



This Comprehensive training system contains the following modules :

- **DCMC** DC Motor Control Module
- **COMPOT** Command potentiometer.
- **SCLS** Simulated Control Laboratory Software.
- Cable Set 4 mm Lead set.
- **SPSU** System Power Supply Unit.

- Analog control -an overview
- Describing and identifying system behavior.
- Time and frequency response.
- Principles of feedback.
- Proportional position control.
- Behavior of second order systems.
- Position control with velocity feedback.
- 3-Term or PID control / Stability.
- The use of computers for control.
- Analog and digital interfacing .
- Direct digital control.

#### **DCMC DC motor control module...**

Features of the **DCMC** DC motor control module include :

- DC motor with on-board drive circuitry.
- Angular position indication disc. Calibrated in degrees.
- Tach-generator with switchable load resistor.
- Continuous rotation potentiometer.
- Gray-coded disc and slotted disc.
- Digital tachometer with r.p.m. Readout.

Note: Specifications are subject to change.

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- Three-position eddy current brake.

#### **COMPOT Command potentiometer module...**

The **COMPOT** Command potentiometer is used to provide a manually generated command signal to the control system. The calibrated indicator disc provides an angular position indication in degrees.

#### **SCLS Simulated Control Laboratory Software**

The simulated control laboratory is a comprehensive teaching package that has been designed specifically for use with the following motor control products :

- **DCMC** DC motor control module.
- **COMPOT** Command potentiometer.

When used in conjunction with a windows™ based PC, the **SCLS** Simulated Control Laboratory Software performs the following functions simultaneously.

- Monitors the reference signal from the Command potentiometer.
- Provides a proportional-integral - derivative (PID) controller with adjustable parameters.
- Generates analog / digital signals to control the DC motor module.
- Responds to analog/digital feedback signals from the DC motor module.
- Displays all control and feedback signals on the PC screen.

A competence-based curriculum manual covering both analog and digital control is provided with the SCLS simulated control Laboratory Software.

**The Simulated control laboratory comprises the following items:**



- Real time Windows™ based Simulated Control Laboratory Software (SCLS)
- PC Interface Module (PCIM) and PC connection cable.
- Analog/Digital Motor control curriculum manual.

The main screen of the SCL Software can be divided into four sections, each of which may be configured independently by the user:

- **Control reference (input) signal**
- **Controller**
- **Plant**
- **Display**

**Control reference (input) Signal :** The input can be set from the internal SCLS signal generator or from the external plant Signal generated by the COMPOT Command potentiometer SCLS can provide sine, step, ramp, sawtooth, random, DC level and pulse waveforms. The sampling rate or frequency can be set.

**Controller :** The controller can be set to :

- Open Loop - Reference Signal output directly to allow open loop identification testing.
- Proportional-Provides control of proportional gain.
- Servo-Provides control of gain and velocity feedback.
- PID-Provides control of proportional band, integral time constant and derivative time constant.

**Plant :** External Analog- Outputs the drive signal via the PC analog interface and measures the voltages representing the motor position and velocity.

- External Digital - Outputs the drive signal via the PC PWM interface and measures position and speed using gray code and slotted discs.
- Servo - Simulates a servo system by providing output and velocity signals. Used with the servo controller for simulations.
- Process - Simulates a 2nd order plant without an integrator Transport delay can be added. Used with the proportional and PID controllers.

The appropriate external plant should be selected when using the DCMC DC motor control module. The servo and process plant simulations can be used to illustrate behavior not displayed by the real plant and can illustrate the differences between theory and practice.

**Display :** The eight-channel real-time display can show all the control signals involved in oscilloscope, bar graph, panel meter and list forms. The channels are color coded according to their positions within the control loop. For clarity, traces can be switched OFF when not required.

The display can be frozen and the values transferred to disk for printing or further analysis. As well as text format, the disk file can be in Excel or Matlab format.

#### PC interface module

- The PC interface module has been designed to connect directly to the parallel part of a PC via the cable supplied.
- The Sockets on the PC Interface module allow direct module connection to the inputs and outputs of the DCMC DC motor module and COMPOT Command potentiometer, via 4 mm leads.
- The PC interface module may be powered from the same power supply as the DCMC DC motor module.
- An instructor's manual and student workbook are also provided.

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### Introduction:

Control systems are at the very heart of the technology-based world in which we live. As we grow increasingly reliant on the technology, we will depend to greater extent on the services of maintenance / repair engineers and technicians. The proposed Motor control trainer offers a progressive hand on approach to teaching control technology. The Motor control trainer has three levels of study, each level is based on a teaching set of control modules. Starting with basic practical introduction to analog control, advanced analog control using three-term controller and Digital control based on a Microprocessor system. The unit has an electro-mechanical unit containing an iron-less rotor DC motor, Analog & digital motor drive circuitry, 3 position Eddy current brake & sensors for speed and position. Virtual Control System Lab software is included in the system to perform all the experiments, so that dynamic results can be seen on PC, stored and analyzed.

### Topics Covered :

- Analog control – an overview
- Describing and identifying system behaviour
- Time and frequency response
- Principles of feedback
- Proportional position control
- Behaviour of second order systems
- Position control with velocity feedback
- 3-Term or PID control
- Stability
- The use of computers for control
- Analog and digital interfacing
- Direct digital control

### Technical Specifications :

The Analog and Digital Motor control training system consist of following modules;

#### DC motor control Module - DCMC

Features of the DC motor control includes:

- DC motor with on-board drive circuitry.
- Angular position indication disc, calibrated in degrees.
- Tacho-generator with switchable load resistor.
- Continuous rotation potentiometer.
- Gray-coded disc and slotted disc.
- Digital tachometer with r.p.m. readout.
- Three-position **eddy current brake**.

#### Command potentiometer module - COMPOT

The Command potentiometer provides a manually generated command signal to the control system. The calibrated indicator disc provides an angular position indication in degrees.

When used in conjunction with a Windows™ based PC, the Simulated control laboratory performs the following functions simultaneously:

- Monitors the reference signal from the Command potentiometer.
- Provides a PID controller with adjustable parameters.
- Generates analog/digital signals to control the DC motor module.
- Responds to analog/digital feedback signals from the DC motor module.
- Displays all control and feedback signals on the PC screen.

#### Simulated Control Laboratory Software - SCLS

The Virtual control laboratory software is a comprehensive teaching package that is designed specifically for use with the motor control modules. The main screen of the Virtual control laboratory software should be divided into four sections, viz. Control reference (input) signal, Controller, Plant & Display. Each of these may be configured independently by the user:

#### PC Interface module:

The PC Interface Module is designed to connect directly to the parallel port of a PC via the cable supplied. The sockets on the Interface module allow direct connection to the inputs and outputs of the DC motor module and Command potentiometer, via 4mm leads. The PC interface module is powered from the same power supply as the DC motor module.

#### Set of 36 x 4MM Interconnection Leads :

This set features lead that comprise high quality multi strand wire & terminated with a 4mm plug at each end.

#### Power Supply Unit - SPSU

With output voltage of 5V @ 3A, -5V @ 1A, ±12V @ 1A with overload protection on all rails, outputs all floating from ground.

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**Objective List for PC based Analog & Digital Motor Control Trainer****Analog Control – Equipment Overview**

- 1 Locate the analog features of the DC Motor, Input Potentiometer and Interface Modules.
- 2 Connects together the modules for Analog control exercises.
- 3 Operates the software controls to drive the DC Motor and observe its behaviour.

**Introduction to Control Systems**

- 1 Outlines the objectives of control.
- 2 Indicates the width of application of control systems.
- 3 Describes what the 'Plant Model' means.

**Time Response**

- 1 Measure the parameters of a plant using step tests.
- 2 Describes the characteristics of a first order lag.
- 3 States the time model of the DC Motor.

**Frequency Response**

- 1 Measure the parameters of a plant using frequency tests.
- 2 Describes the frequency characteristics of a first order lag.
- 3 Explains why Bode Plots are used in preference to other frequency plots.

**Principles of Feedback**

- 1 Identifies the significant parts of a feedback control system and manipulates transfer function blocks.
- 2 Derives the closed loop and error transfer functions from the forward and open loop transfer functions.
- 3 Describes the effect of closing the loop on the steady state performance, stiffness, response time and frequency response.

**Proportional Position Control**

- 1 Accounts for the excellent steady state performance of a proportional servo position system.
- 2 Accounts for the poor transient performance of a proportional servo position system.

**Behavior of Second Order Systems**

- 1 Distinguishes between under-damped, critically damped and over-damped systems.
- 3 Relates the overshoot and damped frequency to damping factor and natural frequency.
- 4 Describes the form of the step response and the frequency response of a second order system.

**Positional Control with Velocity Feedback**

- 1 Sets up a servo system to respond to step inputs using proportional gain and velocity feedback.
- 2 Sets up a servo system to respond to ramp inputs using proportional gain and transient velocity feedback.

**Three-Term or PID Control**

- 1 Defines the purpose of Three-term Control.
- 2 Explains the effects of Proportional Band, Integral Action and Derivative Action.
- 3 Outlines how a PID controller is tuned.

**Stability**

- 1 Shows how positive feedback can occur in a negative feedback system.
- 2 Explains Gain Margin and Phase Margin.
- 3 Shows that transport lag adds phase and destabilizes a system.

**The Use of Computers for Control**

- 1 Describes the advantages and disadvantages of using computers in real-time control.
- 2 Defines what Direct Digital Control, Multi-loop systems and SCADA mean.

**Analog Interfacing**

- 1 Describes how computers handle numbers.
- 2 Explains the workings of a Digital to Analog Converter.
- 3 Explains the operation of a Successive Approximation analog to Digital Converter.
- 4 Describes the effects of amplitude and time quantization of signals.

**Direct Digital Control**

- 1 Describes how numbers are handled within a computer.
- 2 Relates the problems associated with digital integration.
- 3 Explains how digital differentiation is performed.
- 4 Outlines the problems arising from low resolution and slow sampling.

**Digital Interfacing**

- 1 Describes Pulse Width Modulation and other digital drive techniques.
- 2 Describes Gray code position measurement and other absolute and relative digital position measurement techniques.
- 3 Indicates the problems associated with digital speed measurements, Compares the behavior of analog and digital control systems.

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