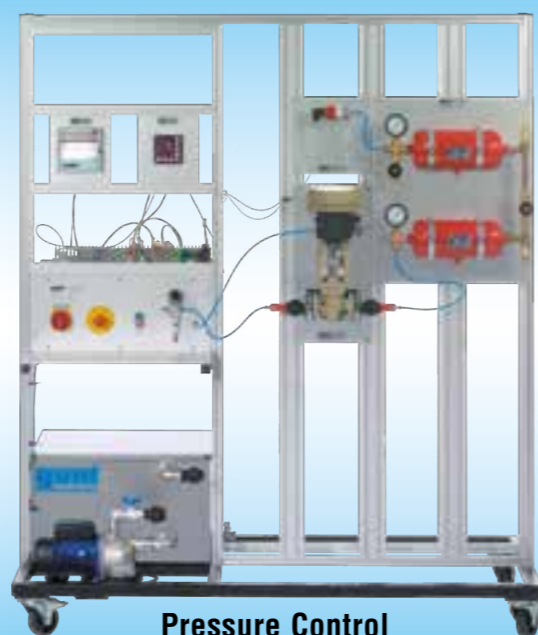


# RT 450 THE MODULAR PROCESS AUTOMATION TRAINING SYSTEM: CLOSED-LOOP AND OPEN-LOOP CONTROL

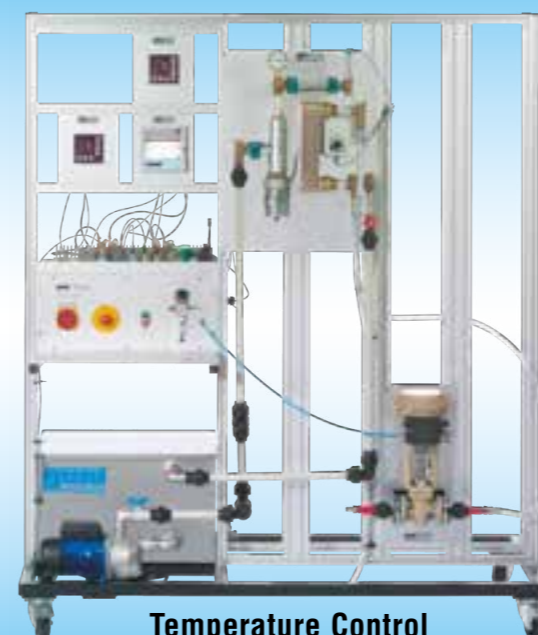
PROCESSES



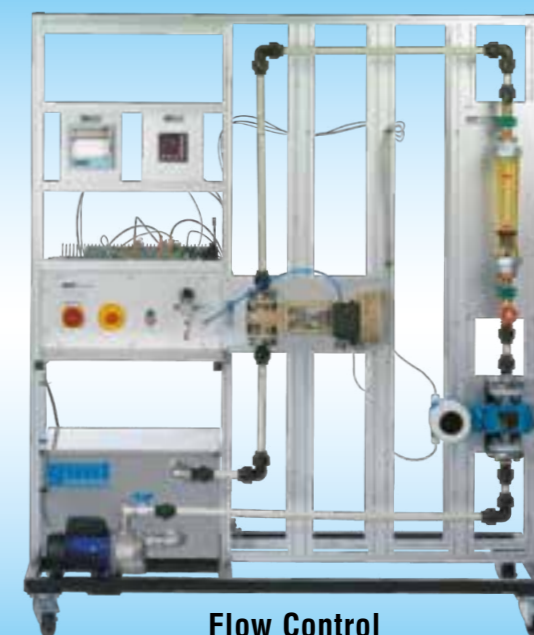
Level Control



Pressure Control



Temperature Control



Flow Control

PROCESSES

## COMPONENTS

RT 450.34 Flow Rate Sensor: Electromagnetic



RT 450.12 Chart Recorder Module



RT 450.42 Part of the PLC Module



## The technological structure of the system



This is the versatility the training system offers...  
...you create the custom combinations!

## A highly expandable system

Looking to teach automation in the metalworking or electrical and electronics engineering sectors? Use this highly versatile and flexible process control training system. It offers everything you require to provide your students with a clearly ordered, wide-ranging introduction to the field of automation.

### Keywords:

Sensors; 2- and 3-wire systems; standard signals; displays; chart recorder; graphical display; Profibus; process control system; closed-loop control; open-loop control; controlled systems; controllers; continuous; switching; PLC; actuators; valves; heaters; wiring; testing; planning; parameter setting; programming; errors; faults; maintenance... and much more.

The overall set-up is completely flexible, modular and expandable in any direction. The structural elements are mounted on panels, ready to connect up. This results in quick assembly and a clear layout. The only other work required is the piping and the electrical wiring. We employ the latest state-of-the-art industrial technology in the training system.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

## DETAILS



All modular in design – only the latest components from actual practice

**RT 450 Process Automation Training System: Base Module**

**Technical Description**

Together with its wide-ranging accessory components, the RT 450 base module provides a modular, fully flexible and open-design system for learning the fundamentals of process automation by means of experimentation. The accessory components are pre-installed on panels. The base module provides an extensive frame for quick and safe mounting of the components required for the various experiments. It includes a water supply with tank and pump, a switch cabinet for power supply as well as connections, maintenance units, and a pressure regulator for an external compressed air supply.

Connecting up the measuring and control cables and the process lines, as well as connection to the electricity supply, form key elements of the programme of exercises. Alongside the purely systematic technical learning content involved, key aspects of the teaching goals are pre-planning, modification, testing, commissioning and optimisation.

Optimal learning is achieved when two or three students work together on a training system as a group.

An instrumentation and control software (RT 450.40) with an interface module for Profibus DP (RT 450.41) is available as an accessory. This enables the key process variables to be displayed and control functions to be executed.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

**Learning Objectives / Experiments**

Together with accessory components, the following learning content and exercises are possible

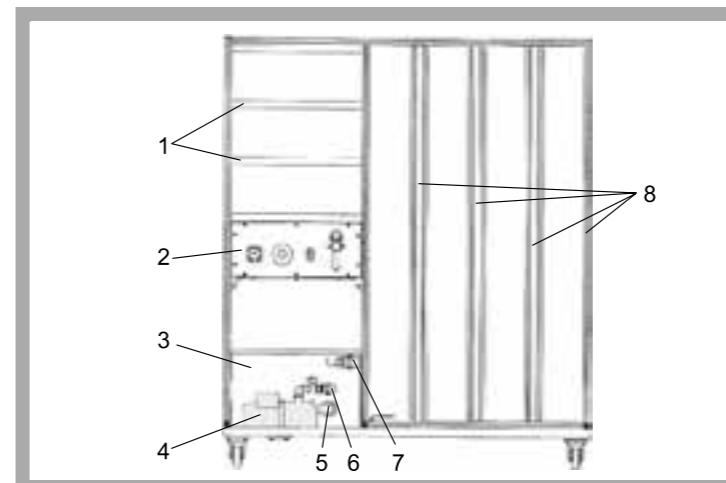
- planning and construction of different process applications
- planning and construction of different automation solutions for the control systems
- familiarisation with the design, function and behaviour of industrial automation components, such as controllers, PLCs, actuators and measuring devices
- commissioning and optimisation of automated process applications
- making process connections (via pipes/hoses), connecting up the electricity supply and the instrumentation and control components
- fundamentals of the use of data acquisition, system control and parameter setting using the RT 450.40 software

\* **Modular training system providing an introduction to the fundamentals of process automation**

\* **Base module with large frame for preassembled components**

\* **Extensive range of accessories available: process application modules, sensors, actuators, controllers, PLCs etc.**

\* **Software for data acquisition, operator control and parameter setting optionally available**

**RT 450 Process Automation Training System: Base Module**


1 frame for electrical modules, 2 switch cabinet with power supply and maintenance and pressure control unit for compressed air, 3 storage tank, 4 centrifugal pump, 5 pump outlet, 6 pump inlet, 7 system water return, 8 aluminium frame



The illustration shows the layout of a level control system. In addition to the base module RT 450, it includes the following components: RT 450.01 (controlled system module: level), RT 450.10 (controller), RT 450.12 (recorder), RT 450.21 (control valve) and RT 450.35 (level sensor).



RT 450.10 (controller), RT 450.12 (recorder) and RT 450.42 (PLC module)

**Specification**

- [1] base module for a flexible process automation training system
- [2] large frame with aluminium rails
- [3] frame for electrical modules
- [4] water circuit with centrifugal pump and tank
- [5] switch cabinet with 24V power supply
- [6] practice-oriented terminal blocks for wiring of the instrumentation and control signals
- [7] 2x maintenance unit and a pressure regulator for compressed air
- [8] installation and connecting material including tools for connecting accessory modules

**Technical Data**

Stainless steel storage tank: 75L  
Centrifugal pump  
- max. head: 20m  
- max. flow rate: 5,4m<sup>3</sup>/h  
- power consumption: 370W  
24VDC supply for components

**Dimensions and Weight**

LxWxH: 1650x850x1950mm  
Weight: approx. 120kg

**Required for Operation**

230V, 50/60Hz, 1 phase or 120V, 60Hz/CSA, 1 phase  
Compressed air supply for RT 450.03, RT 450.20 or RT 450.21: 6...10bar

**Scope of Delivery**

- 1 base module with pump, tank and switch box
- 1 accessory set (tools, compressed air hose, plastic tube, single-core non-sheathed cable, connecting elements)
- 1 set of instructional material

**Order Details**

080.45000 RT 450 Process Automation Training System: Base Module

## RT 450 Process Automation Training System: Base Module

Available Accessories:

CONTROLLED SYSTEM MODULES:

**Product no. Order details**

080.45001 RT 450.01 Controlled System Module: Level  
 080.45002 RT 450.02 Controlled System Module: Flow  
 080.45003 RT 450.03 Controlled System Module: Pressure  
 080.45004 RT 450.04 Controlled System Module: Temperature

CONTROLLER AND RECORDER MODULES:

**Product no. Order details**

080.45010 RT 450.10 Continuous Controller Module  
 080.45011 RT 450.11 Switching Controller Module  
 080.45012 RT 450.12 Chart Recorder Module  
 080.45013 RT 450.13 Digital Display  
 080.45042 RT 450.42 PLC Module with Software

recommended accessory for controller modules:

080.45014 RT 450.14 Software for Controller Configuration

CONTROL VALVES:

**Product no. Order details**

080.45020 RT 450.20 Control Valve, Pneumatically Driven, Kvs 0,4  
 080.45021 RT 450.21 Control Valve, Pneumatically Driven, Kvs 1,0  
 080.45023 RT 450.23 Control Valve, Electrically Driven, Kvs 0,4  
 080.45024 RT 450.24 Control Valve, Electrically Driven, Kvs 1,0

SENSORS:

**Product no. Order details**

080.45030 RT 450.30 Pressure Sensor, 0...6bar  
 080.45031 RT 450.31 Pressure Sensor, 0...2bar  
 080.45032 RT 450.32 Pressure Sensor, 0...100mbar  
 080.45033 RT 450.33 Orifice with Differential Pressure Sensor  
 080.45034 RT 450.34 Flow Rate Sensor: Electromagnetic  
 080.45035 RT 450.35 Level Sensor: Capacitive  
 080.45036 RT 450.36 Temperature Sensor Pt100  
 080.45037 RT 450.37 Thermocouple (K) with Head Transmitter

PC CONNECTION:

**Product no. Order details**

080.45040 RT 450.40 Visualisation Software

required accessory for usage of Visualisation Software:

080.45041 RT 450.41 Profibus DP Module for Controller  
 or  
 080.45043 RT 450.43 Profibus DP Module for PLC

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## RT 450 MODULAR TRAINING SYSTEM: PROCESS AUTOMATION SELECTION OF COMPONENTS, ACCESSORIES, ALTERNATIVES



Level Control



Pressure Control



Flow Control



Temperature Control

### LEVEL CONTROL

RT 450.01 Controlled System Module: Level

RT 450 Process Automation Training System: Base Module

RT 450.10 Continuous Controller Module

RT 450.11 Switching Controller Module ALTERNATIVELY

RT 450.42 PLC Module with Software ALTERNATIVELY

RT 450.21 Control Valve, Pneumatically Driven, Kvs 1,0

RT 450.24 Control Valve, Electrically Driven, Kvs 1,0 ALTERNATIVELY

RT 450.35 Level Sensor: Capacitive

RT 450.31 Pressure Sensor, 0...2bar ALTERNATIVELY

RT 450.32 Pressure Sensor, 0...100mbar ALTERNATIVELY

### FLOW CONTROL

RT 450.02 Controlled System Module: Flow

RT 450 Process Automation Training System: Base Module

RT 450.10 Continuous Controller Module

RT 450.11 Switching Controller Module ALTERNATIVELY

RT 450.42 PLC Module with Software ALTERNATIVELY

RT 450.21 Control Valve, Pneumatically Driven, Kvs 1,0

RT 450.24 Control Valve, Electrically Driven, Kvs 1,0 ALTERNATIVELY

RT 450.34 Flow Rate Sensor: Electromagnetic

RT 450.33 Orifice with Differential Pressure Sensor ALTERNATIVELY

### PRESSURE CONTROL

RT 450.03 Controlled System Module: Pressure

RT 450 Process Automation Training System: Base Module

RT 450.10 Continuous Controller Module

RT 450.11 Switching Controller Module ALTERNATIVELY

RT 450.42 PLC Module with Software ALTERNATIVELY

RT 450.20 Control Valve, Pneumatically Driven, Kvs 0,4

RT 450.23 Control Valve, Electrically Driven, Kvs 0,4 ALTERNATIVELY

RT 450.30 Pressure Sensor, 0...6bar

### TEMPERATURE CONTROL

RT 450.04 Controlled System Module: Temperature

RT 450 Process Automation Training System: Base Module

RT 450.10 Continuous Controller Module

RT 450.11 Switching Controller Module ALTERNATIVELY

RT 450.42 PLC Module with Software ALTERNATIVELY

RT 450.21 Control Valve, Pneumatically Driven, Kvs 1,0

RT 450.24 Control Valve, Electrically Driven, Kvs 1,0 ALTERNATIVELY

RT 450.36 Temperature Sensor Pt100

RT 450.37 Thermocouple (K) with Head Transmitter ALTERNATIVELY

### OPTIONAL ACCESSORIES

RT 450.12 Chart Recorder Module

RT 450.13 Digital Display

RT 450.40 Visualisation Software

RT 450.41 Profibus DP Module for Controller

RT 450.43 Profibus DP Module for PLC ALTERNATIVELY

### RECOMMENDED ACCESSORY

RT 450.14 Software for Controller Configuration

**RT 450.01 Controlled System Module: Level**

**Specification**

- [1] level control loop setup (in conjunction with other modules from the RT 450 series)
- [2] ready-to-install compact panel assembly
- [3] transparent glass tank with overflow, drain valve and manometer
- [4] glass tank can be hermetically sealed
- [5] plexiglass protective sleeve
- [6] PVC tank base and cover
- [7] adjustable safety valve
- [8] fitting for attaching pressure sensor or level sensor
- [9] water as the working medium, supply via base module RT 450
- [10] cascade control option in conjunction with RT 450.02

**Technical Data**

Tank  
 - capacity: max. 7L  
 - filling level: max. 475mm  
 - operating pressure: max. 2bar

Manometer: 0...2,5bar  
 Safety valve: 1...4bar adjustable

**Dimensions and Weight**

LxWxH: 510x330x800mm  
 Weight: approx. 30kg

**Scope of Delivery**

1 level tank mounted on panel, complete with valves, taps, rapid action couplings for fitting sensors, protective sleeve and manometer

**\* Main element in constructing a level control loop**
**Technical Description**

The RT 450.01 consists of a clear plastic level tank as the principle element and uses water as the working medium. The tank is set up in such a way that it is hermetically sealed if all taps and valves are closed. This enables experiments to be performed with the tank under internal pressure. For safety, the level tank is fitted with a safety valve and is enclosed in a transparent plastic protective sleeve. The tank includes fittings for the attachment of a pressure sensor (RT 450.31) or a level sensor (RT 450.35). It is installed in the base module RT 450. A control valve (e.g. RT 450.21) and a controller (RT 450.10) complete the control loop.

**Learning Objectives / Experiments**

- setting up a level control loop
- comparison of different sensors for level measurement
- level control against trapped-air cushion
- level / flow cascade control (with RT 450.02)

**Order Details**

080.45001 RT 450.01 Controlled System  
 Module: Level

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**RT 450.02 Controlled System Module: Flow**

**Specification**

- [1] flow control loop setup (in conjunction with other modules from the RT 450 series)
- [2] ready-to-install compact panel assembly
- [3] rotameter with scale
- [4] stop valve in the inlet section
- [5] water as the working medium, supply via base module RT 450
- [6] optional cascade control in conjunction with RT 450.01

**Technical Data**

Rotameter: 0...2,5m³/h

**Dimensions and Weight**

LxWxH: 250x180x700mm  
 Weight: approx. 10kg

**Scope of Delivery**

1 rotameter mounted on panel, complete with stop valve and connections

**\* Main element in constructing a flow control loop**
**Technical Description**

The RT 450.02 consists of a rotameter as the principle element and uses water as the working medium. A valve can be used to adjust the flow resistance and thus change the flow properties of the controlled system.

A major advantage of this controlled system is that the rotameter allows all changes in the flow rate caused by faults or responses to a control action to be directly observed.

A control loop for flow control experiments is set up using the base module RT 450, a control valve (RT 450.2x), the RT 450.10 controller and a sensor (e.g. RT 450.34).

**Learning Objectives / Experiments**

- setting up of a flow control loop
- comparison of different sensors for flow measurement
- level / flow cascade control (with RT 450.01)

**Order Details**

080.45002 RT 450.02 Controlled System  
 Module: Flow

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**RT 450.03 Controlled System Module: Pressure**

**Technical Description**

The RT 450.03 controlled system module is a panel-mounted ready-to-install element. In conjunction with other modular control components, it enables pressure control systems with different characteristic features to be constructed and investigated.

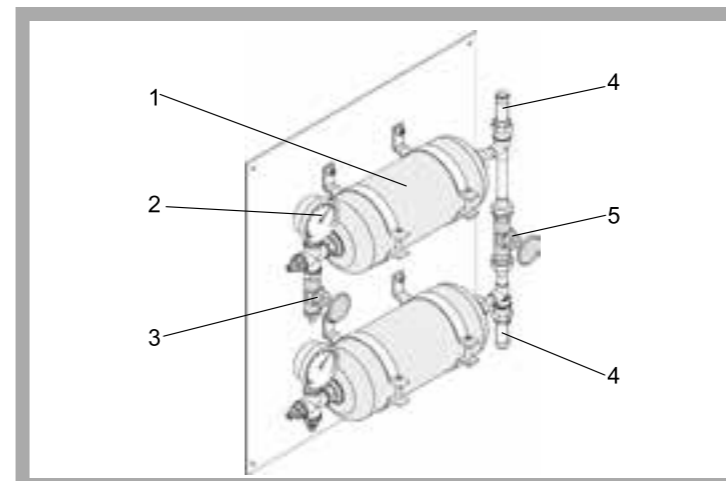
The panel is mounted on the frame of the base module RT 450. RT 450.03 consists of two steel pressure tanks and is operated with compressed air as the working medium. Each tank is fitted with a manometer and a safety valve. One tank also has a drain valve. Both tanks can be fitted with a pressure sensor. The tanks are interconnected by a vent valve and can therefore be connected in series. This makes it possible to represent both first and second order pressure control systems.

The RT 450 base module supplies the controlled system module with its working compressed air. Pneumatic hoses with quick-release couplings connect all the modules to a pressure control loop.

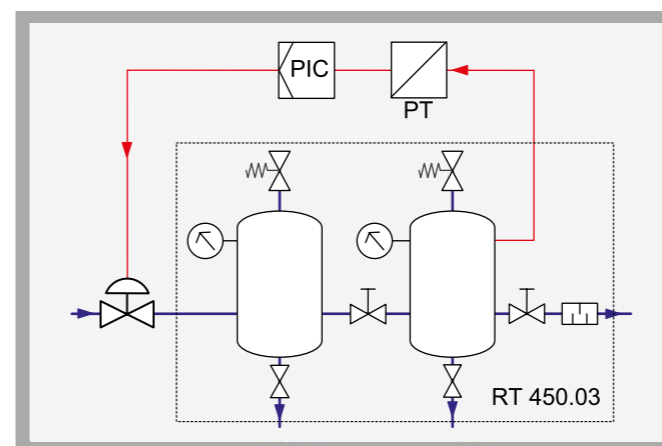
**Learning Objectives / Experiments**

- planning, setting up, testing, optimising and assessing pressure control loops with different objectives and components
- \* constructing a 1<sup>st</sup> order pressure control system
- \* constructing a 2<sup>nd</sup> order pressure control system
- design and function of different instrumentation and control components
- technical terminology and symbols in industrial control engineering
- practical exercises: Implementing process and signal lines
- commissioning and troubleshooting of process engineering systems

- \* Main element in constructing a pressure control loop
- \* Rapid installation into the RT 450 base module by modular panel assembly

**RT 450.03 Controlled System Module: Pressure**


1 pressure tank, 2 manometer, 3 drain valve, 4 safety valve, 5 vent valve



Process schematic



The illustration shows the layout of a pressure control system. In addition to the base module RT 450, it includes the following components: RT 450.03 (controlled system module: pressure), RT 450.10 (controller), RT 450.12 (recorder), RT 450.20 (control valve) and RT 450.30 (pressure sensor).

**Specification**

- [1] construction of a pressure control loop (in conjunction with other modules of the RT 450 series)
- [2] ready-to-install compact panel assembly
- [3] 2 pressure tanks with safety valves
- [4] direct pressure indication by 2 manometers
- [5] valve permits series configuration of both pressure tanks
- [6] series configuration of pressure tanks: investigation of coupled controlled system response compared to single-tank operation
- [7] 2 valves: 1x drain, 1x vent
- [8] copper piping
- [9] compressed air as working medium, supply via base module RT 450

**Technical Data**

- Pressure tank
- capacity: 3L
- operating pressure: max. 6bar
- manometer: 0...10bar
- Safety valve: adjustable to max. 10bar

**Dimensions and Weight**

- LxWxH: 510x175x600mm
- Weight: approx. 15kg

**Required for Operation**

- Compressed air supply via RT 450

**Scope of Delivery**

- 2 pressure tanks mounted on panel, complete with valves and manometers

**Order Details**

080.45003 RT 450.03 Controlled System Module: Pressure

**RT 450.04 Controlled System Module: Temperature**

**Technical Description**

The RT 450.04 controlled system module is a panel-mounted ready-to-install element. In conjunction with other modular control components, it enables temperature control systems with different characteristic features to be constructed and investigated.

The panel is mounted on the frame of the base module RT 450. The main elements of the controlled system module are: an electric heater installed in a section of pipe, and a plate heat exchanger between the primary and secondary water circuits. The heater can either be operated by a switching controller and so act as the control loop actuator, or can operate in continuous duty as a pure energy source. In operation as a continuous controller, with the heater as the energy source, a choice of two different valves (pneumatic or electric) can be used as actuators in the primary circuit.

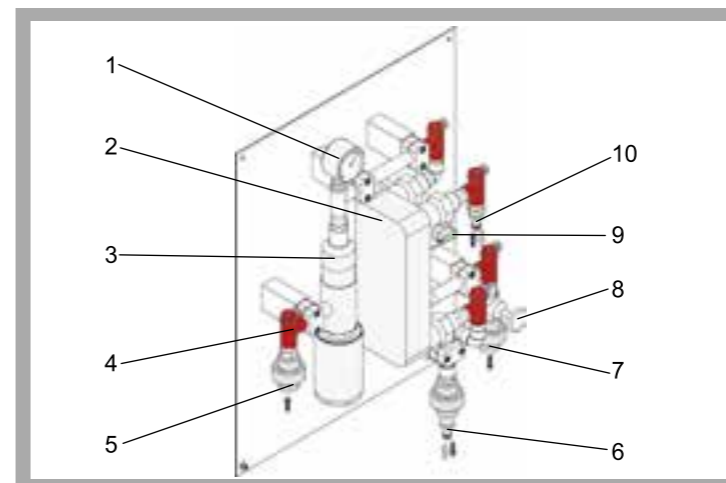
For safety, the heater features a thermostat and a device to protect it from running dry. The primary circuit (with heater) is connected by pipelines to the water supply of the base module RT 450, while the secondary circuit requires a laboratory water supply for cooling. Counterflow or parallel flow cooling is possible. The connection to the laboratory network is made by quick-release couplings and hoses.

**Learning Objectives / Experiments**

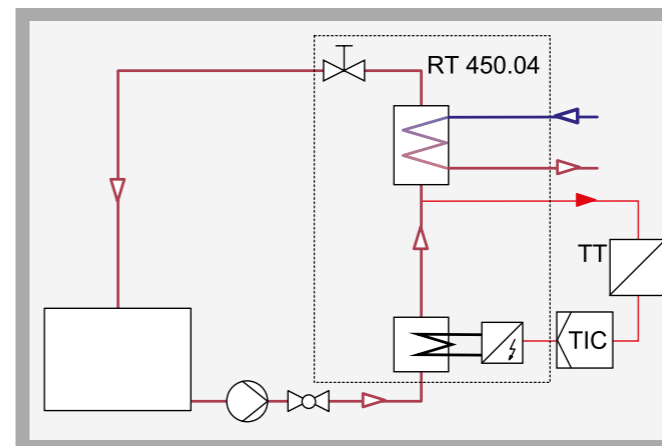
- planning, setting up, testing, optimising and assessing temperature control loops with different objectives and components
- design and function of different instrumentation and control components
- technical terminology and symbols in industrial control engineering
- practical exercises: implementing process and signal lines
- commissioning and troubleshooting of process engineering systems

\* **Main element in constructing a temperature control loop**

\* **Rapid installation into the RT 450 base module by modular panel assembly**

**RT 450.04 Controlled System Module: Temperature**


1 thermometer, 2 plate heat exchanger, 3 heater, 4 temperature measurement points, 5 RT 450 inlet, 6 external water circuit connection, 7 return to RT 450, 8 Regulating valve, 9 heater switch, 10 external water circuit connection



Process schematic for controlled system with heater as actuator and switching controller



The illustration shows the layout of a temperature control system. In addition to the base module RT 450, it includes the following components: RT 450.04 (controlled system module: temperature), RT 450.11 (controller), RT 450.12 (recorder), RT 450.21 (control valve) and RT 450.36 (temperature sensor).

**Specification**

- [1] construction of a temperature control loop (in conjunction with other modules of the RT 450 series)
- [2] ready-to-install compact panel assembly
- [3] electric heater with thermostat and dry-running protection
- [4] direct temperature display at heater outlet with bimetallic thermometer
- [5] heater is either an actuator or a continuous heater
- [6] plate heat exchanger, operating in counter-flow or parallel-current mode
- [7] primary circuit with heater and heat exchanger, connected to water supply of base module RT 450
- [8] flow of primary circuit controlled by hand-operated valve
- [9] secondary circuit of heat exchanger connected to laboratory water supply

**Technical Data**

Plate heat exchanger  
- number of plates: 20  
- heat transfer surface: 0,72m<sup>2</sup>  
- flow rate: max. 3m<sup>3</sup>/h

Heater with thermostat and dry-running protection  
- power output: 2kW  
- temperature limitation by thermostat: 65°C

Thermometer at heater outlet: 0...100°C

**Dimensions and Weight**

LxWxH: 510x200x650mm  
Weight: approx. 20kg

**Required for Operation**

Water connection: max. 3m<sup>3</sup>/h

**Scope of Delivery**

1 heater and 1 plate heat exchanger mounted on panel, complete with piping, valve, safety elements, temperature sensor fixtures, connections to RT 450 piping system

**Order Details**

080.45004 RT 450.04 Controlled System Module: Temperature

**RT 450.10 Continuous Controller Module**


- \* **Digital process controller with extensive functionality**
- \* **Operation and parameterisation optionally via keyboard, configuration software or visualisation software (Profibus)**

**Technical Description**

The digital process controller is pre-installed on a panel. The panel can be attached quickly and easily to the frame of the RT 450 base module. The connections for the process controller are pre-configured on connector assemblies for plugging-in to terminals on the rear of the panel.

The process controller is configured, parameterised and operated by way of the keyboard. Configuration and parameterisation can also be carried out by computer, using the RT 450.14 software.

The process controller can additionally be fitted with the RT 450.41 Profibus module. This enables communication with the RT 450.40 visualisation software.

**Learning Objectives / Experiments**

- functional range of a digital process controller
- configuration, parameterisation and operation via keyboard
- familiarisation with an industry-standard configuration software (RT 450.14, available as an option)
- signal links and standard current signals
- profibus communication (RT 450.41, available as an option)

**Scope of Delivery**

1 controller module

**Specification**

- [1] universal continuous controller module, optimised for the RT 450 modular system
- [2] fixed assignment of inputs and outputs
- [3] programmable controller: P, PI, PD, PID
- [4] configuration and parameterisation of the digital process controller manually or computer-assisted (with RT 450.14) via a TTL interface

**Technical Data**

2 analog inputs: 4...20mA  
2 analog outputs: 4...20mA  
2 binary inputs  
2 relay outputs

**Dimensions and Weight**

LxWxH: 180x240x240mm  
Weight: approx. 2kg

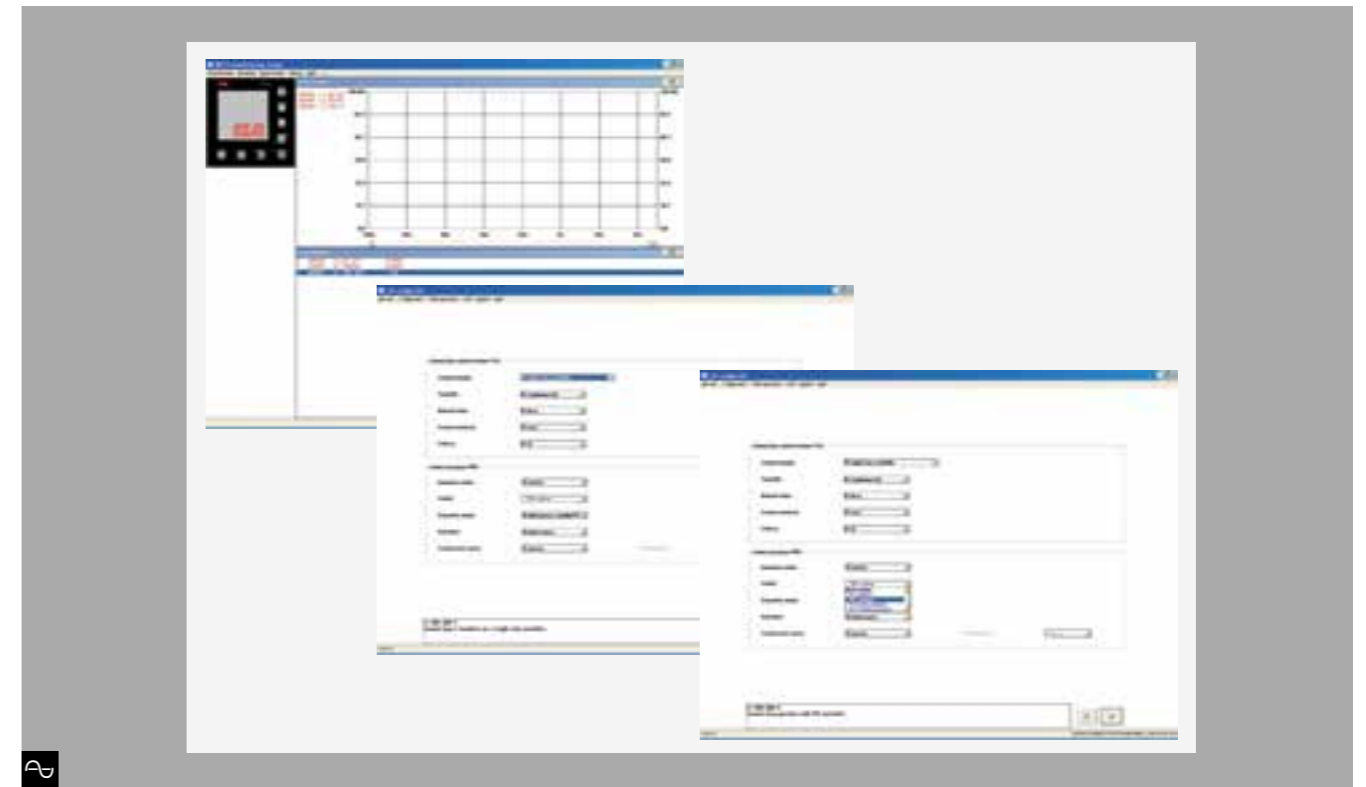
**Required for Operation**

24VDC

**Order Details**

080.45010 RT 450.10 Continuous Controller Module

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**RT 450.14 Software for Controller Configuration**


- \* **Configuration software for controller modules RT 450.10 and RT 450.11**
- \* **User-friendly menu guidance and systematic project management**

**Technical Description**

All the functions which can be realized by way of the keyboard of a process controller can also be realized using the IBIS-R+ configuration software.

The software's user-friendly menu guidance enables assured configuration and parameterisation of the controller modules. Completed projects are saved, managed and reloaded as required.

Controller operation, hardware status polling and chart recording can also be facilitated using the software.

The software can be installed on almost any computer. A V24 adapter to the computer's RS232 port enables connection with the controller module.

**Learning Objectives / Experiments**

- functional range of an industrial controller and a configuration software
- creation and documentation of projects

**Scope of Delivery**

1 IBIS-R+ software CD  
1 adapter cable  
1 manual in German and English

**Specification**

- [1] software for configuration of controller modules RT 450.10, RT 450.11
- [2] parameterisation of pre-defined device functions such as controller parameters and limit values
- [3] selection of functions from function lists contained in the controller module, e.g.: measurement method, measuring range, output, control structure, etc.
- [4] representation of front of unit, measured value trends and parameters on-screen for commissioning purposes

**Technical Data**

IBIS-R+ software  
- recommended as from 486 CPU  
- at least 4 MB RAM  
- at least 18 MB available capacity on hard disk  
- system requirements: Windows Vista or Windows 7

**Order Details**

080.45014 RT 450.14 Software for Controller Configuration

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**RT 450.42 PLC Module with Software**


- \* PLC with included programming software
- \* Module for Profibus communication available

**Technical Description**

The programmable logic controller (PLC) is pre-installed on a panel which can be quickly and easily attached to the frame of the RT 450 base module. All the connections for the PLC are pre-configured on connector assemblies ready for plugging-in to terminals on the rear of the panel.

The PLC package also includes programming software supplied by the PLC manufacturer.

The PLC can be fitted with the Profibus module RT 450.43. This enables the PLC to communicate over the Profibus network. An input/output module is supplied.

**Learning Objectives / Experiments**

- functional range of a PLC
- programming a PLC using included programming software
- electrical connections and signal links
- Profibus communication

**Scope of Delivery**

- 1 PLC module
- 1 CD containing PLC programming software
- 1 input/output module
- 1 interface cable for digital signals

**Specification**

- [1] module for exercises using a programmable logic controller (PLC)
- [2] expansion of analog inputs and outputs
- [3] RS232 port for programming on computer
- [4] PLC programming software
- [5] programming languages: Statement List (STL), Ladder Diagram (LD), Structured Text (ST), Function Block Diagram (FBD)
- [6] Profibus module (RT 450.43) for communication with network available as an option

**Technical Data**

- PLC
- 8 digital inputs: 24VDC
  - 4 analog inputs: 10-bit, 4...20mA
  - 6 digital outputs: 24VDC, max. 100mA
  - 2 analog outputs: 12-bit, 4...20mA
  - program memory: 24kB
- Software
- programming language conforming to IEC61131-3

**Dimensions and Weight**

LxWxH: 215x86x110mm  
Weight: approx. 1kg

**Required for Operation**

24VDC

**Order Details**

080.45042 RT 450.42 PLC Module with Software

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**RT 450.12 Chart Recorder Module**


The illustration shows a similar unit.

- \* Colour 3-channel process recorder

- \* Analog recording of process variables conforming to the variables being measured or in the range 0...100%

**Technical Description**

The recorder module is pre-installed on a panel which can be quickly and easily attached to the frame of the RT 450. The connections for the recorder module are pre-configured on connector assemblies for plugging-in to terminals on the rear of the panel.

Signals are recorded by a line recorder which continuously plots these signals as coloured lines.

The recorder module features a keypad and a display, used to program individual channels as well as the paper feed rate.

**Learning Objectives / Experiments**

- functional range of a line recorder
- adjusting and changing pens and graph paper
- operation, parameterisation and configuration via keyboard
- signal links and standard current signals

**Specification**

- [1] recorder module to record control and process variables
- [2] continuous recording of three independent standard analog signals as coloured lines
- [3] interchangeable pens
- [4] programmable paper feed rates
- [5] drive controlled by stepper motor

**Technical Data**

Recorder module

- 3 channels
- measuring range: 4...20mA
- sampling time: 240ms per channel
- basic accuracy: +/- 0,1% of final value

Paper

- recorder drum
- feed rate: 0, 5, 10, 20, 60, 120, 240, 300, 360, 600, 720, 1800, 3600, 7200mm/h; also freely programmable

Pens

- blue, red, green

**Dimensions and Weight**

LxWxH: 240x144x144mm

Weight: approx. 4kg

**Required for Operation**

24VDC

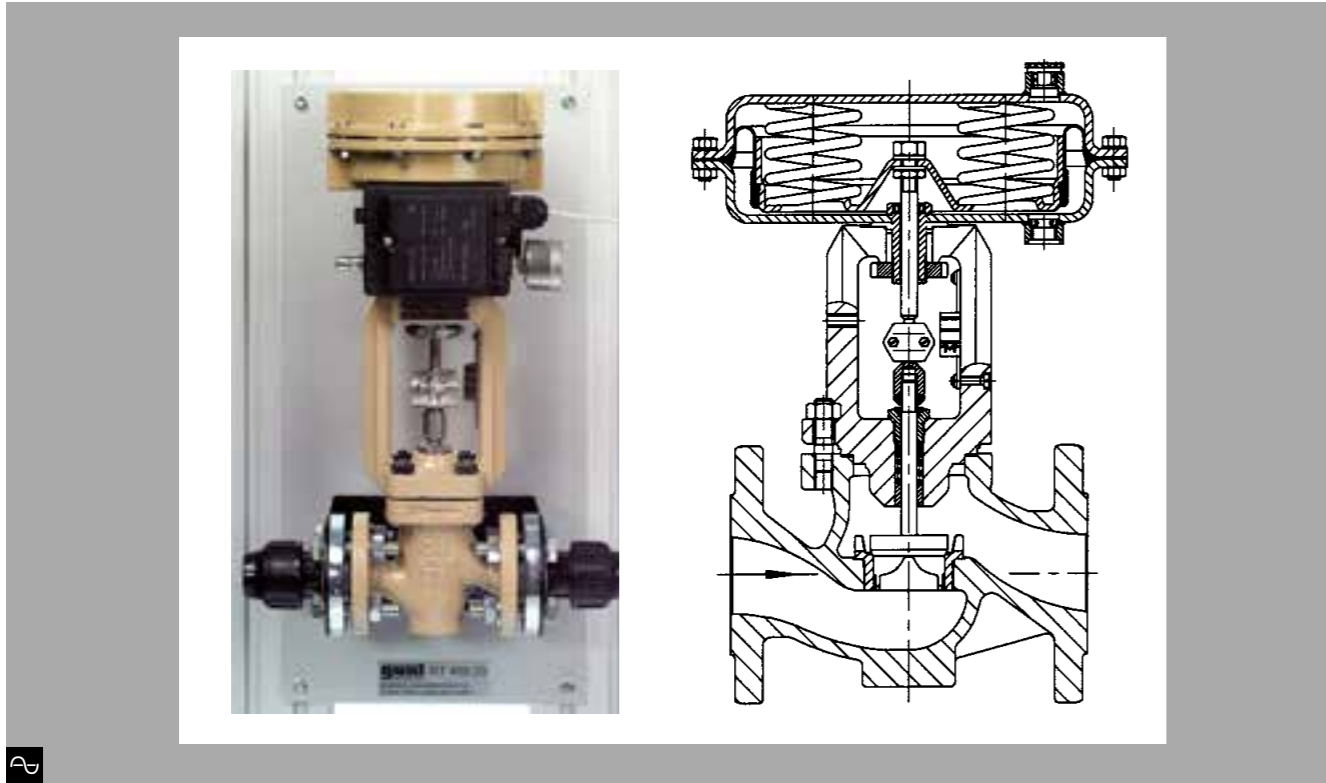
**Scope of Delivery**

1 recorder module

**Order Details**

080.45012 RT 450.12 Chart Recorder Module

G.U.N.T Gerätebau GmbH, Hanskampring 15-17, D-22885 Barsbüttel, Phone +49 (40) 67 08 54-0, Fax +49 (40) 67 08 54-42, E-mail sales@gunt.de, Web http://www.gunt.de  
We reserve the right to modify our products without any notifications.

**RT 450.20 Control Valve, Pneumatically Driven, Kvs 0,4**


\* Industrial control valve with electro-pneumatic positioner

\* Used in the construction of level and flow rate control systems

**Technical Description**

The electro-pneumatic control valve is used primarily as the actuator in a level or flow rate control loop.

The control valve is installed on a panel which can be quickly and easily attached to the frame of the RT 450 base module. An electrical signal input (identical to the controller output) is pre-configured and routed to the base module terminal array which is specific to the particular application.

The control valve is fitted with an electro-pneumatic positioner which requires a supply of compressed air. The valve rod is driven by a pneumatically operated membrane. The electro-pneumatic control valve is set to the safe "closed" position when no auxiliary power is applied.

**Learning Objectives / Experiments**

- functional range of an electro-pneumatically operated control valve
- recording of the flow rate characteristic during the experiment (flow rate dependent on degree of opening)
- standard current signals and correct electrical wiring and interconnection

**Scope of Delivery**

1 control valve with electro-pneumatic positioner

**Specification**

- [1] control valve as actuator in control loop
- [2] electro-pneumatic positioner to actuate the pneumatic control valve drive by an electrical signal
- [3] operating direction: rising
- [4] safety position: closed
- [5] adapter with quick-coupling for experiments with air

**Technical Data**

Control valve: DN 15; PN 16; Kvs value: 0,4;  
characteristic: linear  
Actuator drive: membrane area: 120cm<sup>2</sup>;  
stroke: max. 15mm; nominal signal range: 0,2...1bar;  
electro-pneumatic positioner: input signal: 4...20mA

Hydraulic connection, control valve  
- clamp connector type PA: D=25mm  
- adapter with quick-coupling: 6mm

**Dimensions and Weight**

LxWxH: 426x168x326mm  
Weight: approx. 6kg

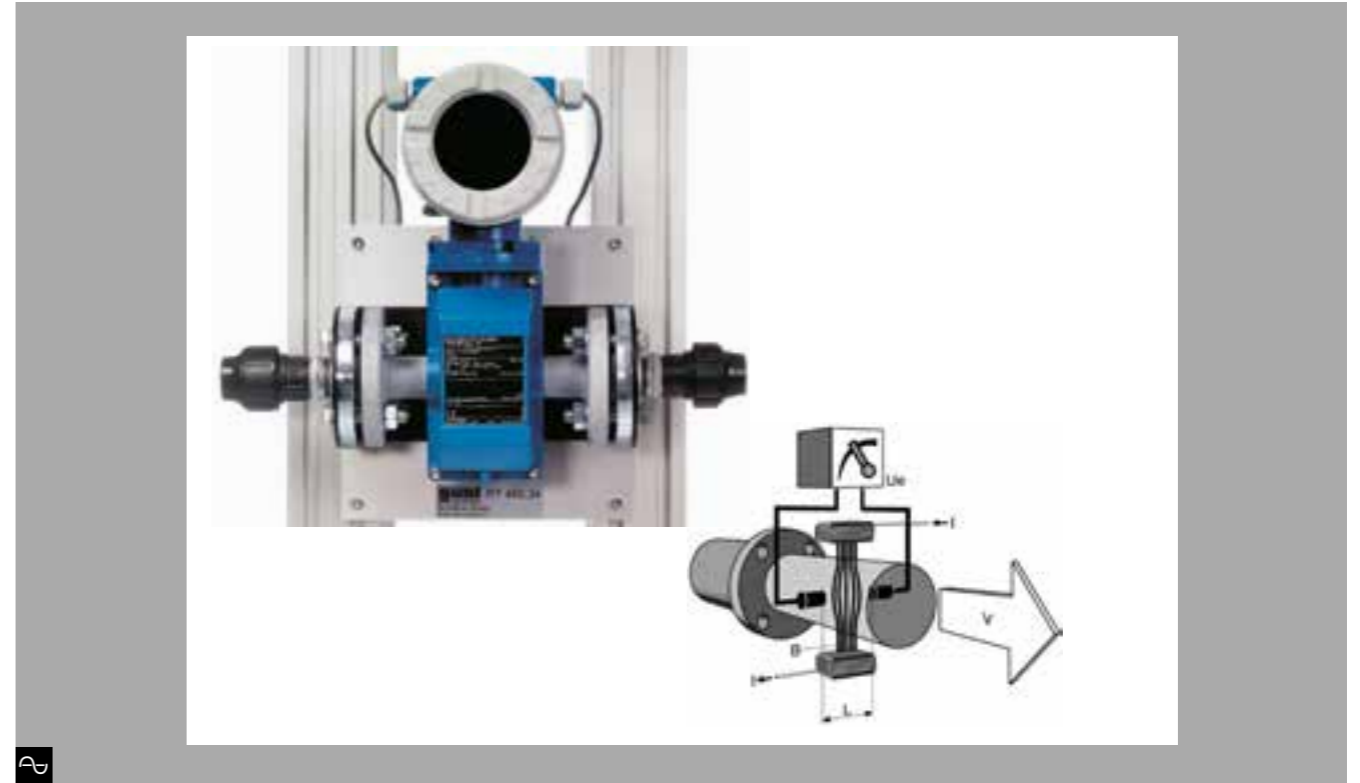
**Required for Operation**

Compressed air supply via RT 450

**Order Details**

080.45020 RT 450.20 Control Valve,  
Pneumatically Driven, Kvs 0,4

G.U.N.T Gerätebau GmbH, Hanskampring 15-17, D-22885 Barsbüttel, Phone +49 (40) 67 08 54-0, Fax +49 (40) 67 08 54-42, E-mail sales@gunt.de, Web http://www.gunt.de  
We reserve the right to modify our products without any notifications.

**RT 450.34 Flow Rate Sensor: Electromagnetic**


\* Industrial flow rate sensor with measurement based on electromagnetic induction

\* Negligible pressure loss

**Technical Description**

The flow rate sensor is a compact unit comprising a measurement sensor and a transducer. This compact unit is required in the construction of a flow rate control loop. It can also be used as an auxiliary instrument in a level control loop.

The flow rate sensor is installed on a panel which can be quickly and easily attached to the frame of the RT 450 base module. The signal output and voltage supply are pre-wired, and are connected to the terminals on the base module.

Negligible pressure loss occurs for flow through the sensor's measuring tube.

**Learning Objectives / Experiments**

- principle of an electromagnetic flow rate sensor
- electrical connections: voltage supply and measurement signal
- standard current signals and correct electrical wiring and interconnection

**Scope of Delivery**

1 flow rate sensor

**Specification**

- [1] compact unit for flow rate measurement
- [2] all electrical connections pre-wired
- [3] flow rate sensor connected by plastic pipes and clamp fittings or pipe adapters
- [4] no pressure loss due to flow resistance

**Technical Data**

Flow rate sensor  
- measurement principle: electromagnetic  
- measuring range: 0...2,5m<sup>3</sup>/h  
- output signal: 4...20mA  
- measuring tube diameter: D=24mm  
- temperature range: 0...60°C  
Measuring medium  
- pressure of measuring medium: max. 16bar  
- minimum conductivity of medium: 50µS/cm

**Dimensions and Weight**

LxWxH: 200x180x350mm  
Weight: approx. 10kg

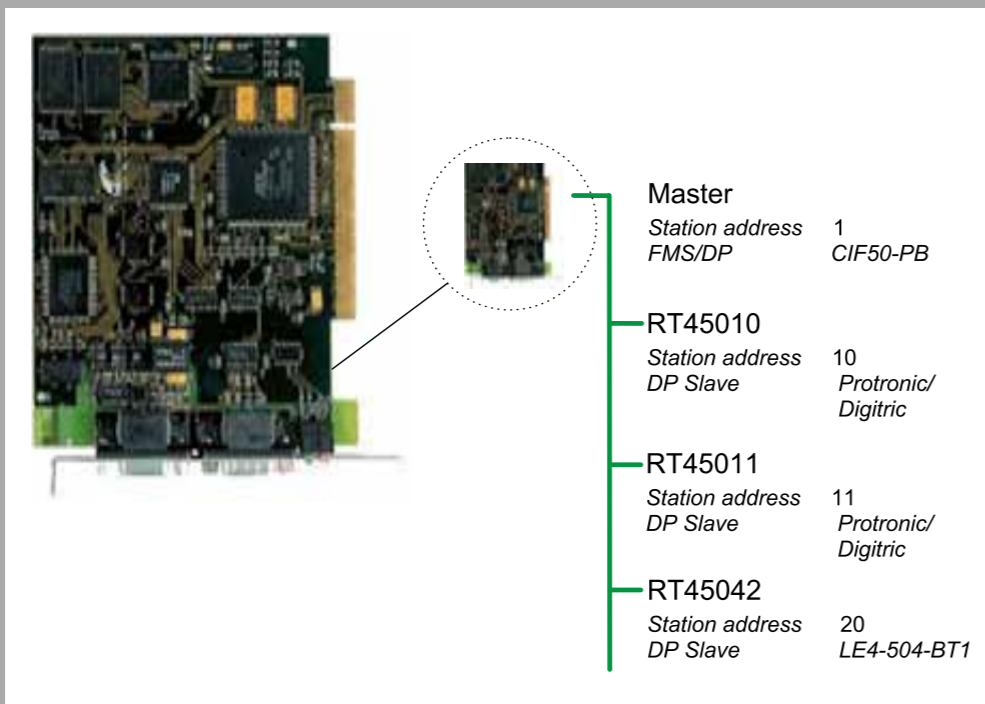
**Required for Operation**

24VDC

**Order Details**

080.45034 RT 450.34 Flow Rate Sensor:  
Electromagnetic

G.U.N.T Gerätebau GmbH, Hanskampring 15-17, D-22885 Barsbüttel, Phone +49 (40) 67 08 54-0, Fax +49 (40) 67 08 54-42, E-mail sales@gunt.de, Web http://www.gunt.de  
We reserve the right to modify our products without any notifications.

**RT 450.40 Visualisation Software**


\* **Field bus integration for a computerised automation system**

\* **Profibus card as field bus master**

\* **Communication with controllers and PLC**

\* **User-friendly GUNT visualisation software**

**Technical Description**

Computer-assisted communication between automation components over a field bus is a standard approach in industrial control systems.

The RT 450 training system works with Profibus DP. A Profibus card performs the function of the field bus master and serves as the communications interface (CIF). The field bus slaves – in this case the controller module and the PLC module – must likewise be field bus-compatible. The components must be equipped with a Profibus module to facilitate this operation.

One of the key features of the visualisation software, based on LabVIEW, is a chart which is used to present visuals of time functions. The software can also be used to operate and parameterise process controllers (RT 450.10 and RT 450.11). The communications interface (CIF) controls the data interchange between the software and the slaves.

Communication is bidirectional: changes made in the software are transmitted directly to the slaves. Controller settings made on the controller's keypad are also transmitted to the software.

Data interchange between the software and the CIF is provided by way of an OPC server. An OPC server is the standard interface for interchange of process data.

**Learning Objectives / Experiments**

- principles of communication when using computerised automation over field bus
- familiarisation with the hardware components and wiring
- installation and configuration routines
- using an application
  - \* closed-loop and open-loop control visualisation software
- familiarisation with the system elements
  - \* Profibus card as communications interface
  - \* OPC server
  - \* system configurator

**RT 450.40 Visualisation Software**


GUNT visualisation software: start menu

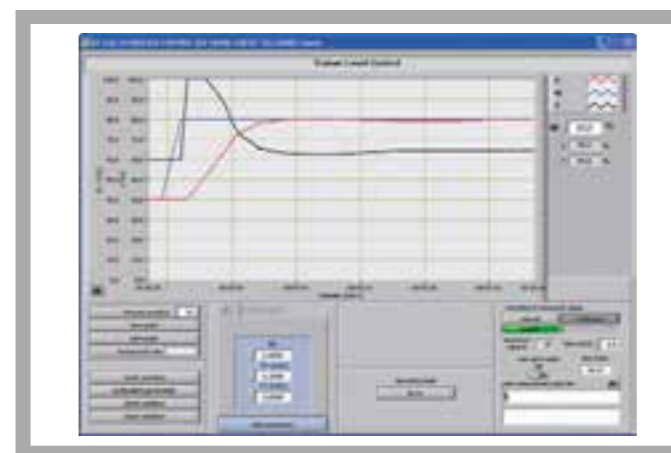
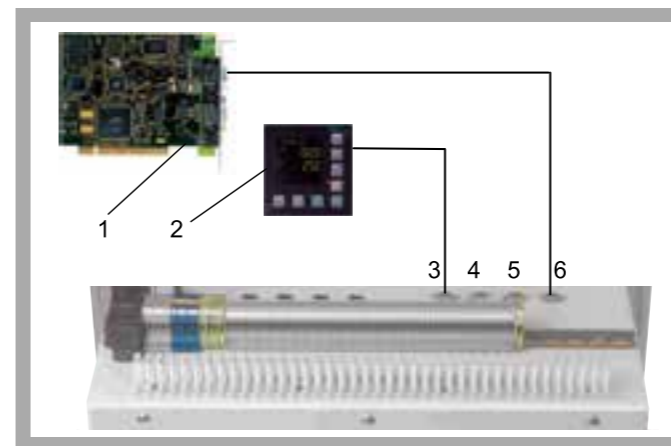


Chart feature to represent time functions in a control system



Profibus connections on RT 450  
1 Profibus card, 2 controller module with Profibus module (RT 450.10),  
3, 4, 5, 6 connections on base system control cabinet

**Specification**

- [1] software for computerised automation
- [2] Profibus card as communications interface (CIF)
- [3] communications interface as field bus master
- [4] controller module RT 450.10 or RT 450.11 with Profibus module RT 450.41 as slave
- [5] PLC module RT 450.42 with Profibus module RT 450.43 as slave
- [6] GUNT visualisation software
- [7] Profibus connections pre-configured on control cabinet of RT 450 base module

**Technical Data**

- Profibus card
- Profibus DP
  - 125 slaves
  - 7168 bytes I/O data
  - dual-port memory
  - RS232 port, diagnostic PCI
  - SyCon configuration software
  - OPC server

System requirements: Windows Vista or Windows 7

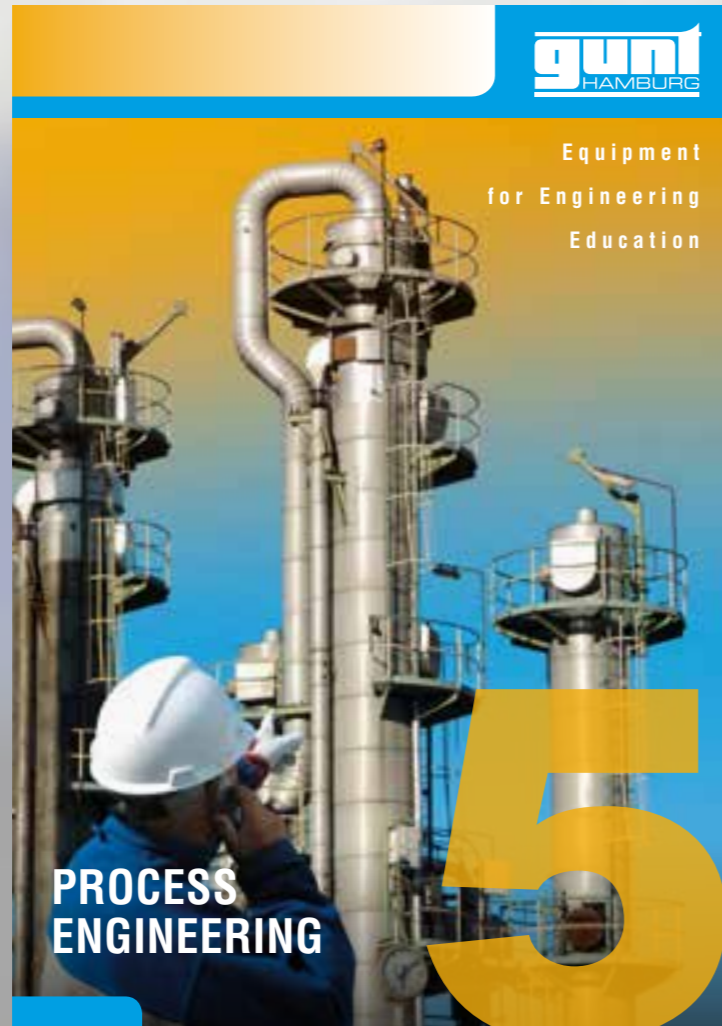
**Scope of Delivery**

- 1 Profibus card
- 1 software CD with GUNT visualisation software
- 1 D-Sub data cable

**Order Details**

080.45040 RT 450.40 Visualisation Software

ALSO AVAILABLE:



### PROCESS ENGINEERING

- Fundamentals of Control Engineering
- Components and Calibration
- Simple Process Engineering Control Systems
- Complex Process Engineering Control Systems
- Fundamentals of Process Engineering
- Mechanical Process Engineering
- Thermal Process Engineering
- Chemical Process Engineering
- Biological Process Engineering
- Water Treatment

## RT450 THE MODULAR TRAINING SYSTEM FOR PROCESS AUTOMATION: CLOSED-LOOP AND OPEN-LOOP CONTROL



*The ideal way to teach and learn  
about automation in all its aspects*

**Flexible**

**Practical**

**Modular  
Expandable**

**Various  
Learning Levels**

THE SYSTEM PROVIDING AN EASY INTRODUCTION TO A COMPLEX SUBJECT

## Teaching Concept and Learning Content

RT450 offers you a flexible and versatile learning platform to provide school and college students with a practical introduction to a wide range of topics and issues in the field of process automation. The close interlinking of practical skills with theoretical/analytical aspects promotes thorough learning.

You can teach systematically categorised learning content or just as well combine complex material into integrated project work. For successful deployment of RT 450 the fundamentals of the subject should already have been taught in advance.

LEARNING TOPICS	SPECIFIC LEARNING CONTENT	Page
Industrial Automation Components	<ul style="list-style-type: none"> <li>∴ Controllers (open/closed loop)</li> <li>∴ Recorders, displays</li> <li>∴ Actuators, sensors</li> </ul>	
Learning the Fundamentals of Control Engineering by Experimentation	<ul style="list-style-type: none"> <li>∴ Controller, controlled system, control loop, actuators</li> <li>∴ Control response: ∴ continuous, switching</li> <li>∴ P, I, D components of the control response</li> <li>∴ Step response to change in manipulating/disturbance variable</li> </ul>	
Familiarisation with Set-Up Procedures	<ul style="list-style-type: none"> <li>∴ Operation, configuration and parameterisation of a digital industrial controller: manually via keypad or using configuration software</li> <li>∴ Setting a 3-channel line recorder with digital menu guidance</li> <li>∴ Programming a PLC</li> </ul>	
Specific Control Applications	<ul style="list-style-type: none"> <li>∴ Pressure, level, flow, temperature</li> <li>∴ Cascade control</li> </ul>	
Planning and Displaying	<ul style="list-style-type: none"> <li>Reading, editing and creating</li> <li>∴ Circuit diagrams</li> <li>∴ Wiring diagrams and plans of terminal connections</li> <li>∴ Work and process schematics</li> <li>∴ Plant installation diagrams</li> </ul>	
Practical Exercises	<ul style="list-style-type: none"> <li>∴ Making pipe connections</li> <li>∴ Making electrical connections, particularly signal links</li> <li>∴ Preparing plant for operation</li> <li>∴ Troubleshooting</li> </ul>	
Familiarisation with Communication and Visualisation Systems	<ul style="list-style-type: none"> <li>Parameterisation and configuration of controllers by software</li> <li>∴ Profibus interconnection of automation components</li> <li>∴ Data acquisition cards</li> <li>∴ Interfaces</li> <li>∴ Data management: save, export</li> </ul>	

## Learning Topics: Industrial Automation Components



Digital industrial controller



Programmable logic control (PLC)



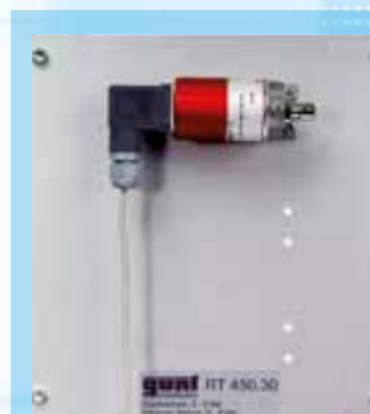
Pneumatic control valve with electro-pneumatic positioner



3-channel line recorder

### Typical questions:

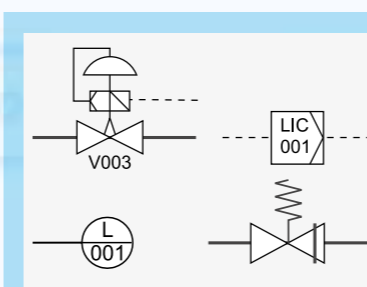
- ∴ What are the functions of the components in an automation system?
  - ∴ What are the functional principles underlying the various transducers?
  - ∴ Is an alimentation needed to operate the unit?
  - ∴ What signals are put out?
  - ∴ What input signals are accepted?
  - ∴ How are the components symbolically represented?
- ...and much more.



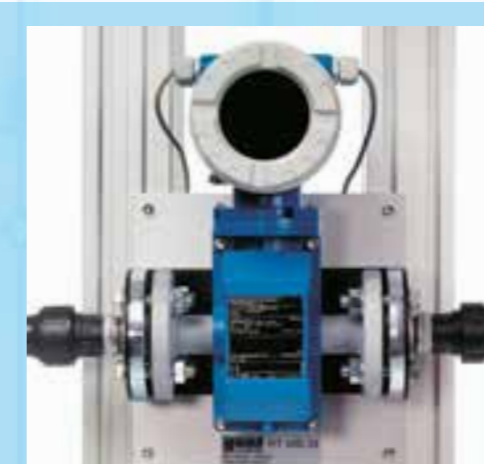
Pressure sensor



Temperature sensor, Pt100



Process engineering symbols



Flow rate sensor, electromagnetic



Level sensor, capacitive

## Learning Topics: Learning the Fundamentals of Control Engineering by Experimentation

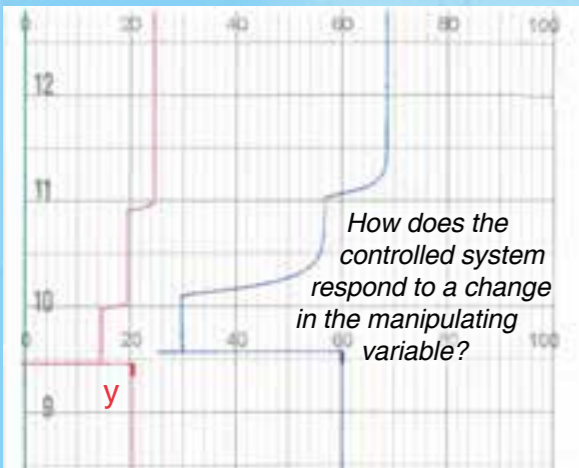


Operation and parameterisation of a digital controller via keypad

### Examples of learning content

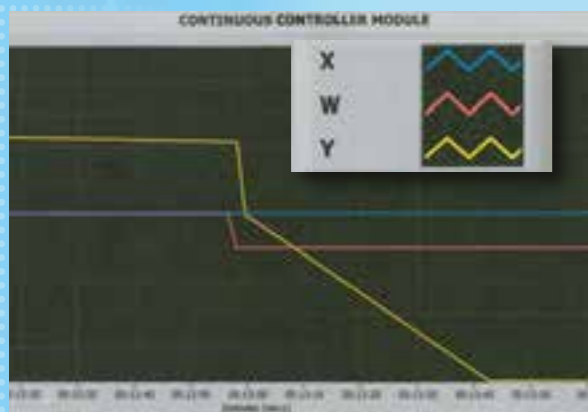
(all taught by experimentation)

- ∴ Response of the controlled system
    - ∴ How does the controlled variable respond to a step change in the manipulating variable?
    - ∴ Controlled system with compensation
    - ∴ Controlled system without compensation
  - ∴ Control action in manual or automatic mode
  - ∴ Various levels of intervention in an industrial digital controller
    - ∴ Operating level
    - ∴ Parameter level
    - ∴ Configuration level
  - ∴ Controller settings via keypad
  - ∴ Effects of the elementary transfer elements of a controller on the manipulating variable
    - ∴ P/I/D component and the various combinations of them (parameter settings)
  - ∴ Critical controller settings
    - ∴ Oscillation
  - ∴ Recording the step response to a change of
    - ∴ Manipulating variable
    - ∴ Disturbance variable
  - ∴ Permanent control deviation of P controller as a function of controller gain
  - ∴ Controller with switching or continuous function
- ...and much more



Paper feed rate 600 mm/h

1.  $y: 15\% \rightarrow 20\%$      *Pressure control: We have a controlled system with compensation*
2.  $y: 20\% \rightarrow 25\%$



PI controller: Change in reference variable ( $w$ )

### NOTE

To prepare the learning success with the RT 450 system, we recommend first conducting experiments with our RT 010, RT 030 and RT 350 training systems.

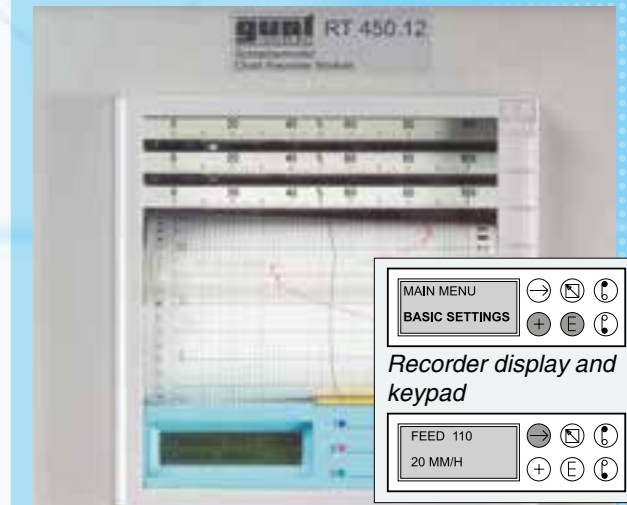
## Learning Topics: Familiarisation with Set-Up Procedures

Digital process engineering instruments such as controllers, recorders and transducers offer wide-ranging options for customisation to specific tasks. The necessary set-up and configuration can often be carried out by way of a keypad or using dedicated software. It is important for students to practise and understand the process of manual set-up by way of a keypad. Later they can learn about the more user-friendly method of set-up and configuration by software.

### Examples of learning content

(all taught by practical exercise)

- ∴ Basic concepts of set-up
  - ∴ Operating level
  - ∴ Parameter level
  - ∴ Configuration level
- ∴ Setting an industrial digital controller
  - ∴ Operation manual/automatic, setpoint changes
  - ∴ Parameterisation e.g. select P, I and D components of the controller
  - ∴ Configuration e.g. set controller mode: switching, continuous ... and much more
- ∴ Setting a digital 3-channel line recorder, e.g.
  - ∴ Paper feed rates
  - ∴ Input definitions for the individual channels
  - ∴ Setting display ranges
- ∴ Familiarisation with a software solution for user-friendly setting of industrial digital controllers
  - ∴ Parameterisation
  - ∴ Configuration
  - ∴ Saving and managing projects
  - ∴ Data transfer between controller and PC



Setting a 3-channel line recorder via keypad



Operation, parameterisation and configuration of a digital industrial controller via keypad



Parameterisation and configuration of an industrial digital controller using the RT 450.14 configuration software

## Learning Topics: Specific Control Applications

The flexibility of the system enables a large number of specific control applications to be set up and tested by way of experiment.

For a level control system, for example, the control device may be an industrial digital controller with continuous output or a PLC for example. The actuator may be a pneumatically operated valve with an electro-pneumatic positioner or a motorised valve featuring a range of actuation options.

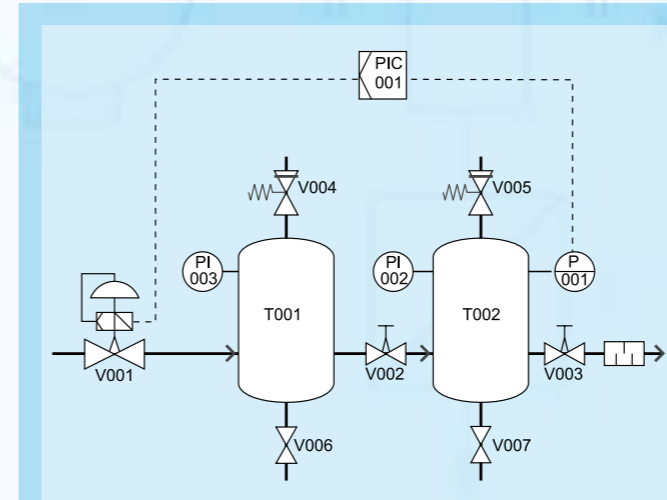
You can measure the level using a capacitive sensor or a pressure sensor to record the hydrostatic pressure on the tank bottom.

...and of course you can analyse your own ideas and issues by way of experiment.

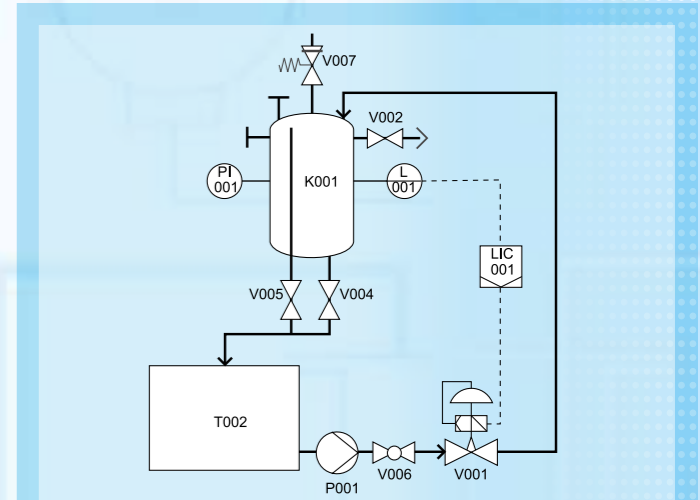
### Examples of learning content (all taught by experimentation)

- ⋮ Pressure control with two pressure tanks connected in series
- ⋮ Level control with an open or closed tank also: program control with an industrial digital controller or with a PLC
  - ⋮ With a capacitive level sensor or with a pressure sensor
  - ⋮ With a motorised valve or electro-pneumatic control valve
- ⋮ Flow control
  - ⋮ With many variants
- ⋮ Temperature control
  - ⋮ With an electric heater, switching mode or with an electro-pneumatically operated control valve and electric heater in continuous operation
- ⋮ Cascade control
  - ⋮ Level / flow
- ⋮ Flow characteristic for an electro-pneumatically operated control valve dependent on valve position
- ⋮ Flow characteristic for an electric motorised valve with position detection

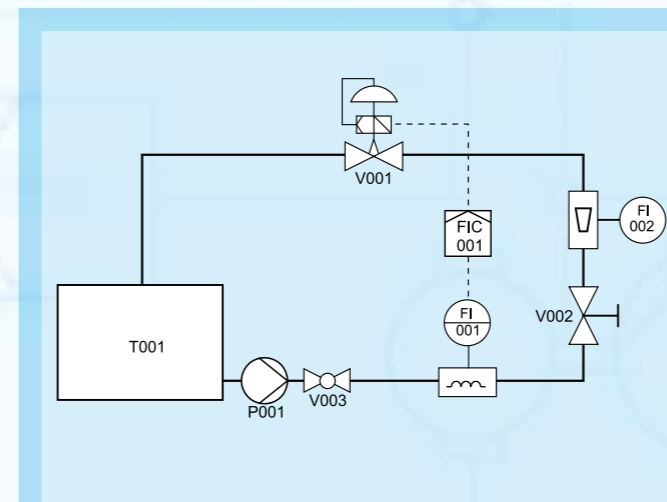
RT 450: Level control with a continuous controller or with a PLC  
Windhoek Polytechnic, Namibia



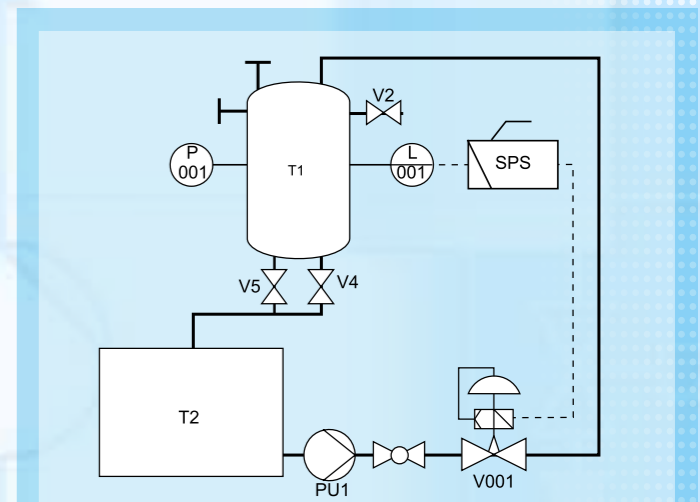
Pressure control



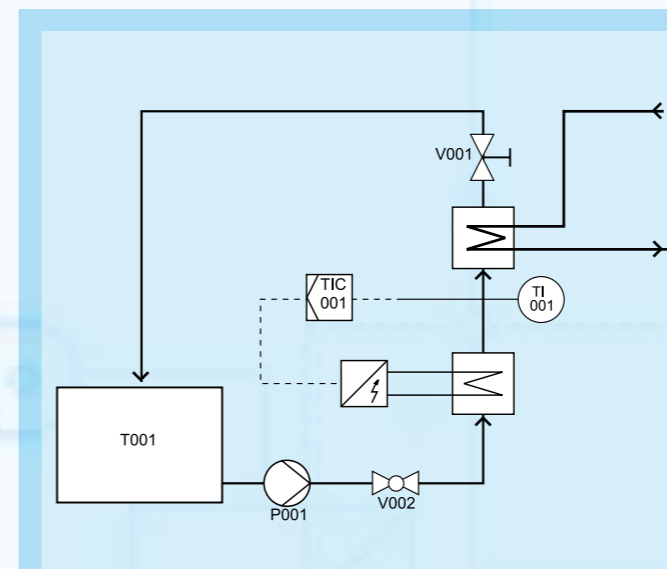
Level control with a continuous controller



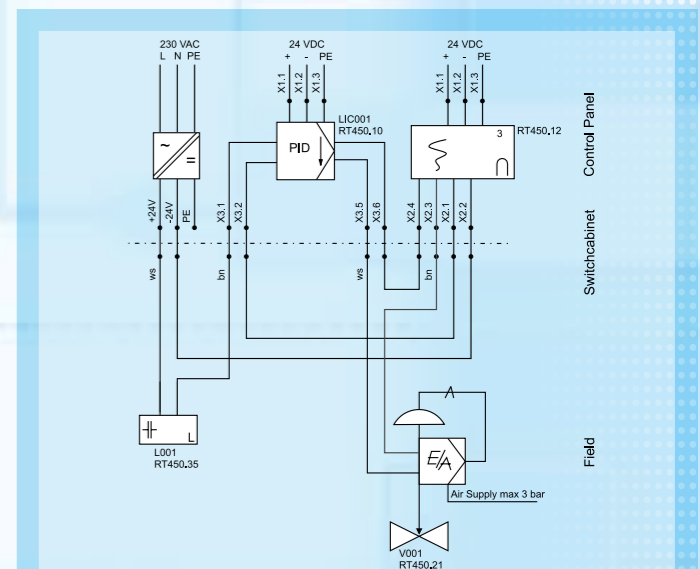
Flow control



Level control with a PLC



Temperature control with a switching controller



Electrical circuit diagram of a level control system



## Polytechnic of Namibia: a Satisfied Customer



Inspection of a recorder chart



Temperature control



School of Engineering,  
Department of Electrical Engineering  
Dean: Z. Oyedokun  
Windhoek, Republic of Namibia



Level control with a continuous controller or PLC



Temperature control



Setting on a digital controller

The Polytechnic of Namibia provides courses in core areas of automation based on experimentation using the GUNT RT 450 system.

Its laboratory houses six complete experimental set-ups. Of them, four are prepared for experiments relating to pressure, level, flow and temperature. Two systems are used by students to develop and realise their own projects.

All systems have a Profibus computer communications interface.

The G.U.N.T. local agent in Namibia – A. Hüster Machinetool (PTY) Ltd. – provides technical service, installs updates and supplies consumables.

## Learning Topics: Planning and Displaying

For all skilled staff, technicians and engineers, the planning and displaying of process and piping systems, electrical circuits, signal and communication structures etc. is a key part of their professional qualification.

The exercises which students can conduct with the RT 450 training system offer wide-ranging options to develop and advance those skills.

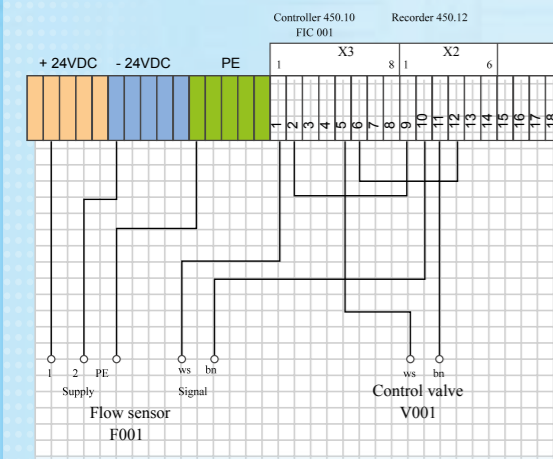
### Examples of learning content

(all taught by practical exercise)

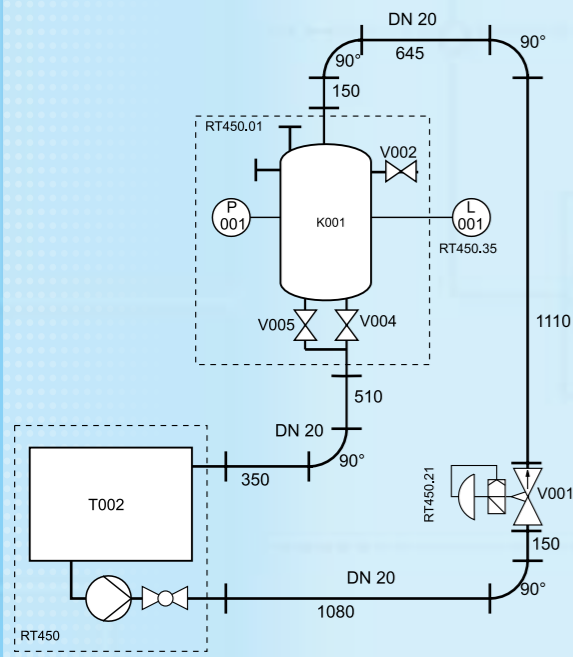
- ∴ Read, edit, understand and create a PI flow diagram for a control loop. Understand the standardised symbols.
- ∴ Create a draft design for assembling a specific control application on the RT 450 frame
- ∴ Create a pipework diagram and the associated component list
- ∴ Create an electrical measurement and control location diagram for electrical integration of the control components
- ∴ Create circuit, wiring diagrams and plan of terminal connections
- ∴ Display and explain the communications concept: e.g. Profibus

Component parts list: Level control system				
Cons. no.	I&C number	Designation	Measuring range, variable	RT 450 component
1	K001	Level tank, transparent	6,9dm <sup>3</sup>	RT 450.01
2	T002	Supply tank	75dm <sup>3</sup>	RT 450 Basic Module
3	P001	Pump	H <sub>max</sub> =20m, Q <sub>max</sub> =4m <sup>3</sup> /h	RT 450 Basic Module
4	L001	Level sensor, capacitive	0 - 47cm	RT 450.35
5	PI001	Pressure gauge	0 - 2.5bar	RT 450.01
6	LIC001	Continuous controller	Digitric 500	RT 450.10
7	V001	Control valve, pneumatically operated, I/P positioner	kv = 1.0	RT 450.21
8	V002	Ventilation valve	1/4"	RT 450.01
9	V003	Drain valve	1/2"	RT 450.01
10	V004	Overflow shutoff valve	1/2"	RT 450.01
11	V005	Safety valve	1/8", 2bar	RT 450.01
12	V006	Pump delivery side stop valve	1"	RT 450 Basic Module

Example of a component list



Plan of terminal connections for flow control



Pipework diagram for level control

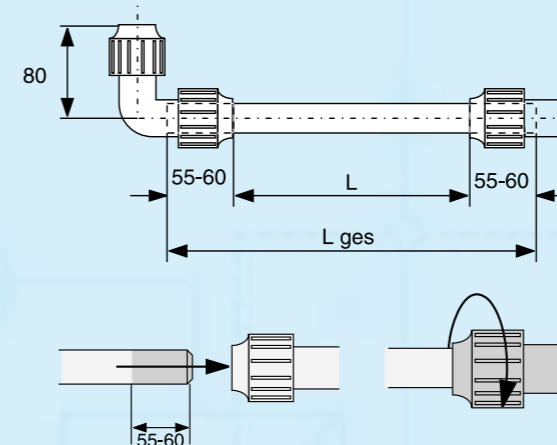
## Learning Topics: Practical Exercises

The basic idea underlying the RT 450 training system is not to create a permanent set-up which will remain the same for all time. On the contrary: the system enables a wide range of adaptations to be made very easily. The set-up can be customised to users' specific ideas and projects. Consequently, a range of skills are repeatedly required which can be intensively practised through to their professional execution. Few tools are needed.

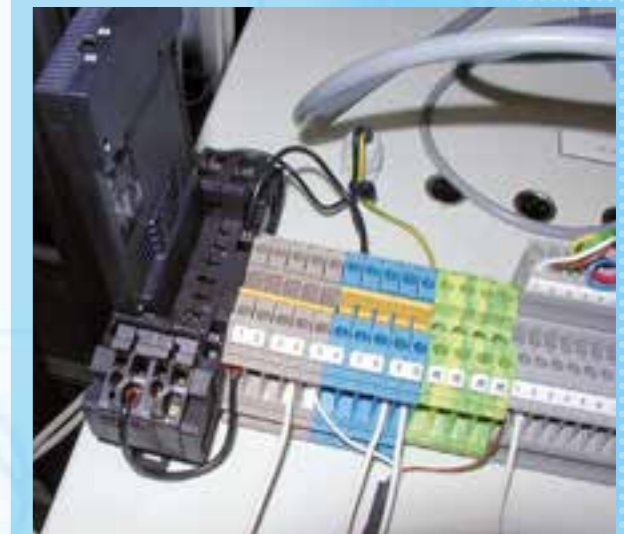
### Examples of learning content

(all taught by practical exercise)

- ∴ Mounting the module panels on the mounting profiles of the RT 450 frame
- ∴ Making the pipework connection for the water circuit
  - ∴ Cutting to length and preparing the pipes
  - ∴ Fixing together using clamp fittings
- ∴ Cutting to length, laying and connecting compressed air hoses
- ∴ Cutting to length and stripping electrical cables, and fitting ferrules to them
- ∴ Connecting the electrical wiring
- ∴ Testing the electrical connections

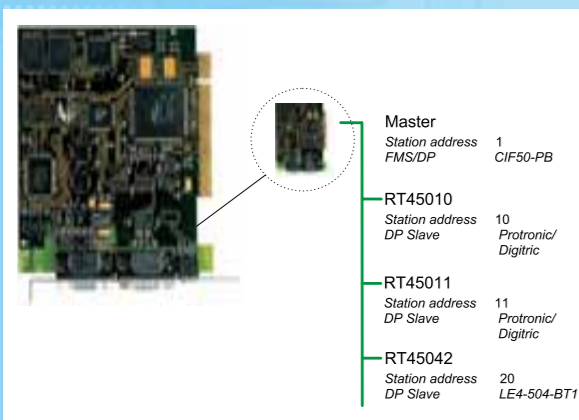


Making connections by plastic pipes



Electrical wiring and connections

## Learning Topics: Familiarisation with Communication and Visualisation Systems



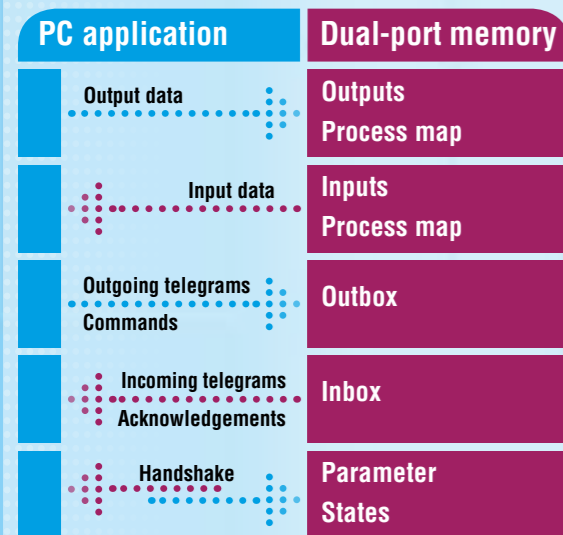
RT 450.40 is pre-set for two controllers and the PLC over Profibus. Changes can be made at any time.

State-of-the-art automation is characterised in that data can be interchanged between system components. The data are carried over bus systems.

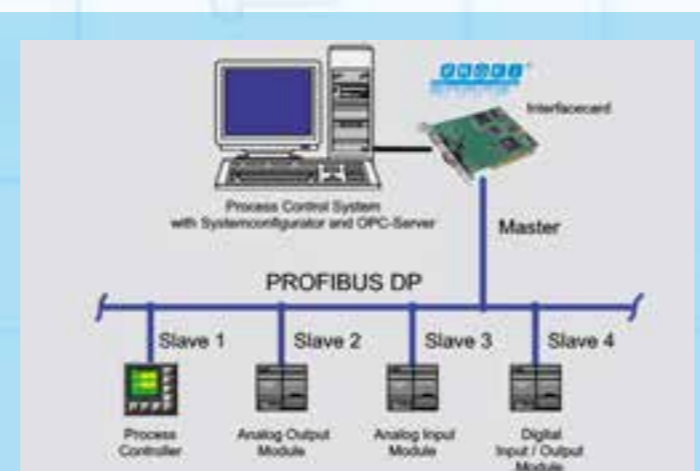
Automation components (controllers, sensors) are highly variable in their setting and configuration. These set-up procedures are usually carried out by dedicated software.

### Examples of learning content

- ∴ Basic concept of a networked automation system
- ∴ Communication over bus systems
- ∴ Integration of a software application
- ∴ Familiarisation with hardware: Profibus PC cards, Profibus plug-in modules on controllers, PLC, PLC Profibus module and measurement sensors
- ∴ Interfaces, installation procedures, errors, faults
- ∴ Dedicated configuration software for controllers, recorders, PC cards etc.



Data interchange between the application and the communications interface is run via a dual-port memory.



Topology of the field bus used, with master and slaves

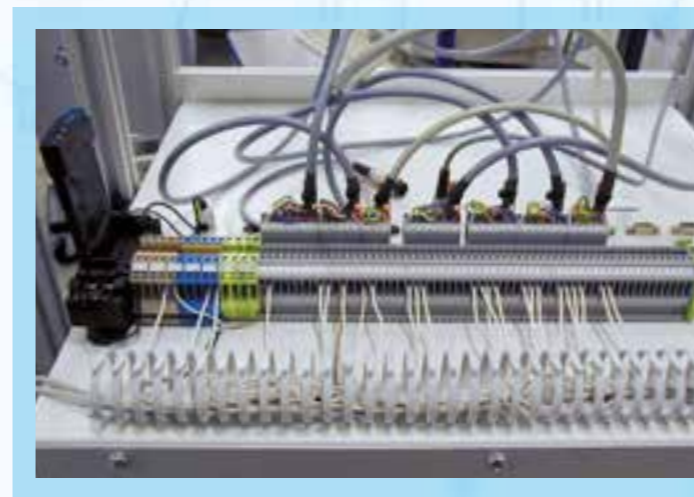


In preparation for covering the topic of **communication networks in automation**, we recommend our training systems:

- ∴ RT 360 Networking of Industrial Controllers and
- ∴ RT 370 Set-Up of Field Bus Systems.

This enables students to develop the fundamental knowledge which will then make it easier to work with the RT 450 training system.

## Technical Details



### Electrical connections – signal connections



The instruments assembled on individual panels are pre-wired on the rear.

As a teaching aid, the connections are categorised and separated accordingly on the various connector assemblies: analog inputs, analog outputs, binary outputs, 24V supply, etc.

These prepared connectors are routed to the corresponding terminal arrays on the control cabinets.

The electrical connections made by the students are limited to those routed to the process (sensors, valves, etc.) and to those necessary to teach correct construction of the electrical current loops.



### Process connections

The process connections – in this case only water – are normally made by plastic pipes, ensuring that a correct, industrial-standard system is established. This procedure takes time, and of course consumes material. If you need to reconfigure more often and quickly, the water connections can very well be made by hoses. This has no influence on the functionality or the data acquired.

The compressed air is supplied via hoses.



## The Instructional Material

We have compiled a comprehensive range of instructional material for the RT 450 training system which will greatly assist you in getting to know the system and in preparing your lessons and laboratory experiments and exercises.

### The instructional material comprises

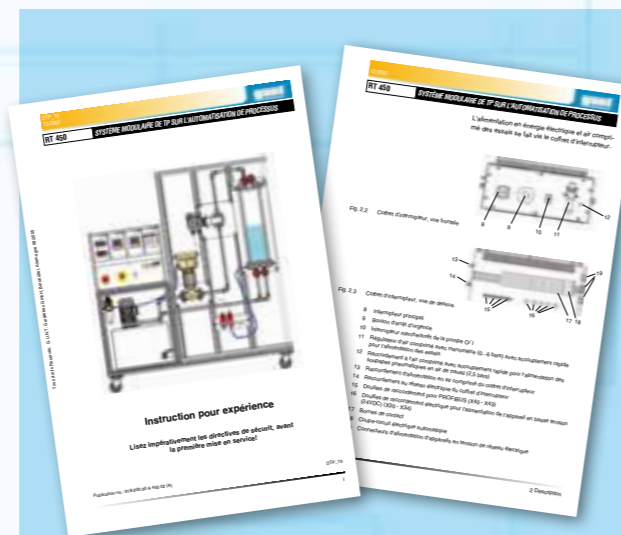
- ∴ Manual: RT 450 system description, approx. 130 pages
- ∴ Manual: fundamentals of control engineering, approx. 20 pages
- ∴ All electrical diagrams for the overall system and for all components
- ∴ Completed reference experiments and sample exercises, approx. 25 worksheets and relevant answers
- ∴ Materials as paper printouts in a folder and additionally as PDF files on a CD

### Updates

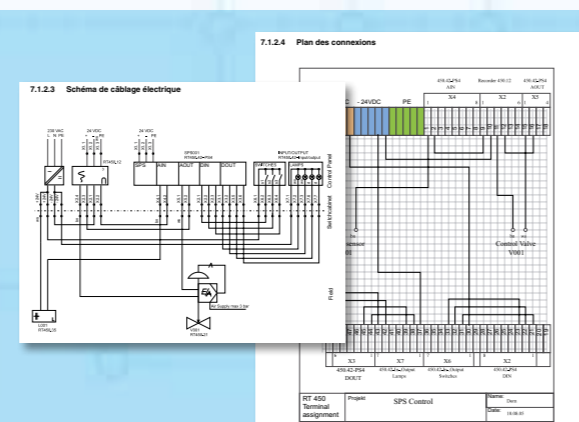
When any updates or additions to the RT 450 system are made – in particular with regard to the instructional material and the software – you, as a GUNT customer, will be notified accordingly.

### Training

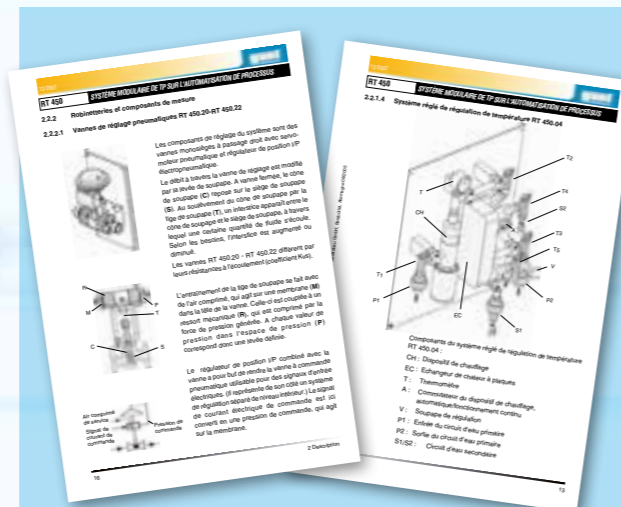
If you require installation or training services for the training system, we will be glad to help.



Manuals: RT 450 system description and fundamentals of control engineering



Electrical circuit diagrams for the overall system and all components



Worksheets for reference experiments and sample exercises

also available:



### GUNT-CATALOGUE No. 2, "MECHATRONICS", COVERS THE FOLLOWING PROGRAM GROUPS

Basic principles	Engineering Drawing	More detailed learning content	Assembly Projects
	Cutaway Models		Maintenance
	Dimensional Metrology		Machinery Diagnosis
	Fasteners and Machine Parts		Automation
	Manufacturing Engineering		

Catalogue 2 covers systems for teaching in the field of metalwork as well as key areas of learning in the electrical trades and mechatronics. It is not a conventional product catalogue, but rather a tool to help you plan your teaching most efficiently.