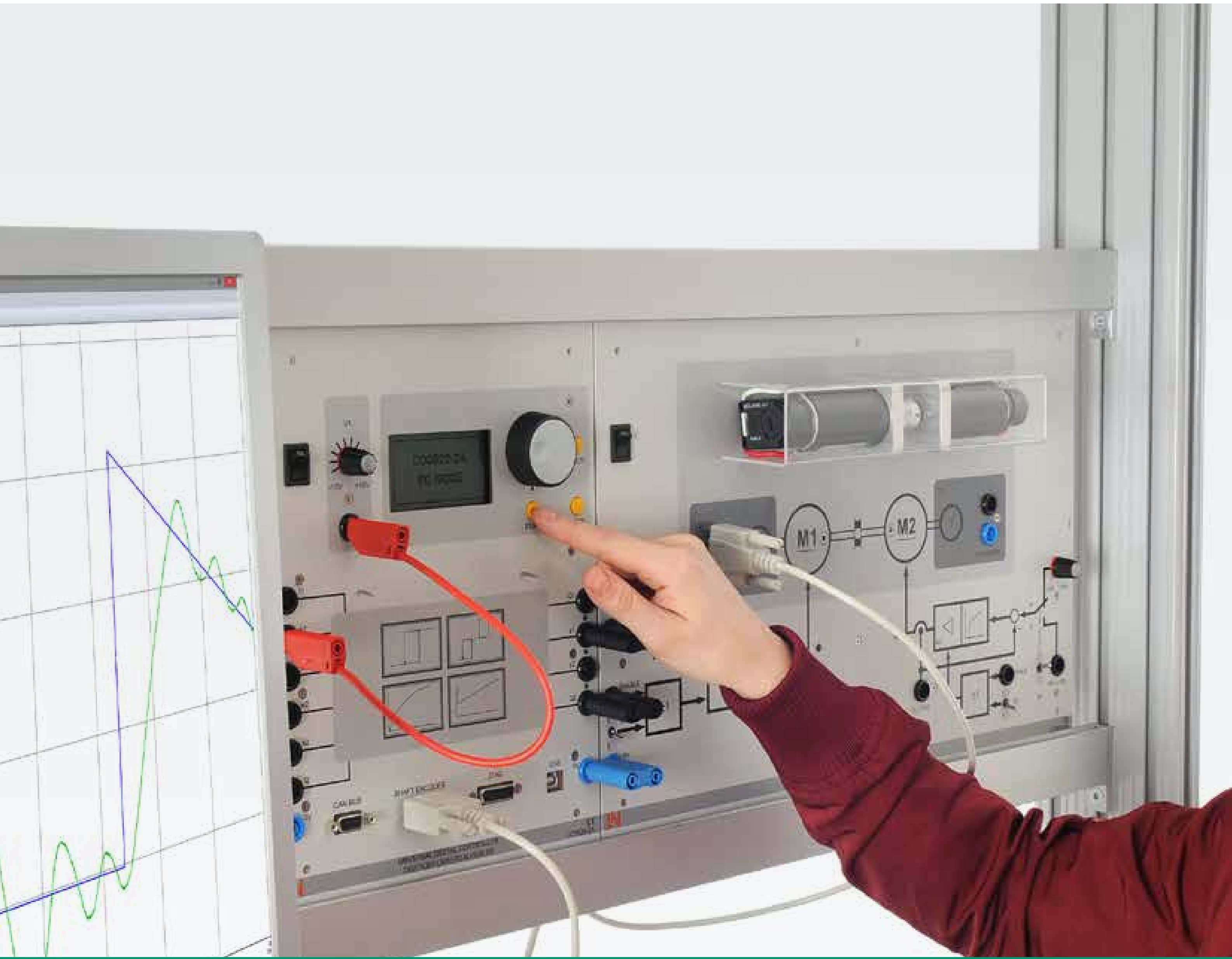
UNIVERSAL DIGITAL CONTROLLER

Training contents

- Combines all types of controller
- Two-position, three-position, P, I, D and PID controllers – in a single device
- Two independent controllers which can be used individually or cascaded
- Graphics-capable, backlit display
- Connection to PC via USB port
- Interface for connection to Matlab (JTAG)
- High-quality digital signal processor (DSP) for short controller cycle times of 125 µs
- 4 analog inputs with measuring range +/-10V
- 2 analog outputs for maximum of +/-10V
- 2 digital inputs and 2 digital outputs
- Input for incremental encoder
- CAN bus interface for expansion of controller
- Potentiometer for setting reference voltage

Order no. CO3620-2A

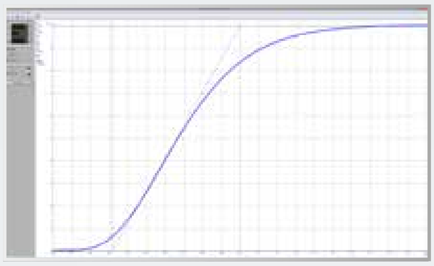
REAL-TIME MEASUREMENT – USER-FRIENDLY ANALYSIS ON PC



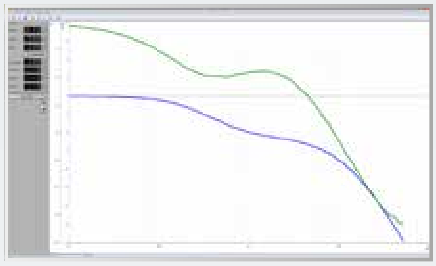
Virtual Instruments
With the help of virtual instruments it is possible to operate the universal digital controller via a PC which can then display the measured data. Virtual instruments have been specially developed for specific tasks. The reduced surface area makes it easy to operate them so that users can stay focused on what is important.

Benefits
- Simple analysis of control loops with various types of controllers
- Selection of control structures (two-position, three-position, PID and cascade controllers) and setting of parameters
- Setting of controller parameter values during operation
- Direct display of controller signals
- Comfortable pre-setting of reference and disturbance variable functions

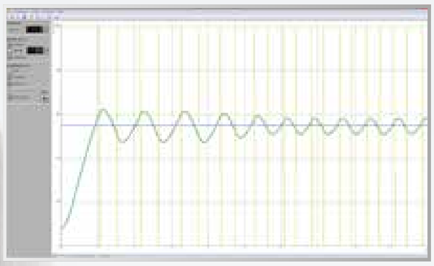
THE UNIVERSAL DIGITAL CONTROLLER

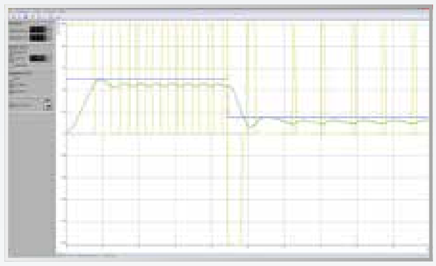


Step response plotter
- Simple setting of parameters for step outputs
- Selection of various controlled variable inputs:
  Analog, PWM, frequency, encoder input
- Automatic scaling of recording time

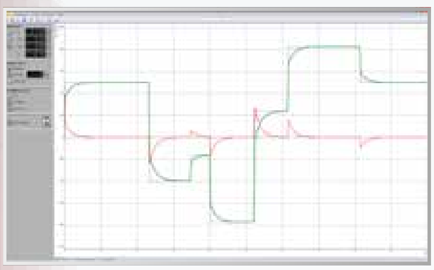


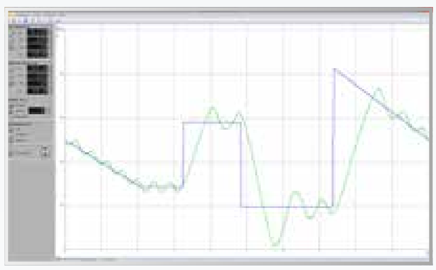
Bode plotter
- Adjustable start and end frequency
- Logarithmic or linear scaling of measuring range
- Display of frequency response or locus





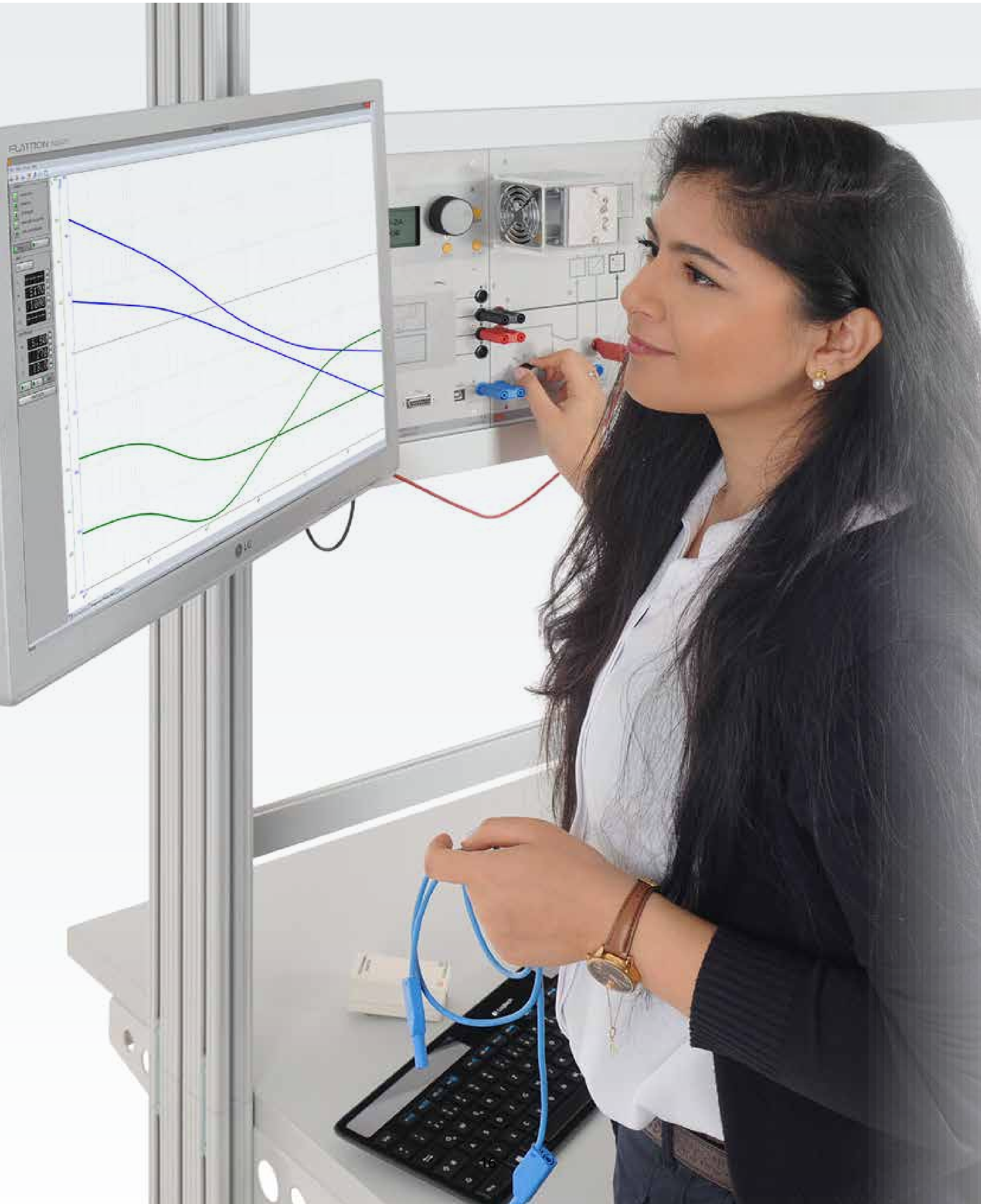
Two-position, three-position controllers
- For operation as discontinuous controllers
- Hysteresis pre-set
- Pre-setting of reference and disturbance variables



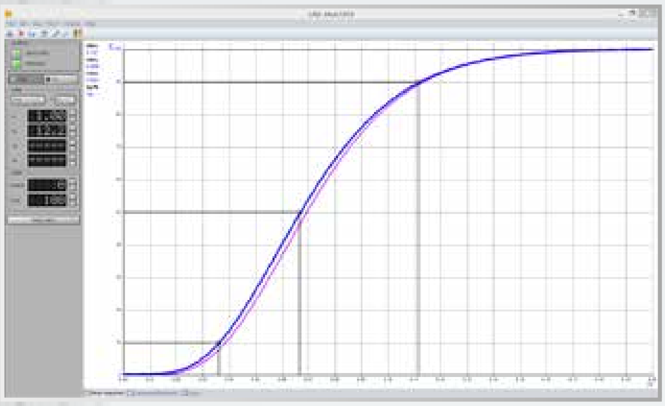


PID and cascade controllers
- For operation as continuous controllers
- Controller components selectable as desired
- Selectable controller cycle times

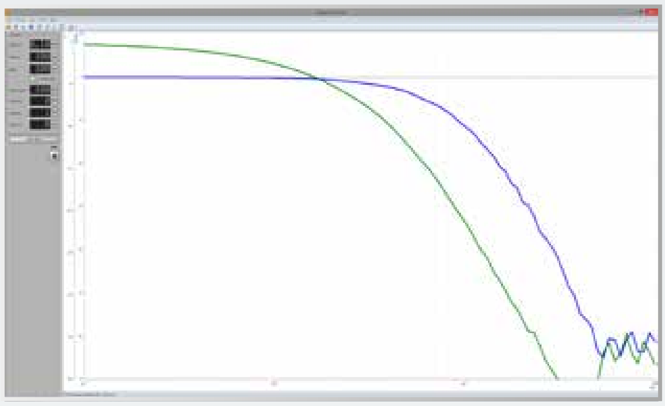
REAL-TIME MEASUREMENT – USER-FRIENDLY ANALYSIS ON PC



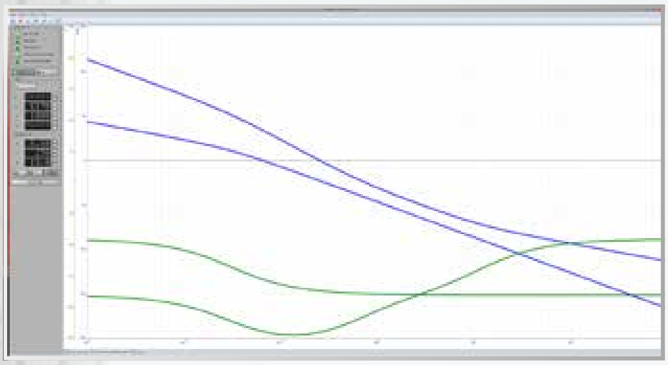
THE UNIVERSAL DIGITAL CONTROLLER



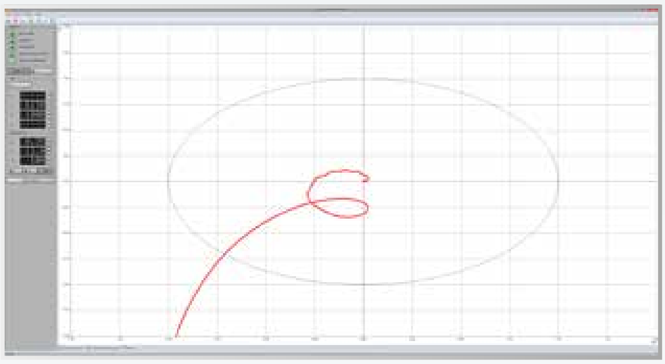
Controlled system responses from the step response plotter can be evaluated in the controlled system analyzer. Here there are special tools available for determining controlled system parameters based on the inflectional tangent method.



Based on the mathematical parameters of the step response, the system analyzer determines the amplitude and phase responses. These responses can then be compared to real characteristic curves from the Bode plotter.



The controlled system analyzer can display how amplitudes and phases change over time in an open control loop including those of the controller itself. The controller elements of the PID controller can be configured individually. The effects can be seen immediately. This means the control loop can be set up using the symmetrical optimum or gain adjustment methods, for example.

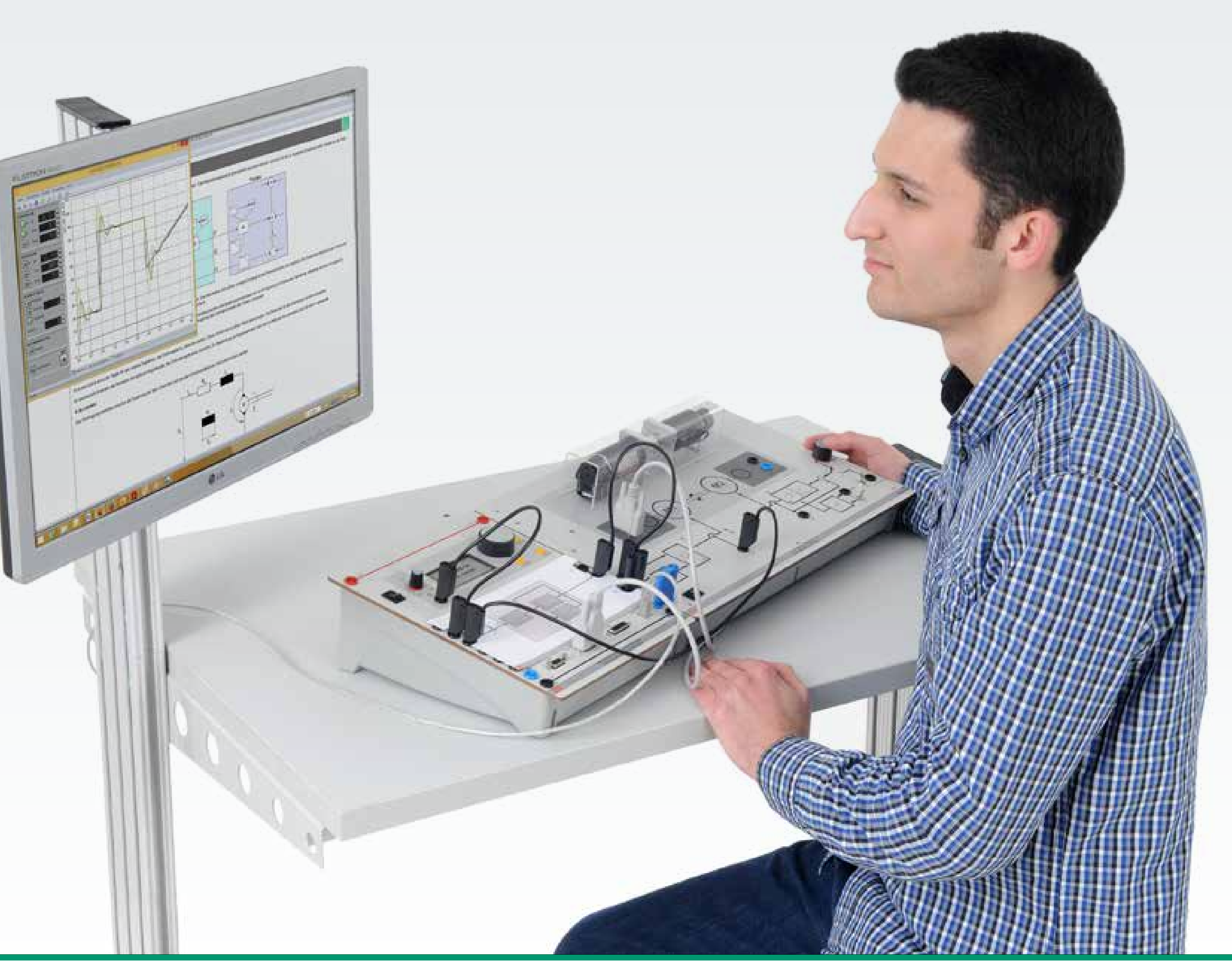


All data acquired can be displayed with the controlled system analyzer with the aid of its locus function. This is an easy way to analyze the quality of a control system.

Benefits

- Analysis of controlled systems in time and frequency domains
- Analysis of controlled system parameters
- Comparison of real controlled system characteristics with mathematical models of the system
- Conversion of system response from time domain to frequency domain
- Optimisation of controller settings with the aid of an open control loop
- Display showing frequency and amplitude response or as Bode plot or locus

MODEL-ASSISTED CONTROLLER DESIGN USING MATLAB®/SIMULINK®



Expand the Universal Digital Controller into a Programmable Rapid Prototyping System
Closed-loop control of variables is involved in almost all equipment and systems. Due to the huge technical strides being made, systems are becoming ever more complex and difficult to program. Implementation therefore frequently involves long periods of development. With the help of a special toolbox, it is possible to model complex controller structures in advance using Matlab®/ Simulink®. The automatically generated code resulting from this can then be tested on real controlled systems.

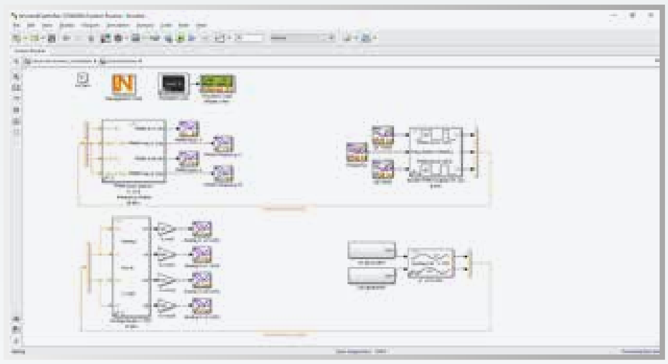
Benefits

- Non-hazardous work using intrinsically safe hardware
- Rapid, model-assisted software generation and parameter setting for closed-loop control
- Keeping track of new research approaches, e.g. state space control, condition monitoring for faults
- A controller cycle time of 125 µs makes it possible to develop even complex algorithms
- Optimisation of controllers or controller structure

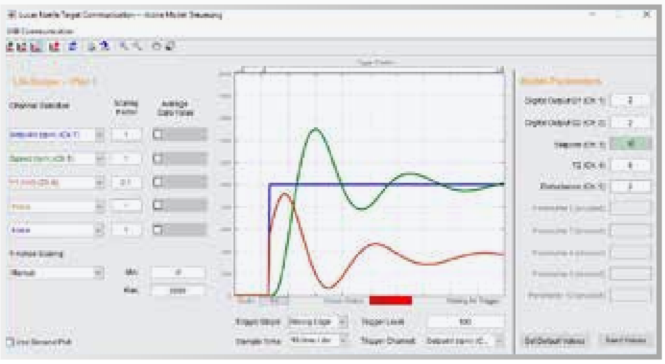
REACH YOUR OBJECTIVE QUICKER WITH MATLAB® TOOLBOX

A toolbox adapted to your hardware makes it possible to rapidly implement your own applications. In the toolbox, users can find all the components they need to control hardware-proximate functions and blocks for rapid transformations and controllers. Apart from the scope provided by Matlab®/Simulink®, the system can also be expanded with any number of your own library elements.

LN Matlab® toolbox
The toolbox provides all the function blocks necessary to communicate with the controller hardware. There are also suitable models for the various types of controlled systems.

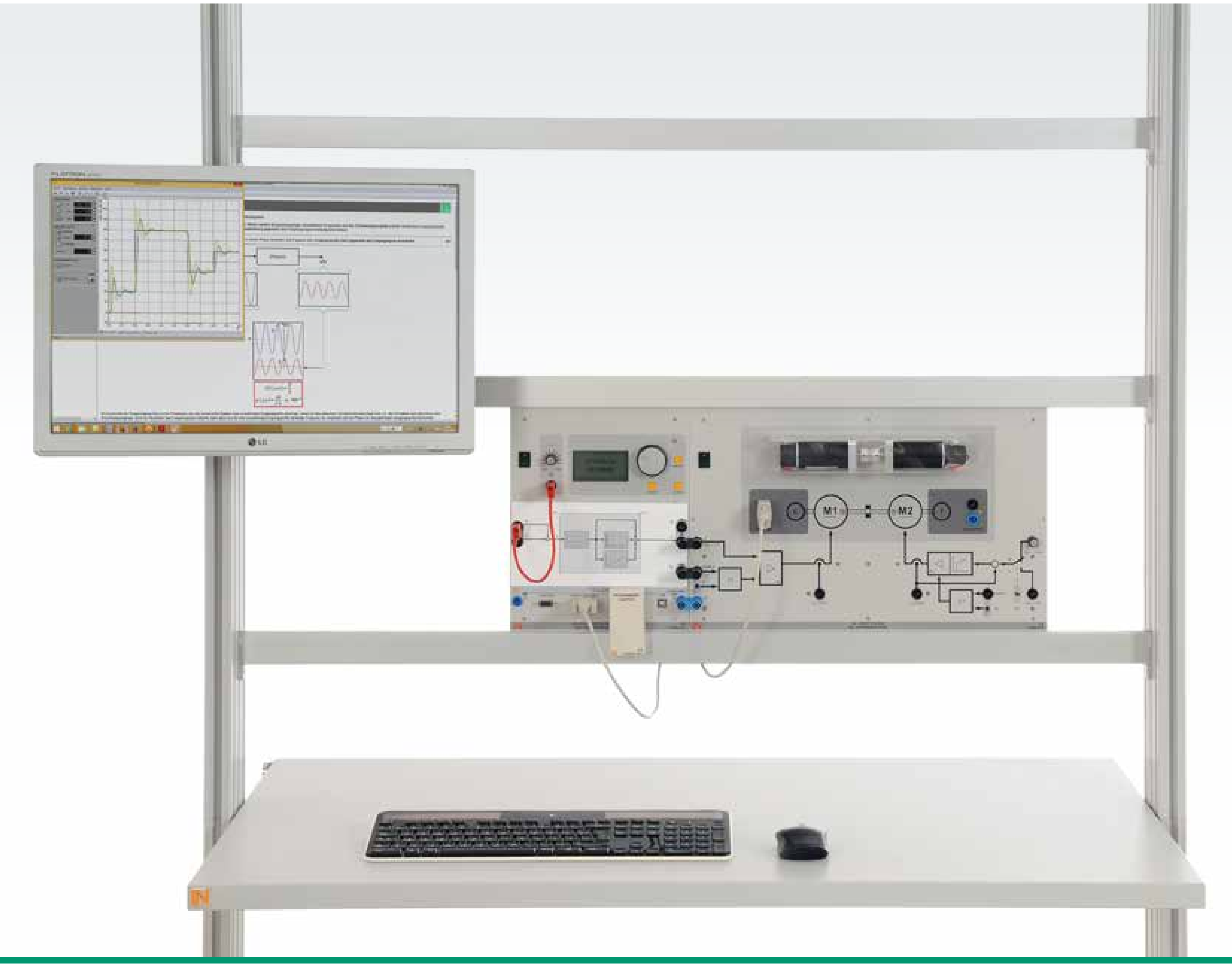


Project templates
Templates specially adapted to the hardware handle the otherwise complex and time-consuming job of hardware configuration. This means that users can immediately focus on programming using Matlab®/Simulink®.



Matlab® scope – direct link to the hardware
A special graphic interface establishes connection between Matlab® and the hardware via a USB link. The ways that internal variables change over time can be graphically displayed as they happen. Various time bases and trigger options are available. In addition to display in the time domain, it is also possible to display signals in the frequency domain. Parameters such as those for the controller itself can easily be transferred from PC to hardware while the system is running.

CLOSED-LOOP CONTROL OF A FOUR-QUADRANT DRIVE SYSTEM

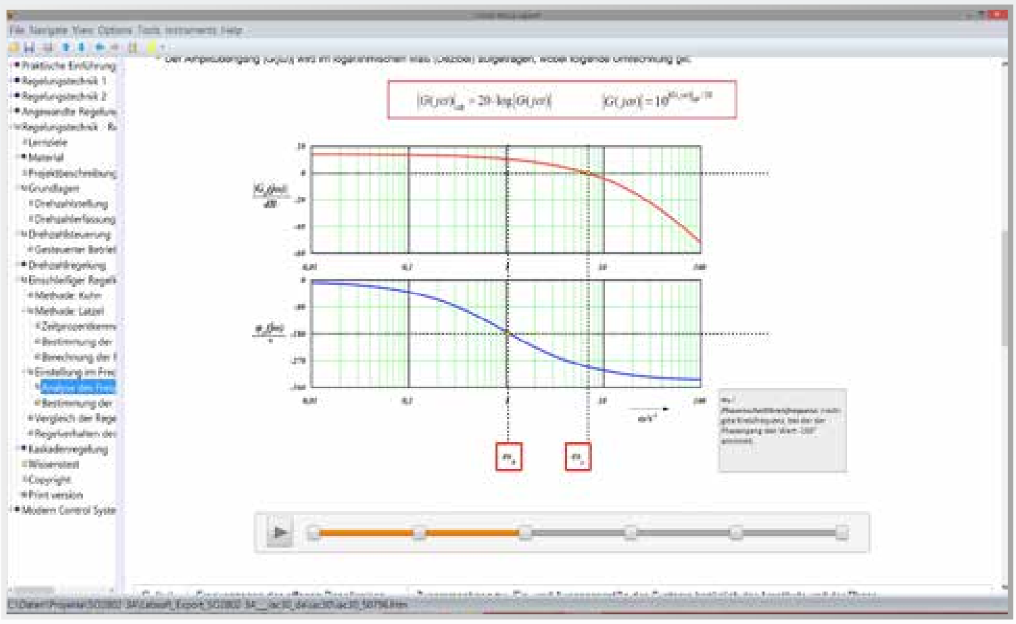


Training System
Closed-loop controlled drives with high-speed dynamic requirements are often used for automation solutions, e.g. for machine tools or robot systems. This training system enables investigation of a wide range of different automatic control concepts with graphic clarity.

Benefits
- Coupled drive system with two 90 W DC motors
- Operation in all 4 quadrants
- Tacho-generator and incremental encoder feedback systems
- Highly dynamic 4-quadrant controller with output current up to 6 A
- Built-in current sensor for simple measurement and automatic control of current
- Built-in automatic current control enables well defined step changes in load

Order no. CO3620-1M

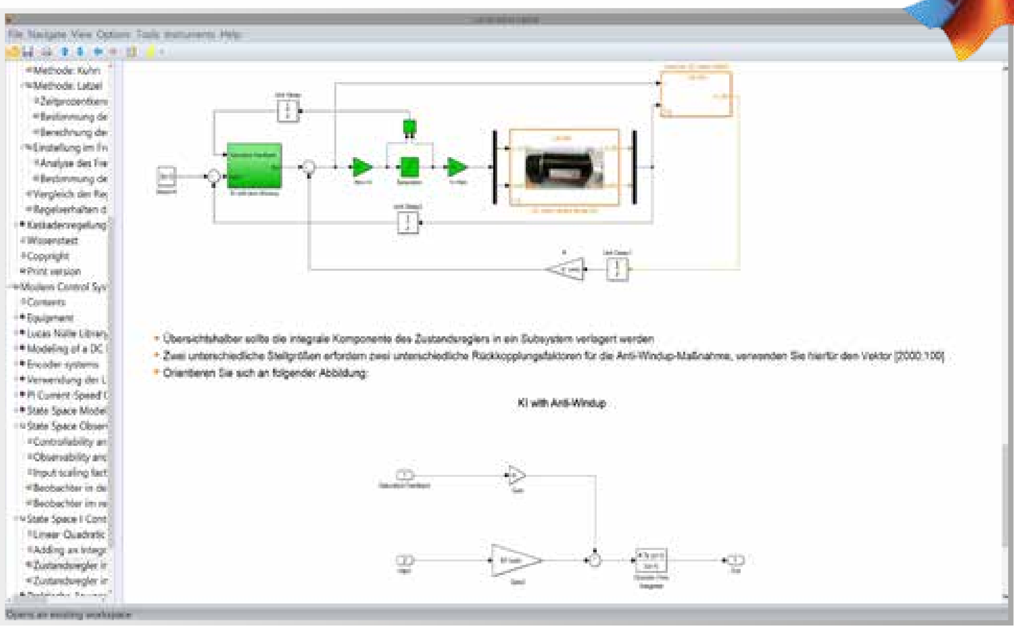
WITH INTERACTIVE LAB ASSISTANT (ILA)



IAC 30 Control of a 4Q Drive System

Training contents

- Design and optimisation of a drive control system in
- 4 quadrants
- Identification of controlled system
- Determination of suitable control parameters in time and frequency domains using methods like those employed in practice (Kuhn, Latzel, Ziegler-Nichols and Bode plots)
- Design and optimisation of a cascade control system for current and speed control

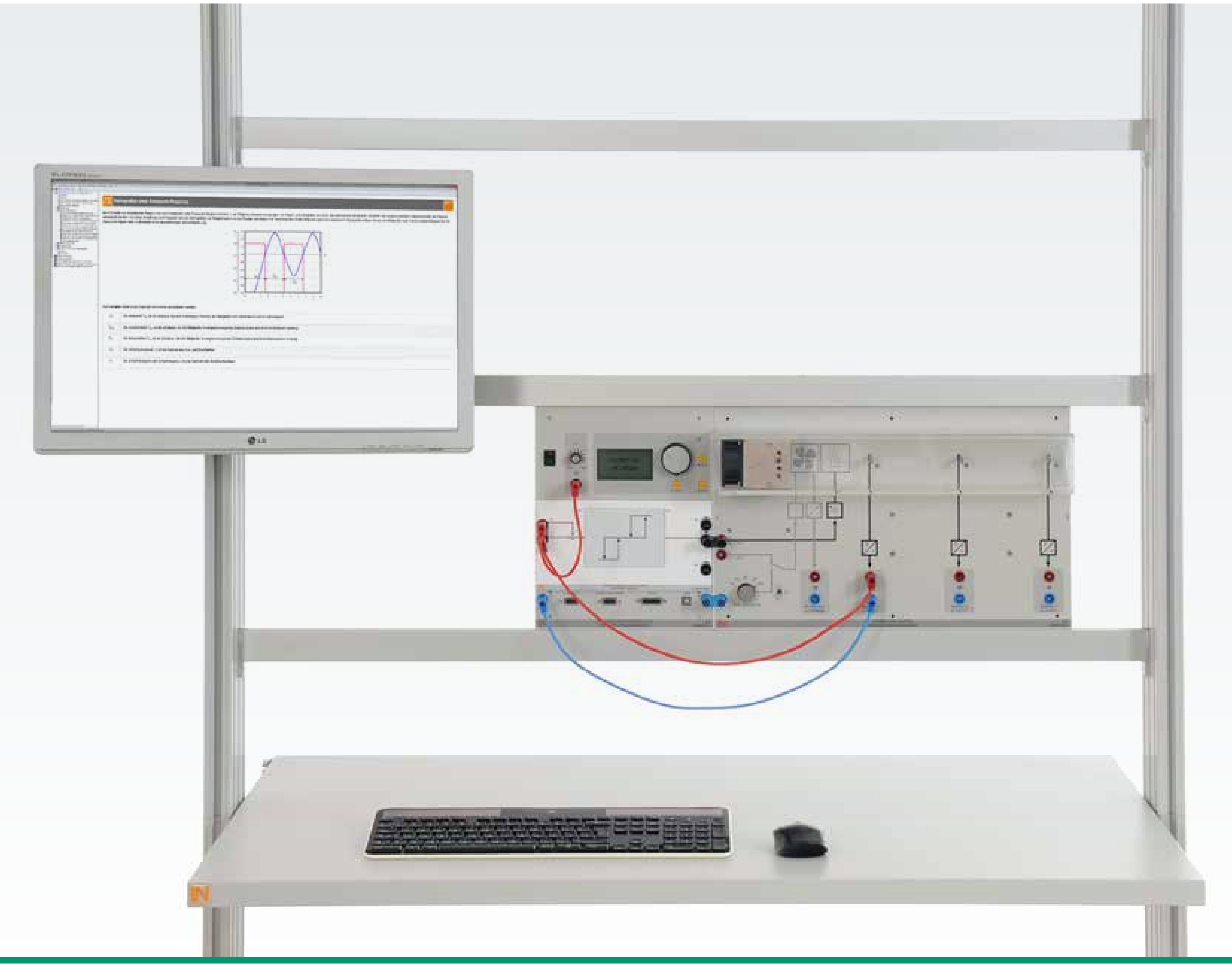


IAC 40 Optimisation of a Closed-Loop-Controlled Drive System Using Matlab®/Simulink®

Training contents

- Creating a hardware-in-the-loop system under real-time conditions
- Modelling and designing a cascade control system
- Creating and optimising current and speed controllers
- Design and optimisation of automatic control system in state space
- Expansion of automatic control system to handle multiple variables

AUTOMATIC CONTROL OF AN AIR-TEMPERATURE CONTROLLED SYSTEM



Training System

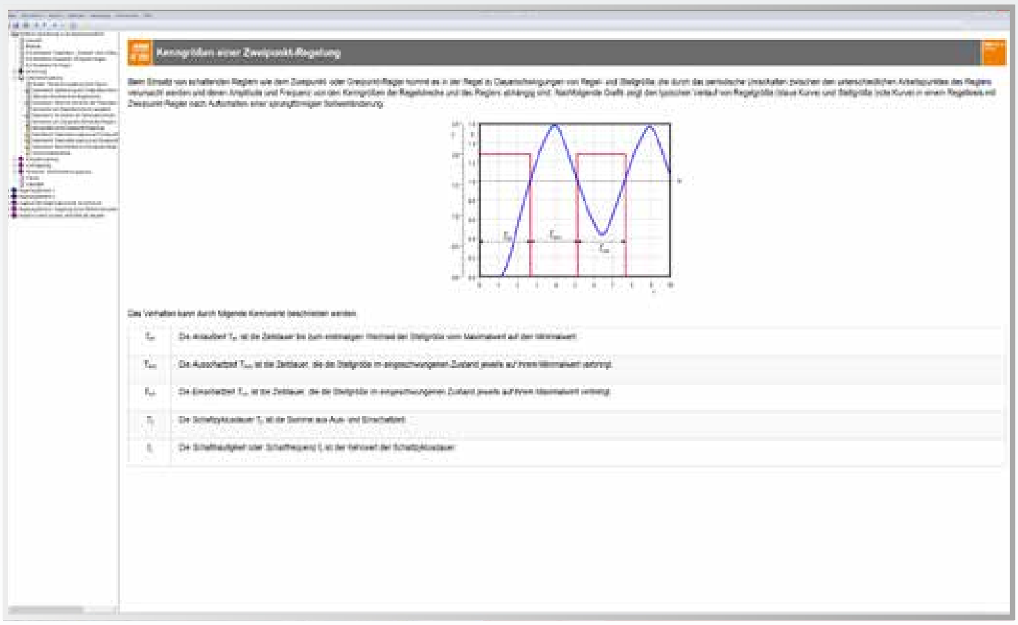
In many areas, the automatic control of temperature represents a classic example of closed-loop control for systems with long time constants. In addition to pure temperature control, it is also possible to take into account the flow rate of air as a second variable. The controlled system is designed in such a way that the time constant is as short as possible, thereby reducing the time it takes to make the measurements and enabling effective operation.

Benefits

- Rapid temperature-controlled system thanks to low-mass heating element
- Built-in power amplifier for controlling heating element
- 3 fast-acting platinum temperature sensors at various distances enable various system parameters to be integrated
- Controlled rate of air flow by means of a speed-controlled fan guarantees reproducible results
- Input for activating disturbance variables enables effective investigation of the control system
- System is fail-safe due to constant temperature monitoring and associated shut-off

Order no. CO3620-2C

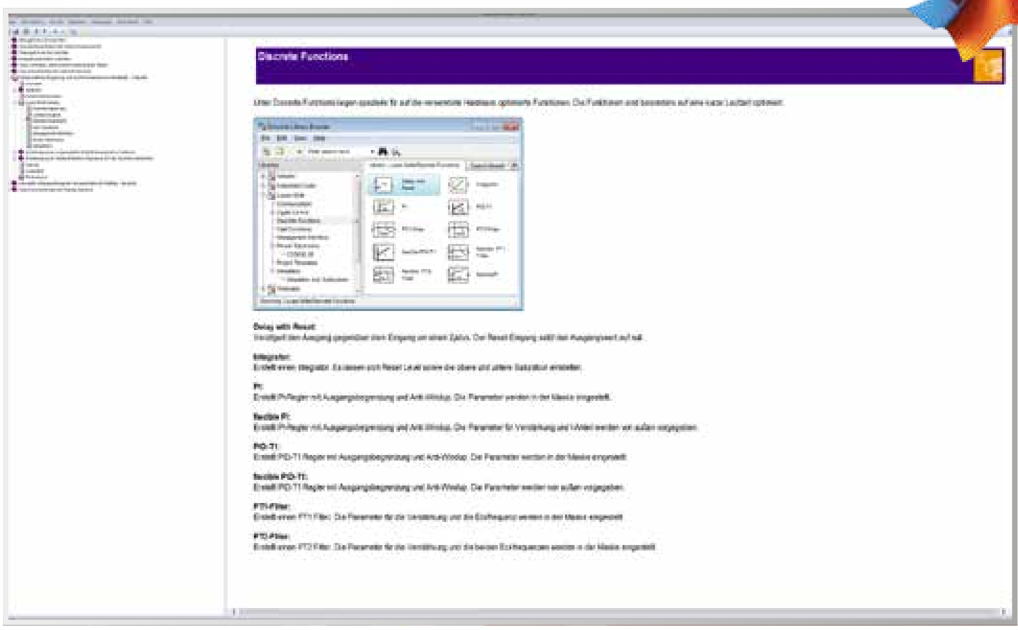
WITH INTERACTIVE LAB ASSISTANT (ILA)



IAC 31 Automatic Control of an Air-Temperature Controlled System

Training contents

- Operation using two-position and three-position controllers
- Automatic temperature control using PID controller
- Recording of controlled system parameters
- Determination of controller parameters
- Effect of disturbances on the automatic control system

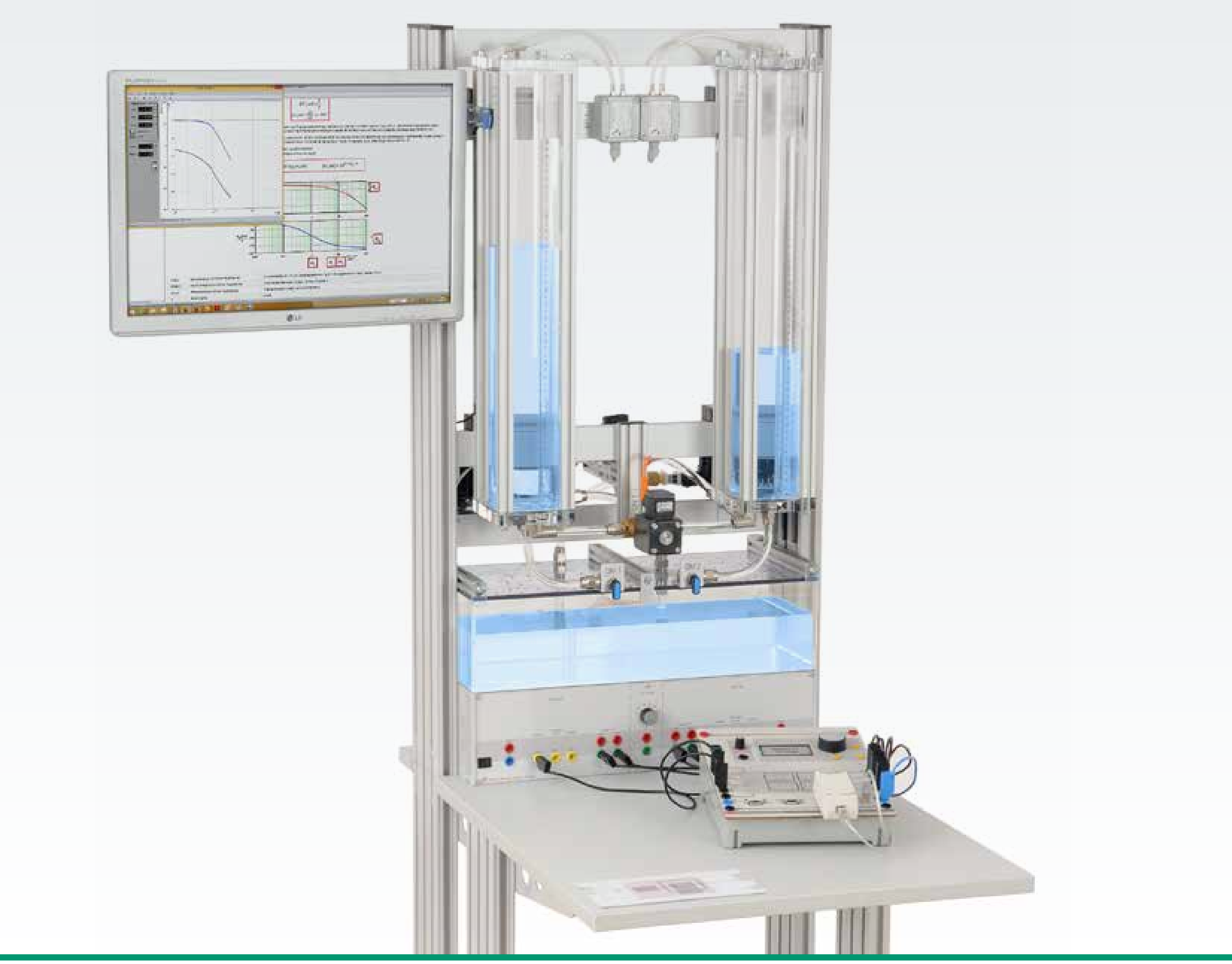


IAC 41 Automatic Control of an Air-Temperature Controlled System Using Matlab®/Simulink®

Training contents

- Creating a hardware-in-the-loop system under real-time conditions
- Modelling and designing the control system
- Simulation and optimisation of automatic control system using a model
- Comparison between model and real control system
- Expansion of control loop to make a multi-variable control system with independent control of temperature and air flow

CLOSED-LOOP CONTROL OF A COUPLED TWO-TANK SYSTEM



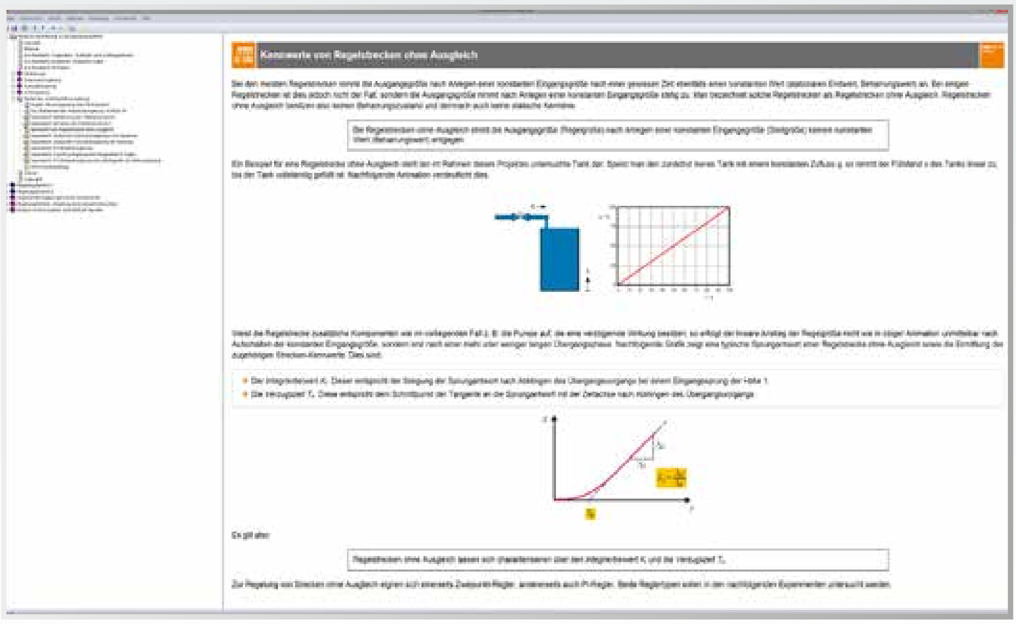
Training System
Measurement and control of liquid filling levels and flow rates make up a large part of process engineering. This training system allows you to implement a wide range of different applications, starting with a simple level controlled system and extending up to a complexly coupled tank system. In addition to determining the liquid levels in the two tanks, it is also possible to measure flow rates.

Benefits

- Two independent tanks which can be filled to a height of 50 cm
- Measurement of height to which tanks are filled via differential pressure sensors
- Two independent diaphragm pumps with built-in power boosters
- Flow rate measurement for both tanks
- Adjustable outlets for each tank
- Coupling of tanks via electronic valve
- Switchable overflow between tanks

Order no. CO3620-2H

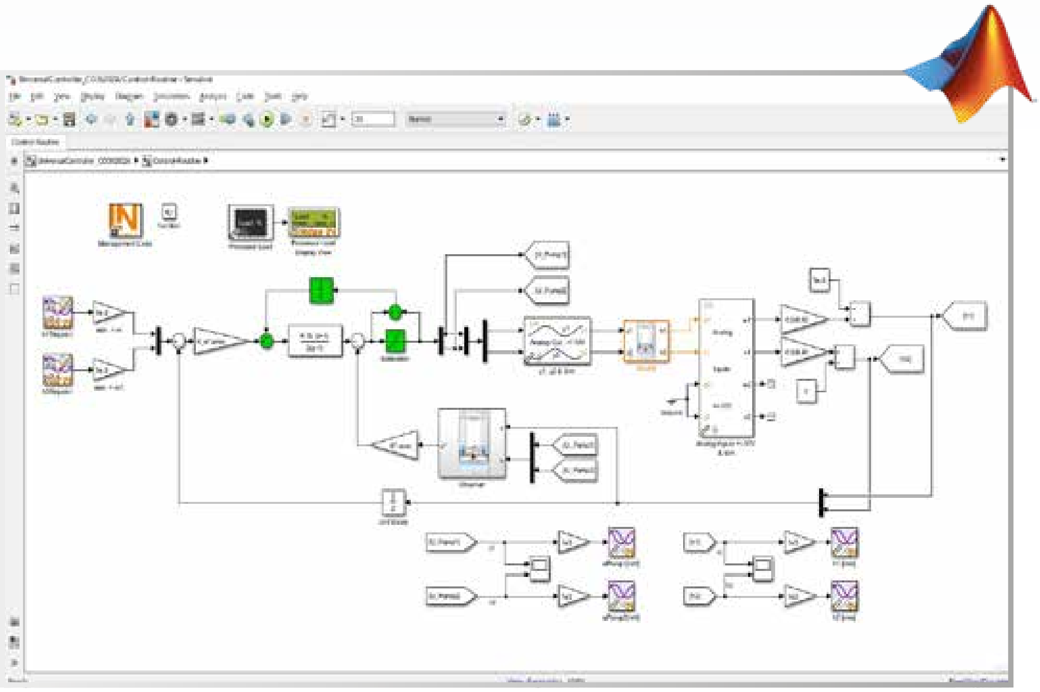
WITH INTERACTIVE LAB ASSISTANT (ILA)



IAC 32 Closed-Loop Control of a Coupled Two-Tank System

Training contents

- Automatic level control using two-position controller
- Automatic level control using PID controller
- Recording of controlled system parameters
- Determination of controller parameters
- Effect of disturbances on the closed-loop control system
- Closed-loop control of a coupled two-tank system

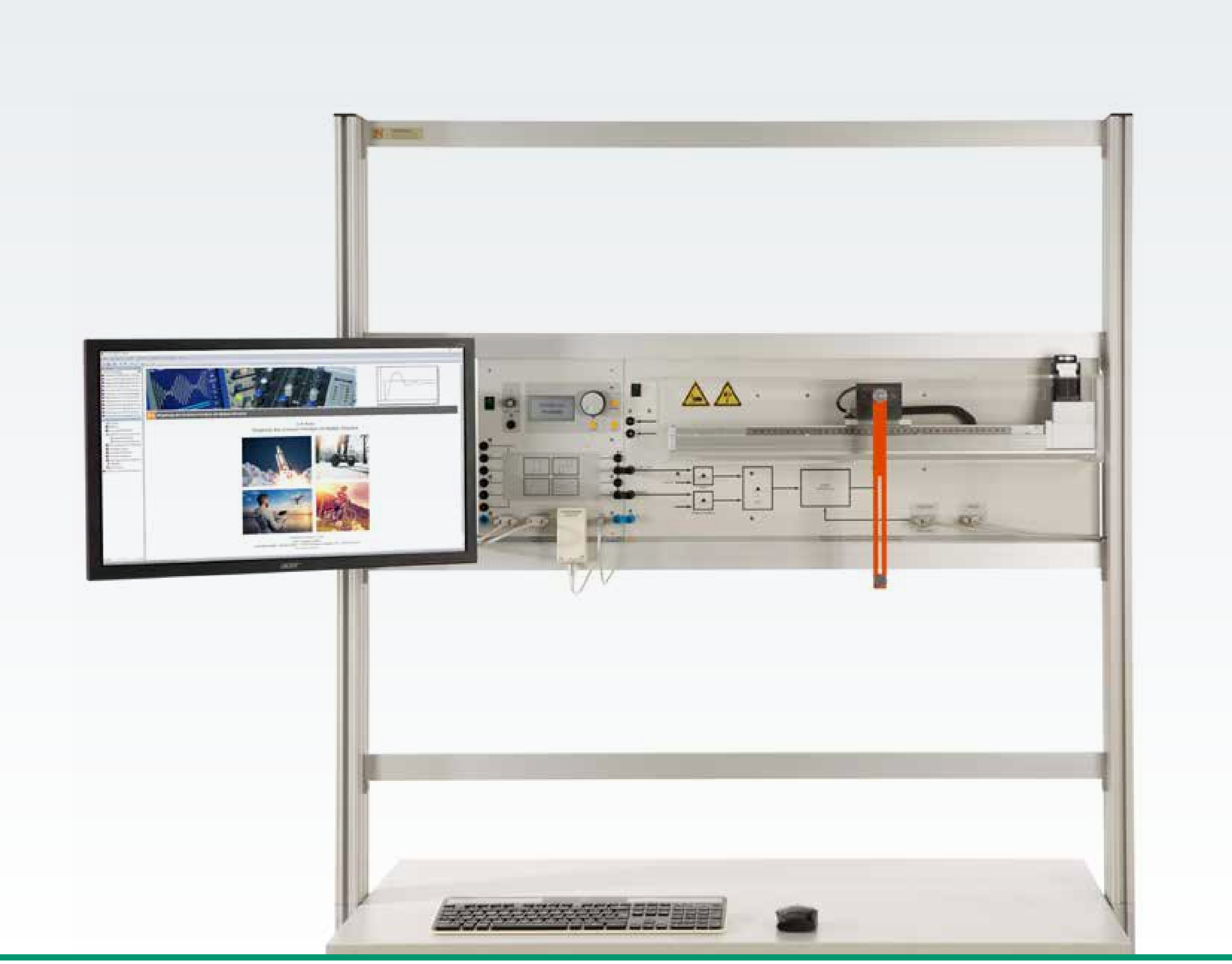


IAC 42 Closed-Loop Control of a Coupled Two-Tank System Using Matlab®/ Simulink®

Training contents

- Creating a hardware-in-the-loop system under real-time conditions
- Modelling and designing an automatic control system
- Simulation and optimisation of automatic control system using a model
- Comparison between model and real automatic control system
- Expansion of the automatic control to make a multi-variable system with independent filling level control in both tanks

AUTOMATIC CONTROL OF A POSITION AND ANGLE CONTROLLED SYSTEM ...



Training System

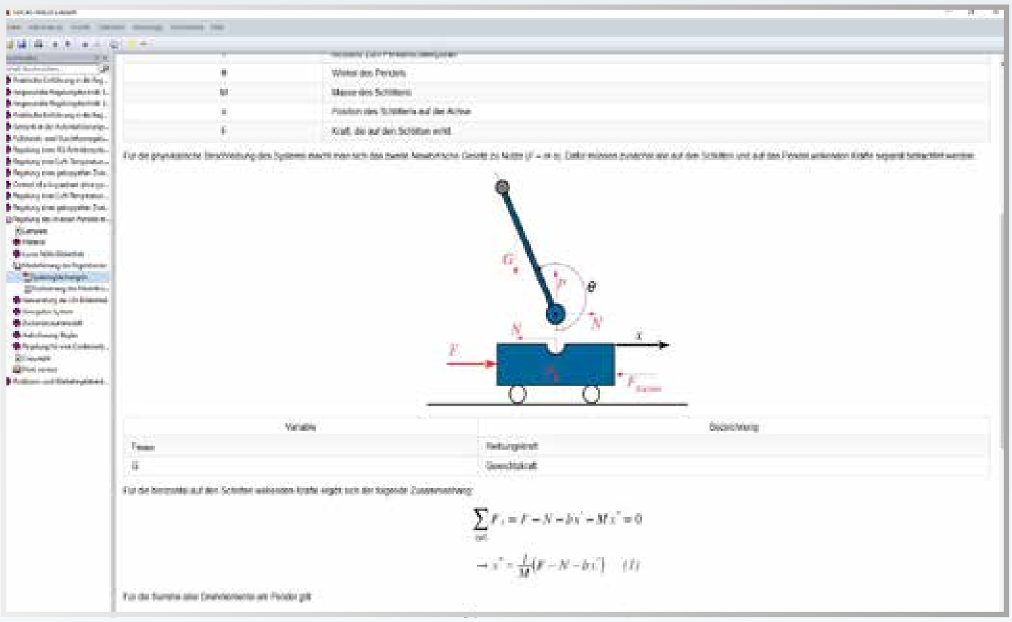
The increasing degree of automation affecting processes in every sector of industry is making a variety of control strategies and algorithms a necessity. The new position and angle controlled system is a training system permitting a broad range of training content to be taught in a vivid and graphic fashion. The material covers subjects from classic positioning control using standard controllers up to and including model-based multi-variable control systems in state space. The swinging and balancing of an inverted pendulum mounted on a carriage to pivot freely when the carriage is horizontally accelerated is a particularly challenging assignment.

Benefits

- High-performance hybrid stepper motor with a power of up to 100 W
- Integrated speed and current control
- Position detection with a high-resolution incremental encoder with 4000 pulses per revolution
- Angle detection using a high-resolution incremental encoder with 16000 pulses per revolution via a CAN interface
- Pendulum rod with a moveable centre of gravity
- Achieving speeds up to 0.5 m/s
- Accelerations up to 10 m/s2

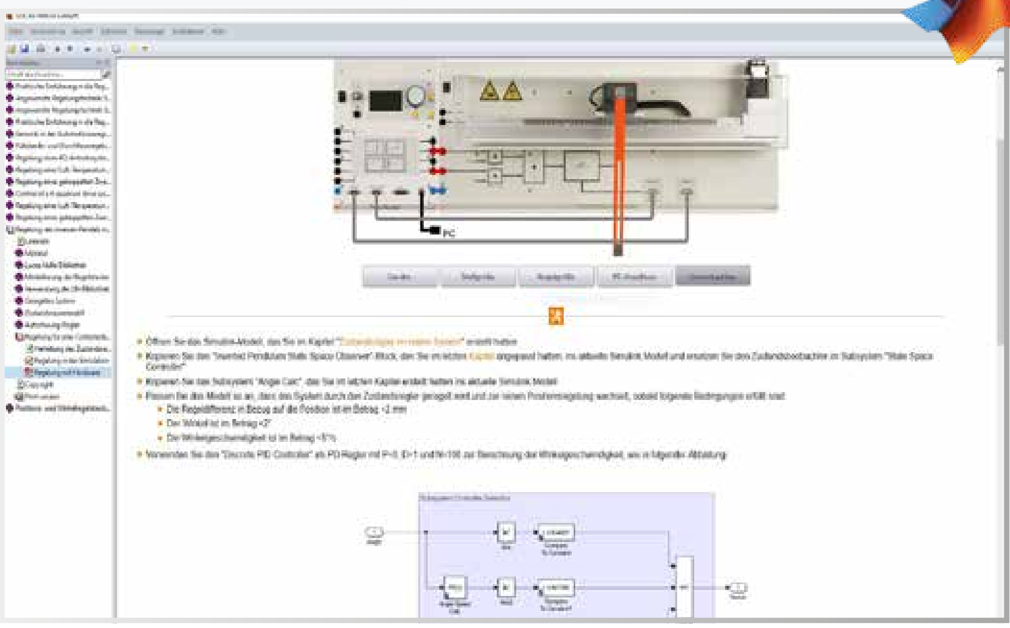
Order no. CO3620-2G

WITH INTERACTIVE LAB ASSISTANT (ILA)



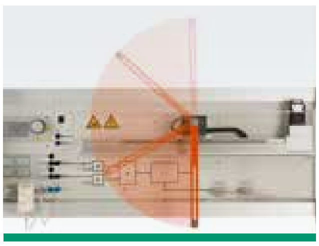
IAC33 Automatic Control of a Position and Angle Controlled System

Training contents
- System analysis in automatic control engineering
- Automatic positioning control of an integral-action controlled system
- Automatic angle control using standard controllers
- Automatic multi-variable control in a cascaded control loop
- Application of different optimisation strategies



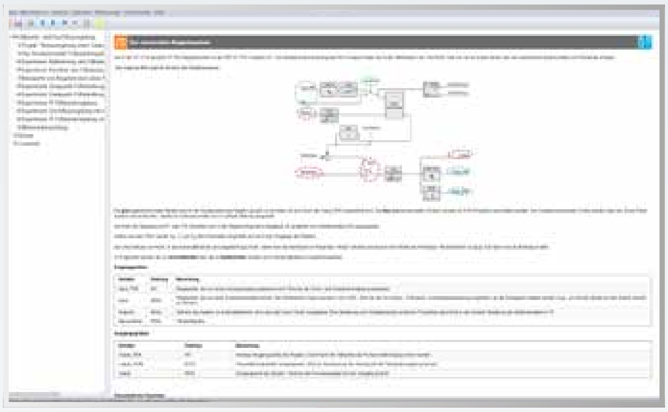
IAC43 Automatic control of a position and angle controlled system with Matlab®/Simulink®

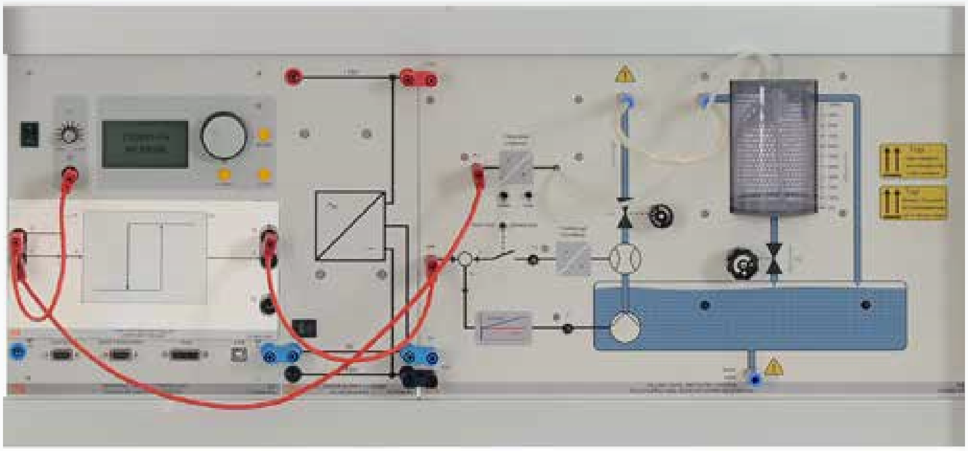
Training contents
- Model development for simulation in Matlab®/ Simulink®
- Classic closed-loop control of position and angle with standard controllers
- Development of a model-based automatic control in real time
- Automatic state-space control of an inverted pendulum as a multi-variable system



- Automatic system control for pendulum oscillation
- Implementation of practical applications, Segway PT and container bridge

AUTOMATIC FILLING LEVEL CONTROL – FLOW-RATE CONTROL





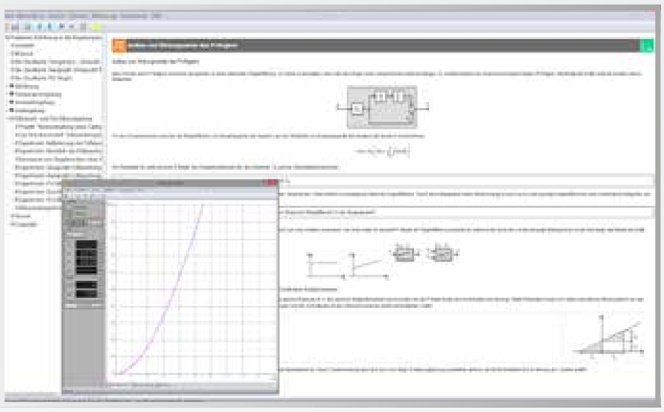
IAC 12 Filling Level Control – Flow-Rate Control
This system is an experiment set-up designed for educational and hands-on purposes in the area of applied closed-loop control. The compact training equipment includes a tank in which the filling level is to be controlled, a pressure measurement transducer to determine the tank's actual filling level and a reservoir tank including a pump. In order for the pump to operate at a constant flow rate, a secondary flow control loop with a flow-rate meter is included. This can be disabled as needed.

Training contents

- Two-position controller in an integral-action controlled system
- Two-position controller with delayed feedback
- Automatic filling level control with feedforward and advanced control
- Set-up, commissioning and optimisation of an automatic flow-rate control system
- Investigation of the automatic flow-rate control response to abrupt disturbance and reference variable step changes

Order no. CO3620-1H

WITH INTERACTIVE LAB ASSISTANT (ILA)



IAC 13 Industrial Filling Level Control System Using PLC

Training contents

- Characteristic parameters of a controlled system
- Design and function of a closed control loop
- Two-position controller in an integral-action controlled system
- Level control with continuous PI/PID controller
- Level control with secondary flow-rate control system
- Response of a control loop to disturbances

Order no. CO3713-8L

PROFESSIONAL CONTROL OF PRESSURE, TEMPERATURE, FILLING LEVEL AND FLOW RATE

IPA 1 Compact Station, Control of Process Variables via PLC

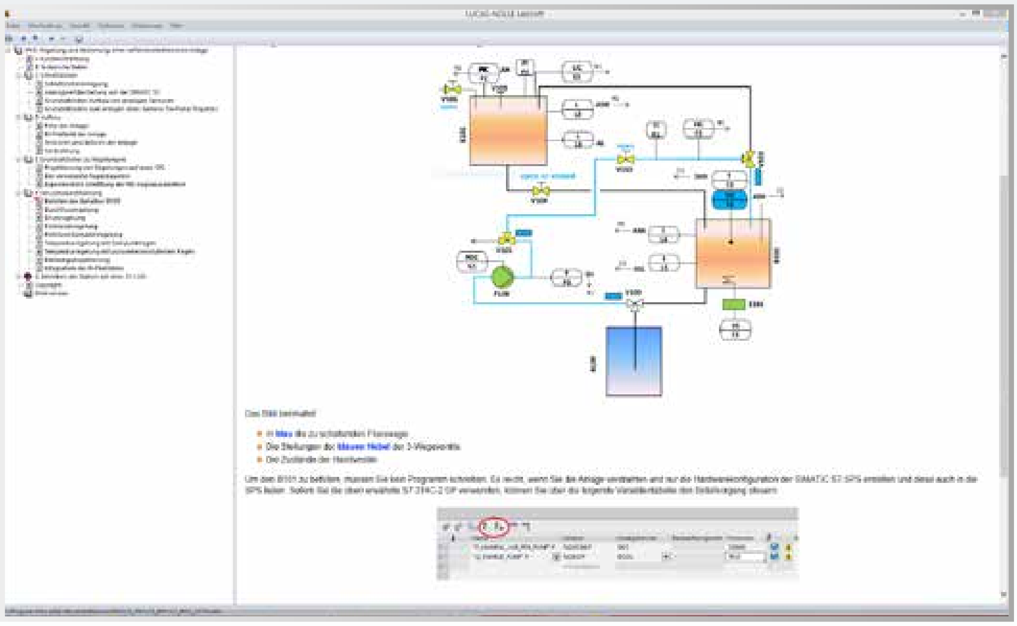
Process Engineering Compact Station with digital controller

Training System
This compact station with four built-in controlled systems is the ideal solution for typical production processes in widely differing sectors of industry. The modular design of the system makes it possible to implement a large number of varied configurations in a safe laboratory environment.

Order no. LM9550

Benefits
- Closely aligned with authentic practice thanks to use of industrial components
- Process engineering sensors for temperature, level, flow rate and pressure
- Combination with any open- and closed-loop control systems from industry or training
- Activation of individual controlled systems by simple resetting of ball valves
- The flexible piping system allows for very rapid changes to the flow plan or for installation of other components
- Built-in display for pressure, temperature, level and flow-rate variables
- Separate operation of the 4 controlled systems
- Manual operation using simulation switches without the need for additional equipment
- Any number of additional stations can be added

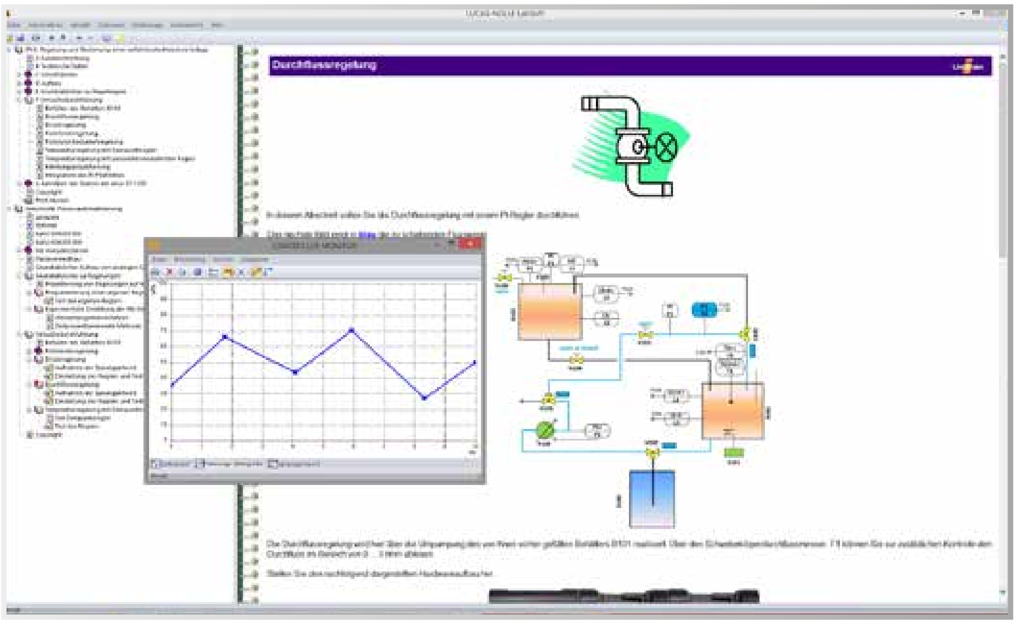
WITH INTERACTIVE LAB ASSISTANT (ILA)



UniTrain Equipment Set: Process Engineering Compact Station with digital controller

Training contents

- Set-up wiring and commissioning of a process engineering system
- Analysis of controlled systems and control loops
- Commissioning of continuous and discontinuous controllers
- Parameter setting and optimisation for P, PI and PID controllers
- Design of open- and closed-loop control programs
- Process operation and observation
- Inspection, maintenance and repairs
- Interconnection of process engineering systems



IPA 1 Compact Station, Control of Process Variables via PLC

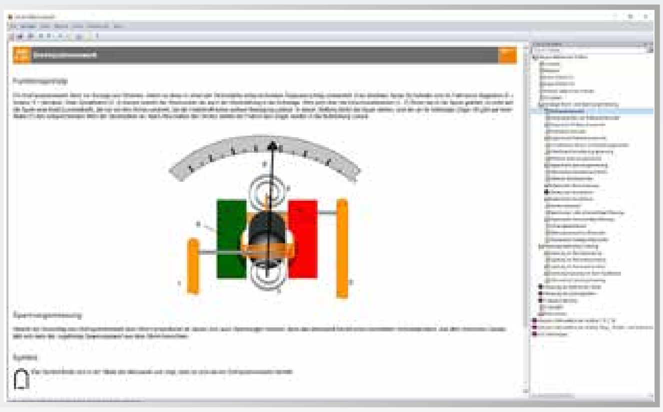
Training contents

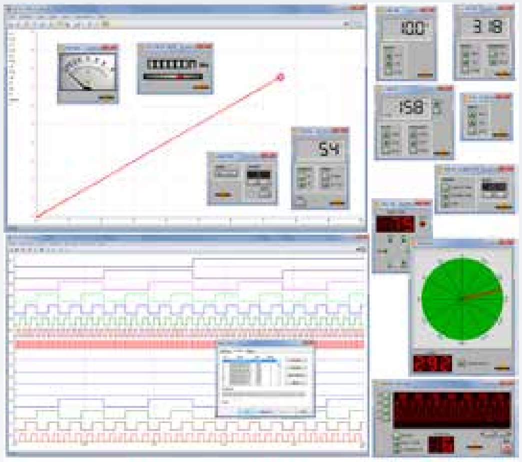
- Selection, use and connection of various sensors
- Measurement of electrical and process variables such as level, flow rate, pressure and temperature
- Use and connection of measurement transducers
- Set-up and commissioning of control loops

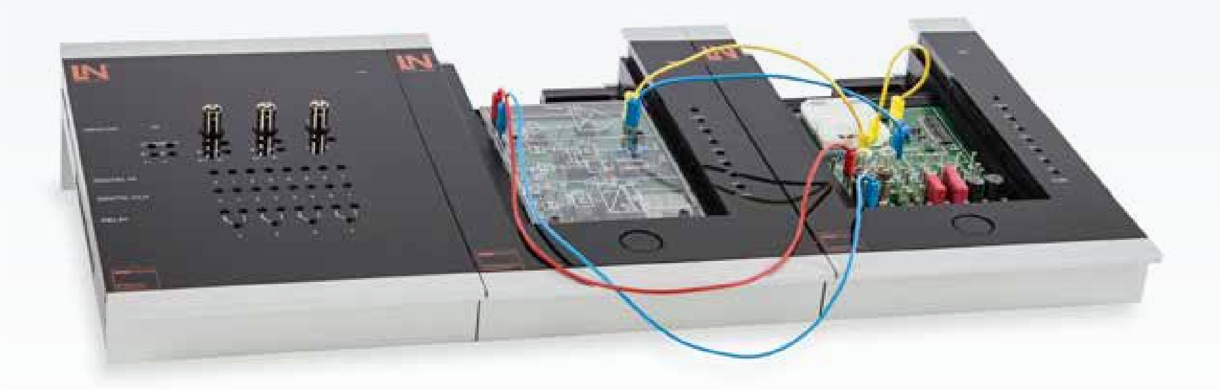
FUNDAMENTALS OF INSTRUMENTATION

Detecting electrical and non-electrical variables is the prerequisite for open-loop and closed-loop control of technical systems in the area of process automation. With our training systems for control, measurement and instrumentation measuring methods are taught hands-on and graphically for the most important physical variables.

MULTIMEDIA INTRODUCTION TO INSTRUMENTATION AS USED IN ACTUAL PRACTICE







UNITRAIN SYSTEM

The UniTrain Training System

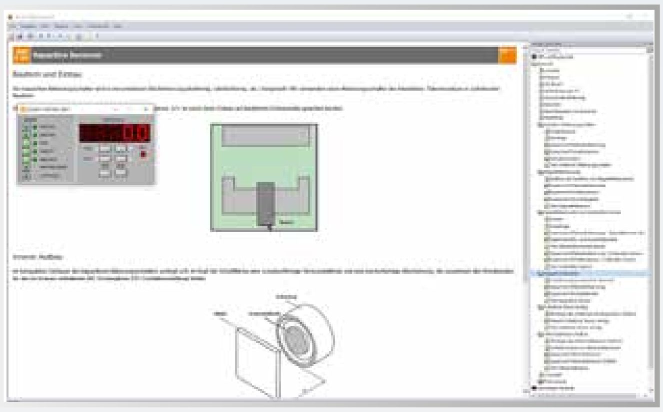
With the multimedia-based experiment and training system, UniTrain, trainees are guided through the theory by means of carefully structured course software with the help of text, graphics, animations, tests of knowledge and guided experiments.
In addition to the training software every course includes a set of experiment cards with which the practical exercises can be carried out. UniTrain multimedia courses use numerous experiments and animations to provide insight into the latest issues involving instrumentation and automatic control technology.

Benefits

- Theory and practice in the same place at the same time
- Extra motivation for students thanks to modern media
- Built-in instruments and power supplies
  - multimeters, ammeter, voltmeters, function generator
  - 4-channel storage oscilloscope
  - … and many other instruments
- Rapid success thanks to well-structured course guidance
- Rapid understanding of theory thanks to animations
- Acquire practical skills through autonomous experimenting
- Constant feedback from tests of understanding and knowledge
- Guided troubleshooting with built-in fault simulation
- Sample solutions for teachers

Order no. CO4203-2A

WITH UNITRAIN



UNITRAIN
SYSTEM

Industrial Sensors

The basis of any automation or closed-loop control system lies in the acquisition of process data related to operating states and variables. This is accomplished using a wide variety of sensors that operate according to a variety of different physical principles. An understanding of sensors is therefore essential for anyone who comes into contact with automation or closed-loop control technology.

Training contents

- Working with capacitive and inductive proximity switches
- Working with various sensors such as magnetic field sensors or optical sensors
- Which sensors are suitable for which materials
- Determination of switching interval, switching hysteresis and switching frequency
- Processing various material samples with the help of an electrically operated X-axis

Order no. CO4203-9D

MEASUREMENT OF NON-ELECTRICAL VARIABLES

UNITRAIN
SYSTEM

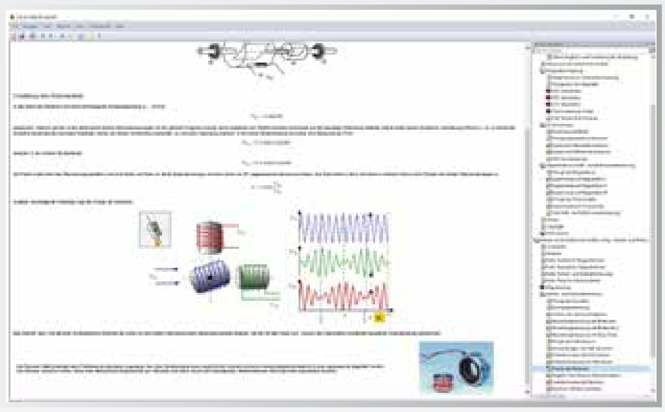
Temperature – Pressure – Force – Torque

In modern industrial practice, it is increasingly necessary to monitor, display or electronically process physical quantities. This requires measurements of non-electrical variables to be transformed into electrical signals by means of suitable sensors.

Training contents

- Explanation of how measurement circuits affect results
- Characteristics of various temperature sensors: NTC, Pt 100, KTY, thermocouples
- Measurement of pressure: Piezo-electric, inductive and resistive pressure sensors
- Principles of measuring force by means of strain gauges, bending bars and torsion rods
- Recording characteristics for various sensors
- Techniques for "linearising" non-linear characteristics
- Listing possible sources of error

Order no. CO4204-8B



Displacement – Angle – Speed

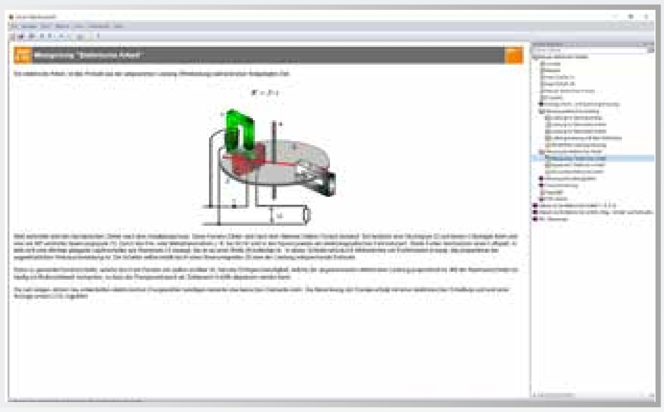
In mechatronics or drive system applications found in production facilities, rapid and precise detection of displacement, angle and speed is decisive for system dynamics, operational efficiency and quality.

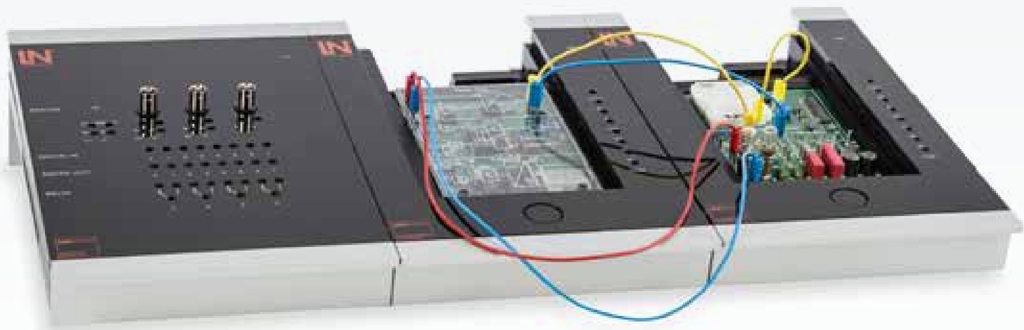
Training contents

- Analog and digital measuring techniques for displacement, angle and speed
- Familiarisation with the necessary sensors, their principle of operation and their characteristics
- Experimental determination of characteristic curves
- Calibration of measurement circuits
- Experiments with capacitive and inductive sensors
- Use of optical and Hall sensors for measuring position of rotating shafts
- Displacement measurement using incremental, BCD and Gray-code encoders
- Investigations on a rotating shaft using a resolver

Order no. CO4204-8C

MEASUREMENT OF ELECTRICAL VARIABLES





UNITRAIN SYSTEM

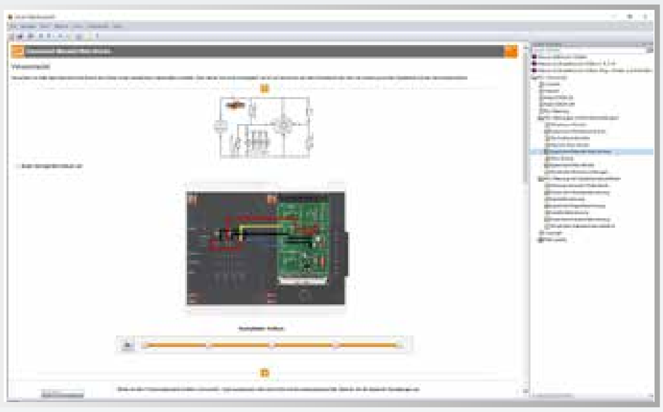
Current / Voltage – Power – Work – Frequency

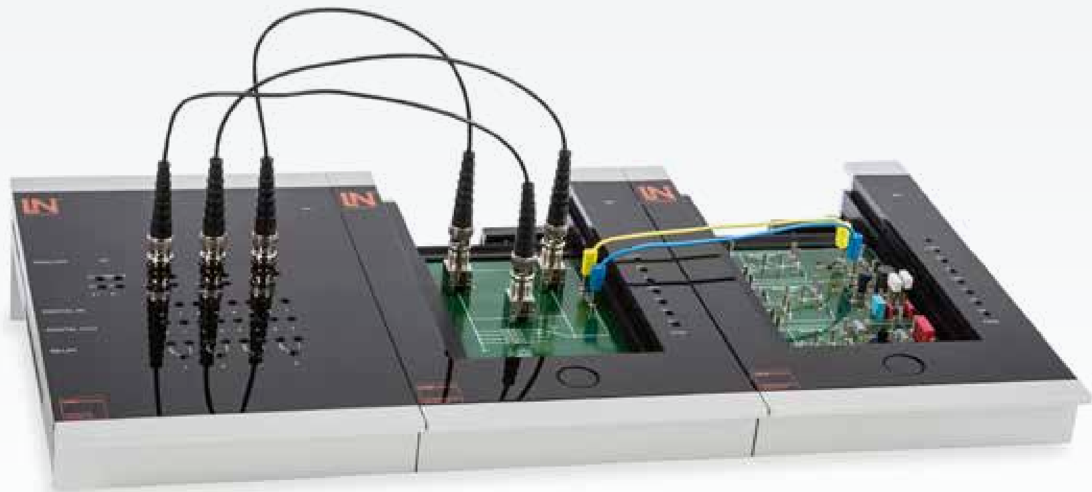
An introduction to electrical measurement instrumentation starts with moving-iron and moving-coil galvanometers. They are used to measure voltage and current, to observe the effect of various waveforms on measurement results and to see how measuring ranges can be extended with the help of additional resistors.

Training contents

- Measurement of power
- Explanation of the measurement principle using a DC circuit
- Learning the differences between active, apparent and reactive power measurements in simple AC circuit experiments
- Measurement and explanation of the power factor
- Measurement of consumption and electrical work with the aid of an electricity meter

Order no. CO4204-8A





UNITRAIN SYSTEM

Resistance – Inductance – Capacitance

Bridges and impedance measuring techniques for determining parameters of passive circuit components, such as resistors, capacitors and inductors have been used for many years in bridge measuring circuits.

Training contents

- Measurements of R, L and C carried out with the help of the following configurable bridges:
  - Wheatstone bridge
  - Maxwell Wien bridge
  - Wien bridge
- Analysis of the measurement principle
- Comparison of measuring methods

Order no. CO4204-8D

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