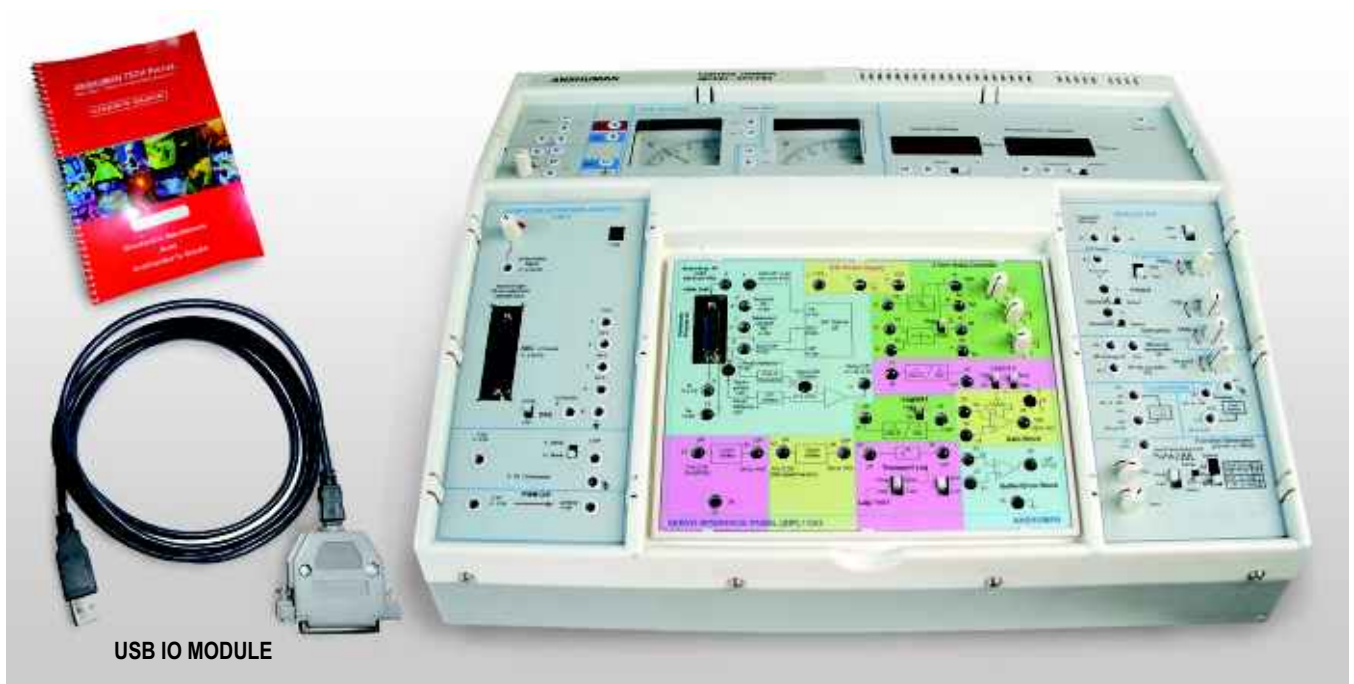


CONTROL TRAINER (Model : XPO - PID) *[a family of training system]*



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.

Specification of Master Unit (MU)

Basic Resources on Top board

- ◆ **Built in power supply**
DC supply $\pm 12V, 500mA$.
1 phase 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 $100^{\circ}C$ & intensity in Lux (2000)
ii) For speed 2000 rpm & voltage upto 20V.
B) Analog Meter - 2Nos.
i) Centre zero for display of process error ($\pm 9V$)
ii) For MV/SP (0-2.5V)
- ◆ **Operating voltage**
Switch selectable 220-240Vac, $\pm 10\%$, 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 (P4/XP/WIN7/FAT32) based PID controller (Optional)

- ◆ **Online monitoring / Data acquisition / PID Software** : on Installable (CD) works under XP, WIN7. 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 & CH 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 T_i (0.01-64000), Sampling Time T_s (0.1-99.9), Derivative Time T_d (0.1-99.9), Proportional Band P_b (1-999), Derivative Gain K_d (1-999), Set Value R_n (0-99.9), PID output Upper Limit U_h (0-99.9), PID output Lower Limit U_l (0-99.9).
- Facility to set units for output viz. Percentage (%), $^{\circ}C$, RPM, Voltage(V), mm, LPH, kg/cm^2 , $\mu si/cm$, degree.
- Optionally experiments with advance process control scheme viz; Ratio, Cascade, feedforward with user selectable Aux PID, Ratio station & programmable FF transfer function calculator.

◆ Computer Interface Adaptor / 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. P4/XP 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 $\pm 9V$.

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 ($\pm 9V$) 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 $\pm 9V$.

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 $\pm 9V$ (2nos).

- **Relay control characteristics :** Hysteresis, 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/PCT1)

- V to I function block: I/P 0 to 2.5V & O/P 0-20 or 4-20mA (100 Ω load) switch settable.
- I to V function block: I/P 4 to 20mA & O/P 0 - 2.5V
- Opamp based relay controlled circuit with set point & feed back controlled 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 / accessories	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 $^{\circ}$ 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	<ul style="list-style-type: none"> • PID tuning by Ziegler - Nichols • Transfer function determination • Operation under various P/I/D options.

Process -II High Temperature



Process II	High Temp.
Table Top assembly / accessories	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	<ul style="list-style-type: none"> • PID tuning by Ziegler - Nichols • Transfer function determination • Operation under various P/I/D options.

Process III : DC Servo Position Control



Process III	DC Servo Position Control
Table Top assembly / accessories	<ul style="list-style-type: none"> • PMDC Motor 12V DC, 40 Watt ND RPM 2000 RPM with gear box (Ratio 30 :1) • Loading : Using PMDC Motor @ 12V/5A max. Servo Amplifier with built in 12V/3A power supply.
Panel	SIP (CE3)
Sensor	<ul style="list-style-type: none"> • 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	<ol style="list-style-type: none"> 1) PID tuning by Ziegler Nichols Motor Process parameter study torque speed (optional) Dynamics measurements & transfer function determination. 2) Close loop position control using 2/3 step controller. 3) Close loop using 2/3 step controller with simulated processes.

Process IV : AC Servo Position Control



Process IV	AC Servo Position Control
Table Top assembly /accessories	<ul style="list-style-type: none"> 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	<ol style="list-style-type: none"> PID tuning 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.

Process V : Stepper Motor



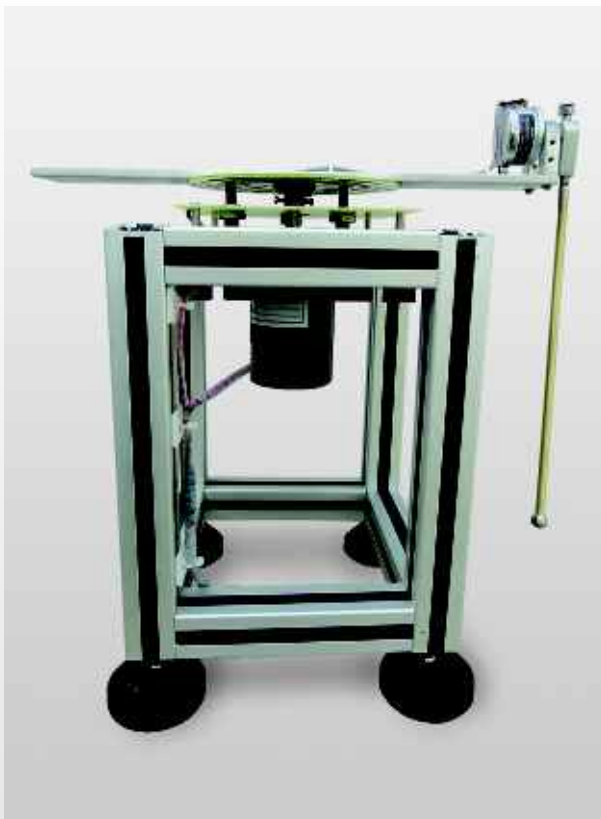
Process V	Stepper Motor
Table Top assembly / accessories	Stepper (3kgcm/12V) Coupled to servo pot.
Panel	P25
Sensor feedback	Servo pot as position
Mech. Dimension (mm) /Wt.	220(L) x 100(W) x 92(H) Powder Coated / 2Kg.
List of Experiments	Study of Stepper motor behaviour under open loop / closed loop

Process IX : AC Voltage Servo Stabilizer



Process IX	AC Voltage Servo Stabilizer
Table Top / 240VAC 100mA assembly/ accessaries	<ul style="list-style-type: none"> 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.	<ul style="list-style-type: none"> Study of AC Servo stabilizer Close loop and open loop behaviour of voltage stabilizer

Process XI : Inverted Pendulum



Process IX	Inverted Pendulum
Table Top assembly / accessaries	DC Servo motor 12VDC/2A, 1800 RPM, 8N/cm, 15W, Standalone servo amplifier with built in power supply 12V/3A, Table Top Set up using 30mm X 30 mm aluminium profile
Panel	SIP(CE3)
Feedback Sensor	Servo pot to indicate vertical standing position
Mech. Dimension/Wt.	200(L) x 200(W) x 300(H) (mm), Wt. of arm = 510gm, wt of setup = 5Kg
List of Experiments	<p>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</p> <p>B) Close loop upright position control of behavior Graph. rotary inverted pendulum using Digital PID controller. Here PID software acts as controller as well as graph plotting device</p>