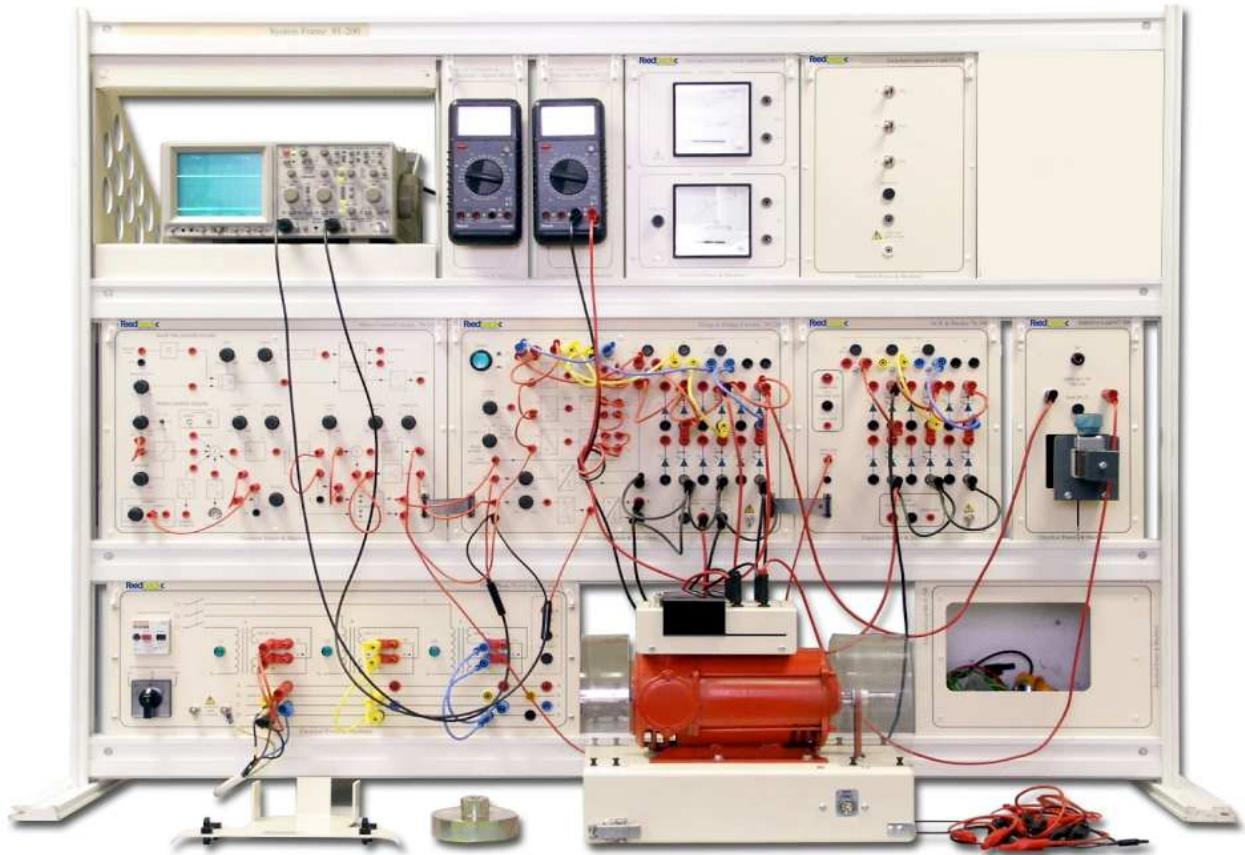


## Powerframes - Power Electronics

## 70 series



The study of power electronic devices, motor drives and circuits is an essential part of any course on power electrical systems. The Series 70 Power Electronics trainers and modules cover the principles, characteristics and operation of single and three phase power electronic circuits and motor drives and have been designed to provide a comprehensive course on modern theory and practice.

The 70 Series Power Electronics trainers and modules form part of the Powerframe range of trainers that provides a flexible and cost-effective way to build a Power and Machines laboratory facility. Three products are available that can be chosen to provide a course of study that fits your training requirements.

They are:

<b>Thyristor Control Principles</b>	<b>70-002</b>
<b>Thyristor &amp; Motor Control</b>	<b>70-003</b>
<b>D.C. Motor Control</b>	<b>70-005</b>

The system is so designed that the Thyristor Control Principles Trainer 70-002 can be used to teach d.c. Motor Control by the inclusion of additional units available in the upgrade package 70-004.

The systems operate from Three Phase supplies, 5 wire connection including Earth, of either 230V/400 V or 120/208 V @ 50/60 Hz 800 VA max, depending on the voltage version.

The image above is representative of a 70-003 system (Oscilloscope not included). See Ordering Information for details on the back page of this range brochure.

## Thyristor Control Principles

70-002

This trainer comprises a Firing and Bridges panel, a Three Phase Supply Panel and electrical loads, instrumentation, etc. to enable the study of the principles and operation of Single and Three Phase thyristor circuits.

### Curriculum Coverage

The Thyristor Control Principles trainer provides extensive training in the principles of thyristor control circuits. The trainer can be used as the basis of a programme, starting with the principles of uncontrolled rectification to simple control using thyristors, then progressing through Single and Three Phase controlled rectification with their associated firing requirements.

The characteristics of various loads: inductive, capacitive and resistive, are studied under half and full-wave, Single and Three Phase rectification, both controlled and uncontrolled. The range of assignment work that can be carried out with the trainer includes:

- **Introduction to Power Electronics**
- **Uncontrolled Rectification Circuits**
  - Single Phase half wave
  - Single Phase full wave
  - Three Phase half wave
  - Three Phase full wave
- **Fully Controlled Rectification Circuits**
  - Single Phase half wave
  - Single Phase full wave
  - Three Phase half wave
  - Three Phase full wave
- **Half Controlled Rectification Single Phase**
- **Half Controlled Rectification Three Phase**
- **a.c. Control Single and Three Phase**

Output from the various converters is measured for Average and RMS values in conjunction with the various RLC load combinations.

### Items supplied with this product are:

Three phase supply	60-132
Switched 3 Phase Resistance Load	67-142
Switched Capacitive Load	67-201
Variable Inductive Load 700 mH	67-300
Moving Iron Voltmeter & Ammeter	68-114
a.c./d.c. Digital Voltmeter/Ammeter	68-116
4mm Patch Lead Set	68-800
Firing Circuits & Bridges	70-220
System Frame	91-200
Oscilloscope/Computer Housing	91-210
Lead Storage Bin	91-240

## Thyristor Principles & Motor Control

**70-003**

This Trainer comprises a Firing & Bridges panel, a Motor Control Circuits panel, a Three Phase Supply Panel, SCR & Diodes Panel, electrical and mechanical loads, instrumentation, etc. to enable the study of the principles of Single and Three Phase rectification applied to passive loads and to apply these thyristor circuits, and principles learnt, to the control of dc motors.

### Curriculum Coverage

In addition to all of the work covered by the Thyristor Control Principles Trainer 70-002, the Thyristor and Motor Control trainer enables the study of dc motor control. Motor speed and current control circuits may be investigated with various types of feedback, including PI control and Four Quadrant control. The range of assignment work that can be carried out with the trainer includes:

### Thyristor Principles

- **Introduction to Power Electronics**
- **Uncontrolled Rectification Circuits**
  - Single Phase half wave
  - Single Phase full wave
  - Three Phase half wave
  - Three Phase full wave
- **Fully Controlled Rectification Circuits**
  - Single Phase half wave
  - Single Phase full wave
  - Three Phase half wave
  - Three Phase full wave
- **Half Controlled Rectification Single Phase**
- **Half Controlled Rectification Three Phase**
- **A.C. Control Single and Three Phase**

Output from the various converters is measured for average and rms values in conjunction with the various RLC load combinations.

### Motor Control

- **Single Phase Half Wave Simple Motor Control**
  - The d.c. Shunt Motor
  - Equations of the dc Motor
  - Speed versus armature voltage
  - Speed versus applied torque
- **Single Phase Full Wave Simple Motor Control**
  - Speed versus armature voltage
  - Speed versus applied torque
- **Closed Loop Proportional Control**
- **Proportional Speed Control using Armature Voltage Feedback**
- **Proportional Speed with Armature Voltage and IR Compensation**
- **Proportional Speed Control with Integral Compensation**
- **Transient Behaviour**
- **Current Limiting Control**
- **Four Quadrant Control**
- **Advanced Four Quadrant Control**
- **Power Inversion\***

\* Note: A second motor is required to carry-out this experiment

## Items supplied with this product are:

Three Phase Supply	60-132
d.c. Shunt Machine	63-111
Switched 3 Phase Resistance Load	67-142
Switched Capacitive Load	67-201
Variable Inductive Load 700 mH	67-300
Inertia Wheel	67-450
Friction Brake	67-470
Moving Iron Voltmeter & Ammeter	68-114
a.c./d.c. Digital Voltmeter/Ammeter	2 x 68-116
d.c. Tachogenerator	68-430
Optical/Contact Tachometer	68-470
4 mm Patch Lead Set	68-800
5-way DIN-DIN Lead	68-810
SCR & Diodes	70-100
Firing Circuits & Bridges	70-220
Motor Control Circuits	70-310
System Frame	91-200
Oscilloscope/Computer Housing	91-210
Lead Storage Bin	91-240

## d.c. Motor Control Trainer

**70-005**

This Trainer comprises a Firing & Bridges panel, a Motor Control Circuits panel, a Three Phase Supply Panel, SCR & Diodes Panel, and dc motor, instrumentation, etc. to enable the study of the principles of Single and Three Phase thyristor circuits and their application in the control of d.c. motors.

### Assignment Courseware

The assignment work is covered in a teaching manual. These include background, practical work, questions and answers. This manual can be used as the basis of a complete course on power electronics.

### Curriculum Coverage

The dc Motor Control trainer enables the study of dc motor control in both Single and Three Phase circuits. Motor speed and current control circuits may be investigated with various types of feedback, including PI control and Four Quadrant control. The range of assignment work that can be carried out with the trainer includes:

- **Single Phase Half Wave Simple Motor Control**
- The dc Shunt Motor
- Equations of the dc Motor
- Speed versus armature voltage
- Speed versus applied torque

- **Single Phase Full Wave Simple Motor Control**
- Speed versus armature voltage
- Speed versus applied torque
  
- **Closed Loop Proportional Control**
- **Proportional Speed Control using Armature Voltage Feedback**
- **Proportional Speed with Armature Voltage and IR Compensation**
- **Proportional Speed Control with Integral Compensation**
- **Transient Behaviour**
- **Current Limiting Control**
- **Four Quadrant Control**
- **Advanced Four Quadrant Control**
- **Power Inversion\***

*\* Note: A second motor is required to carry-out this experiment*

## Items supplied with this product are:

Three Phase Supply	60-132
d.c. Shunt Machine	63-111
Variable Inductive Load 700 mH	67-300
Inertia Wheel	67-450
Friction Brake	67-470
a.c./d.c. Digital Voltmeter/Ammeter	2 x 68-116
d.c. Tachogenerator	68-430
Optical/Contact Tachometer	68-470
4mm Patch Lead Set	68-800
5-way DIN-DIN Lead	68-810
SCR & Diodes	70-100
Firing Circuits & Bridges	70-220
Motor Control Circuits	70-310
System Frame	91-200
Oscilloscope/Computer Housing	91-210
Lead Storage Bin	91-240

## Thyristor Control Upgrade

## 70-004

The Thyristor Control Upgrade is available to customers who have Thyristor Control Principles 70-002, and wish to extend the work to cover Thyristor and Motor Control 70-003.

## Items supplied with this product are:

d.c. Shunt Machine	63-111
Inertia Wheel	67-450
Friction Brake	67-470
a.c./d.c. Digital Voltmeter/Ammeter	68-116
d.c. Tachogenerator	68-430
Optical/Contact Tachometer	68-470
5-way DIN-DIN Lead	68-810
SCR and Diodes	70-100
Motor Control Circuits	70-310

## Description of Modules

### Three Phase Supply 60-132

This panel provides at its outputs the working supplies for the power devices on the Firing Circuits and Bridges panel and SCR and Diode panel. Three transformers, one for each Phase, are used to provide Three Phase outputs of 200 VA for each Phase or they can be combined to produce a Single Phase output of 600 VA.

#### Supply requirements

- Three phase five wire connection
- L1, L2, L3, Neutral and earth
- 380-415 V @ 50 Hz 800 VA or 200-220 V @ 60 Hz 800 VA.

#### Description

A mimic diagram on the front panel depicts the transformers circuit and main input supply connection. Transformers have two secondary windings, each of 100 V a.c. @ 1 A. They can be connected in series of parallel, Star or Delta to provide a range of output voltages and current. A separate d.c. output of 220 V or 110 V @ 1 A is available to supply the motor field. Four bus bar connections are available for transformer interconnection and supply distribution purposes.

#### Connections

- Three Phase power input by 14 way socket on a 2 m lead, to be terminated to customer supply
- Single Phase output on IEC socket, 230 V/120 V @ 2 A at the rear panel
- Interconnection of transformer secondaries by 4 mm plug leads
- Two protective earth terminals are available for connection to external equipment, electrical machines etc.

#### Controls/Circuit protection

- Three Phase thermal/magnetic breaker with ON/OFF push buttons
- Primary power switch to select Three Phase or Single Phase operation with off position
- Three power on indicators, one for each Phase
- Single Phase outlet fused at @ 2 A(T) 20 mm x 5 mm on an IEC socket on the rear panel

### d.c. Shunt Machine 63-111

Mounted on a prefabricated base and equipped with quick-release catches and locating pins, allowing easy coupling with other motor/machines drives and loads in the 60 series range. Each machine is fitted with a mimic schematic plate and connections are made using shrouded 4 mm safety connectors.

- Rated at 250W with separately wound shunt field
- Nominal supply 180/220 V or 90/110 V d.c. armature and field
- Suitable for operation with separately excited or self-excited connections
- Can be used as a d.c. generator
- Nominal speed 3000 rev/min

## Three Phase Switched Resistance Load 67-142-230 volt version

Three switched resistive load banks

- 7 resistive values per bank
- 546 - 3770 ohm per bank
- Rated at 100 w per bank @ 230 V
- Total resistive range 182 - 11,310 ohms

## Three Phase Switched Resistance Load 67-142-120 volt version

Three switched resistive load banks

- 7 resistive values per bank
- 140 - 980 ohm per bank
- Rated at 100 w per bank @ 120 V
- Total resistive range 47 - 2,940 ohms

## Switched Capacitive Load 67-201

- Single Phase switched capacitive load
- Five possible capacitance values
- 10 $\mu$ f, 20 $\mu$ f, 30 $\mu$ f, 40 $\mu$ f and 50 $\mu$ f

## Optical/Contact Tachometer 68-470

- 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

## Inertia Wheel 67-450

Designed for use with the electrical machines this unit fits onto the non-drive end of the d.c. shunt motor. It provides an additional inertia load when investigating control system behaviour in 2, 4, 8 or 12 pulse converter drives. A cover is also provided to restrict access and protect from potential hazards. The dimensions of the wheel are 100 mm x 25 mm of material, mild steel, with a mass of 1.5 kg.

## Friction Brake 67-470

- Fits directly onto the shaft of the machine
- Provides direct loading with integral measurement of the torque output of the motor assemblies under test
- Indicates torque output in either direction up to  $\pm 2$  Nm

## Moving Iron Voltmeter & Ammeter 68-114

- Voltage range 0-500V a.c.
- Current range 0-3 A
- Ammeter is fuse protected
- Meters are to DIN standard 96 x 96 mm

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

- Panel mounted to fit into frame
- Multi-range voltage, amperes, a.c./d.c. on one rotary switch
- Separate on/off switch maintains range setting.
- Battery powered
- Uses standard safety plug leads
- Fused current ranges

## d.c. Tachogenerator 68-430

- Attaches to motor base and shaft to provide a dc voltage or current output for connection to electronic systems or speed indicators
- Output 2 V d.c./1000 to 6000 rev/min
- Connection 5 pin 180° DIN connector

## Variable Inductive Load 67-300

- A load consisting of variable 700 mH inductive component rated at 1 A 220 V 50 Hz
- Variation is by means of an infinitely variable iron core
- Total loading is rated at 220 VAR
- Rated at 250 V a.c.
- Fuse protected against excessive overload

## 4 mm Patch Leads 68-800

For interconnections between panels and bench mounted equipment, the leads are fitted with 4 mm stackable shrouded safety connectors made from double insulated cable. All front panel power connections on the equipment are made with shrouded plug leads.

## 5-way DIN-DIN Lead 68-810

1 m long, this lead is used to connect between the tachogenerator unit (68-430) and the motor controller panel 70-310.

## SCR & Diodes 70-100

The unit extends the use of the Firing Circuits and Bridges 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 Phase or Three Phase, to control power to a passive or active load such as a dc motor. The front panel mimic shows six diode and six thyristors together with voltage & current probes.

### Supply requirements

- Three Phase five wire connection at the rear panel supplied via the Firing Currents and Bridges panel 70-220 from the Three Phase Supply 60-132
- Isolated voltage probe with an output of 1/50th and an output limit of  $\pm 10$  V
- Isolated current probe with an output of 1:1 and an output limit of  $\pm 10$  V

### Circuit protection

- Power devices protected from current overload by fast acting fuses in the Three Phase supply lines
- 3 x 8 A (FF) Size '0' (11/4" x 1/4")

### Connections

- Three Phase connection at the rear panel by 14-way plug and socket lead to the Three Phase power supply 60-132
- 4 mm shrouded plug leads for interconnection of the power devices and probe inputs
- 2 mm shrouded plug leads for probe outputs



## Firing Circuits & Bridges 70-220

The Firing Circuits & 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.

### Supply Requirements

Two supply connections are required

- 1) 230-250 V ac 50/60 Hz or 100-125 V 50/60 Hz, 60 VA for electronic circuits
- 2) Output from Three Phase Power Supply 60-132, 3-phase with neutral connection @ 600 VA max

### 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 4mm plug leads
- Three individual firing pulse circuits that can be connected to produce firing pulses for Single and Three Phase circuits; one, two, four and six pulse options, a.c. or d.c.
- Firing pulse selector, 0 - 180° and 180° - 360° or overlap firing pulses can be selected
- Reference voltage output control, 0-10 V
- Isolated voltage probe output of 1/50th
- Associated variable output control Max output  $\pm 10$  V
- Isolated current probe with 1:1 ratio
- Associated variable output control Max output  $\pm 10$  V
- d.c. output for motor field supply applications, 220 V or 110 V @ 1 A

### Circuit protection

- Power devices protected with fast acting fuses in the Three Phase supply lines
- 3 x 8A (FF) size 'O' (11/4 inch x 1/4 inch)
- Single Phase mains fuse (20 mm x 5 mm) 250 mA(T)

### Connections

- Patching leads are 2 & 4 mm shrouded types
- Single Phase mains by IEC 3 pin socket
- Three Phase supply by 14 way socket to 4 mm plug lead (supplies from 60-132)
- Three Phase output, connection for use with SCR & Diodes panel 70-100

## Motor Control Circuits 70-310

Designed to be used with Firing Circuits and Bridges panel, this unit provides the control circuits for motor control. A mimic diagram depicts the overall available circuits for motor control and these can be interconnected to perform various different control scenarios. Monitor sockets are provided at various points in the circuits to enable a voltmeter or an oscilloscope to be used for investigative measurement.

A separate variable free running oscillator produces triangle and square wave outputs to drive the system continuously when evaluating the system response.

## Motor control circuit controls

- Reference voltage control 0-10 V,  $\pm 10$  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

Inputs with filters are provided for dc tachogenerator and armature voltage. Non filtered inputs are available for current and external sources.

## Electronic Circuit blocks

- P+I Speed controller
- P+I Current controller
- Precision full wave rectifier, positive output
- Precision full wave rectifier, negative output
- Summing amplifiers for speed and current circuits
- Variable time ramp circuit
- Comparator and decision logic with polarity indicating LED's

## Protective circuits

The speed, current and ramp circuits are clamped to zero when the power to the Bridge Circuits panel is switched on or off. This hold condition is indicated by a LED on the front panel.

## Connections

Power for the internal electronic circuits is supplied to the unit from the bridge circuit's panel via a 16-way ribbon socket interconnecting lead. All circuit monitor points and interconnections are made with shrouded 2 mm plug leads.

## System Frame 91-200

- Easy 'lift-in/out' panel removal
- Maximises bench space
- Provides clear view of multi-panel experiments

## Oscilloscope/Computer Housing 91-210

- Suitable for conventional desktop computer (horizontal) and oscilloscope cases
- Can be positioned anywhere in the A4 area of the frame
- Aperture opening: Width 410 mm, Height 200 mm, Depth 495 mm

## Universal Lead Storage Bin 91-240

- Holds items associated with the PowerLab System
- Can be used in either landscape or portrait format

## Ancillary Equipment

Dual trace Oscilloscope 20 MHz, preferably with digital storage or with a long persistence tube. A suitable oscilloscope is available from Feedback Instruments Limited.

## Ordering Information

Please quote the following product names and numbers when ordering and specify which voltage rating you require either 230 V/400 V at 50/60 Hz or 120 V/208 V at 60 Hz:

Thyristor Control Principles	70-002
Thyristor Control Principals & dc Motor Control	70-003
dc Motor Control Upgrade for 70-002	70-004
dc Motor Control	70-005
Digital Storage Oscilloscope	9999-01874



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Feedback reserves the right to change these specifications without notice