SYSTEME FÜR DIE TECHNISCHE AUSBILDUNG
EQUIPMENT FOR ENGINEERING EDUCATION

LABORATORY PLANNING GUIDE

L50 v3 Basic Control Engineering Laboratory

Contents:

made in Germany

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L50 v2 Basic Control Engineering Laboratory

Covered subjects according to the curriculum of Basic Control Engineering

Major topics of learning content:

- fundamentals of control engineering based on the example of a
  * level control system with integral control action
  * rapid flow control system
  * pressure control system with PT behaviour
  * temperature control system
  * speed control system with PT behaviour
  * linear position control system with integral control action
- open loop control response
- investigation of a controlled system without feedback
- effects of different controller parameters & methods on the response of closed loop system
- recording of step responses
  * reference variable and disturbance variable
- controller optimisation
- software-based controlled system simulation
- comparison of different controlled system parameters
- components of a control loop
- operation and parameterisation of an industrial controller
- comparison of various controller types
  * P, PD, PI, PID controllers and two-point controller
- disturbance feed forward control
- familiarisation with a PLC and the essential fundamentals such as
  * Boolean algebra
  * compiling statement lists, interconnection diagrams and block diagrams
  * adapting the program to a given handling process
- exercises in
  * programming, logical “AND” / “OR” gates, logic relays, output and input
- configuration of program sequences by way of connectors, incorporating
  * timers, counters, cascade circuits, higher-order monitoring relays etc.
- fault finding
- familiarisation with and analysis of an automated materials handling process
  * understanding and analysis of the mechanical, pneumatic and electrical functions
  * familiarisation with the symbols, terms and modes of representation of pneumatic and electrical function diagrams
  * familiarisation with automation components: cylinders, solenoid valves, photoelectric proximity switches
- simulation of a punching process
  * conveyor belt is stopped for punching and also as soon as workpiece drops from belt end
- workpiece control simulation
  * light-coloured workpieces are separated out; dark items reach the belt end
- familiarisation with, and carrying out of the calibration of an electronic pressure sensor
- plotting the sensor output signal dependent on the pressure applied
- familiarisation with the design and operation of a piezo-resistive electronic pressure sensor

- familiarisation with the installation and connection of the pressure sensor
- applications, measuring ranges and accuracies of typical electronic pressure sensors
- Mode of operation and application of different sensors
  * one-way and reflex photoelectric barrier
  * inductive and capacitive proximity switch
  * reflex photoelectric proximity switch, infrared and red light
  * limit switch and reed contact
- together with the accessory control loop components
  * mode of operation of control loop components: transducers, actuators, controllers
  * familiarisation with different signals: pneumatic, electrical
  * correct connection of control loop components and their transmission behaviour
  * calibration of manometers

Main concept:

The laboratory is designed for accommodation of 24 students + 2 laboratory staff:

- 2 - 4 students form a team and work together at a workstation / training system
- 21 workstations in 11 different types
- All workstations are floor standing or on a laboratory table
- 14 of the workstations are equipped with a PC
- Each workstation is equipped with a manual containing technical information, basic theory, experiment instructions, evaluation help and safety advice.
- Student teams are scheduled to change workstations from lab session to lab session in order to perform the entire range of experiments within the course duration.
- Average time per experiment: 90 to 120 minutes.
- 2 workstations for laboratory staff (with PC and internet access)
- 1 printer for common use
- 1 cupboard for small parts, consumables, tools, paper etc.

Initial training provided for laboratory personnel:

Trainer: Specialized engineer of G.U.N.T. Gerätebau GmbH, Germany.

To be conducted immediately after installation and commissioning of the equipment.

General topics to be covered for any of the educational systems:

- Basic familiarization with the system.
- Functions and components.
- Overall system configuration aspects.
- Start-up and operational aspects.
- Conduction experiments, including evaluation and calculation.
- Using the system with and without the software (where applicable).
- Trouble shooting and maintenance aspects.
- Hands-on, practical familiarization aspects.
- Seminar participants with the delivered system.
- Details of the manuals.
- Safe operation and preventive maintenance.

Requirements / Utilities:

Power supply:

- 230 V / 50 Hz / 1 phase – at least 40 power sockets

Laboratory computer network:

- 2 internet connections for staff
- 14 internet connections for students

Location:

- Laboratory space min 84 m²
- This laboratory could be installed on any floor (e.g. ground floor or 1st floor)

Schedule of Requirements

L50 v3 Basic Control Engineering Lab

Item No.	Description	Quantity
Item 1	Training system: level control, HSI	2 pcs.
Item 2	Training system: flow control, HSI	2 pcs.
Item 3	Training system: pressure control, HSI	2 pcs.
Item 4	Training system: temperature control, HSI	2 pcs.
Item 5	Training system: speed control, HSI	2 pcs.
Item 6	Training system: position control, HSI	2 pcs.
Item 7	Room temperature control	4 pcs.
Item 8	PLC module	1 pcs.
Item 8.1	PLC application: Materials handling process	1 pcs.
Item 9	Calibrating a pressure sensor	1 pcs.
Item 10	Principles of industrial sensors	1 pcs.
Item 11	Calibration trainer	1 pcs.
Item 11.1	Controller, electronic	1 pcs.
Item 11.2	Pressure transmitter, electronic	1 pcs.
Item 11.3	Differential pressure transmitter, electronic	1 pcs.
Item 11.4	Current-to-pressure converter	1 pcs.
Item 11.5	Pneumatic control valve with electro-pneumatic positioner	1 pcs.
Item 11.6	Control valve, electric	1 pcs.
Item 11.7	Thermocouple type K and calibrator	1 pcs.
Item 11.8	Bourdon tube pressure gauge	1 pcs.
Item 11.9	Diaphragm pressure gauge	1 pcs.
Item 11.10	Tool set	1 pcs.

Tender Specification

L50 v3 Basic Contr. Eng. Lab.

Point of Delivery:		**Customer:**	
End User:		**Date:**	
Ref.-No.:		**Sales Rep.:**	

Item	Description / Specification	Qty. / Picture
Item 1	**Training system: level control, HSI**	2

	Learning objectives/experiments
	- fundamentals of control engineering based on the example of a level control system with integral control action
	- open loop control response
	- investigation of a controlled system without feedback
	- effects of different controller parameters and methods on the response of the closed loop system
	- recording of step responses
	  - reference variable
	  - disturbance variable
	- controller optimisation
	- software-based controlled system simulation
	  - comparison of different controlled system parameters
	
	Specification
	[1] experimental unit for control engineering experiments
	[2] level control process with transparent tank
	[3] speed-controlled pump
	[4] level measurement by pressure sensor
	[5] disturbance variables generated by electromagnetic proportional valve in tank outlet
	[6] tank with overflow and graduated scale
	[7] software-based controlled system simulation
	[8] process schematic on front panel
	[9] networkable software
	[10] software with control functions and data acquisition via USB under Windows 7, 8.1, 10
	
	Technical data
	Level-controlled tank
	- capacity: 1200mL
	Storage tank
	- capacity: 3700mL
	Pump
	- power consumption: 18W
	- max. flow rate: 8L/min
	- max. head: 5m
	Proportional valve: Kvs: 0,7m³/h
	Pressure sensor: 0...30mbar (0...300mm)
	Software controller configurable as P, PI, PID and switching controller
	Software
		
		GUNT RT 010

Point of Delivery:		**Customer:**	
End User:		**Date:**	
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Item	Description / Specification	Qty. / Picture
	- process schematic with controller type selection (manual, continuous controller, two- or three-point controller, programmer) - time functions - simulation function - disturbance variable input 230V, 50Hz, 1 phase 230V, 60Hz, 1 phase 120V, 60Hz, 1 phase UL/CSA optional Dimensions and weight LxWxH: 600x450x800mm Weight: approx. 22kg	
Item 2	**Training system: flow control, HSI**	2

	Learning objectives/experiments
	- fundamentals of control engineering based on the example of a rapid flow control system
	- open loop control response
	- effects of different controller parameters and methods on the response of the closed loop system
	- recording of step responses
	  - reference variable
	  - disturbance variable
	- controller optimisation
	- software-based controlled system simulation
	  - comparison of different controlled system parameters
	
	Specification
	[1] experimental unit for control engineering experiments
	[2] flow control system with variable-area flow meter
	[3] electromagnetic proportional valve as actuator
	[4] turbine wheel flow sensor
	[5] generation of disturbance variables by altering pump speed
	[6] software-based controlled system simulation
	[7] process schematic on front panel
	[8] networkable software
	[9] software with control functions and data acquisition via USB under Windows 7, 8.1, 10
	
	Technical data
	Storage tank
	- capacity: approx. 3000mL
		
		GUNT RT 020

Point of Delivery:		**Customer:**	
End User:		**Date:**	
Ref.-No.:		**Sales Rep.:**	

Item	Description / Specification	Qty. / Picture
	Pump - power consumption: 18W - max. flow rate: 8L/min - max. head: 6m Rotameter: 20...250L/h Proportional valve: Kvs: 0,7m³/h Flow sensor: 0,5...3L/min Software controller configurable as P, PI, PID and switching controller Software - process schematic with controller type selection (manual, continuous controller, two- or three-point controller, programmer) - time functions - simulation function - disturbance variable input 230V, 50Hz, 1 phase 230V, 60Hz, 1 phase 120V, 60Hz, 1 phase UL/CSA optional Dimensions and weight LxWxH: 600x450x600mm Weight: approx. 21kg	
Item 3	**Training system: pressure control, HSI**	2

	Learning objectives/experiments
	- fundamentals of control engineering based on the example of a pressure control system with PT1 behaviour
	- open loop control response
	- effects of different controller parameters and methods on the response of the closed loop system
	- recording of step responses
	  - reference variable
	  - disturbance variable
	- controller optimisation
	- software-based controlled system simulation
	  - comparison of different controlled system parameters
	
	Specification
	[1] experimental unit for control engineering experiments
	[2] pressure control in a tank
	[3] speed controlled diaphragm gas pump
	[4] electronic pressure sensor
	[5] solenoid valve to generate disturbance variables
		
		GUNT RT 030

Point of Delivery:		**Customer:**	
End User:		**Date:**	
Ref.-No.:		**Sales Rep.:**	

Item	Description / Specification	Qty. / Picture
	[6] software-based controlled system simulation [7] process schematic on front panel [8] networkable software [9] software with control functions and data acquisition via USB under Windows 7, 8.1, 10 Technical data Diaphragm gas pump - max. flow rate: 3L/min - max. positive pressure: 1bar - max. negative pressure: 250mbar abs. Pressure tank - capacity: 400mL - operating pressure: 1bar - max. pressure: 10bar Pressure control range: 0...1bar Solenoid valve: Kvs: 0,11m³/h Pressure transducer: 0...1bar Manometer: 0...1bar Software controller configurable as P, PI, PID and switching controller Software - process schematic with controller type selection (manual, continuous controller, two- or three-point controller, programmer) - time functions - simulation function - disturbance variable input 230V, 50Hz, 1 phase 230V, 60Hz, 1 phase 120V, 60Hz, 1 phase UL/CSA optional Dimensions and weight LxWxH: 600x450x340mm Weight: approx. 18kg	
Item 4	**Training system: temperature control, HSI**	2
	Learning objectives/experiments -fundamentals of control engineering based on the example of a temperature control system. System dead time can be obtained from the response - open loop control response - effects of different controller parameters and methods on the response of the closed loop system	

Point of Delivery:		**Customer:**	
End User:		**Date:**	
Ref.-No.:		**Sales Rep.:**	

Item	Description / Specification	Qty. / Picture

	- recording of step responses
	  - reference variable
	  - disturbance variable
	- controller optimisation
	- software-based controlled system simulation
	  - comparison of different controlled system parameters
	
	Specification
	[1] experimental unit for control engineering experiments
	[2] temperature control of a heated metal bar
	[3] heating and cooling by Peltier element
	[4] temperature sensors at 3 different points along axis of bar to establish thermal lags
	[5] software activated fan to generate disturbance variables
	[6] software-based controlled system simulation
	[7] process schematic on front panel
	[8] networkable software
	[9] software with control functions and data acquisition via USB under Windows 7, 8.1, 10
	
	Technical data
	Heated bar: DxL: 20x200mm, aluminium
	Peltier element
	- power consumption depending on temperature
	  - power at 300K: 38,2W
	  - power at 50°C: 44,3W
	- operated by DC voltage
	Fan
	- power consumption: 2W
	- max. flow rate: 40m³/h
	Temperature sensor: 0...100°C
	Thermometer: 0...100°C
	Temperature control range: 0...100°C
	Software controller configurable as P, PI, PID and switching controller
	Software
	- process schematic with controller type selection (manual, continuous controller, two- or three-point controller, programmer)
	- time functions
	- simulation function
	- disturbance variable input
	230V, 50Hz, 1 phase
	230V, 60Hz, 1 phase
	120V, 60Hz, 1 phase
	UL/CSA optional
	
	Dimensions and weight
		
		GUNT RT 040

Point of Delivery:		**Customer:**	
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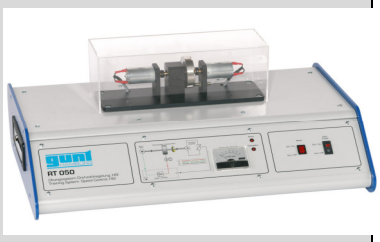
Ref.-No.:		**Sales Rep.:**	

Item	Description / Specification	Qty. / Picture
	LxWxH: 600x450x260mm Weight: approx. 16kg	
Item 5	**Training system: speed control, HSI**	2

	Learning objectives/experiments
	- fundamentals of control engineering based on the example of a speed control system with PT1 behaviour
	- open loop control response
	- effects of different controller parameters and methods on the response of the closed loop system
	- recording of step responses
	  - reference variable
	  - disturbance variable
	- controller optimisation
	- software-based controlled system simulation
	  - comparison of different controlled system parameters
	
	Specification
	[1] experimental unit for control engineering experiments
	[2] speed control of a DC motor with shaft and flywheel
	[3] transparent protective cover for motor/generator set
	[4] inductive speed sensor
	[5] generation of disturbance variables by adjustable generator load
	[6] software-based controlled system simulation
	[7] process schematic on front panel
	[8] networkable software
	[9] software with control functions and data acquisition via USB under Windows 7, 8.1, 10
	
	Technical data
	Motor
	- max. speed: 4500rpm
	- max. motor power output: 10W
	- max. torque: 1,7Ncm
	Generator
	- max. speed: 4500rpm
	- max. power output: 10W
	- max. torque: 1,7Ncm
	Tachometer (analogue): 0...6000rpm
	Software controller configurable as P, PI and PID controller
	Software
	- process schematic with controller type selection (manual, continuous controller, programmer)
		
		GUNT RT 050

Point of Delivery:		**Customer:**	
End User:		**Date:**	
Ref.-No.:		**Sales Rep.:**	

Item	Description / Specification	Qty. / Picture
	- time functions - simulation function - disturbance variable input 230V, 50Hz, 1 phase 230V, 60Hz, 1 phase 120V, 60Hz, 1 phase UL/CSA optional Dimensions and weight LxWxH: 600x450x310mm Weight: approx. 18kg	
Item 6	**Training system: position control, HSI**	2
	Learning objectives/experiments - fundamentals of control engineering based on the example of a linear position control system with integral control action - open loop control response - effects of different controller parameters and methods on the response of the closed loop system - recording of step responses - reference variable - controller optimisation - software-based controlled system simulation - comparison of different controlled system parameters Specification [1] experimental unit for control engineering experiments [2] linear position control of carriage with linear drive and gear motor [3] rotary encoder as displacement sensor [4] transparent protective cover [5] 2 microswitches to shut down at end positions [6] software-based controlled system simulation [7] process schematic on front panel [8] networkable software [9] software with control functions and data acquisition via USB under Windows 7, 8.1, 10 Technical data DC motor - transmission ratio: i=50 - speed: 85rpm - torque: 200Nmm Travel: max. 300mm	 GUNT RT 060

Point of Delivery:		**Customer:**	
End User:		**Date:**	
Ref.-No.:		**Sales Rep.:**	

Item	Description / Specification	Qty. / Picture
	Max. traverse rate: 45mm/s Scale: 0...300mm Software controller configurable as P, PI, PID Software - process schematic with controller type selection (manual, continuous controller, programmer) - time functions - simulation function 230V, 50Hz, 1 phase 230V, 60Hz, 1 phase 120V, 60Hz, 1 phase UL/CSA optional Dimensions and weight LxWxH: 600x450x280mm Weight: approx. 20kg	
Item 7	**Room temperature control**	4

	Learning objectives/experiments
	- components of a control loop
	- operation and parameterisation of an industrial controller
	- comparison of various controller types
	  - P, PD, PI and PID controllers
	  - two-point controller
	- layout of control loops
	  - open control loop
	  - closed control loop
	- generation of disturbances
	
	Specification
	[1] investigation of a temperature control loop
	[2] control loop components on panels allowing for variation in installation in frame
	[3] soldering iron as controlled system
	[4] power controller as actuator
	[5] parameterisable digital industrial controller
	[6] thermocouple type K as temperature sensor
	[7] transducer for thermocouple with digital temperature display
	[8] bar display for manipulating variable
	[9] 2 metal plates with differing thermal conductivities for disturbance generation
	[10] line recorder available as accessory
		
		GUNT RT 200

Point of Delivery:		**Customer:**	
End User:		**Date:**	
Ref.-No.:		**Sales Rep.:**	

Item	Description / Specification	Qty. / Picture
	Technical data Soldering iron power output: 16W Controller - input signals: 0/4...20mA and 0...10V - output signals: 0...20mA - parameterisable as P, PI or PID controller 2-point controller Power controller - output power: 0...16W - input signal: 0...20mA Thermocouple and transducer - measuring range: 0...400°C - output signal: 0...10VDC 2 metal plates for disturbance generation - stainless steel - copper 230V, 50Hz, 1 phase 230V, 60Hz, 1 phase 120V, 60Hz, 1 phase UL/CSA optional Dimensions and weight LxWxH: 800x500x840mm Weight: approx. 38kg	
Item 8	**PLC module**	1
	Learning objectives/experiments - familiarisation with a PLC - familiarisation with the essential fundamentals such as - Boolean algebra - compiling statement lists - interconnection diagrams and block diagrams - exercises in - programming - logical "AND" / "OR" gates - logic relays - output and input - configuration of program sequences by way of connectors, incorporating - timers - counters - cascade circuits	 GUNT IA 130

Point of Delivery:		**Customer:**	
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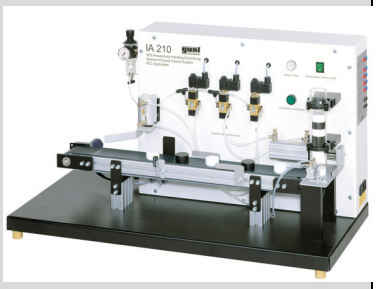
Ref.-No.:		**Sales Rep.:**	

Item	Description / Specification	Qty. / Picture
	- higher-order monitoring relays etc. - fault finding Specification [1] module for basic exercises on a programmable logic controller (PLC) [2] self-contained PLC module, usable as part of a complex system [3] integrated patchboard for creating circuits with input and output elements [4] PLC with 2 integrated setpoint encoders [5] programming software to IEC 61131-3; software via USB under Windows 7, 8.1, 10 [6] example program supplied Technical data PLC - connections - 16 digital inputs - 16 digital outputs - 2 analogue inputs - 1 analogue output - memory type: PLC back-up battery for 32kByte RAM and clock - Rated voltage: 24VDC Software - graphical user interfaces - programming languages to IEC/EN 61131-3: - statement list (STL) - ladder diagram (LD) - function block diagram (FBD) - structured text (ST) - multiple dialogue languages (German, English, French, Spanish) - graphical topology configurator 230V, 50Hz, 1 phase 230V, 60Hz, 1 phase 120V, 60Hz, 1 phase UL/CSA optional Dimensions and weight LxWxH: 620x350x450mm Weight: approx. 15kg	

Tender Specification

L50 v3 Basic Contr. Eng. Lab.

Point of Delivery:		**Customer:**	
End User:		**Date:**	
Ref.-No.:		**Sales Rep.:**	
Item	**Description / Specification**		**Qty. / Picture**

Item 8.1	**PLC application: materials handling process**	1
	Learning objectives/experiments - familiarisation with and analysis of an automated materials handling process - understanding and analysis of the mechanical, pneumatic and electrical functions - familiarisation with the symbols, terms and modes of representation of pneumatic and electrical function diagrams - familiarisation with automation components: cylinders, solenoid valves, photoelectric proximity switches - familiarisation with the use of a PLC - basic methods of programming - adapting the program to the given handling process - simulation of a punching process - conveyor belt is stopped for punching - conveyor belt also stops as soon as workpiece drops from belt end - workpiece control simulation - light-coloured workpieces are separated out; dark items reach the belt end Specification [1] compact unit for experiments in the field of automation [2] handling device with solenoid valves [3] double-acting cylinder (15mm stroke): fixing / discharge of workpieces to container [4] double-acting cylinder (80mm stroke): pushes workpiece onto conveyor belt [5] double-acting cylinder (40mm stroke): executes the process (sorting or punching) [6] conveyor belt with guide plates and DC motor [7] cylindrical Plexiglas storage container holding 11 workpieces [8] 15 workpieces made of Polyoxymethylene (POM): 10x white, 5x black [9] pneumatic components fitted with quick-release couplings for 4mm hoses [10] operation of actuators with compressed air [11] lab jacks to external PLC [12] set of laboratory cables and pneumatic hoses [13] compressed air supply: max. 6bar, 3bar recommended Technical data 3 electrically operated 5/2-way valves	 GUNT IA 210

Point of Delivery:		**Customer:**	
End User:		**Date:**	
Ref.-No.:		**Sales Rep.:**	

Item	Description / Specification	Qty. / Picture
	- with spring return - with pilot valve Reflex photoelectric proximity switch - pnp, light-switching - 5...150mm Geared DC motor - reduction ratio: 142,5:1 - nominal torque 5,92Nm - nominal speed: 22rpm Polyester weave conveyor belt Workpieces, DxH: 40x20mm 230V, 50Hz, 1 phase 230V, 60Hz, 1 phase 120V, 60Hz, 1 phase UL/CSA optional Dimensions and weight LxWxH: 1000x450x580mm Weight: approx. 46kg	
Item 9	**Calibrating a pressure sensor**	1
	Learning objectives/experiments - familiarisation with, and carrying out of the calibration of an electronic pressure sensor - plotting the sensor output signal dependent on the pressure applied - familiarisation with the design and operation of a piezo-resistive electronic pressure sensor - familiarisation with the installation and connection of the pressure sensor - information on applications, measuring ranges and accuracies of typical electronic pressure sensors Specification [1] calibration unit with dead-weight piston manometer and hand-operated spindle [2] electronic pressure sensor with ceramic measuring cell, integrated amplifier and voltage output [3] digital display for output signal [4] additional pressure sensor as cutaway model [5] set of weights [6] transmission medium: hydraulic oil [7] process schematic on front panel	 GUNT IA 110

Point of Delivery:		**Customer:**	
End User:		**Date:**	
Ref.-No.:		**Sales Rep.:**	

Item	Description / Specification	Qty. / Picture

	Technical data
	Pressure sensor
	- measuring range: 0...2,5bar
	- supply: 24VDC
	- output signal: 0...10VDC
	Piston manometer with pressure piston
	- diameter: 12mm
	- number of weights: 5
	- pressure graduations:
	  - 0,5bar
	  - 1,0bar
	  - 1,5bar
	  - 2,0bar
	  - 2,5bar
	Digital display: 4 1/2 digits
	Hydraulic oil: HLP ISO 32
	230V, 50Hz, 1 phase
	230V, 60Hz, 1 phase
	120V, 60Hz, 1 phase
	UL/CSA optional
	
	Dimensions and weight
	LxWxH: 600x450x450mm
	Weight: approx. 20kg	

Item 10	**Principles of industrial sensors**	1
	Learning objectives/experiments Mode of operation and application of different sensors - one-way photoelectric barrier - reflex photoelectric barrier - inductive proximity switch - capacitive proximity switch - reflex photoelectric proximity switch, infrared - reflex photoelectric proximity switch, red light - limit switch - reed contact Specification [1] training kit for familiarisation with position and displacement sensors [2] base plate with scale [3] sensor supply unit with 4 light-emitting diodes [4] sensors mounted on adjustable fixture	 GUNT IA 120

Point of Delivery:		**Customer:**	
End User:		**Date:**	
Ref.-No.:		**Sales Rep.:**	

Item	Description / Specification	Qty. / Picture
	[5] 5 measuring plates [6] all mountings and components housed in aluminium storage case Technical data Measuring plates, LxW: 145x70mm - aluminium sheet: d=2mm, smooth, black - steel sheet: d=2mm, textured, matt black - steel sheet: d=2mm, smooth, silver - plexiglas plate: d=5mm, transparent - plastic plate: d=5mm, smooth, white Gauge screw: 0...25mm Sensors - reflex photoelectric barrier: pnp, dark-switching - light guide: pnp, dark-switching - reflex photoelectric proximity switch: pnp, light-switching, 5...150mm - photoelectric proximity switch: pnp, light-switching - inductive proximity switch: pnp, NO contact - capacitive proximity switch: NO contact, 1...8mm - limit switch: 1 NO contact, 1 NC contact - reed contact: switching distance: 5mm, max. 1W at 24V Power supply - output voltage: 3...12VDC, graduated - output current 1000mA 230V, 50Hz, 1 phase 230V, 60Hz, 1 phase 120V, 60Hz, 1 phase UL/CSA optional Dimensions and weight LxWxH: 510x410x200mm (case) LxWxH: 460x150x27mm (base plate) LxWxH: 160x85x140mm (sensor supply) Total weight: approx. 14kg	
Item 11	**Calibration trainer**	1
	Learning objectives/experiments - together with the accessory control loop components - mode of operation of control loop components: transducers, actuators, controllers - familiarisation with different signals: pneumatic, electrical - correct connection of control loop components - transmission behaviour of control loop components	

Point of Delivery:		**Customer:**	
End User:		**Date:**	
Ref.-No.:		**Sales Rep.:**	

Item	Description / Specification	Qty. / Picture
	- calibration of manometers Specification [1] investigation of transmission behaviour and calibration of control loop components and measuring instruments [2] sending and measuring pneumatic and electrical signals [3] 2 pressure regulators with manometers [4] height-adjustable tank and scale to set low pressures [5] 2 controllers to send and measure current signals [6] 2 DC voltage sources to supply control loop components with auxiliary power [7] 2 precision manometers, D=160mm [8] control loop components and meters available as accessories Technical data 2 pressure regulators - 0...1,6bar - 0...6bar Pressure range, height-adjustable tank - 0...1000mm head 2 controllers - 1 output each: 4...20mA - 1 input each: 4...20mA 2 DC voltage sources - each 24VDC Measuring ranges - pressure: - 0...1,6bar - 0...6bar 230V, 50Hz, 1 phase 230V, 60Hz, 1 phase 120V, 60Hz, 1 phase UL/CSA optional Dimensions and weight LxWxH: 1000x750x2150mm Weight: approx. 110kg	 GUNT RT 304
Item 11.1	**Controller, electronic**	1
		GUNT RT 305.01
	Pressure transmitter, electronic	1

Point of Delivery:		**Customer:**	
End User:		**Date:**	
Ref.-No.:		**Sales Rep.:**	

Item	Description / Specification	Qty. / Picture
Item 11.2		GUNT RT 305.02
Item 11.3	**Differential pressure transmitter, electronic**	1
		GUNT RT 305.03
Item 11.4	**Current-to-pressure converter**	1
		GUNT RT 305.04
Item 11.5	**Pneumatic control valve with electro-pneumatic positioner**	1
		GUNT RT 305.05
Item 11.6	**Control valve, electric**	1
		GUNT RT 305.06
Item 11.7	**Thermocouple type K and calibrator**	1
		GUNT RT 305.07
Item 11.8	**Bourdon tube pressure gauge**	1
		GUNT RT 305.08
Item 11.9	**Diaphragm pressure gauge**	1
		GUNT RT 305.09
Item 11.10	**Tool set**	1

Tender Specification

L50 v3 Basic Contr. Eng. Lab.

Point of Delivery:		**Customer:**	
End User:		**Date:**	
Ref.-No.:		**Sales Rep.:**	
Item	**Description / Specification**		**Qty. / Picture**
			GUNT RT 305.10

Technical Data Sheets

L50 v3 Basic Control Engineering Lab.

Item	Description	Code	Qty.
	Praxis Lab for 24 Students:		
Item 1	Training system: level control, HSI Please click here for further information: www.gunt.de/images/download/RT0x0_english.pdf	RT 010	2
Item 2	Training system: flow control, HSI Please click here for further information: www.gunt.de/images/download/RT0x0_english.pdf	RT 020	2
Item 3	Training system: pressure control, HSI Please click here for further information: www.gunt.de/images/download/RT0x0_english.pdf	RT 030	2
Item 4	Training system: temperature control, HSI Please click here for further information: www.gunt.de/images/download/RT0x0_english.pdf	RT 040	2
Item 5	Training system: speed control, HSI Please click here for further information: www.gunt.de/images/download/RT0x0_english.pdf	RT 050	2
Item 6	Training system: position control, HSI Please click here for further information: www.gunt.de/images/download/RT0x0_english.pdf	RT 060	2
Item 7	Room temperature control	RT 200	4
Item 8	PLC module	IA 130	1
Item 8.1	PLC application: materials handling process	IA 210	1
Item 9	Calibrating a pressure sensor	IA 110	1
Item 10	Principles of industrial sensors	IA 120	1
Item 11	Calibration trainer	RT 304	1
Item 11.1	Controller, electronic	RT 305.01	1
Item 11.2	Pressure transmitter, electronic	RT 305.02	1
Item 11.3	Differential pressure transmitter, electronic	RT 305.03	1
Item 11.4	Current-to-pressure converter	RT 305.04	1

Item	Description	Code	Qty.
Item 11.5	Pneumatic control valve with electro-pneumatic positioner	RT 305.05	1
Item 11.6	Control valve, electric	RT 305.06	1
Item 11.7	Thermocouple type K and calibrator	RT 305.07	1
Item 11.8	Bourdon tube pressure gauge	RT 305.08	1
Item 11.9	Diaphragm pressure gauge	RT 305.09	1
Item 11.10	Tool set	RT 305.10	1

RT 010

Training system: level control, HSI

Learning objectives/experiments

- fundamentals of control engineering based on the example of a level control system with integral control action
- open loop control response
- investigation of a controlled system without feedback
- effects of different controller parameters and methods on the response of the closed loop system
- recording of step responses
  - reference variable
  - disturbance variable
- controller optimisation
- software-based controlled system simulation
  - comparison of different controlled system parameters

Description

- **experimental unit with clear level control system**
- **extensive range of experiments on fundamentals of control engineering**
- **state-of-the-art software for all experimental units of the RT 010 – RT 060 series, with extensive controller and recorder functions**
- **software-based simulation of the controlled system**

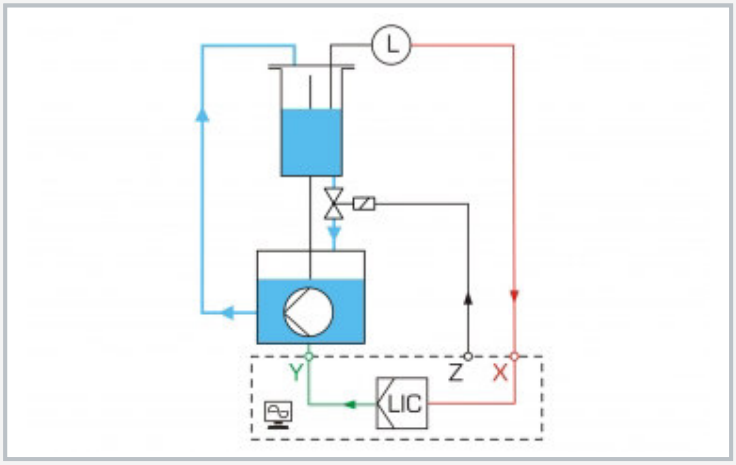
This compact experimental unit offers every opportunity to learn the fundamentals of control engineering through experimentation on a level control system.

The experimental setup is mounted in a housing which also accommodates all the electronics. The transparent level-controlled tank is fed from the storage tank with the aid of a speed-controlled pump. The liquid level is measured using a pressure sensor. The sensor output signal is sent to the software controller. The controller's output signal influences the speed of the pump motor and therefore delivery flow rate. To investigate the influence of disturbance variables, an electromagnetic proportional valve in the tank outlet can be activated by the software.

The powerful state-of-the-art software is an integral part of the training system, embodying the principle of hardware/software integration (HSI). It enables the experiments to be conducted and evaluated in a user-friendly manner. The software has network capability. The link between the experimental unit and the PC is made via a USB port.

RT 010
Training system: level control, HSI

1 level-controlled tank with overflow, 2 pump, 3 displays and controls, 4 storage tank, 5 proportional valve



Process schematic

Software screenshot: PI control of level control system: step response to change in reference variable with different values for K_p and T_n

Specification

[1] experimental unit for control engineering experiments
[2] level control process with transparent tank
[3] speed-controlled pump
[4] level measurement by pressure sensor
[5] disturbance variables generated by electromagnetic proportional valve in tank outlet
[6] tank with overflow and graduated scale
[7] software-based controlled system simulation
[8] process schematic on front panel
[9] networkable GUNT software
[10] GUNT software with control functions and data acquisition via USB under Windows 7, 8.1, 10

Technical data

Level-controlled tank
- capacity: 1200mL

Storage tank
- capacity: 3700mL

Pump
- power consumption: 18W
- max. flow rate: 8L/min
- max. head: 5m

Proportional valve: Kvs: 0,7m³/h
Pressure sensor: 0...30mbar (0...300mm)
Software controller configurable as P, PI, PID and switching controller
Software
- process schematic with controller type selection (manual, continuous controller, two- or three-point controller, programmer)
- time functions
- simulation function
- disturbance variable input

230V, 50Hz, 1 phase
230V, 60Hz, 1 phase
120V, 60Hz, 1 phase
UL/CSA optional
LxWxH: 600x450x800mm
Weight: approx. 22kg

Required for operation

PC with Windows

Scope of delivery

1 experimental unit
1 GUNT software CD + USB cable
1 hose
1 handbook: fundamentals of control engineering (RT 010 – RT 060)
1 manual for RT 010

RT 010

Training system: level control, HSI

Optional accessories

020.30009	WP 300.09	Laboratory trolley

RT 020

Training system: flow control, HSI

Description

- **experimental unit with clear flow control system**
- **extensive range of experiments on fundamentals of control engineering**
- **state-of-the-art software for all experimental units of the RT 010 – RT 060 series, with extensive controller and recorder functions**
- **software-based simulation of the controlled system**

This compact experimental unit offers every opportunity to learn the fundamentals of control engineering through experimentation on a flow control system. The experimental setup is mounted in a housing which accommodates all the electronics.

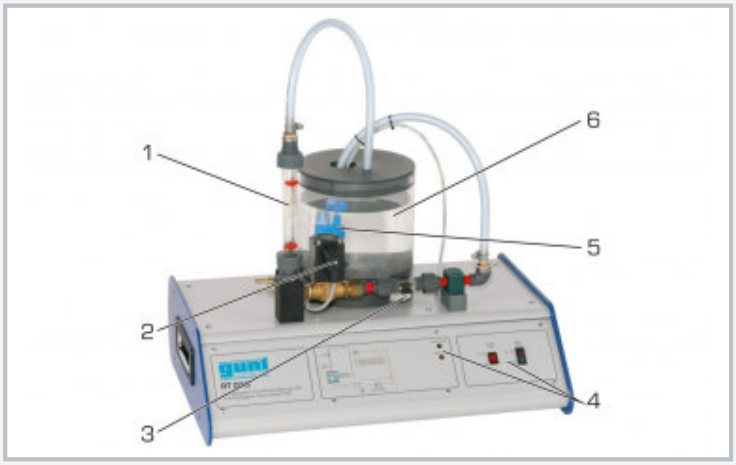
A piping system with two flow meters is supplied with flow by a speed-controlled pump from the transparent storage tank. The rotameter offers the advantage that the flow rate can be observed directly at any time. The flow rate is measured by a turbine wheel flow sensor. The sensor output signal is sent to the software controller. The output signal from the controller influences the setting of an electromagnetic proportional valve. To investigate the influence of disturbance variables, the pump speed can be altered by way of the software.

The powerful state-of-the-art software is an integral part of the training system, embodying the principle of hardware/software integration (HSI). It enables the experiments to be conducted and evaluated in a user-friendly manner. The software has network capability. The link between the experimental unit and the PC is made via a USB port.

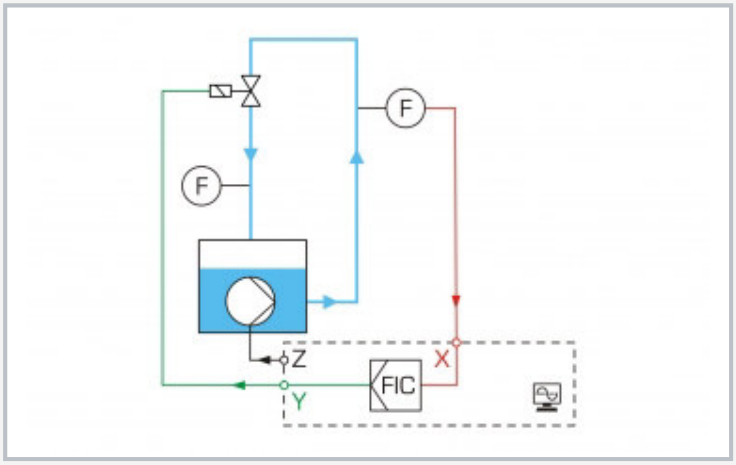
Learning objectives/experiments

- fundamentals of control engineering based on the example of a rapid flow control system
- open loop control response
- effects of different controller parameters and methods on the response of the closed loop system
- recording of step responses
  - reference variable
  - disturbance variable
- controller optimisation
- software-based controlled system simulation
  - comparison of different controlled system parameters

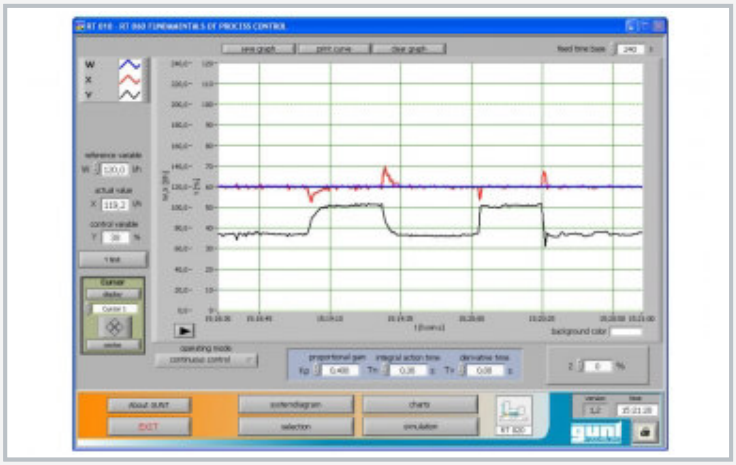
RT 020
Training system: flow control, HSI



1 rotameter, 2 proportional valve, 3 flow sensor, 4 displays and controls, 5 pump, 6 storage tank



Process schematic



Software screenshot: flow control, controller with PI response with different values for K_p and T_n, introduction of a disturbance variable

Specification

[1] experimental unit for control engineering experiments
[2] flow control system with variable-area flow meter
[3] electromagnetic proportional valve as actuator
[4] turbine wheel flow sensor
[5] generation of disturbance variables by altering pump speed
[6] software-based controlled system simulation
[7] process schematic on front panel
[8] networkable GUNT software
[9] GUNT software with control functions and data acquisition via USB under Windows 7, 8.1, 10

Technical data

Storage tank
- capacity: approx. 3000mL

Pump
- power consumption: 18W
- max. flow rate: 8L/min
- max. head: 6m

Rotameter: 20...250L/h
Proportional valve: Kvs: 0,7m³/h
Flow sensor: 0,5...3L/min
Software controller configurable as P, PI, PID and switching controller
Software
- process schematic with controller type selection (manual, continuous controller, two- or three-point controller, programmer)
- time functions
- simulation function
- disturbance variable input

230V, 50Hz, 1 phase
230V, 60Hz, 1 phase
120V, 60Hz, 1 phase
UL/CSA optional
LxWxH: 600x450x600mm
Weight: approx. 21kg

Required for operation

PC with Windows

Scope of delivery

1 experimental unit
1 hose
1 GUNT software CD + USB cable
1 handbook: fundamentals of control engineering (RT 010 – RT 060)
1 manual for RT 020

RT 020

Training system: flow control, HSI

Optional accessories

020.30009	WP 300.09	Laboratory trolley

RT 030

Training system: pressure control, HSI

Description

- **experimental unit with diaphragm gas pump and pressure tank**
- **extensive range of experiments on fundamentals of control engineering**
- **state-of-the-art software for all experimental units of the RT 010 – RT 060 series, with extensive controller and recorder functions**
- **software-based simulation of the controlled system**

This compact experimental unit offers every opportunity to learn the fundamentals of control engineering through experimentation on a pressure control system.

The experimental setup is mounted on a housing which accommodates all the electronics. The pressure tank is charged with compressed air by a diaphragm gas pump. The advantage of the dial-gauge manometer is that the pressure in the tank can be observed directly at any time. The pressure is measured using a pressure sensor. The sensor output signal is sent to the software controller. The output signal from the controller influences the speed of the diaphragm gas pump and hence the flow rate. An air consumer is simulated by way of a flow control valve. A solenoid valve through which air can escape can be activated by the software to investigate the influence of disturbance variables.

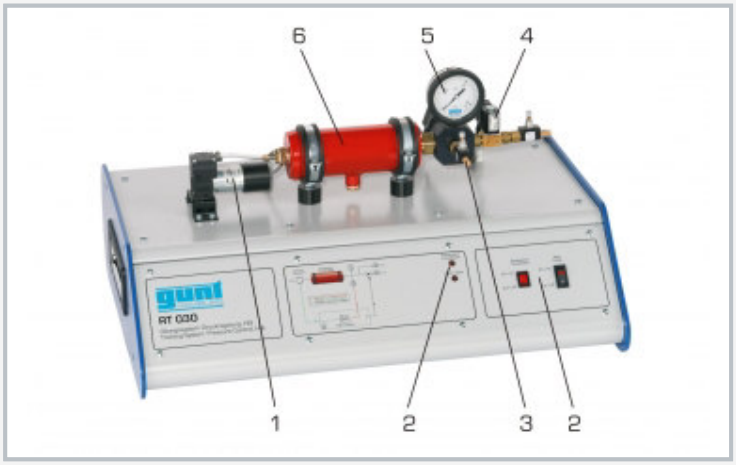
The powerful state-of-the-art software is an integral part of the training system, embodying the principle of hardware/software integration (HSI). It enables the experiments to be conducted and evaluated in a user-friendly manner. The software has network capability. The link between the experimental unit and the PC is made via a USB port.

Learning objectives/experiments

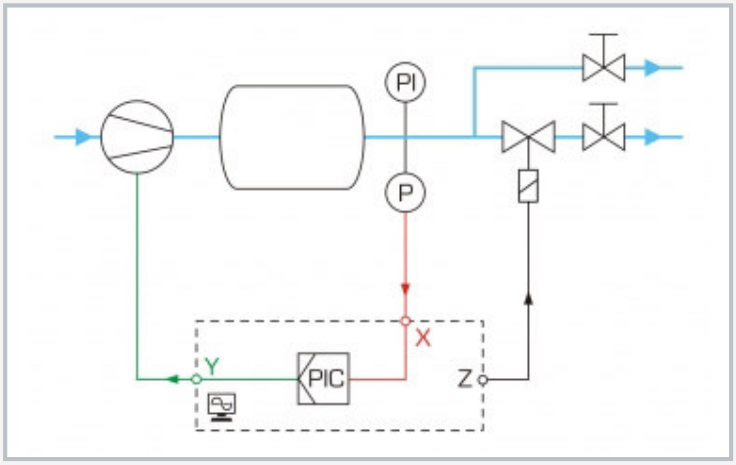
- fundamentals of control engineering based on the example of a pressure control system with PT_1 behaviour
- open loop control response
- effects of different controller parameters and methods on the response of the closed loop system
- recording of step responses
  - reference variable
  - disturbance variable
- controller optimisation
- software-based controlled system simulation
  - comparison of different controlled system parameters

RT 030

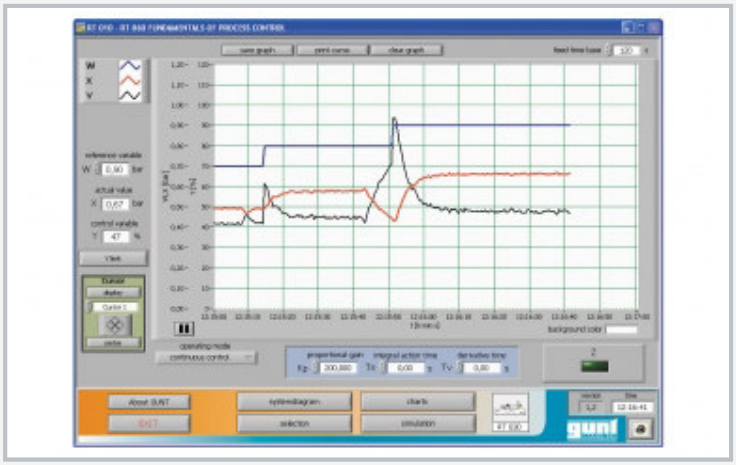
Training system: pressure control, HSI



1 diaphragm gas pump, 2 displays and controls, 3 drain valve, 4 solenoid valve to generate disturbance variables, 5 manometer, 6 pressure tank



Process schematic



Software screenshot: continuous P control: a step of the reference variable results in a permanent control deviation

Specification

[1] experimental unit for control engineering experiments
[2] pressure control in a tank
[3] speed controlled diaphragm gas pump
[4] electronic pressure sensor
[5] solenoid valve to generate disturbance variables
[6] software-based controlled system simulation
[7] process schematic on front panel
[8] networkable GUNT software
[9] GUNT software with control functions and data acquisition via USB under Windows 7, 8.1, 10

Technical data

Diaphragm gas pump
- max. flow rate: 3L/min
- max. positive pressure: 1bar
- max. negative pressure: 250mbar abs.

Pressure tank
- capacity: 400mL
- operating pressure: 1bar
- max. pressure: 10bar

Pressure control range: 0...1bar
Solenoid valve: Kvs: 0,11m³/h
Pressure transducer: 0...1bar
Manometer: 0...1bar
Software controller configurable as P, PI, PID and switching controller
Software
- process schematic with controller type selection (manual, continuous controller, two- or three-point controller, programmer)
- time functions
- simulation function
- disturbance variable input

230V, 50Hz, 1 phase
230V, 60Hz, 1 phase
120V, 60Hz, 1 phase
UL/CSA optional
LxWxH: 600x450x340mm
Weight: approx. 18kg

Required for operation

PC with Windows

Scope of delivery

1 experimental unit
1 GUNT software CD + USB cable
1 handbook: fundamentals of control engineering (RT 010 – RT 060)
1 manual for RT 030

RT 030

Training system: pressure control, HSI

Optional accessories

020.30009	WP 300.09	Laboratory trolley

RT 040

Training system: temperature control, HSI

Description

- **experimental unit with temperature control system**
- **extensive range of experiments on fundamentals of control engineering**
- **heating and cooling with Peltier element**
- **state-of-the-art software for all experimental units of the RT 010 – RT 060 series, with extensive controller and recorder functions**
- **software-based simulation of the controlled system**

This compact experimental unit offers every opportunity to learn the fundamentals of control engineering through experimentation on a temperature control system.

The experimental setup is mounted on a housing which accommodates all the electronics. A metal bar, which is thermally insulated with cladding, is heated or cooled at one end by a Peltier element. Three temperature transducers along the axis of the bar allow the variation in temperature along the length of the bar, and hence the associated thermal lags, to be obtained for differing operating conditions. A dial-gauge thermometer offers the advantage that the temperature can be read off directly at any time. The temperature is measured using a thermal resistor (PTC). The sensor output signal is sent to the software controller. The output signal from the controller influences the operating voltage of the Peltier element and hence the heating capacity. A fan that dissipates part of the heating power can be activated by the software to investigate the influence of disturbance variables.

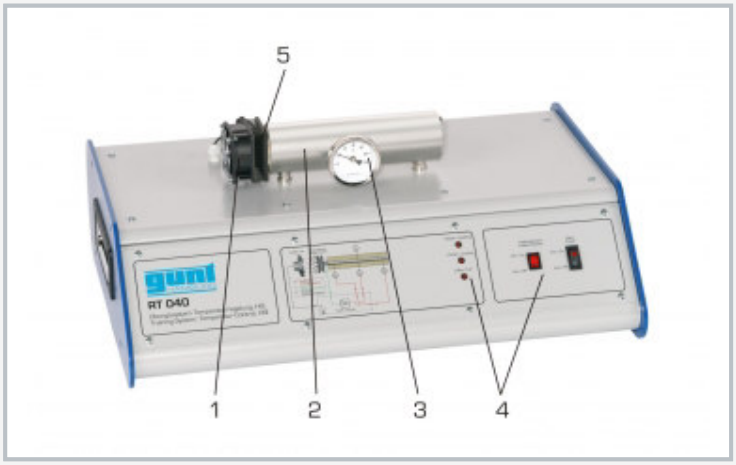
The powerful state-of-the-art software is an integral part of the training system, embodying the principle of hardware/software integration (HSI). It enables the experiments to be conducted and evaluated in a user-friendly manner. The software has network capability. The link between the experimental unit and the PC is made via a USB port.

Learning objectives/experiments

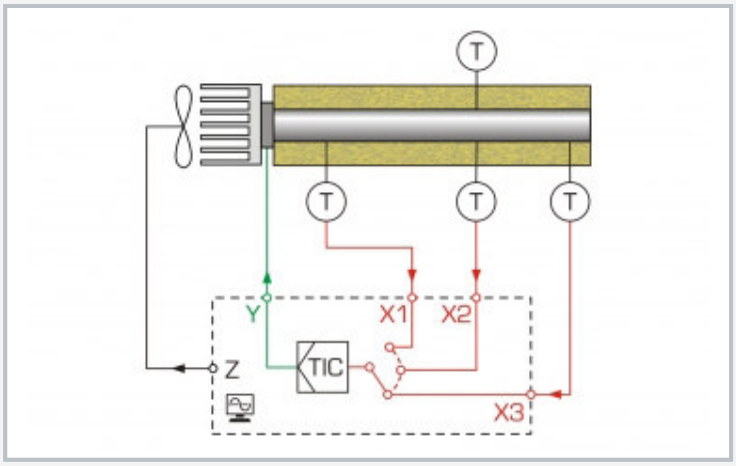
- open loop control response
- effects of different controller parameters and methods on the response of the closed loop system
- recording of step responses
  - reference variable
  - disturbance variable
- controller optimisation
- software-based controlled system simulation
  - comparison of different controlled system parameters

RT 040

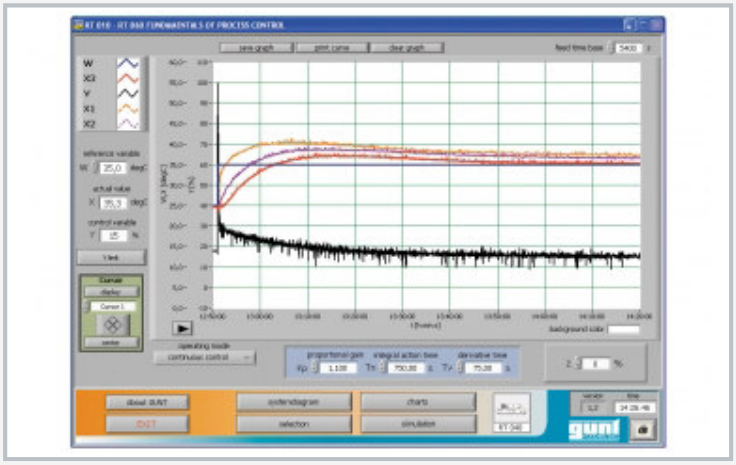
Training system: temperature control, HSI



1 fan, 2 bar in cladding tube, 3 thermometer, 4 displays and controls, 5 heater/cooler



Process schematic



Software screenshot: step response to reference variable with PID controller with non-optimised values for K_p, T_n and T_v

Specification

[1] experimental unit for control engineering experiments
[2] temperature control of a heated metal bar
[3] heating and cooling by Peltier element
[4] temperature sensors at 3 different points along axis of bar to establish thermal lags
[5] software activated fan to generate disturbance variables
[6] software-based controlled system simulation
[7] process schematic on front panel
[8] networkable GUNT software
[9] GUNT software with control functions and data acquisition via USB under Windows 7, 8.1, 10

Technical data

Heated bar: DxL: 20x200mm, aluminium
Peltier element
- power consumption depending on temperature
  - power at 300K: 38,2W
  - power at 50°C: 44,3W
- operated by DC voltage

Fan
- power consumption: 2W
- max. flow rate: 40m³/h

Temperature sensor: 0...100°C
Thermometer: 0...100°C
Temperature control range: 0...100°C
Software controller configurable as P, PI, PID and switching controller
Software
- process schematic with controller type selection (manual, continuous controller, two- or three-point controller, programmer)
- time functions
- simulation function
- disturbance variable input

230V, 50Hz, 1 phase
230V, 60Hz, 1 phase
120V, 60Hz, 1 phase
UL/CSA optional
LxWxH: 600x450x260mm
Weight: approx. 16kg

Required for operation

PC with Windows

Scope of delivery

1 experimental unit
1 GUNT software CD + USB cable
1 handbook: Fundamentals of control engineering (RT 010 – RT 060)
1 manual for RT 040

RT 040

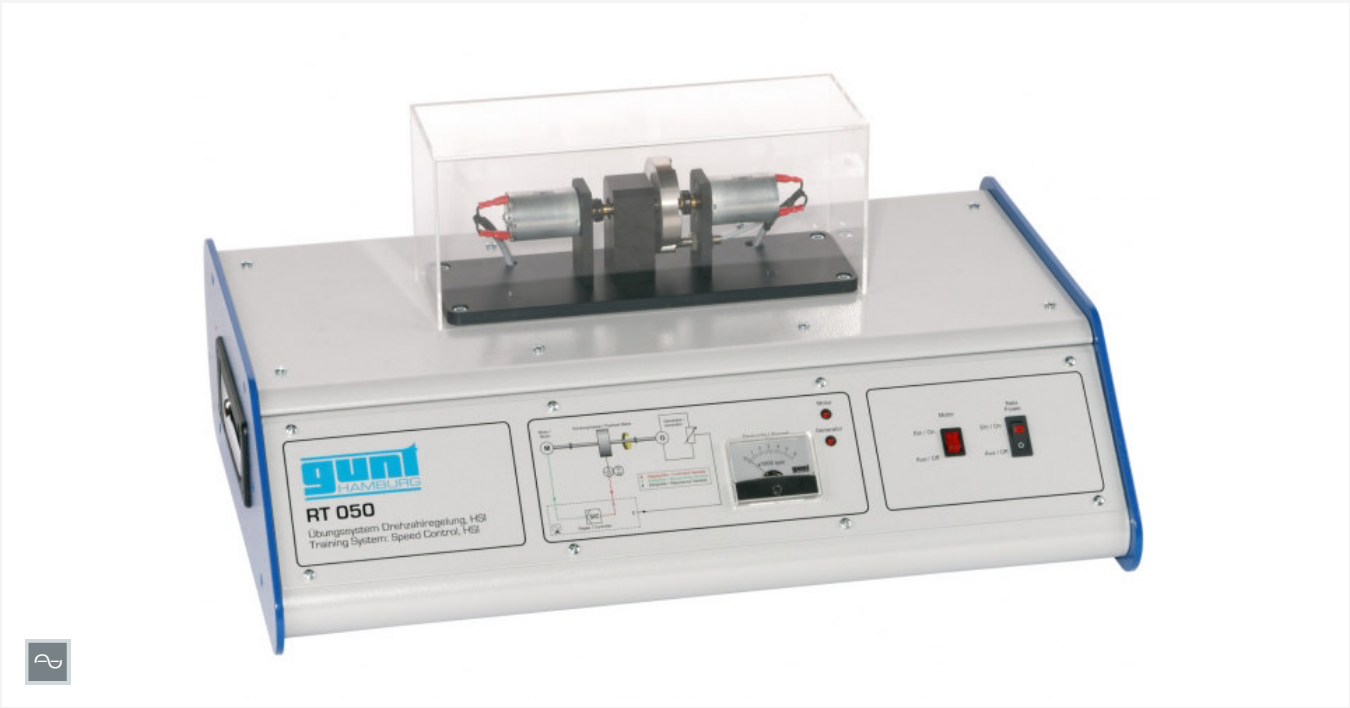
Training system: temperature control, HSI

Optional accessories

020.30009	WP 300.09	Laboratory trolley

RT 050

Training system: speed control, HSI



Description

- **experimental unit with speed control system**
- **extensive range of experiments on fundamentals of control engineering**
- **state-of-the-art software for all experimental units of the RT 010 – RT 060 series, with extensive controller and recorder functions**
- **software-based simulation of the controlled system**

This compact experimental unit offers every opportunity to learn the fundamentals of control engineering through experimentation on a speed control system.

The experimental setup is mounted on a housing which accommodates all the electronics. A transparent protective cover permits safe observation of the experiments. A DC motor drives a shaft with a mass flywheel. The dial gauge allows the speed to be read off directly at any time. The speed is measured inductively using a speed sensor. The output signal from the sensor is sent to the software controller. The output signal from the controller influences the motor current. A generator acting as a mechanical resistance to shaft rotation can be activated by the software to study the influence of disturbance variables.

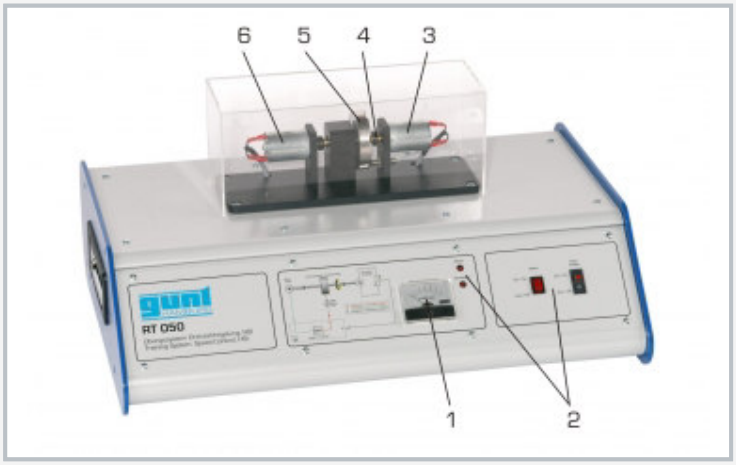
The powerful state-of-the-art software is an integral part of the training system, embodying the principle of hardware/software integration (HSI). It enables the experiments to be conducted and evaluated in a user-friendly manner. The software has network capability. The link between the experimental unit and the PC is made via a USB port.

Learning objectives/experiments

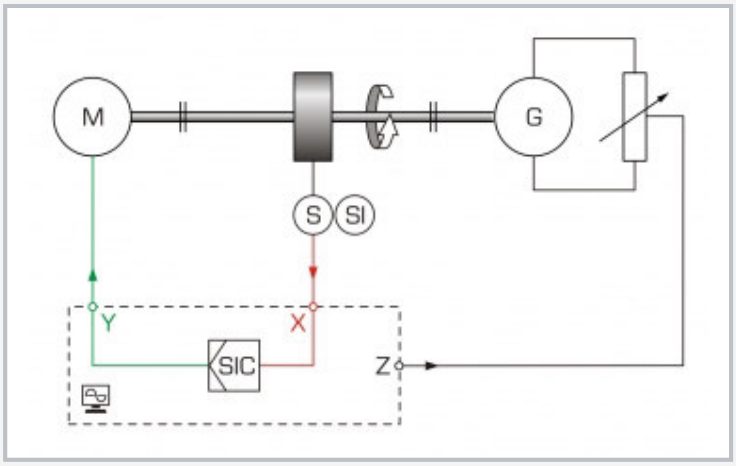
- fundamentals of control engineering based on the example of a speed control system with PT_1 behaviour
- open loop control response
- effects of different controller parameters and methods on the response of the closed loop system
- recording of step responses
  - reference variable
  - disturbance variable
- controller optimisation
- software-based controlled system simulation
  - comparison of different controlled system parameters

RT 050

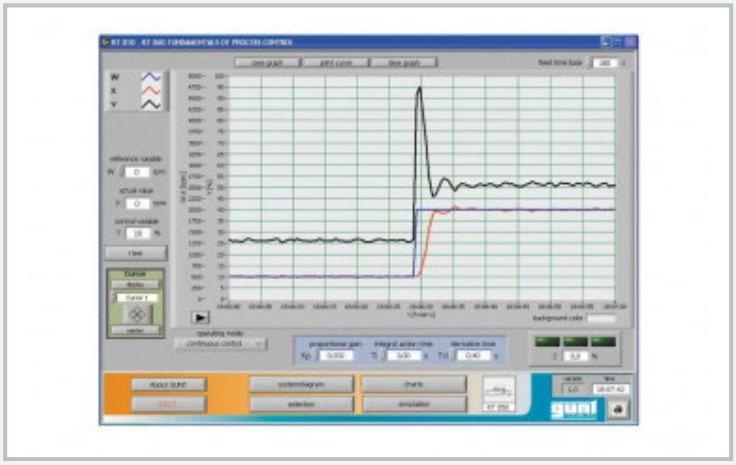
Training system: speed control, HSI



1 tachometer, 2 displays and controls, 3 generator, 4 speed sensor, 5 rotor, 6 motor



Process schematic



Software screenshot: step response to change in reference variable with PID controller (acceptable control quality)

Specification

[1] experimental unit for control engineering experiments
[2] speed control of a DC motor with shaft and flywheel
[3] transparent protective cover for motor/generator set
[4] inductive speed sensor
[5] generation of disturbance variables by adjustable generator load
[6] software-based controlled system simulation
[7] process schematic on front panel
[8] networkable GUNT software
[9] GUNT software with control functions and data acquisition via USB under Windows 7, 8.1, 10

Technical data

Motor
- max. speed: 4500min $^{-1}$
- max. motor power output: 10W
- max. torque: 1,7Ncm

Generator
- max. speed: 4500min $^{-1}$
- max. power output: 10W
- max. torque: 1,7Ncm

Tachometer (analogue): 0...6000min $^{-1}$
Software controller configurable as P, PI and PID controller
Software
- process schematic with controller type selection (manual, continuous controller, programmer)
- time functions
- simulation function
- disturbance variable input

230V, 50Hz, 1 phase
230V, 60Hz, 1 phase
120V, 60Hz, 1 phase
UL/CSA optional
LxWxH: 600x450x310mm
Weight: approx. 18kg

Required for operation

PC with Windows

Scope of delivery

1 experimental unit
1 GUNT software CD + USB cable
1 handbook: fundamentals of control engineering (RT 010 – RT 060)
1 manual for RT 050

RT 050

Training system: speed control, HSI

Optional accessories

020.30009	WP 300.09	Laboratory trolley

RT 060

Training system: position control, HSI

Description

- **experimental unit with clear linear position control system**
- **extensive range of experiments on fundamentals of control engineering**
- **state-of-the-art software for all experimental units of the RT 010 – RT 060 series, with extensive controller and recorder functions**
- **software-based simulation of the controlled system**

This compact experimental unit offers every opportunity to learn the fundamentals of control engineering through experimentation on a linear position control system.

The experimental setup is mounted on a housing which accommodates all the electronics. A transparent protective cover permits safe observation of the experiments. A carriage can be moved by a DC motor via a toothed belt. The linear positioning is measured by a rotary encoder and delivered as a voltage signal. The output signal from the sensor is sent to the software controller. The output signal from the controller influences the motor current. The motor is automatically shut down if the carriage reaches one of the two end positions.

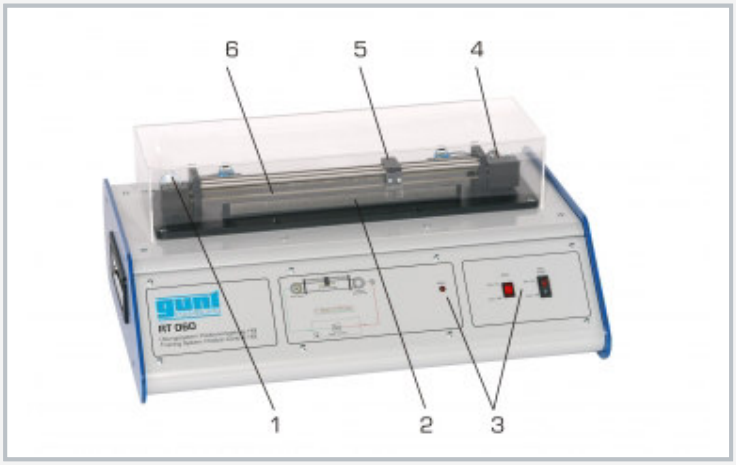
The powerful state-of-the-art software is an integral part of the training system, embodying the principle of hardware/software integration (HSI). It enables the experiments to be conducted and evaluated in a user-friendly manner. The software has network capability. The link between the experimental unit and the PC is made via a USB port.

Learning objectives/experiments

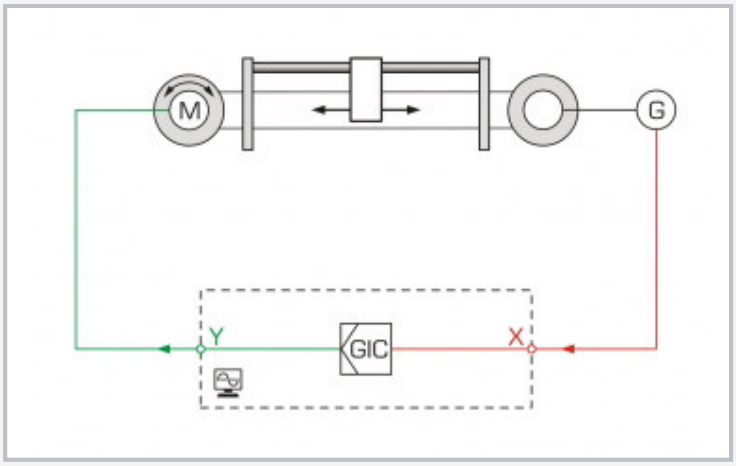
- fundamentals of control engineering based on the example of a linear position control system with integral control action
- open loop control response
- effects of different controller parameters and methods on the response of the closed loop system
- recording of step responses
  - reference variable
- controller optimisation
- software-based controlled system simulation
  - comparison of different controlled system parameters

RT 060

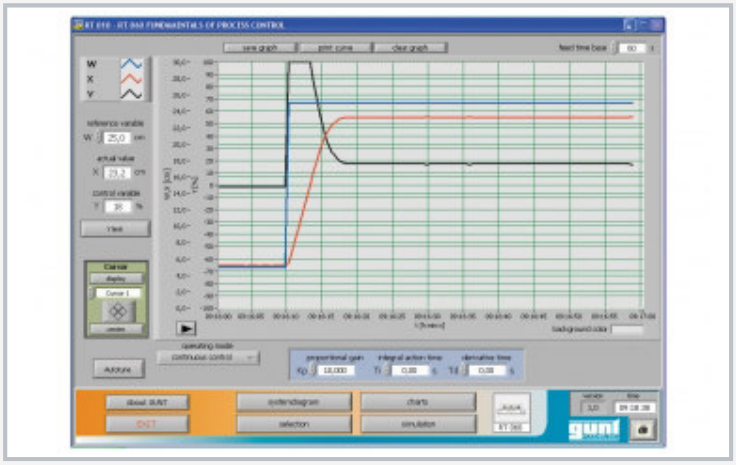
Training system: position control, HSI



1 motor, 2 scale, 3 displays and controls, 4 rotary encoder, 5 carriage, 6 toothed belt



Process schematic



Software screenshot: step response to change in reference variable with P controller (permanent control deviation)

Specification

[1] experimental unit for control engineering experiments
[2] linear position control of carriage with linear drive and gear motor
[3] rotary encoder as displacement sensor
[4] transparent protective cover
[5] 2 microswitches to shut down at end positions
[6] software-based controlled system simulation
[7] process schematic on front panel
[8] networkable GUNT software
[9] GUNT software with control functions and data acquisition via USB under Windows 7, 8.1, 10

Technical data

DC motor
- transmission ratio: i=50
- speed: 85min^{-1}
- torque: 200Nmm

Travel: max. 300mm
Max. traverse rate: 45mm/s
Scale: 0...300mm
Software controller configurable as P, PI, PID
Software
- process schematic with controller type selection (manual, continuous controller, programmer)
- time functions
- simulation function

230V, 50Hz, 1 phase
230V, 60Hz, 1 phase
120V, 60Hz, 1 phase
UL/CSA optional
LxWxH: 600x450x280mm
Weight: approx. 20kg

Required for operation

PC with Windows

Scope of delivery

1 experimental unit
1 GUNT software CD + USB cable
1 handbook: fundamentals of control engineering (RT 010 – RT 060)
1 manual for RT 060

RT 060

Training system: position control, HSI

Optional accessories

020.30009	WP 300.09	Laboratory trolley

RT 200

Room temperature control

Learning objectives/experiments

- components of a control loop
- operation and parameterisation of an industrial controller
- comparison of various controller types
  - P, PD, PI and PID controllers
  - two-point controller
- layout of control loops
  - open control loop
  - closed control loop
- generation of disturbances

Description

- **introduction to industrial control engineering**
- **simple temperature control loop with parameterisable industrial controller**
- **control loop components laid out separately on panels**
- **layout of control loops**

This experimental unit aids introduction to industrial control engineering. The objective is to control the temperature in a virtual room. The individual components of this temperature control loop are laid out separately on panels. They are inserted in the frame and interconnected by cables.

The controlled system is a soldering iron. The soldering iron represents the heater in the virtual room. The room, with a temperature sensor, is mapped out on the panel as an aid to understanding.

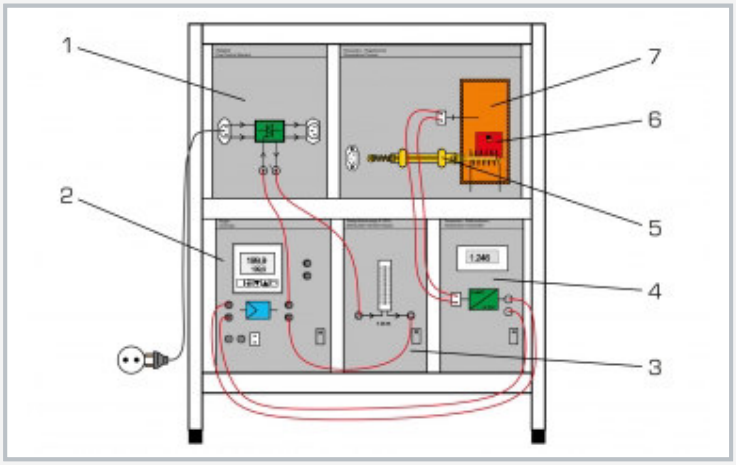
The real temperature sensor is a thermocouple on the tip of the soldering iron. The transducer converts the temperature signal from the thermocouple into a standard voltage signal. This signal is sent to the input of an industrial controller. There the signal is compared against the reference variable. The controller sends a signal corresponding to the variation (manipulating variable) to the actuator. The actuator is a power controller which influences the electrical power to the soldering iron.

To generate disturbance variables, metal plates with differing thermal conductivities can be attached to the soldering iron. The industrial controller is parameterisable as a P, PD, PI or PID controller.

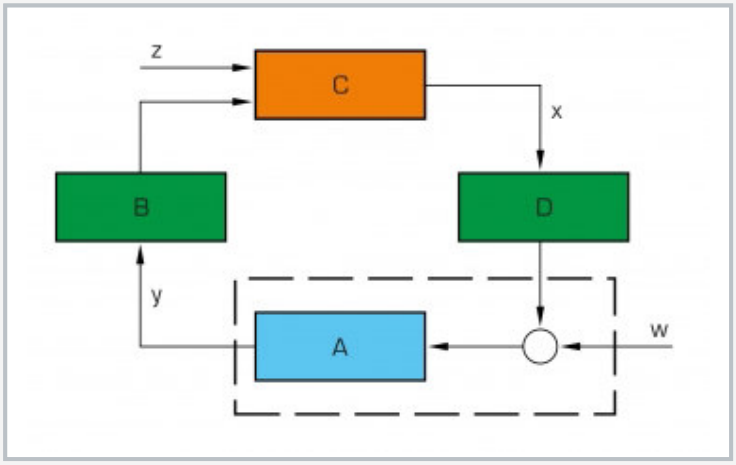
It can also function as a two-point controller. The controlled variable (virtual room temperature) and the manipulating variable are displayed digitally.

A line recorder (RT 200.01) is available as an accessory to record the control processes.

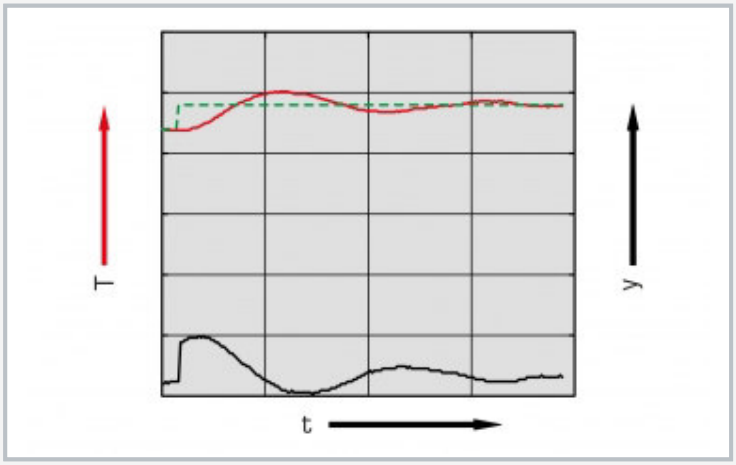
RT 200
Room temperature control



1 power controller, 2 controller, 3 manipulating variable bar display, 4 transducer, 5 soldering iron, 6 metal plate, 7 implied heating room



A controller, B actuator (power controller), C controlled system (soldering iron), D thermocouple and transducer;
y manipulating variable, w reference variable, x controlled variable, z disturbance variable



Control response with a PI controller: Characteristic curves of the controlled variable (red), reference variable (green) and manipulating variable y (black); T temperature, t time

Specification

[1] investigation of a temperature control loop
[2] control loop components on panels allowing for variation in installation in frame
[3] soldering iron as controlled system
[4] power controller as actuator
[5] parameterisable digital industrial controller
[6] thermocouple type K as temperature sensor
[7] transducer for thermocouple with digital temperature display
[8] bar display for manipulating variable
[9] 2 metal plates with differing thermal conductivities for disturbance generation
[10] line recorder (RT 200.01) available as accessory

Technical data

Soldering iron power output: 16W
Controller
- input signals: 0/4...20mA and 0...10V
- output signals: 0...20mA
- parameterisable as

P, PI or PID controller
2-point controller
Power controller
- output power: 0...16W
- input signal: 0...20mA

Thermocouple and transducer
- measuring range: 0...400°C
- output signal: 0...10VDC

2 metal plates for disturbance generation
- stainless steel
- copper

230V, 50Hz, 1 phase
230V, 60Hz, 1 phase
120V, 60Hz, 1 phase
UL/CSA optional
LxWxH: 800x500x840mm
Weight: approx. 38kg

Scope of delivery

1 frame
1 panel, controlled system
1 panel, actuator
1 panel, controller
1 panel, transducer
1 panel, bar display
2 metal plates
1 set of cables
1 set of instructional material

RT 200
Room temperature control

Optional accessories

080.20001	RT 200.01	3-channel line recorder
020.30009	WP 300.09	Laboratory trolley

IA 130
PLC module

Description

- **self-contained PLC module for basic exercises**
- **suitable for use in complex applications**
- **programming software to IEC 61131-3**

The IA 130 can be used to perform basic exercises on a PLC (programmable logic controller). A PLC is essentially a computer adapted to the needs of industry. Its inputs and outputs are not designed for humans, but for use in the control of machines. Machine and operator interact solely by way of limit switches, momentary-contact switches or photoelectric switches.

The front panel is designed as a laboratory patchboard, where the input ports and output ports of the PLC can be connected to switches and displays via laboratory cables. In order to write programs the PLC must be connected to a PC (not supplied) via a USB interface.

The PLC programming software conforms to the international standard IEC 61131-3, and permits programming in the following languages: Statement List (STL), Ladder Diagram (LD), Structured Text (ST) and Function Block Diagram (FBD).

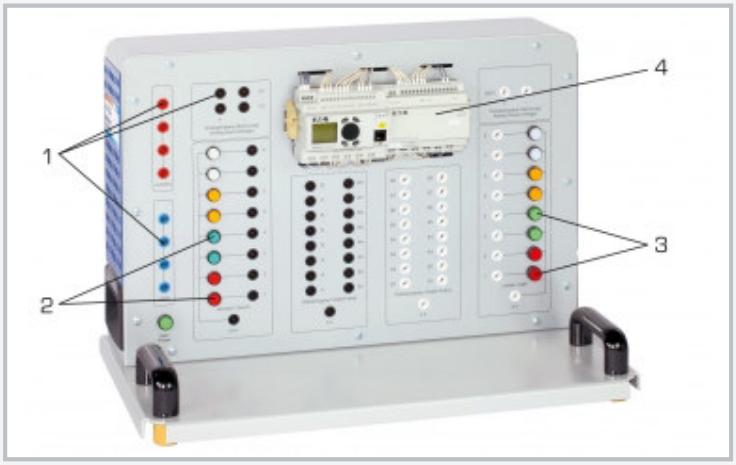
Ladder Diagrams are based on graphical representations with contacts, coils and boxes, as per the circuit diagrams. Function Block Diagram language is based on graphical representation of the interlinking of logical function blocks, analogous to the logic diagrams. Statement List is an assembler-type language with a small, standardised non-hardware-dependent command set. Structured Text is a language similar to PASCAL, with mathematical expressions, assignments, function calls, iteration, condition selection, and PLC-specific add-ons. An example program is included in the module.

IA 130 can be used as a control element in conjunction with electrical, pneumatic or hydraulic applications, such as with the handling device IA 210 or the mixing process RT 800.

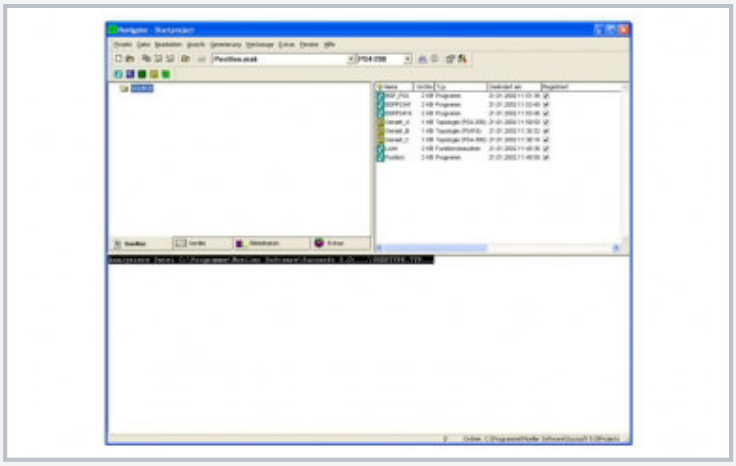
Learning objectives/experiments

- familiarisation with a PLC
- familiarisation with the essential fundamentals such as
  - Boolean algebra
  - compiling statement lists
  - interconnection diagrams and block diagrams
- exercises in
  - programming
  - logical “AND” / “OR” gates
  - logic relays
  - output and input
- configuration of program sequences by way of connectors, incorporating
  - timers
  - counters
  - cascade circuits
  - higher-order monitoring relays etc.
- fault finding

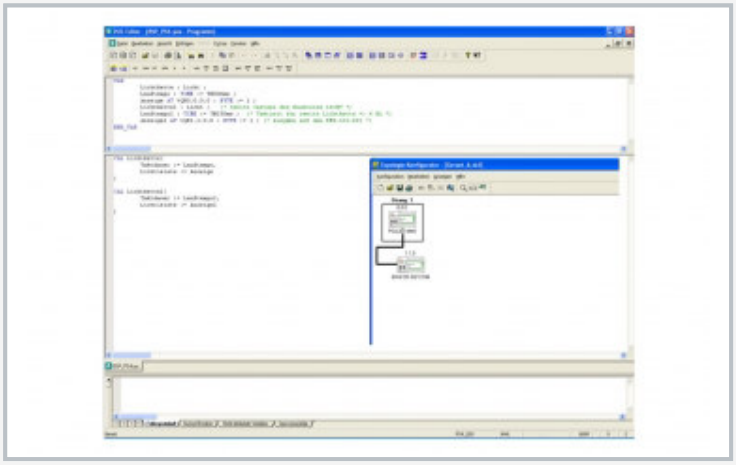
IA 130
PLC module



1 lab jacks, 2 pushbutton, 3 lamps, 4 PLC



Screenshot of PLC software: start screen



Screenshot of PLC software: POU editor (POU = Program Organisation Unit) and topology configurator

Specification

[1] module for basic exercises on a programmable logic controller (PLC)
[2] self-contained PLC module, usable as part of a complex system
[3] integrated patchboard for creating circuits with input and output elements
[4] PLC with 2 integrated setpoint encoders
[5] programming software to IEC 61131-3; software via USB under Windows 7, 8.1, 10
[6] example program supplied

Technical data

PLC
- connections
  - 16 digital inputs
  - 16 digital outputs
  - 2 analogue inputs
  - 1 analogue output
- memory type: PLC back-up battery for 32kByte RAM and clock
- Rated voltage: 24VDC

Software
- graphical user interfaces
- programming languages to IEC/EN 61131-3:
  - statement list (STL)
  - ladder diagram (LD)
  - function block diagram (FBD)
  - structured text (ST)
- multiple dialogue languages (German, English, French, Spanish)
- graphical topology configurator

230V, 50Hz, 1 phase
230V, 60Hz, 1 phase
120V, 60Hz, 1 phase
UL/CSA optional
LxWxH: 620x350x450mm
Weight: approx. 15kg

Required for operation

PC with Windows

Scope of delivery

1 experimental unit
1 PLC software + USB cable
1 set of laboratory cables
1 set of instructional material

IA 130
PLC module

Optional accessories

020.30009	WP 300.09	Laboratory trolley

IA 210

PLC application: materials handling process

Description

- **automation fundamentals system**
- **handling demonstrator**
- **simulation of a punching process**
- **simulation of workpiece control**

IA 210 is a compact teaching and practice unit for the control of a materials handling process using a PLC. Two processes can be simulated: a punching process, or workpiece control in the form of a sort operation. All components are in a clearly laid out design.

Black and white cylindrical workpieces are fed from a container onto a conveyor belt. On the belt is a reflex photoelectric proximity switch which differentiates between light and dark and feeds the white items to the pre-selected process (punching or sorting). The black workpieces are always carried to the end of the belt, where they drop into a collector.

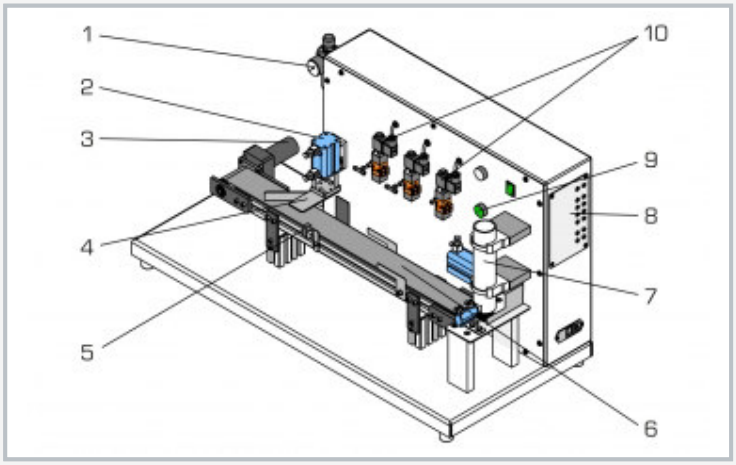
Three 5/2-way solenoid valves, three double-acting cylinders and a pneumatic roller pushbutton can be operated via the PLC to execute the necessary steps: releasing the workpiece from the container; pushing the workpiece onto the conveyor belt; sorting or punching the workpiece. For punching, the workpiece is brought to a predefined position. The working cylinder can switch between sorting and punching modes by a simple sequence of actions.

The unit is designed for operation in conjunction with a PLC module. Use of PLC module IA 130 is recommended.

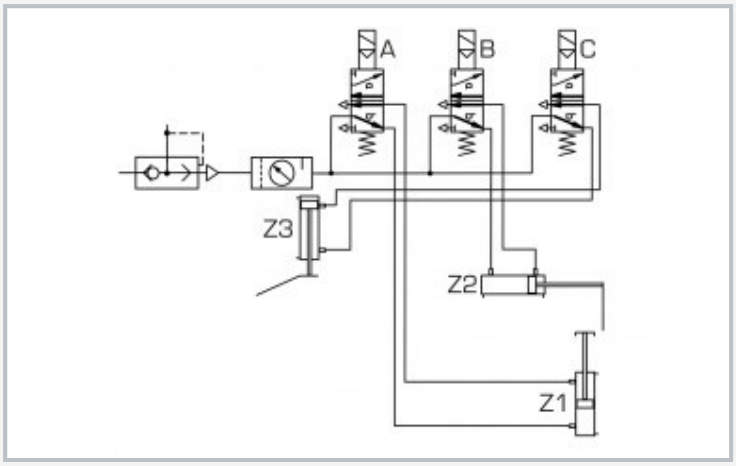
Learning objectives/experiments

- familiarisation with and analysis of an automated materials handling process
  - understanding and analysis of the mechanical, pneumatic and electrical functions
  - familiarisation with the symbols, terms and modes of representation of pneumatic and electrical function diagrams
  - familiarisation with automation components: cylinders, solenoid valves, photoelectric proximity switches
- familiarisation with the use of a PLC
  - basic methods of programming
  - adapting the program to the given handling process
- simulation of a punching process
  - conveyor belt is stopped for punching
  - conveyor belt also stops as soon as workpiece drops from belt end
- workpiece control simulation
  - light-coloured workpieces are separated out; dark items reach the belt end

IA 210
PLC application: materials handling process



1 maintenance unit, 2 double-acting cylinder, 3 conveyor belt drive motor, 4 punching or sorting device, 5 reflex photoelectric proximity switch, 6 conveyor belt, 7 container for 11 workpieces, 8 electrical connections for solenoid valves and sensors, 9 display of limit switch, 10 5/2-way solenoid valve



Pneumatic connection diagram

Electrical connections of the solenoid valves and sensors

Specification

[1] compact unit for experiments in the field of automation
[2] handling device with solenoid valves
[3] double-acting cylinder (15mm stroke): fixing / discharge of workpieces to container
[4] double-acting cylinder (80mm stroke): pushes workpiece onto conveyor belt
[5] double-acting cylinder (40mm stroke): executes the process (sorting or punching)
[6] conveyor belt with guide plates and DC motor
[7] cylindrical Plexiglas storage container holding 11 workpieces
[8] 15 workpieces made of Polyoxymethylene (POM): 10x white, 5x black
[9] pneumatic components fitted with quick-release couplings for 4mm hoses
[10] operation of actuators with compressed air
[11] lab jacks to external PLC
[12] set of laboratory cables and pneumatic hoses
[13] compressed air supply: max. 6bar, 3bar recommended

Technical data

3 electrically operated 5/2-way valves
- with spring return
- with pilot valve

Reflex photoelectric proximity switch
- pnp, light-switching
- 5...150mm

Geared DC motor
- reduction ratio: 142,5:1
- nominal torque 5,92Nm
- nominal speed: 22min^{-1}

Polyester weave conveyor belt
Workpieces, DxH: 40x20mm

230V, 50Hz, 1 phase
230V, 60Hz, 1 phase
120V, 60Hz, 1 phase
UL/CSA optional
LxWxH: 1000x450x580mm
Weight: approx. 46kg

Required for operation

compressed air connection: min. 3bar

Scope of delivery

1 experimental unit
1 set of workpieces
1 set of laboratory cables
2 collecting tanks
1 set of instructional material

IA 210
PLC application: materials handling process

Optional accessories

058.13000	IA 130	PLC module
020.30009	WP 300.09	Laboratory trolley

IA 110
Calibrating a pressure sensor

Description

- **test-pressure generated with dead-weight piston manometer**
- **electronic pressure sensor with ceramic measuring cell**
- **plotting a calibration curve**
- **compact experimental unit for group working or demonstration**

The experimental unit IA 110 can be used to calibrate an electronic pressure sensor under practical conditions.

The test pressure is generated with a conventional piston manometer. The piston is loaded with weight rings and generates a defined test pressure $p = F_G/A_P$, where F_G is the force due to the weights and A_P is the cross-sectional area of the piston. A hand-operated spindle is used to relieve the pressure after measurement allowing the piston to return to a rest position. The influence of friction is minimised by rotating the piston during measurement. The test pressure generated in this way is applied to the diaphragm of a pressure sensor. The pressure-dependent electrical output signal is indicated on a digital display.

The pressure sensor used is a state-of-the-art ceramic measuring cell, in which strain-dependent piezo resistors are mounted on a ceramic diaphragm.

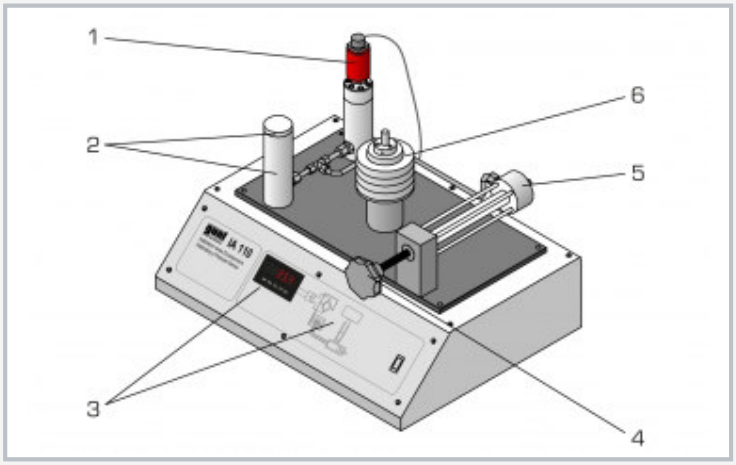
The resistors are configured to form a measuring bridge. An integrated amplifier circuit evaluates the pressure-dependent detuning of the measuring bridge and outputs a proportional voltage signal.

The kit also includes a second pressure sensor in the form of a cutaway model for enhanced clarity. The entire experimental unit is contained in a compact housing, and is easy to handle.

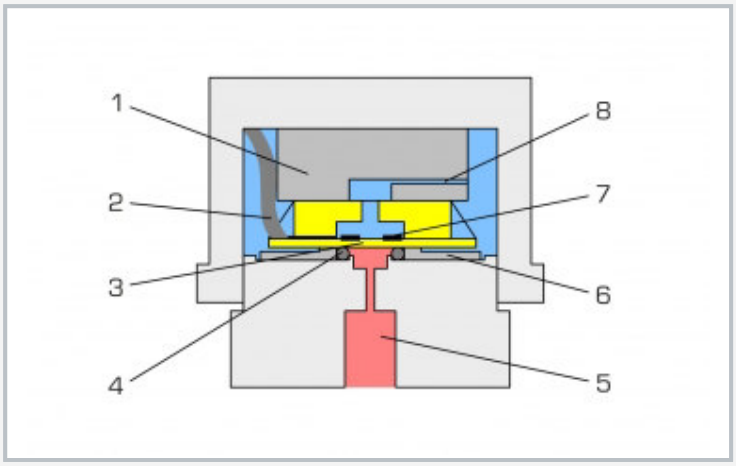
Learning objectives/experiments

- familiarisation with, and carrying out of the calibration of an electronic pressure sensor
- plotting the sensor output signal dependent on the pressure applied
- familiarisation with the design and operation of a piezo-resistive electronic pressure sensor
- familiarisation with the installation and connection of the pressure sensor
- information on applications, measuring ranges and accuracies of typical electronic pressure sensors

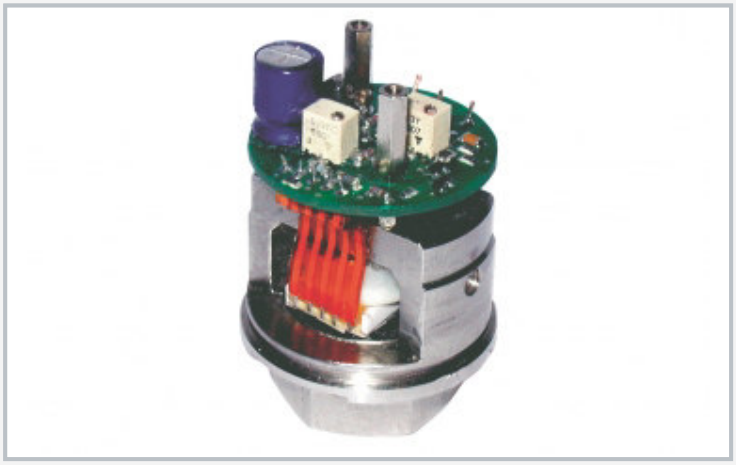
IA 110
Calibrating a pressure sensor



1 pressure sensor being calibrated, 2 cylinder with cover to receive the loading device, 3 digital display for displaying the output signal and process schematic, 4 manual adjustment spindle for compensating cylinder, 5 compensating cylinder, 6 holder for weight carrier with piston and weights



1 brace, 2 connecting cable, 3 ceramic measuring cell with diaphragm, 4 sealing ring, 5 pressure connection, 6 pressure plate, 7 piezo resistors, 8 pressure equalisation bore for relative pressure measurement



Interior layout of an electronic pressure sensor

Specification

[1] calibration unit with dead-weight piston manometer and hand-operated spindle
[2] electronic pressure sensor with ceramic measuring cell, integrated amplifier and voltage output
[3] digital display for output signal
[4] additional pressure sensor as cutaway model
[5] set of weights
[6] transmission medium: hydraulic oil
[7] process schematic on front panel

Technical data

Pressure sensor
- measuring range: 0...2,5bar
- supply: 24VDC
- output signal: 0...10VDC

Piston manometer with pressure piston
- diameter: 12mm
- number of weights: 5
- pressure graduations:
  - 0,5bar
  - 1,0bar
  - 1,5bar
  - 2,0bar
  - 2,5bar

Digital display: 4 1/2 digits

Hydraulic oil: HLP ISO 32

230V, 50Hz, 1 phase
230V, 60Hz, 1 phase
120V, 60Hz, 1 phase
UL/CSA optional
LxWxH: 600x450x450mm
Weight: approx. 20kg

Scope of delivery

1 experimental unit
1 set of weights
1 oil (1L)
1 cutaway model
1 set of instructional material

IA 110
Calibrating a pressure sensor

Optional accessories

020.30009	WP 300.09	Laboratory trolley

IA 120
Principles of industrial sensors

Description

- **familiarisation with key sensors: mode of operation and application**
- **all components are protected in a sturdy case**

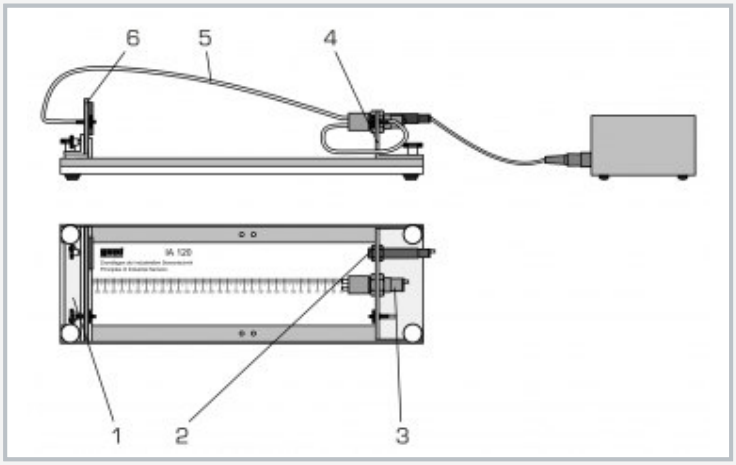
This training kit can be used to investigate a selection of different sensor types commonly used in industrial automation: optical, capacitive and inductive proximity switches to record displacement and proximity. These sensors are mounted on a base plate with the relevant accessories. The trigger distance is determined by moving the sensor holder. The base plate is provided with a scale for this purpose.

A separate supply unit powers the sensors and displays the switching state by way of light-emitting diodes.

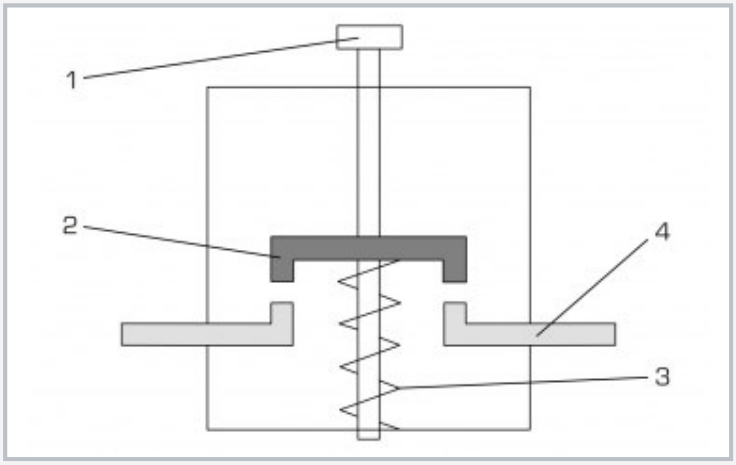
Learning objectives/experiments

- mode of operation and application of different sensors
  - one-way photoelectric barrier
  - reflex photoelectric barrier
  - inductive proximity switch
  - capacitive proximity switch
  - reflex photoelectric proximity switch, infrared
  - reflex photoelectric proximity switch, red light
  - limit switch
  - reed contact

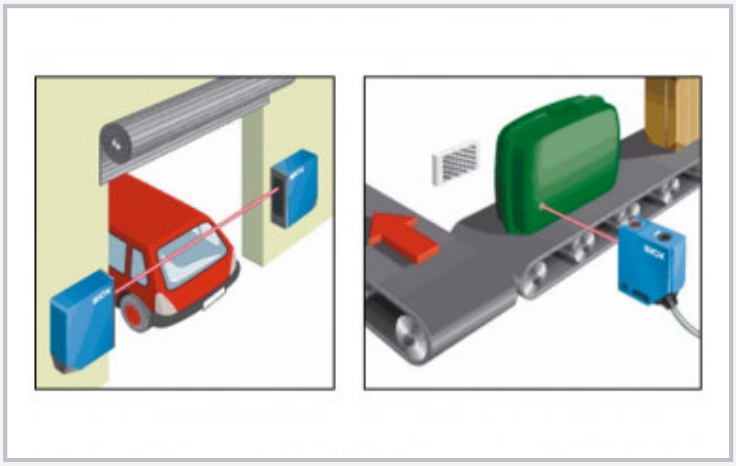
IA 120
Principles of industrial sensors



1 slide, 2 reflex photoelectric barrier, 3 light guide, 4 sensor holder (interchangeable), 5 fibre-optic cable, 6 reflector holder



Electric limit switch: 1 momentary-contact switch, 2 switching element, 3 spring, 4 connection



Left: transmissive photoelectric switch, right: reflex photoelectric switch

Specification

[1] training kit for familiarisation with position and displacement sensors
[2] base plate with scale
[3] sensor supply unit with 4 light-emitting diodes
[4] sensors mounted on adjustable fixture
[5] 5 measuring plates
[6] all mountings and components housed in aluminium storage case

Technical data

Measuring plates, LxW: 145x70mm
- aluminium sheet: d=2mm, smooth, black
- steel sheet: d=2mm, textured, matt black
- steel sheet: d=2mm, smooth, silver
- plexiglas plate: d=5mm, transparent
- plastic plate: d=5mm, smooth, white

Gauge screw: 0...25mm
Sensors
- reflex photoelectric barrier: pnp, dark-switching
- light guide: pnp, dark-switching
- reflex photoelectric proximity switch: pnp, light-switching, 5...150mm
- photoelectric proximity switch: pnp, light-switching
- inductive proximity switch: pnp, NO contact
- capacitive proximity switch: NO contact, 1...8mm
- limit switch: 1 NO contact, 1 NC contact
- reed contact: switching distance: 5mm, max. 1W at 24V

Power supply
- output voltage: 3...12VDC, graduated
- output current 1000mA

230V, 50Hz, 1 phase
230V, 60Hz, 1 phase
120V, 60Hz, 1 phase
UL/CSA optional
LxWxH: 510x410x200mm (case)
LxWxH: 460x150x27mm (base plate)
LxWxH: 160x85x140mm (sensor supply)
Total weight: approx. 14kg

Scope of delivery

1 experimental unit, complete
1 case
1 set of instructional material

RT 304
Calibration trainer

The illustration shows the RT 304 with accessories.

Learning objectives/experiments

- together with the accessory control loop components
  - mode of operation of control loop components: transducers, actuators, controllers
  - familiarisation with different signals: pneumatic, electrical
  - correct connection of control loop components
  - transmission behaviour of control loop components
  - calibration of manometers

Description

- **investigation of the transmission behaviour of actuators and transducers**
- **calibration of control loop components and measuring instruments using precision measuring technique**
- **various control loop components and measuring instruments available as accessories**

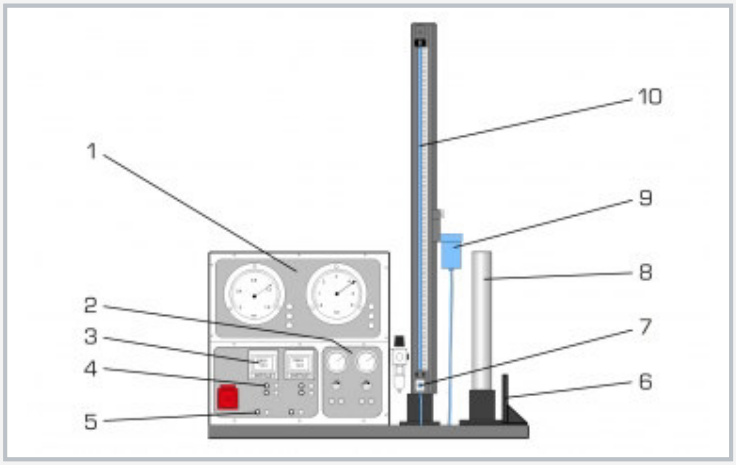
The calibration trainer is used to investigate the transmission behaviour of electrical and pneumatic control loop components such as transducers and control valves. Electrical and pneumatic signals can be generated to effect actuation of the individual control loop components. A precision measuring technique facilitates the recording of the output signals from the control loop components.

Two pressure regulators with manometers are included to generate pneumatic signals and supply the control loop components with auxiliary power. A height-adjustable tank with a level tube and scale is used to set low pressures for manometer calibration. The pressure regulators can also be used to calibrate at higher pressures.

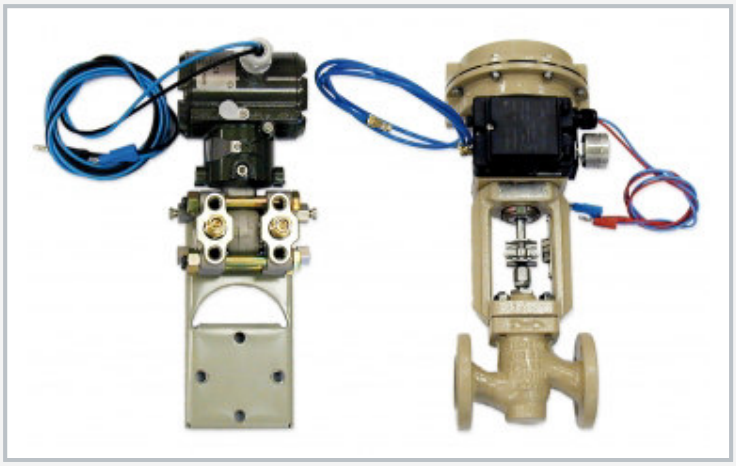
Two direct voltage sources are included as auxiliary power sources for components requiring an electrical supply. Direct current signals can be sent and measured with two controllers. Two precision manometers permit measurement of pneumatic output signals from control loop components.

Various control loop components such as transducers, control valves and controllers are available as accessories. They are mounted on the calibration trainer and connected by way of the supplied hoses and cables.

RT 304
Calibration trainer



1 precision manometer, 2 pressure regulator, 3 controller, 4 connections for current signals, 5 DC voltage sources, 6 fixture for control loop components, 7 connection for low pressures, 8 assembly tube for control loop components, 9 height-adjustable tank, 10 level tube with scale for low pressures



Available accessories: RT 305.03 differential pressure transmitter (left) and RT 305.05 pneumatic control valve with electro-pneumatic positioner (right)

Available accessories: RT 305.02 pressure transmitter, electronic (left) and RT 305.07 thermocouple type K and calibrator (right)

Specification

[1] investigation of transmission behaviour and calibration of control loop components and measuring instruments
[2] sending and measuring pneumatic and electrical signals
[3] 2 pressure regulators with manometers
[4] height-adjustable tank and scale to set low pressures
[5] 2 controllers to send and measure current signals
[6] 2 DC voltage sources to supply control loop components with auxiliary power
[7] 2 precision manometers, D=160mm
[8] control loop components and meters available as accessories

Technical data

2 pressure regulators
- 0...1,6bar
- 0...6bar

Pressure range, height-adjustable tank
- 0...1000mm head

2 controllers
- 1 output each: 4...20mA
- 1 input each: 4...20mA

2 DC voltage sources
- each 24VDC

Measuring ranges
- pressure:
  - 0...1,6bar
  - 0...6bar

230V, 50Hz, 1 phase
230V, 60Hz, 1 phase
120V, 60Hz, 1 phase
UL/CSA optional
LxWxH: 1000x750x2150mm
Weight: approx. 110kg

Required for operation

compressed air connection: 6...8bar

Scope of delivery

1 trainer
1 set of cables
1 set of hoses
1 set of instructional material

RT 304
Calibration trainer

Optional accessories

Transducers		
080.30502	RT 305.02	Pressure transmitter, electronic
080.30503	RT 305.03	Differential pressure transmitter, electronic
080.30504	RT 305.04	Current-to-pressure converter
Analogue pressure measurement		
080.30508	RT 305.08	Bourdon tube pressure gauge
080.30509	RT 305.09	Diaphragm pressure gauge
Temperature measurement		
080.30507	RT 305.07	Thermocouple type K and calibrator
Control valves		
080.30505	RT 305.05	Pneumatic control valve with electro-pneumatic positioner
080.30506	RT 305.06	Control valve, electric
Controller		
080.30501	RT 305.01	Controller, electronic
Other accessories		
080.30510	RT 305.10	Tool set

3.9 RT 305.09 Diaphragm pressure gauge

Fig. 3.26 Diaphragm pressure gauge

Measuring principle (as for spring-tube pressure gauge)

Function

A constrained, corrugated diaphragm undergoes deformation as a result of pressure. This shifts the moving connection point on the elastic measuring element back by a certain distance, which is converted into a rotary movement for the pointer on a scale by lever transmission with a gear segment and pinion. Devices of this type are suitable for excess pressure, vacuum and absolute pressure. Diaphragm pressure gauges should be preferred if a high level of overload protection is required, the pressure is to be measured in high viscosity, inhomogeneous and multi-phase products or for measurements on highly corrosive media.

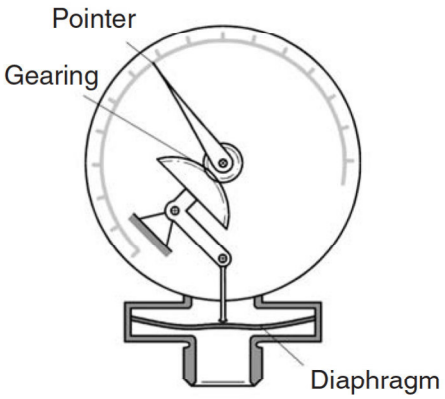


Fig. 3.27 Diaphragm pressure gauge principle

Diaphragm pressure gauge connection

Screw pressure gauge directly into test fittings on pressure measuring instrument level tube. The extent of the zero point offset (h_2) is approx. 100 mm, which means that:

$h = h_1 - h_2$, *in mm*

where h: Pressure of water column

h_1: Total height of water column

h_2: Zero point offset