NEW

Instrumentation and Control Technology

Training Systems for Training
Technicians and Engineers

MATLAB & SIMULINK

Contents

Best Quality for Best 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 bespoke products which precisely match customers' needs at inexpensive prices but in the highest quality. The basis of the concept lies in the acquisition of data concerning the status of the production system and the closed-loop control of process variables. This is accomplished using a wide variety of sensors, which operate by means of various different physical principles. Knowledge of sensor systems is therefore essential for anyone coming into contact with automation or closed-loop control as well as for mechatronics technicians.

… has a major impact on education and training

Changing demands require new, modern, practice-oriented training systems. These instruct trainees on the most up-to-date technology and the skills required to work with it.

For your inspiration you can watch videos of these training systems at www.lucas-nuelle.com.

More Than a Training System

Complete Solution for Instrumentation and Control Technology Labs

Using modern training media to present complex subjects in vivid fashion

Investigating instrumentation and control technology in production systems controlled using process control technology

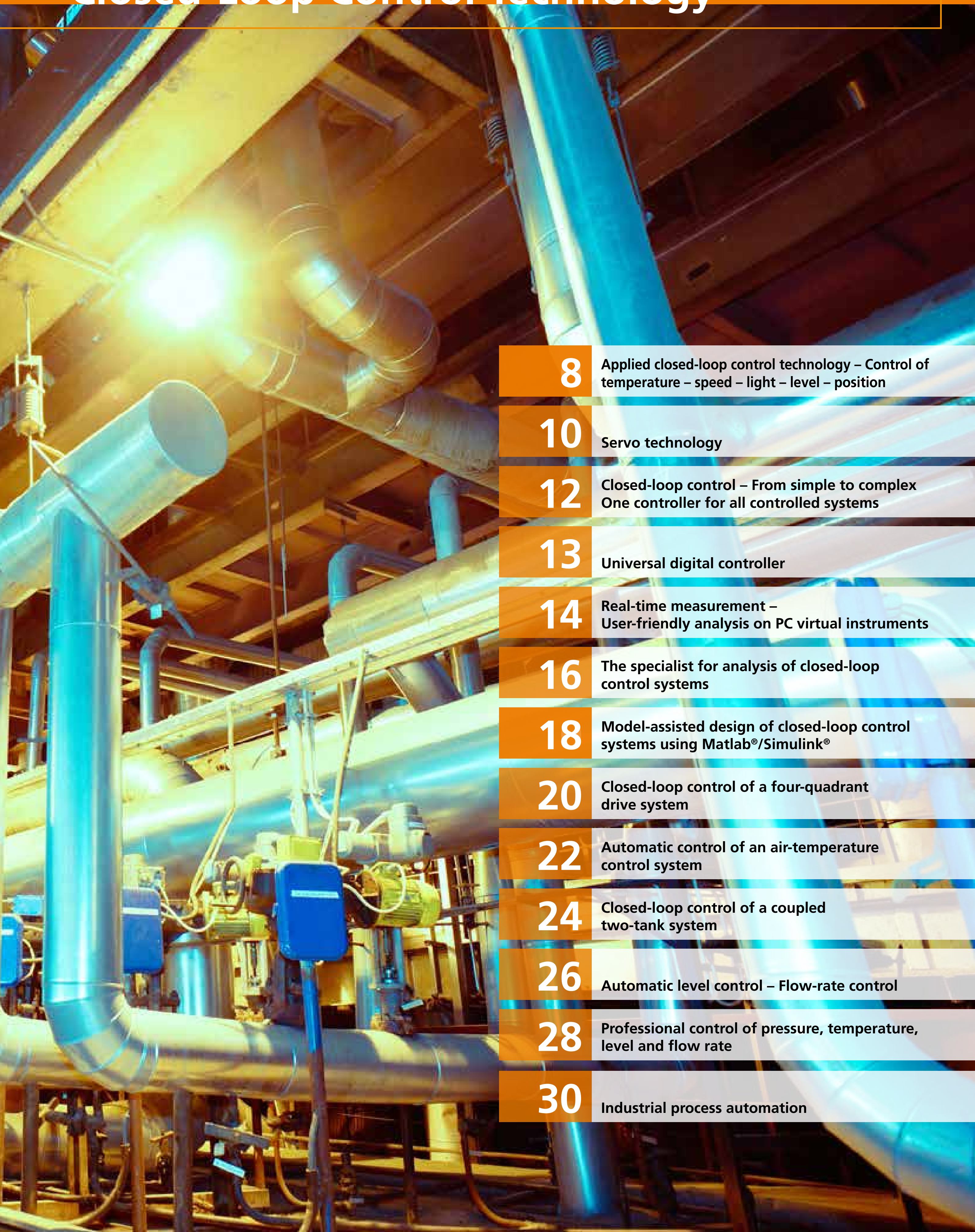
Various applications of closed-loop control to bring you up to speed to perform real-life work

You can always keep in touch with what's going on.
With the help of Classroom Manager you can manage your trainees, modify the training resources for each accordingly and always be aware of their learning progress.

Complete solution for instrumentation and control technology: models of typical industrial tools, controllers, PLC systems, drives and sensors

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

Closed-Loop Control Technology



Compact Closed-Loop Control

Closed-Loop Control of Temperature – Speed – Light – Level – Position

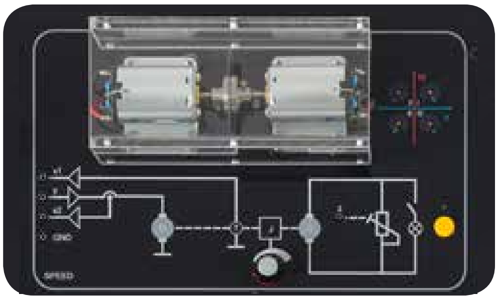
In the age of automation closed-loop control is of the utmost importance for technical systems. A fundamental understanding of how various types of controllers and controlled systems respond in the time and frequency domains is vital when choosing the controllers to be used and ensuring that the controlled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

Training contents

- Operating principles for open- and closed-loop control
- Design and function of continuous and discontinuous controllers
- Investigation of control loops with continuous and discontinuous controllers in time and frequency domains as used in practice
- 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 lighting in a room
- Design of a closed-loop level control system for an installation of tanks
- Investigation of a servo position control system as used in practice

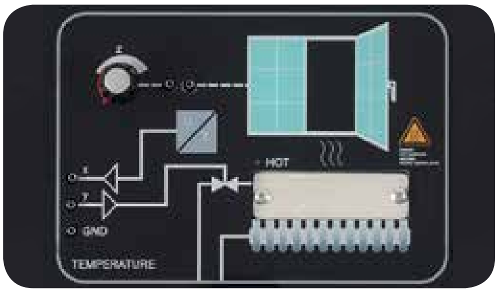
Compact Closed-Loop Control – 5 Different Controlled Systems on One Board

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 system

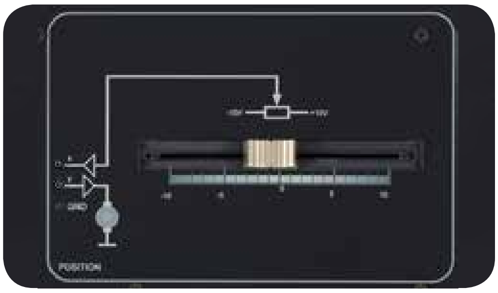


Fill level controlled system
- Digital modelling of a fill level control system
- Adjustable inlet
- Outlet adjustable as a disturbance variable
- Visualisation of fill level as well as inlet and outlet via LED display

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



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

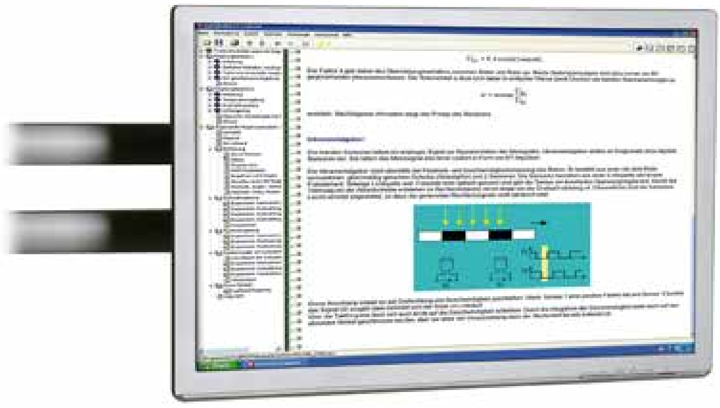


Light controlled system
- System is unaffected by ambient light
- Built-in LED light source and sensor
- Preset for interfering light to aid investigation of control system

Servo Technology

Precision Control of Angle and Speed

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. A project involves implementation of a time-dependent positioning sequence for a rotating platform.



Training contents

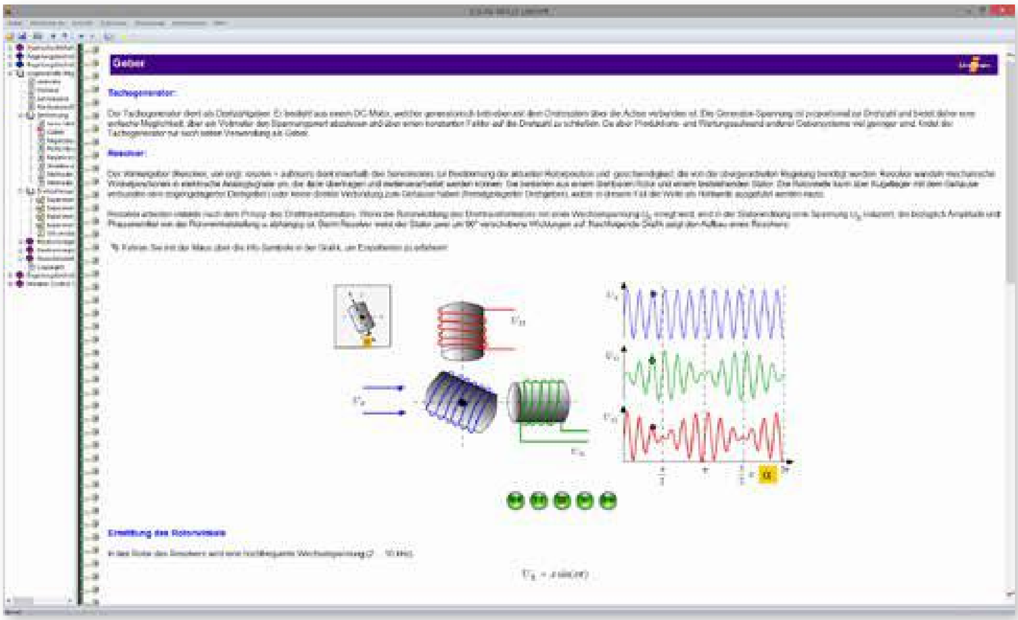
- Analysis of open- and closed-loop control implications for a DC servo-motor
- Closed-loop control of angle and speed
- Detection of position and speed of a DC servo by means of an incremental encoder
- Determination of control characteristic, lag time, transient response, system deviation and control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

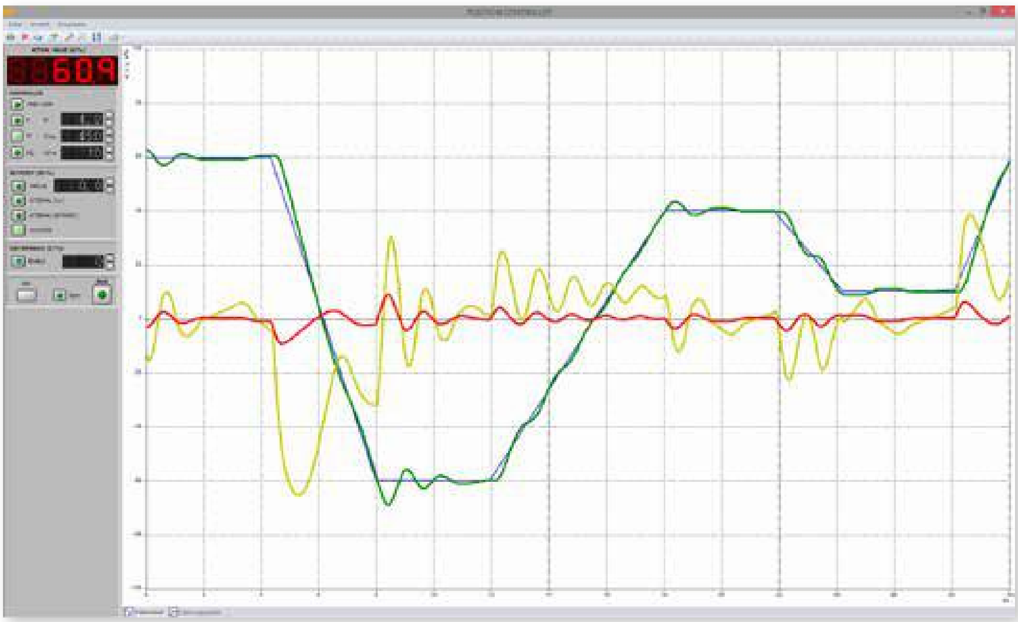
Interactive Lab Assistant

How does servo-control work?

In practice it is often important to move a motor to certain positions, e.g. for the kinetic movement of a robot, or to maintain certain speeds. In most cases, digital controllers are used for this.

This ILA course shows the individual steps needed to calculate parameters for a controller and optimise its operation.





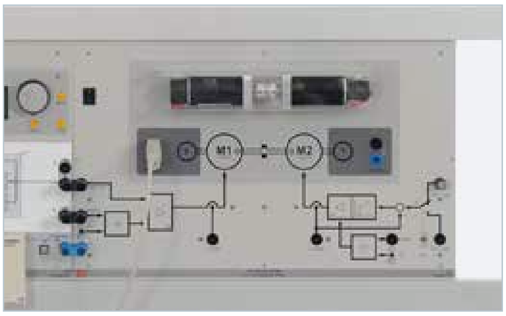
Position, speed and cascade controllers

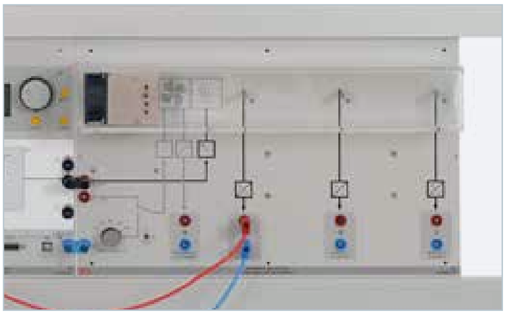
The ILA course provides the different instruments for automatic position and speed control. Learn how various control parameters affect the drive system. Optimise the controllers and analyse how speed, position and system deviation change over time with the help of the relevant tools. Determine measures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

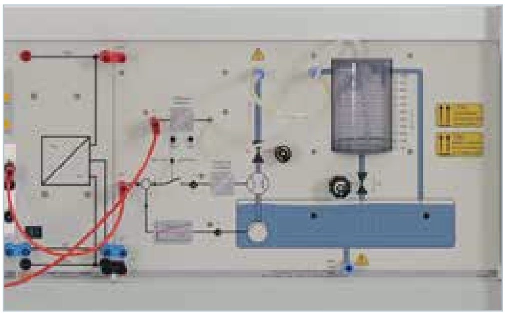
Closed-Loop Control – From Simple to Complex

One Controller for All Controlled Systems

To make it possible for your students to achieve success rapidly, 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 controlled systems.







Your benefits

- Compact, simple-to-operate system which is intrinsically safe
- Can be combined with all controlled systems
- Measurement and display of control variables
- Output of reference and disturbance variables
- Enables creation of complex control algorithms with the help of Matlab®/Simulink® and their execution in real time

Universal Digital Controller

Training contents

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

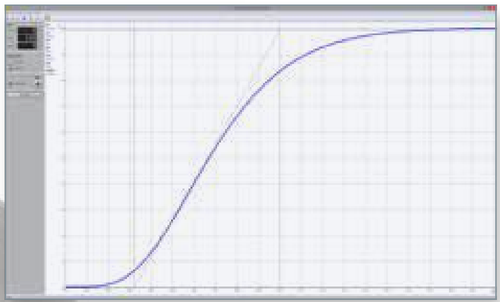
Real-Time Measurement – User-Friendly Analysis on PC

Virtual Instruments

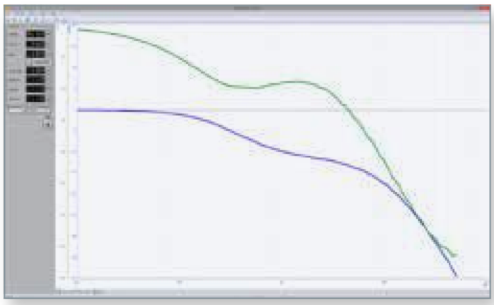
With the help of the virtual instruments it is possible to operate the universal digital controller via a PC which can then display the measured data. Virtual instruments have been specially developed for specific tasks. The reduced surface area makes it easy to operate them so that users can stay focused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

Your benefits

- Simple analysis of controlled systems 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

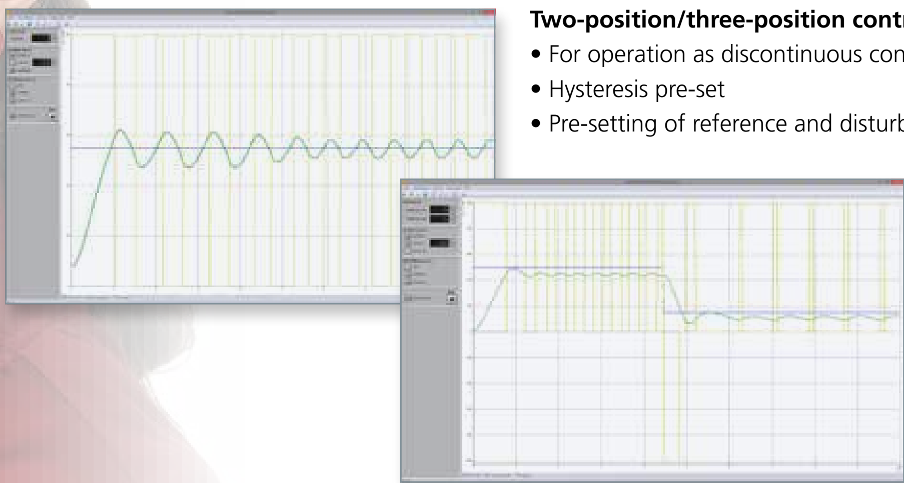


Step response plotter
- Simple setting of parameters for step outputs
- Selection of various controlled variable inputs: Analog, PWM, frequency, encoder input
- Automatic scaling of recording time

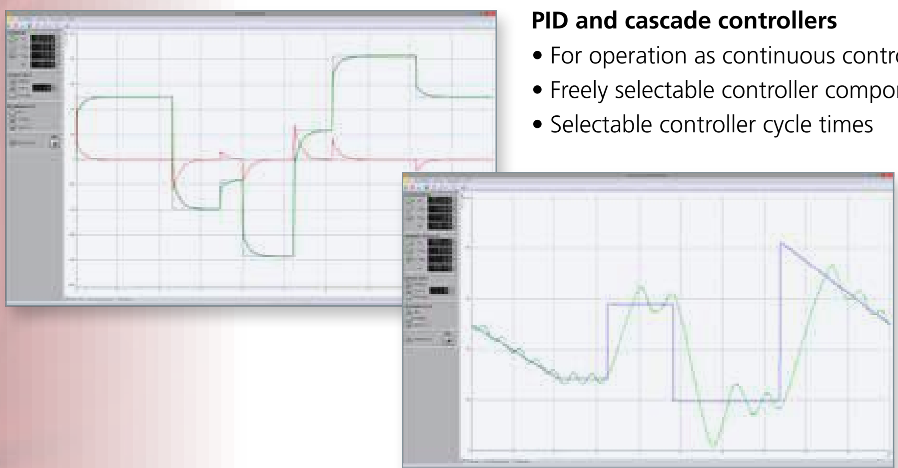


Bode plotter
- Adjustable start and end frequency
- Logarithmic or linear scaling of measuring range
- Display of frequency response or locus

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
- Freely selectable controller components
- Selectable controller cycle times



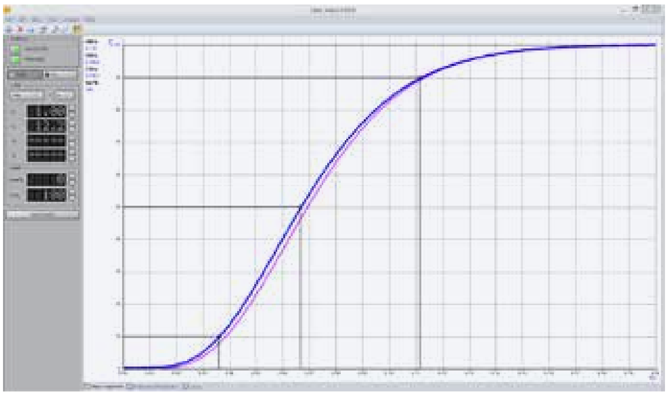
The Specialist for Analysis of Closed-Loop Control Systems

Controlled System Analyser

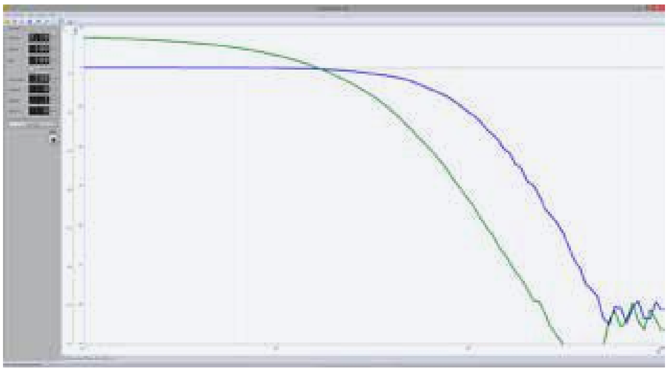
Your benefits

- 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 help of an open control loop
- Display showing frequency and amplitude response as Bode plot or locus

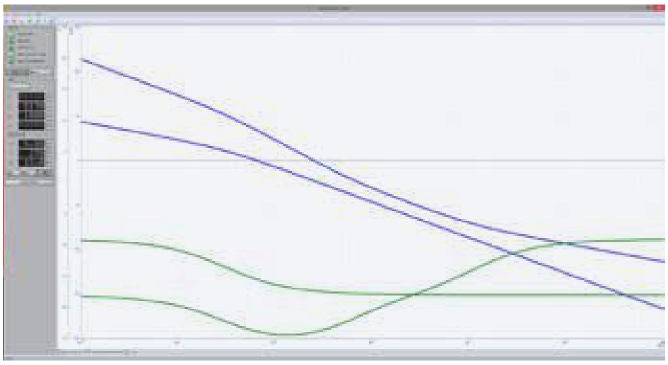
Step responses recorded by the step response plotter can be analysed using the controlled system analyser. Special tools are available for determining controlled system parameters via the inflectional tangent method.



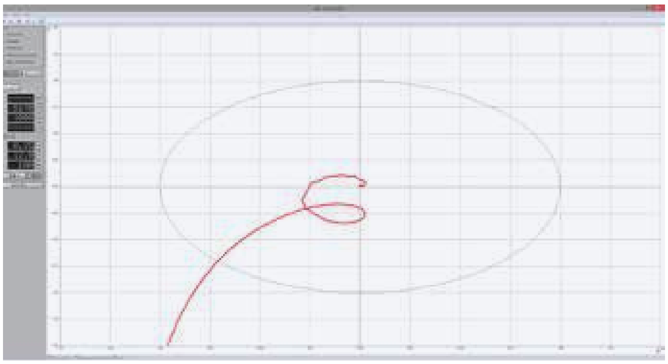
The controlled system analyser can determine the amplitude and phase responses of the system from the mathematical attributes of the step response. These can then be compared with the real responses as shown by the Bode plotter.



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



All data acquired can be displayed with the controlled system analyser with the help of its locus function. This is a simple way of analysing the quality of a control system.



Model-Assisted Design of Closed-Loop Control Systems Using Matlab®/Simulink®

Enhance the Universal Digital Controller to Create a Programmable Rapid Prototyping System

Almost all equipment and machinery involves closed-loop control of variables. 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.

Your benefits

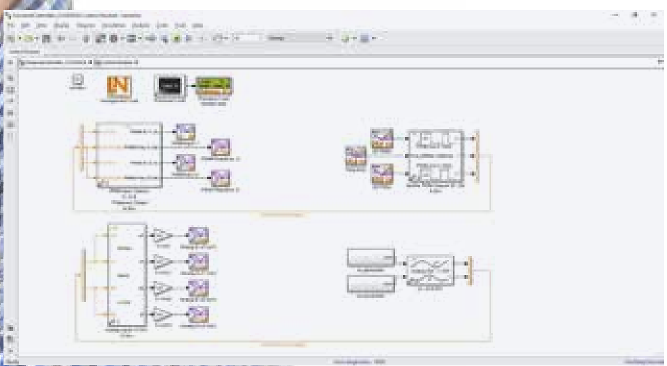
- Non-hazardous work with intrinsically safe hardware
- Rapid software generation and parameter setting for control systems assisted by modelling
- Follow new research approaches, e.g. state space control, condition monitoring for faults
- A controller cycle time of 125 µs even makes it possible to develop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

Achieve Your Objective Quicker with Matlab® Toolbox

A tool box 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.

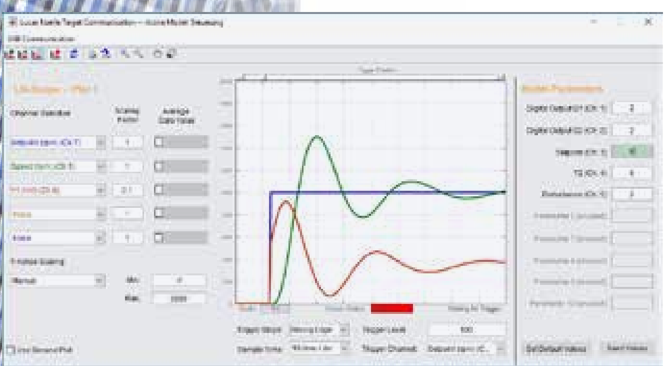
LN Matlab toolbox

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®.



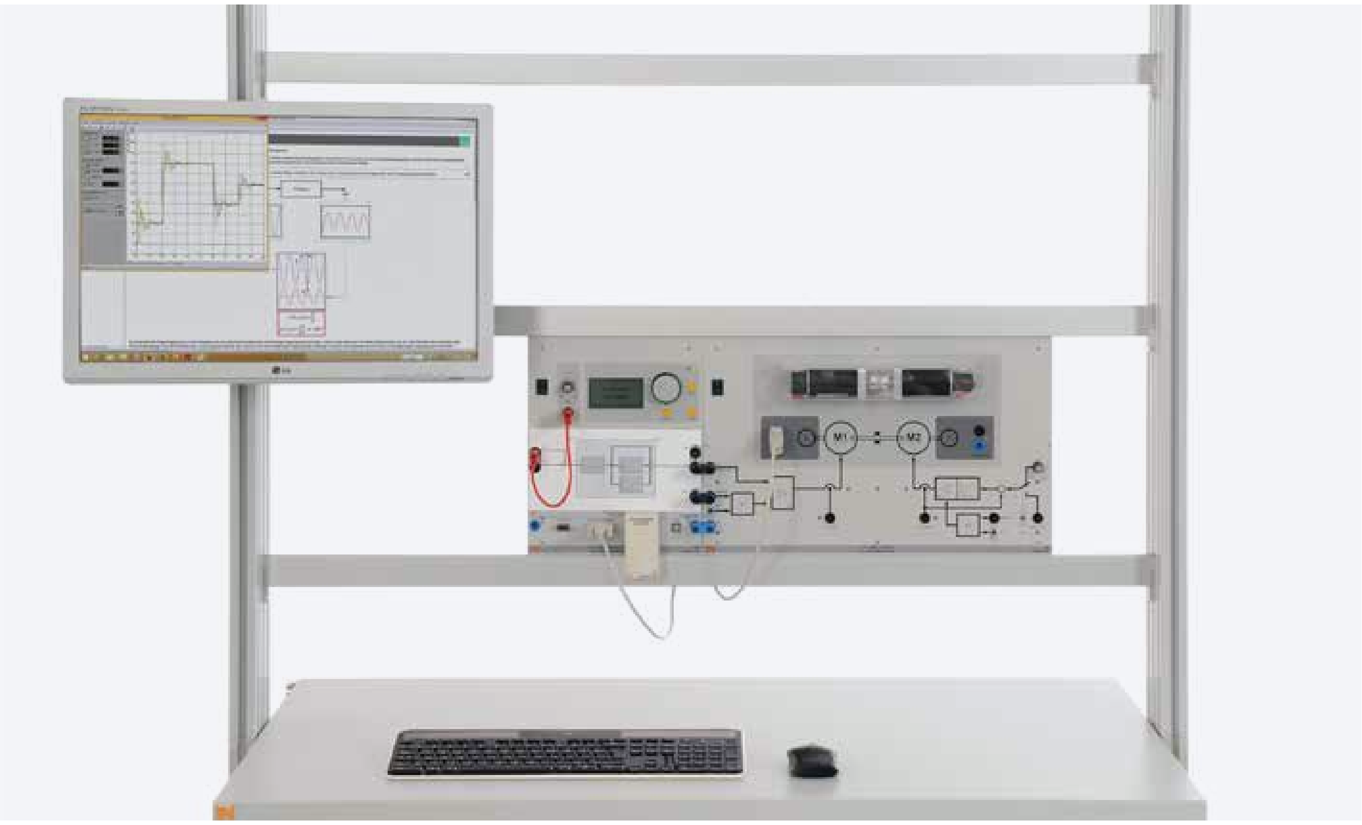
Matlab® Scope – direct link to the hardware

A special graphic interface establishes connection between Matlab® and the hardware via a USB link. The way that internal variables change over time can be graphically displayed as they happen. Various time bases and trigger options are available. Apart from 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.

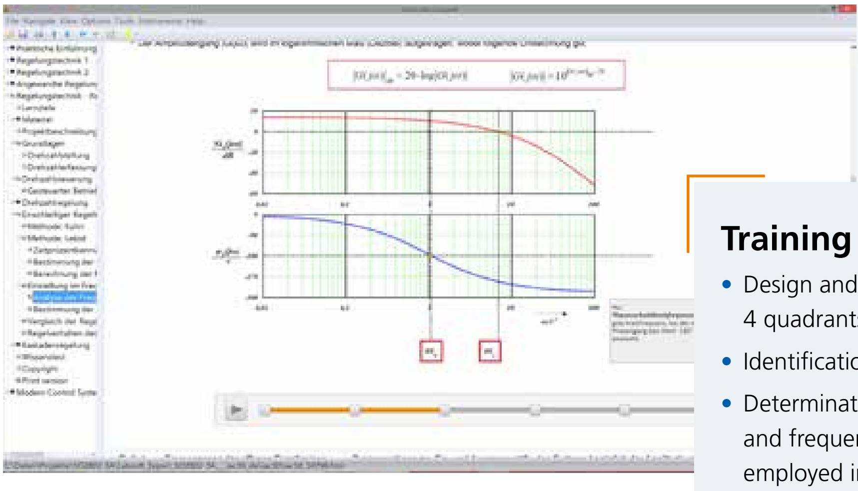


Your benefits

- 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 control of current
- Built-in automatic current control enables well defined step changes in load

with Interactive Lab Assistant (ILA)

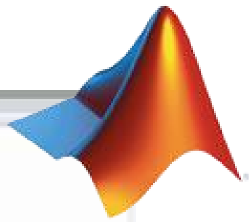
IAC 30 Control of a 4Q Drive System

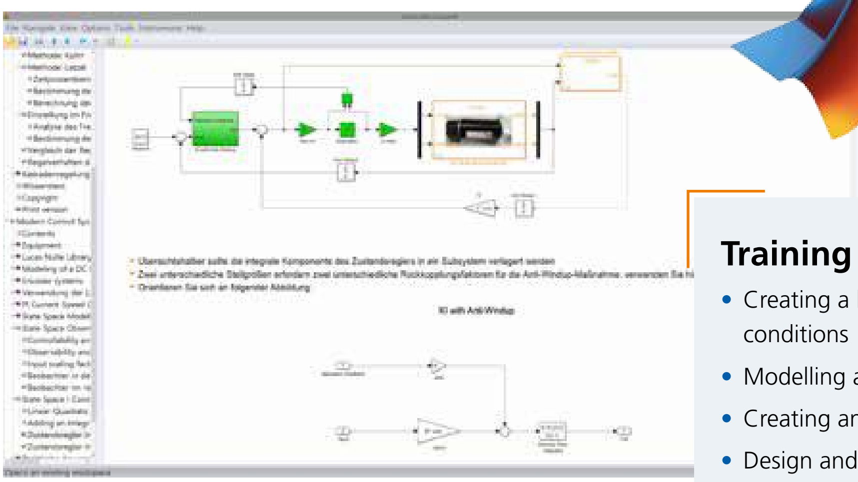


Training contents

- 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®





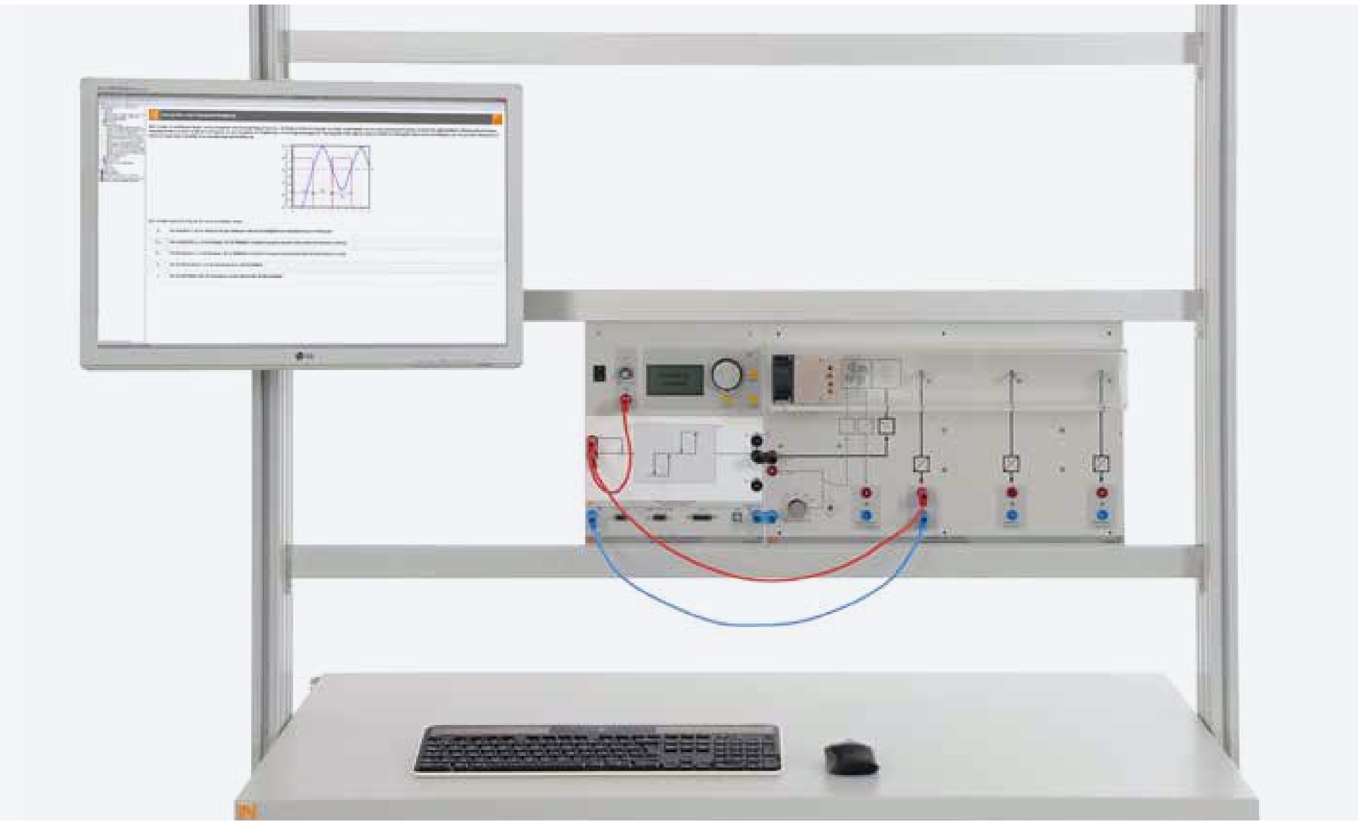
Training contents

- 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 control system in state space
- Expansion of control system to handle multiple variables

Automatic Control of an Air-Temperature Control 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.

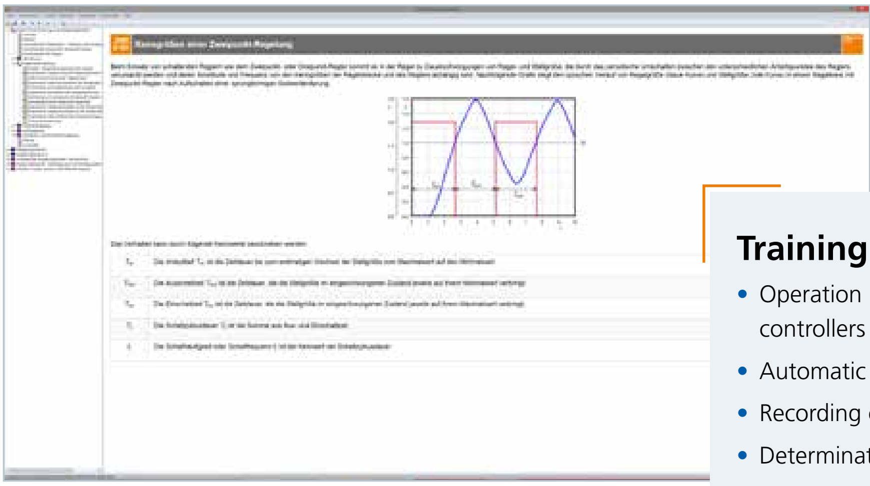


Your benefits

- 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

with Interactive Lab Assistant (ILA)

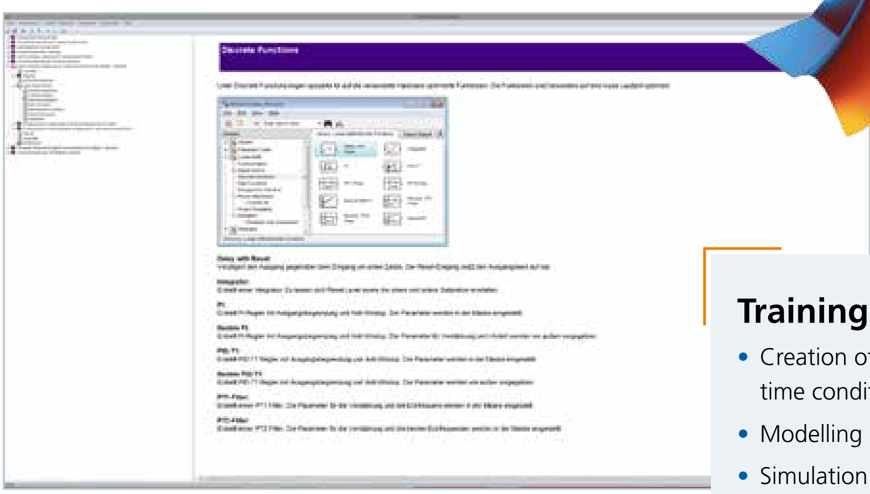
IAC 31 Automatic Control of an Air-Temperature System



Training contents

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

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



Training contents

- Creation of 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 control system
- Expansion of control system to make a multiple-variable controller with independent control of temperature and air flow

Closed-Loop Control of a Coupled Two-Tank System ...

Training System

Measurement and control of fill 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 complex coupled tank system. Apart from determination of fill levels, it is also possible to measure flow rates.

Your 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

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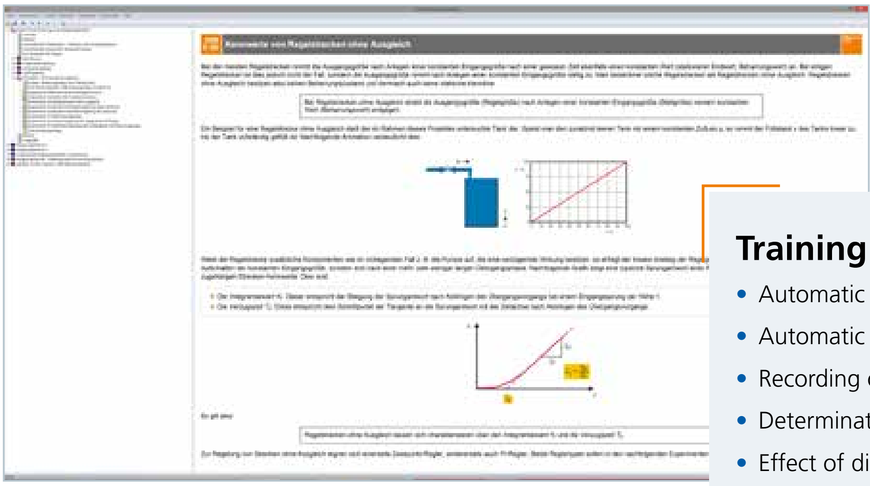
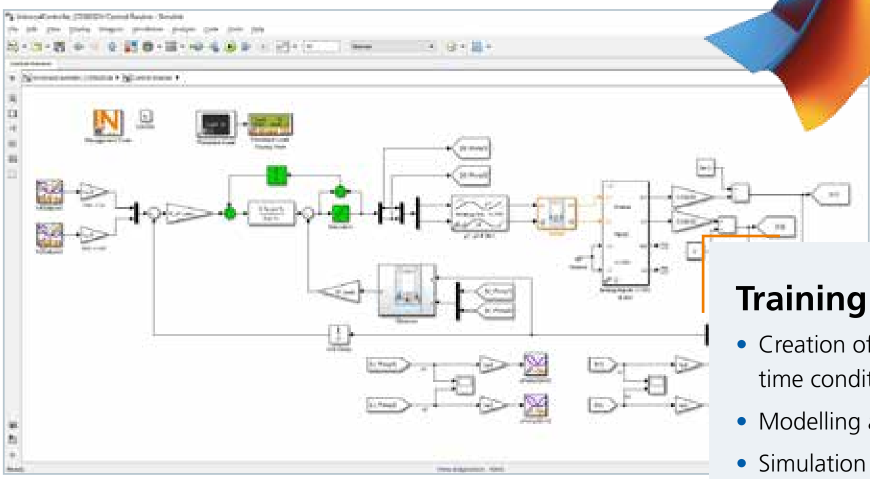
IAC 32 Closed-Loop Control of a Coupled Two-Tank System



Training contents

- Automatic level control using two-position controller
- Automatic level control using PID controller
- Recording of control system parameters
- Determination of controller parameters
- Effect of disturbances on the 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®



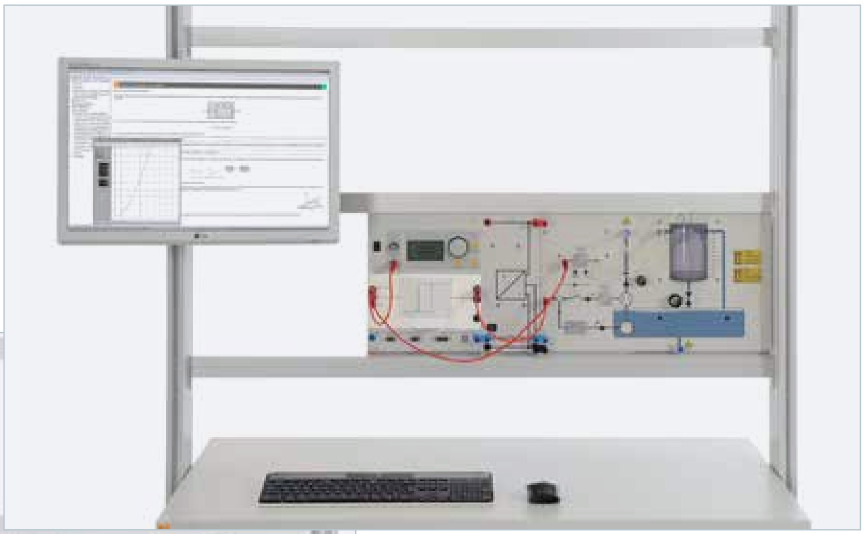
Training contents

- Creation of a hardware-in-the-loop system under real-time conditions
- Modelling and designing a control system
- Simulation and optimisation of control system using a model
- Comparison between model and real control system
- Expansion of control system to make a multiple-variable controller with independent control of levels in both tanks

Automatic Level Control – Flow-Rate Control ...

Training System

This system is an experiment set-up designed for educational and hands-on purposes for experiments on applied closed-loop control. The compact training equipment includes a tank in which the level is to be controlled, a pressure measurement transducer to determine the actual level to which the tank is filled and a reservoir tank including 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.



IAC 12 Automatic level control – Flow-rate control

IAC 13 Industrial level control system using PLC

Your benefits

- Authentic level controlled system with pump, plus level and flow-rate measurement
- Set-up of tank and reservoir without leaks
- Built-in pump with power booster
- Level measurement via differential pressure sensor with calibration function
- Built-in flow-rate meter
- Control valves from inlet and outlet

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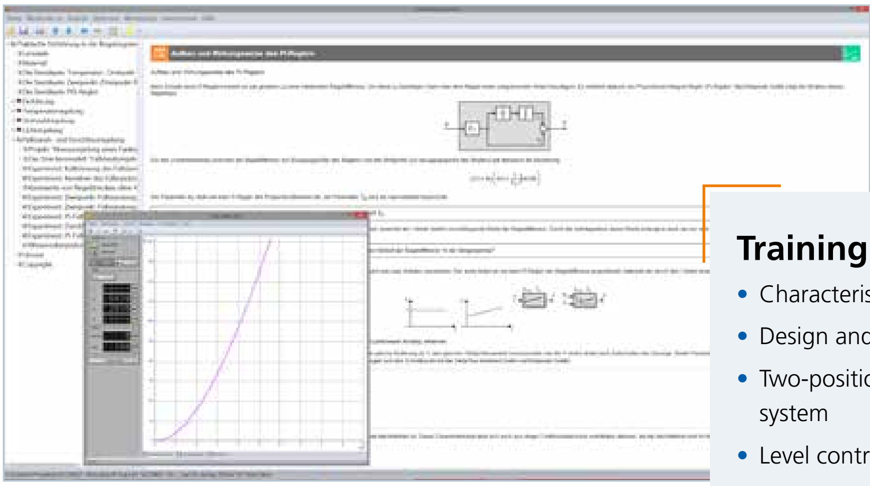
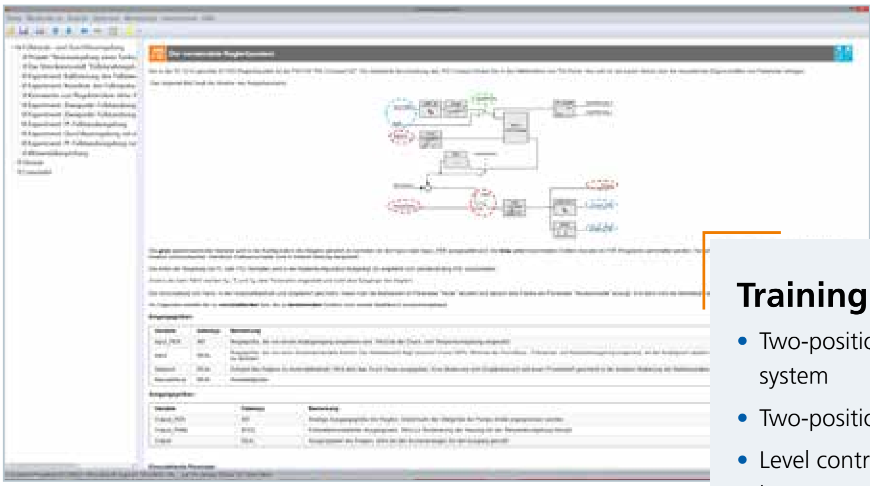
IAC 13 Industrial Level Control System Using PLC



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

IAC 12 Level Control – Flow-Rate Control



Training contents

- Two-position controller in an integral-action controlled system
- Two-position controller with delayed feedback
- Level control with switchable disturbance variables and input control
- Set-up, commissioning and optimisation of automatic flow-rate control system
- Investigation of flow-rate control response to abrupt step changes in disturbance and reference variables

Professional Control of Pressure, Temperature, Level and Flow Rate ...

Training Systems

This compact station with 4 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.

UniTrain Equipment Set: Process Engineering Compact Station

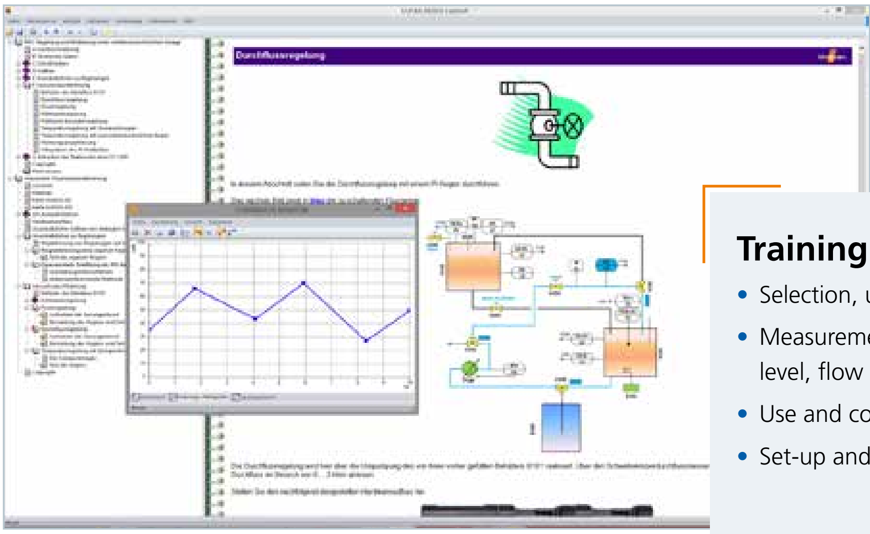
IPA 1 Compact Station, Control of Process Variables via PLC

Your benefits

- Closely aligned with authentic practice thanks to use of genuine 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 sources
- 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)

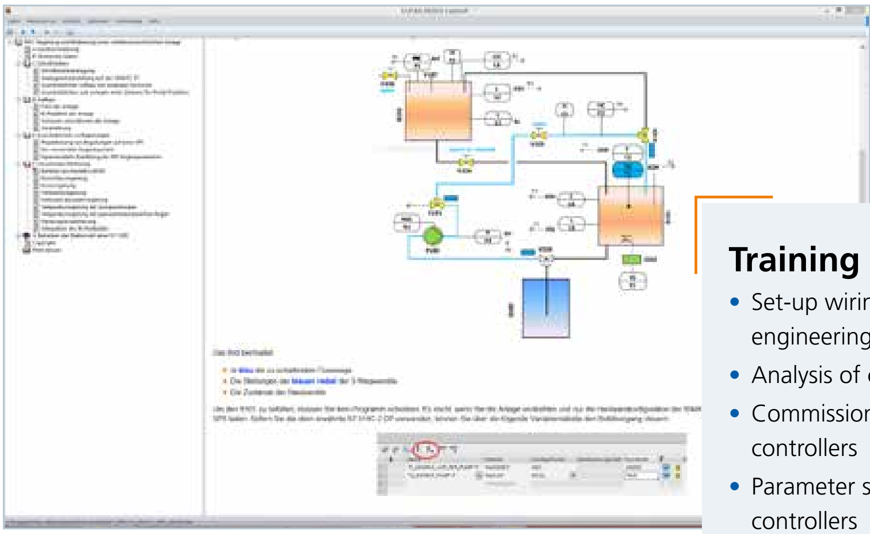
IPA 1 Compact Station, Control of Process Variables via PLC



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

UniTrain Equipment Set: Process Engineering Compact Station



Training contents

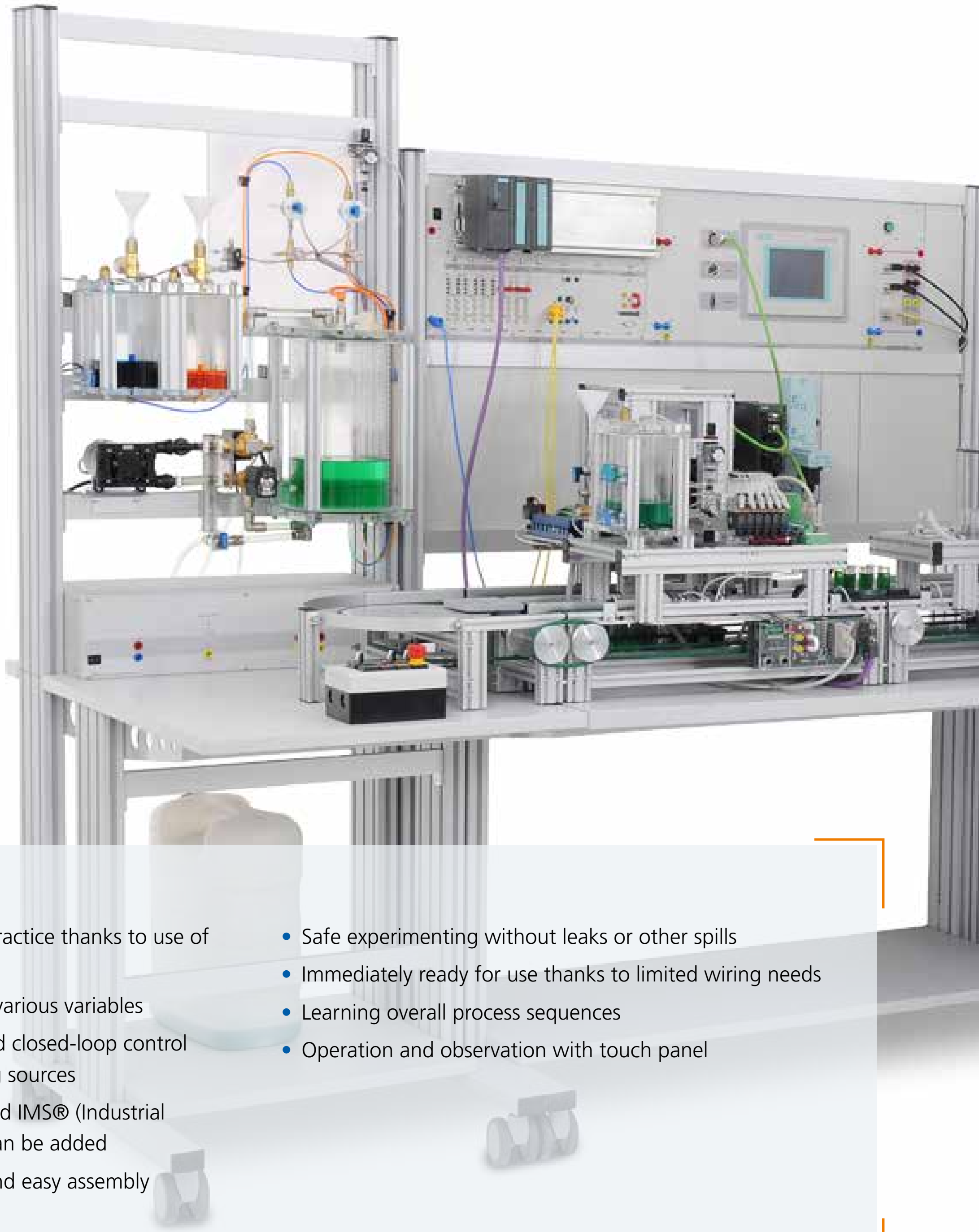
- Set-up wiring and commissioning of a process engineering system
- Analysis of controlled systems and control loops
- Commissioning of continuous and discontinuous controllers
- Parameter setting and optimisation for P, PI and PID controllers
- Design of open- and closed-loop control programs
- Process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

Industrial Process Automation

From Closed-Loop Control of Individual Controlled Systems to Flexible Process Automation

Smart factories

Major changes in the world of industry are now placing serious demands on the teaching of training content. Due to changes in the way operations are run, the topics of "practical skills" and "management of individual working processes" are gaining ever increasing importance in practice.



Your benefits

- Closely aligned with authentic practice thanks to use of genuine industrial components
- Process engineering sensors for various variables
- Combination with any open- and closed-loop control systems from industry or training sources
- Any number of additional IPA and IMS® (Industrial Mechatronics System) stations can be added
- Modular design enables quick and easy assembly
- Safe experimenting without leaks or other spills
- Immediately ready for use thanks to limited wiring needs
- Learning overall process sequences
- Operation and observation with touch panel

Interconnected thinking and action

In order to implement training topics such as the assembly and installation of components and plant modules as well as commissioning, operation and maintenance of plant, it is essential to understand the overall system which underlies all these things.

Renewed training approaches

These factors suggest that it is vital to place process engineering training systems at the core of vocational training from the very start. This helps the technical theory being conveyed to be etched firmly into students' memories by using the systems in learning situations which closely emulate working practice. Learning by means of complex process engineering training systems gives trainees an easy introduction into how things are really done in practice.

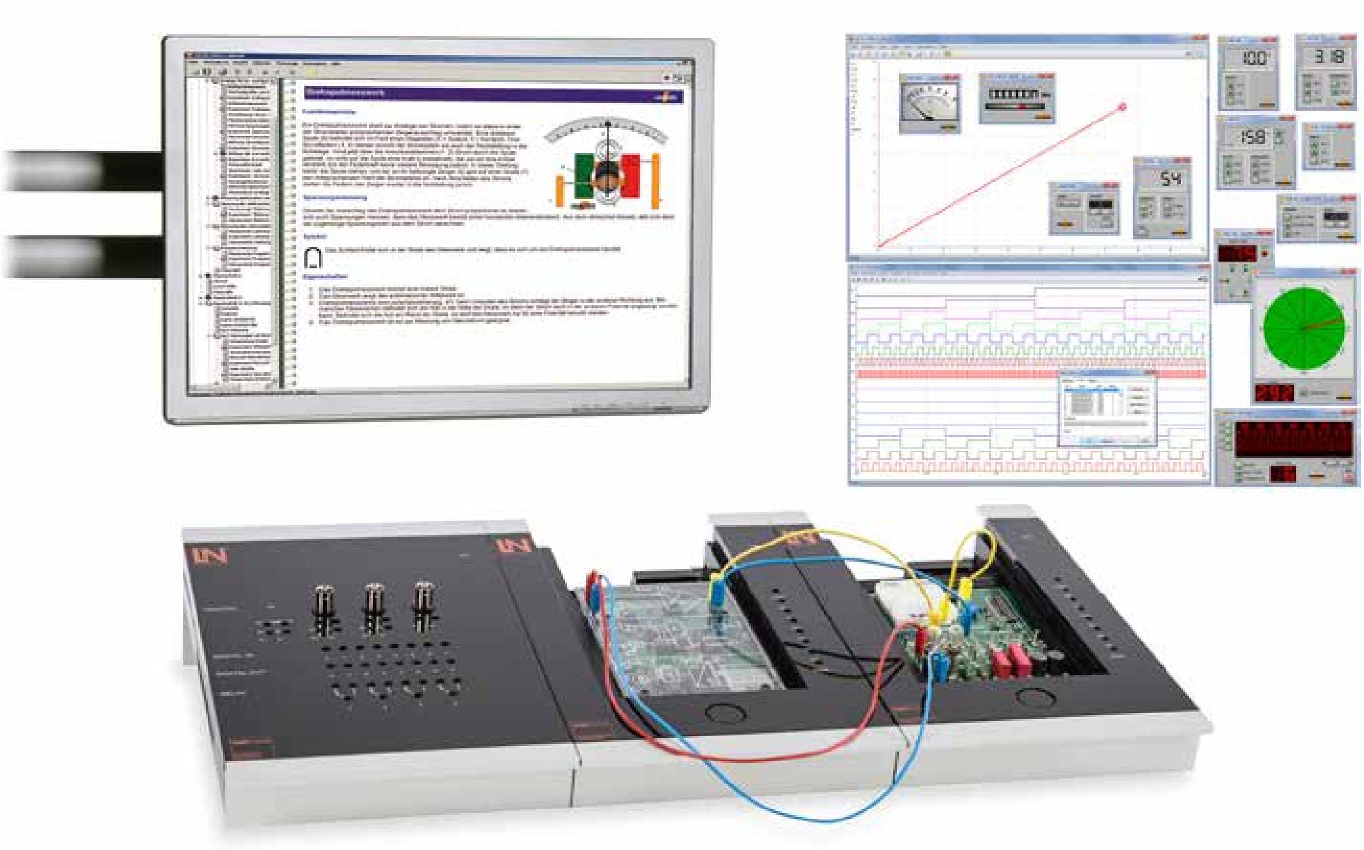

GAS
PRESSURE
bar
psi

Instrumentation

Multimedia Introduction to Instrumentation as Used in Practice ...

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 and tests of knowledge and equally well 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 give an insight into the latest issues in instrumentation and automatic control technology.



Your 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 guidance through course
- Rapid understanding thanks to animated theory illustrations
- Gaining practical skills thanks to experimenting alone
- Constant feedback from tests of understanding and knowledge
- Guided troubleshooting with built-in fault simulation
- Sample solutions for teachers

with UniTrain

Industrial Sensors

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

Training contents

- Working with capacitive and inductive proximity switches
- Working with various sensors such as magnetic field 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 driven X-axis

Measurement of Non-Electrical Variables

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

Measurement of Non-Electrical Variables

Displacement – Angle – Speed

In mechatronic or drive applications for production facilities, rapid and precise detection of displacement, angle and speed are decisive in terms of dynamics, economy and quality.

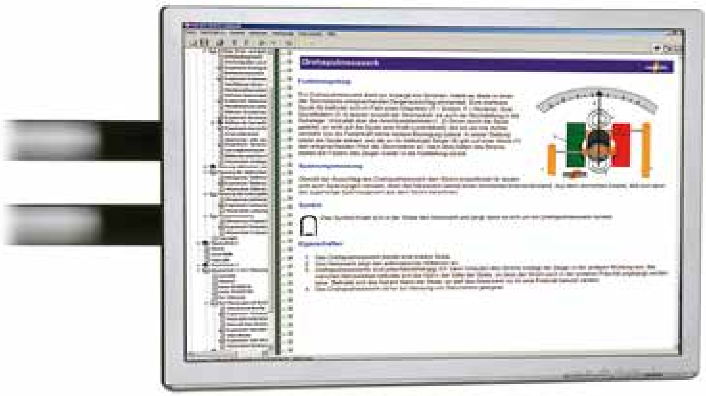
Training contents

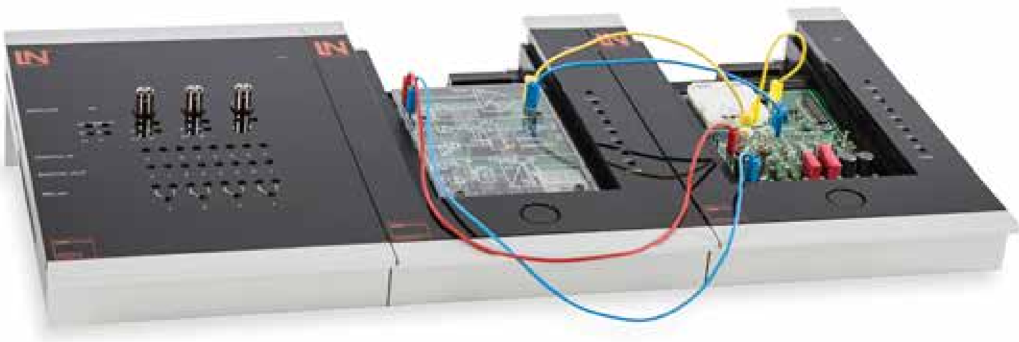
- Analog and digital measuring techniques for displacement, angle and speed
- Familiarisation with the necessary sensors, their principle of operation and their characteristics
- Experimental determination of characteristic curves
- Calibration of measurement circuits
- Experiments with capacitive and 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

Measurement of Electrical Variables

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 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 power factor
- Measurement of consumption and electrical work with the aid of an electricity meter

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 measurement principle
- Comparison of measuring methods

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