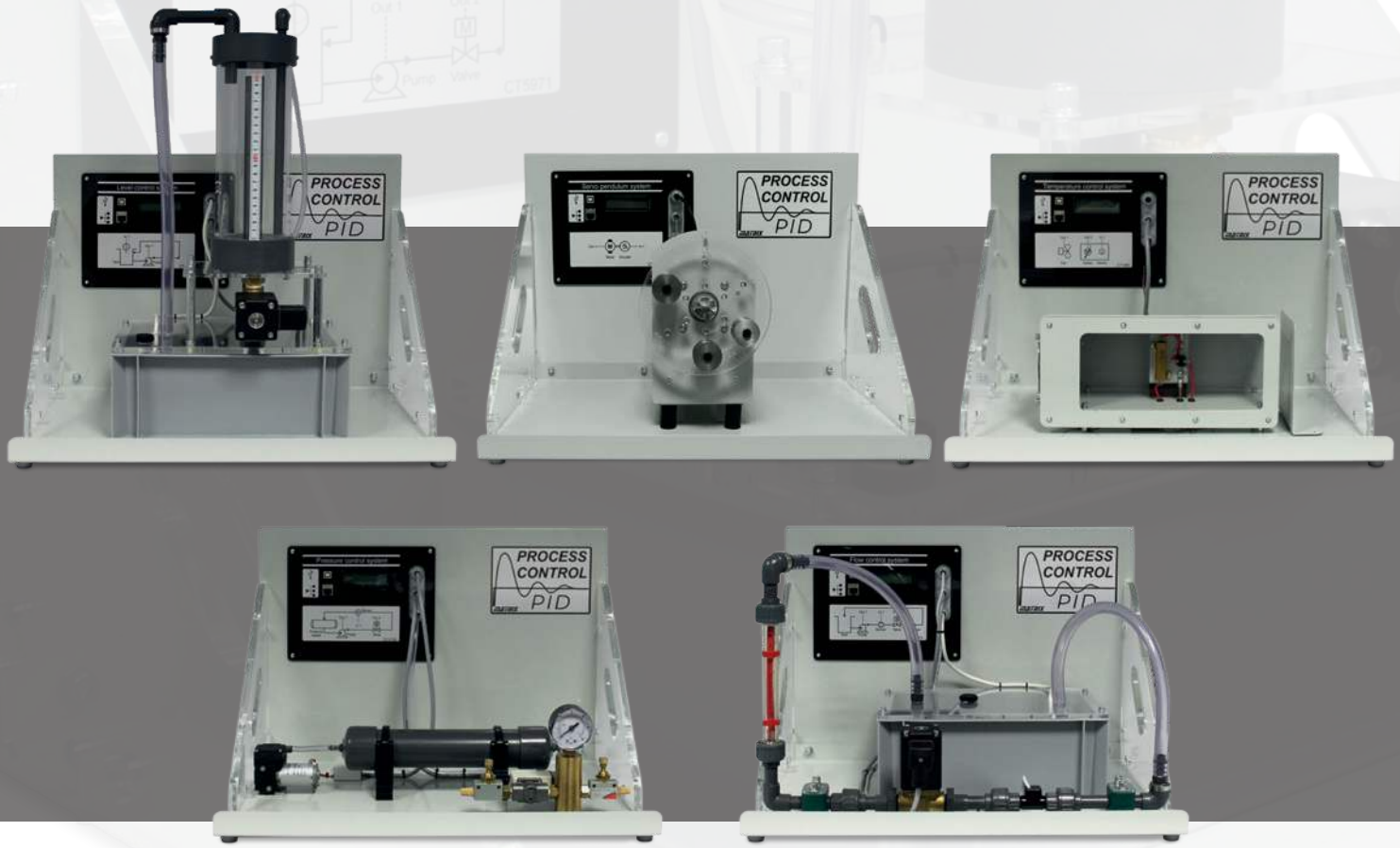
PROCESS CONTROL

PID

Modern Process Control



MATRIX

www.matrixtsl.com

Summary

Temperature

Flow

Pressure

Level

Servo/Pendulum

The Modern Process Control system from Matrix, allows students to investigate the principles of industrial process control, using independent Temperature, Pressure, Flow, Level and Servo/Pendulum systems. An advanced digital controller/logger with USB, WiFi, Bluetooth and LAN communications is built into each set of equipment.

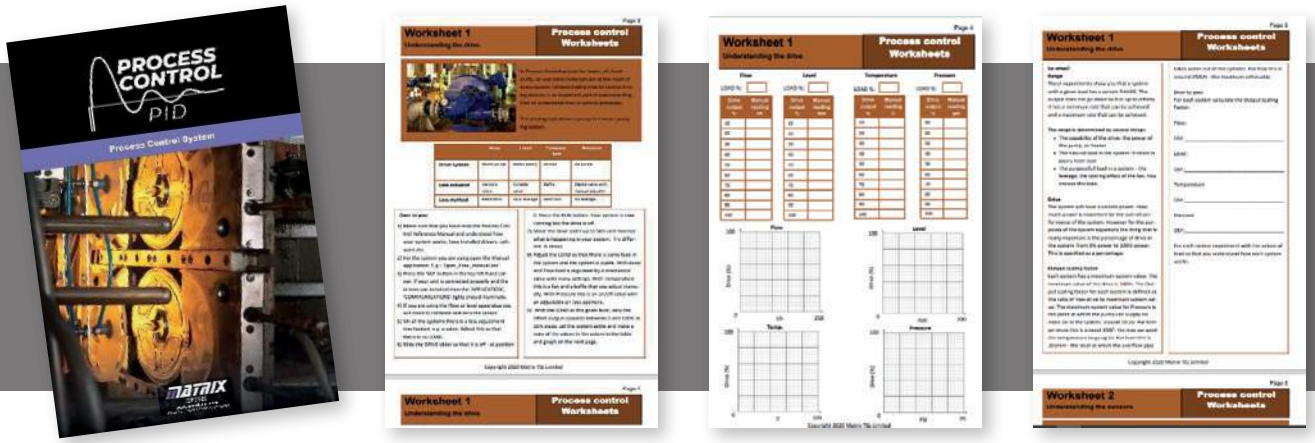
Three sets of Windows PC software are supplied free of charge: Basic control, On Off control and PID control. Software includes all settings and functions and on-screen graphing of Set point, Process value and Kp, Ki, and Kd terms in the Control Equation which is displayed dynamically. Data can be viewed on the internal graph or saved to a CSV file for later analysis.

Equipment is compatible with 110 – 240V operation with power supply provided. Full documentation is supplied with the units, including a Reference manual for the equipment and a curriculum workbook which guides students through the use of Process control systems.

An API is provided which makes the equipment compatible with MATLAB, Labview or other software.

These sets of equipment are suitable for delivery of various qualifications for students aged 16 and above, studying multiple disciplines including instrumentation and control, electronic engineering, mechanical engineering, and chemical engineering.

Curriculum



All units come with a full curriculum with hours of learning, including teachers notes and a user manual. Both of which are available in our learning centre at www.matrixtsl.com/learning

Learning objectives

- Servo control systems
- Inverting pendulums
- Drive systems and their scaling factors
- Sensor characteristics, scaling factors, calibration
- On/off control systems, oscillation, hysteresis
- System time constants
- P control systems and offset error
- PI control systems
- PID control systems
- Control functions and block diagrams
- Pseudocode implementations of P, PI and PID systems
- Recognition of problems in PID systems
- Integral wind up issues and overcoming them
- Derivative filtering
- Ziegler Nichols algorithm
- Manual tuning of PID systems
- Transfer Functions for digitally samples systems

These learning objectives are covered in the worksheets with the software provided.

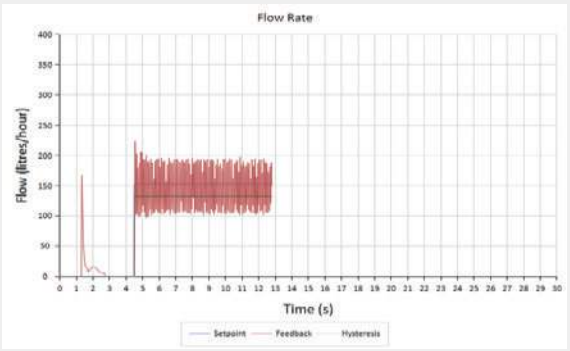
Worksheets and Curriculum

- Understanding the drive
- Understanding the sensors
- On/Off control systems
- System time constant
- P controller
- PI controller
- PID controller
- Zeigler Nichols algorithm
- Integral wind up
- Derivative filter
- Manual tuning
- Interfacing with MATLAB/LabVIEW
- Servo pendulum - angle control

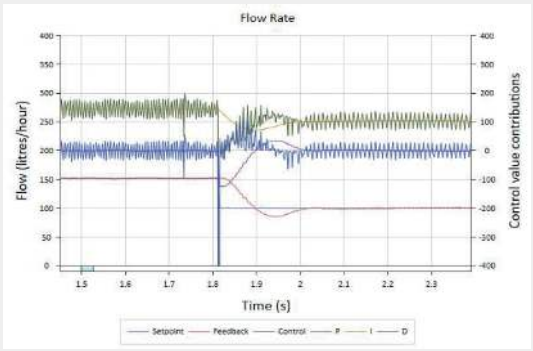
Flow

The Flow system consists of a water tank, variable speed pump, a turbine type flow sensor, an electrically operated proportional valve and a variable area flow meter (rotameter). This allows students to adjust the flow rate via the pump speed and the valve opening to develop a PID based control system.

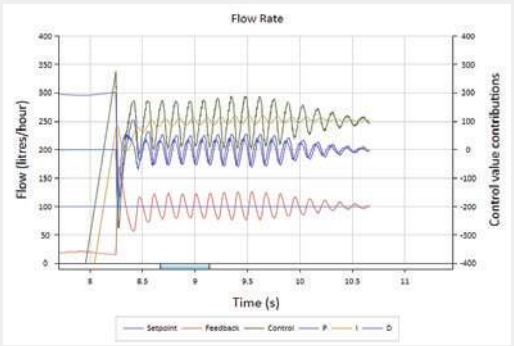
Typical results :



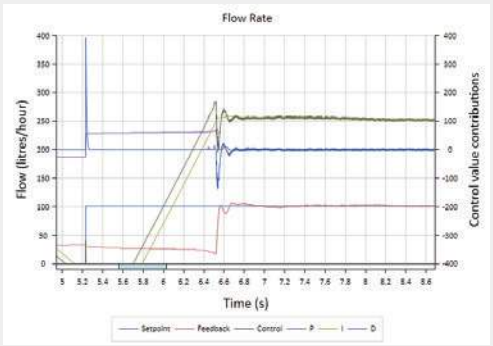
On/Off control



Zeigler Nichols PID classic settings



PID classic with derivative filter



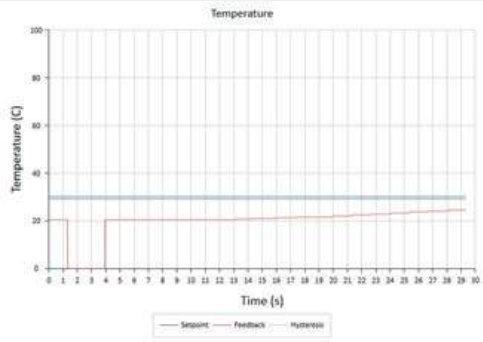
Zeigler Nichols no overshoot settings

Includes
● 4mm x 1.5mm Wall clear PVC tube (300mm)
● UK head for 24V PSU
● 24V PSU 60w 2.5a
● Flow process control assembly
● Barley pot for process control
● USB lead
Order code - CT0673 / CT0673EU / CT0673USA

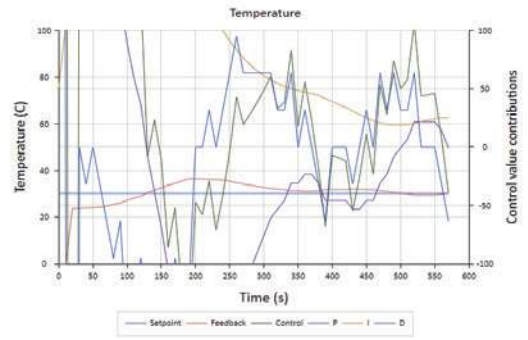
Temperature

The temperature process control system includes a heated plate within a duct and a thermocouple. A fan at one end of the duct blows ambient air over the block, to change the control conditions and provide a disturbance to the system. The system allows students to adjust the heater power and the air flow rate to develop a PID based control system then adjust these parameters to achieve the required time/temperature change profile for the system in response to step changes in system requirements.

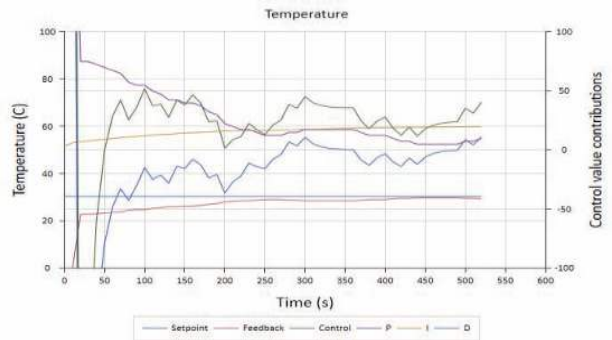
Typical results :



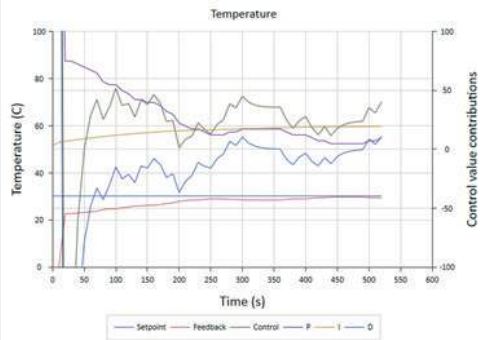
On/Off control



Ziegler Nichols PID classic settings



Ziegler Nichols no overshoot settings



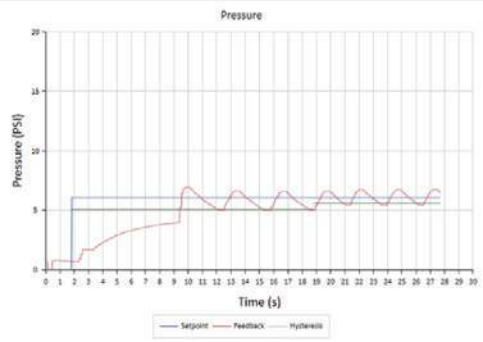
Ziegler Nichols integral clamp
+ derivative filter

Includes
● UK head for 24V PSU
● 24V PSU 60w 2.5a
● Temperature process control system
● USB lead
Order code – CT1491 / CT1491EU / CT1491USA

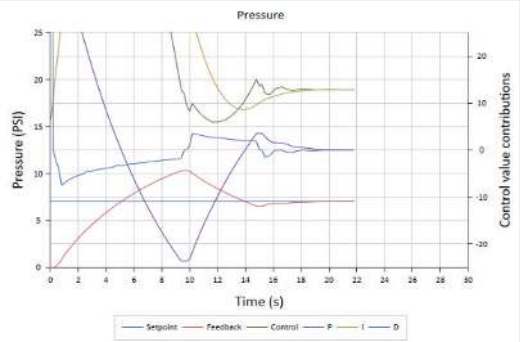
Pressure

The Pressure system consists of a variable speed reciprocating air pump (compressor), the speed of which can be adjusted by students, a pressure vessel and an outflow system. The outflow system allows the air to escape via either a manually operated needle valve - providing an ongoing outflow, or via a solenoid valve and second needle valve - providing a step change in outflow. The vessel pressure is measured by a Bourdon type mechanical gauge along with a pressure sensor. The Bourdon gauge provides a visual indication of the pressure in the vessel and a means for students to check and calibrate the controller input from the pressure sensor.

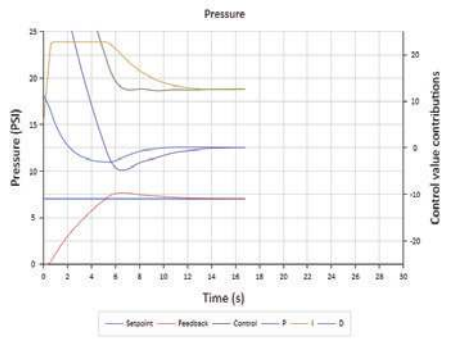
Typical results :



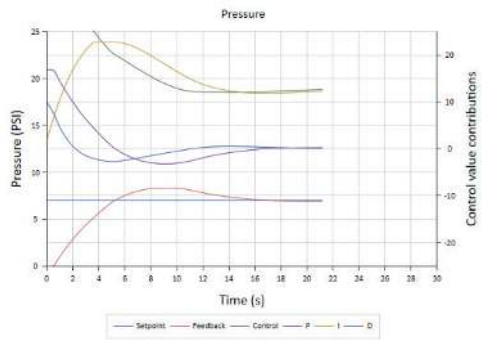
On/Off control



Ziegler Nichols PID classic settings



Ziegler Nichols PID classic with integral clamping



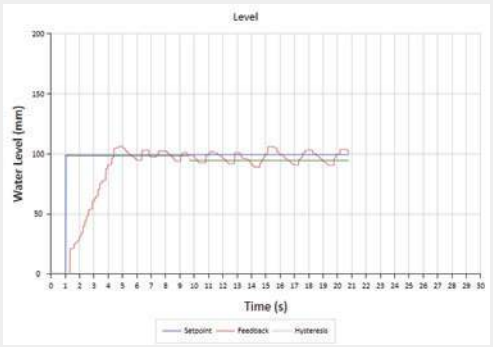
Ziegler Nichols no overshoot settings

Includes
● UK head for 24V PSU
● 24V PSU 60w 2.5a
● Pressure process control system
● USB lead
Order code – CT1733 / CT1733EU / CT1733USA

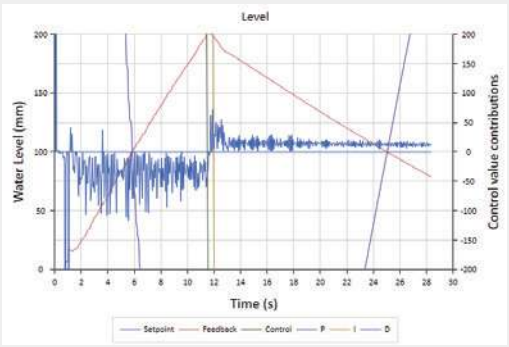
Level

The Level system consists of a reservoir water tank, a variable speed pump, a pressure-based level sensor, and clear process vessel with a scale. A proportional valve provides the process vessel drain. An overflow pipe in the process vessel prevents it being overfilled and the system allows students to adjust the pump speed and valve opening.

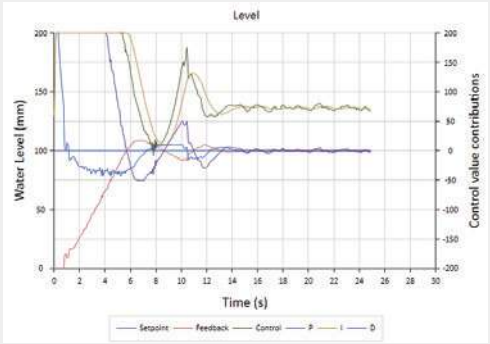
Typical results :



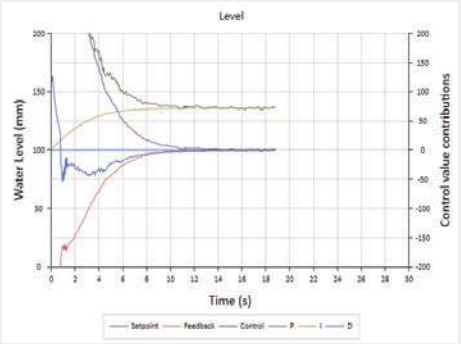
On/Off control



Ziegler Nichols PID classic settings



Ziegler Nichols no overshoot settings



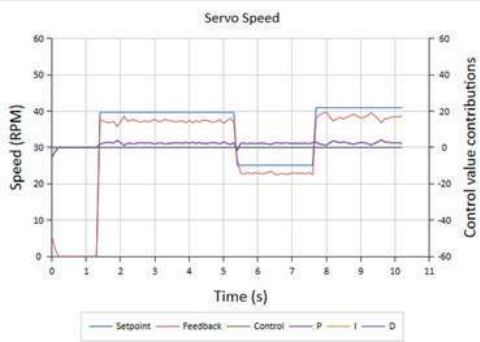
Manually tuned for no overshoot

Includes
● 4mm x 1.5mm wall clear PVC tube (300mm)
● UK head for 24V PSU
● 24V PSU 60w 2.5a
● Level process control system assembly
● Barley pot for process control
● USB lead
Order code – CT5971 / CT5971EU / CT5971USA

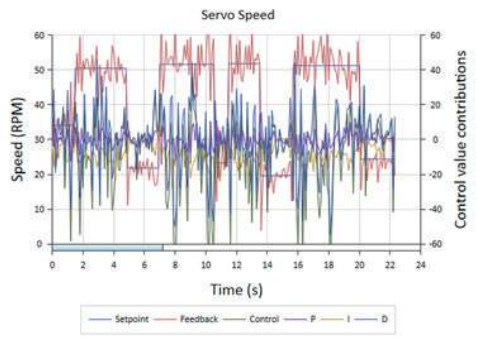
Servo Pendulum Motor Control

The system consists of a powerful DC motor mounted on a rugged frame. A disc with captive nuts is attached to the DC motor and students are able to screw in 100-gram weights to different parts of the disc to alter the characteristics of the system. A single weight at 0 degrees forms an inverting pendulum.

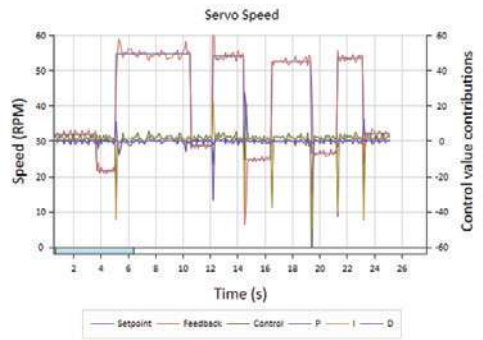
Typical results :



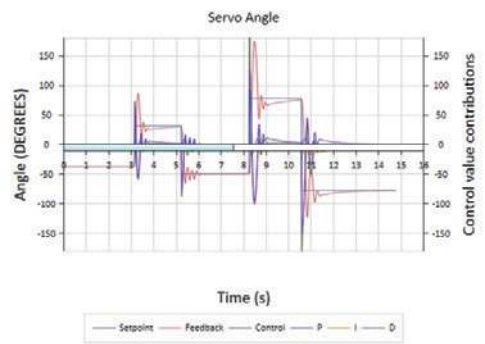
On/Off control



Ziegler Nichols PID classic settings (no derivative filter)

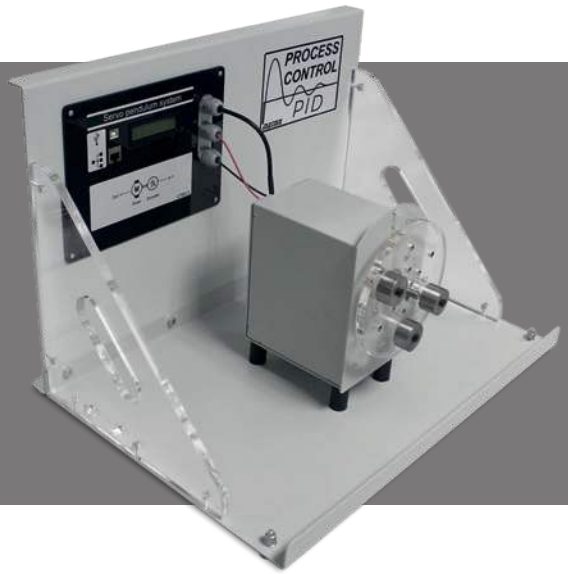


Ziegler Nichols no overshoot settings



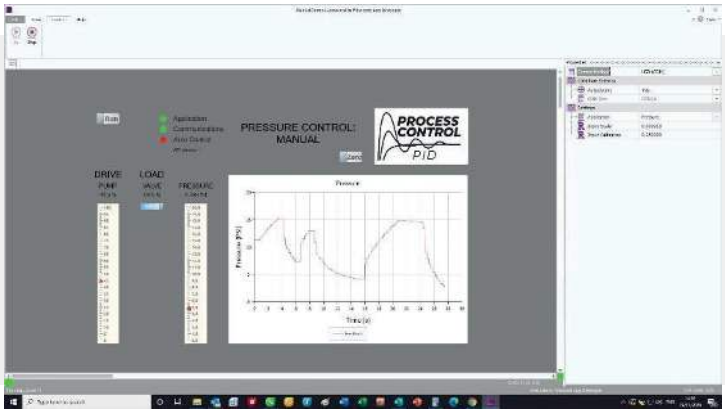
Manually tuned for reduced overshoot

Includes
● UK head for 24V PSU
● 24V PSU 60w 2.5a
● Servo pendulum motor control system
● USB lead
Order code – CT9513 / CT9513EU / CT9513USA

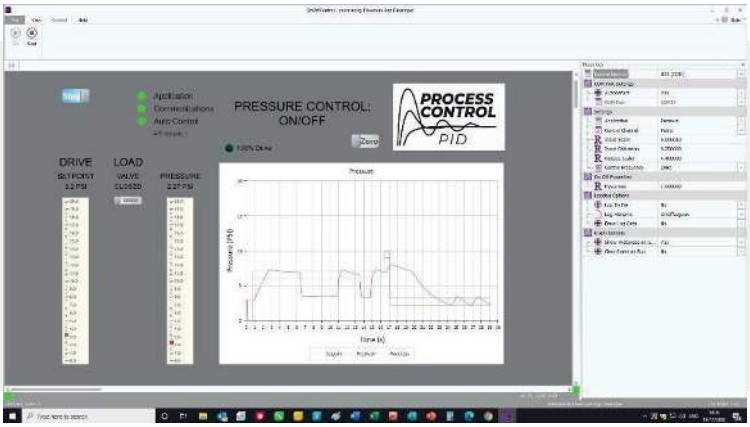


Software and Interfacing

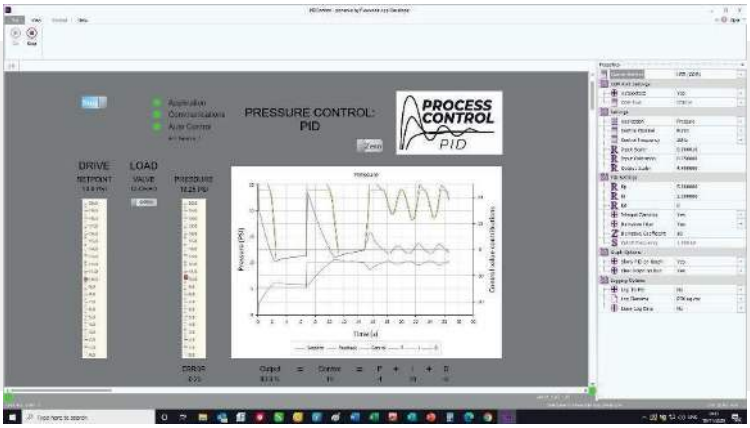
There are currently 3 software applications available with the unit. The software is available free of charge as a download from the Matrix website.
Manual Control gives low level access to the Drive and Load in each system and allows students to calibrate the sensors and drive systems.



On / Off Control allows students to explore controlling each system with a simple on off algorithm, to see the oscillations this produces and to explore the effects of hysteresis.



PID Control allows students to enter values for Kp, Ki, Kd and see how the system reacts to those values.



MATLAB / LabVIEW Compatability

The MATLAB software is available as a download from the Matrix web site. The Control functionality is controlled via a USB COM port or Networked connection to the computer. We have provided a library of functions to allow the various aspects of the Control Hardware to be investigated and controlled.

An Application Programming Interface is provided which makes the equipment compatible with MATLAB, Labview or other software.

Below is a table showing the API specification. This shows you the structure of each command.

	Cmd Code	Param Bytes	Param	Return Bytes	Return	Details
Get API Version	A	0		1	Version	Gets the API version Number
SetAutoPID	B	2	Channel, Enable	0		Controls if the Auto PID is running or not, default not running Channel: 0-1 Enable: 0=Off, 1=5Hz, 2=10Hz, 3=20Hz, 4=50Hz, 5=100Hz, 6=200Hz, 7=500Hz, 8=1000Hz
SetAutoPIDParam	C	5	Index, Value0, Value1, Value2, Value3	0		Sets one of the Auto PID parameters Index: 0=P, 1=I, 2=D, 3=IntergralClamping, 4=DefivativeFitering, 5=Derivative Filter Coefficient
SetAutoPIDSetpoint	D	4	SP0, SP1, SP2, SP3	0		Control the setpoint value as a real world value
SetManualDuty	E	3	Channel, DutyMSB, DutyLSB	0		Sets one of the motor driver output duties Channel: 0=OP0, 1=OP1, Duty = 0-20000
SetFeedbackMethod	F	9	ControlType FBScaler0, FBScaler1, FVScaler2, FBScaler3 OPScaler0, OPScaler1, OPScaler2, OPScaler3	0		Sets which type of feedback to try and collect FBMethod: 0=Level Pressure, 1=Flow Rate, 2=Pressure Pressure, 3=Temperature Temp Also sets Feedback and Output Scalers
GetFeedback	G	0		4	FB0, FB1, FB2, FB3	Gets the Feedback Value as a Real World Value
GetOutput	H	0		1	Output	Gets the Scaled Output Value as an integer 0 - 100
SetAutoOnOff	I	2	Channel, Enable	0		Controls if the Auto On/Off is running or not, default not running Channel: 0-1 Enable: 0=Off, 1=5Hz, 2=10Hz, 3=20Hz, 4=50Hz, 5=100Hz, 6=200Hz, 7=500Hz, 8=1000Hz
SetAutoOnOffParam	J	4	Value0, Value1, Value2, Value3	0		Sets the On/Off hysterises
GetPIDComponent	K	1	Index	4	Comp0, Comp1, Comp2, Comp3	Gets a component of the PID calculation in real world units, 0=P, 1=I, 2=D
ZeroSensor	L	0		0		Zeros the Pressure Sensors
SetAutoPIDFlip	M	1	Flip	0		Controls if the PID and On/Off control requires positive or negative feedback
GetDataArraySize	N	0		1	ArraySize	Returns the number of queued samples in the data array
GetDataArray	O	0		10	SPMSB, SPLSB FBMSB, FBLSB PMSB, PLSB IMSB, ILSB DMSB, DLSB	Returns a single queued sample from the data array
GetDataArray x 6	P	1	Count	60	6 x GetDataArray	Returns Count * 6 queued samples from the data array, sent in packets of 60 bytes
Set Wifi Mode	Q	1	Mode	0		Configures whether to host or join a network 0=Off / 1=Host / 2=Join
Set Wifi SSID	R	STR	STRING	0		Set the WIFI SSID - Max 32 Chars
Set Wifi Password	S	STR	STRING	0		Set the Password - Empty string leaves network open - Max 32 Chars
Set Bluetooth Mode	T	1	Mode	0		Configures whether to power up BT module 0=Off / 1=On
Set Bluetooth Name	U	STR	STRING	0		Set the BT Friendly Name
Set Bluetooth Key	V	STR	STRING	0		Set the BT Passkey
Set CAN ID	W	2	ID	0		Sets the CAN bus listen ID
Set CAN Mode	X	1	Mode	0		Configures whether to power up CAN module 0=Off / 1=On
Get Wifi IP	Y	0		STR	STRING	Collects the WIFI IP address if the WIFI is enabled
Set WIFI Port	Z	2	PortMSB, PortLSB	0		Sets the WIFI Port Number
Set Ethernet Mode	a	1	Mode	0		Configures whether to power up the Ethernet module 0=Off / 1=On
Set Ethernet IP	b	4	IP0, IP1, IP2, IP3			Sets the Ethernet IP address bytes
Set Ethernet Port	c	2	PortMSB, PortLSB	0		Sets the Ethernet Port Number
Set Auto Prescaler	d	1	Prescaler	0		Sets the auto mode prescaler to divide down the calculation frequency if required
Reset To Boot	z	0		0		Reset to Bootloader Mode

MATLAB / LabVIEW Compatibility

LabVIEW™

MATLAB

PROCESS CONTROL PID

For more information, do not hesitate to contact us

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MATRIX

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