

Regulflex

Modular didactic carbonated beverage production line for process studies regulation and associated instrumentation

Regulflex at a glance

What is Regulflex

- ✓ Regulflex is an innovative concept for teaching process control, instrumentation and regulation.
- ✓ This concept is based on the use of a real process (production of carbonated beverages) to put the practical work into practice.
- ✓ The students work on the different parts of the manufacturing process. As the systems are modular and interconnectable, they allow the complete process to be operated after a separate study.
- ✓ These systems allow the implementation of simple On/Off (ON/OFF), ON/OFF with hysteresis, P, PI, PID algorithms and/or complex controls (Cascade, Proportional, Predictive, Split range, ...) by controlling physical quantities such as **PRESSURE, LEVEL, FLOW, TEMPERATURE** and other associated quantities.

Strengths :

- ✓ Modularity of the operating parts: one system is enough to start working, various assemblies of systems are possible with different study contexts (cold water production, syrup or gas dosing, storage with or without pressure...)
- ✓ Modularity of the control parts (3 types of control proposed: Industrial Controller, PLC and DCS)
- ✓ The chosen manufacturing process has a number of advantages:
 - Playful approach (making soda)
 - Presence of the main physical quantities (flow, temperature, level, pressure)
 - Easy implementation and contextualisation (water, dye, syrup, air, CO₂)
 - Presence of simple (TOR, P, PI, PID) and complex (Cascade, Predictive, Ratio, Split range, ...) controls
- ✓ Robustness of the operating parts integrating industrial components (stainless steel pipes and tanks, industrial valves and sensors)
- ✓ Up to 12 students can work simultaneously.



Regulflex systems and modules

- ✓ **Regulflex1 Buffer Tank (Level/Flow)** : Level control (Pressureless storage), flow rate and instrumentation
- ✓ **Regulflex2 Dosing (Flow/Reporting)** : Liquid flow control (Dosing), ratio and instrumentation
- ✓ **Regulflex3 Refrigeration (Flow/Temperature)** : Temperature control (Cooling), flow and instrumentation
- ✓ **Regulflex4 Carbonation (Flow/Pressure)**: Flow control on gas (Carbonation "Gas CO₂ "), pressure and instrumentation
- ✓ **Regulflex5 Storage Tank (Pressure/Level)** : Pressure regulation (Pressure storage), level and instrumentation
- ✓ **Communicating Industrial Controller Module** : Module for the study of industrial PID controllers
- ✓ **PLC module with PID**: Module for the study of PID control by PLCs
- ✓ **DCS Module**: Digital Control Systems (DCS) Study Module
- ✓ **Supervision** : Process supervision via operator panel
- ✓ **Calibration** : Calibration devices for sensors (Current loop, Pressure, Temperature, ...)





Families of components covered

- ✓Level measurements (∩ Ultrasonic sensor, Capacitive probe, Hydrostatic pressure, Bubbler tube, ...)
- ✓Flow measurements (∩ Rotameter, vane flow meters, electromagnetic flow meters, ultrasonic flow meters, thermal mass flow meters, ...)
- ✓Pressure measurements (∩ Differential, Relative, Hydrostatic, ...)
- ✓Temperature measurements (∩ PT100, Thermocouple J and K, ...)
- ✓Various measurements (∩ Density, Sugar content (Brix degree), ...)
- ✓Valves (∩ Solenoid valves, Proportional solenoid valves, Proportional control valve with analogue positioner, ...)
- ✓Pumps (∩ Volumetric dosing, Volumetric vane, ...)
- ✓Converters (∩ Current/Pressure, Current/Voltage, Inverters, ...)
- ✓Storage (∩ Stainless steel tanks with and without pressure)
- ✓Static components (∩ Plate heat exchanger, static mixer, ...)
- ✓Industrial refrigeration (∩ Condensing unit, Expansion valve, Filter drier, Pressure switches, Thermostats, Evaporator)
- ✓Communication & Fieldbus (∩ Ethernet, Profibus DP, CANopen, Profibus PA, Hart Protocol)
- ✓Process control (∩ Industrial controller, Industrial PLC, SNCC)
- ✓Calibration tools (∩ Current generator, mV generator, decade box, precision manometer with pump).

Educational activities

Numerous activities developed along four axes:

- ❶ Study (Instrumentation, Measurement and analysis of controlled and regulating quantities, Signal conditioning and transmission, Identification, ...)
- ❷ Design (Electrical diagram, IT diagram, Control loops, Programming on controller, PLC and SNCC)
- ❸ Control (Process control and regulation, Alarm monitoring and management, Supervision, ...)
- ❹ Maintain (Calibration control, System tests and measurements (free tapping), Checks and diagnostics, Prevention, Improvements...)

Presentation of the study context of soft drink manufacturing

Main components of a soft drink

- ✓Water :
 - It must be of very good quality so as not to affect the taste or properties of the product being manufactured.
- ✓Sugar :
 - It is stored in a tank in powder form and then dissolved in water to the desired concentration.
- ✓Citric acid :
 - Acts on the hardness of the water and allows a better conservation of the final product. It also adds a refreshing flavour to the product.
- ✓Flavours and textures :
 - Different flavours and textures as well as colourings and preservatives are added depending on the drink to be produced.
- ✓Carbon dioxide "CO₂" :
 - Food-grade CO₂ is injected under pressure during the carbonation phase in order to dissolve it in the liquid constituting the beverage to be manufactured. Depending on the concentration of CO₂, a more or less fizzy drink is obtained. As an indication, "soda" type drinks contain about 5g/l of CO₂.

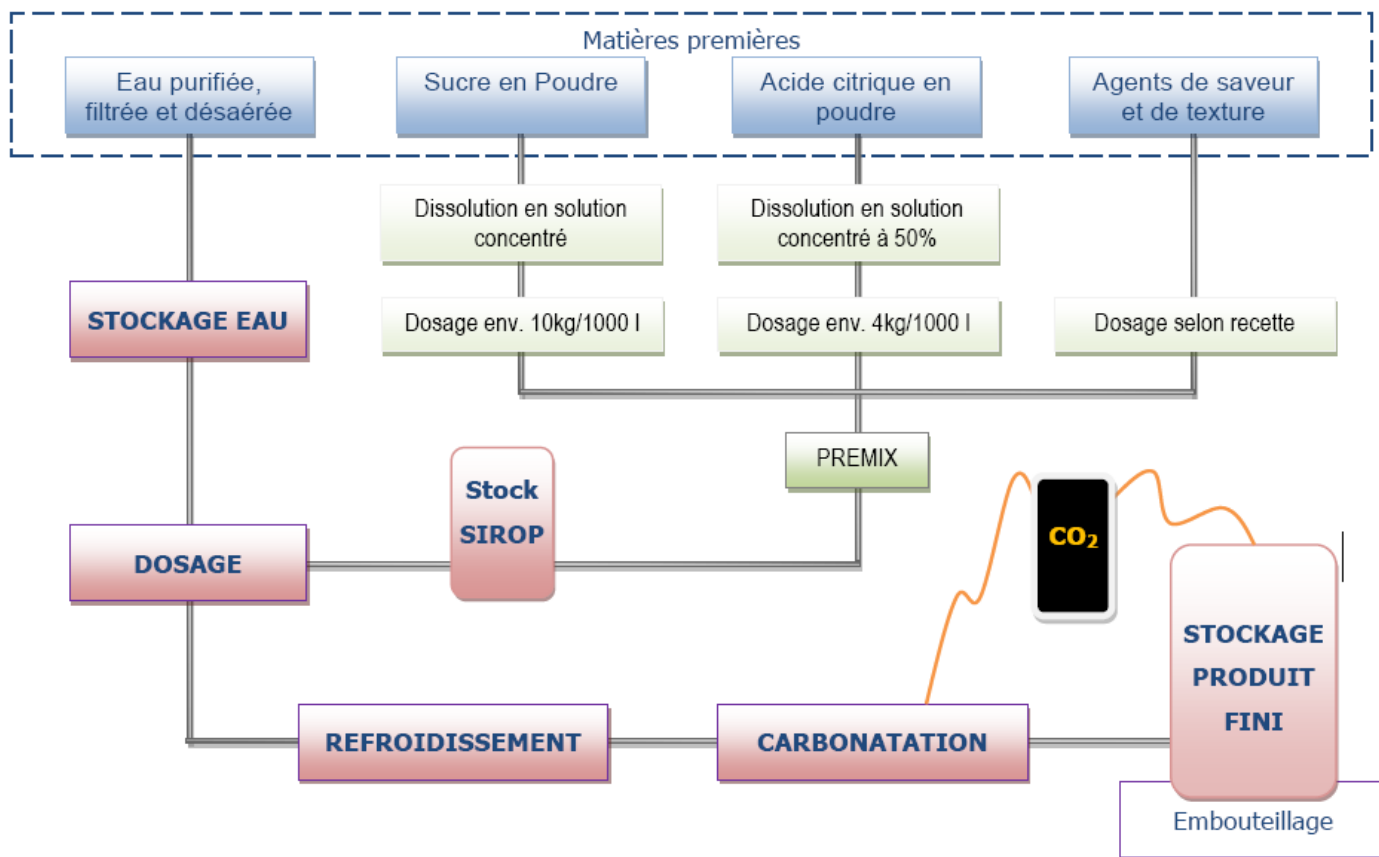
The different phases of production :

- ✓Water purification and de-aeration :
 - The filtered and purified water is passed through a de-aerator and emerges with an oxygen content of between 0.5 and 1 mg/l. De-aerated water increases the shelf life of the product and also allows for better dissolution of CO₂ during the carbonation phase.
- ✓The making of syrup :
 - The "syrup" is made by mixing the following ingredients: sugar, citric acid, flavours and textures, possibly colouring and preservatives. This syrup is stored in a buffer tank before dosing.
- ✓Dosage:
 - The water and syrup are then mixed using a dosing pump and flow meter or ratio control.
- ✓Cooling before carbonation :
 - In order to obtain a good dissolution of the CO₂ in the mixture (water+syrup) it is necessary to cool this liquid, using a plate exchanger.
- ✓Carbonation :
 - Carbonation consists of uniformly dissolving the CO₂ in the water+syrup mixture.
 - Several parameters must be taken into account to achieve good carbonation.
 - The water used is treated to obtain a higher quality, then deaerated to reduce the O₂ content in the water to between 0.5 mg/l and 1mg/l. To do this, water is injected at high pressure into a tank through showers. The air in the tank is sucked out and rejected. This operation is carried out until the desired O₂ level is reached.
 - The temperature of the liquid and the pressure of the CO₂ at the mixer inlet are both related to the level of CO₂ dissolved in the soda. For most sodas the level is 7 to 8g/l.
 - Example of temperature/pressure ratio for a concentration of 8g/l:
- ✓Storage under pressure before bottling :
 - To prevent the product from deteriorating (degassing or over carbonation) during filling, it is stored in a tank under CO₂ pressure. This tank is sized according to the speed of the filling module.

Liquid temperature in °C	5	15	20
Pressure of CO ₂ at the mixer inlet in bar	1.7	2.7	3.2

Presentation of the study context of soft drink manufacturing

➤ Overview of the carbonated wood production process:



Operating modes of the REGULFLEX line

Through a multi-technological, modular and evolutionary approach, all the REGULFLEX modules allow the realities of a manufacturing process to be understood. The REGULFLEX line is designed and delivered to operate with the following materials: Water, Air, Syrup or food colouring, CO₂ gas (CARBOPUB C).

Current operating mode :

✓ In order to limit the costs of consumables and raw materials to a strict minimum, the various systems of the line can operate with water, dye and air only. In this configuration, the soda production is "simulated" while allowing the study and the complete piloting of the various regulation loops.

Air and water supply to the systems

- ✓ The systems can be interconnected but can also be operated independently by connecting each to the drinking water network of the facility.
- ✓ Compressed air is supplied from the facility's compressed air network via a general FRL block.

Demonstration mode of operation :

✓ All REGULFLEX modules allow a "real" production of soda from water, syrup and CO₂. This realistic mode of operation can therefore be implemented in a specific way (end of year project, demonstrations or open house, exhibition, etc.).

Electrical connections

- ✓ A general power supply box allows all the modules to be connected to the establishment's electrical network. This general electrical box also authorises the management of safety devices (emergency stop) on all the modules.
- ✓ Each module is equipped with a connection and measurement box. This box contains the various measurement and control plugs (safety plugs, BNC plugs, etc.) required to connect the control systems (controller, PLC and/or SNCC).

Operating data

- ✓ Operating flow rate: 2 to 4 L/min
- ✓ Operating pressure: 6 bar



Regulflex architecture

➤ *The manufacturing stages covered by Regulflex*

MODULE N° 1 - RN10

Régulation de Niveau/Débit sur un réservoir tampon d'eau.

- >> Régulation du niveau d'eau dans une cuve
- >> Régulation sur débit d'eau en entrée ou en sortie de cette cuve

MODULE N° 2 - RD10

Régulation de Débit/Rapport à l'aide d'une pompe doseuse.

- >> Régulation de Débit/Rapport entre "Eau" et "Sirop"
- >> Taux de sucre "Brix" transmetteur de densité

MODULE N° 3 - RT10

Régulation de Température/Débit à l'aide d'échangeurs à plaques.

- >> Régulation de température et de débit simple
- >> Régulation de température dite "prédictive"

MODULE N° 4 - RG10

Régulation Débit Eau/Débit Gaz (Carbonatation avec mélangeur statique).

- >> Régulation de débit "volumique" sur liquide
- >> Régulation de pression et de débit "massique" sur gaz

MODULE N° 5 - RP10

Régulation de Pression dans une cuve fermée avec ou sans liquide à l'intérieur.

- >> Régulation de pression (Injection/Echappement)
- >> Régulation du niveau de liquide dans cette cuve

SYSTEMES DE PILOTAGE

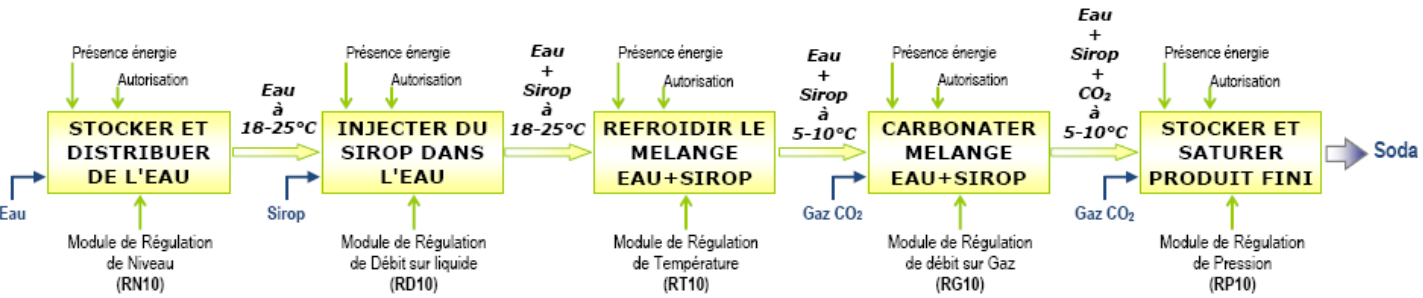
Régulateurs, Automates, SNCC ...

Application Industrielle

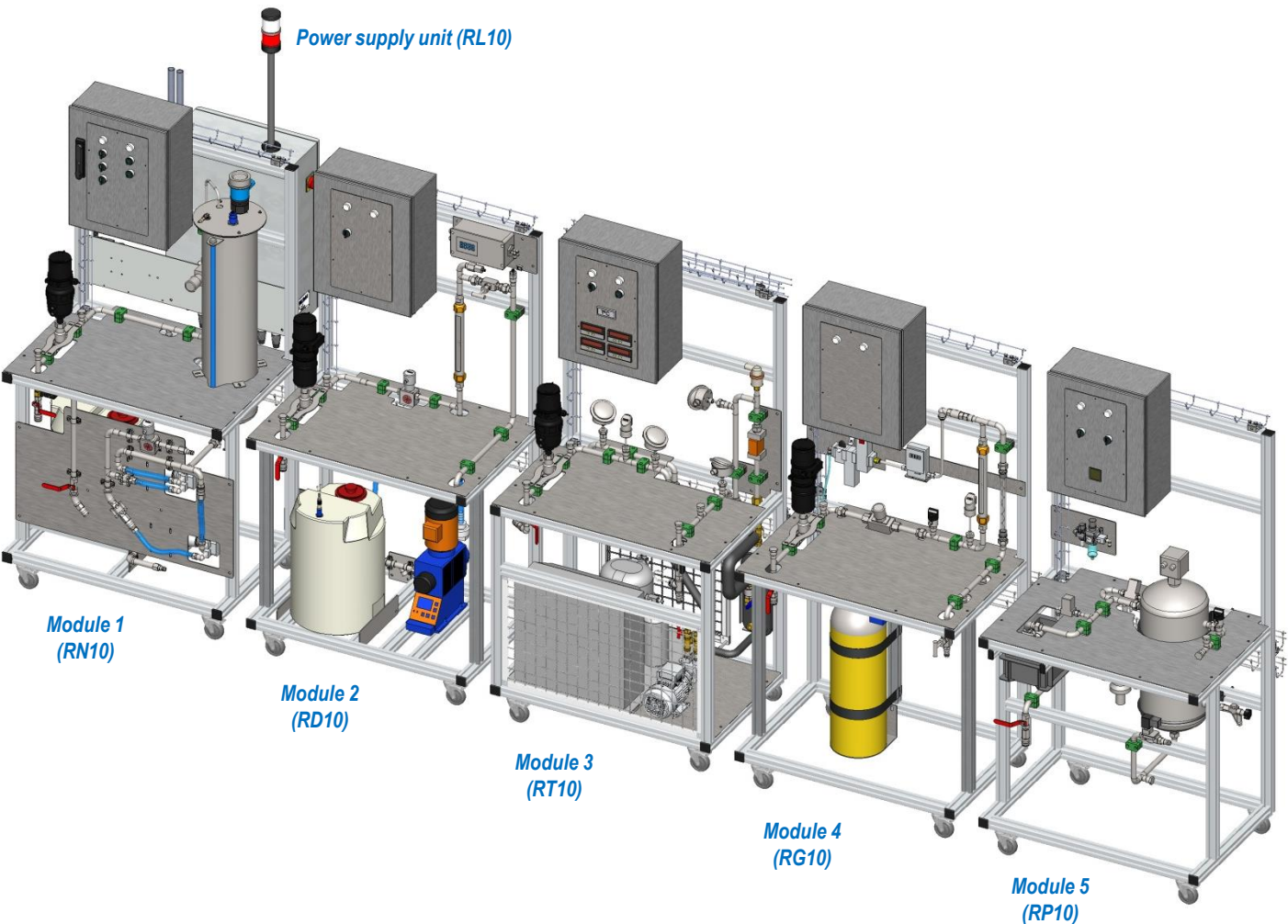


REGULFLEX architecture

➤ **Functional analysis**

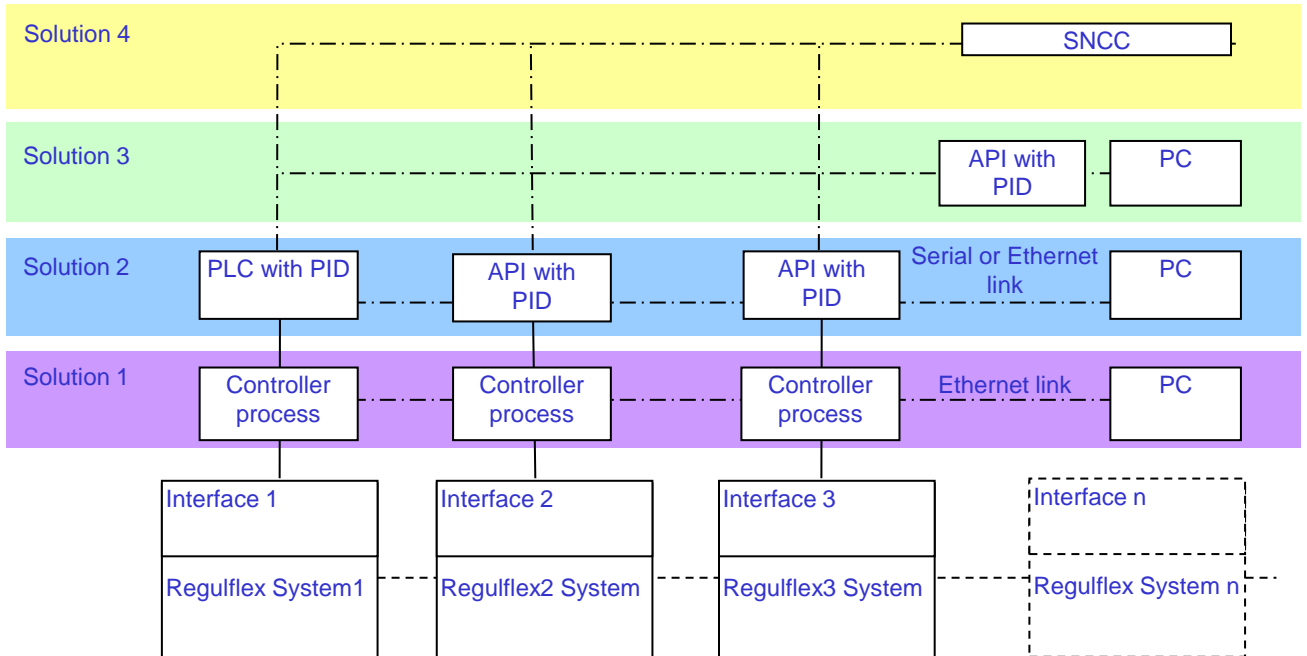
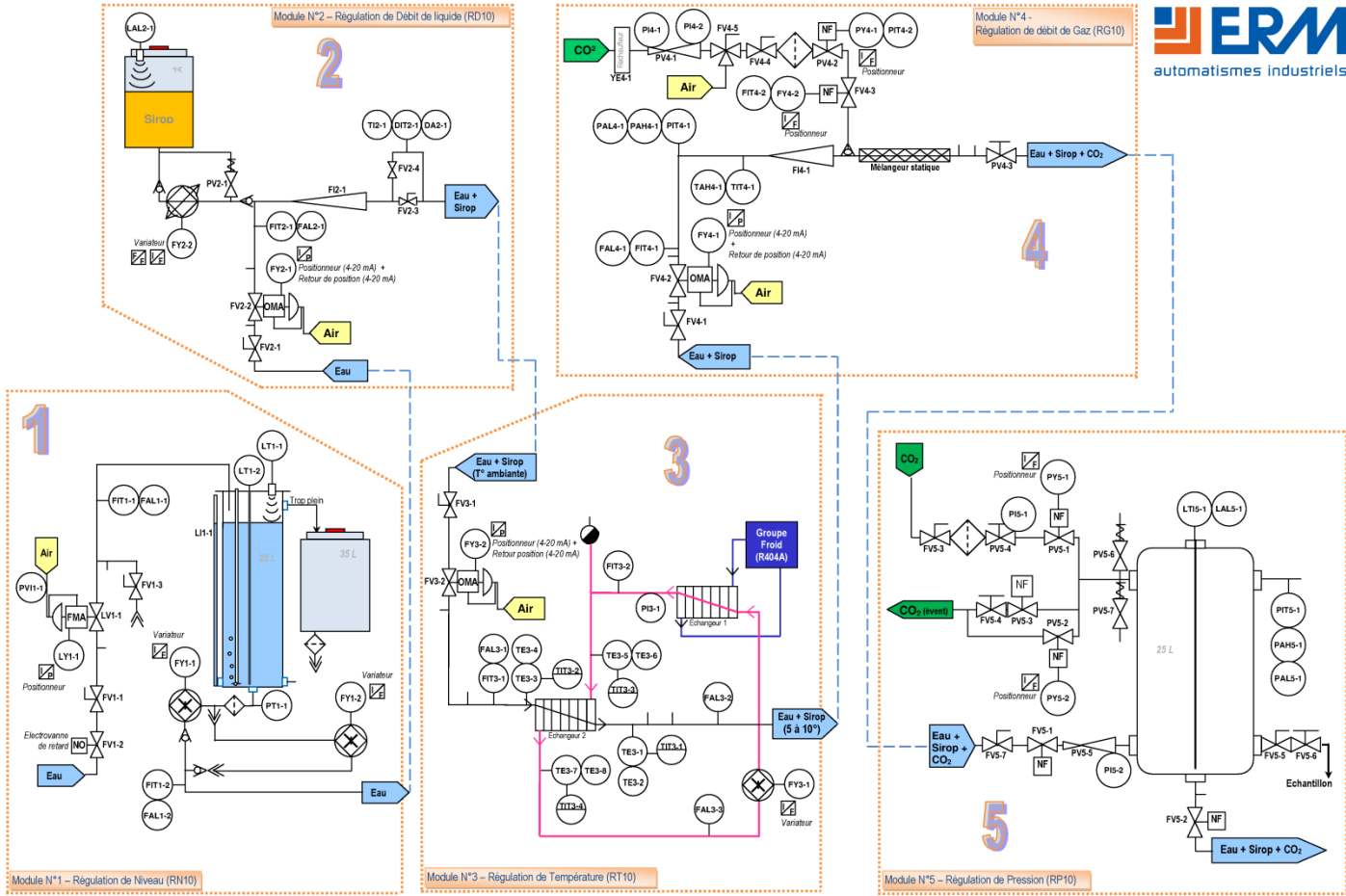


➤ **General layout of REGULFLEX modules**



REGULFLEX architecture

➤ Complete overview of the REGULFLEX carbonated soft drink production line



Buffer tank (Level/Flow control)

Study system (buffer tank) for level, flow and instrumentation control

Régulflex 1

Buffer Tank (Flow Level Control) at a glance

Sections

- ✓ Electrical engineering, Industrial maintenance, Automation, Control, Water professions....

Educational activities

- ✓ Study of the different measurement principles (physical laws, sensors, transmitters, etc.)
- ✓ Study of a control valve (measurement of the ΔP , calculation of the C_v , drawing of the installed characteristic, etc.)
- ✓ Identification of an Open Loop and/or Closed Loop system (Description of the different methods)
- ✓ Simple level control. (Study of P,PI,PD,PID algorithms), response to a change in setpoint, response to a disturbance
- ✓ Predictive level control, cascade control (implementation of complex strategies, dead time compensation, etc.)
- ✓ Single or split range flow control

Specific components

- ✓ Level measurement ▯ Ultrasonic sensor, pressure sensor, capacitive probe, bubbler rod, ...
- ✓ Flow measurements ▯ Rotameter, Vane flow meter, ...
- ✓ Free sockets ▯ Reserve for instrumentation
- ✓ Valve ▯ Control valve with current/pressure converter)
- ✓ Pumps ▯ Volumetric vane pumps with variable speed drives)
- ✓ Converters ▯ Current/Pressure, Current/Voltage
- ✓ Storage ▯ Atmospheric stainless steel tanks
- ✓ Communication & Fieldbus (Option) ▯ Profibus PA, HART Protocol
- ✓ Process control ▯ Controller, PLC, DCS

Highlights

- ✓ Three types of commands can be used
- ✓ Product dedicated to the study of industrial instrumentation, level and flow control
- ✓ System based on a real application (Buffer tank of a soda production line)

Related products

- ✓ RC10: Communicating Industrial Controller Module
- ✓ RC21: PLC module with PID and Touch Panel (Schneider M340 version with 16E/16S TOR - 8E ANA - 4S ANA + Ethernet TCP/IP + Web Server + CANopen Bus)
- ✓ RC31: PLC Module with PID and Touch Panel (Siemens S7-1500 version with 8E/8S digital - 24E ANA, of which 4 HART - 20S ANA + Ethernet TCP/IP)
- ✓ RC12: Digital Control System Module
- ✓ RC40: Pressure calibrator with pneumatic pump
- ✓ RC41: Calibrator for RTD temperature sensors (Pt100, PT1000, ...)
- ✓ RC42: Calibrator for Thermocouple (Tc) Temperature Sensors
- ✓ RM13: Option - 0/4-20 mA Current Loop Calibrator

References

- ✓ RN10: Buffer Tank (Flow Level Control)
- ✓ RL10: Power and Safety Box (For one or more Regulflex systems)
- ✓ RN11: Second process circulating pump option (for closed loop operation or split range control)
- ✓ RN12: Option Capacitive level transmitter
- ✓ RM10: Option: Diaphragm for pressure and flow measurement
- ✓ RM11: Option: 4-20mA/Hart pressure sensor

Features

- ✓ L/ W/ H (with RL10 power supply unit): 920 x 1000 x 2230mm
- ✓ Electrical power: 240Vac - 50 Hz single phase (RL10 - System Power and Safety Box)
- ✓ Weight (with RL10 power supply): 210kg





Regulflex 1

Description technique

Functional description

- ✓ This module corresponds to a water storage tank. The purpose of this module is to regulate the liquid level in the tank by acting on the water supply valve.

Product used:

- ✓ Water

Adjusted variable:

- ✓ Water level in the tank

Control variable :

- ✓ Water flow rate at the inlet and/or outlet of the

Disturbance variable:

- ✓ Variation of the water flow in and out of the tank

How it works

This module is dedicated to the study of level control. The objective is to maintain a constant water level in the storage tank during the use of the system, taking into account the various disturbances that the system undergoes. The optimum value of the controlled variable therefore corresponds to the set value defined by the user (water level in the tank).

- ✓ The level in the tank is regulated by adjusting the water inlet flow rate through an electro-pneumatic control valve. One or more sensors measure the water level in the tank, and transmit the information to a controller (or PLC, SNCC,...) which controls the control valve in opening or closing.
- ✓ Disturbances on the water inlet or outlet flow are possible.
- ✓ A delay system (Normally Open Solenoid Valve) can be implemented in the water supply to the control valve.
- ✓ Both circulation pumps (for closed loop operation or split range control)

Second process circulation pump (option RN11)

A second circulation pump placed at the outlet of the storage tank can be used. This option then allows two separate operations of the module.

- ✓ Operation N°1: Use of the level control module (RN10) in closed circuit. Pump N°1 manages the water inlet flow into the tank and pump N°2 sets the water outlet flow from this same tank.
- ✓ Operation N°2: Use of two circulation pumps to allow the management of a "Small flow" and/or "Large flow" at the outlet of the storage tank. The two pumps and their associated frequency inverters can be used simultaneously. A universal transmitter is also associated with each inverter/pump assembly in order to carry out "complex" control modes (Example: Regulation of the tank outlet flow rate with control of the two pumps in "Split Range")

Sockets and loose fittings

There are "free" tappings on the pipework to add various sensors. Students can calibrate, set up and test different sensors on the existing process.

Electricity, water and air supply :

- ✓ The air and water supply must be provided from the establishment's water and air supply (max. P. 6 bar).
- ✓ The power supply is provided by the RL10 power supply box (one RL10 box can supply up to 5 systems in the Regulflex line).

Connection to other Regulflex systems :

- ✓ This module can be connected to one of the following systems to implement all or part of the manufacturing process:
 - Module N°2 (RD10) - Dosing (Flow/Ratio) : Flow control study system, ratio and instrumentation.
 - Module N°3 (RT10) - Refrigeration (Flow/Temperature) : Study system for temperature control (Cooling), flow and instrumentation.
 - Module N°4 (RG10) Carbonation (Flow/Pressure): Carbonation of a liquid with measurement of flow, pressure and temperature.
 - Module N°5 (RP10) Pressure vessel (Level/Pressure): Study system (pressure storage) of pressure regulation, level and instrumentation
- ✓ It can be operated by three types of controls:
 - Industrial Controller Module (RC10) : Study of industrial PID single-loop and/or dual-loop controllers
 - Industrial Controller Module (RC21/RC31): Study of Industrial Controllers in PID regulation
 - DCS Module (RC12) : Study of Digital Control Systems
- ✓ Process supervision is possible:
 - Using the WinnCC Flexible environment (RC31)
 - Using the Touch Panel (RC21)

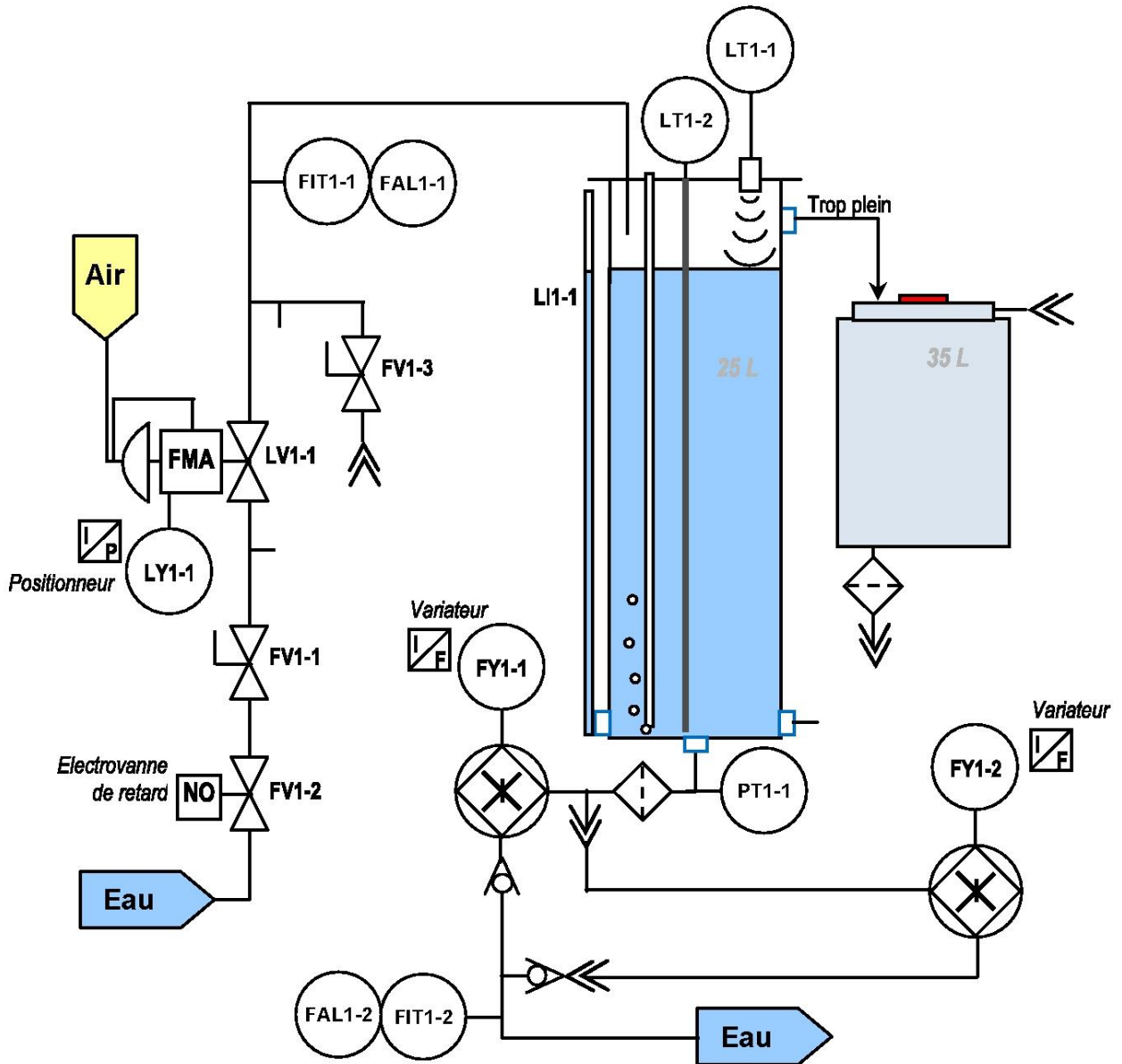
Communication

- ✓ The option "4-20mA/Hart pressure sensor" (RM11) allows to realize control loops via a transmitter communicating through a fieldbus HART protocol.

Regulflex 1

Technical Description

>IT Sci



FIT1-1 /FAL1-1: Flow transmitter with display (Rotor flow meter 0,08-20l/min - 4-20 mA signal) + Alarm contact for "low" flow detection (24Vdc digital signal)

FIT1-2 /FAL1-2: Flow transmitter with display (Rotor flow meter 1-16l/min - 4-20 mA signal) + Alarm contact for "low" flow detection (24Vdc digital signal)

FV1-1: 1/4 turn manual ball valve with full bore

FV1-2: Normally Open Solenoid Valve for "Delay" on water supply

FV1-3: 1/4 turn manual ball valve with full bore

FY1-1: Frequency converter for circulation pump control N°1 (4-20mA signal)

FY1-2 (OPTION) : Frequency converter for circulation pump control N°2 (4-20mA signal)

LI1-1: Level indicator in the tank (Transparent tube)

LT1-1: Ultrasonic level transmitter (4-20 mA signal)

LT1-2 (OPTION): Capacitive Level Transmitter (Capacitive Channel - 4-20 mA signal)

LV1-1: Pneumatic level control valve ("Closed by Lack of Air" valve)

LY1-1: "Current/Pressure" I/P positioner for level control valve (4-20 mA signal)

PT1-1 (OPTION): Relative pressure transmitter (0-200mbar - 4-20 mA signal)

PVI1-1: Air supply pressure gauge for pneumatic valve (0 - 10 Bar)



Regulflex 1

Pedagogical approach

Educational activities

- ✓ Study of the different measurement principles (physical laws, sensors, transmitters, etc.)
- ✓ Study of a control valve (measurement of ΔP , calculation of C_v , drawing of the installed characteristic, etc.)
- ✓ Identification of an Open Loop and/or Closed Loop system (Description of the different methods)
- ✓ Simple level control. (Study of P,PI,PD,PID algorithms), response to a change in setpoint, response to a disturbance
- ✓ Level control with delay. (Implementation of complex strategies, dead time compensation, ...)
- ✓ Flow control at the storage tank outlet (simple or complex "Split Range" control strategy)
- ✓ Predictive control of the storage tank level (depending on the tank outlet flow rate)
- ✓ Complex level control (cascade) (depending on the water inflow)

Examples of practical work proposed by ERM

- ✓ TP1 Generic Regulflex: Methods for identifying and controlling "Stable" and "Integrating" systems
 - BROIDA's method
 - ZIEGLER NICHOLS method
 - Empirical method or "tuner" method (successive approaches)
- ✓ TP2 Generic Regulflex: Principle of "Volumetric" and "Massive" flow measurement and regulation
 - Type of measure
 - Method, Calculations...
- ✓ TP3 Generic Regulflex: Sizing and implementation of depressors
- ✓ TP4 Generic Regulflex: Complex regulations that can be implemented on the system (Cascades, Predictive, Split Range, ...)

Dosing (Flow control Ratio)

Flow control study system, report and instrumentation

Regulflex 2

Dosing (Flow Control Ratio) at a glance

Securities

- ✓ Electrical engineering, Industrial maintenance, Automation, Control, Water professions....

Educational activities

- ✓ Analogue and digital measurements
- ✓ System identification
- ✓ Study of a metering pump in a control system.
- ✓ Ratio regulation (calculation of the coefficient according to the flow rates, observation of saturation at high flow rates, etc.).

Specific components

- ✓ Level measurements (Low Threshold) □ Ultrasonic sensor
- ✓ Flow measurements □ Rotameter, Vane flow meter
- ✓ Various measurements □ Temperature, Concentration, Sugar content (° Brix)
- ✓ Pumps □ Volumetric diaphragm dosing pump
- ✓ Valve □ Electropneumatic control valve with integrated positioner and position feedback
- ✓ Process control (□ Regulator, PLC, SNCC)

Highlights

- ✓ Three types of commands can be used
- ✓ Ideal product for the study of industrial instrumentation, flow control on liquids.
- ✓ System based on a real application (Syrup dosing on a soft drink production line)

Related products

- ✓ RC10: Communicating Industrial Controller Module
- ✓ RC21: PLC module with PID and Touch Panel (Schneider M340 version with 16E/16S TOR - 8E ANA - 4S ANA + Ethernet TCP/IP + Web Server + CANopen Bus)
- ✓ RC31: PLC Module with PID and Touch Panel (Siemens S7-1500 version with 8E/8S digital - 24E ANA, of which 4 HART - 20S ANA + Ethernet TCP/IP)
- ✓ RC12: Digital Control System Module
- ✓ RC40: Pressure calibrator with pneumatic pump
- ✓ RC41: Calibrator for RTD temperature sensors (Pt100, PTt000, ...)
- ✓ RC42: Calibrator for Thermocouple (Tc) Temperature Sensors
- ✓ RM13: Option - 0/4-20 mA Current Loop Calibrator

Features

- ✓ L/ W/ H (with RL10 power supply unit): 920 x 1000 x 2230mm
- ✓ Electrical power: 240Vac - 50 Hz single phase (RL10 - System Power and Safety Box)
- ✓ Weight (with RL10 power supply): 200kg

References

- ✓ RD10: Dosing (Flow control Ratio)
- ✓ RL10: System Power and Safety Cabinet (Can be used with one or more systems)
- ✓ RD11: Control valve option (For complex controls)
- ✓ RD12: Optional Indicator Density (Brix) and Temperature Transmitter
- ✓ RM10: Option: Diaphragm for pressure and flow measurement
- ✓ RM11: Option: 4-20mA/Hart pressure sensor





Regulflex 2

Functional description

- ✓ This module allows the implementation of different regulation strategies on liquids in order to carry out a dosage (Water + syrup (or colouring) mixture). The injection of syrup (or dye) into the water is carried out using a volumetric diaphragm dosing pump. The system also includes an optional electro-pneumatic control valve with integrated positioner.
- ✓ The syrup is stored in a tank whose low level (low threshold) is monitored with an ultrasonic sensor (measurement without contact with the product).
- ✓ Simple flow control or proportion/density control can be implemented on the system. The syrup flow rate corresponds to the flow rate to be controlled. The water flow rate is the pilot flow rate (also called "free flow rate").

➤ **Product used:** *Water, syrup (or dye),*

➤ **Set value:** *Injection rate of syrup (or dye)*

➤ **Control variable :** *Water flow rate*

➤ **Disturbance variables:** *Variation of water flow*

How it works

- ✓ Proportional control .
 - This type of regulation aims to control a flow Q_a to another "free" flow Q_l by imposing a fixed proportionality factor K_d between these two flows. In this module, the syrup flow rate is the flow rate to be controlled and the water flow rate represents the free flow rate (or pilot).
 - A solution using a dosing pump is proposed. The water flow rate is measured, and the syrup injection rate (dosing) is adapted according to a predefined ratio.
 - In case of high flow rates, the limits of the proportion can be shown ("saturation" phenomenon).

Storage of syrup (or dye)

The syrup (or dye) is stored in a closed container and connected to the dosing pump. A digital level sensor detects the low level of storage (Detection for Alarm and Dosing Stop).

Control valve (option RD11)

A control valve placed at the inlet of the module can be implemented to allow autonomous use of the RD10. This option can also be used for: water flow regulation or water ratio regulation.

Density transmission (option RD12)

A density transmitter (measurement of the sugar level °Brix) can be used to create: a control loop measuring the sugar level of the water + syrup solution and acting on the dosing pump.

Sockets and loose fittings :

There are "free" tappings on the pipework to add various sensors. Students can calibrate, set up and test different sensors on the existing process.

Electricity, water and air supply

- ✓ The power supply is provided by the RL10 power supply box (one RL10 box can supply up to 5 Regulflex systems).
- ✓ The air and water supply must be provided from the establishment's water and air supply (max. P. 6 bar).

Connection to other Regulflex systems

- ✓ This module can be connected to one of the following systems to implement all or part of the manufacturing process:
 - Module n°1 (RN10) - Buffer tank (Level/Flow): Study system for level, flow and instrumentation control
 - Module N°3 (RT10) - Refrigeration (Flow/Temperature) : Study system for temperature control (Cooling), flow and instrumentation.
 - Module N°4 (RG10) Carbonation (Flow/Pressure): Carbonation of a liquid with measurement of flow, pressure and temperature.
 - Module N°5 (RP10) Pressure vessel (Pressure/level): Study system (pressure storage) of pressure regulation, level and instrumentation
- ✓ It can be operated by three types of controls:
 - Industrial Controller Module (RC10) : Study of industrial PID single-loop and/or dual-loop controllers
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- ✓ Process supervision is possible:
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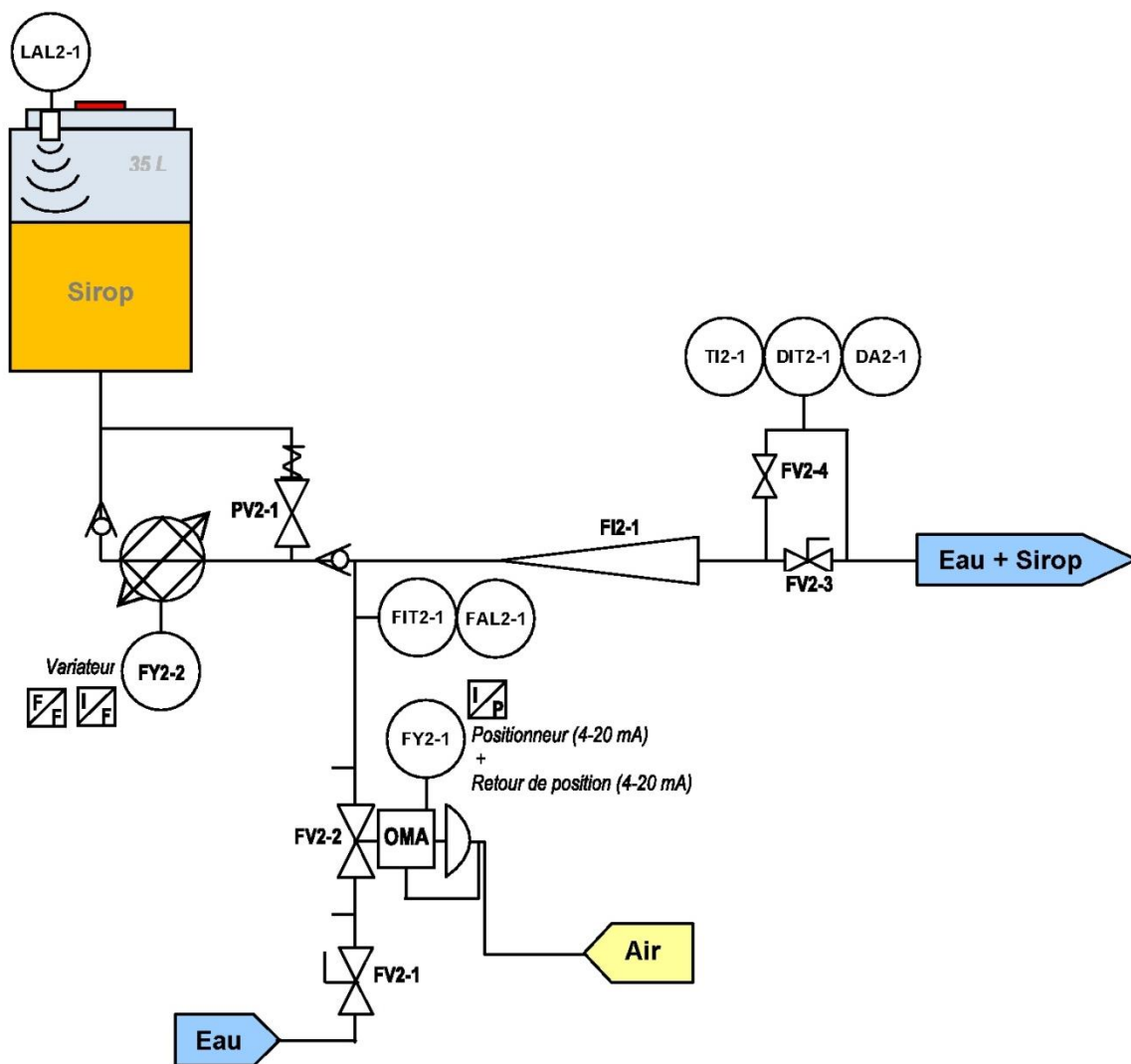
Communication

The "4-20mA/Hart pressure sensor" option (RM11) allows control loops to be implemented via a transmitter communicating via a fieldbus HART protocol.

Regulflex 2

Technical description

➤ IT Scheme



DIT2-1/DA2-1/TI2-1 (OPTION): Density transmitter indicator "°Brix" (4-20 mA signal) + Alarm contact (24 Vdc digital signal) + "°C" temperature indicator

FI2-1: "Rotameter" float flow indicator (0 to 500 l/h)

FIT2-1/FAL2-1: Flow Transmitter Indicator (Rotor Flow Meter 1-16l/min- 4-20 mA signal + Alarm contact for "low" flow detection (24Vdc digital signal)

FV2-1: 1/4 turn manual ball valve with full bore

FV2-2 (OPTION) : Pneumatic flow control valve ("Open by Lack of Air" valve)

FV2-3: Manual needle valve

FV2-4 (OPTION): Mechanical flow regulator/limiter (2l/min Max.)

FY2-1 (OPTION) : Current/Pressure positioner for flow control valve with position feedback (4-20 mA signal)

FY2-2: Control electronics for dosing pump (4-20mA signal or digital via "relay")

LAL2-1: Ultrasonic level transmitter (24 Vdc digital signal)

PV2-1: Safety valve for syrup injection circuit (12 bar)

TI2-1 (OPTION): Temperature Indicator



Regulflex 2

Pedagogical approach

Educational activities

- ✓ Study of the different principles of analogue and digital measurements
- ✓ Identification of the system in BO, BF
- ✓ Study of a metering pump in a control system.
- ✓ Ratio control (Calculation of the coefficient according to the flow rates, observation of saturation at high flow rates).

Examples of Practical Work offered by ERM

- ✓ TP1 Generic Regulflex: Methods for identifying and controlling "Stable" and "Integrating" systems
 - BROIDA's method
 - ZIEGLER NICHOLS method
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- ✓ TP2 Generic Regulflex: Principle of "Volumetric" and "Massive" flow measurement and regulation
 - Type of measure
 - Method, Calculations...
- ✓ TP3 Generic Regulflex: Sizing and implementation of depressors
- ✓ TP4 Generic Regulflex: Complex regulations that can be implemented on the system (Cascades, Predictive...)
- ✓ TP5: Study of ratio control

Food refrigeration (Flow Temperature Control)

Study system (food refrigeration) of temperature control, flow and instrumentation

Regulflex 3

Food refrigeration (Flow Temperature Control) at a glance

Sections

✓Electrical engineering, Industrial maintenance, Automation, Regulation...

Educational activities

- ✓Study of the different measurement principles
- ✓System identification (Use of different methods)
- ✓Simple temperature control (study of P,I,D actions)
- ✓Mixed or predictive control
- ✓Speed variation
- ✓Heat balances
- ✓Power calculation, heat exchanger sizing

Specific components

- ✓Flow measurements □ Rotameter, Thermal mass flow meter
- ✓Temperature measurements □ PT100, Thermocouple J, Thermocouple K, Conditioners, ...
- ✓Pumps □ Volumetric electric pump with speed variation
- ✓Converter □ Resistance/Current
- ✓Process components □ Plate heat exchangers
- ✓Industrial refrigeration □ Condensing unit, Expansion valve, Evaporator, Pressure switches, Thermostats, ...
- ✓Communication & Fieldbus (Option)
- ✓Process control □ Controller, PID PLC, SNCC

Highlights

- ✓Three types of commands can be used
- ✓Ideal product for industrial instrumentation and temperature and flow control
- ✓Study of the refrigeration circuit for chilled water production
- ✓System based on a real application (chilled water production of a soda production line)

Related products

- ✓RC10: Communicating Industrial Controller Module
- ✓RC21: PLC module with PID and Touch Panel (Schneider M340 version with 16E/16S TOR - 8E ANA - 4S ANA + Ethernet TCP/IP + Web Server + CANopen Bus)
- ✓RC31: PLC Module with PID and Touch Panel (Siemens S7-1500 version with 8E/8S digital - 24E ANA, of which 4 HART - 20S ANA + Ethernet TCP/IP)
- ✓RC12: Digital Control System Module
- ✓RC40: Pressure calibrator with pneumatic pump
- ✓RC41: Calibrator for RTD temperature sensors (Pt100, PT1000, ...)
- ✓RC42: Calibrator for Thermocouple (Tc) Temperature Sensors
- ✓RM13: Option - 0/4-20 mA Current Loop Calibrator

References

- ✓RT10: In-line Refrigeration (Flow Temperature Control)
- ✓: Option: Diaphragm for pressure and flow measurement
- ✓RL10: System Power and Safety Cabinet (Can be used with one or more systems)
- ✓RT11: Temperature measurement option for heat balances (3 additional sensors)
- ✓RT12: Flow control valve option
- ✓RM10RM11: Option: 4-20mA/Hart pressure sensor

Features

- ✓L/ W/ H (with RL10 power supply unit): 920 x 1000 x 2230mm
- ✓Electrical power: 240Vac - 50 Hz single phase (RL10 - System Power and Safety Box)
- ✓Weight (with RL10 power supply): 240kg
- ✓This system is accompanied by a technical and educational file





Regulflex 3

Technical description

Functional description

✓ This module brings a liquid (e.g. Water+Syrup mixture) to a temperature of about 5°C before the carbonation stage necessary for the manufacture of soda. This cooling step allows to limit the pressure of CO₂ insertion in the liquid. All heat exchanges are carried out using plate heat exchangers

Products used

- Water + syrup (or Water) mixture
- Glycol water (40%)
- Refrigerant R452A.

Set variable: Temperature of the liquid at the module outlet

Control variable: Brine flow rate

Disturbance variables

- Flow rate of the water+syrup mixture (or water) at the inlet,
- Temperature of the water+syrup (or water) mixture at the inlet ,
- Ambient temperature

How it works

✓ Simple temperature control :
 • The water + syrup mixture from the previous module entering the system forms a first fluid circuit. A second fluid circuit (glycol water) is used to cool the water+syrup mixture.
 • The two liquids pass through a plate heat exchanger. The temperature of the water+syrup mixture at the exchanger outlet (fluid to be cooled) is then measured. Depending on the temperature of the water+syrup mixture, the flow rate of the cooling circuit (glycol water) is adjusted to obtain and/or maintain the set temperature.

Stitches and loose connections

✓ There are "free" tapings on the pipework to add various sensors. Students can calibrate, set up and test different sensors on the existing process.

Electricity, water and air supply

✓ The power supply is provided by the RL10 power supply box (one RL10 box can supply up to 5 Regulflex systems).
 ✓ The air and water supply must be provided from the establishment's water and air supply (max. P. 6 bar).

Temperature measurement for heat balances (option RT11)

Three additional temperature sensors (Thermocouple J, Thermocouple K, PT1000) can be used to study different scaling according to the type of temperature sensor and to perform a heat balance on the temperature exchange performed on the system.

Control valve (option RT12)

A control valve placed at the input of the module can be implemented to allow autonomous use of the RT10. This option can also be used for: water flow control or cascade control

Connection to other Regulflex systems

- ✓ This module can be connected to one of the following systems to implement all or part of the manufacturing process:
 - Module n°1 (RN10) - Buffer tank (Level/Flow): Study system for level, flow and instrumentation control
 - Module N°2 (RD10) - Dosing (Flow/Ratio) : Flow control study system, ratio and instrumentation.
 - Module N°4 (RG10) Carbonation (Flow/Pressure): Carbonation of a liquid with measurement of flow, pressure and temperature.
 - Module N°5 (RP10) Pressure vessel (Level/Pressure): Study system (pressure storage) of pressure regulation, level and instrumentation
- ✓ It can be operated by three types of controls:
 - Industrial Controller Module (RC10) : Study of industrial PID single-loop and/or dual-loop controllers
 - Industrial Controller Module (RC21/RC31): Study of Industrial Controllers in PID regulation
 - DCS Module (RC12) : Study of Digital Control Systems
- ✓ Process supervision is possible:
 - Using the WinnCC Flexible environment (RC31)
 - Using the Touch Panel (RC21)

Communication

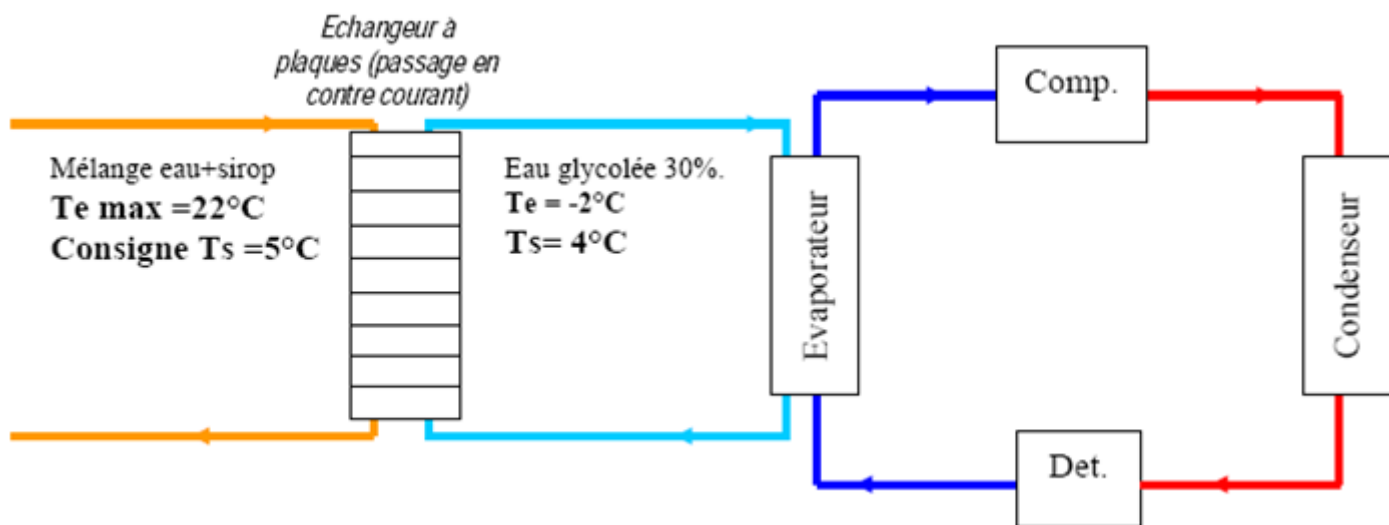
The option "4-20mA/Hart pressure sensor" (RM11) allows to realize control loops via a transmitter communicating through a fieldbus HART protocol.

Technical description

Regulflex 3

Heat exchange

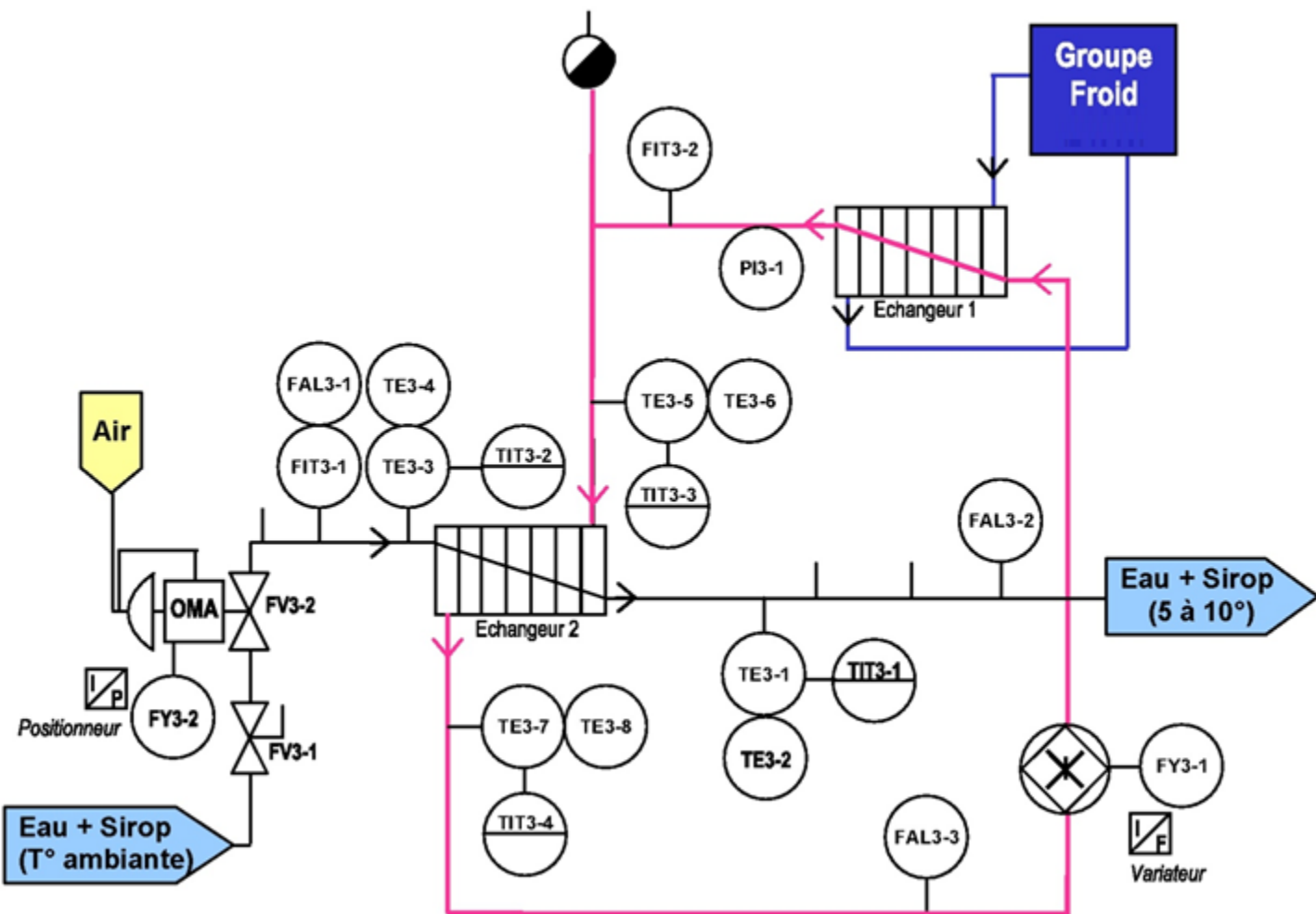
- ✓ The temperature control module integrates a self-contained chiller to generate a chilled water circuit (40% glycol water). This chilled water is cooled to -2°C as it passes through the evaporator of the chiller to bring the temperature of the water+syrup mixture to between 5 and 10°C .
- ✓ Generally speaking, it is important to note that cooling the water+syrup mixture facilitates its carbonation.
- ✓ The second exchange circuit (Evaporator) is necessary to avoid contact between the refrigerant and the water+syrup mixture.



Regulflex 3

Technical description

➤ IT Scheme



- FAL3-2: Float flow sensor ("FlowSwitch" - Detection setting: 1.5 l/min)*
- FAL3-3: Paddle flow sensor ("FlowSwitch" - detection setting 4 l/min)*
- FIT3-1/FAL3-1: Indicator Mass Flow Transmitter (4-20 mA Signal) / 24 Vdc Discrete Alarm Contact*
- FIT3-2: "Vortex" Flow Transmitter Indicator (4-20 mA signal)*
- FV3-1: 1/4 turn manual ball valve with full bore*
- FY3-1: Frequency inverter for brine circulation pump control (4-20 mA signal / 0 to 8l/min)*
- PI3-1: Pressure indicator (0-10 bar)*
- TE3-1/TE3-2: "Duplex" temperature sensor (PT100 - 3 wires)*
- TE3-3/TE3-4 (OPTION): "Duplex" temperature sensor (PT1000 - 3 wires)*
- TE3-5/TE3-6 (OPTION): "Duplex" temperature sensor (Thermocouple J - 3 wires)*
- TE3-7/TE3-8 (OPTION): "Duplex" temperature sensor (K thermocouple - 3 wires)*
- TIT3-1: Digital Temperature Indicator Transmitter (4-20 mA signal)*
- TIT3-2 (OPTION): Digital Temperature Indicator Transmitter (4-20 mA signal)*
- TIT3-3 (OPTION): Digital Temperature Indicator Transmitter (4-20 mA signal)*
- TIT3-4 (OPTION): Digital Temperature Indicator Transmitter (4-20 mA signal)*
- FV3-2 (OPTION) : Pneumatic flow control valve ("Open by Lack of Air" valve)*
- FY3-2 (OPTION) : Current/Pressure positioner for flow control valve with position feedback (4-20 mA signal)*



Regulflex 3

Pedagogical approach

Educational activities

- ✓ Study of the different principles of measurement.
- ✓ System identification (Use of different methods)
- ✓ Study of a circulation pump (Control, Servo control, Flow rate, ...).
- ✓ Simple temperature control (study of P,I,D actions)
- ✓ Trend (or mixed) control.
- ✓ Heat balances.
- ✓ Calculation of cooling capacities, sizing of exchangers.

Examples of practical work proposed by ERM

- ✓ TP1 Generic Regulflex: Methods for identifying and controlling "Stable" and "Integrating" systems
BROIDA's method
ZIEGLER NICHOLS method
Empirical method or "tuner" method (successive approaches)
- ✓ TP2 Generic Regulflex: Principle of "Volumetric" and "Massive" flow measurement and regulation
Type of measurement, Method, Calculations...
- ✓ TP3 Generic Regulflex: Sizing and implementation of depressors
- ✓ TP4 Generic Regulflex: Complex regulations that can be implemented on the system (Cascades, Predictive...)
- ✓ TP5: Study of Temperature Control
- ✓ TP6: Identification and operating principle of refrigeration production
- ✓ TP7: Thermal and thermodynamic measurements and operation

Carbonation (Pressure Flow Control)

Regulflex 4

Study system (Carbonation) of flow control, pressure and instrumentation

Module N°4 (RG10)

Carbonation (Flow/Pressure) at a glance

Sections

- ✓ Electrical engineering, Industrial maintenance, Automation, Regulation....

Educational activities

- ✓ Study of the different sensors (pressure, flow, temperature) and the CO analyser₂.
- ✓ Calibration of various measuring devices (pressure, flow, temperature)
- ✓ Study of a simple PID control
- ✓ CO mass flow control₂

Specific components

- ✓ Flow measurements □ Thermal mass
- ✓ Pressure measurements □ Relative
- ✓ Temperature measurements □ PT100
- ✓ Various measurements □ CO₂ dissolved in Option
- ✓ Valves □ CO thermal mass controller meter₂
- ✓ Storage □ Pressure vessel: CO₂ cylinder with heater (cylinder not supplied)
- ✓ Process components □ Static mixer
- ✓ Communication & Fieldbus □ Profibus
- ✓ Process control □ Controller, PID PLC, SNCC

Highlights

- ✓ Three types of commands can be used
- ✓ Ideal product for industrial instrumentation and flow and pressure control
- ✓ System based on a real application (Carbonation of the water/syrup mixture of a soda production line)

Related products

- ✓ RC10: Communicating Industrial Controller Module
- ✓ RC21: PLC module with PID and Touch Panel (Schneider M340 version with 16E/16S TOR - 8E ANA - 4S ANA + Ethernet TCP/IP + Web Server + CANopen Bus)
- ✓ RC31: PLC Module with PID and Touch Panel (Siemens S7-1500 version with 8E/8S digital - 24E ANA, of which 4 HART - 20S ANA + Ethernet TCP/IP)
- ✓ RC12: Digital Control System Module
- ✓ RC40: Pressure calibrator with pneumatic pump
- ✓ RC41: Calibrator for RTD temperature sensors (Pt100, PTt1000, ...)
- ✓ RC42: Calibrator for Thermocouple (Tc) Temperature Sensors
- ✓ RM13: Option - 0/4-20 mA Current Loop Calibrator

References

- ✓ RG10: Carbonation (Flow Control Pressure)
- ✓ RL10: System Power and Safety Cabinet (Can be used with one or more systems)
- ✓ RG11: Flow control valve option (For complex controls)
- ✓ RG12: Optional In-line Dissolved CO₂ Transmitter
- ✓ RM10: Option: Diaphragm for pressure and flow measurement
- ✓ RM11: Option: 4-20mA/Hart pressure sensor

Features

- ✓ L/ W/ H (with RL10 power supply unit): 920 x 1000 x 2230mm
- ✓ Electrical power: 240Vac - 50 Hz single phase (RL10 - System Power and Safety Box)
- ✓ Weight (with RL10 power supply): 160kg





Regulflex 4

Technical description

Functional description

Carbonation consists of uniformly dissolving the CO₂ gas in the water+syrup mixture.

Products used: CO₂ + Water+syrup mixture (or Water)

Variable set: CO content, CO₂ dissolved

Control variable: CO mass flow rate, Water volume flow rate, CO injection pressure and temperature

Disturbance variables: Flow rate, temperature and pressure of the water+syrup mixture

How it works

✓ The volume flow, temperature and pressure of the water+syrup mixture are measured. The pressure and mass flow rate of the CO₂ gas at the inlet of the static mixer are controlled according to the measured values.

✓ The CO₂ content of the liquid is measured at the outlet of the mixer.

Sockets and loose fittings

There are "free" tappings on the pipework to add various sensors. Students can calibrate, set up and test different sensors on the existing process.

Electricity, water and air supply

✓ The power supply is provided by the RL10 power supply box (one RL10 box can supply up to 5 Regulflex systems).

✓ The air and water supply must be provided from the establishment's water and air supply (max. P. 6 bar).

Control valve (option RG11)

A control valve placed at the inlet of the module can be implemented to allow autonomous use of the RG10. This option also allows for water flow regulation.

Dissolved CO₂ transmitter (option RG12)

A dissolved CO₂ transmitter can be used to provide: a control loop that measures the amount of CO₂ in the liquid and acts on the mass flow controller (or the RG11 control valve).

Connection to other Regulflex systems

- ✓ This module can be connected to one of the following systems to implement all or part of the manufacturing process:
 - Module n°1 (RN10) - Buffer tank (Level/Flow): Study system for level, flow and instrumentation control
 - Module N°2 (RD10) - Dosing (Flow/Ratio) : Flow control study system, ratio and instrumentation.
 - Module N°3 (RT10) - Refrigeration (Flow/Temperature) : Study system for temperature control (Cooling), flow and instrumentation.
 - Module N°5 (RP10) Pressure vessel (Level/Pressure): Study system (pressure storage) of pressure regulation, level and instrumentation
- ✓ It can be operated by three types of controls:
 - Industrial Controller Module (RC10) : Study of industrial PID single-loop and/or dual-loop controllers
 - Industrial Controller Module (RC21/RC31): Study of Industrial Controllers in PID regulation
 - DCS Module (RC12) : Study of Digital Control Systems
- ✓ Process supervision is possible:
 - Using the WinnCC Flexible environment (RC31)
 - Using the Touch Panel (RC21)

Communication

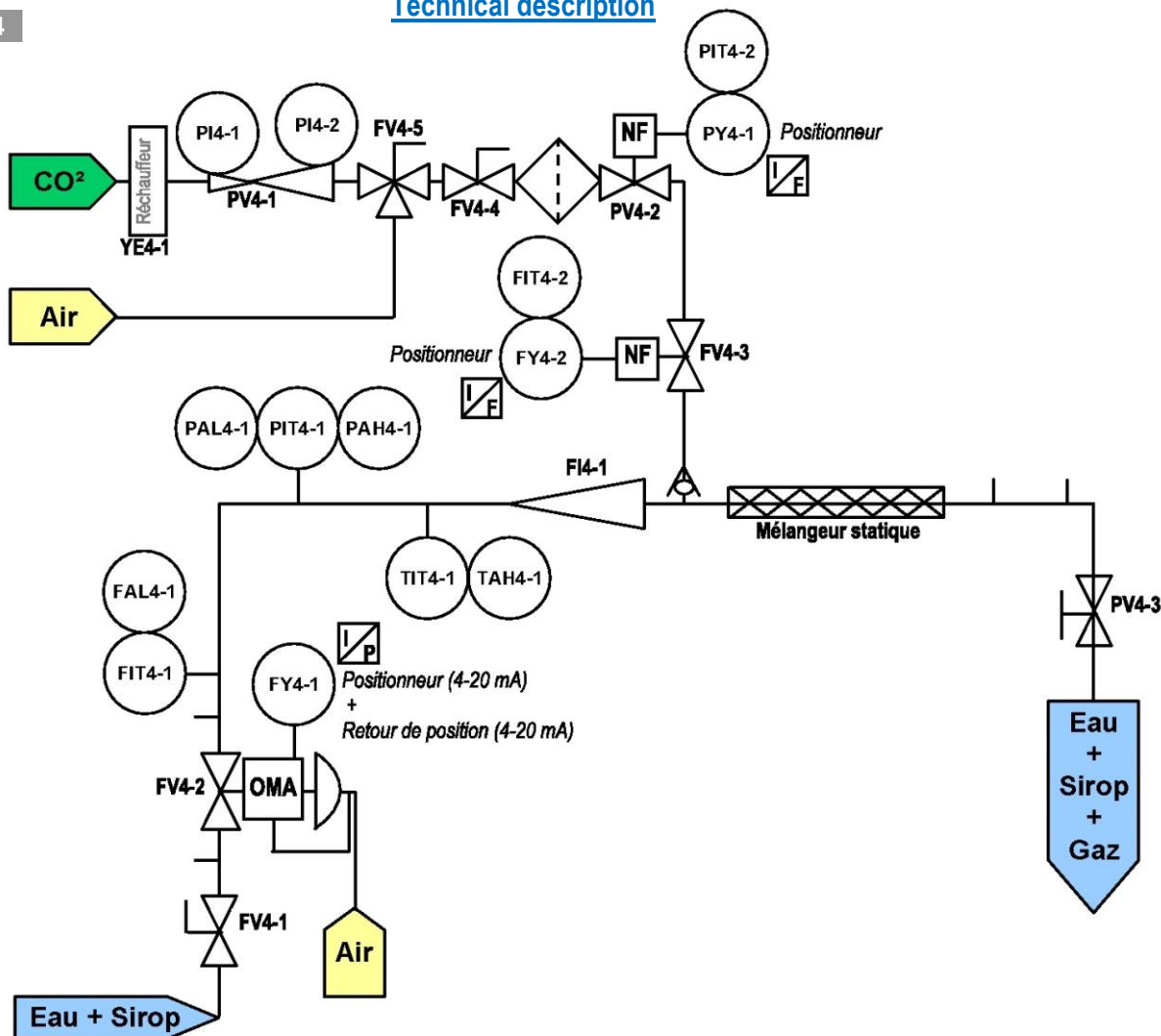
The option "4-20mA/Hart pressure sensor" (RM11) allows to realize control loops via a transmitter communicating through a fieldbus HART protocol.



Regulflex 4

Technical description

IT Scheme



FI4-1: Float Flow Indicator (Rotameter)

FIT4-1: Electromagnetic flow transmitter with display (4-20 mA / 0.8-16l/m)

FIT4-2/FAL4-1: Mass flow transmitter with display (4-20 mA / 0-20 NL/min with CO₂) + Alarm contact for "low" flow detection (24Vdc digital signal)

FV4-1: Manual ¼ turn valve with full bore

FV4-2 (OPTION) : Pneumatic flow control valve ("Open by Lack of Air" valve)

FV4-3: Gas flow control solenoid valve ("Normally Closed" valve)

FV4-4: ¼ turn manual shut-off valve

FV4-5: Manual "3-way" ball valve with full bore

FY4-1 (OPTION) : Positioner Current/Pressure "I/P" flow control valve + position feedback (4-20 mA)

FY4-2: Current/Frequency positioner "I/F" for gas flow control solenoid valve (4-20 mA)

PIT4-1/PAL4-1/PAH4-1: Pressure transmitter with display (4-20 mA / 0-10 bar) + Alarm contacts for "high" and "low" flow detection (24Vdc digital signal)

PIT4-2: Pressure transmitter with display (4-20 mA / 0-10 bar)

PV4-1 / PI4-1 / PI4-2: Manual pressure regulator for CO₂ gases with upstream and downstream pressure indicators

PV4-2: Solenoid valve for gas pressure regulation ("Normally Closed" valve)

PV4-3: Manual needle valve to pressurise the circuit

PY4-1: Current/Frequency Positioner "I/F" for Gas Pressure Control Valve (4-20 mA)

TIT4-1: Temperature transmitter with display (4-20 mA / -10 to +40°C) + Alarm contact for "high" temperature detection (24Vdc digital signal)

YE4-1: Gas heater (P=500W)



Regulflex 4

Pedagogical approach

Educational activities

- ✓ Study of the different sensors (pressure, flow, temperature) and the dissolved CO₂ analyser.
- ✓ Calibration of various measuring devices (pressure, flow, temperature)
- ✓ Study of a PID control
- ✓ Gas mass flow control (Air or CO₂)
- ✓ Ratio control

Examples of Practical Work offered by ERM

- ✓ TP1 Generic Regulflex: Methods of identification and regulation of "Stable" and "Integrating" systems
 - BROIDA's method
 - ZIEGLER NICHOLS method
 - Empirical method or "tuner" method (successive approaches)
- ✓ TP2 Generic Regulflex: Principle of "Volumetric" and "Massive" flow measurement and regulation Type of measurement, Method, Calculations...
- ✓ TP3 Generic Regulflex: Sizing and implementation of depressors
- ✓ TP4 Generic Regulflex: Complex regulations that can be implemented on the system (Cascades, Predictive...)
- ✓ TP5: Study of pressure regulation

Pressure vessel (Pressure Level Control)

Regulflex 5

Pressure, level and instrumentation control study system

Pressure vessel (Pressure/Level) at a glance

Sections

- ✓ Electrical engineering, Industrial maintenance, Automation, Regulation....

Educational activities

- ✓ Study of the different measurement principles (pressure, level, etc.)
- ✓ Calibration of the equipment used
- ✓ Identification of the system in BO, BF
- ✓ Simple pressure control (PID action study)
- ✓ Study of sequential operation, filling, emptying

Specific components

- ✓ Level measurements □ Capacitive probe
- ✓ Pressure measurements □ Relative pressure
- ✓ Valves □ Solenoid valves, proportional valves
- ✓ Storage □ Stainless steel pressure vessels
- ✓ Process control Controller, PID PLC, SNCC

Highlights

- ✓ Three types of commands can be used
- ✓ Ideal product for the study of industrial instrumentation and pressure and level control
- ✓ System based on a real application (Pressure vessel before bottling in a soda production line)

Related products

- ✓RC10: Communicating Industrial Controller Module
- ✓RC21: PLC module with PID and Touch Panel (Schneider M340 version with 16E/16S TOR - 8E ANA - 4S ANA + Ethernet TCP/IP + Web Server + CANopen Bus)
- ✓RC31: PLC Module with PID and Touch Panel (Siemens S7-1500 version with 8E/8S digital - 24E ANA, of which 4 HART - 20S ANA + Ethernet TCP/IP)
- ✓RC12: Digital Control System Module
- ✓RC40: Pressure calibrator with pneumatic pump
- ✓RC41: Calibrator for RTD temperature sensors (Pt100, PT1000, ...)
- ✓RC42: Calibrator for Thermocouple (Tc) Temperature Sensors
- ✓RM13: Option - 0/4-20 mA Current Loop Calibrator

References

- ✓RP10: Pressure vessel (Pressure/Level)
- ✓RL10: System Power and Safety Cabinet (Can be used with one or more systems)
- ✓RM10: Option: Diaphragm for pressure and flow measurement
- ✓RM11: Option: 4-20mA/Hart pressure sensor

Features

- ✓L/ W/ H (with RL10 power supply unit): 920 x 1000 x 2230mm
- ✓Electrical power: 240Vac - 50 Hz single phase (RL10 - System Power and Safety Box)
- ✓Weight (with RL10 power supply): 160kg





Technical description

Regulflex 5

Functional description

✓ In an industrial soda manufacturing and production system, it is necessary to adapt the carbonation process to the bottling unit (manufacturing, packaging, batch management, etc.). To do this, it is necessary to set up a storage tank for the carbonated product under CO₂ pressure. This is to guarantee a perfectly carbonated product during bottling.

✓ Therefore, the pressure regulation inside this buffer tank must be precisely controlled so as not to let the product de-gas or over-carbonate the product before bottling.

Products used: CO₂ + Water/Syrup mixture (or only air in case of simple pressure regulation)

Set variable: Pressure in the vessel

Control variable: Gas flow rate "CO₂" (or Air in case of simple pressure regulation)

Disturbance variables: Liquid level in the tank, ambient temperature, opening/closing of the tank outlet, etc.

How it works

✓ Simple pressure regulation without liquid in the tank:

- The tank is supplied with air from the facility's network via the first flow control valve (Supply). This valve is used to regulate the air flow to the tank.
- The second flow control valve or leakage valve is used to disrupt the pressure regulation in the vessel by controlling the gas outlet flow (Event).

Pressure regulation with liquid in the tank :

- The tank is continuously supplied with liquid. When a sufficient level of liquid is reached in the tank (adjustable threshold), the pressure control in the tank starts with the aim of maintaining the defined pressure setpoint.
- A bottling simulation is ensured by the cyclic opening/closing of a solenoid valve placed at the tank outlet (configurable operating cycle).
- The pressure in the storage tank is then maintained by controlling the two solenoid valves (one for the supply and the other for the discharge of the gas).
- The regulation can be "Simple" (independent control of the two electrovalves) or "Complex" (Split Range control).

✓ To be noted:

- The module can be operated as a stand-alone unit using only air and water or with CO₂ + Water/Syrup mix when used in conjunction with other Regulflex modules.
- The pressure and level safety on the tank is ensured by limit switches integrated in the various sensors (level/pressure) as well as by two safety valves placed directly on the tank.

CO₂ supply

This module is supplied with CO₂, from a standard storage bottle ("CarboPub" bottle), the outlet pressure of the bottle varies between 80 and 50 bar. A regulator and a heater are integrated on this CO₂ bottle.

Sockets and loose fittings

There are "free" tappings on the pipework to add various sensors. Students can calibrate, set up and test different sensors on the existing process.

Electricity, water and air supply

✓ The power supply is provided by the RL10 power supply box (one RL10 box can supply up to 5 Regulflex systems).

✓ The air and water supply must be provided from the establishment's water and air supply (max. P. 6 bar).

Connection to other Regulflex systems

✓ This module can be connected to one of the following systems to implement all or part of the manufacturing process:

- Module n°1 (RN10) - Buffer tank (Level/Flow): Study system for level, flow and instrumentation control
 - Module N°2 (RD10) - Dosing (Flow/Ratio) : Flow control study system, ratio and instrumentation.
 - Module N°3 (RT10) - Refrigeration (Flow/Temperature) : Study system for temperature control (Cooling), flow and instrumentation.
 - Module N°4 (RG10) Carbonation (Flow/Pressure): Carbonation of a liquid with measurement of flow, pressure and temperature.
- ✓ It can be operated by three types of controls:
- Industrial Controller Module (RC10) : Study of industrial PID single-loop and/or dual-loop controllers
 - Industrial Controller Module (RC21/RC31): Study of Industrial Controllers in PID regulation
 - DCS Module (RC12) : Study of Digital Control Systems
- ✓ Process supervision is possible:
- Using the WinnCC Flexible environment (RC31)
 - Using the Touch Panel (RC21)

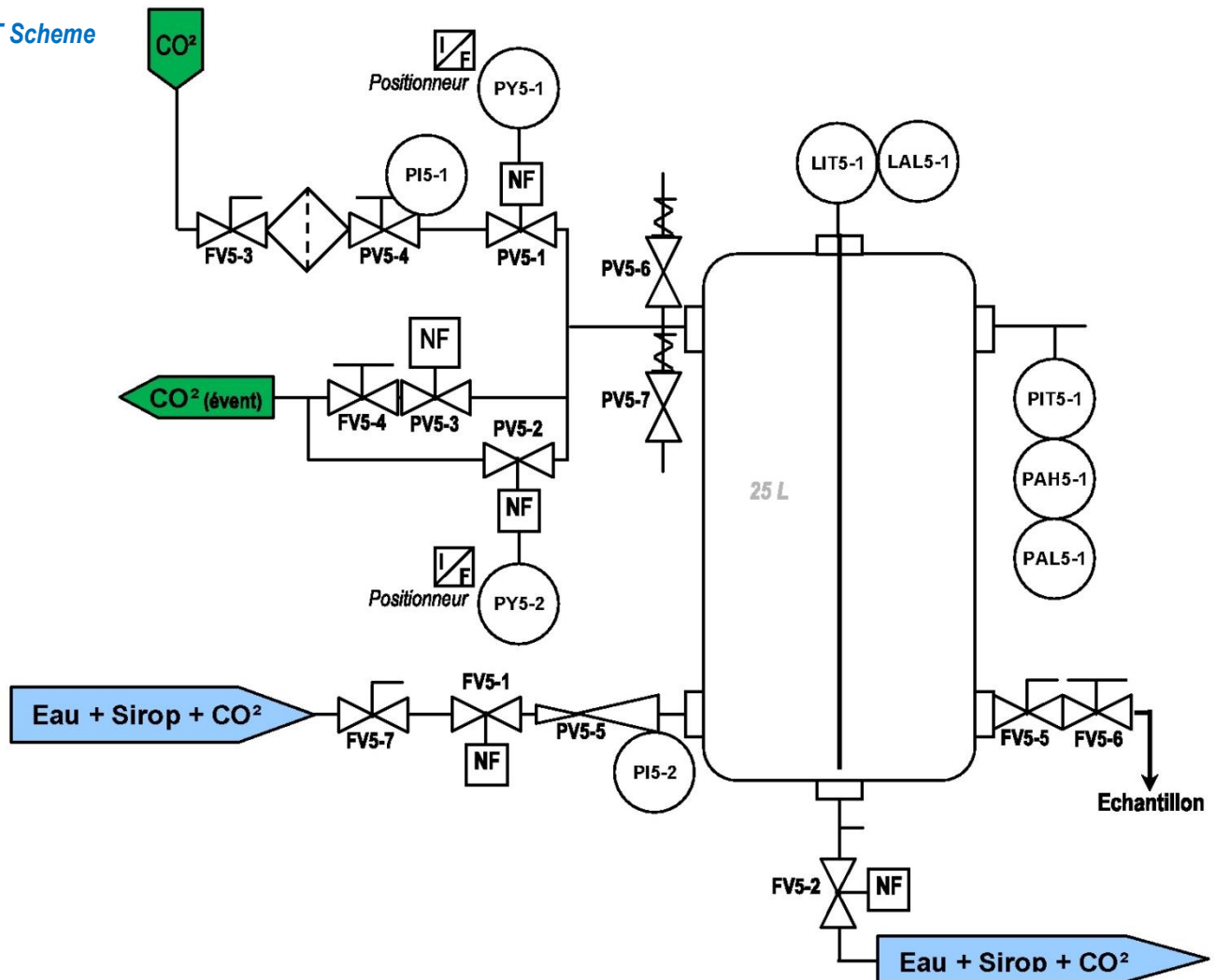
Communication

The "4-20mA/Hart pressure sensor" option (RM11) allows control loops to be implemented via a transmitter communicating via a fieldbus HART protocol.

Technical description

Regulflex 5

> IT Scheme



- FV5-1: Solenoid valve for liquid inlet ("Normally Closed" valve - 24 Vdc)
- FV5-2: Solenoid valve for liquid withdrawal ("Normally Closed" valve - 24 Vdc)
- FV5-3: ¼ turn manual shut-off valve
- FV5-4: Manual air flow control valve
- FV5-5: Manual ¼ turn ball valve with full bore
- FV5-6: Tap for sampling finished product
- FV5-7: Manual ¼ turn ball valve with full bore
- LAL5-1: Threshold relay (24 Vdc discrete contacts)
- LIT5-1: Capacitive Level Transmitter with Display (Capacitive Channel - 4-20 mA)
- PV5-1: Control valve for gas injection into the tank (Normally Closed Valve)
- PV5-2: Control valve for exhausting the gas contained in the "vent" tank (Normally Closed Valve)
- PV5-3: Solenoid valve for leak simulation (Normally Closed Valve - 24 Vdc)
- PV5-4 / PI5-1: Manual pressure regulator with display (0-10 bar)
- PV5-5 / PI5-2: Pressure relief valve with downstream pressure indicators
- PV5-6: Safety valve for excess pressure in the tank (7 bar)
- PV5-7: Vacuum breaker valve for vacuum in the tank
- PIT5-1 / PAL5-1 / PAH5-1 : Pressure transmitter with display + Alarm contacts for "high" and "low" pressure detection (24Vdc digital signal)
- PY5-1: Current/Frequency Positioner "I/F" for Gas Pressure Control Valve (4-20 mA)
- PY5-2: Current/Frequency Positioner "I/F" for Gas Pressure Control Valve (4-20 mA)



Regulflex 5

Pedagogical approach

Educational activities

- ✓ Study of the different measurement principles (pressure, level, vibrating plate)
- ✓ Calibration of the equipment used
- ✓ System identification
- ✓ Study of the control valve (direction of action, intrinsic characteristic, installed characteristic)
- ✓ Simple pressure control (PID action study)
- ✓ Study of sequential operation, filling, emptying
- ✓ Split range control

Examples of Practical Work offered by ERM

- ✓ TP1 Generic Regulflex: Methods for identifying "Stable" and "Integrating" (Unstable) systems
 - BROIDA's method
 - ZIEGLER NICHOLS method
 - Empirical method or "tuner" method (successive approaches)
- ✓ TP2 Generic Regulflex: "Volumetric" and "Mass" flow measurement and control
 - Type of measure
 - Method, Calculations...
- ✓ TP3 Generic Regulflex: Sizing and implementation of depressors
- ✓ TP4 Generic Regulflex: Complex regulations that can be implemented on the system (Cascades, Predictive...)
- ✓ TP5: Study of Pressure Regulation

Communicating industrial controller

Industrial PID controller study module

The Communicating Industrial Controller modules at a glance

Sections

All sections dealing with automation, control and communication

Highlights & Key Activities

- ✓ Implementation of simple PID control with alarm management.
- ✓ Programmable manually on the front panel or by PC ("Itools" software via Ethernet link, "Itools" software in free version with OPC scope session limited to 20min continuously)
- ✓ Integrated graphical function for plotting and printing curves (e.g. identification of systems by Brodia and Ziegler-Nichols methods).
- ✓ Front panel allowing:
 - Changing all parameters (Thresholds, K, Td, Ti, Output, Setpoint, ...)
 - The Auto/manu switch.
 - Continuous display of the measurement and setpoint
- ✓ Self-tuning function for searching for P, I, D parameters

Specific components

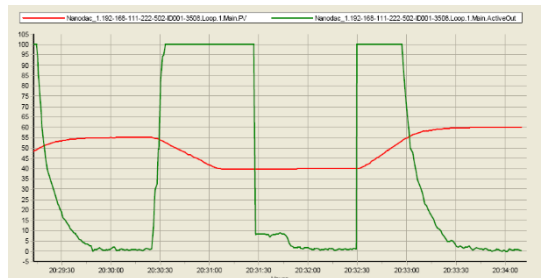
- ✓ EUROTHERM bi-loop controller Model 3508 :
 - 2 Analogue inputs 4-20mA
 - 2 Analog 4-20 mA outputs
 - 2 digital inputs
 - 2 digital outputs
 - Internal guideline
 - Internal calculation blocks
 - PC configuration software (Itools)

Features

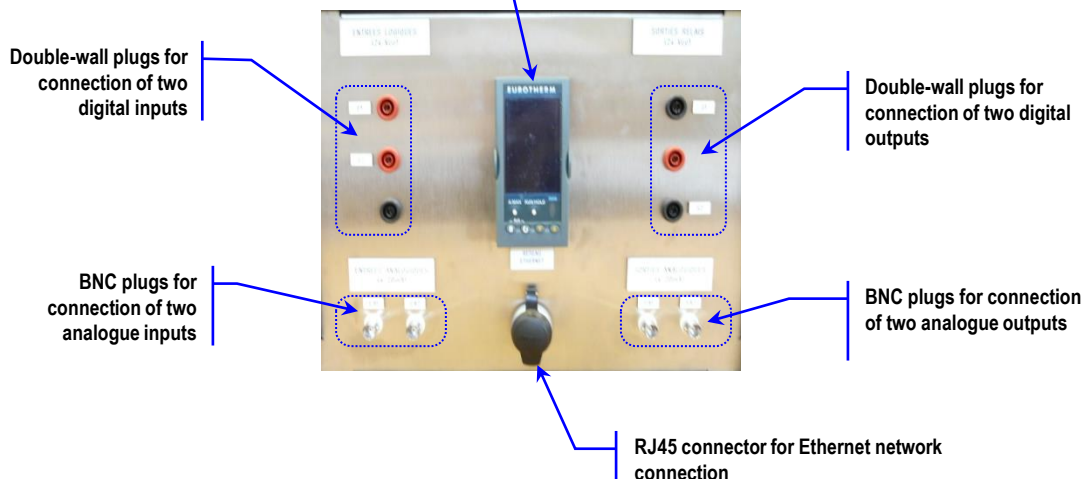
- ✓ 300 mm
- ✓ Electrical energy: 230 V single phase
- ✓ Weight: 3 kg

References

- ✓ RC10 : Industrial communicating controller module
- ✓ RM13 : Option - 0/4-20 mA Current Loop Calibrator



Bi-loop process controller Model 3508 (EUROTHERM)



Siemens S7-300 PLC Module

Study module for PID controllers

The S7-300 PLC modules at a glance

Sections

All sections dealing with automation, control and communication

Highlights & Key Activities

- ✓ This module includes a PLC with advanced functions.
- ✓ PC programming
- ✓ Communication via an Ethernet link
- ✓ Integration of several PID loops to control the entire line
- ✓ Graphical interface time scale for clean and accurate plotting correct identification of systems (Broida method, Ziegler-Nichols, ...)
- ✓ Self-tuning function to search for P, I, D parameters

Specific components

- ✓ PLC with digital and analogue input/output cards:
 - Internal and external set point variables
 - Feed-forward input on PID controller
 - calculation blocks (report, lead/lag blocks, ...)
- ✓ Communication couplers: Profibus DP; Profibus PA; Ethernet TCP/IP; AS-Interface, colour touch panel, "WinCCflexible" supervision; ...

➤ Main components

- ✓ The PLC used is a CPU S7-1500 from the SIEMENS SIMATIC S7-1500 range
- ✓ Ethernet TCP/IP" coupler



Features

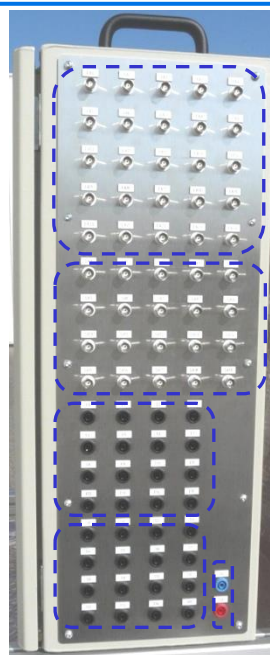
- ✓ L/ W/ H: 520x510x310 mm
- ✓ Electrical energy: 230 V single phase
- ✓ Weight: 20 kg

References

- ✓ RC31: PLC Module with PID and Touch Panel (S7-1500 version with 8E/8S On/Off + 24 EANA of which 4 HART - 20 SANA + Ethernet TCP/IP)
- ✓ RM13: Option - 0/4-20 mA Current Loop Calibrator



Left view



Right view

SCHNEIDER PLC module

Study module for PID controllers

The PLC modules with PID card at a glance

Sections :

All sections dealing with automation, control and communication

Highlights & Key Activities :

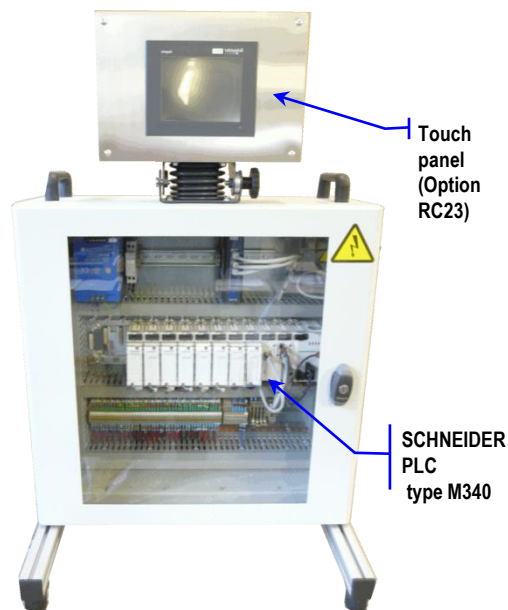
- ✓ This module includes a PLC with advanced functions.
- ✓ Programming via PC using UNITY PRO software (not supplied)
- ✓ Communication via Ethernet, Modbus or CANopen
- ✓ PID controller software block

Specific components :

- ✓ SCHNEIDER Type M340 PLC
- ✓ Basic hardware configuration :
 - CPU 340-20 Modbus + CANopen
 - TCP/IP Ethernet Coupler with integrated web server (16 MB)
 - 16 digital inputs and 16 digital outputs
 - 8 Analogue Inputs and 4 Analogue Outputs
- ✓ Additional API cards (Option) :
 - 2 x 8 Analogue Inputs
 - 2 x 8 Analogue Outputs

Principles of components

- ✓ The PLC used a CPU 340-20 from the new SCHNEIDER M340 range.
- ✓ It includes a TCP/IP Ethernet coupler with web server (16 MB)
- ✓ Associated with this CPU are digital and analogue I/O boards on a dedicated 12 slot rack.

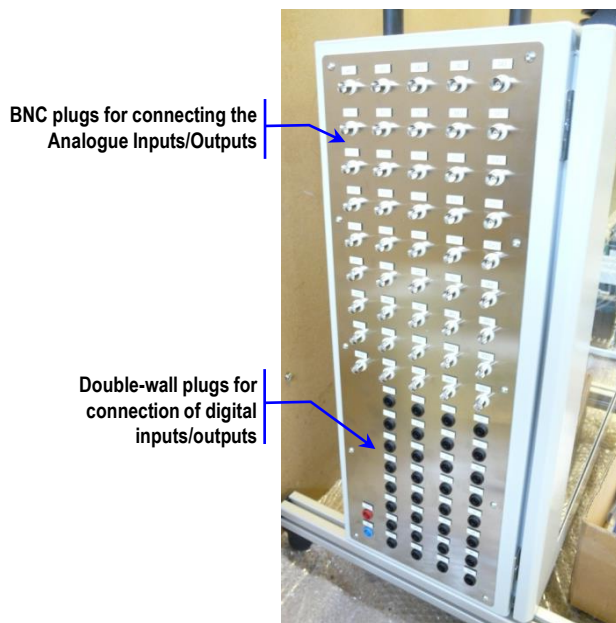
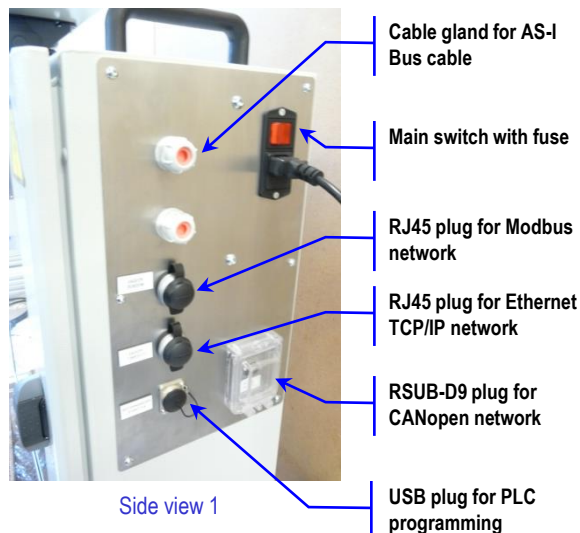


Features

L/ W/ H: 520x510x310 mm
 Electrical energy: 230 V single phase
 Weight: 25 kg

References

- ✓ RC21: PLC module with PID and Touch Panel (Schneider M340 version with 16E/16S TOR - 8E ANA - 4S ANA + Ethernet TCP/IP + Web Server + CANopen Bus)
- ✓ RM13: Option - 0/4-20 mA Current Loop Calibrator



SNCC module

Module for the study of Digital Control Systems

The SNCC modules at a glance

Sections

All sections dealing with automation, control and industrial communication

Highlights & Key Activities :

- ✓ Industrial Digital Control System (IDCS)
- ✓ Ethernet and Modbus Master/Slave communication (Serial or TCP)
- ✓ Profibus DP communication (Option)
- ✓ Multiple PID loops and process software library
- ✓ Continuous and sequential control
- ✓ Structured block programming

Particular components :

- ✓ 12.1" XGA colour touchscreen
- ✓ LINtools" programming software with function block library with control blocks, timing, logic, maths,...
- ✓ Data recording and trending

Features

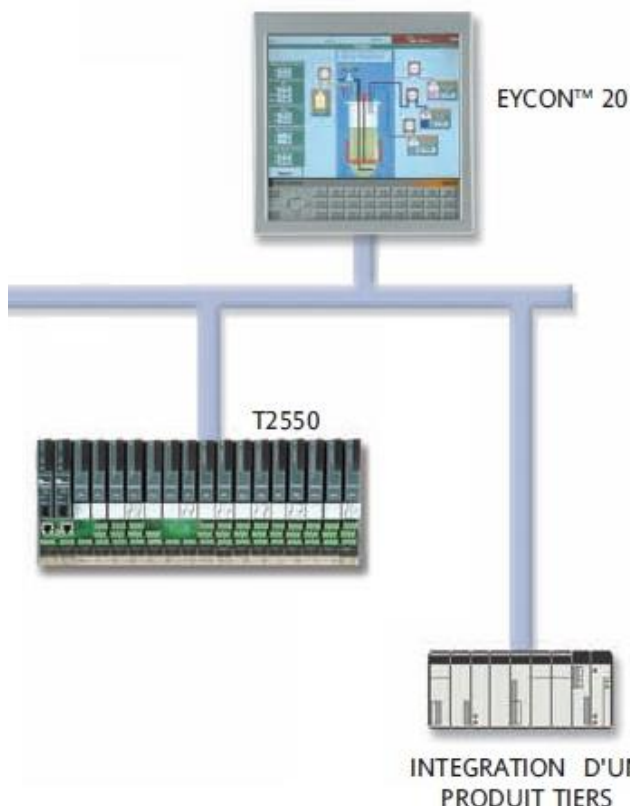
- ✓ L/ W/ H: 660x530x760 mm
- ✓ Electrical energy: 230 V single phase
- ✓ Weight: 35 kg

This system is accompanied by a technical and educational file



References

RC12: Digital Control System Module



Calibrators and process recorders

Tools for calibrating temperature and pressure sensors and recording measurements

Pressure calibrator with pneumatic pump



> Product content and features

- ◆ Electronic pressure calibrator with display (battery operated)
- ◆ Standard sensor or digital pressure gauge (0-10 bar range)
- ◆ Hand pump for generating pneumatic test pressure (-0.9 to 20 bar)
- ◆ Pneumatic and electrical connection kit
- ◆ Carrying case

> References :RC40

Calibrator for RTD temperature sensors (Pt100, Pt1000...)



> Product content and features

- ◆ Measurement and simulation Pt50, Pt100, Pt200, Pt500, Pt1000
- ◆ Min / Max / Average / Hold / Alarm function
- ◆ Automatic detection of 2, 3, 4 wire assemblies
- ◆ Generation of test values in programmable steps and ramps in manual or automatic mode (freehand)
- ◆ Cords
- ◆ Carrying case

> References: RC41

Calibrator for Thermocouple (TC) temperature sensors



> Product content and features

- ◆ Measurement and simulation of thermocouples J, K, T, B, R, S, E, N, L, U, C, D and mV
- ◆ Min / Max / Average / Hold / Filter / Alarm function
- ◆ Generation of test values in programmable steps and ramps in manual or automatic mode (freehand)
- ◆ Cords
- ◆ Carrying case

> References: RC42

4-channel universal paperless digital recorder



> Product content and features

- ◆ 4 universal inputs (CT, RTD, mA, mV, V) with recording speed up to 8 Hz (125 ms)
- ◆ 3.5" TFT colour display (non-touch) with 4 navigation keys on the front panel (IP65)
- ◆ Internal flash memory for data storage = 50 MB
- ◆ 1 USB port (for recording up to 8 GB)
- ◆ 1 Ethernet port (For remote configuration or recording via FTP over Ethernet)

> References :RC17