CONTROL TRAINER (Model : XPO - PID) *[Family of training systems]*

USB IO MODULE

SALIENT FEATURES

- Learn how an Analog as well as Digital PID works.
- Facility to monitor behavior of the controller output (Un) & process variable (MV) either on PC screen or on CRO. Settable time constants.
- P4/XP or latest version window based PID controller (DDC) software package with P, PI & PID control, Ratio & cascade control, three operating modes, Online graph drawing & data acquisition modes (SCADA). PC not in scope of supply
- Can learn about different processes using simulated building blocks as well as real life processes using replaceable experiment panels/processes and built in square / triangle / sin function generator as disturbance.
- Graph printing facility for laboratory journal entries.
- Aesthetically designed injection molded electronic desk (master unit) carrying useful experiment resources like Power supplies, DPMs, Computer Interface, Analog PID controller with central slot to hold various replaceable experiment panels / processes.
- Connection through sturdy 4mm Banana sockets & Patch cords, Students workbook & Instructor's Guide provided.
- Useful for Post Graduate projects and research purpose.
- Optionally SDK for Matlab & Labview provided.

Specification of Master Unit (MU)

Basic Resources on Top board

Built in power supply

DC supply ±12V,500mA.

1phase sine reference for cosine firing 30Vpp max.

17Vdc, 500mA unregulated for driving pulse X'mer

Variable DC power supply : 7 to 14V/3A

Display

A) DPM - 2Nos.

i) For Temp. upto 100°C & intensity in Lux (2000)

ii) For speed 2000 rpm & voltage upto 20V.

B) Analog Meter - 2Nos.

i) Centre zero for display of process error (±9V)

ii) For MV/SP (0-2.5V)

Operating voltage

Switch selectable 220-240Vac, ±10%, 50Hz, 75VA

Mechanical Dimensions

Master Unit :460mm(W), 160mm (H), 350mm(D)

Net weight: 6.5 Kg. Gross weight : 8.5 Kg.

b) Panel : 215mm(W), 165mm(H), 40mm(D)

Net weight: 700gm approx.

PC (WIN7/8/10) based PID controller (Optional)

Online monitoring / Data acquisition / PID Software : on Installable (CD) works under XP, WIN7/8/10 PC with parallel port / USB needed.

Operating modes

a) Simulator Mode

Tests data already stored in files (*.txt) & Drawing graph for all P,PI,PD & PID modes.

b) Process Monitoring Mode

Drawing graphs of analog data presented at CH 0 & CH1 of Computer Interface. Cursors for X & Y axis for measurement & online graphs savings for reproduction

c) PID controller Mode

- PID controller with parameters like Integral Time Ti (0.01-64000), Sampling Time Ts (0.1- 99.9), Derivative Time Td (0.1-99.9), Proportional Band Pb(1-999), Derivative Gain Kd(1-999), Set Value Rn (0-99.9), PID output Upper Limit Uh(0-99.9), PID output Lower Limit Ul (0-99.9).
- Facility to set units for output viz. Percentage (%), °C, RPM, Voltage(V), mm, LPH, kg/cm^2, msi/cm, degree.
- Supports experiments with advance process control scheme viz; Ratio, Cascade, feed forward with user selectable Aux PID, Ratio station & programmable FF transfer function calculator, selective and split control strategies, Multi DPM Screen.

Computer Interface Adapter / CIA

- Optoisolated Adaptor to prevent damage to PC parallel port (25 pin LPT) due to wrong connections. Interfaces through 25 pin M to F cable 1mtr Length. PC/WINXP/7/8/10 not in scope of supply.

  4 ADC channels : 0 to 2.5V full scale.

  1 DAC channel : O/P 2.5 V FS.

  V to I Function block : Input : 0-2.5Vdc

  O/p: 0-20 or 4-20mA, in 100E load Max
- USB IO module to interface 25 pin D connector on CIA panel to USB PC port enclosed in 25 Pin D shell using Type A to mini B cable.

- V to PWM function block : I/P -0-2.5V, O/P-1KHz PWM O/P ±9V.

Analog PID (APID) controller with built in low freq. function generator

- **Controller selection P,PI,PD,PID with slide switch**
  Parameter settings : Integral Time Ti (0.5-25Sec)
  : Derivative Time Td (0-2Sec)
  : Proportional Band Pb (5-200%)
  : Set point (-9V- +9V)
- **Operating modes :** Fast (X 100/10mSec) for oscilloscope,
  Slow (X 0.1/1Sec) for PC interface.
- 2 No. Level shifter converting process O/p (±9V) to 0-2.5V for PC interface & Actuator panel
- Test points for Process Error, Set Point (Rn), Measured Value (Cn), Controller output (Un).

Built in function generator

- O/p waveform selectable sine, triangular & square.
- O/p freq. range from 0.016Hz to 166Hz, 4 steps & fine control pot.
- Variable amplitude control 0 to ±9V.

Modular Expt. Panels offered

(Must select atleast one of following panels to work)

1) Process Simulator Panel / CE1

[Provided with 49 banana tags]

- Functional blocks for Lag (3 No.), Integrator (3 No.), Transport Lag (1 No.), Summer (2 No.), Gain (1 No.), Inverter (2 No.) for constructing simulated Type 0,1,2,3 & 1st,2nd,3rd Order processes to work under PID.
- Experiments with Lead / Lag / Lead - Lag compensators to control behaviour of matching processes using above function blocks.
- Open loop & close loop response of processes under different P, PI, PID - Analog or Digital controllers. Experimental varification of PID Controller settings (Pb, Ti, Td)
- Auto Tuning explained using Ziegler Nicolas I & II.
- Fast (10mS) & slow (1sec) mode selection for all processes to observe response on either CRO or PC using CIA.
- Drawing Bode plot & Nyquist plots, transfer function determination.
- Advance process control scheme viz; Ratio, Cascade, feed forward.
- Level shifters (2No) +9V to 0-2.5V & 0-2.5V to +9V to match voltage levels of PC (2.5V) and opamps (+9V).

2) Thyristor Actuator panel (TAP) /EMT9 (CE2)

[Provided with 13 banana tags]

- Thyristor bridge based 0-200V/3A cosine firing circuit, I/P 0 to 2.5Vdc. Supports signal conditioning of RTD (PT100), Thermocouple K type & Photodiode to give output 0-2.5Vdc (FS).
- Facilitates closed loop control experiments based on temperature, light intensity, speed measurement using built in P/PI controller as well as external Analog / Digital PID controller.

3) Stepper Motor Demonstrator Expt. Panel (P25) / (Modified)

[Provided with 15 banana tags]

Direction, speed, auto, manual operations of Stepper Motor, Position control by step operation, Position control by continuous operation, Angle control by step operation, Speed control by control switch, Angle control by software, Dynamic current / torque characteristics. Closed loop experiment with servo pot for PID experiments, V to F function block.

4) Servo Interface panel (SIP) / CE3

[Provided with 36 banana tags]

Control Interface circuit for AC & DC servo motor, signal conditioning circuit for speed sensor to O/P 0 - 2.5VDC (2500RPM) with speed direction.

Level shifter 0 - 2.5V to ± 9V (2nos).

- **Relay control characteristics :** Hystersis, Dead band & Relay control circuit (2term & 3 term), process block for 2Nos. of 1st order lag / integral + transport lag, error and gain block for process simulation. Phase plane analysis by display of X & X dot.

5) Computer Interface panel / CIP

- V to I function block: I/P 0 to 2.5V & O/P 0-20 or 4-20mA (100Ω load) switch settable.
- I to V function block : I/P 4 to 20mA & O/P 0 - 2.5V
- Opamp based relay control circuit with set point & feed back controll to drive 2 Φ synchronus motor using 2 relays, manual & auto operation.

Process -I Temperature/Light

Optional Process Setup :

Process I	Temp/Light
Table Top assembly / accessaries	Process box containing 3 high wattage (60W) bulbs under aluminum plate as heater. Built in fan, lamp as disturbance generator.
Panel	TAP (CE2/EMT9)
Sensor	RTD for temp. control upto 100°C with built in CAL facility, Photodiode for light intensity control upto 2000lux.
Mechanical Dimension	280(L)x115(W)x160(H) Powder Coated Weight : 2Kg.

List of Experiments:

- PID tunning by Ziegler - Nichols
- Transfer function determination
- Operation under various P/I/D options.
- Open loop response to step input (transfer function determination)
- Close loop control with Analog PID
- Close loop control with Digital PID
- Close loop control with built in Proportional controller / lag compensator (PI controller) PID control with PWM O/P

Process -II High Temperature

Process II	High Temp.
Table Top assembly / accessaries	Electric Bunsen Burner (300W) with 50cc heating volume. (Works with DPID only as large transport lag)
Panel	TAP (CE2/EMT9)
Sensor	K type stainless tube encapsulated TC for temp control upto 550°C
Mech. Dimension / Wt.	200(L)x130(W)x270(H) Powder Coated Weight: 2Kg.

List of Experiments

- PID tunning by Ziegler - Nichols
- Transfer function determination
- Operation under various P/I/D options.
- Open loop response to step I/P transfer function determination)
- Close loop control with Digital PID
- Close loop control with set point change
- Close loop control with process disturbance

Process III : DC Servo Position Control

Process III	DC Servo Position Control
Table Top assembly / accessaries	• PMDC Motor 12V DC, 40 Watt ND RPM 2000 RPM with gear box (Ratio 30 :1) • Loading : Using PMDC Motor @ 12V/5A max. Servo Amplifer with built in 12V/3A power supply.
Panel	SIP (CE3)
Sensor	• Photo reflective speed sensor with direction detect using 2 pairs of photo emitter detector giving Quadrature o/p's • Servo pot as position feedback
Mechanical Dimension /Wt.	365(L)X220(W)X95(H)mm / 10Kg

List of Experiments

- PID tunning by Ziegler Nichols Motor Process parameter study torque speed (optional) Dynamics measurements & transfer function determination.
- Close loop position control using 2/3 step controller.
- Close loop using 2/3 step controller with simulated processes.
- Open loop speed control of DC servo motor process III.
- Speed/Velocity control of DC motor
- Close loop control with analog pid
- Close loop control with digital PID
- Position control of DC motor
- Cascade control of speed & position feedback

Process IV : AC Servo Position Control

Process IV	AC Servo Position Control
Table Top assembly /accessories	• AC geared (50:1) 2 phase servo motor. Main winding : 230VAC Control Winding : 6VAC /1A O/P shaft RPM 25 (D), ND RPM 2500 • Loading: Using small PMDC motor @ 12V/1A max. Servo amplifier with built in 12V/ 3A Power Supply.
Panel	SIP (CE3)
Sensor	Servo pot as position feedback
Mechanical Dimension / Wt.	365(L)X220(W)X95(H) mm / 8 kg.

List of Experiments

- PID tunning by Ziegler Nichols Motor Process parameter study torque speed (optional) Dynamics measurements & transfer function determination.
- Close loop position control using 2/3 step controller.
- Close loop using 2/3 step controller with simulated processes.
- Working with real life process IV. (AC servo motor position control)
- Position control of AC motor
- Open loop Response and determination transfer function.
- Torque-Speed Characteristics Of AC Servo Motor Close loop control of AC SERVO Motor (optional)
- Set Point Position Control of AC Motor

Process V : Stepper Motor

Process V	Stepper Motor
Table Top assembly / accessaries	Stepper (3kgcm/12V) Coupled to servo pot.
Panel	P25
Sensor feedback	Servo pot as position
Mech. Dimension (mm) /Wt.	220(L) x 100(W) x 92(H) Powder Coated / 2Kg.

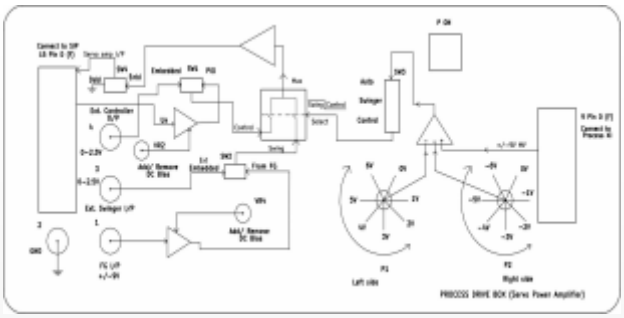
List of Experiments

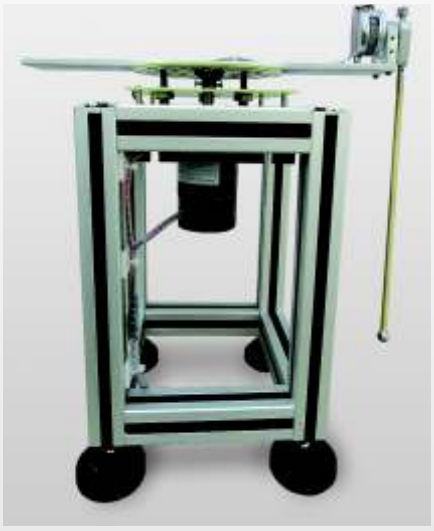
1) Study of Stepper motor behaviour underopen loop / closed loop
2) Open loop stepper control under Manual/Auto modes
3) Closed loop stepper motor control using PID Controller

Process IX : AC Voltage Servo Stabilizer

Process IX	AC Voltage Servo Stabilizer
Table Top / 240VAC 100mA assembly/ accessaries	• AC synchronous 2 Phase Motor 60 rpm, 2 kgcm Torque. • Variac 0-270VAC/0.75Amp.
Panel	CIP
Sensor	PT (270 VAC Prim. /12 VAC 100mA Sec.) followed by Precision Rectifier O/P 0-2.5V DC
Mechanical Dimension/Wt.	365(L) X 220 (W) X 95 (H) mm/ 8 kg.
List of expt.	• Study of AC Servo stabilizer • Working with real life process IX (Servo Voltage Stabilizer) • Close loop and open loop behaviour of voltage stabilizer

Process XI : Inverted Pendulum





Process XI	Inverted Pendulum
Process XI setup	Table top assembly containing DC Servo motor 24VDC/1.3A, 1600 RPM, 12N/cm, 20W, mounted on alluminium profile (30 x 30) table with 10K servo pot as F/B, 300mm long pendulum with 18 dia MS sphere, round track PCB slip rings with 3 graphite brushes.
Process Drive Box	Containing servo amplifier with built in power supply 12V/3A. **Front Operator Panel :** Consisting of 15 pin D (F) connector to interface to SIP & 9 pin D(F) to connect to process XI, 4mm BS5 socket to apply swinger FG I/P from XPO-PID (MU), 3 position switch to select Auto/control/swinger mode, 2 pot knobs to set angular range for control. Optionally can interface with embedded controller using to 2 AOs (3.3V compatible), 1 AI for MV on SIP (3.3V compatible) for students project
Panel	SIP(CE3) located in XPO-PID MU
Feedback Sensor	10K heavy duty Servo pot to indicate vertical standing position, O/P (+9-0- 9V)
Mech. Dimension/Wt.	Table : 200(L) x 200(W) x 350(H) (mm), Wt. of setup = 5Kg Drive Box: 365(L) x 220(W) x 95(H)mm Wt. : 8 kg

List of Experiments :

A) Close loop upright position control of rotary inverted pendulum using 2/3 terms relay controller. Here PID software is used in process monitoring mode to plot

B) Close loop upright position control of rotary inverted pendulum using Digital PID controller. Here PID software acts as controller as well as graph plotting device

C) Close loop upright position control of rotary inverted pendulum using Op-amp based proportional controller (gain of 100 hence can be termed as ON/OFF too). Here Virtual workbench / PID software is used for plotting graph.