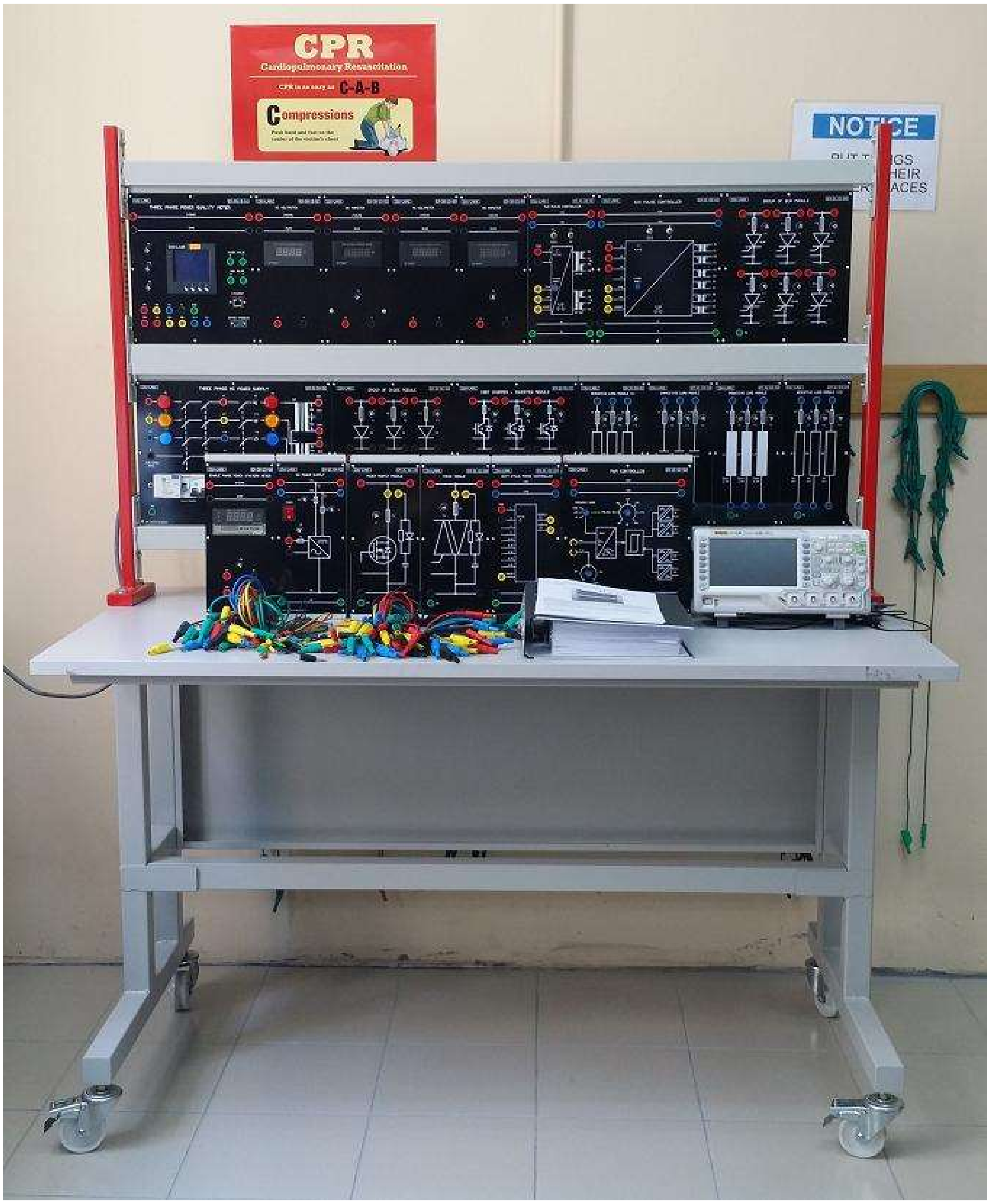
POWER ELECTRONICS TRAINER

EM-21800QM

SCIENSCOPE
EDU-LABS

worldskills Malaysia



Power Electronics has evolved from static converter technology into a significant field within electrical engineering and electronics. By using power semiconductors power electronics performs such functions as switching, controlling and converting of electrical energy with the greatest possible efficiency. One area of application for power electronics is drive technology. Here, speed variable DC and three-phase four-quadrant drives can easily be realized using modern power electronics. As a result of this development we can no longer imagine industry, workshop tools, commercial enterprises and household appliances without thyristor speed control units, smooth-starting circuits, frequency converters etc. The EDULAB DIDACTIC training panel system EM-21800QM for power electronics and drive now makes it possible to convey the technical knowledge of this field.

The experiments permit practice-oriented, hands-on training to be carried out, thus assuring the trainees of the proficiency needed to handle the tasks and the equipment found in this field. The training panels and functional units with block circuit diagrams and signal diagrams permit clear and understandable assembly of the experiment circuits. Beginning with the basic circuits, the student proceeds to tackle more complex circuits in power electronics and drive technology using a proven step-by-step method designed for didactic results. And of course, the model behind the entire system is the circuitry used in industrial applications.

EXPERIMENTS COVER THE FOLLOWING TOPICS:

SECTION 1: DIODE AND UNCONTROLLED RECTIFIER CIRCUIT (AC-DC CONVERSION)

1-1 Power Diode
1-2 Single Phase Half Wave Rectifier Circuit
1-3 Full Wave Rectifier Circuit with Center Tap Transformer
1-4 Single Phase Full wave Bridge Rectifier Circuit
1-5 Three Phase Half Wave Rectifier Circuit
1-6 Three Phase Full Wave with Center Tap Transformer Rectifier Circuit
1-7 Three Phase Full Wave Bridge Rectifier Circuit

SECTION 2: SCR AND CONTROLLED RECTIFIER CIRCUIT (AC-DC CONVERSION)

2-1 SCR and Single Phase Controller
2-2 Single Phase Half Wave Controlled Rectifier Circuit
2-3 Single Phase Full Wave Controlled Rectifier With Center Tap Transformer Circuit
2-4 Single Phase Bridge Full Wave Controlled Rectifier Circuit
2-5 Single Phase Full Wave Half Controlled Rectifier Circuit SCR based Inverters
2-6 Three Phase Half Wave Controlled Rectifier Circuit
2-7 Three Phase Full Wave Controlled Rectifier With Center Tap Transformer Circuit
2-8 Three Phase Bridge Full Wave Controlled Rectifier Circuit
2-9 Three Phase Full Wave Half Control Bridge Rectifier Circuit
2-10 Star-Delta Connections Control Rectifier Circuit
2-11 Delta–Connected Three Phase Bi-direction Connection
2-12 Star-Connected Three Phase Bidirectional Connection

SECTION 3: THYRISTORS AND CONTROLLED CIRCUIT (AC-AC CONVERSION)

3-1 Triac
3-2 Single Phase AC Voltage Control Circuit (On-Off Control)
3-3 Single Phase AC Voltage Control Circuit (Phase Control)
3-4 Three Phase Full Wave AC Voltage Control Circuit

SECTION 4: CHOPPER CIRCUIT (DC-DC CONVERSION)

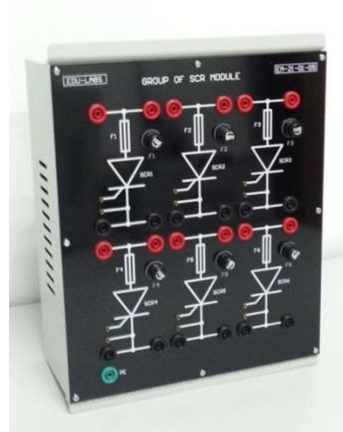
4-1 PWM Generation and Gate Drive Circuit
4-2 IGBT Chopper / Inverter Circuit
4-3 MOSFET Chopper Circuit
4-4 Darlington Chopper Circuit
4-5 Hi-Bridge Converter
4-6 **The DC Motor Control of H-Bridge converter**

EXPERIMENTS MODULE CONSISTS OF THE FOLLOWING:

GROUP OF DIODE MODULE
EM-21-01-03

- Device : Fast Acting Silicon Diode
- Quantity : 6
- Voltage : 500V
- Current : 15A
- Protection : 5A Fuse With Fuse Holder
- Terminal Socket : 4mm Safety Type
- Unit Type : Panel H2

GROUP OF SCR MODULE
EM-21-01-05 (2 UNITS)



- Device : Silicon Control Rectifier
- Quantity : 6
- Voltage : 600V
- Current : 15A
- Protection : 5A Fuse With Fuse Holder
- Terminal Socket : 4mm Safety Type
- Unit Type : Panel H2

TRIAC MODULE
EM-21-01-06

- Device : TRAIC
- Quantity : 1
- Voltage : 600V
- Current : 15A
- Protection : 5A Fuse With Fuse Holder
- Terminal Socket : 4mm Safety Type
- Unit Type : Panel H1

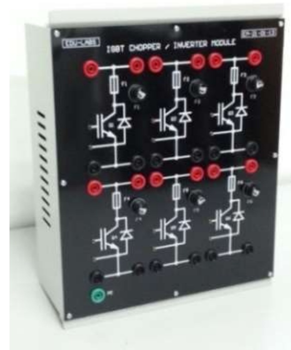
POWER MOSFET MODULE
EM-21-01-10

- Device : Power Field Effect Transistor (N-Channel Enhancement Mode Silicon Gate)
- DC Input Voltage : Maximum 220V
- DC Output Current : Maximum 5A
- Switching Frequency : 0...15KHz
- Quantity : 1
- Voltage : 600V
- Current : 15A
- Protection : 5A Fuse With Fuse Holder
- Terminal Socket : 4mm Safety Type
- Unit Type : Panel H1

DARLINGTON TRANSISTOR MODULE
EM-21-01-12

- Device : Darlington Transistor
- DC Input Voltage : Maximum 220V
- DC Output Current : Maximum 5A
- Switching Frequency : 0...15KHz
- Quantity : 1
- Voltage : 600V
- Current : 15A
- Protection : 5A Fuse With Fuse Holder
- Terminal Socket : 4mm Safety Type
- Unit Type : Panel H1

IGBT CHOPPER / INVERTER MODULE
EM-21-01-13



- Device : Silicon Insulated Gate Bipolar Transistor (N-Channel Enhancement Mode Silicon)
- DC Input Voltage : Maximum 220V
- DC Output Current : Maximum 5A
- Switching Frequency : 0...15KHz
- Quantity : 6
- Voltage : 600V
- Current : 15A
- Protection : 5A Fuse With Fuse Holder
- Terminal Socket : 4mm Safety Type
- Unit Type : Panel H2

TWO PULSE CONTROLLER
EM-21-02-01 (2 UNITS)

- Power Supply : +15V/0V/-15V
- Input / Output : Transformer & Pulse Transformer
- Synchronization Voltage : 5-220V,50/60Hz
- Control Voltage : 0-10V
- Trigger Angle : 0-30°
- Trigger Control Delay Angle : 0-180° & 180°-360°
- Pulse Output : Single Pulse, Train Pulse
- Protection : 5A Fuse With Fuse Holder
- Terminal Socket : 4mm Safety Type
- Unit Type : Panel H1

SIX PULSE CONTROLLER
EM-21-02-02

- Power Supply : +15V/0V/-15V
- Input / Output : Transformer & Pulse Transformer
- Synchronization Voltage : 5-400V, 50/60Hz
- Control Voltage : 0-10V
- Trigger Angle : 0-30°
- Trigger Control Delay Angle: 0-180° & 180°-360°
- Pulse Output : Single Pulse & Train Pulse
- Protection : 5A Fuse With Fuse Holder
- Terminal Socket : 4mm Safety Type
- Unit Type : Panel H2

PWM CONTROLLER
EM-21-02-03

- Output: Pulse Width Modulation Isolated Pulse Output
- Frequency Variable : 0...20kHz : x1, x10, x100 (Switchable)
- Duty Ratio : 0...100% (Reverse / Forward)
- Protection : 5A Fuse With Fuse Holder
- Terminal Socket : 4mm Safety Type
- Unit Type : Panel H2

DUTY CYCLE PHASE CONTROLLER
EM-21-02-04

- Power Supply : +15V/0V/-15V
- Synchronization Voltage : 5-400V,50/60Hz
- Output Phase Control : Positive and Negative
- Duty Cycle (D) : 0.00, 0.25, 0.50, 0.75, 1.00
- Protection: 5A Fuse With Fuse Holder
- Terminal Socket: 4mm Safety Type
- Unit Type : Panel H1

RESISTIVE LOAD MODULE (I)
EM-21-03-01

- Configuration : STAR , DELTA
- Resistor : 3X100Ohm / 100 Watt
- Protection : 5A Fuse With Fuse Holder
- Terminal Socket : 4mm Safety Type
- Unit Type : Panel H1

INDUCTIVE LOAD MODULE
EM-21-03-02

- Configuration : STAR , DELTA
- Inductor : 50mH/2.5A
- Protection : 5A Fuse With Fuse Holder
- Terminal Socket : 4mm Safety Type
- Unit Type : Panel H1

CAPACITOR LOAD MODULE
EM-21-03-03

- Configuration : STAR , DELTA
- Capacitor : 0.1uF / 450V
- Protection : 5A Fuse With Fuse Holder
- Terminal Socket : 4mm Safety Type
- Unit Type : Panel H1

RESISTOR LOAD MODULE (II)
EM-21-03-04 (3 UNITS)

- Configuration : STAR , DELTA
- Resistor : 3x1.0 Ohm/5Watt
- Protection : 5A Fuse With Fuse Holder
- Terminal Socket : 4mm Safety Type
- Unit Type : Panel H1

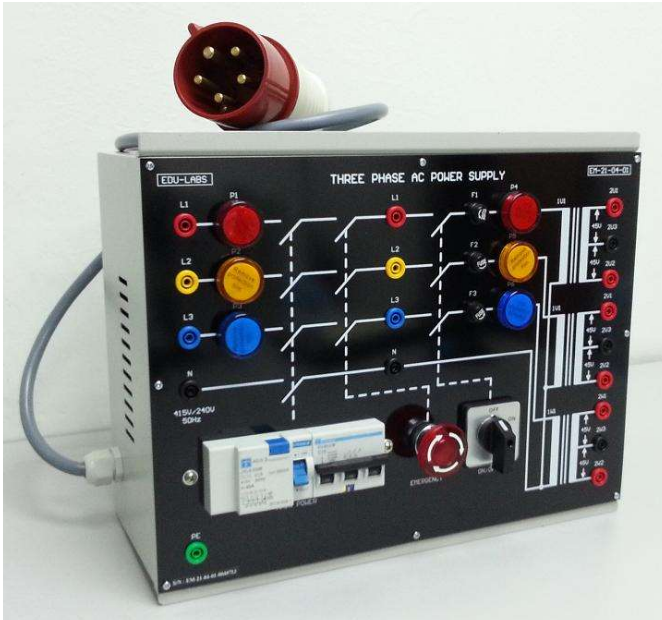
DC POWER SUPPLY MODULE
EM-21-04-02

- Output Type : DC Fixed Output Voltage
- Output Voltage : +15V/0/-15V
- Output Current : 2A
- Power Supply : 240V,50Hz
- Protection : Short Circuit & 5A Fuse With Fuse Holder
- Terminal Socket : 4mm Safety Type
- Unit Type : Panel H1

CONNECTING SAFETY LEAD SET
EM-30-15-04

- The set consists of 2 type lead set and 2 type bridging plug set in 5 different coded colors and lengths chosen to allow the realization of all experiment manual.
- Leads are capable of 15A current safety plugs.
- Safety Stackable Test Leads Set (4mm): 25cm x 15 units; 50cm x 20 units; 100cm x 15 units
- Stackable Test Leads Set (2mm): 45cm x 10 units
- 19mm Bridging Plug Set x 10 units
- 19mm Bridging Plug Set (Stackable) x 10 units

THREE PHASE AC POWER SUPPLY
EM-21-04-01



- Input Voltage: Three Phase 415V, 50Hz
- Output Type : AC Fixed Output Voltage
- AC Input Voltage : 3 x 240/415V+N+PE
- Transformer Output : 3 x 45V-0V-45V
- Output Current : 2.0A
- Circuit Breaker, Earth Leakage Circuit Breaker, Power Switch, Emergency Switch, Pilot Lamp
- Protection : 5A Fuse With Fuse Holder
- Terminal Socket : 4mm Safety Type
- Unit Type : Panel H4

DIGITAL DC VOLTMETER
EM-30-13-01

- Modular design
- Measurement range : 0 ~ 600Vdc
- Display : 3 ½ digits 14.2 mm LED
- Accuracy : ± 0.2% ± 1 digit
- Resolution : 1V
- Input impedance : 1MΩ
- Power source : 220Vac, 50/60 Hz
- Unit Type : Panel H1
- Terminals: 4mm Safety Sockets (Color Coded)

DIGITAL DC AMMETER
EM-30-13-02

- Modular design
- Measurement range : DC 0 ~ 10 A
- Display : 3 ½ digits 14.2 mm LED
- Accuracy : ± 0.3% ± 1 digit
- Resolution : 0.01 A
- Input impedance : < 0.1Ω
- Power source : 220Vac, 50/60 Hz
- Unit Type : Panel H1
- Terminals: 4mm Safety Sockets (Color Coded)

DC MOTOR
EM-30-01-05

- Nominal Power: 180W (1/4HP)
- Nominal Voltage: 220VDC
- Nominal Current: 1.50 A
- Nominal Speed: 1500 rpm
- Cooling Method: Self Cooled
- Terminals: 4mm Safety Socket
- Base Plate: Attachable To Break Load Unit
- Coupling: EM-21-CS (Option)

THREE PHASE INDUCTION MOTOR
EM-30-02-01

- Nominal Power: 180W (1/4HP)
- Nominal Voltage: 240VAC / 415VAC (Delta/Star)
- Nominal Current: 1.15 / 0.95A (Delta/Star)
- Nominal Speed: 1500 rpm
- Cooling Method: Total Enclosed Fan Cooled
- Terminals: 4mm Safety Socket
- Base Plate: Attachable To Break Load Unit
- Coupling: EM-21-CS (Option)

DIGITAL AC VOLTMETER
EM-30-13-03 (2 UNITS)

- Modular design
- Measurement range : 0 ~ 600Vac
- Display : 3 ½ digits 14.2 mm LED
- Accuracy : ± 0.2% ± 1 digit
- Resolution : 1V
- Input impedance : 1MΩ
- Power source : 220Vac, 50/60 Hz
- Unit Type : Panel H1
- Terminals: 4mm Safety Sockets (Color Coded)

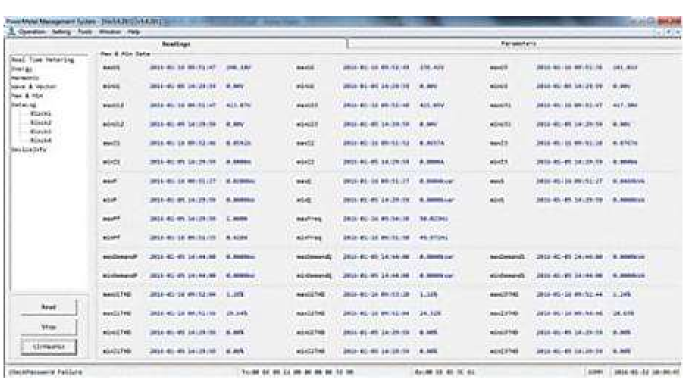
DIGITAL AC AMMETER
EM-30-13-04

- Modular design
- Measurement range : AC 0 ~ 5A
- Display : 3 ½ digits 14.2 mm LED
- Accuracy : ± 0.3% ± 1 digit
- Resolution : 0.01 A
- Input impedance : < 0.1Ω
- Power source : 220Vac, 50/60 Hz
- Unit Type : Panel H1
- Terminals: 4mm Safety Sockets (Color Coded)

THREE PHASE POWER QUALITY METER
EM-30-13-16

- Modular design
- Display Type: HD LCD Display
- Real-Time Measurement
  - Phase voltage: V1, V2, V3, Vlnavg Line voltage: V12, V23, V31, Vllavg Current: I1, I2, I3, Iavg, In Active power: per phase and total active power Reactive power: per phase and total reactive power Apparent power: per phase and total apparent power Power factor: per phase and total power factor Total frequency
- Energy And Demand
  - Four quadrant active energy: Import, Export, Total, Net Four quadrant reactive energy: Import, Export, Total, Net Active, Reactive, Apparent demand
- Power Quality Analysis
  - Voltage unbalance Current unbalance Voltage THD (Total harmonic distortion), Odd-even harmonic distortion Voltage individual harmonics, Crest factor Current THD, Odd-even harmonic distortion Current individual harmonics, K factor
- Communication
  - **Ethernet 10/100M network port**
  - RS485 communication port
  - MODBUS RTU communication protocol
- Trend Logging
  - Phase voltage Line voltage Current Active power Reactive power Apparent power Power factor Frequency Three-phase unbalance Active energy Reactive energy Apparent energy Phase
- Settable Logging Interval
  - Logging from 1min to 60min, interval settable
- Software Accessibility
  - 4 Tariffs (DataLog) Sharp, peak, flat, valley in different season and schedule (TOU)
- **POWER MANAGEMENT SOFTWARE** interface
- Accuracy: ±0.5%
- Protection: Fuse
- Power Supply: AC240VAC, 50Hz
- Terminals: 4mm Safety Socket
- Unit Type : Panel H2

POWER MANAGEMENT SOFTWARE
EM-30-13-16-PMS



- PC software for power quality meter
- True-RMS measuring parameters
- ANSI and IEC 0.2 accuracy class
- Power quality analysis
- 4 quadrant energy
- Data logging
- Measure individual harmonics from 2^{nd} to 49^{th}
- TOU, 4 Tariffs, 6 Seasons, 6 Schedules
- Complete with **Ethernet 10/100M network cable**

EXPERIMENTAL TABLE EM-30-16-01-02	EXPERIMENT PANEL FRAME EM-30-16-02-02
 ○ 5' Standard Desktop ○ Dimension: • Length : 1500mm • Width : 800mm • Height : 850mm ○ Complete with heavy duty castor wheel (Front Lockable) ○ 3 Layer Drawer (Optional)	 ○ Din Standard A4 With Two Shelves ○ Side Frame: T Shape ○ Dimension: ○ Length : 1450mm ○ Width : 20mm ○ Height : 300mm

Power Electronics Trainer EM-21800QM – Objective & Experiments Lists

Experiment 1: Power Diode

Objectives: the trainee is able to

1. Describe the principle of power diode within the alternating-current circuit.
2. Determine the characteristic of power diode.
3. Determine the shape of the voltage-current characteristic curve within the alternating-current circuit for resistive load.
4. Determine the form factor.

Experiments Lists

1. Experiment 1.1: Voltage and current characteristic
2. Experiment 1.2: Determination of the shape of the voltage-current characteristic curve
3. Experiment 1.3: Determine the form factor

Experiment 2: Thyristor (SCR)

Objectives: the trainee is able to

1. Determine the shape of SCR characteristic curve
2. Describe the controlling of SCR
3. Calculate the average and RMS value of output voltage
4. Explain the correlation between phase angle of the firing pulse and output voltage

Experiments List

1. Experiment 2.1: Voltage and current characteristic of SCR
2. Experiment 2.2: Determination of the shape of the voltage-current characteristic curve of SCR

Experiment 3: Triac

Objectives: the trainee is able to

1. Determine the characteristic of triac
2. Measure the voltage in triac circuit
3. Describe the principle of triac

Experiments List

1. Experiment 3.1: Characteristic of Triac
2. Experiment 3.2: Control of the current

Experiment 4: Single Phase Half-Wave Rectifier

Objectives: the trainee is able to

1. Determine the voltage ratio for resistive load
2. Determine the shape of the voltage-current characteristic curve for resistive load
3. Determine the current ratio for resistive load
4. Determine the ripple for resistive load
5. Determine the shape of the voltage-current characteristic curve for resistive-inductive load

Experiments Lists

1. Experiment 4.1: Voltage Ratio for Resistive Load
2. Experiment 4.2: Voltage-Current Characteristic Curve for Resistive Load
3. Experiment 4.3: Current Ratio for Resistive Load
4. Experiment 4.4: Ripple Factor for Resistive Load
5. Experiment 4.5: Voltage-Current Characteristic Curve for Resistive-Inductive Load

Experiment 5: Full-wave rectifier with center tap

Objectives: the trainee is able to

1. Determine the voltage ratio
2. Measure the shape of the voltage-current characteristic curve for resistive load
3. Determine the current ratio
4. Determine the ripple for resistive load
5. Measure the shape of the voltage-current characteristic curve for resistive-inductive load

Experiments Lists

1. Experiment 5.1: voltage ratio for resistive load
2. Experiment 5.2: voltage-current characteristic curve for resistive load
3. Experiment 5.3: current ratio for resistive load
4. Experiment 5.4: Ripple factor for resistive load
5. Experiment 5.5: Voltage-current characteristic curve for resistive-inductive load

Experiment 6: Single Phase Full-Wave Bridge Rectifier

Objectives: the trainee is able to

1. Determine the voltage ratio for resistive load
2. Measure the diode voltage drop
3. Measure the shape of the current characteristic curve for resistive load
4. Determine the current ratio for resistive load
5. Determine the voltage factor for resistive load
6. Measure the shape of the voltage-current characteristic curve for resistive-inductive load

Experiments list:

1. Experiment 6.1: voltage ratio for resistive load
2. Experiment 6.2: Voltage drop on diode
3. Experiment 6.3: The shape of diode conducting current curve for resistive load
4. Experiment 6.4: Current ratio for resistive load
5. Experiment 6.5: Ripple factor for resistive load
6. Experiment 6.6: Voltage-current characteristic curve for resistive-inductive load

Experiment 7: Three Phase Half-Wave Rectifier

Objectives: the trainee is able to

1. Determine the voltage ratio for resistive load
2. Measure the shape of the current characteristic curve for resistive load
3. Determine the current ratio for resistive load
4. Determine the ripple factor for resistive load
5. Measure the shape of the voltage-current characteristic curve for resistive-inductive load

Experiments Lists

1. Experiment 7.1: voltage ratio for resistive load
2. Experiment 7.2: Voltage-current characteristic curve for resistive load
3. Experiment 7.3: Current ratio for resistive load
4. Experiment 7.4: Ripple factor
5. Experiment 7.5: Voltage-current characteristic curve for resistive-inductive load

Experiment 8: Three Phase Full-Wave Tap Rectifier

Objectives: The trainee is able to

1. Determine the voltage ratio for resistive load
2. Measure the shape of the voltage-current characteristic curve for resistive load
3. Determine the current ratio for resistive load
4. Determine the ripple factor for resistive load
5. Measure the shape of the voltage-current characteristic curve for resistive-inductive load

Experiment Lists

1. Experiment 8.1: Voltage Ratio for Resistive Load
2. Experiment 8.2: Voltage and Current Characteristic Curve for Resistive Load
3. Experiment 8.3: Current Ratio for Resistive Load
4. Experiment 8.4: Ripple Factor
5. Experiment 8.5: Voltage-Current Characteristic Curve for Resistive-Inductive Load

Experiment 9: Three Phase Full-Wave Bridge Rectifier

Objectives: the trainee is able to

1. Determine the voltage ratio for resistive load
2. Measure the shape of the voltage-current characteristic curve for resistive load
3. Determine the current ratio for resistive load
4. Determine the ripple factor for resistive load
5. Measure the shape of the voltage-current characteristic curve for resistive-inductive load

Experiments Lists

1. Experiment 9.1: Voltage ratio for resistive load
2. Experiment 9.2: Voltage characteristic curve for resistive load
3. Experiment 9.3: Current ratio for resistive load
4. Experiment 9.4: Ripple factor
5. Experiment 9.5: Voltage-current characteristic curve for resistive-inductive load

Experiment 10: Single Phase Half-Wave Controlled Rectifier

Objectives: the trainee is able to

1. Acquaint the relations between delay angle α and output voltage U_O
2. Measure the shape of the voltage-current characteristic curve for resistive load
3. Measure the shape of the voltage-current characteristic curve for resistive-inductive load

Experiments Lists

1. Experiment 10.1: The relations between delay angle α and output voltage U_O
2. Experiment 10.2: Voltage-current characteristic curve for resistive load

3. Experiment 10.3: Voltage-current characteristic curve for resistive-inductive load

Experiment 11: Full-Wave Controlled Rectifier with Center Tap

Objectives: the trainee is able to

1. Acquaint the relations between delay angle α and output voltage U_O
2. Measure the shape of the voltage-current characteristic curve for resistive load
3. Measure the shape of the voltage-current characteristic curve for resistive-inductive load

Experiments Lists

1. Experiment 11.1: The relations between delay angle α and output voltage U_O
2. Experiment 11.2: Voltage-current characteristic curve with resistive load
3. Experiment 11.3: Voltage-current characteristic curve for resistive-inductive load

Experiment 12: Single Phase Full-Wave Fully Control Bridge

Objectives: the trainee is able to

1. Acquaint the relations between delay angle α and output voltage U_O
2. Measure the shape of the voltage-current characteristic curve with resistive load
3. Measure the shape of the voltage-current characteristic curve with resistive-inductive load

Experiments List

1. Experiment 12.1: The relations between delay angle α and output voltage U_O
2. Experiment 12.2: Voltage-current characteristic curve with resistive load
3. Experiment 12.3: Voltage-current characteristic curve for resistive-inductive load

Experiment 13: Three Phase Half-Wave Control Rectifier

Objectives: the trainee is able to

1. Acquaint the relations between delay angle α and output voltage U_O
2. Measure the shape of the voltage-current characteristic curve with resistive load
3. Measure the shape of the voltage-current characteristic curve with resistive-inductive load

Experiments List

1. Experiment 13.1: The relations between delay angle α and output voltage U_O
2. Experiment 13.2: Voltage-current characteristic curve with resistive load
3. Experiment 13.3: Voltage-current characteristic curve for resistive-inductive load

Experiment 14: Three Phase Full-wave Control Rectifier with Center Tap

Objectives: the trainee is able to

1. Measure the shape of the voltage-current characteristic curve with resistive load

Experiments List

1. Experiment 14.1: Voltage-current characteristic curve with resistive load

Experiment 15: Three phase Full-Wave Fully-Control Bridge

Objectives: the trainee is able to

1. Acquaint the relations between delay angle α and output voltage U_O
2. Measure the shape of the voltage-current characteristic curve with resistive load

Experiments Lists

1. Experiment 15.1: The relations between delay angle α and output voltage U_O
2. Experiment 15.2: Voltage and line current characteristic curve

Experiment 16: Single Phase Full-Wave Half Controlled Bridge

Objectives: The trainee is able to

1. Acquaint the relations between delay angle α and output voltage U_O
2. Measure the shape of the voltage-current characteristic curve with resistive load
3. Measure the shape of the voltage-current characteristic curve with resistive-inductive load

Experiments Lists

1. Experiment 16.1: The relations between delay angle α and output voltage U_O
2. Experiment 16.2: Voltage- current characteristic curve
3. Experiment 16.3: Voltage-current characteristic curve for resistive-inductive load

Experiment 17: Three Phase Full-wave Half Control Bridge

Objectives: the trainee is able to

1. Acquaint the relations between delay angle α and output voltage U_O
2. Measure the shape of the voltage-current characteristic curve with resistive load
3. Measure the shape of the voltage-current characteristic curve with resistive-inductive load

Experiments Lists

1. Experiment 17.1: The relations between delay angle α and output voltage U_O
2. Experiment 17.2: Voltage-current characteristic curve with resistive load
3. Experiment 17.3: Voltage and line current characteristic curve for resistive-inductive load
4. Experiment 17.4: SCR current characteristic curve for resistive-inductive load

Experiment 18: Single Phase Bidirectional Connection On Resistive Load

Objectives: the trainee is able to

1. Determine the shape of the voltage and current characteristic curve at the converter on resistive load
2. Measure the shape of the SCR current characteristic curve on resistive load
3. Examine the phase control of triac
4. Indicate the control function of $U_{O(\alpha)}/U_O = f(\alpha)$ and $P_{O(\alpha)}/P_O = f(\alpha)$

Experiments List

1. Experiment 18.1: Voltage- current characteristic curve on resistive load
2. Experiment 18.2: SCR current characteristic curve on resistive load
3. Experiment 18.3: Phase control of triac

Experiment 19: Delta–Connected Three Phase Bi-direction Connection

Experimental objectives: the trainee is able to

1. Experiment 19.1: Determine the phase control characteristic of the delta–connected three phase bidirectional connection on resistive load
2. **Experiment 19.2: Determine the phase control characteristic of the delta–connected three phase bidirectional connection on Three Phase Induction Motor**

Experiment 20: Star-Connected Three Phase Bidirectional Connection

Objectives: the trainee is able to

1. Experiment 20.1: Determine the phase control characteristic of the star–connected three phase bidirection connection on resistive load
2. **Experiment 20.2: Determine the phase control characteristic of the star–connected three phase bidirection connection on Three Phase Induction Motor**

Experiment 21: PWM Generation Circuit

Objectives: The trainee is able to

1. Examine the produced waveform of the PWM Controller

Experiment Lists

2. Experiment 21.1: PWM Generation Circuit

Experiment 22: IGBT Chopper Circuit

Objectives: the trainee is able to

1. Acquaintance the principle of chopper circuit
2. Indicate the relationship of $V_O = f(Duty\ \ Cycle)$
3. Measure the voltage and current
4. Determine the relationship between ripple current and pulse width

Experiments list :

1. Experiment 22.1: The relationship of $V_O = f(Duty\ \ Cycle)$ in IGBT chopper circuit
2. Experiment 22.2: The voltage-current characteristic curve in IGBT chopper circuit
3. Experiment 22.3: The relationship between ripple current and pulse width
4. Experiment 22.4: The relationship between ripple current and frequency

Experiment 23: MOSFET Chopper Circuit

Objectives: The trainee is able to

1. Acquaintance the principle of chopper circuit
2. Indicate the relationship of $V_O = f(Duty\ \ Cycle)$ in MOSFET chopper circuit
3. Measure the voltage and current
4. Determine the relations between ripple current and pulse width

Experiment Lists

1. Experiment 23.1: The relationship of $V_O = f(Duty\ \ Cycle)$ in MOSFET chopper circuit
2. Experiment 23.2: The voltage-current characteristic curve in MOSFET chopper circuit
3. Experiment 23.3: The relationship between ripple current and pulse width
4. Experiment 23.4: The relationship between ripple current and frequency

Experiment 24: Darlington Transistor Chopper Circuit

Objectives: The trainee is able to

1. Acquaintance the principle of chopper circuit
2. Indicate the relationship of $V_O = f(Duty\ \ Cycle)$ in Darlington transistor chopper circuit
3. Measure the voltage and current
4. Determine the relations between ripple current and pulse width

Experiment Lists

1. Experiment 24.1: The relationship of $V_O = f(Duty\ \ Cycle)$ in darlington transistor chopper circuit
2. Experiment 24.2: The voltage-current characteristic curve in darlington transistor chopper circuit
3. Experiment 24.3: The relationship between ripple current and pulse width
4. Experiment 24.4: The relationship between ripple current and frequency

Experiment 25: Cycloconverters

Experimental objectives: the trainee is able to

1. Experiment 25.1: Acquaintance the principle of cycloconverters
2. Experiment 25.1: Measure the output voltage on resistive load

Experiment 26: H-Bridge Converter

Objectives: The trainee is able to

1. Acquaintance the principle of H-Bridge converter
2. Measure the quantities and direction of output voltage and current

Experiments Lists

1. Experiment 26.1: The output voltage of H-Bridge converter
2. Experiment 26.2: The output current of H-Bridge converter
3. **Experiment 26.3: The DC Motor Control of H-Bridge converter**

Note: Layout and specification may change without prior notices for products continuous development and improvement process.