EDULABS DIDACTIC

POWER ELECTRONICS TRAINER

EXPERIMENT 9

EXPERIMENTS MANUAL

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

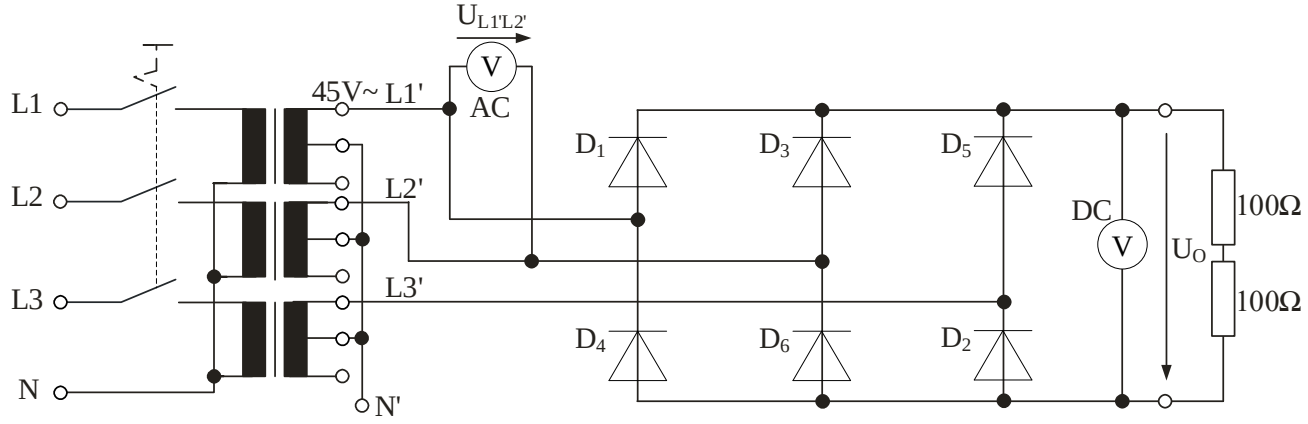
Equipment designation

No.	Item	Model	Quantity
1	Group of Diode Module	EM-21-01-03	1
2	Resistive Load Module (I)	EM-21-03-01	1
3	Inductive Load Module	EM-21-03-02	1
4	Capacitive Load Module	EM-21-03-03	1
5	Resistive Load Module (II) **(Optional 2 units)**	EM-21-03-04	**3**
6	DC Voltmeter	EM-30-13-01	1
7	DC Ammeter (10A)	EM-30-13-02	1
8	AC Voltmeter	EM-30-13-03	1
9	AC Ammeter (5A)	EM-30-13-04	1
10	Three Phase Power Quality Meter	EM-30-13-16	1
11	Three Phase Power Supply 45-0-45V, 2A	EM-21-04-01	1
12	19mm Shunt / Bridging Plug Set	EM-30-15-06	4
13	19mm Shunt / Bridging Plug Set (Stackable)	EM-30-15-08	7
14	2mm Stackable Test Lead Set (Banana Plug Type) (5 color coded)	EM-30-15-10	2
15	4mm Stackable Test Lead Set (Banana Plug Type)	EM-30-15-12	3
16	4mm Safety Stackable Connecting Lead	EM-30-15-01	1 set
17	Digital Storage Oscilloscope (Optional)	TDS-2102C	1

Procedure

Experiment 9.1: Voltage ratio for resistive load

1. Construct the circuit according to current diagram Figure 9.1.



WARNING: THIS EXPERIMENT INVOLVES HIGH VOLTAGE MEASUREMENT UP TO 107VDC FOR THE OUTPUT VOLTAGE.

2. Use AC Voltmeter (EM-30-13-03) to measure the RMS voltage; $U_{L1'L2'}$ and DC Voltmeter (EM-30-13-01) to measure the average output voltage; U_O.
3. Turn ON power supply. Measure and record the following voltages.
4. Turn OFF power supply.

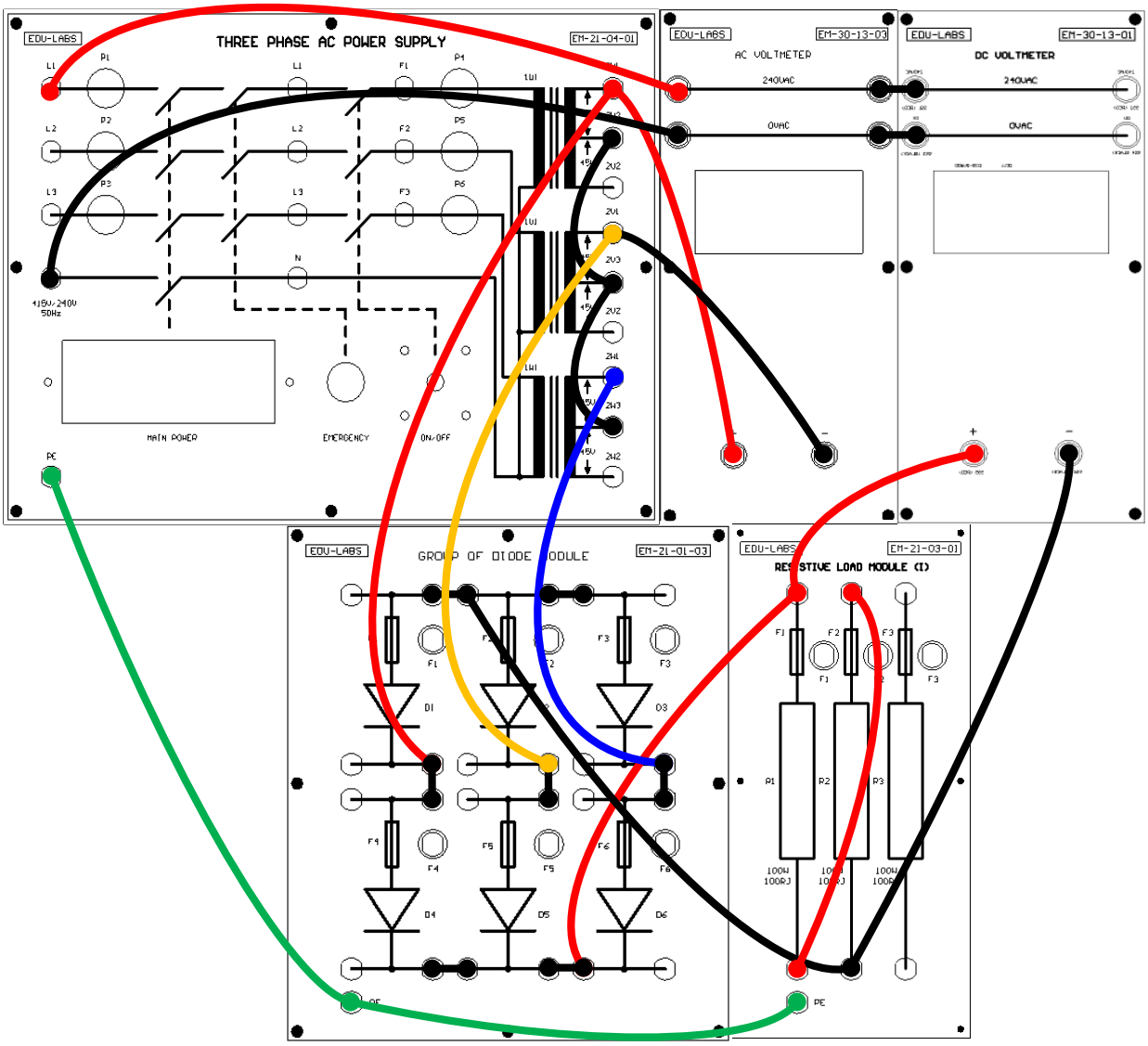


Figure 9.1 Current diagram for determine the voltage ratio for resistive load

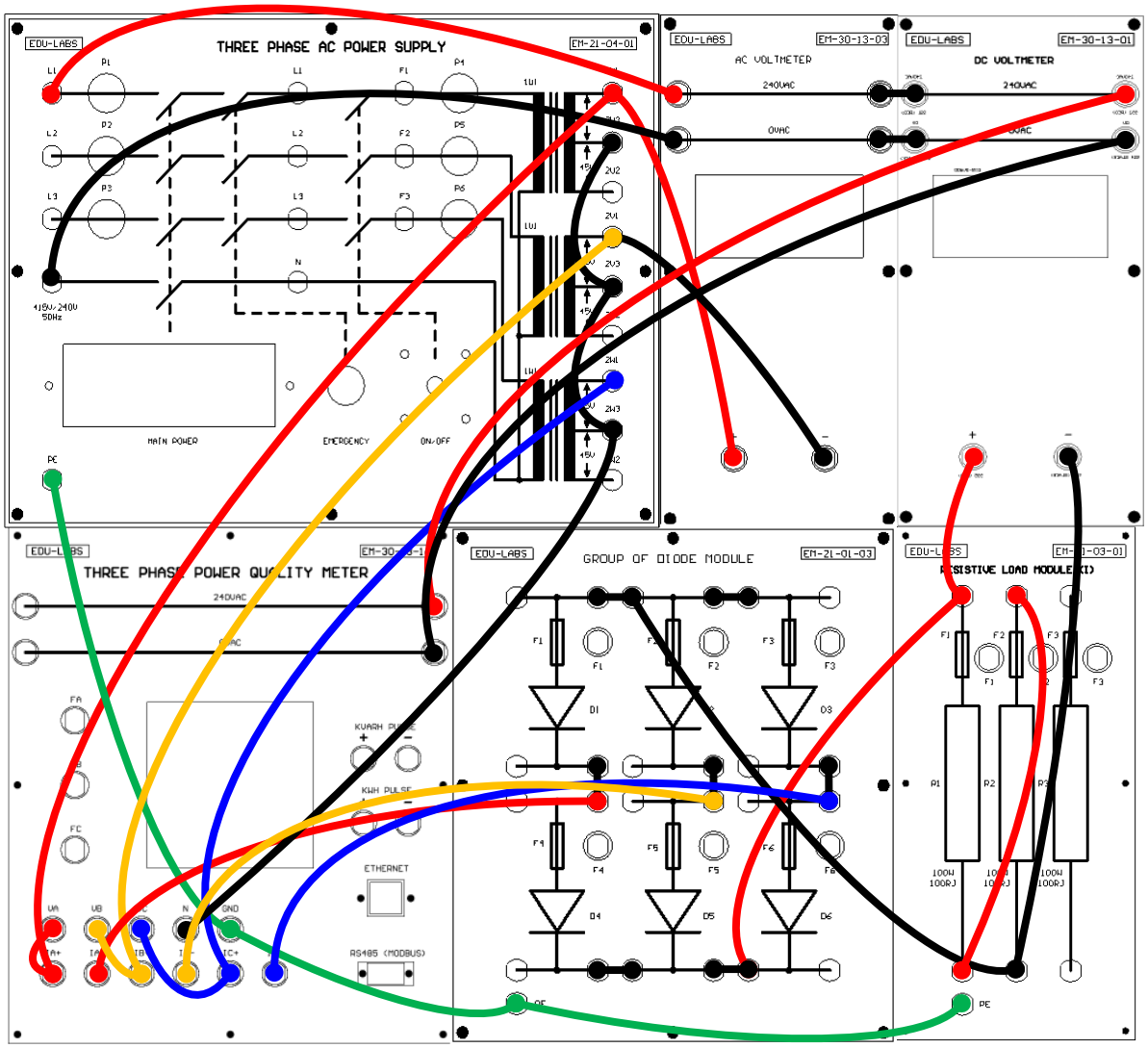


Figure 9.1 Current diagram for determine the voltage ratio for resistive load with three phase power quality meter

Note on the current diagram 9.1:

- *Supply voltage (star connection) =* $U_{L1'N'} = U_{L2'N'} = U_{L3'N'} = 45V$ *(phase voltage or line to neutral voltage)*
- *Line to line voltage =* $U_{L1'L2'}$

Three Phase Power Quality Meter EM-30-13-16	
$V_{L1'N}$	46.82V
$V_{L2'N}$	47.16V
$V_{L3'N}$	47.24V
$V_{L1'L2}$	81.51V
$V_{L2'L3}$	81.92V
$V_{L3'L1}$	81.40V
I_{L1}	0.426A
I_{L2}	0.427A
I_{L3}	0.428A
DC Ammeter & DC Voltmeter Measurement	
V_O	107V
I_O	0.81A

NOTE: Above are the values of the measurement result.

$U_{L1'L2'} = \ldots\ldots\ldots \boldsymbol{V_{rms}}$ $U_O = \ldots\ldots\ldots \boldsymbol{V_{avg}}$	$U_{L2'L3'} = \ldots\ldots\ldots \boldsymbol{V_{rms}}$ $U_O = \ldots\ldots\ldots \boldsymbol{V_{avg}}$	$U_{L3'L1'} = \ldots\ldots\ldots \boldsymbol{V_{rms}}$ $U_O = \ldots\ldots\ldots \boldsymbol{V_{avg}}$	$U_{avg} = \ldots\ldots\ldots \boldsymbol{V_{rms}}$ $U_O = \ldots\ldots\ldots \boldsymbol{V_{avg}}$

Expected Result

$U_{L1'L2'} = \mathbf{81.51V_{rms}}$ $U_O = \mathbf{107V_{avg}}$	$U_{L2'L3'} = \mathbf{81.92V_{rms}}$ $U_O = \mathbf{107V_{avg}}$	$U_{L3'L1'} = \mathbf{81.40V_{rms}}$ $U_O = \mathbf{107V_{avg}}$	$U_{avg} = \mathbf{81.61V_{rms}}$ $U_O = \mathbf{107V_{avg}}$

5. Calculate the voltage ratio (theoretical value is 0.74)

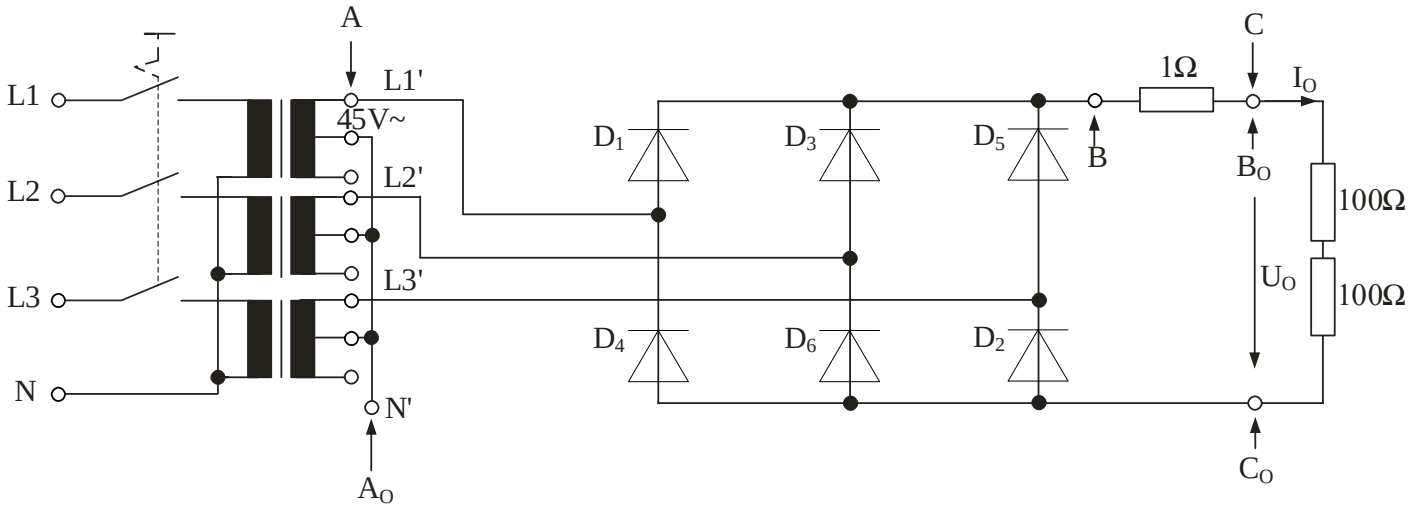
$\frac{U_{L1'L2'}}{U_O} = \ldots\ldots\ldots$	$\frac{U_{L2'L3'}}{U_O} = \ldots\ldots\ldots$	$\frac{U_{L3'L1'}}{U_O} = \ldots\ldots\ldots$	$\frac{U_{avg}}{U_O} = \ldots\ldots\ldots$

Expected Result

$\frac{\boldsymbol{U_{L1'L2'}}}{\boldsymbol{U_O}} = \mathbf{0.76}$	$\frac{\boldsymbol{U_{L2'L3'}}}{\boldsymbol{U_O}} = \mathbf{0.77}$	$\frac{\boldsymbol{U_{L3'L1'}}}{\boldsymbol{U_O}} = \mathbf{0.76}$	$\frac{\boldsymbol{U_{avg}}}{\boldsymbol{U_O}} = \mathbf{0.76}$

Experiment 9.2: Voltage current characteristic curve for resistive load

1. Reconstruct the circuit according to current diagram Figure. 9.2.



WARNING: THIS EXPERIMENT INVOLVES HIGH VOLTAGE MEASUREMENT UP TO 106VDC FOR THE OUTPUT VOLTAGE.

2. Oscilloscope setting:
   - 2.1 Volts/Div (Channel 1) = 20V
   - 2.2 Volts/Div (Channel 2) = 20V
   - 2.3 Time/Div (both channel) = 5ms
3. Turn ON power supply

4. Measure the waveform of input voltage; $U_{L1'N}$(A – A_0) and output voltage; U_O(C – C_0) and output current; I_O(B – B_0), then record the waveform in Table 9.2.1.

Note on the current measuring: determine the current by measure voltage drop on additional resistor 1 Ω (according to Ohm's Law; I = $\frac{V}{1\Omega}$)

5. Turn OFF power supply.

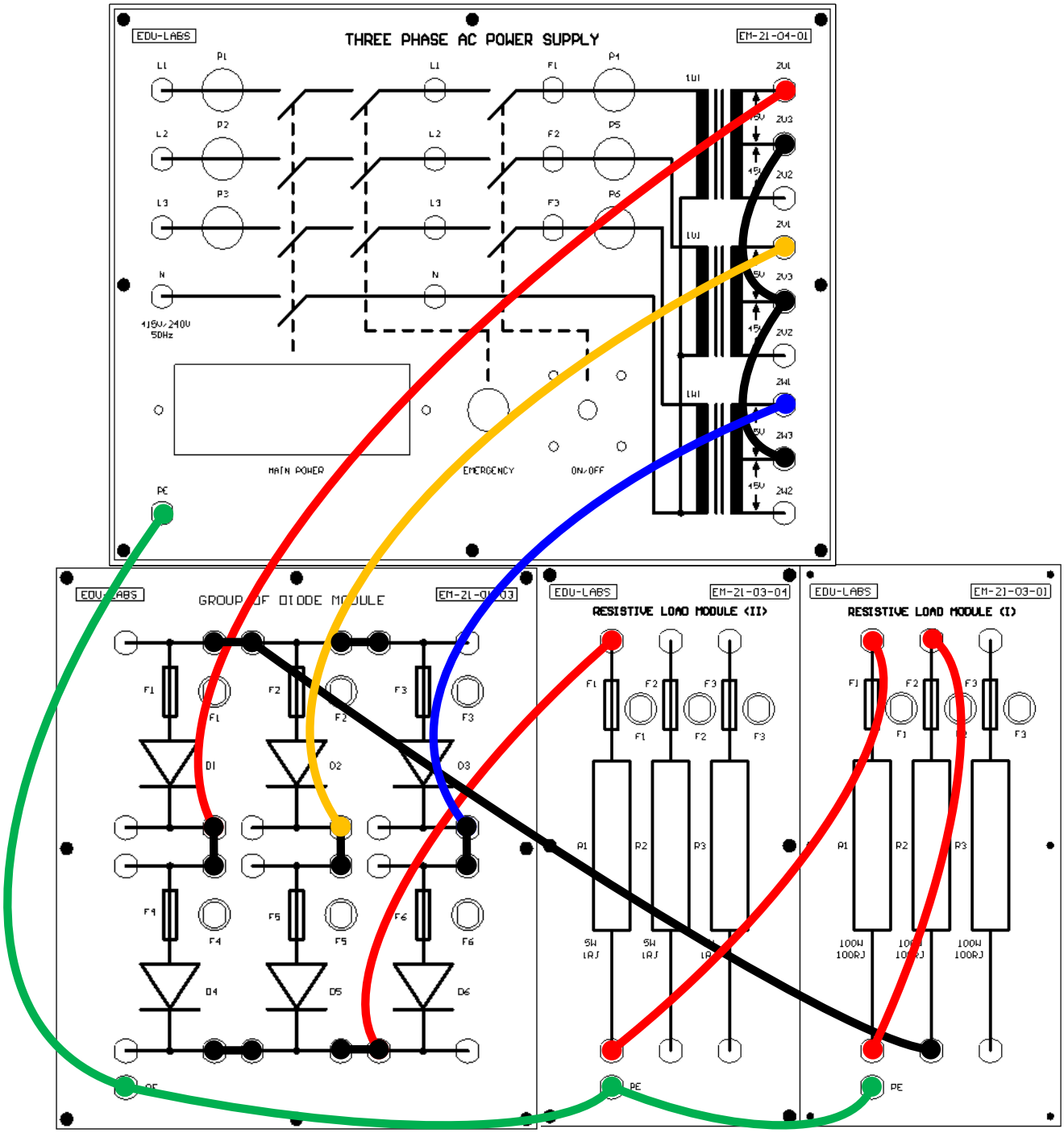


Figure 9.2 Current diagram for measure the shape of the voltage characteristic curve for resistive load

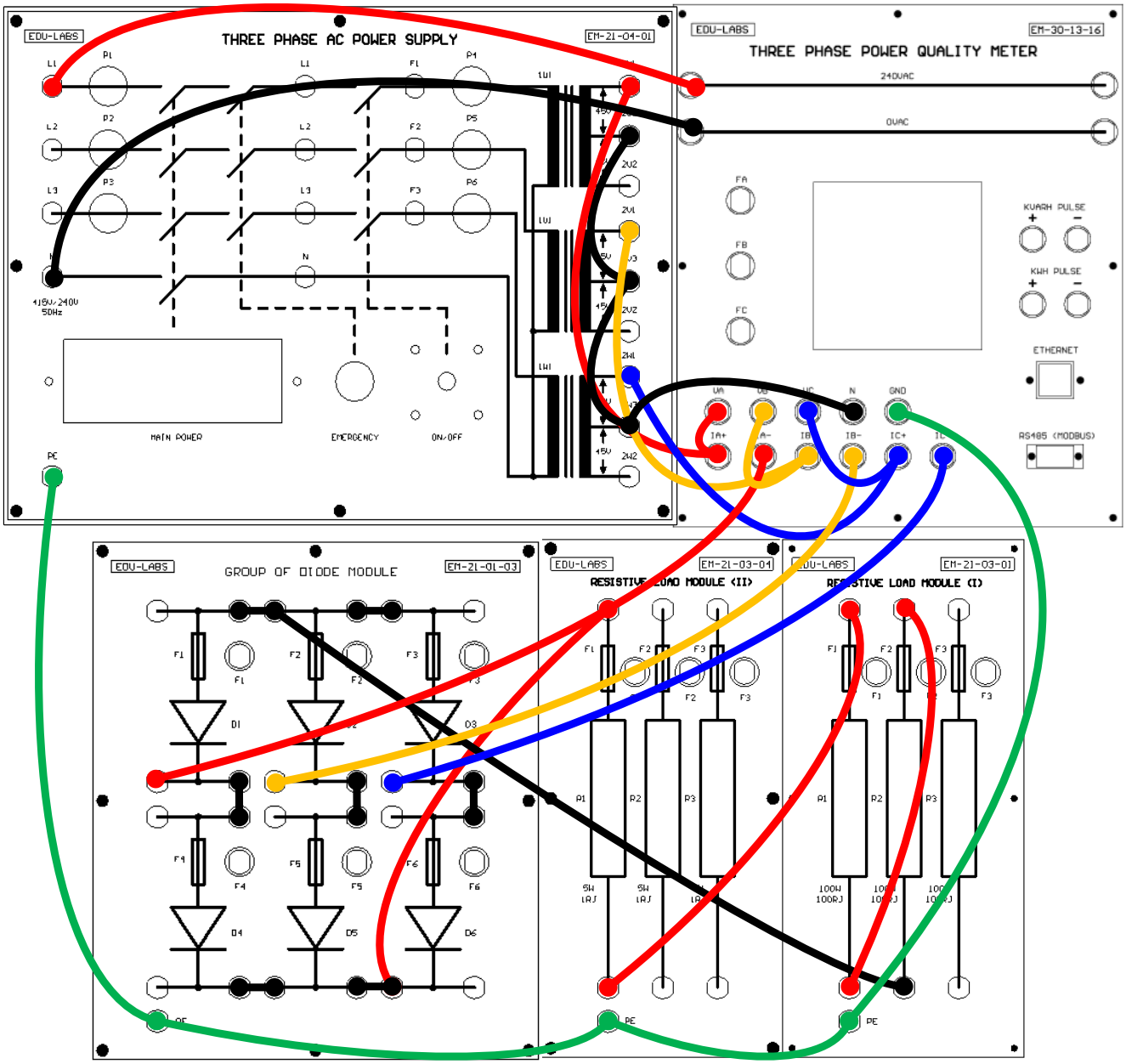


Figure 9.2 Current diagram for measure the shape of the voltage characteristic curve for resistive load with three phase power quality meter

Note on the experiment 9.2: In the case of 2 channels measuring of the oscilloscope must be connected the same ground point or separate them by isolation circuit set to protect the short circuit

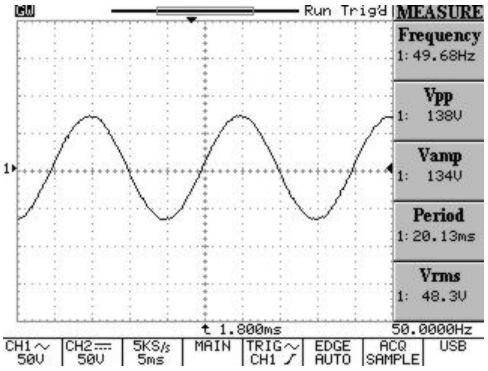
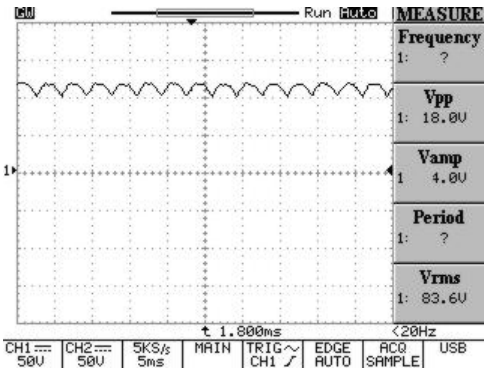
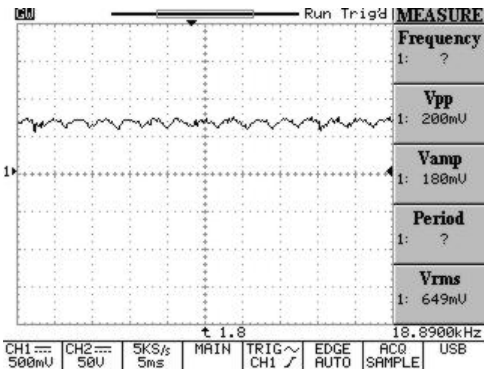
Points	Value
Three Phase Power Quality Meter EM-30-13-16	
$V_{L1'N}$	46.75V
$V_{L2'N}$	47.14V
$V_{L3'N}$	47.15V
$V_{L1'L2}$	81.41V
$V_{L2'L3}$	81.80V
$V_{L3'L1}$	81.24V
I_{L1}	0.423A
I_{L2}	0.424A
I_{L3}	0.425A
DC Ammeter & DC Voltmeter Measurement	
V_O	106V
I_O	0.80A

NOTE: Above are the values of the measurement result.

Experiment Table 9.2.1

Points	Waveform
$U_{L1'N}(A - A_0)$	
$U_O(C - C_0)$	
$I_O(B - B_0)$	

Expected Result Table 9.2.1

Points	Waveform
$U_{L1'N}(A - A_0)$	
$U_O(C - C_0)$	
$I_O(B - B_0)$	

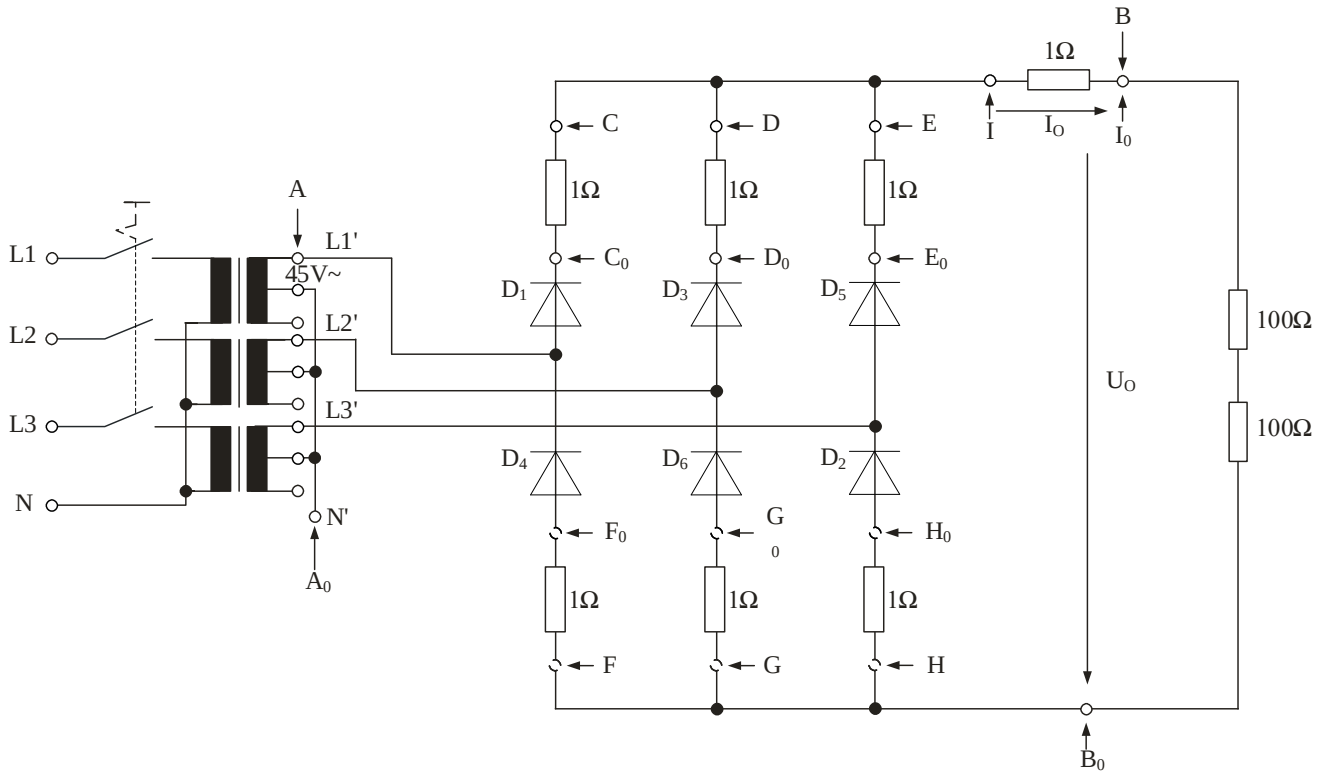
6. Reconstruct the circuit according to current diagram Figure 9.3 to measure the waveform of diode current.
7. Oscilloscope setting:
   7.1 Volts/Div (Channel 1) = 1V
   7.2 Volts/Div (Channel 2) = 20V
   7.3 Time/Div (both channel) = 5ms

8. Turn ON power supply.
9. Measure the waveform of input voltage; $U_{L1'N}(A - A_0)$, output current; $I_O(I - I_0)$ and diode current; $I_{D1}(C - C_0)$, $I_{D2}(H - H_0)$, $I_{D3}(D - D_0)$, $I_{D4}(F - F_0)$, $I_{D5}(E - E_0)$ and $I_{D6}(G - G_0)$ by using channel 1 only, then record the waveform in Table 9.2.2.

NOTE 1: ALL the wave form must be measure separately because they have different reference point. Otherwise the circuit will short and it will damage the oscilloscope.

NOTE 2: In the case of 2 channels measuring of the oscilloscope must be connected the same ground point or separate them by isolation circuit set to protect the short circuit

10. Turn OFF power supply.



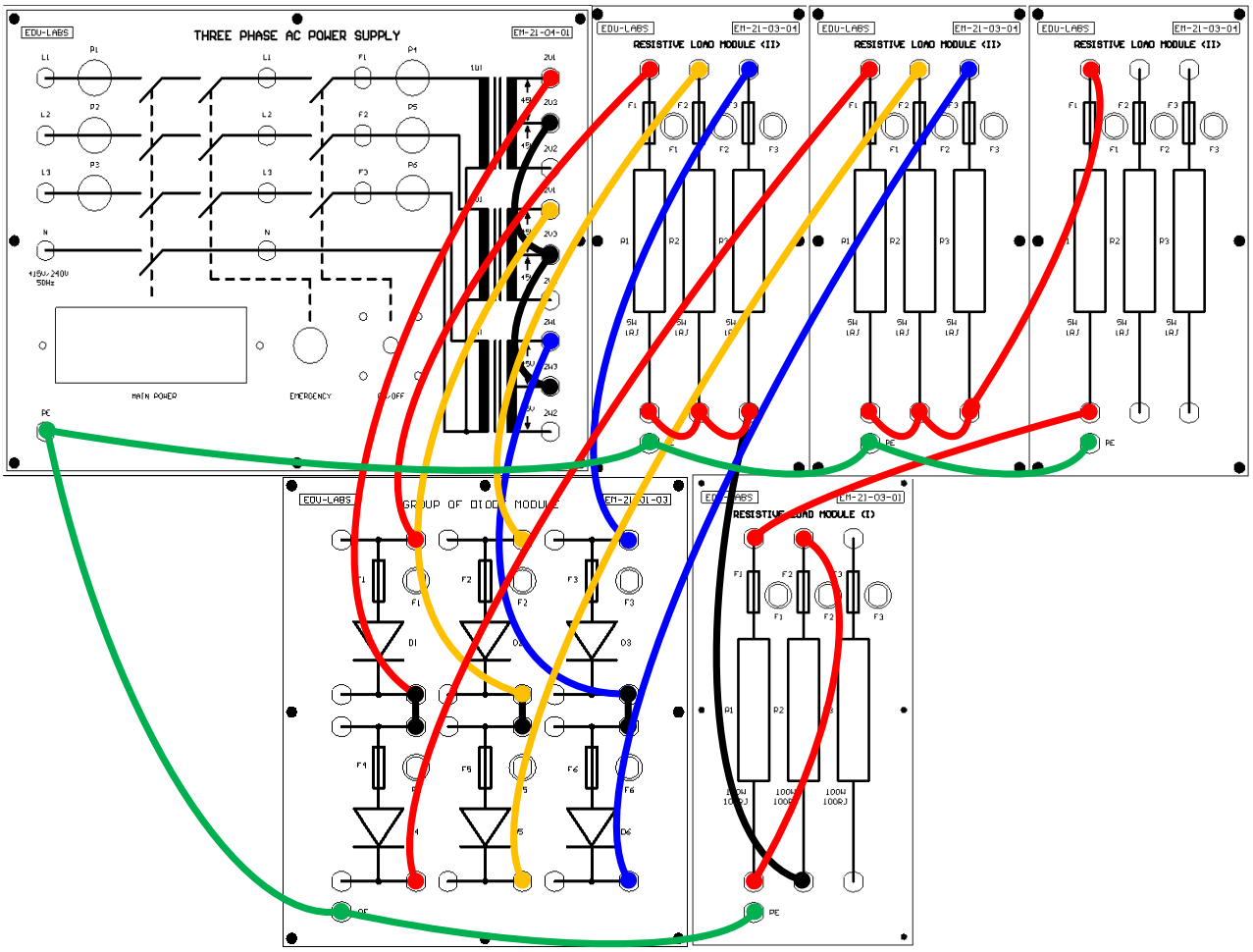


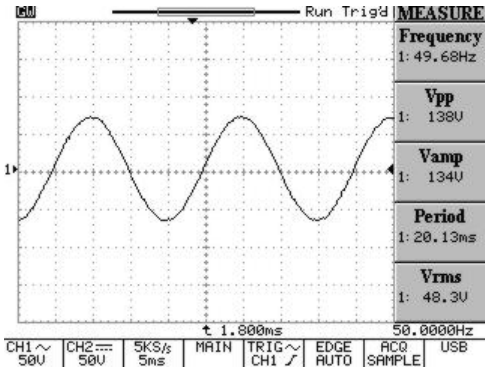
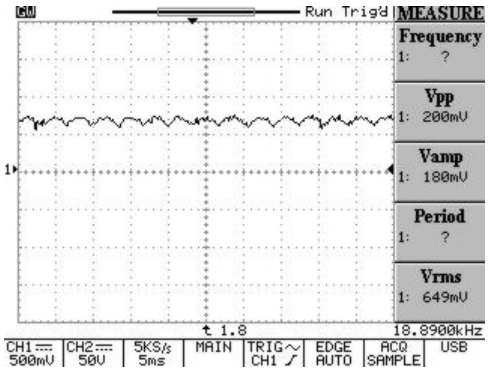
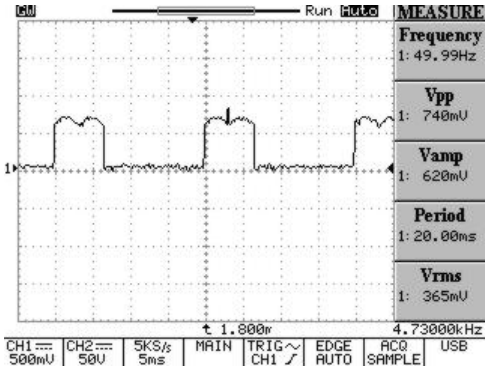
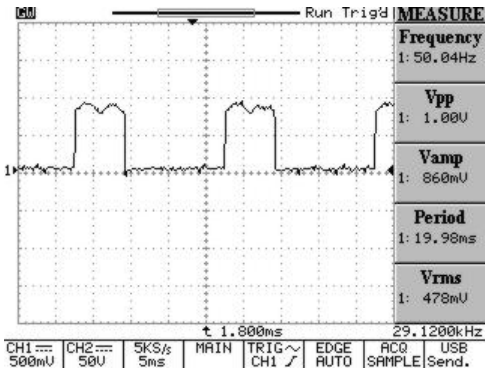
Figure 9.3 Current diagram for measure the oscillogram of current

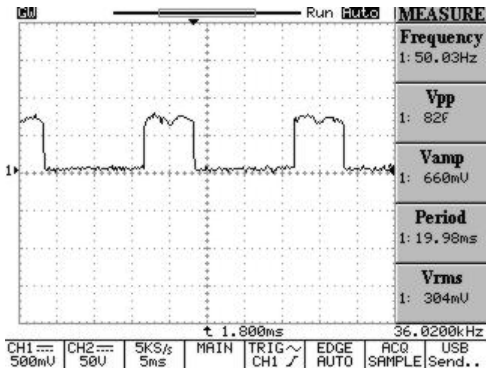
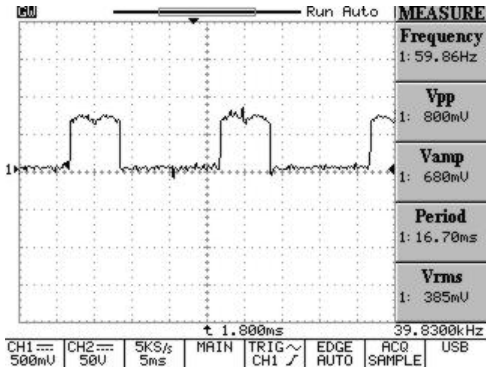
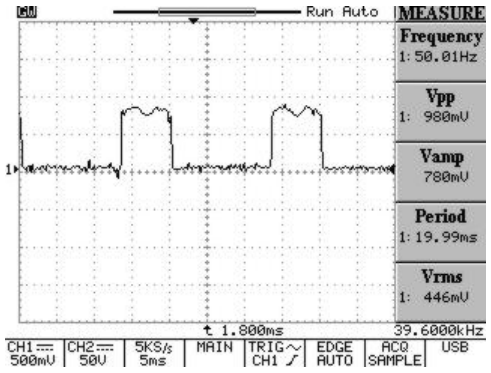
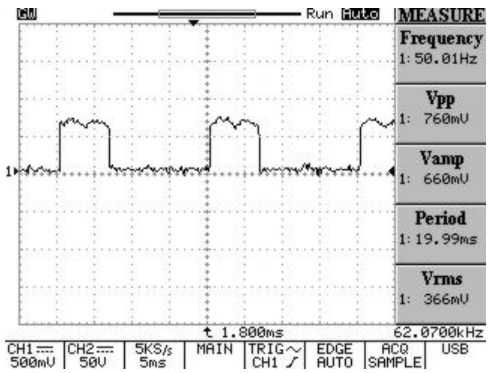
Experiment Table 9.2.2

Point	Waveform
$U_{L1'N}$ (A – A_0)	
I_O(B – B_0)	
D_1 (C – C_0)	
D_2 (H – H_0)	
D_3 (D – D_0)	

D_4 (F – F_0)	
D_5 (E – E_0)	
D_6 (G – G_0)	

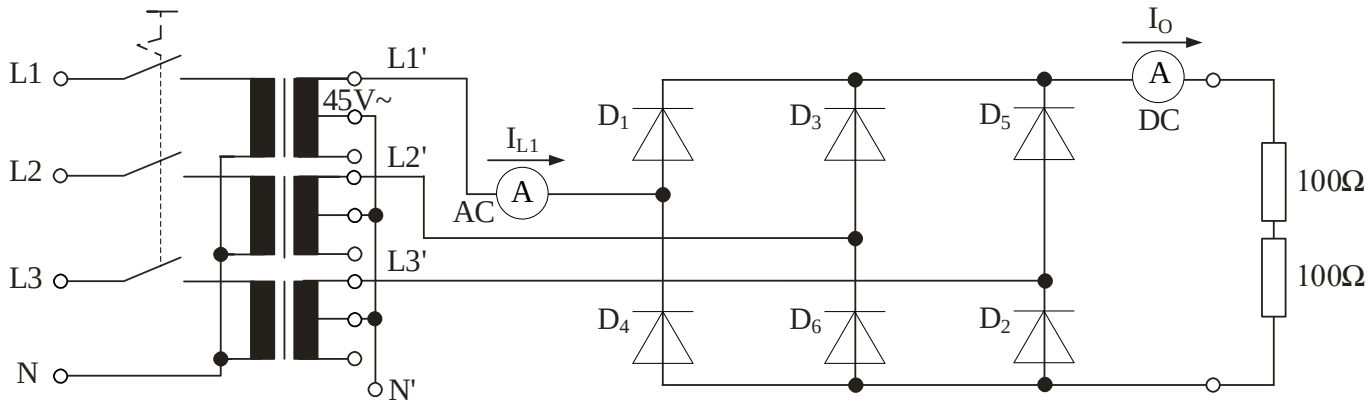
Expected Result Table 9.2.2

Point	Waveform
$U_{L1'N}$ (A – A_0)	
I_O (B – B_0)	
I_{D1} (C – C_0)	
I_{D2} (H – H_0)	

I_{D3} (D – D_0)	
I_{D4} (F – F_0)	
I_{D5} (E – E_0)	
I_{D6} (G – G_0)	

Experiment 9.3: Current ratio for resistive load

1. Construct the circuit according to current diagram Figure 9.4



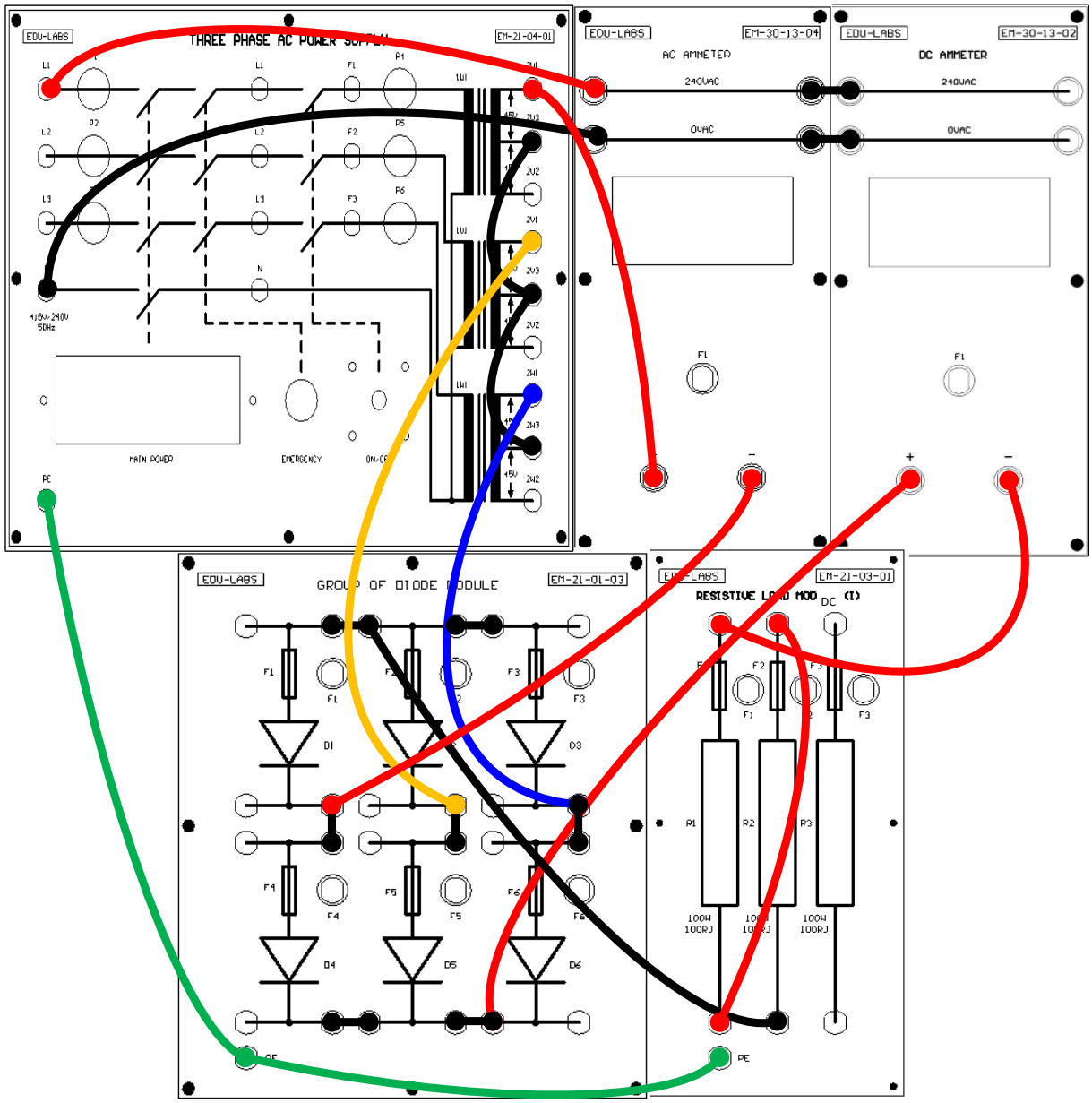


Figure 9.4 Current diagram for determine the current ratio for resistive load

2. Use the AC Ammeter to measure the RMS line current; L1 and DC Ammeter to measure the average output current; I_O

3. Turn ON Power Supply, measure and record the following current, and turn OFF Power Supply

$$I_{L1(rms)} = \text{.....A}$$
$$I_{o(avg)} = \text{.....A}$$

Expected Result

$$I_{L1(rms)} = \mathbf{0.39A}$$
$$I_{o(avg)} = \mathbf{0.81A}$$

4. Use DC Ammeter for measure the average line current; L1

5. Turn ON power supply, measure and record the value

$$I_{L1'(avg)} = \text{.....A}$$

Expected Result

$$I_{L1'(avg)} = \mathbf{0A}$$

6. Calculate the following current ratio

$$\frac{I_{L1'(rms)}}{I_{O(avg)}} = \_\_\_\_\_ = \_\_\_\_\_$$

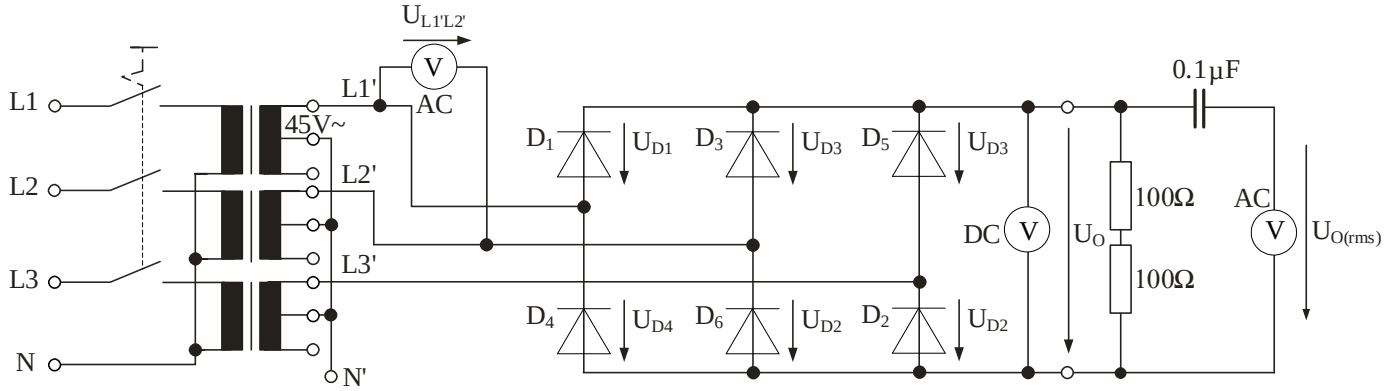
$$\frac{I_{L1'(avg)}}{I_{O(avg)}} = \_\_\_\_\_ = \_\_\_\_\_$$

Expected Result

$$\frac{I_{L1'(rms)}}{I_{O(avg)}} = \frac{0.39}{0.81} = \mathbf{0.48}$$
$$\frac{I_{L1'(avg)}}{I_{O(avg)}} = \frac{0}{0.81} = \mathbf{0}$$

Experiment 9.4: Ripple factor

1. Construct the circuit according to current diagram Figure. 9.4



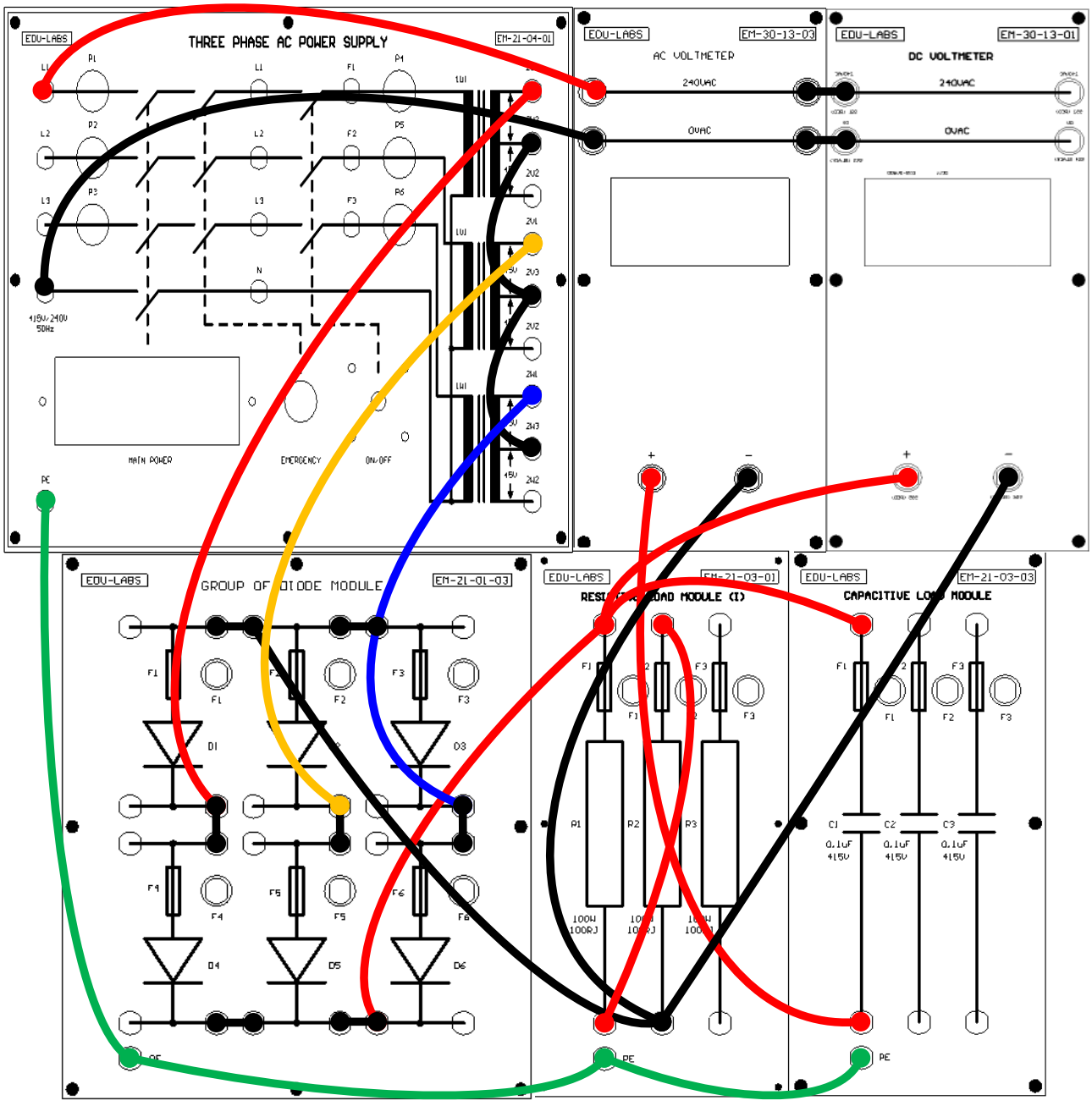


Figure 9.5 Current diagram for determine the voltage output factor for resistive load

2. Use DC Voltmeter to measure the average voltage and AC Voltmeter to measure the RMS voltage, measure and record them.

$$U_{O(avg)} = \ldots\ldots\ldots \text{V}$$

$$U_{o(rms)} = \ldots\ldots\ldots \text{V}$$

Expected Result

$$U_{O(avg)} = 107\text{V}$$

$$U_{o(rms)} = 10\text{V}$$

3. Calculate the Ripple Voltage: U_{ripple}

$$U_{ripple} = \sqrt{U_{o(rms)}^2 - U_{o(avg)}^2}$$

$$= \ldots\ldots\ldots$$

Expected Result

$$U_{ripple} = \mathbf{-106.53}$$

4. Calculate the Ripple Factor: *RF*

$$RF = \sqrt{\left(\frac{U_{o(rms)}}{U_{o(ave)}}\right)^2 - 1}$$

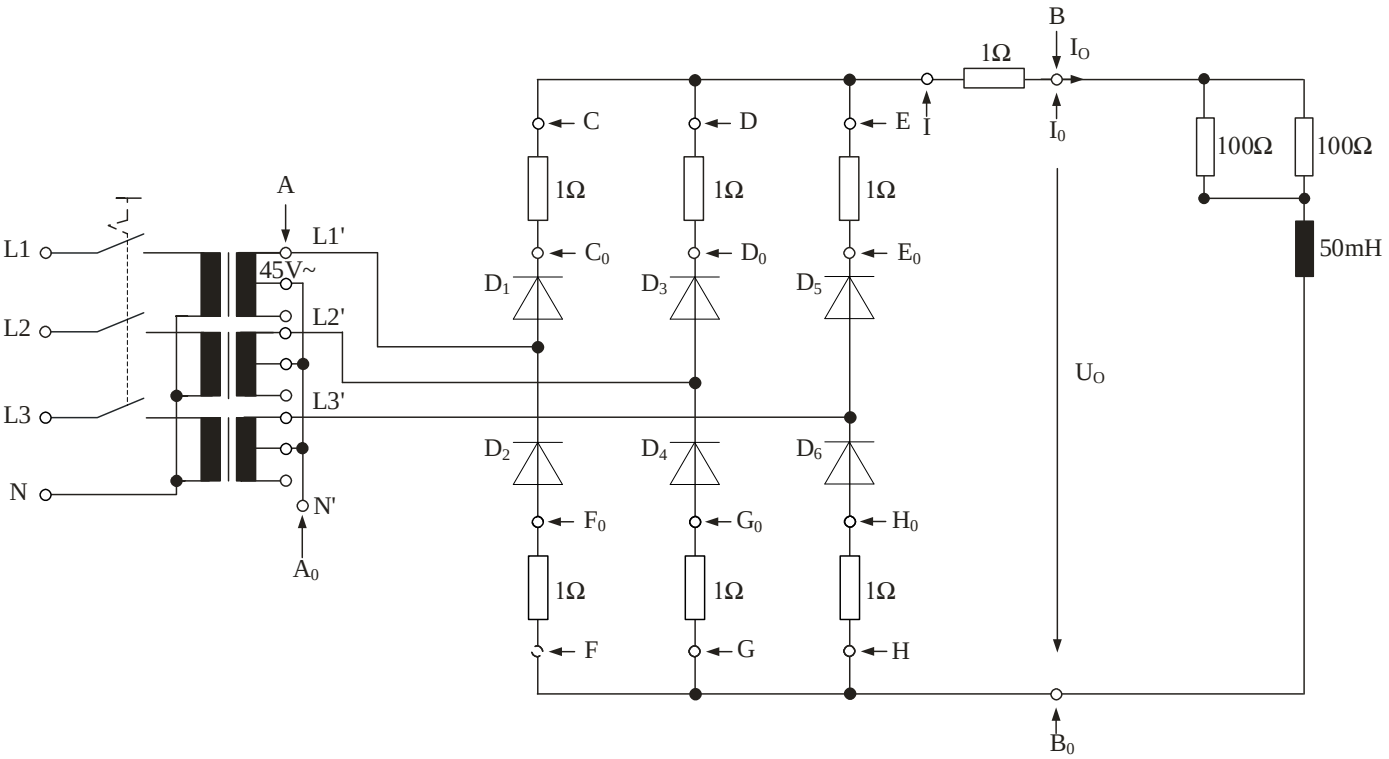
$$= \ldots\ldots\ldots$$

Expected Result

$$RF = \mathbf{-0.99}$$

Experiment 9.5: Voltage-current characteristic curve for resistive-inductive load

1. Construct the circuit according to current diagram Figure 9.5



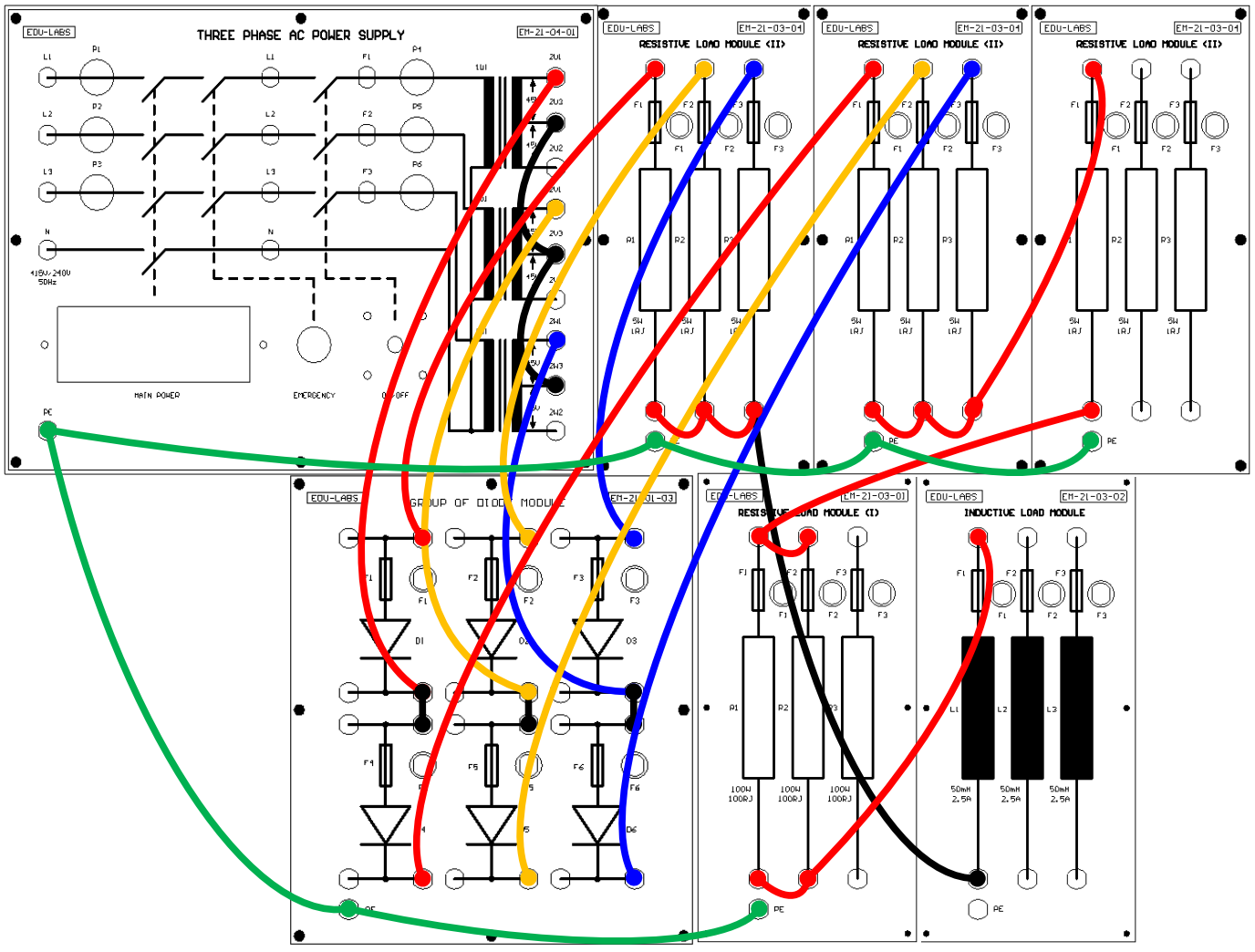


Figure 9.5 Current diagram for measure the voltage-current characteristic curve for resistive-inductive load

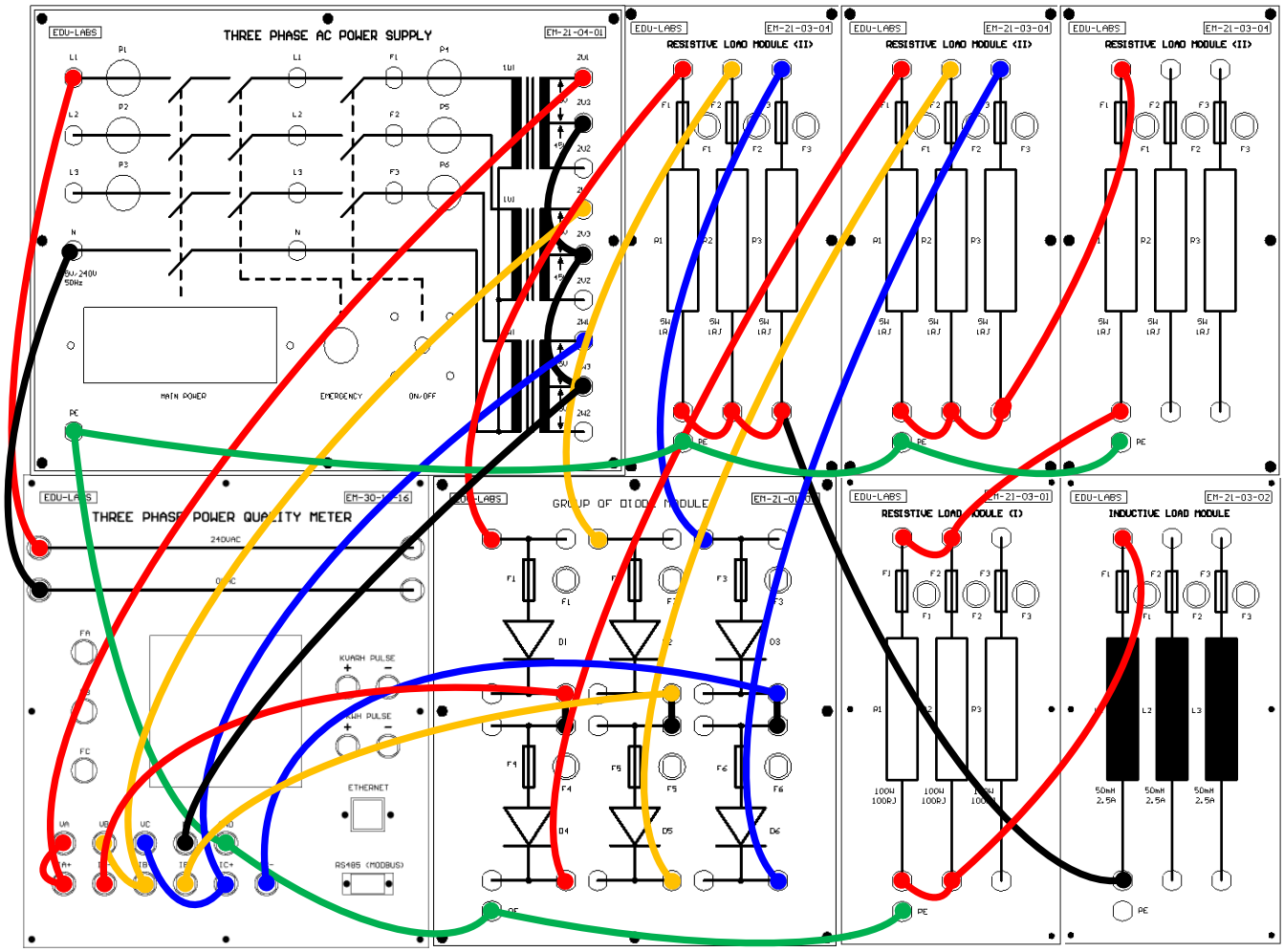


Figure 9.5 Current diagram for measure the voltage-current characteristic curve for resistive-inductive load with three phase power quality meter

Points	Value
Three Phase Power Quality Meter EM-30-13-16	
$V_{L1'N}$	45.05V
$V_{L2'N}$	45.35V
$V_{L3'N}$	45.42V
$V_{L1'L2}$	78.24V
$V_{L2'L3}$	78.71V
$V_{L3'L1}$	78.15V
I_{L1}	1.621A
I_{L2}	1.625A
I_{L3}	1.614A
DC Ammeter & DC Voltmeter Measurement	
V_O	91V
I_O	3.12A

NOTE: Above are the values of the measurement result.

WARNING: THIS EXPERIMENT INVOLVES HIGH VOLTAGE AND HIGH CURRENT MEASUREMENT UP TO 91VDC FOR THE OUTPUT VOLTAGE AND UP TO 4A FOR THE OUTPUT CURRENT.

2. Turn ON power supply

3. Measure the waveform of phase voltage; $U_{L1'N}$, $U_{L2'N}$ and $U_{L3'N}$, then record the waveform.

4. Measure the waveform of output voltage; U_O (B-B_0), then record the waveform.

5. Measure the waveform of diode current D_1 (C-C_0), D_3 (D-D_0), D_5 (E-E_0), D_2 (F-F_0), D_4 (G-G_0), D_6 (H-H_0) and output current; I_O (I- I_0) then record the waveform.

   NOTE: ALL the waveforms MUST be measure separately because they have different reference point and it will short circuit if they are measure together and it can damage the oscilloscope.

6. Turn OFF power supply.

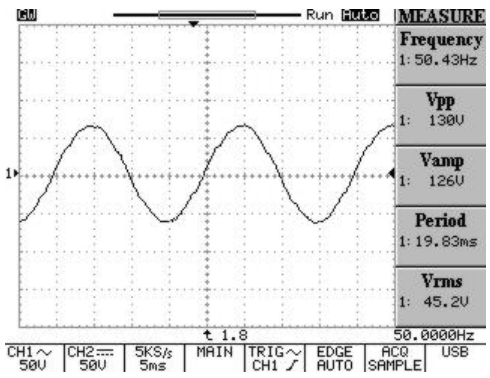
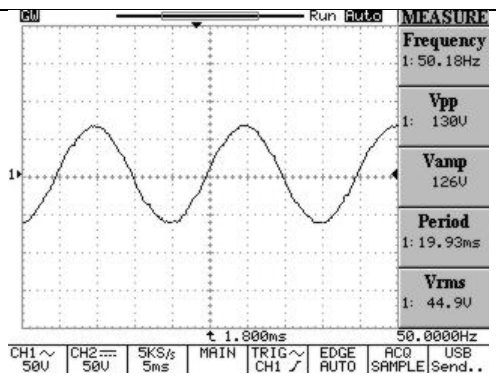
Experiment Result 9.5.1

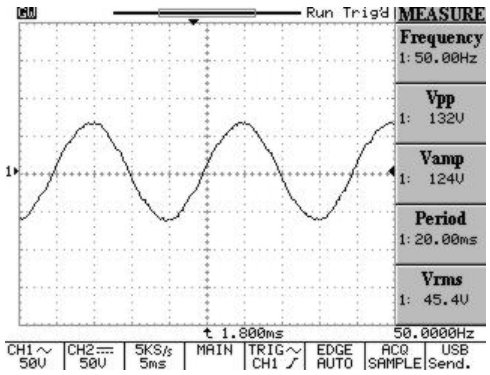
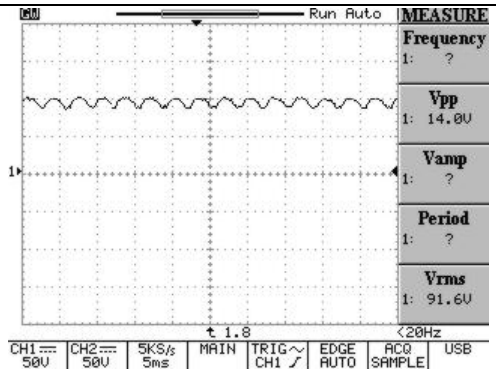
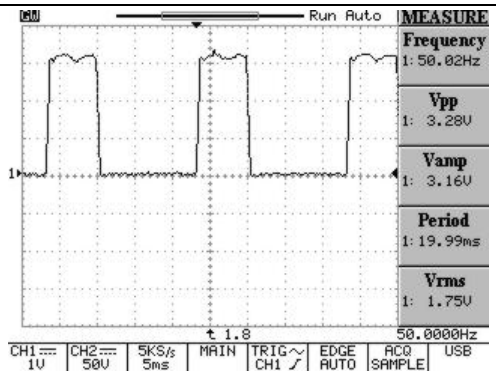
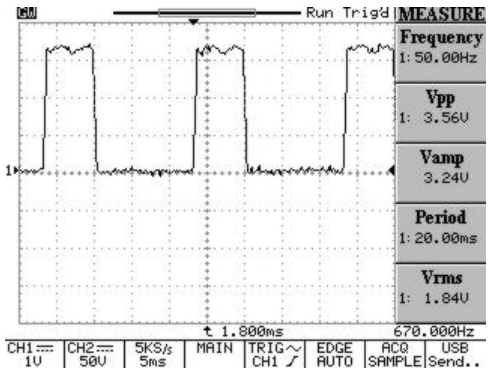
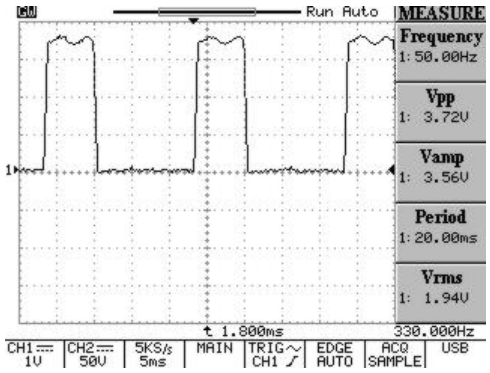
Points	Waveform
$U_{L1'N}$	
$U_{L2'N}$	
$U_{L3'N}$	

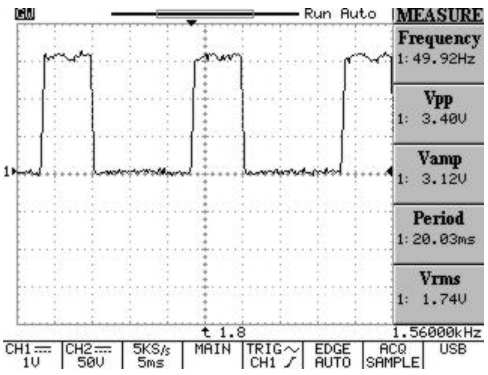
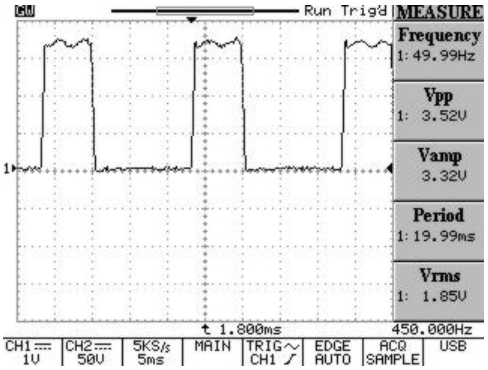
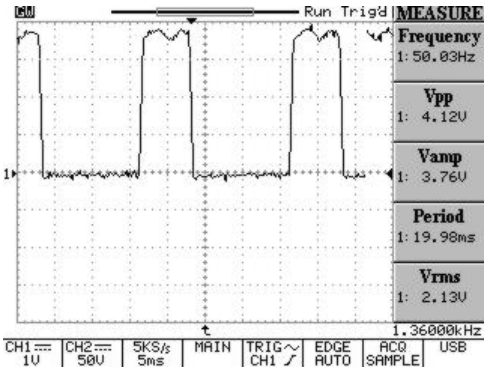
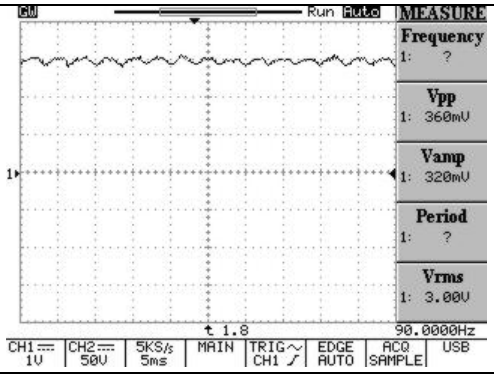
U_O (B-B_0)	
ID_1 (C-C_0)	
ID_2 (F-F_0)	
ID_3 (D-D_0)	
ID_4 (G-G_0)	

ID_5 (E-E_0)	
ID_6 (H-H_0)	
I_O (I- I_0)	

Expected Result Table 9.5.1

Points	Waveform
$U_{L1'N}$	
$U_{L2'N}$	

$U_{L3'N}$	
U_O (B-B_0)	
ID_1 (C-C_0)	
ID_2 (F-F_0)	
ID_3 (D-D_0)	

ID_4 (G-G_0)	
ID_5 (E-E_0)	
ID_6 (H-H_0)	
I_O (I- I_0)	

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The Seller warrants to the Purchaser that any equipment manufactured by it and bearing its name plate to be free from defects in material or workmanship, under proper and normal use and service, as follows: If, at any time within one (1) year from the date of shipment, the Purchaser notifies the Seller that in his opinion, the equipment is defective, and returns the equipment to the Seller's originating factory prepaid, and the Sellers inspection finds the equipment to be defective in material or workmanship **except part like switches, knob, push button, lighting, etc.** the Seller will promptly correct it by either, at its option, repairing any defective part or material or replacing it free of charge and return shipping lowest cost transportation prepaid by purchaser (if Purchaser requests premium transportation, Purchaser will be billed for difference in transportation costs). If inspection by the Seller does not disclose any defect in material or workmanship, the Seller's regular charges will apply. This warranty shall be effective only if use and maintenance is in accordance with Seller's instructions and written notice of a defect is given to the Seller within such period. **THIS WARRANTY IS EXCLUSIVE AND IS IN LIEU OF ANY OTHER WARRANTIES, WRITTEN, ORAL OR IMPLIED. SPECIFICALLY, WITHOUT LIMITATION, THERE IS NO WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PURPOSE**. The liability of the Seller shall be limited to the repair or replacement of materials or parts as above set forth.

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