

# Electrical Power & Machines

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d.c. Machines

a.c. Single & Three Phase Machines

Dissectible Machines

Single & Three phase Transformers

Measurement & Control

Power Electronics

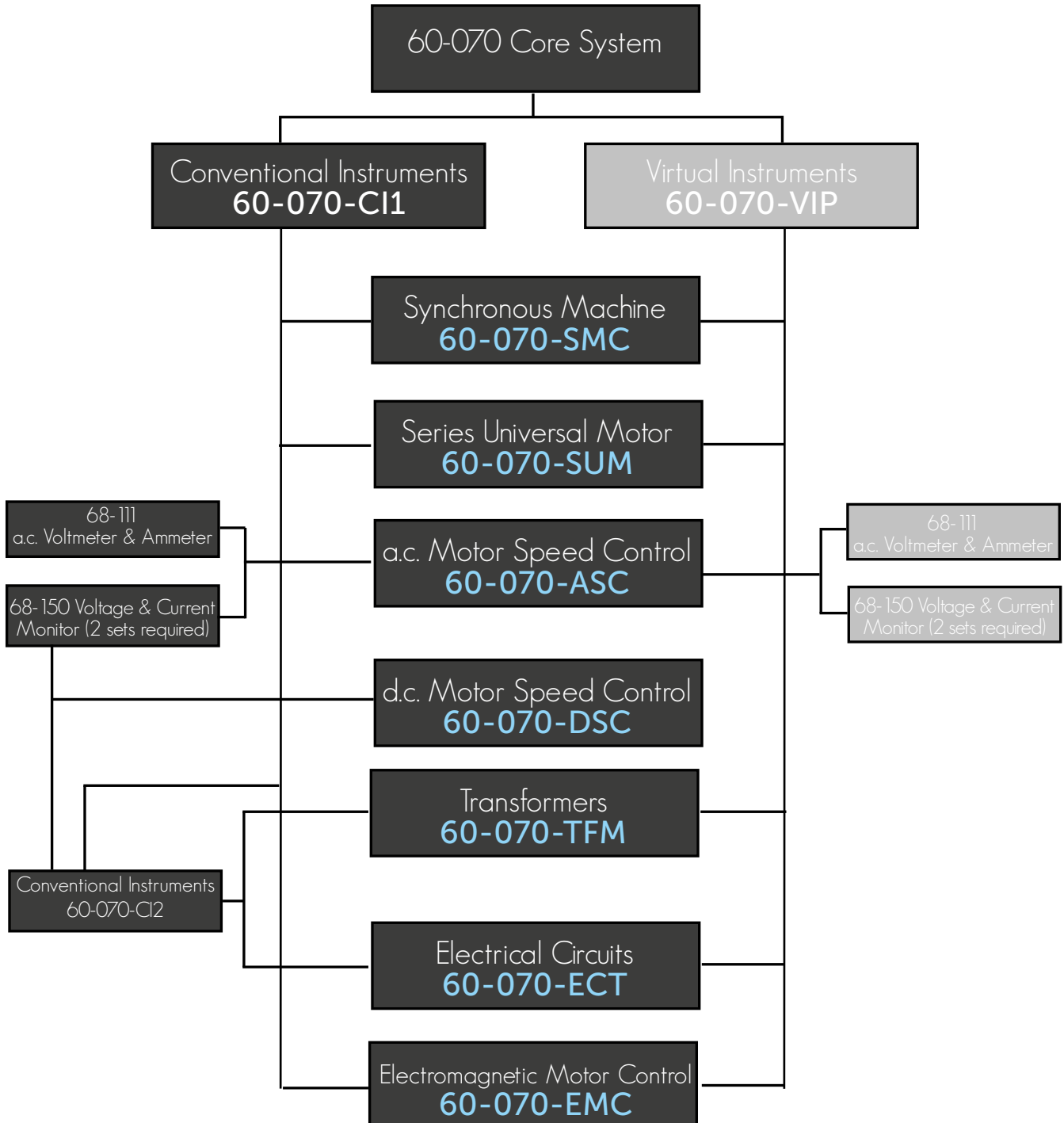
Conventional & Virtual (PC based) Instrumentation

Renewable Energy - Photovoltaics

The generation and distribution of electricity is fundamental to everyday life throughout the World. This versatile range of equipment enables students at all levels to gain a “hands-on” understanding of the how and why as to the use of different types of motors and generators in various applications.

Conventional instrumentation is important in many application but the application of PC based instrumentation enhances the learning process and enables students to see, make calculations and plot characteristics effectively and efficiently.

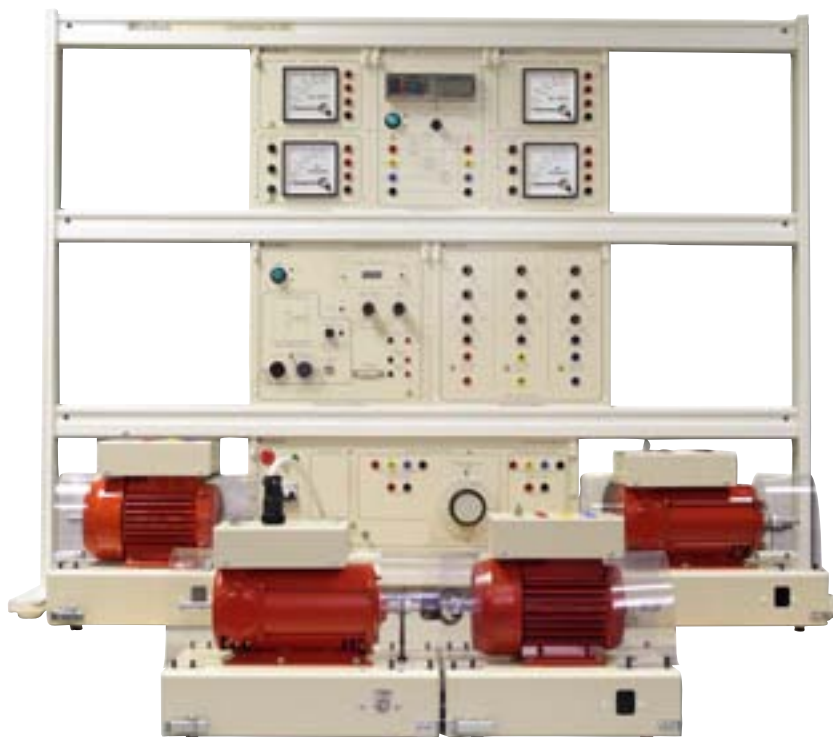
## Electrical Power & Machines Range Structure



When putting together your 60-070 system, start by choosing either conventional or virtual instrumentation, then follow the flow chart from top to bottom to ensure that you have all the components you require.

# 60-070 SERIES

Powerframes Core System



60-070 Core System

The core system provides a cost effective introduction to this area of study. Safety and protection of the student and equipment are of prime importance, using 250 W rated machines which have characteristics typical of the machine types.

It includes a d.c. compound machine, single and three phase motors, required power supplies, resistive load and swinging field dynamometer.

Comprehensive manuals are supplied covering Theory and Practical work ensuring the effectiveness of the learning experience.

**Please see range structure chart at front of chapter for reference.**

## Features

- Industrial style d.c., single & three phase a.c. machines
- Simple assembly and connection
- Choice of conventional or PC based instrumentation

## Subject areas

- Operation and characteristics
- d.c. shunt, series and compound machines
- a.c. motors
- Starting requirements



64-501 Three Phase Induction Motor - Squirrel Cage



67-014 Manual Swinging Field Dynamometer



64-110 Single Phase Induction Motor



63-120 d.c. Compound Wound Machine

The following modules comprise the Core system:

**63-120 d.c. Compound Wound Machine.** The Compound d.c. Machine can be used to compare the characteristics of d.c. series, shunt and compound machines as both a motor and a generator.

**64-110 Single Phase Induction Motor.** The Capacitor Start (Induction Run) single phase motor has main and auxiliary windings identified and their effect on the starting and running characteristics are studied.

**64-501 Three Phase Induction Motor - Squirrel Cage.** The Squirrel Cage Induction Motor is used widely throughout industry. Topics covered are speed and slip, reversal of rotation and torque/speed characteristics.

Please see range structure chart at front of chapter for reference.

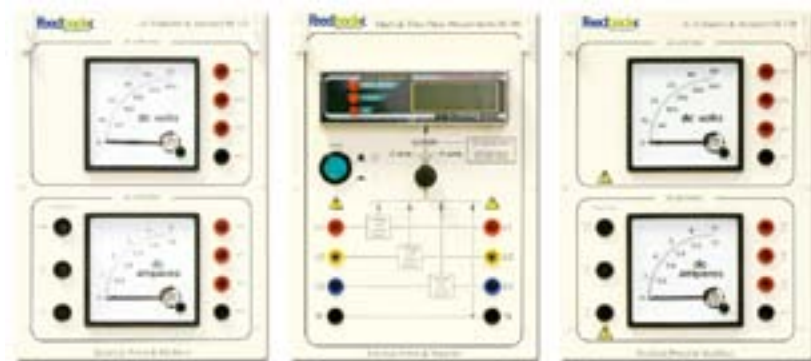
**67-014 Manual Swinging Field Dynamometer.** This is a versatile machine loading system comprising an electrical dynamometer with integral tacho-generator and includes a torque/speed controller. It can be used to manually apply a load to a motor or control the speed of a generator, acting as a constant speed motor drive.

**60-105 Universal Power Supply** This provides sufficient fixed and variable d.c. and three-phase power supplies to conduct all the experiments offered by the 60-070 Core System. It is fully protected and requires a five-wire three-phase supply.

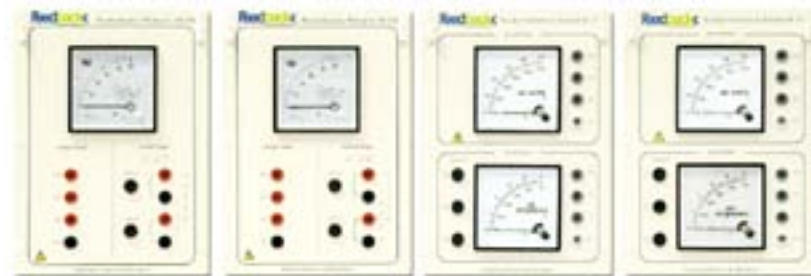
**67-142 Switched Three-Phase Resistance Load.** The 67-142 provides three banks of switched resistors which are used for loading purposes and for teaching basic circuit theory.

# 60-070 SERIES

Powerframes Core System



60-070-CI1



60-070-CI2

## Features for both

- Large scale meters
- industrial quality
- 2% accuracy
- All ammeters are fused protected

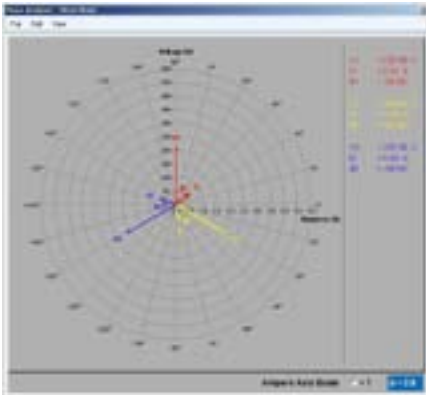
### 60-070-CI1 Conventional Instruments

Analogue meters are very relevant for power measurement as they enable trends to be observed, whilst electronic digital measuring systems provide greater accuracy.

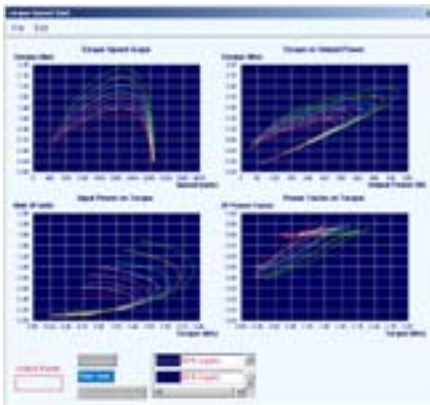
### 60-070-CI2 Conventional Instruments

Additional analogue meters which are required for making measurements when using the optional modules for measurements for transformers and electrical circuits. This includes two wattmeters required for single and three phase power measurements.

Please see range structure chart at front of chapter for reference.



Phasor diagram screen



Graph plots screen



Meter screen

### 60-070 PC based instrumentation

Virtual Instrumentation adds a multitude of benefits to the 60-070 core system enabling students to perform a variety of automatic tests on electrical machines and static devices with the ability to observe results on a PC screen. Such tests include torque/speed plots, measurement of motor in-rush current and loading of machines.

The pack comprises the 68-500 Multichannel I/O Module which connects to a PC via a USB Interface. A software package provides a suite of virtual instruments, which includes nine analogue or digital meters plus a graphical display of torque and speed and a means of either loading or driving a machine via the PC.

In addition to the meters the software provides very powerful plotting features. Any measured or calculated parameters (eg. Torque and Speed or Power Factor and Current) can be plotted against each other. The student can save or export the data for future use.

The Phasor Diagram graphically shows the real-time relationship between the various single or three-phase voltages and currents. A Transient Recorder allows plotting of in-rush current and starting characteristics of machines.

Please see range structure chart at front of chapter for reference.

# 60-070 SERIES

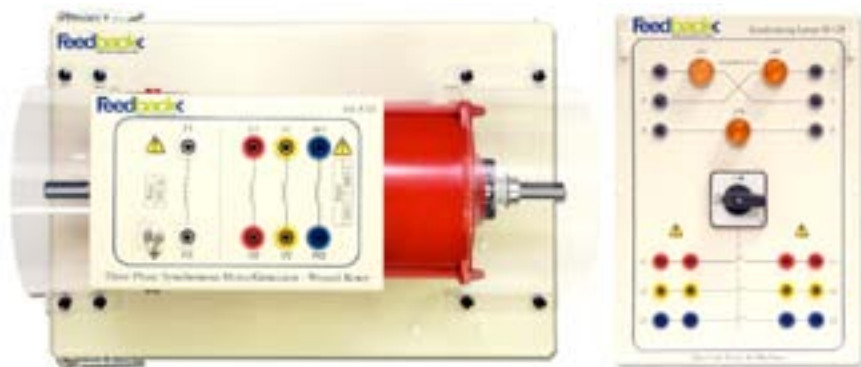
Additional Machines



## Series Universal Motor 60-070-SUM

This is a simple, versatile and very widely used motor which may be operated using a d.c. or single phase a.c. supply. Practicals explore the use of these different types of supply and compare the benefits.

The need for a compensation winding is demonstrated and motor characteristics plotted showing the relationships of Speed, Power and Efficiency against torque.



## Synchronous Machine 60-070-SMC

This machine may be used as a motor or generator. Starting requirements, synchronisation, load and no-load characteristics and use as a synchronous capacitor are topics covered in the comprehensive manuals.

In addition, use of the synchronising module demonstrates how the three phase generator may be synchronised with the power supply.

Please see range structure chart at front of chapter for reference.



The 60-070-ASC and 60-070-DSC are additions to the 60-070 Core System.



**60-070-ASC a.c. motor Speed Control** introduces the concepts of speed control of a.c. motors using a variable frequency drive. This is intended for use with the 64-501 Three Phase Induction Motor.

#### Subject Areas

- Basic theory and control functions
- Inverter current & voltage waveforms
- Carrier frequency
- Frequency speed control & motor voltage
- Torque/speed test at various frequencies
- Voltage boost
- Voltage/frequency characteristics



**60-070-DSC d.c. motor Speed Control** option gives a comprehensive introduction to Power Electronics and d.c. motor drives. This is intended for use with the 63-120 d.c. Compound Machine.

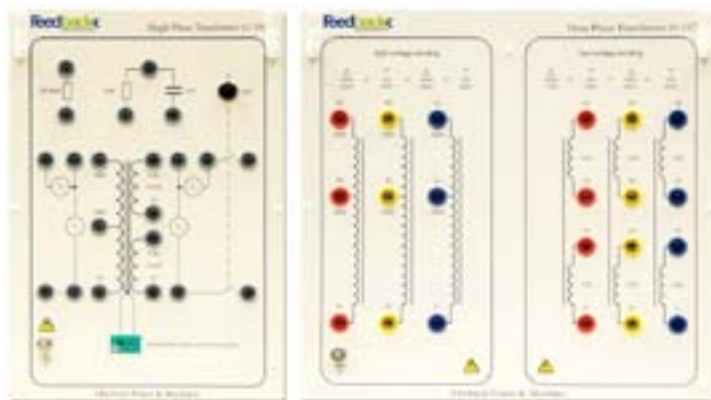
#### Subject Areas

- Thyristor control principles
- Motor voltage & current waveforms
- Speed regulation with & without phase angle control
- Phase angle against motor speed
- Effect of feedback voltage on speed regulation
- current limit control
- Torque against speed performance

Please see range structure chart at front of chapter for reference.

# 60-070 SERIES

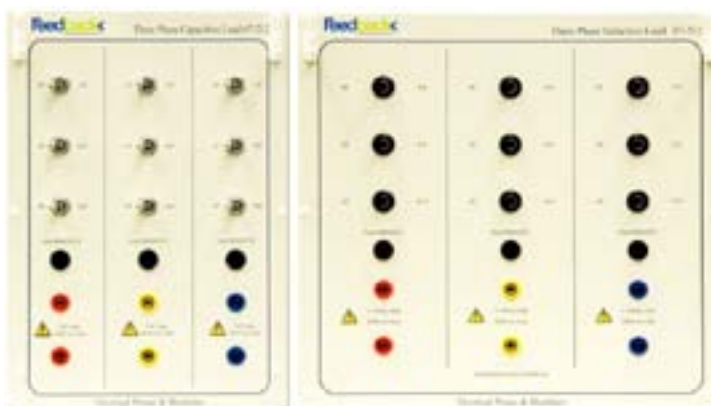
Transformers & Electrical circuits



**60-070-TFM Single & Three phase Transformers.** This option includes single and three phase transformers and allows the study of typical transformer characteristics.

### Subject Areas - 60-070-ECT

- Ohms Law
- Kirchoffs Law
- Resistance, capacitance & inductance
- Series, parallel & equivalent circuits
- a.c. & d.c. circuits
- Vectors & phasor diagrams



### 60-070-ECT - Electrical Circuits

This option comprises three phase inductive and capacitive loads, which when combined with the three phase resistive load (provided with the core system), allows full study of resistive and reactive circuits.

### Subject Areas - 60-070-TFM

- Voltage and current ratios
- Polarity, series and parallel connection
- Phase relationships
- Star, delta and Zig-Zag windings
- Autotransformers
- No-load & on-load characteristics

Please see range structure chart at front of chapter for reference.



**60-070-EMC Electromagnetic Motor Control.** 60-070-EMC Electromagnetic Motor Control option provides and applies many different control devices that are commonly used to control a.c. & d.c. machines.

Electromagnetic contactor, pushbuttons, rotary switches and indicator lights are all used with this instrument, enabling technicians and engineers alike to understand their use and application.

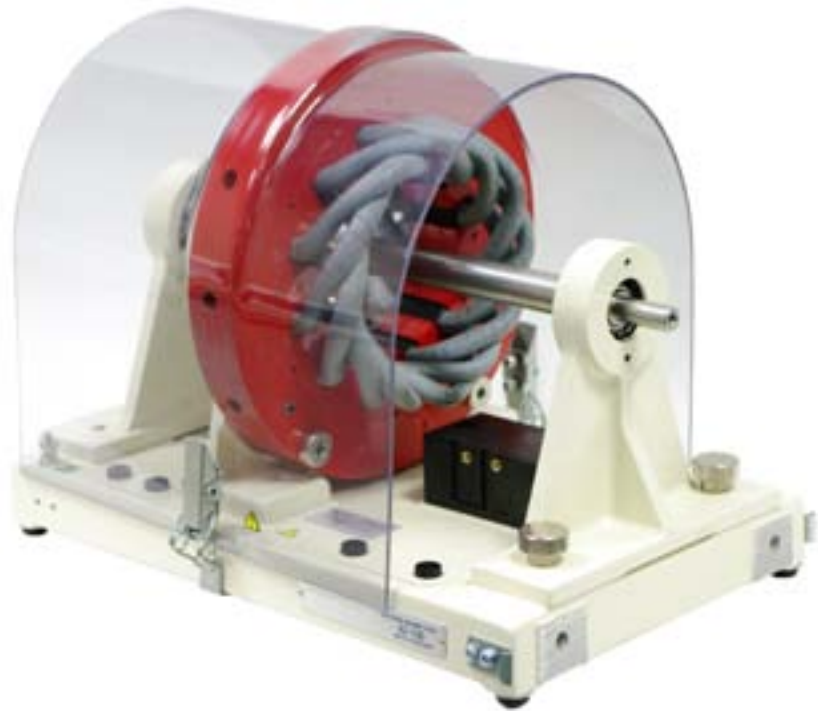
Please see range structure chart at front of chapter for reference.

#### Subject Areas

- DOL starters
- Inching/jogging
- Primary impedance starter
- Forward/Reverse operation
- Two wire and three wire control
- d.c. injection braking
- Plug-braking
- Dynamic braking
- d.c. motor starter
- Introduction to switchgear
- Motor configurations

# 62-100

## Dissectible Machine



### 62-100 - The Dissectible Machine

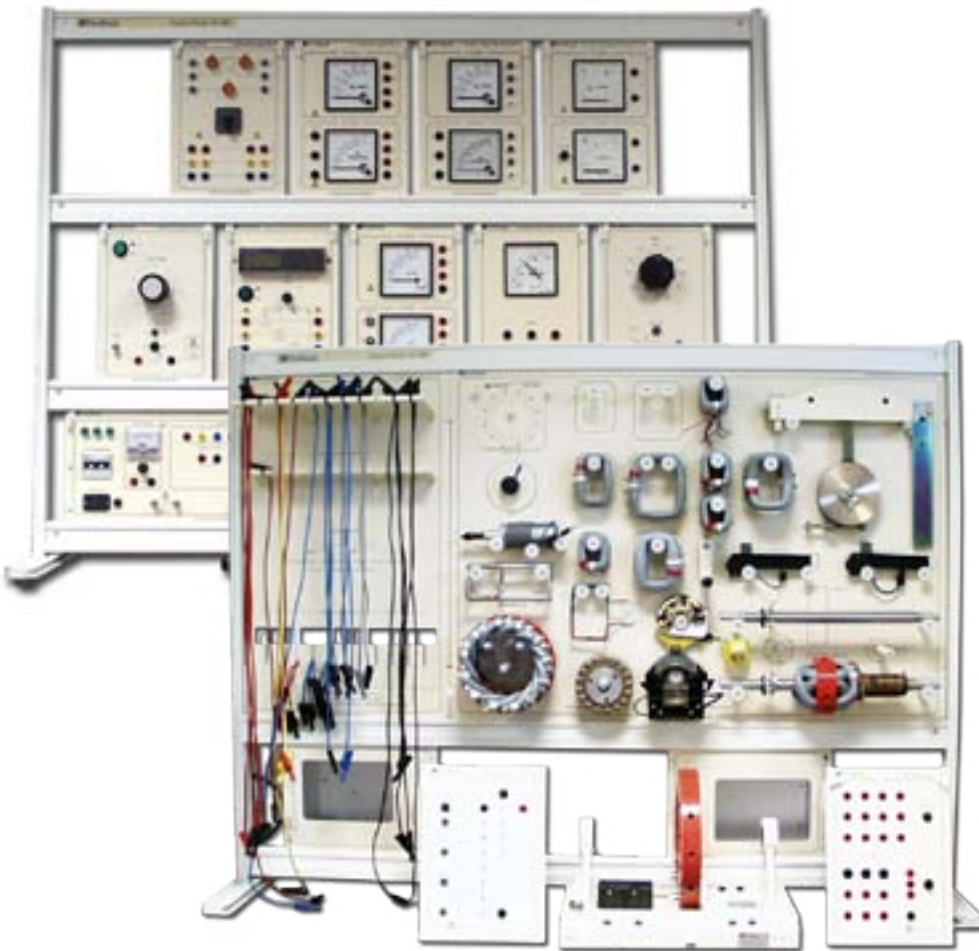
The unique Dissectible Machine System enables students to construct and investigate many different machine assemblies.

The System may be used to study a wide range of topics, from the principles of magnetic circuits and electrical machine theory through to Three-phase synchronous machines.

Students are able to see clearly the component parts of the machine and how they are interconnected, both electrically and mechanically. They may assemble machines from these component parts and then investigate the operation and characteristics of each machine.

### Subject Areas

- Identification of constituent parts of an electrical machine
- Electromagnetic principles
- Elementary machine principles
- d.c. motors and generators
- Series, shunt and compound motor types
- a.c. single and three phase motor and generators
- Series, universal, single phase capacitor, split phase and repulsion motor
- Synchronous motors and generators - single and three phase
- Split field, shaded pole and stepper motors
- Electrical machine faults



### 62-005 - Complete Dissectible Machines System

This trainer provides all the components to perform the full range of student assignments.

The bench-top, free-standing frames divide the equipment into two distinct areas. One frame specifically holds all the component parts of the Dissectible Machine on an inventory control panel that includes connecting lead storage, component storage for couplings and nuts and bolts etc.

The second frame houses the workstation. It consists of a wide range of a.c. and d.c. meters, resistive and capacitive loads and power supplies. Fixed and variable a.c. and d.c. supplies are provided and require a three phase supply input of 400 - 415 V a.c. from a five wire system. Total power requirement is 6 kVA.

### System components

- Baseplate
- Frame ring
- Shaft
- Coupling
- Fixed and removable bearing housings
- Wound Stator
- Squirrel cage rotor
- Hand crank
- Centrifugal switch
- Brush holders and brushes
- Commutator/slip rings
- Interpoles
- Armature poles and hub
- Field poles
- Armature, field and Interpole coils
- Compound field coils
- Tools and hardware

# 70 SERIES

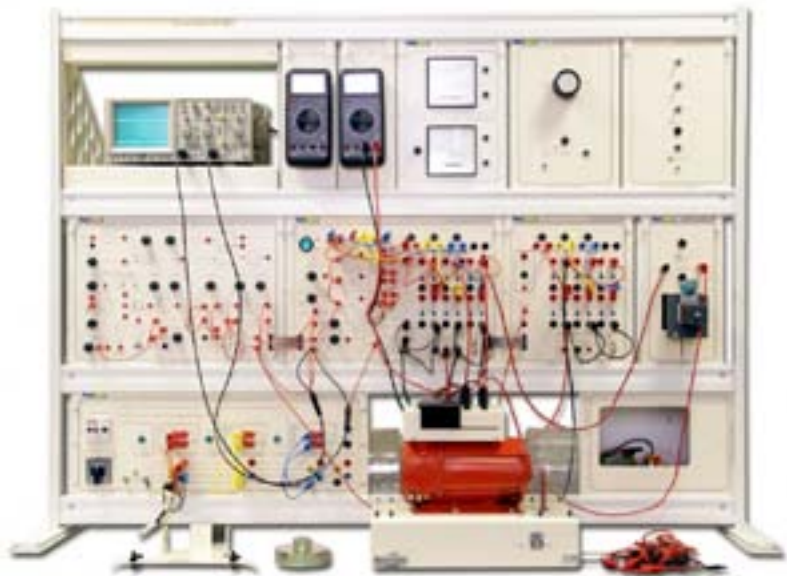
Electrical Power and Machines



Bi-directional load, voltage & current waveforms

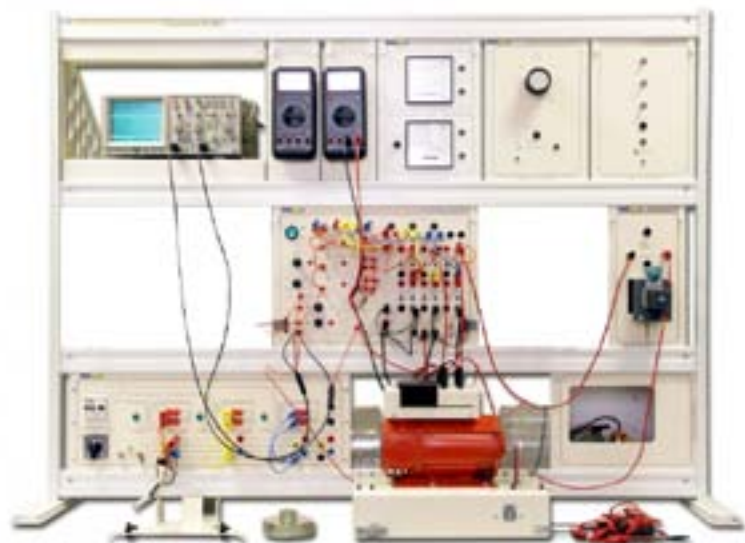


Six Pulse voltage and current waveforms



**70-005 d.c. Motor Control Trainer** covers the study of motor characteristics and parameters using single and three phase thyristor circuits.

Motor speed and current control circuits are investigated with various types of Feedback - armature voltage and current, tachogenerator and PI controllers. Four Quadrant control may be implemented for continuous and discontinuous current operation in single and three phase circuits.



**70-002 Thyristor Control Principals** trainer covers the principles of uncontrolled rectification and simple control using thyristors.

The characteristics of various thyristor circuits are studied using inductive, capacitive and resistive loads using single and three phase controlled rectification and associated firing circuits.

Please see range structure chart at front of chapter for reference.



The **PV75-100 Photovoltaic Principles Trainer** explores the principles and everyday applications of this renewable energy source. A state of the art light source (consisting of very high brightness white LEDs) emulates solar energy as received by a PV cell in a safe environment which protects the student from excessive heat and light.

An adjustable shading vane shows the effect of varying light levels, cloud, and angle of elevation of the sun, simulating variations which may be observed in a solar day.

Comparison can be made between amorphous and mono-crystalline cells. Measurements of voltage and current may then be made using the PC based Instrumentation, thus facilitating the study of d.c. and a.c. power conversion and energy storage.

- Maximum Power Point (MPP) tracking
- a.c. to d.c. conversion
- Boost and buck converter topologies
- a.c. inversion
- Cells in parallel and series
- Plotting of MPP curve
- Function of bypass diodes
- Effect of temperature on PV cells

