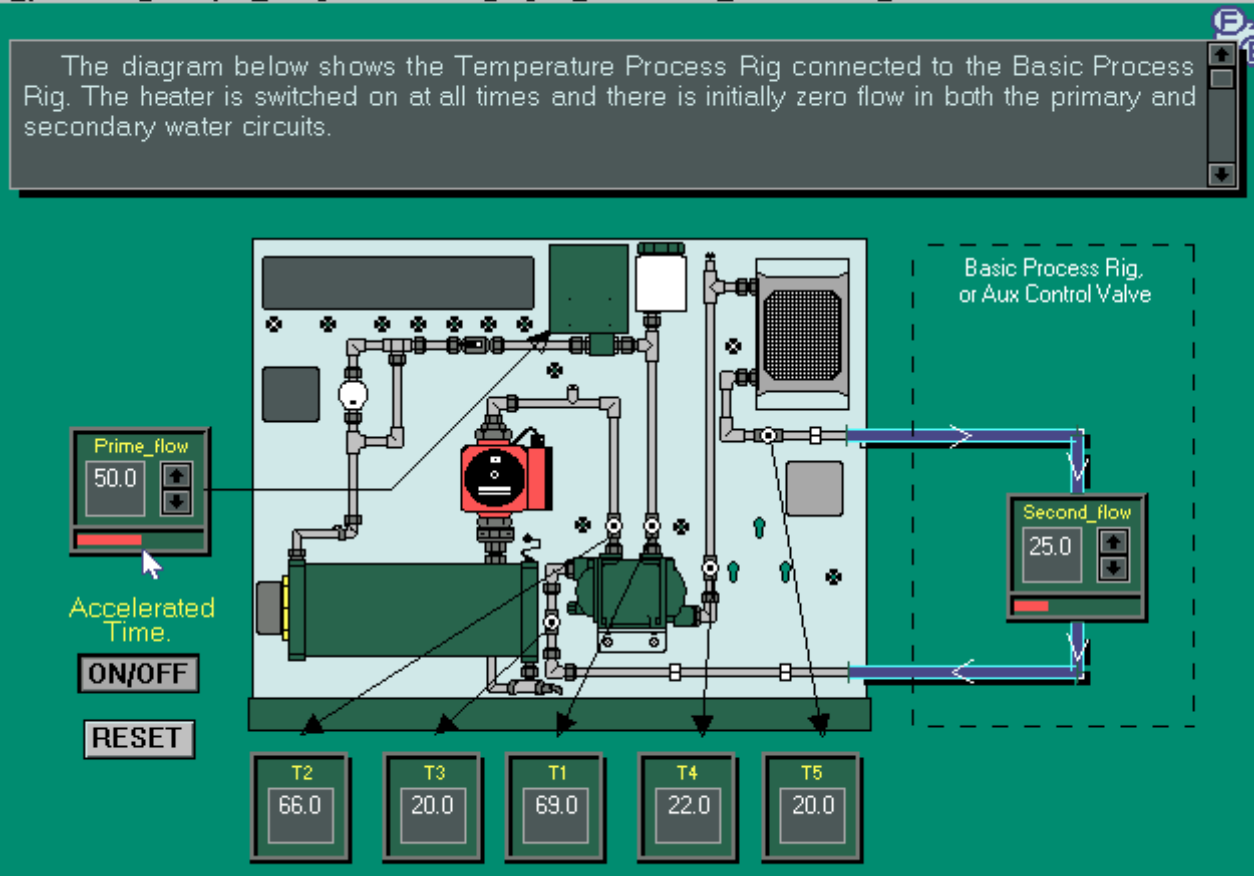


# PROCON PROCESS CONTROL TRAINERS

Assignment 19 (Temperature Process Control) Practical 1

System Theory Background Patching Practical Questions Colours

The diagram below shows the Temperature Process Rig connected to the Basic Process Rig. The heater is switched on at all times and there is initially zero flow in both the primary and secondary water circuits.



Basic Process Rig, or Aux Control Valve

Prime\_flow  
50.0  
Accelerated Time  
ON/OFF  
RESET

Second\_flow  
25.0

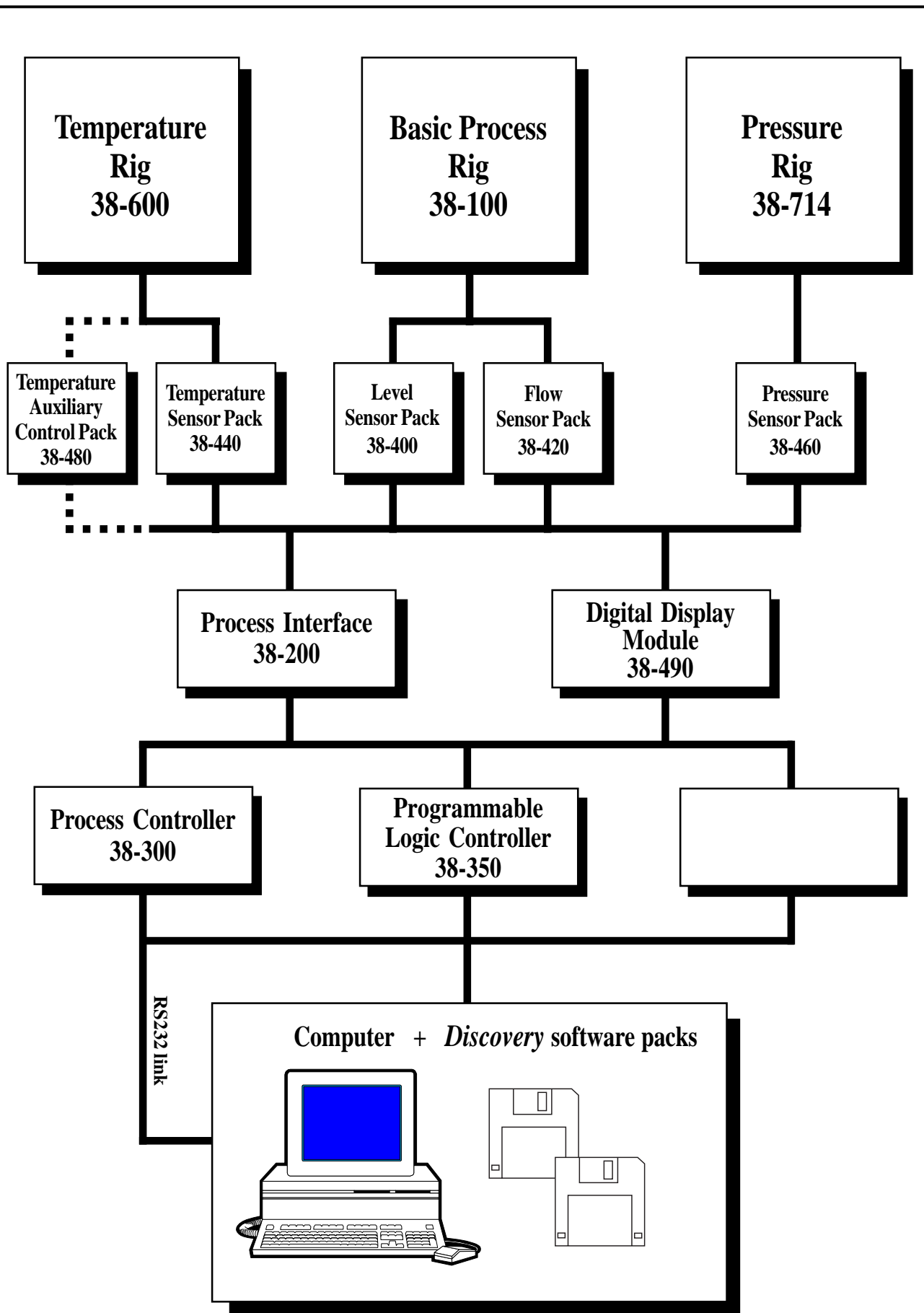
T2 66.0  
T3 20.0  
T1 69.0  
T4 22.0  
T5 20.0

## Industrial Process Control Trainers with *Discovery* software

- Level & Flow Control
- Temperature Control
- Pressure Control



*Technology Training for tomorrow's world*



*The Product Range*

## Features

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- **Rigs for Level & Flow, Temperature and Pressure control.**
- **Uses industry standard Process Controller.**
- **Uses industry standard 4-20mA signals.**
- **Uses industry standard RS485 Serial Communications Bus.**
- **High degree of modularity - easily reconfigurable.**
- ***Discovery* software.**
- **Fully protected by Earth Leakage Circuit Breaker.**

## Description

---

The PROCON range of Industrial Process Control Trainers is based on a series of interchangeable units which allows a building block approach to be adopted. Each Trainer comprises a Process Rig, a Process Interface, a Process Controller and various Sensors.

Bench-mounted Process Rigs for Level and Flow, Temperature and Pressure are offered and each has sensors to measure process variables.

Each sensor is available as part of a Sensor Pack which includes a small transmitter module. This arrangement illustrates common industrial practice, where the transmitter is mounted close to its sensor and provides a standard 4-20mA output signal.

The Process Interface is common to each system. It provides all the necessary power outlets for a Process Rig and all interconnections between the sensors and a controller. It forms the central module of any system.

The Process Controller houses an ABB Kent-Taylor Commander 300 Industrial Process Controller which is micro-processor based and easily configured by the user to provide a range of control func-

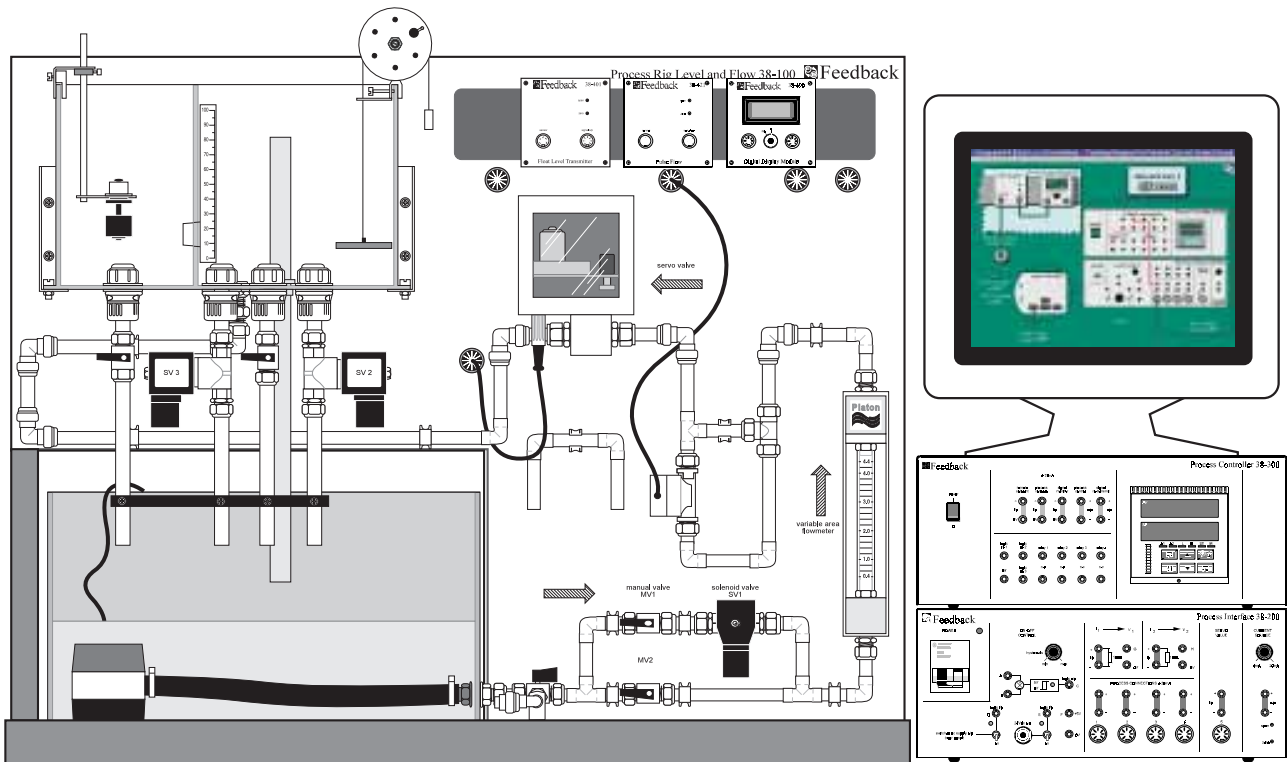
tions from simple 2-state control to full 3-term PID control. It also features an autotune facility which can analyse the requirements of a process and configure control for optimum performance.

All Controller functions can also be driven from a PC via a standard RS232/485 serial link and the unique *Discovery* Computer Aided Learning software environment provides real-time on-screen process monitoring with animated mimic screens and a virtual chart-recorder, together with theory, background information and questions.

Optional additions to the systems include a Programmable Logic Controller and a Data Acquisition Unit. These allow the extension of the work possible on the Process Rigs to include ladder logic and programming, the development of advanced control algorithms and the use of advanced process control techniques such as Fuzzy Logic and Neural Networks to control the Rigs.

The Rigs may be operated separately, either with or without *Discovery* software, or the Level & Flow Rig (the Basic Process Rig) may be connected to the Temperature Rig to form a Dual Loop system.

# PROCON Level/Flow Process Control System 38-001



## Features

- Self-contained benchtop system.
- Water used as the process fluid.
- Contains a selection of level and flow sensors and indicators.
- *Discovery* software provides on-screen instruction and instrumentation.
- Flow controlled by unique linearly profiled motorised gate valve.
- Robust centrifugal pump delivers 5 litre/min.
- On/Off and proportional control.
- P, PI and full PID control with autotune facility.
- May be coupled to the Temperature Rig for dual loop control.

## Description

The PROCON Level/Flow Process Control System is based around the PROCON Basic Process Rig. This is a single loop system, using water as the process fluid, which allows study of the principles of process control using liquid level and flow rates as the process variables to be controlled.

This Control System includes:

- Basic Process Rig.
- Process Interface.
- Process Controller.
- Level Sensor Pack.
- Flow Sensor Pack.
- Digital Display Module.
- Discovery* Software.

The system consists of a completely self-contained, low pressure flowing water circuit supported on a bench-mounted panel, making it suitable for individual student work or for group demonstration.

The circuit includes:

- *Sump Tank.*
- *Dual-compartment Process Tank.*
- *Circulating Pump.*
- *Visual indication Flow Meter.*
- *Motorised linear flow Gate Valve.*
- *3 Solenoid operated valves.*
- *4 Manual valves.*
- *Pulse flow sensor.*
- *Potentiometer Float level sensor.*
- *On/Off Float level switch.*

The Process Interface is connected to the Basic Process Rig and provides all of the necessary power outlets for the Rig, its sensors and the Process Controller. It also has 4-20mA inputs, a 4-20mA current source, current-to-voltage converters and a voltage comparator with variable hysteresis. Protection is provided by a residual current circuit breaker.

The Process Controller houses an industry standard ABB Kent-Taylor Commander 300 controller and provides all the input and output facilities required for controlling the Rig. It is fully compatible with the Process Interface and

together they provide a simple and convenient means of electrically configuring the system.

In combination with the hardware, the **Discovery** Software provided with the system forms an innovative and motivating delivery method, which enables a wide range of assignments to be carried out. Background theory, equipment connection and electrical patching, practical control, instructions and questions, together with PC-based instrumentation, integrated into the **Discovery** delivery system, supply all the instruction and measurement requirements of the assignments.

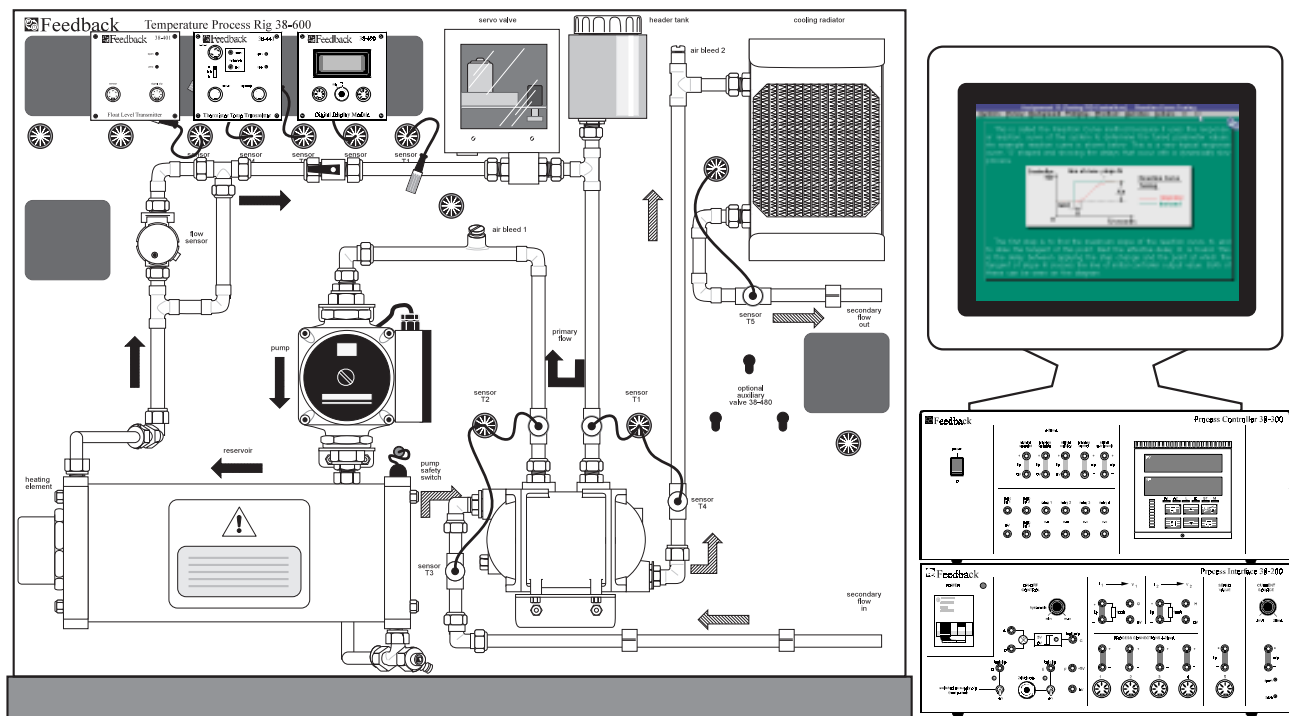
## Assignments

---

The **Discovery** Software assignments provided with the **PRO CON** Level/Flow Process Control System are:

- **Introduction to PRO CON**
- **Flow/Level Rig Familiarisation**
  - The Centrifugal Pump.*
  - The Manual Valves and the Flow Gauge.*
  - The Servo Valve.*
  - The Solenoid Valves.*
- **Flow/Level Rig Calibration**
  - A Level-Volume Correspondence.*
  - Flow Meter Calibration.*
  - Servo Valve Calibration.*
  - Solenoid Valve Calibration.*
- **Interface Familiarisation**
  - Circuit Breaker & Circuit Loop Connections.*
  - The Servo Valve.*
  - The Current-Voltage Converters.*
- **Interface Calibration**
  - Current Source Calibration.*
- **Controller Familiarisation**
  - Serial Communication.*
  - Navigating the Controller.*
  - Using the Controller.*
- **Controller Calibration**
  - Controller Calibration.*
  - Controller Relays.*
  - Reading the Controller.*
- **Float Level Transmitter**
  - The Float Level Transmitter (FLT).*
  - Calibrating the FLT.*
  - A Level Control Demonstration.*
- **Pulse Flow Transmitter**
  - The Pulse Flow Transmitter (PFT).*
  - Calibrating the PFT.*
  - A Flow Control Demonstration.*
- **On/Off Control**
  - On/Off Pump Control.*
  - On/Off Solenoid Control.*
  - The Float Switch.*
  - Controller On/Off Control.*
- **Proportional Control: Level**
  - Simulation.*
  - Proportional Control of Level.*
  - Proportional Control and Offset.*
  - Proportional Band.*
- **Proportional Control: Flow**
  - Servo Proportional Control.*
  - Proportional Control Offset.*
- **PI & PID: Level Control**
  - PI Control of Level.*
  - Limitations of PI Control.*
  - PID Control of Level.*
- **PI & PID: Flow Control**
  - PI Control of Flow.*
  - PID Control of Flow.*
- **Tuning PID Controllers**
  - Zeigler-Nichols Tuning.*
  - Self-Tuning.*
- **Process Controller: Advanced**
  - Remote Set-Point.*
  - Profile Programming.*
  - Time Proportioned Output.*

# PROCON Temperature Process Control System 38-002



## Features

- **Dual-circuit benchtop system.**
- **Water used as the process fluid.**
- **Can be operated from mains water supply or connected to the PROCON Level/Flow Process Control System.**
- **Temperature monitored by five sensors in primary and secondary circuits.**
- **Flow also monitored.**
- **Discovery software provides on-screen instruction and instrumentation.**
- **Primary circuit flow controlled by motorised gate valve.**
- **Primary circuit heater and pump.**
- **Secondary circuit fan-assisted cooling radiator.**
- **P, PI and full PID control with autotune facility.**
- **May be coupled to the Level/Flow Rig for dual loop control.**

## Description

The PROCON Temperature Process Control System is based around the PROCON Temperature Process Rig. This is a two loop system, using water as the process fluid, which allows study of the principles of process control using primary and secondary circuit temperatures as the process variables to be controlled.

This Control System includes:

**Temperature Process Rig.**  
**Process Interface.**

**Process Controller.**

**Temperature Sensor Pack.**

**Auxiliary Temperature Control Pack.**

**Digital Display Module.**

**Discovery Software.**

The Temperature Process Rig consists of a dual loop, low pressure, flowing water circuit supported on a bench-mounted panel, making it suitable for individual student work or for group demonstration.

The System includes:

- **Closed primary hot water circuit.**
- **Electrical heater.**
- **Heat exchanger.**
- **2 Motorised flow valves.**
- **Pulse flow sensor.**
- **5 Thermistor temperature sensors.**
- **Fan-assisted cooling radiator.**
- **Signal conditioning units.**

The primary circuit loop includes a heat exchanger through which hot water from an electrically heated reservoir is continuously circulated. The secondary circuit also passes through the heat exchanger and contains a fan-assisted cooling radiator. Thermocouple temperature sensors are located in the inlet and

outlet streams of the heat exchanger. The primary flow rate is also monitored.

The **PROCON** Temperature Process Control System may be used on its own, supplied by a cold mains water supply through the Auxiliary Temperature Control Pack. This comprises a motorised valve, a flow meter and a signal conditioning unit. Alternatively, the **PROCON** Temperature Process Control System may be connected to the Basic Process Rig, which then supplies the cold water circuit. With this combination of rigs more complex control systems may be investigated.

The Process Interface and Process Controller are identical to those used in the **PROCON** Level/Flow Process Control System.

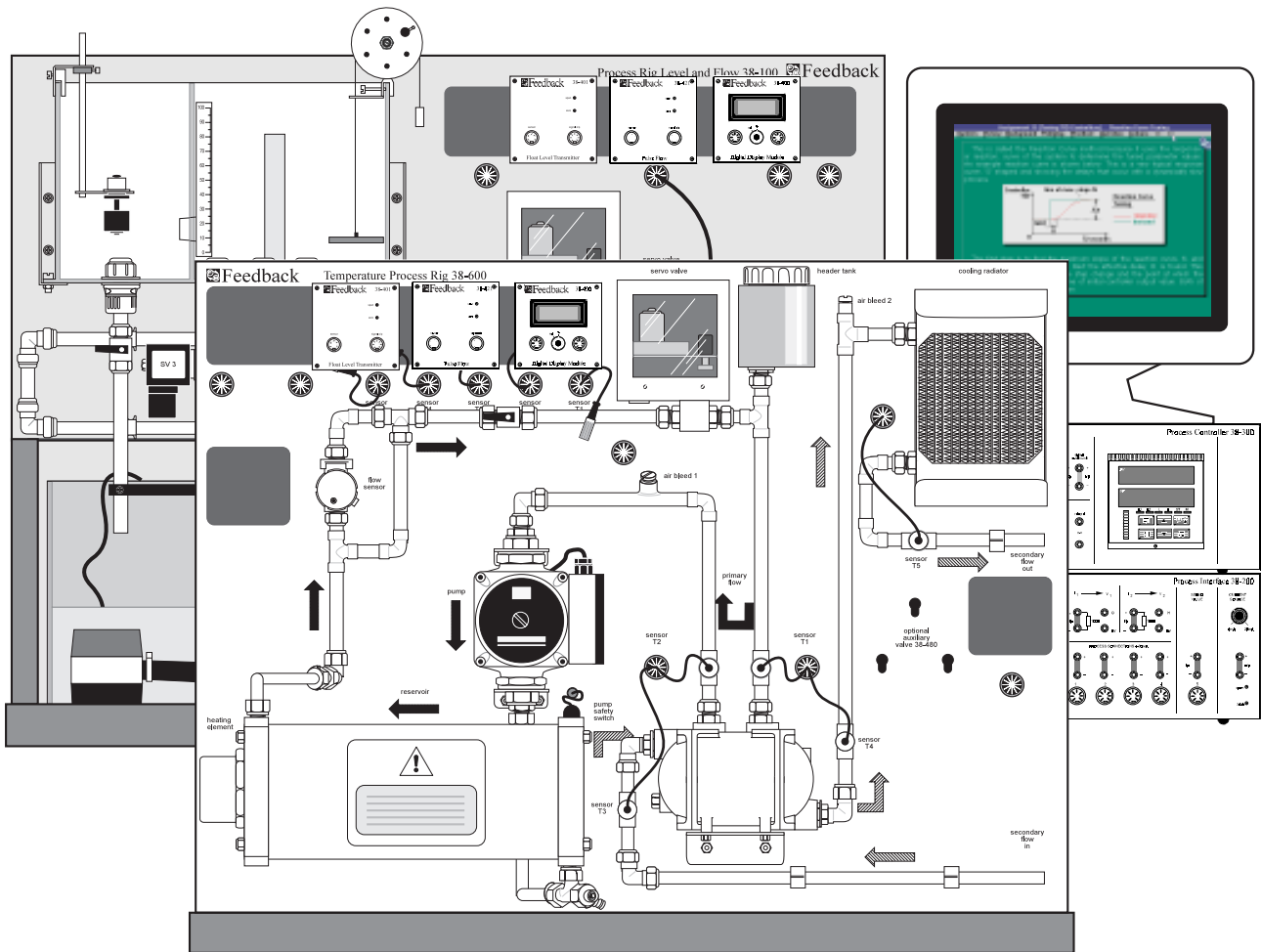
## Assignments

**Discovery** Software, similar to that with the **PROCON** Level/Flow Process Control System, is provided and the assignments that can be performed are:

- **Introduction to PROCON**
- **Flow/Level Rig Familiarisation**
  - The Centrifugal Pump.*
  - The Manual Valves and the Flow Gauge.*
  - The Servo Valve.*
  - The Solenoid Valves.*
- **Flow/Level Rig Calibration**
  - A Level-Volume Correspondence.*
  - Flow Meter Calibration.*
  - Servo Valve Calibration.*
  - Solenoid Valve Calibration.*
- **Interface Familiarisation**
  - Circuit Breaker & Circuit Loop Connections.*
  - The Servo Valve.*
  - The Current-Voltage Converters.*
- **Interface Calibration**
  - Current Source Calibration.*
- **Controller Familiarisation**
  - Serial Communication.*
  - Navigating the Controller.*
  - Using the Controller.*
- **Controller Calibration**
  - Controller Calibration.*
  - Controller Relays.*
  - Reading the Controller.*
- **Pulse Flow Transmitter**
  - The Pulse Flow Transmitter (PFT).*
  - Calibrating the PFT.*
  - A Flow Control Demonstration.*
- **Proportional Control: Flow**
  - Servo Proportional Control.*
  - Proportional Control Offset.*
- **PI & PID: Flow Control**
  - PI Control of Flow.*
  - PID Control of Flow.*
- **Temperature Rig Initialisation**
  - Calibration of the Thermistor Temperature Transmitter.*
  - Thermistors.*
  - Bleeding the Secondary Flow.*
- **Temperature Rig Familiarisation**
  - On/Off Heater Control.*
  - Operation of the Heat Exchanger.*
  - Operation of the Cooler.*
- **Manual Flow control**
  - Simulation.*
  - Primary Flow Control.*
  - Secondary Flow Control.*
- **Temperature Process Control**
  - Single Loop Control.*
  - Industrial Process Control.*
  - Automatic On/Off Control.*
- **P, PI, PID Temperature Control**
  - Proportional Control of Temperature.*
  - PI Control of Temperature.*
  - PID Control of Temperature.*
- **Complex Control Loops**
  - Flow Ratio Control.*
  - Dual Loop Temperature and Flow Control.*
  - Dual Loop Temperature and Level Control.*

# PROCON Level/Flow and Temperature Process Control System

38-003



## Features

The combined PROCON Level/Flow and Temperature Process Control System has all of the features of the individual Level/Flow and Temperature systems **PLUS**:

- Remote Set Point Control.*
- Set Point Ratio Control (Dual Loop).*
- Cascade Control.*
- Feed-forward Control.*

This Control System includes:

- Basic Process Rig.**
- Temperature Process Rig.**
- 2 Process Interfaces.**
- 2 Process Controllers.**
- Level Sensor Pack.**
- 2 Flow Sensor Packs.**
- Temperature Sensor Pack.**
- 2 Digital Display Modules.**
- Discovery Software.**

## Assignments

The full set of assignments associated with both the Level/Flow and the Temperature Process Control Systems can be performed. In addition

the work may be extended with investigations in Remote Set Point Control, Set Point Ratio Control (Dual Loop), Cascade Control and Feed-forward Control.

### Remote Set-Point Control

Remote Set-Point Control can be achieved with the PROCON Level/Flow and Temperature Process Control System by using the two Process Controllers supplied.

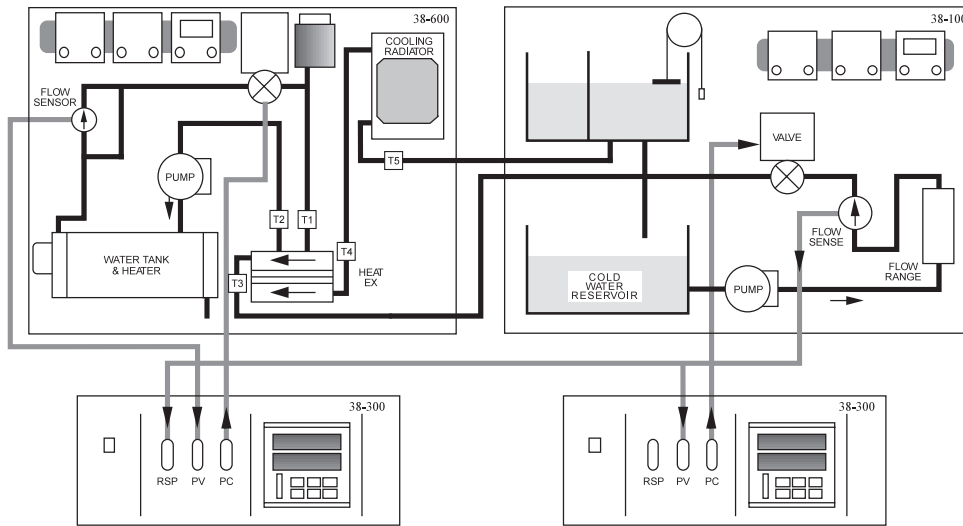
The 4-20mA analogue Remote Set-Point input allows various forms of cascade control to be implemented between linked or interactive control loops.

The process set-point can be Local and Remote or Dual, selected from the front panel, or in response to a logic input. When Dual Set-Point is selected the function can be ratio or bias action.

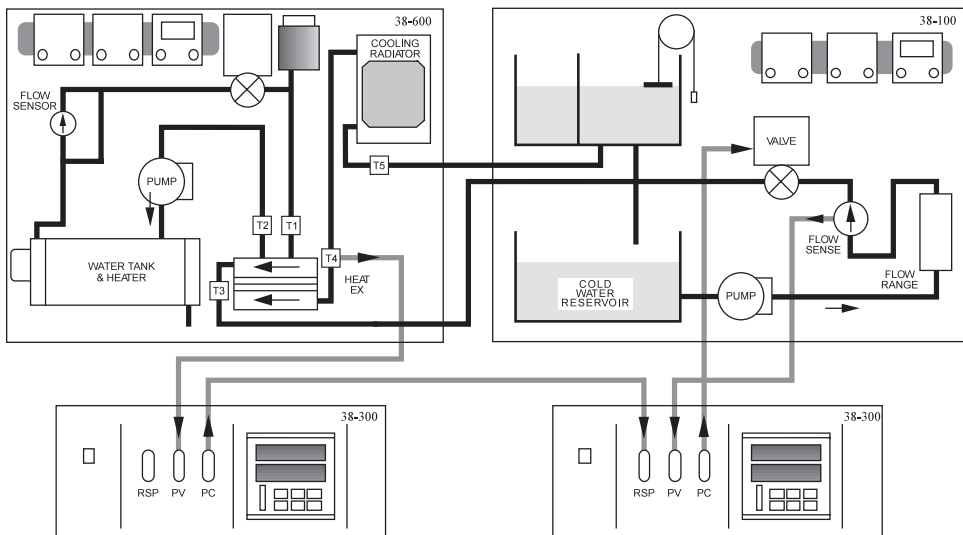
The Remote Set-Point facility provides the means to study the following subject areas:

- *Setting up a primary and secondary controller.*
- *Set-point ratio control (Dual Loop).*
- *Cascade Control (Temperature and Flow).*
- *Feed-forward Control (Flow and Flow).*

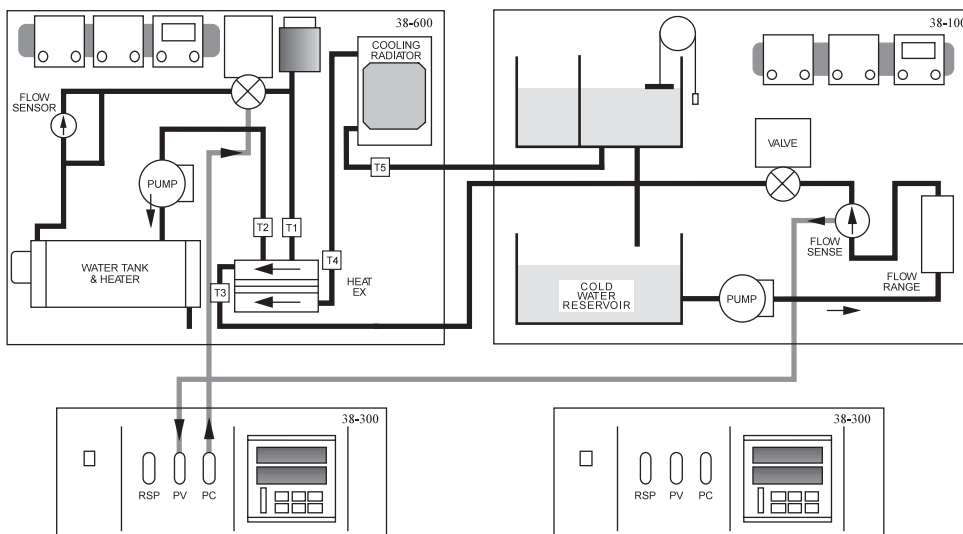
Three schematic diagrams showing how PROCON can be used in experimental set-ups.



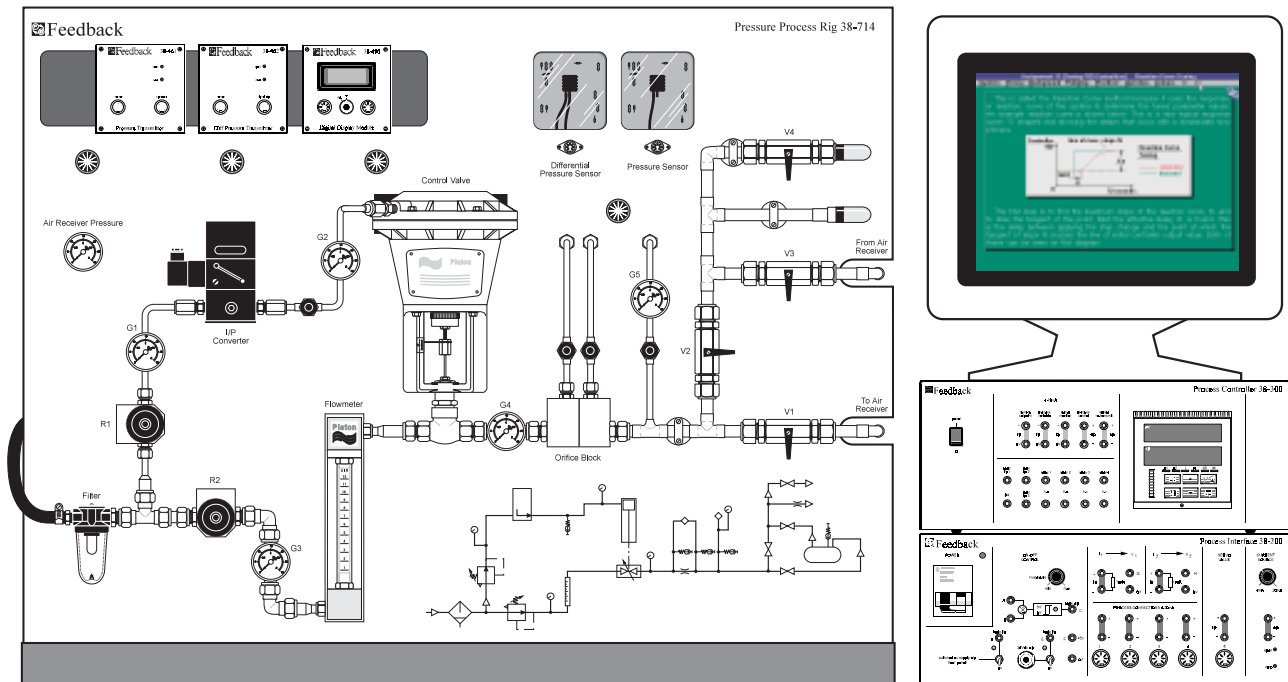
1. Set-point ratio control (Dual Loop)



2. Cascade Control (Temperature Control)



3. Feed-forward Control (Flow and Flow)



## Features

- **Benchtop system.**
- **Air used as the process fluid.**
- **Fully gauged for pressure and flow rate.**
- **Differential and gauge Pressure Sensors.**
- **Pneumatically operated control valve.**
- **Standard industrial components.**

The PROCON Pressure Process Control System is a single loop pneumatic control system which allows study of the principles of process control pressure as the process variable to be controlled.

This Control System includes:

- Pressure Process Rig.**
- Process Interface.**
- Process Controller.**
- Pressure Sensor Pack.**
- Digital Display Module.**
- Discovery Software.**

The Pressure Process Rig consists of a low pressure air circuit supported on a bench-mounted panel, making it suitable for individual student work or for group demonstration.

The circuit includes:

- **Input supply filter/drier.**
- **Input converter.**
- **Pneumatically operated control valve.**
- **2 Regulators.**
- **4 Manual valves.**

- **6 Gauges.**
- **Sight flow meter.**
- **Orifice Block with changeable Orifice Plates.**
- **Differential Pressure Sensor.**
- **Process Pressure Sensor.**
- **27 litre Air Receiver Tank.**
- **20psi Safety Relief Valve.**
- **Diffusers.**

The Pressure Process Rig is supplied with compressed air at a recommended input pressure of 40psi. An input filter/drier is used to clean the supplied air. Separate regulated branches provide air for the process and for valve control.

The process branch comprises a regulator, a pneumatically operated control valve, an orifice block with changeable orifice diameters and differential and process pressure sensors. The process air flow can be discharged to atmosphere via diffusers, or to the air receiver tank.

The valve control branch comprises a regulator and an electrically operated current to pressure

input converter which feeds the control input of the control valve. The input converter operates with 4-20mA current.

Signal conditioning for the sensors is provided by pressure transmitters. The Differential Pressure Transmitter includes a square root extractor circuit to linearise the differential pressure sensor output.

The system is fully equipped with pressure gauges to indicate the pressures around the system.

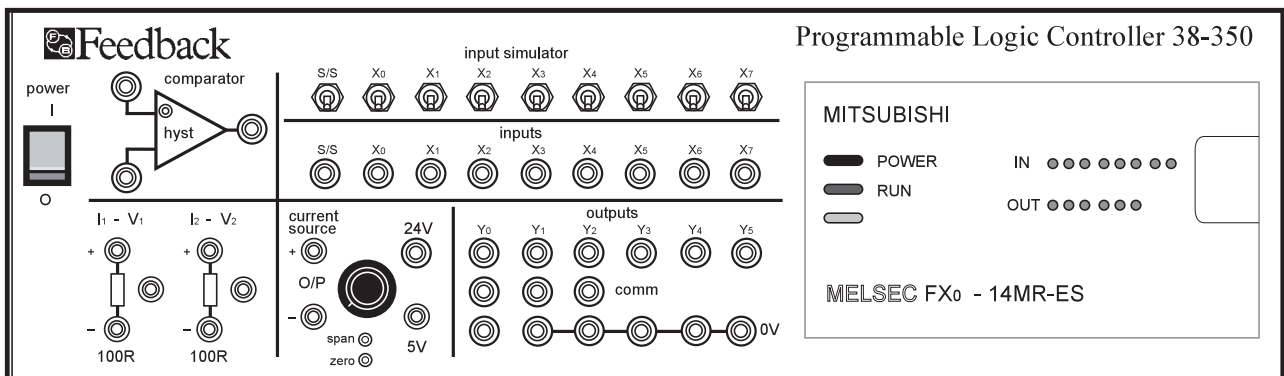
The Process Interface and Process Controller are identical to those used in the **PROCON** Level/Flow Process and Temperature Process Control Systems.

## Assignments

---

**Discovery** Software, similar to that for the other **PROCON** Process Control Systems, is provided and the assignments that can be performed are:

- **Introduction to PROCON**
- **Pressure Rig Familiarisation**
  - The Input Converter.*
  - The Pneumatic Control Valve.*
  - The Pressure Sensors and Gauges.*
  - The Air Receiver.*
- **Pressure Rig Calibration**
  - Pressure Sensor Calibration.*
  - Differential Pressure Sensor Calibration.*
  - Input Converter Calibration.*
  - Pneumatic Control Valve Calibration.*
- **Interface Familiarisation**
  - Circuit Breaker & Circuit Loop Connections.*
  - The Input Converter.*
  - The Current-Voltage Converters.*
- **Interface Calibration**
  - Current Source Calibration.*
- **Controller Familiarisation**
  - Serial Communication.*
  - Navigating the Controller.*
  - Using the Controller.*
- **Controller Calibration**
  - Controller Calibration.*
  - Controller Relays.*
  - Reading the Controller.*
- **Pressure Transmitter**
  - The Pressure Transmitter (PT).*
  - Calibrating the PT.*
  - A Pressure Control Demonstration.*
- **Differential Pressure Transmitter**
  - The Differential Pressure Transmitter (DPT).*
  - Calibrating the DPT.*
  - The Square Root Extractor.*
  - A Flow Control Demonstration.*
- **Manual Control**
  - Operation of Pneumatic Control Valve.*
  - System Response without Air Receiver.*
  - System Response with Air Receiver.*
- **Proportional Control: Pressure**
  - Proportional Control of Pressure.*
  - Proportional Control and Offset.*
  - Proportional Band.*
- **Proportional Control: Flow**
  - Proportional Control of Flow.*
  - Proportional Control and Offset.*
  - Proportional Band.*
- **PI & PID: Pressure Control**
  - PI Control of Pressure.*
  - Limitations of PI Control.*
  - PID Control of Level.*
- **PI & PID: Flow Control**
  - PI Control of Flow.*
  - PID Control of Flow.*
- **Tuning PID Controllers**
  - Zeigler-Nichols Tuning.*
  - Self-Tuning.*
- **Process Controller: Advanced**
  - Remote Set-Point.*
  - Profile Programming.*
  - Time Proportional Output.*



**Features**

- Stand-alone PLC or fully compatible with PROCON equipment range.
- Uses Industrial Standard PLC unit.
- Housed in sturdy metal case.
- All connections brought out to 4mm sockets.
- Power supply included.
- Complete with input simulator bank, variable 4-20mA current source, current to voltage converters and a voltage comparator.
- PLC unit can be programmed in Instruction List or Ladder Logic formats.
- Supplied with PC-based software for program development.
- Introductory tutorial guide to PLCs.
- Hand-held programmer available as an option.

**Description**

The Programmable Logic Controller is a fully functioning industrial PLC unit housed in a rugged metal case with all connections brought out to 4mm sockets. The unit is capable of operating with 24V or 5V logic signals and can also accept 4-20mA current loop inputs via the current to voltage converters and the voltage comparator. A variable 4-20mA current source with adjustable span and zero is also provided. The voltage comparator has a variable hysteresis setting to allow the PLC to control analogue events.

The Controller is fully compatible with the PROCON range of Process Control Rigs and controllers.

**Program Development Software**

The unit is supplied with a PC-based program development environment which allows programs to be created in either Instruction list or Ladder logic formats. Once developed the programs are downloaded to the PLC for execution. The software has a monitoring facility which allows the status of the various PLC registers to be displayed on the PC as the program is running. Programs are stored in an EEPROM in the PLC unit so the program is retained when the unit is switched off.

The PLC unit also has an externally adjustable timer which, together with the variable hysteresis control, is very useful for control applications.

**Application**

When used in conjunction with a Process Controller, it is possible to use the Programmable Logic Controller with any of the processes incorporating on/off control elements.

The user may create sequences using conventional ladder logic and demonstrate the programming on the controller itself, without a process actually being connected.

Together with a Process Rig, Process Interface and Process Controller the following subject areas may be studied:

- **Production of Ladder Logic Diagrams for sequence control and evaluation using manual switches and LED's.**

Sensing and Sequencing control of the following:

- **Basic Process Rig:**  
Control of the Water Pump.  
Control Solenoid Valves.
- **Basic Process Rig with the Level Sensor Pack:**  
Sensing the level in the Process Tank.  
Control of the Water Pump.  
Control of Solenoid Valves.
- **Temperature Process Rig:**  
Sensing Temperature.  
Control of the Heater.  
Control of the Circulating Pump.

# PROCON Tender Specifications

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## **PROCON Level/Flow Process Control System 38-001**

A self-contained, benchtop mounted, Level and Flow Process Control trainer using water as the process fluid. The system to contain a Basic Process Rig, a Process Interface, an industry standard Process Controller and Level and Flow Sensors and Transmitters producing 4-20mA signals. The system to operate with computer aided laboratory software which provides on-screen instruction, control and instrumentation. Sixteen computer-based assignments are to be provided with the system.

---

## **PROCON Temperature Process Control System 38-002**

A self-contained, benchtop mounted, Temperature Process Control trainer using water as the process fluid. The system to contain a Temperature Process Rig, a Process Interface, an industry standard Process Controller and Temperature and Flow Sensors and Transmitters producing 4-20mA signals. The system to operate with computer aided laboratory software which provides on-screen instruction, control and instrumentation. Sixteen computer-based assignments are to be provided with the system.

---

## **PROCON Level/Flow and Temperature Process Control System 38-003**

A self-contained, benchtop mounted, Level/Flow and Temperature Process Control trainer using water as the process fluid. The system to contain a Basic Process Rig, a Temperature Process Rig, two Process Interfaces, two industry standard Process Controllers and Level, Flow and Temperature Sensors and Transmitters producing 4-20mA signals. The system to operate with computer aided laboratory software which provides on-screen instruction, control and instrumentation. Twenty two computer-based assignments are to be provided with the system.

---

## **PROCON Pressure Process Control System 38-004**

A self-contained, benchtop mounted, Pressure Process Control trainer using air as the process fluid. The system to contain a Pressure Process Rig, a Process Interface, an industry standard Process Controller and Pressure Sensors and Transmitters producing 4-20mA signals. The system to operate with computer aided laboratory software which provides on-screen instruction, control and instrumentation. Sixteen computer-based assignments are to be provided with the system.

---

## **Programmable Logic Controller 38-350**

A stand-alone, robustly packaged unit which is fully compatible with the Level, Flow, Temperature and Pressure Process Control Systems. The Controller to include power supply and use an industrial standard PLC unit. To be programmed in Instruction List or Ladder Logic formats and supplied with PC-based software for program development. The Controller to operate with 5V and 24V logic signals and 4-20mA current loops. A 4-20mA current source with adjustable span and zero is also to be included.

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# PROCON Process Control Trainer Product Numbers

Listed below are the product numbers of the constituent parts of the four Process Control Systems. Each of the systems may be ordered complete, using the composite order numbers given in the heading of the relevant section. However, if you already have a compatible controller, interface or measuring equipment you may not need all of the equipment in the systems. In such cases you may order just the equipment that you do require. Please contact either your local agent, or Feedback, if you require more information.

<b>Equipment in PROCON Level/Flow Process Control System 38-001 Composite</b>	Basic Process Rig	38-100
	Process Interface	38-200
	Process Controller	38-300
	Level Sensor Pack	38-400
	Flow Sensor Pack	38-420
	Digital Display Module	38-490
	<b>Discovery Software Pack</b>	38-900
<b>Equipment in PROCON Temperature Process Control System 38-002 Composite</b>	Temperature Process Rig	38-600
	Process Interface	38-200
	Process Controller	38-300
	Temperature Sensor Pack	38-440
	Auxiliary Control Pack	38-480
	Digital Display Module	38-490
	<b>Discovery Software Pack</b>	38-900
<b>Equipment in PROCON Level/Flow and Temperature Process Control System 38-003 Composite</b>	Basic Process Rig	38-100
	Temperature Process Rig	38-600
	Process Interface (2 off)	38-200
	Process Controller (2 off)	38-300
	Level Sensor Pack	38-400
	Flow Sensor Pack	38-420
	Temperature Sensor Pack	38-440
	Digital Display Module (2 off)	38-490
	<b>Discovery Software Pack</b>	38-900
<b>Equipment in PROCON Pressure Process Control System 38-004 Composite</b>	Pressure Process Rig	38-714
	Process Interface	38-200
	Process Controller	38-300
	Pressure Sensor Pack	38-460
	Digital Display Module	38-490
	<b>Discovery Software Pack</b>	38-930
<b>Optional Equipment</b>	Programmable Logic Controller	38-350

## Ordering Information

To order any of the PROCON Process Control Systems simply quote the title and number of the System, as given at the start of each section.

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For further information on these and other equipment in the Control & Instrumentation range contact . . . . .



**Feedback Instruments Limited**

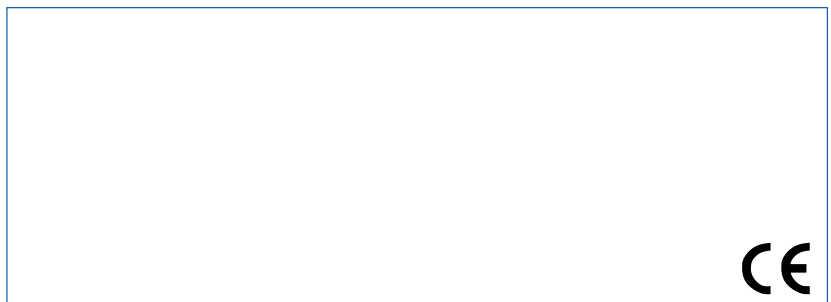
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