

## Electrical Power & Machines Range

60-070



Electrical Power and Machines is one of the most important areas of study for students in further and higher education.

As we become more aware of the finite energy resources available to us it is imperative that we use them in the most efficient manner. Engineers and technicians need to know which machines and motors are best suited for particular applications, how to generate and distribute power with the minimum losses and how electrical circuits behave at higher voltages and currents.

For example would the same type of motor be ideal for use in a DVD Drive as might be required for a power tool or a locomotive? How can we distribute and utilise the maximum amount of power? Why do we use Three Phase electrical power generation?

Feedback Instruments Limited has been supplying teaching and training systems to educational establishments throughout the World since 1958. Using the experience we have gained, we have configured a teaching system for Electrical Power and Machines which addresses the requirements of colleges and universities and enables students to get a "hands-on" understanding in these subjects.

This datasheet describes the modular 60-070 system which provides curriculum coverage for Electrical Circuits, Transformers and Motors and Generators. From our knowledge of the market we believe that the standard configurations described here will satisfy the needs of most courses at different academic levels. However, the system is modular and can be configured to suit individual requirements.

The 60-070 and all the other products in the complete Electrical Power and Machines range are available for operation with three phase 230/400 V 50 Hz or 120/208 V 60 Hz supplies. Please specify clearly when ordering which supply you will be using.

### Features

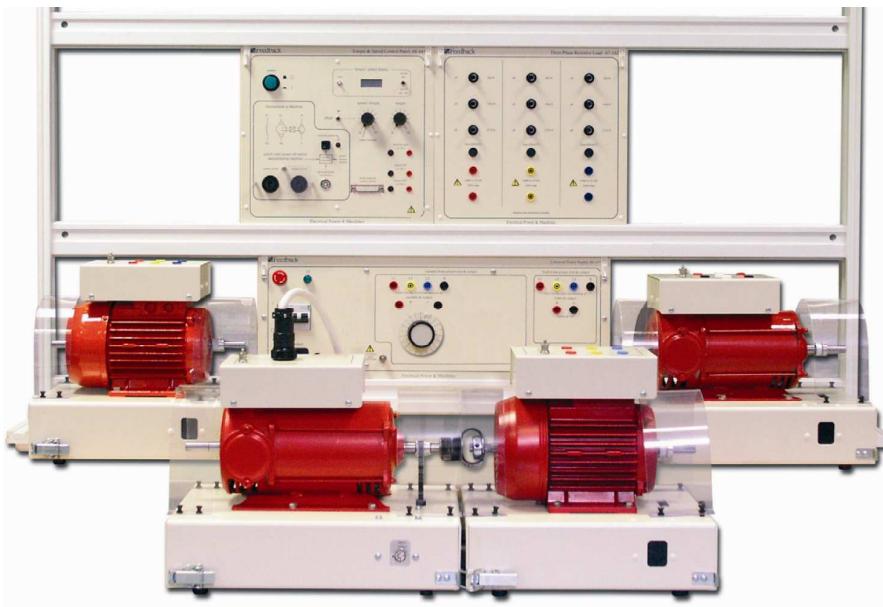
- d.c. Machines
- Single Phase Machines
- Three Phase Machines
- Electrical Circuits
- Single Phase Transformers
- Three Phase Transformers
- Electromagnetic Motor Control
- d.c. Motor Speed Control
- a.c. Motor Speed Control
- Measuring Instruments

### System Benefits

- Low cost start-up
- Core system can be extended
- High level of electrical and mechanical safety built-in
- Low cost installation - suitable for bench-top use
- Easily portable machines and system components
- Modular concept provides flexibility for individual requirements
- Choice of conventional or virtual instruments
- All products provide with in-depth teaching manuals

## Electrical Machines Core System

60-070-230 / 60-070-120



The 60-070 Core System provides a versatile but cost effective introduction to the study of Electrical Power and Machines which will be sufficient for many applications but can be enhanced at any time by adding any of the various modules described later in this brochure.

Safety has been paramount during the development of this system and every effort has been made to protect both the user and the equipment. Safety 4mm sockets are used throughout for interconnections and guards are provided to cover rotating components.

All machines and motors are nominally rated at 250 W and are bench mounted. They are purpose designed to provide characteristics more typical of large machines. All other modules; power supplies, loads, measuring instruments, etc. are available separately and mount in a rigid insulating frame into which they can be easily inserted or removed. A detailed manual providing both theory and experimental procedures is provided in hard copy and electronic formats to help the student to gain a working understanding of the subjects listed.

In order to make full use of the system some additional measuring instruments are required. Feedback can supply both conventional or PC based meters as described on the following pages and referenced in the experimental manual. Alternatively any suitable instruments can be used although experimental procedures might be slightly more difficult to follow in certain instances.

The 60-070-230 (230 V version) or 60-070-120 (120 V version) Core System comprises:

- 63-120 d.c. Compound Wound Machine
- 64-110 Single Phase Induction Motor - Capacitor Start/Induction Run
- 64-501 Three Phase Induction Motor - Squirrel Cage, Dual Voltage
- 67-014 Manual Swinging Field Dynamometer
- 60-105 Universal Power Supply
- 67-142 Switched Three Phase Resistance Load
- 91-200 System Frame

plus motor couplings, leads, safety guards and comprehensive manual.

## Features

- Low cost entry level
- Industrial style d.c., single and three phase machines
- Choice of instrumentation available
- Supplied with comprehensive Torque/Speed measurement system

- High level of electrical and mechanical safety
- Quick and easy machine coupling
- Multi-output d.c., single and three phase protected supply

## Curriculum Coverage

### d.c. Motors and Generators

- d.c. Shunt Motor
- d.c. Series Motor
- d.c. Compound Motor
- d.c. Separately Excited Motor

- d.c. Shunt Generator
- d.c. Compound Generator
- Separately Excited dc Generator

### a.c. Motors

- Single Phase Induction Motor - Capacitor Start / Induction run
- Starting requirements
- Effect of start capacitor

- Effect of capacitor output on output characteristics
- Torque/speed and efficiency characteristics

### Three phase ac Motors

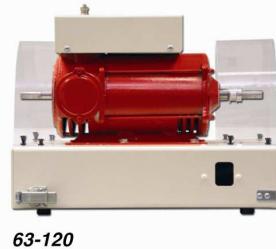
- Three phase Squirrel Cage Induction Motor
- Star connected motor
- Voltages and currents

- Delta connected motor voltages and currents
- Torque/speed and efficiency characteristics

## The core system comprises:

### 63-120 d.c. Compound Wound Machine

The Compound dc Machine can be used to compare the characteristics of d.c. machines with windings connected in Series, Shunt or Compound configurations as both a motor and a generator.



### 64-110 Single Phase Induction Motor - Capacitor Start / Induction Run

The Capacitor Start (Induction Run) single phase machine is very widely used. The main and auxiliary windings identified and their effect on the starting and running characteristics being studied.

### 64-501 Three Phase Induction Motor - Squirrel Cage, Dual Voltage

The Squirrel Cage Induction Motor is the most cost effective three phase machine used widely throughout industry. Among the many topics considered are Speed and Slip, reversal of rotation and torque/speed characteristics.

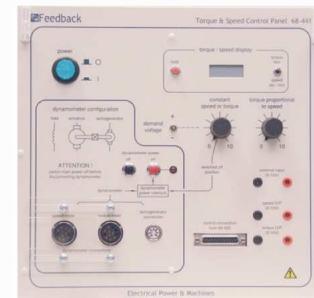
### 67-014 Manual Swinging Field Dynamometer

This is a very versatile machine loading system comprising an electrical Dynamometer with integral Tachogenerator 67-502 and the 68-441 Torque/Speed controller and all connecting leads. It can be used to manually apply torque load to a motor or control the speed of a generator, acting as a constant speed motor drive.



67-502

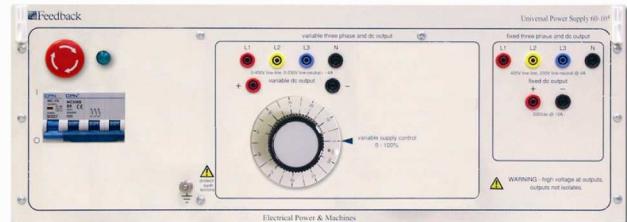
A strain gauge beam is used for torque measurement that provides torque values in both torque and speed modes. Also provided is the facility to carry out locked rotor tests by means of a mechanism that prevents the shaft from rotating, being held and allowed to move in sympathy with the swinging field of the dynamometer machine. In addition it can be used in constant torque, torque proportional to speed modes. These modes can also be controlled with external analogue signals or via a PC.



68-441

### 60-105 Universal Power Supply

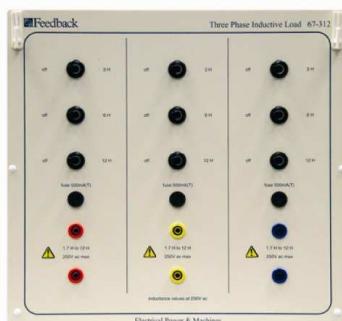
This provides sufficient fixed and variable dc and Three Phase power supplies to conduct all the experiments offered by the 60-070 Core System and Options. It is fully protected. It requires a three phase five wire supply.



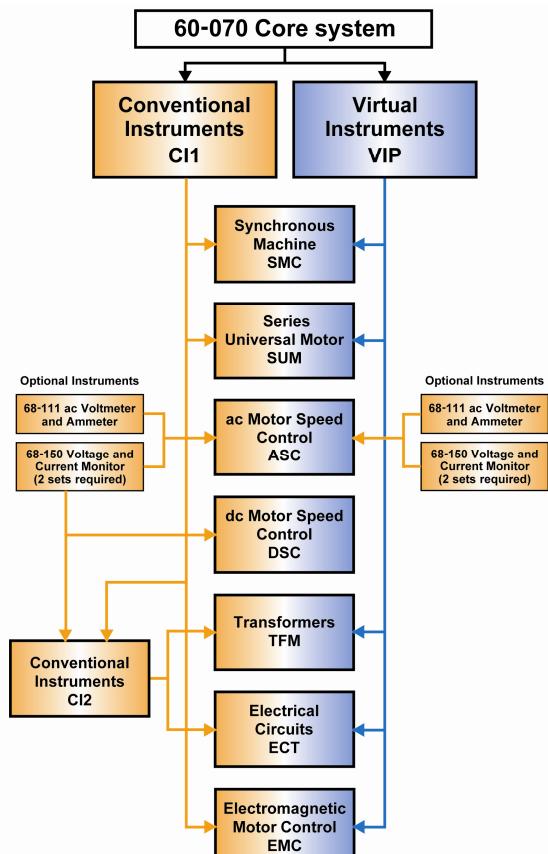
60-105

### 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.

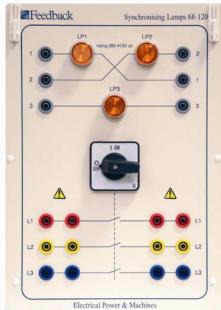
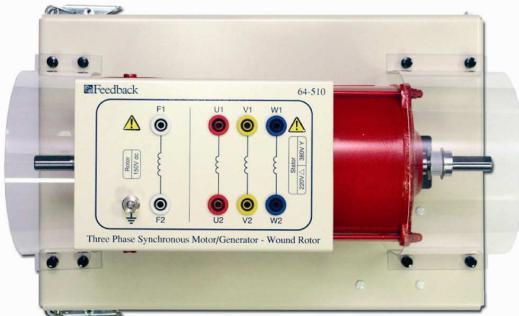


67-142



Core System additional machines

## Synchronous Machine 60-070-SMC



### Three Phase Synchronous Machine & Synchronising Module 60-070-SMC

The Three Phase Synchronous Machine can be used as a Motor or a Generator. Starting requirements, synchronisation, load and no-load characteristics and its use as a synchronous capacitor are some of the topics covered. In addition the Synchronising Module shows how the Three Phase generator can be

synchronised to the existing power supply. The versatility of the 60-070 allows sophisticated experiments to be performed, such as, running the machine up to synchronous speed, synchronising as a generator, changing to synchronous mode to a motor and studying the characteristics and pull-out torque.

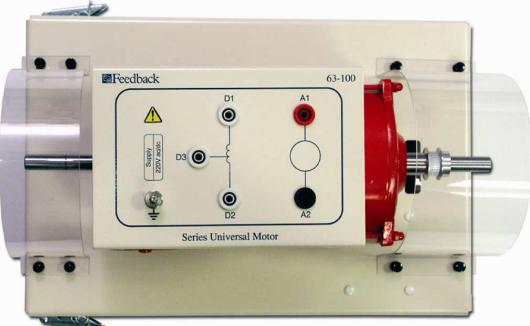
### Features

- Lamps dark or lamps bright configuration possible
- Synchronising switch included
- Star or delta winding configuration possible
- High degree of mechanical and electrical protection

### Curriculum Coverage

- Open circuit test
- Short circuit test
- Effect of speed variation on output voltage and frequency
- Synchronisation procedure
- Operation of a synchronous machine
- Voltage regulation of a synchronous machine
- Variable reactor V curves

## Series Universal Motor 60-070-SUM



The Series Universal Motor is a simple, versatile and very widely used device which can operate using a d.c. supply or a single phase ac supply. Comparison is made between the operation using the different supplies and the need for a compensation winding is shown. All electrical machines available in the 60-070 series are fitted with fully shrouded electrical connectors, shaft guards; alignment pins and quick fasten and release mechanical catches to retain coupled machines.

### Features

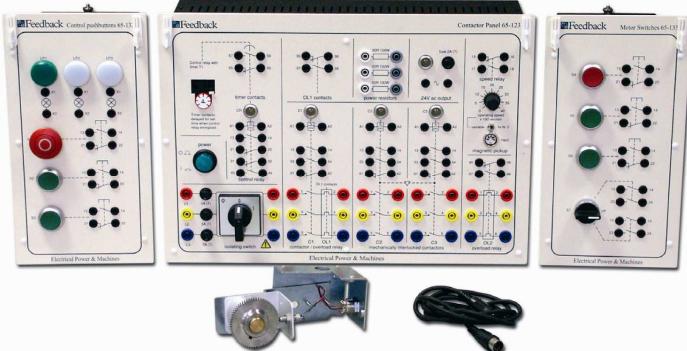
- Mimic diagram of motor windings
- Realistic industrial frame size
- Electrical and mechanical protection

### Curriculum Coverage

- Motor characteristics with dc supply
- Speed versus torque
- Power versus torque
- Efficiency versus torque
- Motor characteristics with ac supply
- Speed versus torque
- Power versus torque
- Efficiency versus torque
- Control of shaft direction of rotation
- Compensation winding

Core System additional equipment

## Electromagnetic Motor Control 60-070-EMC



The use of power relays to provide a switched sequence of events for starting, stopping, forward and reversing of electrical machines has been traditionally carried out by Electromagnetic control gear. The application of these devices is widely used today and therefore the principles need to be understood.

The EMC Electromagnetic Motor Control 60-070 provides study methods and terminology associated with the implementation of control devices in some of the most commonly used circuits for control of ac and dc machines, to a level that can be understood by both maintenance engineers and technicians alike.

The equipment consists of a wide range of control gear that is provided on three panels. One has electromagnetic contactors, and the other two have pushbutton and rotary switch gear and indicator lights.

### Contactor Panel 65-123

This is the main control panel. It consists of a 'power' control supplies switch, three phase isolating switch, contactor and overload relays, mechanically interlocked contactors, control and speed relays, and timer circuit. Additionally, power resistors are provided and magnetic pick-up connection terminals. A low voltage, protected ac output is also provided to supply the control circuit configuration. All components are connected to a mimic diagram on the front of the unit.

### Control Pushbuttons 65-132

To manually operate the contactors and relays available in the 65-123 panel and to provide an indication of the control sequence status a variety of pushbuttons and colored indicators are available. The pushbuttons and indicators provided are typical for their application, following industrial practices, both in function and connectivity.

### Motor Switches 65-133

This panel is similar to the Control Pushbuttons panel in function but provides a selector switch control to implement dual circuit operation. Together the two panels, in conjunction with the Contactor Panel, are used to demonstrate a wide range of typical motor control applications.

### Magnetic Pickup 68-431

The magnetic pickup is used to sense and measure the rotational shaft speed of a motor. The unit 68-431 consists of a steel gear, which is rotated by the shaft of a motor in front of a magnetic sensor that produces a pulse output. Output from the 68-431 units is supplied to the speed relay input circuit, which converts the pulses to a voltage proportional to speed.

## Features

- Provides study of a wide range of motor control circuits
- Typical industrial control gear components
- Low voltage control circuit operation
- Safety using 2 mm and 4 mm shrouded connections

## Curriculum Coverage

- DOL starter, electromagnetic, locally controlled
  - Two wire control
  - Three wire control
  - Local and Remote control
- DOL starter, starting/inching/jogging
- Star/Delta starter
  - Timer control of start to run
  - Shaft speed switching
- Primary impedance starter
- DOL starter: Forward/Reverse operation
- DOL starter with dc injection braking
  - Timer control
  - Speed relay control
- DOL starter with plug-braking
  - Timer control
  - Speed relay control
- d.c. motor starter
  - Operation with Timing relay
  - Operation with speed relay
- Dynamic braking of a d.c. Motor
  - without added inertia
  - with added inertia
- Introduction to switchgear
  - Switching devices
  - Electromagnetic switches
  - Sensing relays
  - Overload protection of motors
  - a.c. contactor
  - a.c. switch utilisation
  - Switchgear symbols
- Motor configurations
  - Three-phase Induction Motor - Star Connection
  - Three-phase Induction Motor - Delta Connection
  - d.c. Compound-wound Motor - Shunt Connection

## d.c. Motor Speed Control 60-070-DSC



The dc Compound Machine 63-120 is supplied as part of the Core System



is by an internal current limiting circuit. Front panel controls allow the variation of:

- Set Speed
- Minimum Speed
- IR Compensation
- Acceleration/deceleration Time

## Features

- Easily configurable
- Built-in safety features
- Comprehensive students manual includes theory and Practicals
- Safe output waveform display using isolated probes
- Suitable for use with dc motor 63-120

- Speed range 0-3000 rev/min, provides 300W output
- IR compensation control for improved speed regulation
- Electronic armature current limit
- Acceleration and deceleration control
- For use in testing of generators (in conjunction with the d.c. motor)

## Curriculum Coverage

- Thyristor dc motor control principles
- Motor voltage and current waveforms
- Speed regulation with and without phase angle control
- Phase angle versus motor speed

- Effect of feedback voltage on speed regulation
- Current limit control
- Torque/speed performance

## Optional Instruments

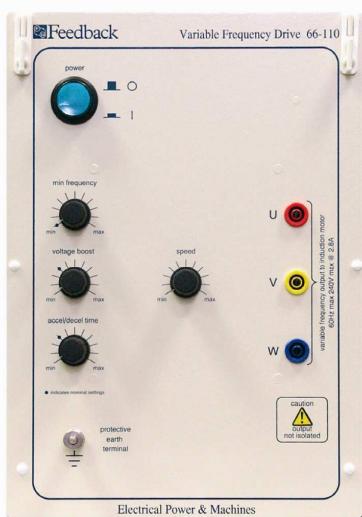
In order to perform all the experiments in the manual for the above product the following instruments are required (unless 60-070-VIP is already available in the lab).

### Voltage and Current Monitor 68-150 (2 sets required)

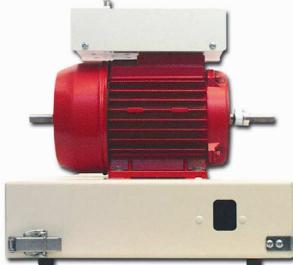
- For use where isolated voltage and current waveform measurements are required
- Precision four terminal shunt current monitor
- Shunt output isolated via voltage probe
- Probes output connects directly to a scope for safe monitoring
- Current monitor output 100 m V/A
- Isolated voltage probe input 1000 V d.c. or 700 V a.c. rms
- Switched attenuation 1/200 and 1/20 d.c. to 15 MHz bandwidth
- Battery powered or external 6 V d.c. power adapter
- Fully shrouded 4 mm connections with BNC to scope



## a.c. Motor Speed Control 60-070-ASC



The Three phase Induction Motor 64-501 is supplied as part of the Core System



The ASC ac Motor Speed Control option introduces the concepts of speed control of ac motors using a variable frequency drive. It comprises one additional module, the 66-110 Variable Frequency Drive.

Experiments are performed using the 64-501 Three Phase Squirrel Cage Induction Motor which is included in the 60-070 Core System.

Connections to the Motor are made using safety 4mm sockets and all outputs are fully overload protected.

Front panel controls allow the variation of:

- Set Speed
- Minimum Frequency
- Voltage Boost
- Acceleration/deceleration Time

## Features

- Easily configurable
- Built-in safety features
- Comprehensive students manual includes theory and Practicals
- Safe output waveform display using isolated probes
- Suitable for use with Induction Motor 64-501

- **Basic control functions for:**
  - Max and min speed settings
  - Acceleration and deceleration times
  - Torque boost
  - Variable frequency control
- Protection is provided for over-current and over-voltage

## Curriculum Coverage

- Basic Theory
- Control Functions
- Inverter Voltage Waveforms
- Carrier Frequency
- Inverter Current Waveforms
- Frequency, Speed, Current and Motor Voltage
- Torque-Speed test at various frequency settings
- Voltage Boost
- Voltage/Frequency (V/F) characteristics

## Optional Instruments

In order to perform all the experiments in the manual for the above product, 2 sets of Voltage and Current Probes (as described previously) and the following instrument are required:

### a.c. Voltmeter and Ammeter 68-111

- A rectifier voltmeter and moving iron ammeter
- Suited to the measurement of variable frequency drive and a.c. supplies
- Rectifier voltmeter range 0 -250 V and 0 – 500 V a.c.
- Moving iron ammeter range 0 – 3 A, fuse protected
- Meters are DIN standard 96 x 96 mm
- Safety earth connection provided



## Individual Modules

### Universal Power Supply 60-105

- Comprehensive Power Supply
- Circuit breaker protection
- 3-phase: nominally 0 – 400 V a.c. line at 4 A
- 3 x Single Phase: each nominally 0 – 230 V a.c. line to neutral at 4 A d.c. nominally 0 – 270 V at 6 A
- Three Phase 400 V line, 230 V Single Phase, fixed d.c. 220 V 10 A
- Single Phase power distribution
- Safety earth connection provided



## Variable a.c./d.c. Supply 5 A 60-121

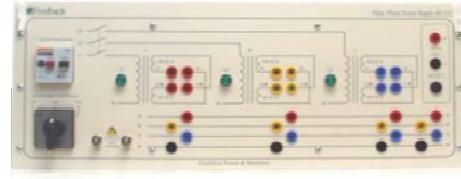
- A variable a.c./d.c. supply using a variable transformer and a silicon bridge rectifier circuit
- Provides up to 240 V a.c. or 220 V d.c. at up to 5 A
- Equipped with ON/OFF switch, variable voltage control, a.c./d.c. selector and current overload protection
- Nominal voltage 220/240 V a.c., 50/60 Hz 5 A
- Safety earth connection provided



## Three Phase Supply 60-132

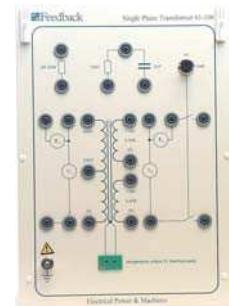
The 60-132 can be configured to provide the desired single phase or three phase power to the 70-220

- Overcurrent power switch
- 600 VA output on single and 3-phase at 200 VA per phase
- Star or delta 3-phase configuration
- 2 x 100 V windings per phase
- Input requirement: 380 – 415 V 5 wire. 3 x line, neutral and earth



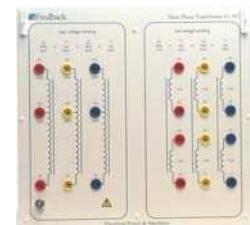
## Single Phase Transformer 61-106

- Multi-windings for series and parallel connection
- 400 V, 230 V and 2 x 115 V windings
- Power rating 100 VA
- Mimic panel of transformer windings
- Frame or bench mounting
- Safety earth connection provided



## Three Phase Transformer 61-107

- Primaries for 380/415 V a.c. Star or Delta connection
- 2 x 115 V, 0.43 A secondaries per phase
- Power rating 300 VA
- Connects via 4 mm colour coded shrouded safety sockets on mimic panel
- Frame mounting
- Safety earth connection provided



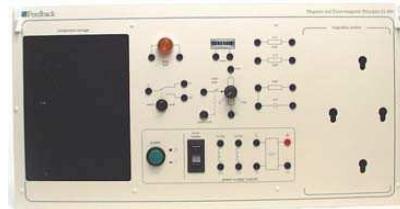
## Three Phase Earth Leakage Breaker 60-140-1

- For use in systems where earth leakage breakers are not provided as part of the electrical installation but overcurrent protection has been installed
- Suitable for connection to 3-phase, five wire systems
- Provides a termination point for mains power on frame systems
- 4 pole, 30 mA trip, earth leakage breaker
- Three phase power 'on' indicators
- Single phase outlets on front and rear
- Safety earth terminals
- Input 380/415 V 3-phase 50/60 Hz with neutral and earth connections
- User connection terminal block provided internally
- Output 220/240 V single phase from IEC shuttered sockets, fuse protected at 10 A
- 3-phase on rear panel connector for use with frames supplies 60-105 and 60-125
- Provides additional protection against the hazard of electric shock



## Magnetic and Electromagnetic Principles 61-400

- Add-on to the Powerframes configuration, comprises: a frame mounted panel and a series of magnetic and electromagnetic components
- Allows the investigation of a wide range of magnetic and electromagnetic principles, e.g. flux paths of cores, Motor and Generator principles and Transformer concepts
- Supply required 120 or 230 V a.c.



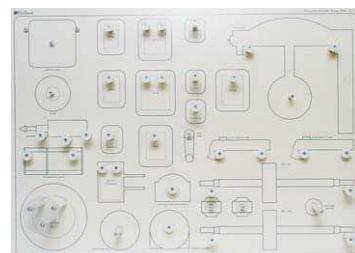
## Dissectible Machines Tutor 62-100

- A fully dissectible experimental machines kit
- Build, operate and test over 50 different a.c., d.c. and 3-phase machine assemblies
- Well protected rotating parts
- Operates at low power levels minimising the risk of accidents



## Dissectible Machines Storage Panel 62-101

- Holds coils and components for the Dissectible Machine
- Provides easy inventory control
- Clearly identified positions for components
- Can be mounted in a system frame or wall-mounted



## Rotatable Brush Gear 62-102

- Replaces the Dissectible Machine static brush gear
- Easily fitted to non-drive end mounting
- Can be rotated to any angle with respect to the neutral axis
- Scale calibrated in 5° increments
- Thumbscrew locking



## Series Universal Motor 63-100

- Rated at 250 W continuous
- Maximum speed 6,000 rev/min
- Power Requirement 220 V d.c. or Single Phase a.c. 50 Hz supply
- Double ended shaft with 12 mm diameter
- Safety earth connection provided



## d.c. Shunt Machine 63-111

- Rated at 250 W with separately wound shunt field
- Nominal supply 180/220 V d.c. armature and field
- Suitable for operation with separately excited or self-excited connections
- Can be used as d.c. motor or generator
- Nominal speed 3,000 rev/min
- Double ended shaft with 12 mm dia
- Safety earth connection provided



## d.c. Compound Wound Machine 63-120

- Rated at 250 W continuous
- Nominal speed 2,000 rev/min
- Maximum speed 6,000 rev/min
- Power requirement 220 V d.c.
- Operates as a d.c. series, shunt and compound motor or generator
- Double ended shaft with 12 mm dia
- Safety earth connection provided



## d.c. Variable Speed Drive 63-501

Comprises a 250 W horsepower d.c. motor mounted on a base unit compatible with all the machines in the Powerframes range. Contained in the base of the motor is a thyristor-controlled power supply which provides a shaft speed range from zero to 4250 rev/min, with all controls and fuses on the front panel. It has constant current overload limiting electronic control to give good regulation, and a fool-proof soft-start to ensure safe run-up to full speed. A built-in tachogenerator with integral metering is also provided for indication of shaft speed. Drive shaft diameter 12 mm.



## Capacitor Start Single Phase Induction Run - 64-110

- Rated 250 W
- Rotates at up to 2850 rev/min at 50 Hz
- Power requirement 220 V Single Phase a.c.
- 12 mm shaft diameter
- Double ended shaft
- Safety earth connection provided



## Three Phase Induction Motor - Squirrel Cage, Dual Voltage 64-501

- Dual voltage machine, 380/415 V, Star, 220/240 V Delta
- Rated at 250 W
- Rotates at up to 2980 rev/min at 50 Hz
- Power requirement 380/415 V, 50 Hz, Three Phase a.c. or 220/240 V delta
- 12 mm shaft diameter
- Double ended shaft
- Safety earth connection provided



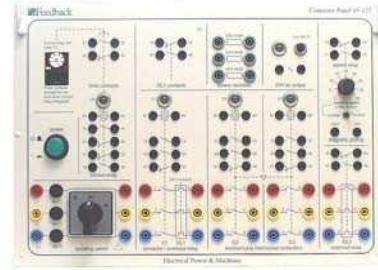
## Three Phase Synchronous Motor/ Generator - Wound Rotor 64-510

- Can be used as a motor or generator
- Rated at 415/240 V 200 W
- Synchronous speed 3,000 rev/min@50 Hz
- Power Requirement 380/415 V Three Phase a.c. star or 220/240 V delta
- Nominal rotor supply 100 V d.c.
- 12 mm shaft diameter
- Double ended shaft
- Safety earth connection provided



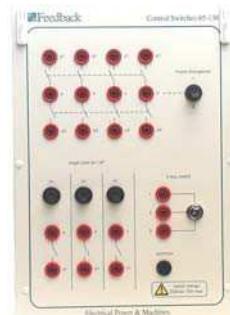
## Contactor Panel 65-123

- 3-phase isolating switch, fused at 5 A
- Power control pushbutton connecting 24 V a.c. to contactors, relay and speed control circuit
- Contactor with thermal overload relay
- 2 contactors mechanically interlocked
- Control relay fitted with pneumatic timer
- Speed relay with adjustable speed threshold to 4,000 rev/min
- Three 50 ohm 100 W power resistors
- Supply requirements 230 V or 120 V a.c. 50/60 Hz
- Safety earth connection provided



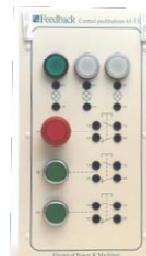
## Control Switches 65-130

- Heavy duty power switches used in measurement and electrical circuit switching
- Multipoint metering
- Component selection
- Switches are:- 1 x 3 way, 3 x 1 way, 1 x 4 way
- Switch ratings 240 V a.c. 10 A
- Used with 62-100 Dissectible Machine
- Safety earth connection provided



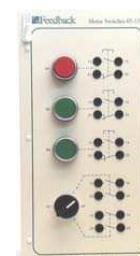
## Control Pushbuttons 65-132

- Three pushbuttons with contacts, 1 N/O and 1 N/C  
One button mushroom head type, two flush head type
- Three indicator lamps, two white, one green – 24 V/0.12 A
- For use with Contactor Panel 65-123
- Safety earth connection provided



## Motor Switches 65-133

- Three pushbuttons with contacts, 1 N/O and 1 N/C  
One button mushroom head type, two flush head type
- Three position selector switch, 1/OFF/2. 1 and 2 positions have 1 N/O and 1 N/C contacts
- For use with Contactor Panel 65-123
- Safety earth connection provided



## Variable Frequency Drive 66-110

- A Three Phase variable frequency output voltage to vary the speed of the Three Phase Induction Motor 64-501
- **Basic control functions are provided for:**
- Maximum & minimum speed settings.
- Acceleration & deceleration times
- Torque boost
- Variable Frequency Control
- Protection is provided for overcurrent & overvoltage. Output power 0.4 kW
- Supply: 180-250 V a.c. at 5 A 50/60 Hz single phase
- Motor earth terminal



## d.c. Motor Speed Controller 66-120

- Suitable for use with 63-110 and 63-120 d.c. motors
- Speed range 0 to 3,000 rev/min. Provides 300 W output
- Adjustable IR compensation control for improved speed regulation
- Used as a drive when testing generators
- Acceleration & deceleration control
- Supply 200-240 V a.c. at 5 A 50/60 Hz
- Motor earth terminal



## Variable Resistance 200 ohms 3 A 67-113

- High power variable resistance element for use where short-term dissipation is required in applications such as:
  - ❖ Generator loading
  - ❖ Motor starting
  - ❖ Motor speed control applications
- Fuse protected at 3.15 A
- Safety earth connection provided



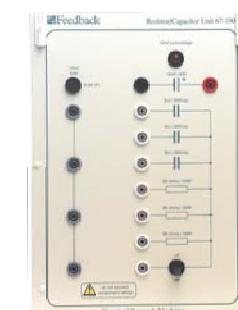
## Switched 3-phase Resistance Load 230/380V 67-142

- Three resistor switched load banks
- Seven resistor values per bank
- 547 – 3770 ohms per bank. 100 W per bank
- Total Three Phase loading for Star@400 V or Delta@230 V, 300 watts
- Fuse protected at 0.5 A
- Safety earth connection provided



## Resistor/Capacitor Unit 67-190

- Low power resistive/reactive component unit
- Resistive elements 3 x 68 ohms
- Capacitive elements: 2 µF, 4 µF and 8 µF
- Nominal ratings:
  - Resistance 50 W each
  - Capacitors 400 V (63 V for 10 mF)
- Fuse protected at 3.15 A
- Specifically for use with 62-100 Dissectible Machine components
- Safety earth connection provided



## Switched Capacitive Load 50µF 67-201

- Three capacitive switched load
- Seven capacitive values
- 10 – 50 µF
- 976 VAR@250 V a.c., 50 Hz
- Fuse protected at 4 A
- Safety earth connection provided



## Switched 3-phase Capacitive Load 230/380 V 67-212

- Three capacitive switched load banks
- Seven capacitive values per bank
- 1 – 7  $\mu\text{F}$  per bank
- 116 VAR@230 V a.c., 50 Hz per bank
- Total Three Phase loading for star @400 V or Delta@230 V, 348 VAR
- Fuse protected at 0.8 A per bank
- Safety earth connection provided



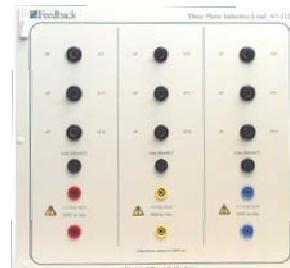
## Inductive Load 700 mH 67-300

- A load consisting of a variable 700 mH inductive component
- Variation is obtained by means of an infinitely variable sliding iron core
- Fused at 2 A, 250 V max
- Rated at 2 A 220 V 50 Hz
- Safety earth connection provided



## Switched 3-phase Inductive Load 230/380 V 67-312

- Three inductive switched load banks
- Seven inductive values per bank
- 1.7 H – 12 H per bank
- 100 VAR@230 V, 50 Hz per bank
- Total Three Phase loading for Star@400 V or Delta@230 V, 300 VAR
- Fuse protected at 0.5 A per bank
- Safety earth connection provided



## Inertia Wheel 67-450

- Used with the Electrical Machine
- Fits onto non drive end of shaft to increase existing rotor inertia on synchronous generators and d.c. machines
- Provides additional inertia load on control systems to investigate their behaviour
- Mass 1.5 kg
- Fits 12 mm shaft diameter



## Friction (Prony) Brake 67-470

- Fits directly onto the shaft of Feedback machines
- Provides direct loading with integral measurement of the torque output of various motor assemblies
- Indicates torque output in either direction
- Fits 12 mm, 1/2 and 5/8 inch shafts
- Torque range  $\pm 2$  Nm



## Manual Swinging Field Dynamometer 67-502

- Movable frame and field assembly
- Higher accuracy torque output
- Strain gauge gives an output proportional to load torque in both torque and speed modes
- Lock rotor test facility for stall torque measurements
- Powered directly from 68-441 Control Panel
- Permanently mounted d.c. Tachogenerator
- Speed:  $\pm 5000$  rpm maximum
- Torque:  $\pm 3$  Nm maximum



## Electronic Single and Three Phase Measurements 68-100

- Measures voltage, current, power, power factor, watts, KVA, KVAR and KWH etc. on 3 to 4 wire, balanced/unbalanced 3-phase systems
- Rated at 750 V a.c. at 5 A per phase
- Supply 230 or 120 V a.c. 50/60 Hz
- Digital readout of values
- Programmable setting
- Simple connections by 4 mm shrouded connecting leads



## d.c. Voltmeter and Ammeter 68-110

- Moving coil d.c. voltmeter
- Voltmeter ranges 0 - 50, 0 - 250, and 0 - 500 V d.c.
- Ammeter range 0 - 1 A, 0 - 5A & 0 - 10 A d.c.
- Ammeter is fuse protected
- Meters are to DIN standard 96 x 96 mm
- Safety earth connection provided



## a.c. Voltmeter and Ammeter 68-111

- A rectifier voltmeter and moving iron ammeter
- Suited to the measurement of variable frequency drives and a.c. supplies
- Rectifier voltmeter range 0 – 250 V and 0 – 500 V a.c.
- Moving iron ammeter range 0 - 3 A
- Meters are DIN standard 96 x 96 mm
- Safety earth connection provided



## d.c. Milli-ammeter, Centre Zero 68-113

- Ideal instrument for use in:
  - ❖ Electrical circuit investigations
  - ❖ Motor/generator set-ups
- Provides direct indication of polarity and polarity reversal
- Ranges:-  $\pm 1$  mA,  $\pm 1$  A and  $\pm 5$  A
- Meters are to DIN standard 96 x 96 mm
- Safety earth connection provided



## Moving Iron Voltmeter and Ammeter 68-114

- For use on a.c. circuits
- Voltage ranges up to 500 V
- Current range to 2 A
- Ammeter is fuse protected
- Meters are to DIN standard 96 x 96 mm
- Safety earth connection provided



## a.c./d.c. Voltmeter and Ammeter 68-116

- A frame mountable multi-range digital meter used to carry-out a wide range of measurements

### Measurements:

- d.c. voltage in ranges 2, 20, 200 & 1,000 V
- a.c. voltage in ranges 2, 200 & 750 V
- d.c. current in ranges 2, 20, 200 & 2,000 mA
- Fuse rated at 2 A (T) 20 x 5 mm for the 2,000 mA range
- Single standard 9 V battery



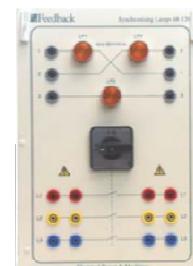
## Rectifier Voltmeter and Ammeter 68-117

- Ideally suited to a.c. measurements over a wide range of voltages and currents with good accuracy
- Voltmeter ranges 0 – 50 V, 0 – 250 V, 0 – 500 V
- Ammeter ranges 0 - 1, 0 – 5 A and 0 – 10 A
- The ammeter is fuse protected for all ranges, 1 A, 5 A and 10 A (T) size '0'
- Module has earth terminal post



## Synchronising Lamps 68-120

- Basic synchronising by phase indicator lamps grouped in a triangle
- Can be connected for lamps-bright or lamps-dark technique
- A power switch is provided to connect the systems together
- Accommodates Single or Three Phase
- Safety earth connection provided
- 380 – 415 V operation



## a.c. Volt and Frequency Meter 68-121

- Used with synchronous machines single and Three phase
- Frequency and voltage measurements
- Ideally suited to the application of synchronising generators and supplies
- Voltage range 0 – 500 V
- Frequency range 45 – 65 Hz
- Safety earth connection provided



## Voltage and Current Monitor 68-150

- For use where current waveform measurements are required
- Output from shunt isolated via voltage probe
- The probe's output connects directly to a oscilloscope for safe monitoring & display
- Current monitor output 5 V/A
- Internally fixed at 2 A (F) 20 x 5 mm fuse
- Isolated voltage probe input 1000 V d.c. or 700 V a.c. rms
- Switched attenuation 1/200 and 1/20 d.c. to 5 MHz bandwidth
- Battery powered 9 V d.c.
- Fully shrouded 4 mm connections with BNC to oscilloscope



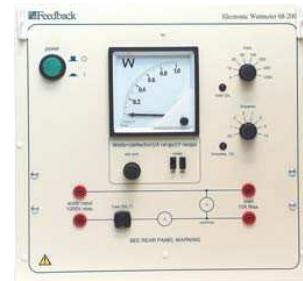
## Differential Voltage Probe 68-151

- Differential isolation probe
- Probes output connects directly to an oscilloscope allowing safe conditions for monitoring & display
- Requires 4 x 5 V batteries AA size
- Switched attenuation 1/200 & 1/20 d.c. to 15 MHz bandwidth
- Shrouded 4mm plugs for circuit connection with BNC connector to oscilloscope
- Maximum input 1,000 V d.c. 700 V RMS



## a.c./d.c. Electronic Wattmeter 68-200

- Selectable voltage and current ranges up to 1,000 V 10 A
- Measurement up to 10 kW
- Ideally suited for use at frequencies of 20 Hz to 20 kHz
- Multi-scaled analogue meter displays measured power value
- Meter to DIN standard 96 x 96 mm
- Supply requirement 230 or 120 V a.c. 50/60 Hz
- Fuse protected current range 10 A(T). Size 11/4 x 1/4 inch
- Overload indicators



## a.c./d.c. Electrodynamic Wattmeter 68-204

- Selectable voltage and current ranges up to 500 V 0.5 A/1A
- Measurement up to 500 W
- Ideally suited for use at mains supply frequencies of 50/60 Hz and d.c.
- Multi-scaled analogue meter displays measured power value
- Meters are to DIN standard 96 x 96 mm
- Fuse protected current ranges 0.5 A (T). Size 20 x 5 mm.
- Safety earth connection provided.



## d.c. Tachogenerator 68-430

- Fits to base of 63 and 64 series electrical machines
- Provides d.c. output proportional to shaft speed
- Output 2 V d.c./1,000 rev/min on 5 pin DIN socket



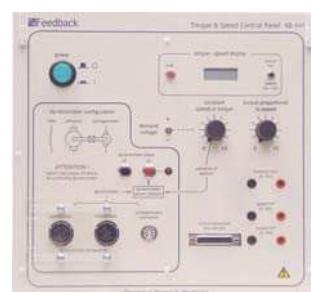
## Magnetic Pick-up 68-431

- Provides a single pulse train suitable for speed measurement
- Attaches to motor base and shaft on 63 and 64 series electrical machines
- Output 64 pulses/rev
- Connects via 5 pin DIN 180° connector
- For use with Contactor Panel 65-123



## Torque and Speed Control 68-441

- Used with machine Dynamometer 67-502
- Provides manual control of torque and speed
- Constant torque and torque proportional with speed controls
- Digital display for speed or torque
- Can be used with 68-500 virtual instrumentation panel
- Speed range  $\pm 5,000$  rev/min. Torque range  $\pm 3$  Nm
- Supply 220 – 250 V a.c. 50 Hz



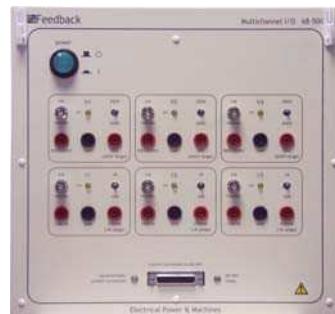
## Hand-held Digital Optical/Contact Tachometer 68-470

- Versatile measuring of shaft speed
- Non-contact by photo sensing
- Direct shaft contact through conical rubber drive
- Measurement range 99,999 rev/min non-contact, 20,000 rev/min contact
- Battery powered



## Multi-channel I/O Unit 68-500 with USB interface and software

- Used with software to evaluate the behaviour of electrical systems
- Software provides on-screen instrumentation of:
  - ❖ a.c. and d.c. Voltmeters and ammeters
  - ❖ d.c. Wattmeter
  - ❖ Single and Three phase Wattmeter
  - ❖ Phase Meter
- VA Meter
- Vector display
- Six isolated channels
- 3 voltage & 3 isolated current channels
- Supply 230 or 120 V a.c. 50/60 Hz



## Shaft Couplings and Keys

Couples 62, 63 & 64 series motors to motor/generator for multi-machine experiments.

- 68-702** 1/2 inch to 12 mm  
**68-703** 12 mm shaft to 12 mm shaft  
**68-704** 12 mm to 5/8 inch  
**68-705** 1/2 inch to 5/8 inch



## Standard set of Patch leads 68-800

For interconnections between panels and bench mounted equipment. Leads are fitted with 4 mm stackable shrouded safety connectors made from double insulated cable. 33 lead of various colours & lengths.



## 5 pin DIN-DIN lead 68-810

1 M long, this lead is used to connect between the tachogenerator unit 68-430 or Magnetic Pick-up 68-431 to the appropriate control panel.



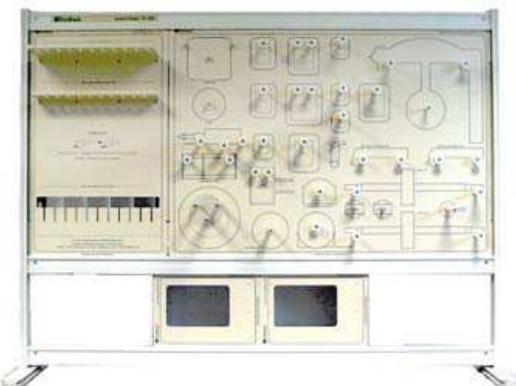
## Lead Storage 91-245

The storage rack is designed to take the three lengths of patch lead used in the 68-800 lead set. Frame or wall mounting.



## Dissectible Machines Storage System 90-100

The storage system holds all coils, leads and components for the Complete Dissectible Machines System 62-005. It has clearly identified positions for components for easy inventory control, with two extra bins for further storage.



## System Frame 91-200

- Easy "lift-in/out" panel removal.
- Maximises bench space.
- Provides clear view of multi-panel experiments.
- Made from non-conductive fibre-glass reinforced resin loaded material.



## Storage Bi 91-240

- Holds items associated with the Powerframes system.
- Can be used in either landscape or portrait format.



## Oscilloscope/Computer Housing 91-210-1

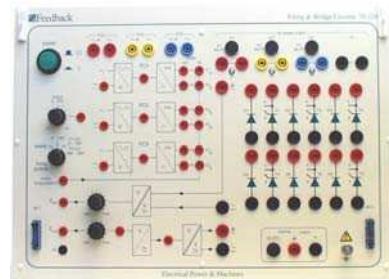
- Suitable for conventional desktop computer and oscilloscope cases.
  - Can be positioned anywhere in the A4 area of the frame.
- Size: W: 380 mm, H: 250 mm, D: 500 mm.



## Power Electronic Modules

### Firing and Bridge circuits 70-220

The Firing & Bridges panel contains the diode and thyristor devices required for Single and Three Phase uncontrolled and controlled rectification together with the firing circuits for the thyristors. The panel also contains the power supplies required for operating the firing circuits, and isolated voltage and current probes for use in waveform observation and control purposes.



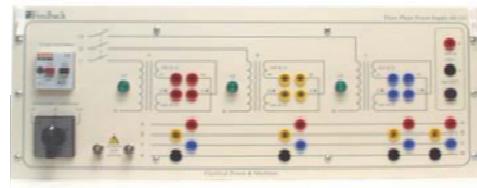
#### The unit contains

- Front panel mimic diagram of circuits and devices.
- Six power diodes and six thyristors that can be connected into various circuit configurations with 4 mm plug leads.
- Three individual firing pulse circuits that produce firing pulses for Single & Three Phase circuits; 1, 2, 4 & 6 pulse options.
- Firing pulse selector, 0 - 180° or 180° and 360° or overlap firing pulses can be selected.
- Reference voltage output control, 0 – 10 V.
- Supply requirements - 120 or 240 V a.c. and Three Phase output from the power supply unit 60-132.

### Three Phase Supply 60-132

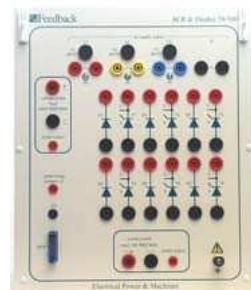
The 60-132 can be configured to provide the desired single phase or three phase power to the 70-220.

- Overcurrent power switch.
- 600 VA output on single and 3-phase at 200 VA per phase.
- Star or delta 3-phase configuration.
- 2 x 100 V windings per phase.
- Input requirement: 380 – 415 V 5 wire. 3 x line, neutral and earth.



### SCR and Diodes 70-100

The unit extends the use of the Firing and Bridge circuits panel by providing a second set of power diodes and thyristors. From these, a thyristor converter can be interconnected to form, with the Bridges panel, a dual converter, either Single or 3-Phase, to control power to a passive or active load such as a d.c. motor. The front panel mimic shows six diode and six thyristors together with voltage and current probes.

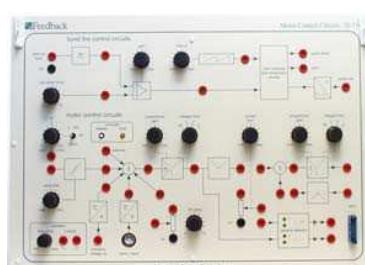


#### Supply requirements

- Three Phase five wire connection at the rear panel, L1, L2, L3, neutral and earth supplied via the Bridges panel from the Three Phase Supply 60-132.
- Operating voltage nominally 170 V 50/60 Hz Three Phase.

### Motor Control Circuits 70-310

Designed to be used with Firing Circuits and Bridges panel, this unit provides the control circuits for motor control and zero crossing burst fire study. A mimic diagram depicts the available circuits for motor control. These can be interconnected to perform different control options. A second circuit is shown for burst fire control that is connected to the bridge circuits for study of a.c. power control. Monitor sockets are provided at various points on the circuit for a voltmeter or an oscilloscope to be used for measurement.



#### Burst Fire Circuit Controls

- Set power level
- Error amplifier gain
- Pulse interval time control

## Motor Control Circuit Controls

- Reference voltage control  
0 – 10 V, ±10 V or OFF by selector switch.
- Acceleration/deceleration time.
- Speed controller proportion gain.
- Speed controller Integral action time.
- Current controller proportional gain.
- Current controller Integral action time.
- Current limit variable control.
- Separate variable attenuator

## Ordering Information

60-105	Universal Power Supply	68-114	Moving Iron Voltmeter & Ammeter
60-121	Variable a.c./d.c. Supply 5 A	68-117	Rectifier Voltmeter and Ammeter
60-132	3-Phase Supply (Power Electronics)	68-120	Synchronising Lamps
61-106	Single Phase Transformer	68-121	a.c. Volt and Frequency Meter
61-107	Three Phase Transformer	68-150	Voltage and Current Monitor
61-140-1	Three Phase Earth Leakage Breaker	68-151	Differential Voltage Probe
61-400	Electromagnetic and Magnetic Principles	68-200	a.c./d.c. Electronic Wattmeter
62-100	Dissectible Machines Tutor	68-204	a.c./d.c. Electrodynamic Wattmeter
62-101	Dissectible Machines Storage Panel	68-430	d.c. Tachogenerator
62-102	Rotatable Brush Gear	68-431	Magnetic Pick-up
63-100	Series Universal Motor	68-441	Torque and Speed Control Panel
63-111	d.c. Shunt Machine	68-470	Hand-held Digital Optical/Contact Tachometer
63-120	d.c. Compound Wound Machine	68-500	Multi-channel I/O Unit with I/O board and software
63-501	d.c. Variable Speed Drive	68-702	Shaft Coupling 1/2 inch to 12 mm
64-110	Capacitor Start Single Phase Induction Run	68-703	Shaft Coupling 12 mm to 12 mm and Key
64-501	3-Phase Induction Motor - Squirrel Cage, Dual Voltage	68-704	Shaft Coupling 12 mm to 5/8 inch and Key
64-510	3-Phase Synchronous Motor/Generator - Wound Rotor	68-705	Shaft Coupling 1/2 inch to 5/8 inch and Key
65-123	Contactor Panel	68-800	Standard set of Patch leads
65-130	Control Switches	68-810	5 pin DIN-DIN lead
65-132	Control Pushbuttons	90-100	Dissectible Machines Storage System
65-133	Motor Switches	91-200	System Frame
66-110	Variable Frequency Drive	91-210-1	Oscilloscope/Computer Housing
66-120	d.c. Motor Speed Controller	91-240	Storage Bin
67-113	Variable Resistance 200 W 3 A	91-245	Lead Storage
67-142	Switched 3-phase Resistance Load 230/380 V	70-100	SCR and Diodes
67-190	Resistor/Capacitor Unit	70-220	Firing and Bridge circuits
67-201	Switched Capacitive Load 50 µF	70-310	Motor Control circuits
67-212	Switched 3-phase Capacitive Load 230/380 V	60-070-CS	Electrical machines Core System
67-300	Inductive Load 700 mH	60-070-SMC	Synchronous machine
67-312	Switched 3-phase Inductive Load 230/380 V	60-070-SUM	Series Universal Motor
67-450	Inertia Wheel	60-070-CI1	Conventional Instruments
67-470	Friction (Prony) Brake	60-070-VIP	Virtual Instrumentation
67-502	Manual Swinging Field Dynamometer	60-070-TFM	Transformers
68-100	Electronic Single and Three Phase Measurements	60-070-ECT	Electrical Circuits
68-110	d.c. Voltmeter and Ammeter	60-070-EMC	Electromagnetic Motor Control
68-111	a.c. Voltmeter and Ammeter	60-070-DSC	d.c. Motor Speed Control
68-113	d.c. Milli ammeter, Centre Zero	60-070-ASC	a.c. Motor Speed Control
68-116	a.c./d.c. Voltmeter & Ammeter (Digital)	60-070-CI2	Conventional Instruments
		60-140-1	Three Phase Earth Leakage Breaker

# Feedback

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Feedback reserves the right to change these specifications without notice.