DEPARTMENT OF ELECTRICAL ENGINEERING
BENGAL ENGINEERING AND SCIENCE UNIVERSITY, SHIBPUR

Industrial Electronics Laboratory **8th Semester, Electrical**

Expt. No 851-PE/1

Experiment no:-1

Study of Power circuit of a Single Phase Thyristorized Full-controlled Rectifier

A) Preparatory notes:-

i. Equip yourself with the theory of the 1-ϕ thyristorized full-controlled rectifier (using centre-tapped transformer) from 'Suggested readings', as given in iii. below.

ii. A particular student will be allowed to conduct the experiments only after she/he has made a detailed survey of the working of the circuits and made investigations on certain pertinent points. As an example, the following points should be clear:
   a) What is the need for providing transformers in the power (and control) circuits?
   b) How do you decide on the voltage ratios and relative polarities of the transformers employed in the control circuit and the power circuit?
   c) What is 'cosine wave triggering technique' and why is it used?
   d) Does the load parameters of the power circuit have any influence on selection of the frequency and pulse width of the high frequency clock signal of the control circuit?
   e) What should be the expected load voltage, load current (v_L, i_L) and device voltage (v_{AK}) waveforms for different loads and at a particular firing angle?

The students can approach the teachers to clarify any doubt before the day of the experiment.
The students may be prevented from conducting experiments or let off with **fail/simple pass** grade in case the teacher is not satisfied with the level of preparation.

iii. Suggested Readings:
   a) Power Electronics by M. H. Rashid
   b) Thyristorized Power Controllers by G. K. Dubey, S. R. Doradla, Joshi and Sinha
   c) Power Electronics by Cyril W. Lander
   d) Thyristor DC drives by P.C. Sen
   e) Principles of Alternating Circuits by Kerchner and Corcoran
   (for calculation of Fourier coefficients from oscilloscope waveforms graphically)

B) Objective: -

i. **To study** the principle and details of operation of the 1-phase controlled rectifier
ii. **To analyse** the performance of the rectifier with different types of loads
iii. **To evaluate** the content of harmonics in such a power converter.

C) Set under test: -

i. A laboratory-built 1-ϕ thyristorized full-controlled rectifier (using centre tapped transformer) along with its logic and gate driver circuits.

D) Apparatus: -

i. Power scope
ii. Ammeter
iii. Voltmeter
iv. Tachometer
v. Different loads namely:
   a) **Resistance** (use the given 70Ω rheostat for the purpose, as a constant resistance)
   b) **Resistance-inductance** (use the given 70Ω rheostat & the given choke for the purpose)
   c) **Separately excited DC motor** (use the given 0.5HP, 220V, 2.3A, 1500 rpm, shunt DC motor) equipped with spring balance-belt-pulley loading arrangement.

Present the apparatus list in the format below:

Sl. No.	Description of Apparatus	Quantity used	Range and rating	Maker's name	Maker's number

E) Circuit Diagram:-

Refer to Figs. 1.1a, 1.1b for understanding the power circuit of the converter.

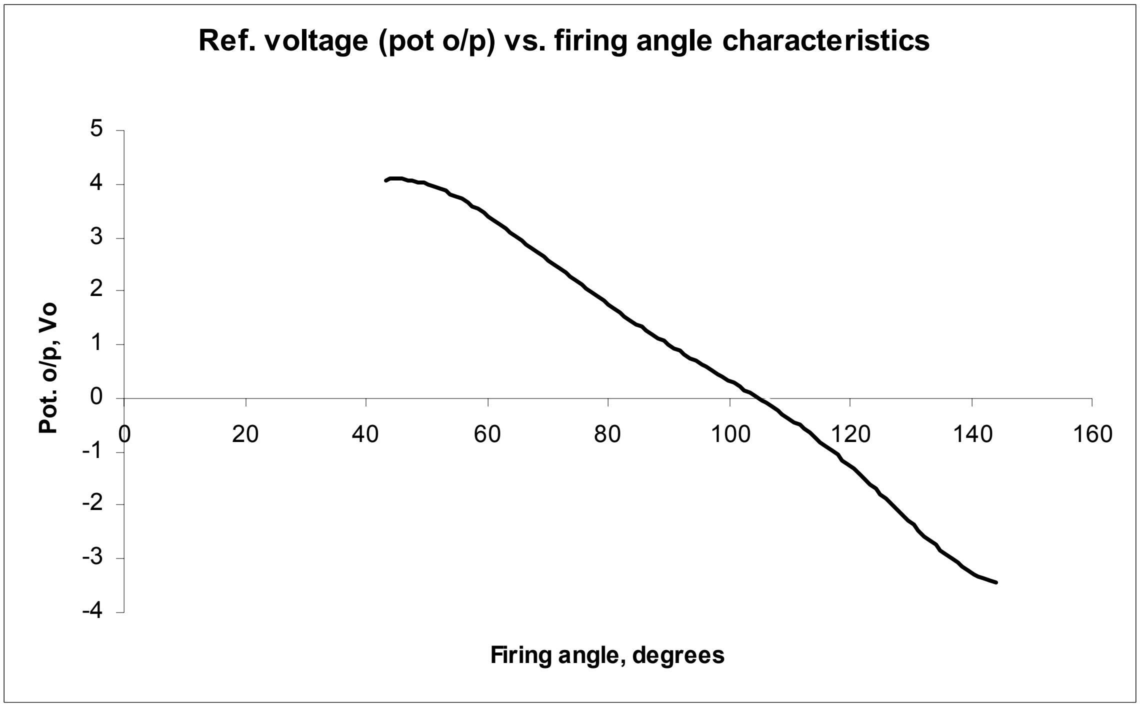
F) Procedure and Results: -

DO NOT SWITCH ON THE POWER CIRCUIT WITHOUT CONSULTING YOUR TEACHER.

KEEP POWER CIRCUIT AND CONTROL CIRCUIT OFF INITIALLY.

RUN-I:- STUDY OF CONTROL CIRCUIT

a) Put on the plug, which powers up the control circuit. Put on the 3-way switch SW_C. Identify the potentiometer in the logic circuit responsible for varying the firing angle (α) of the thyristors. Identify the potentiometer output node and the logic circuit ground.
THE EXPERIMENTAL PLOT OF REFERENCE VOLTAGE (i.e. POT OUTPUT) VERSUS FIRING ANGLE IS GIVEN BELOW:



RUN-II:- STUDY OF POWER CIRCUIT

a) Try to relate the power circuit, as drawn on the front panel of the converter, with the circuit diagrams of Fig.s 1.1a and 1.1b given in this instruction sheet. Identify the nodes A_1, A_2, GND, ……, G_1, K_1, G_2, K_2 on the front panel. Identify the switch SW_P on the front panel.

RUN-III:- PERFORMANCE OF POWER CIRCUIT

Initially keep the switches SW_P and SW_C off.

a) WITH RESISTIVE LOAD: Complete the wiring of the power circuit with resistive load (70Ω), as per Fig. 1.1a. Connect voltmeter, ammeter as shown. Keeping the load constant, switch on SW_C first. Turn the potentiometer knob such that the pot output with respect to logic ground is negative maximum. Now, switch on SW_P. Vary the pot for setting different firing angles. Fill up table 1.1 (All columns except the column marked 'calculated') for three values of firing angles, say, α_1, α_2 and α_3.
For any one firing angle setting, (ask the teacher), take the following waveforms from the **dual channel** power scope, in one particular transparency:
   1) Load voltage (v_L), load current (i_L)
   2) Load current (i_L), voltage across thyristor T_1 (v_{AK})

All waveforms must have voltage and time scales specified. They must be properly captioned, with proper legends. Zero voltage (Ground) line must be marked.

b) WITH INDUCTIVE LOAD: Repeat the same steps, for the same 3 sets of firing angles, α_1, α_2 and α_3 as above (RUN IIIa), **but with inductive load** (Take 70Ω rheostat and the given choke for the purpose). Switch on SW_C first. Turn the potentiometer knob such that the pot output with respect to logic ground is negative maximum. Now, switch on SW_P. Vary the pot for setting different firing angles. Fill up table 1.1 (All columns except the column marked 'calculated') and take power scope waveforms as outlined in RUN IIIa.

Table-1.1

Type of load	Firing angle, α (degrees)	I_L (A)		V_L (V)	
		Meter reading	Calculated	Meter reading	Calculated
R-load					
R- L load					

Put off the switches SW_P and SW_C. ***FIRST, PUT OFF SW_P AND THEN SW_C.***

c) WITH DC MOTOR LOAD:

1) Observe the nameplate ratings of the given DC motor. Identify the armature and the field winding of the same with a multimeter. Connect the DC motor and complete the wiring of the circuit as shown in Fig. 1.1b with the necessary meters. Set the given 70Ω rheostat to a value equal to around 1Ω and use it as R_X of Fig. 1.1b (Use the voltage drop across R_X for considering the load current waveform in the power scope.). Note the field connection, the necessity of the field clamping diode (D_3).
2) Loosen up the screws of the loading system to ensure that there is no load on the motor shaft. Check for any zero error of the spring balances in this condition and note it.
3) Switch on SW_C. Set α = a value as large as possible by setting the pot output at around -4.9V.
4) Switch on SW_P. Soft-start the motor on no-load, by slowly decreasing 'α', i.e. by slowly increasing the potentiometer output. The motor starts. Set pot output = 0V (i.e. $\alpha = 90^0$ ideally) Let the motor settle. Note the load current and load voltage readings in the meters provided. Note the no-load speed from a tachometer. Take the following power scope waveforms in the two channels:
    - Load voltage (v_L), load current (i_L) – 1^{st} *transparency*
    - Load current (i_L), voltage across thyristor T_1 (v_{AK}) – 2^{nd} *transparency*
5) Keep same pot setting, i.e. same 'α'. Start putting load on the motor by tightening the screws of the loading arrangement. Increase the load to such an extent that the motor settles at a speed equal to approximately two-third of the no-load speed of the previous case. Note this speed on a tachometer and the spring balance readings at this load. Also note the load current and the load voltage in the connected meters. At this load, take the following power scope waveforms in the two channels:
    - Load voltage (v_L), load current (i_L) – 1^{st} *transparency*
    - Load current (i_L), voltage across thyristor T_1 (v_{AK}) – 2^{nd} *transparency*

6) Observe the effects of loading from the meter readings and from the power scope waveforms, by comparing with the ‘no-load case’. Fill up the following table (All columns except the column marked ‘calculated’):

All waveforms must have voltage and time scales specified. They must be properly captioned, with proper legends. Zero voltage (Ground) line must be marked.

Table 1.2

R_x = Armature resistance = Field resistance =

Loading condition	Spring Balance reading (lb)	Firing angle, α (degrees)	I_L (A)		V_L (V)	
			Meter reading	Calculated	Meter reading	Calculated
No-load						
On-load						

<u>NOTE:</u> Diameter of the pulley (with belt): 14 cm.

F) Report: -

i. Fill up the columns marked ‘Calculated’ in Table 1.1 and 1.2 after finding them out graphically from proper waveforms taken in the related ‘Runs’. (<u>Show **at least one** sample calculation for each table.)</u>

ii. Calculate the DC motor efficiency during the loaded condition, from the meter readings of that run (Run IV-c-6) and from the load and motor parameters, as required.

iii. Find out the Fourier coefficients of the load current and load voltage waveforms **graphically** for **the particular** value of firing angle for which you have taken the waveforms for each type of load, i.e. R, R-L and motor (R-L-E) under loaded condition **(Consult book of Kerchner & Corcoran to find out how the coefficients are found graphically from experimental instantaneous waveform data).**

iv. Discuss any special observation that you might have made while doing this experiment.

Probable questions that might be asked:

a) For resistive load, the D.C. voltage is not equal to the theoretical value obtained under cosine wave control—why?

b) With motor load, thyristor conducts even below the back e.m.f level. Why?

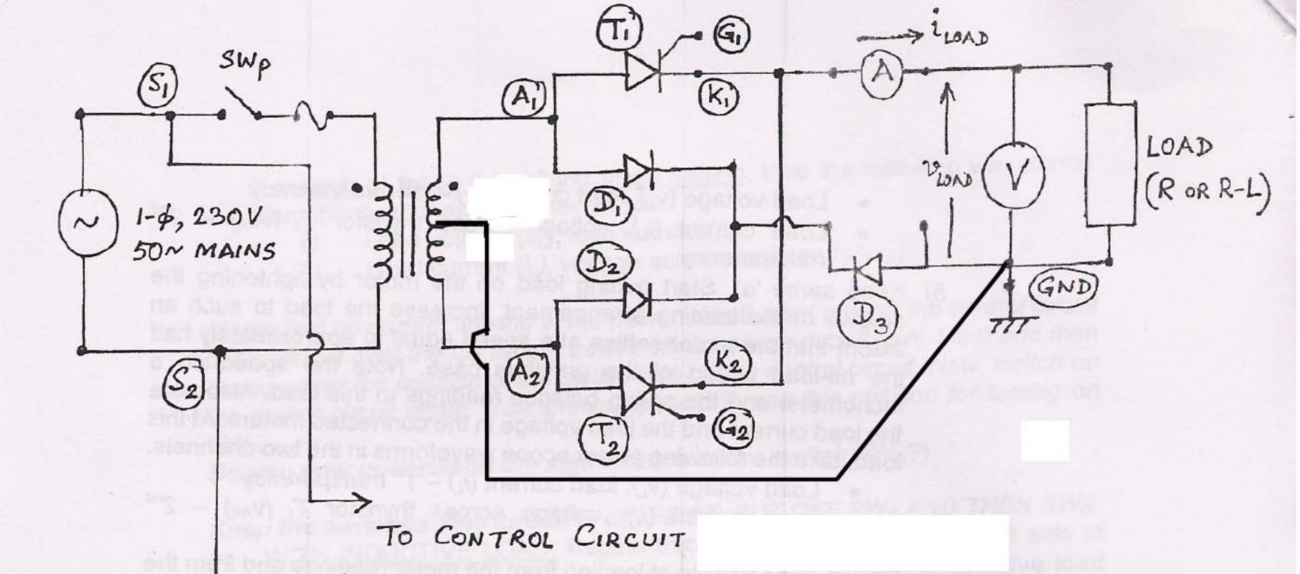


FIG. 1.1a: POWER CIRCUIT OF THE 1-φ THYRISTORIZED FULL-CONTROLLED RECTIFIER WITH RESISTIVE OR RESISTIVE-INDUCTIVE LOAD.

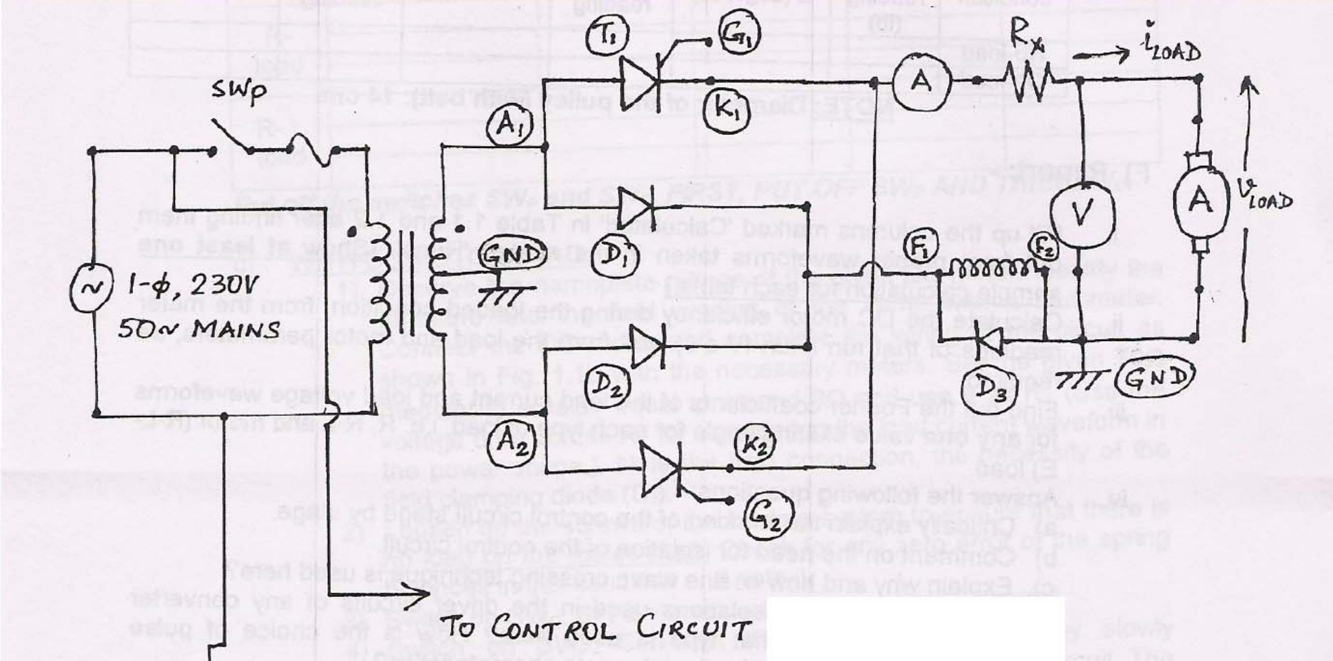


FIG. 1.1b: POWER CIRCUIT OF THE 1-φ THYRISTORIZED FULL-CONTROLLED RECTIFIER WITH DC MOTOR (R-L-E) LOAD

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Industrial Electronics Laboratory …………………**8^{th} Semester, Electrical**

Expt. No 851-PE/2 **Experiment no:-2**

Study of Power Circuit of a Three Phase Full-Controlled Bridge Rectifier

A) Preparatory notes:-

i. Equip yourself with the theory of the 3-ϕ thyristorized full-controlled bridge rectifier from 'Suggested readings', as given in iii. below.

ii. A particular student will be allowed to conduct the experiments only after she/he has made a detailed survey of the working of the circuits and made investigations on certain pertinent points. As an example, the following points should be clear:

a) What is the need for providing transformers in the power and control circuits?
b) How do you decide on the voltage ratios and relative polarities of the transformers employed in the control circuit and the power circuit?
c) Does the load parameters of the power circuit have any influence on the frequency and duty ratio of the high frequency clock influencing the triggering pulses?
d) What should be the expected load voltage, current (v_L, i_L) and device voltage (v_{AK}) waveforms for different loads and firing angles?
e) What happens if all the lower SCRs of the power circuit of the full-bridge rectifier are replaced by diodes?

The students can approach the teachers to clarify any doubt before the day of the experiment.

The students may be prevented from conducting experiments or let off with **fail/simple pass** grade in case the teacher is not satisfied with the level of preparation.

iii. Suggested Readings:

a) Power Electronics by M. H. Rashid
b) Thyristorized Power Controllers by G. K. Dubey, S. R. Doradla, Joshi and Sinha
c) Power Electronics by Cyril W. Lander
d) Thyristor DC drives by P.C. Sen
e) Principles of Alternating Circuits by Kerchner and Corcoran

(for calculation of Fourier coefficients graphically from oscilloscope plots)

B) Objective: -

i. **To study** the principle and details of operation of the 3-phase thyristorized fully controlled bridge rectifier
ii. **To analyse** the performance of the rectifier with different types of loads, with and without freewheeling diode.
iii. **To evaluate** the content of harmonics in such a power converter.

C) Set under test: -

i. A laboratory-built 3-ϕ thyristorized full-bridge rectifier along with its logic and gate driver circuits.

D) Apparatus: -

i. Power scope
ii. Ammeter
iii. Voltmeter
iv. Different loads namely:
   a) **Resistance** (choose 2 of the given 4 no.s 100W@230V resistors,)
   b) **Resistance-inductance** (use the above resistors & the given choke for the purpose)

Present the apparatus list in the format below:

Sl. No.	Description of Apparatus	Quantity used	Range and rating	Maker's name	Maker's number

E) Circuit Diagram:-

Refer to Figs. 2.1 for understanding the power circuit of the converter.

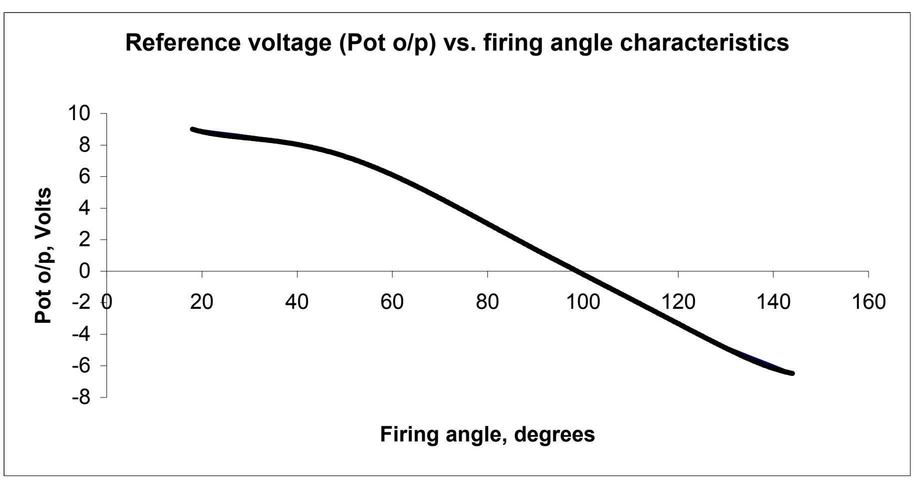
F) Procedure and Results: -

DO NOT SWITCH ON THE POWER CIRCUIT WITHOUT CONSULTING YOUR TEACHER.

KEEP POWER CIRCUIT AND CONTROL CIRCUIT OFF INITIALLY.

RUN-I:- STUDY OF CONTROL CIRCUIT

a) Identify the control circuit potentiometer responsible for varying the firing angle of the thyristors. Identify the control (logic) circuit ground. Identify the 3-pin plug to power up the control circuit. Identify the MCB of the control circuit. Below is given the experimentally obtained characteristics of the reference voltage (pot output) versus the firing angle:



RUN-II:- STUDY OF POWER CIRCUIT

a) Try to relate the power circuit, as drawn on the front panel of the converter, with the power circuit diagram of Fig. 2.1 given in this instruction sheet. Identify the 3 numbers of two-way switches for powering up the power circuit, on the front panel. Identify the switch SW_{dc} and the DC fuse on the front panel. Identify the freewheeling diode terminals.

RUN-III:- PERFORMANCE OF POWER CIRCUIT

a) WITH RESISTIVE LOAD: Complete the wiring of the power circuit with resistive load (use the wall-mounted resistors), as per Fig. 2.1a. **(Please note that the loading resistors are all to be connected in parallel and one by one to be switched on, if loading is to be increased.)** Connect voltmeter, ammeter as shown. **Connect the freewheeling diode, if you feel necessary**. Make the control circuit operative first (Put on the 3-pin plug that powers up the control circuit first. Then, switch on the iron-clad 3-pole main-switch housed on the wall behind the setup. Finally, switch on the MCB of the control circuit). Then switch on the power circuit by putting on the 3 two-way switches of the power circuit simulatneously. Use 2 no.s 100W@230V resistors in parallel as the load resistances. Use the 2A range of the given MC ammeter. You should henceforth work this value of load resistance all throughout. Now set the required firing angle, α. Fill up table 2.1 (All columns except the column marked 'calculated') for three values of firing angles, say, α_1, α_2 and α_3.

For any one of these three firing angle setting (ask the teacher), take the following waveforms from the **dual channel** power scope:

1) Load voltage (v_L), load current (i_L)
2) Load current (i_L), voltage across thyristor T_1 (v_{AK})

b) WITH INDUCTIVE LOAD: Repeat the same steps, for the same 3 sets of firing angles, α_1, α_2 and α_3 as above (RUN IIIa), **but with inductive load** (Keep the same value of resistance as that for RUN IIIa for the purpose). Fill up table 2.1 (All columns except the column marked 'calculated') and take power scope waveforms for the same value of α, as outlined in RUN IIIa.

Table-2.1

Type of load	Firing angle, α (degrees)	I_L (A)		V_L (V)		Comments
		Meter reading	Calcula-ted	Meter reading	Calcula-ted	
R-load* (R= Ω)						
R- L load* (R= Ω, L= mH)						

* With/without freewheel diode, as necessary.

Report: -

i. Fill up the columns marked 'Calculated' in Table 2.1 after finding them out **from proper waveforms** taken in the related 'Run'. (Show **at least one** sample calculation)

ii. Find out the Fourier coefficients of the load current and load voltage from your experimental waveform data for **any one** value of firing angle for each type of load, i.e. R, and R-L load Follow Kerchner and Corcoran's book named "Principles of Alternating Current Machinery for graphically calculating the Fourier coefficients.

iii. Answer the following questions:
   a) The average value of output voltage is different for different type of load with same firing angle. Why? What type of load will give maximum average voltage for same firing angle?
   b) Discuss any special observation that you might have made while doing this experiment.

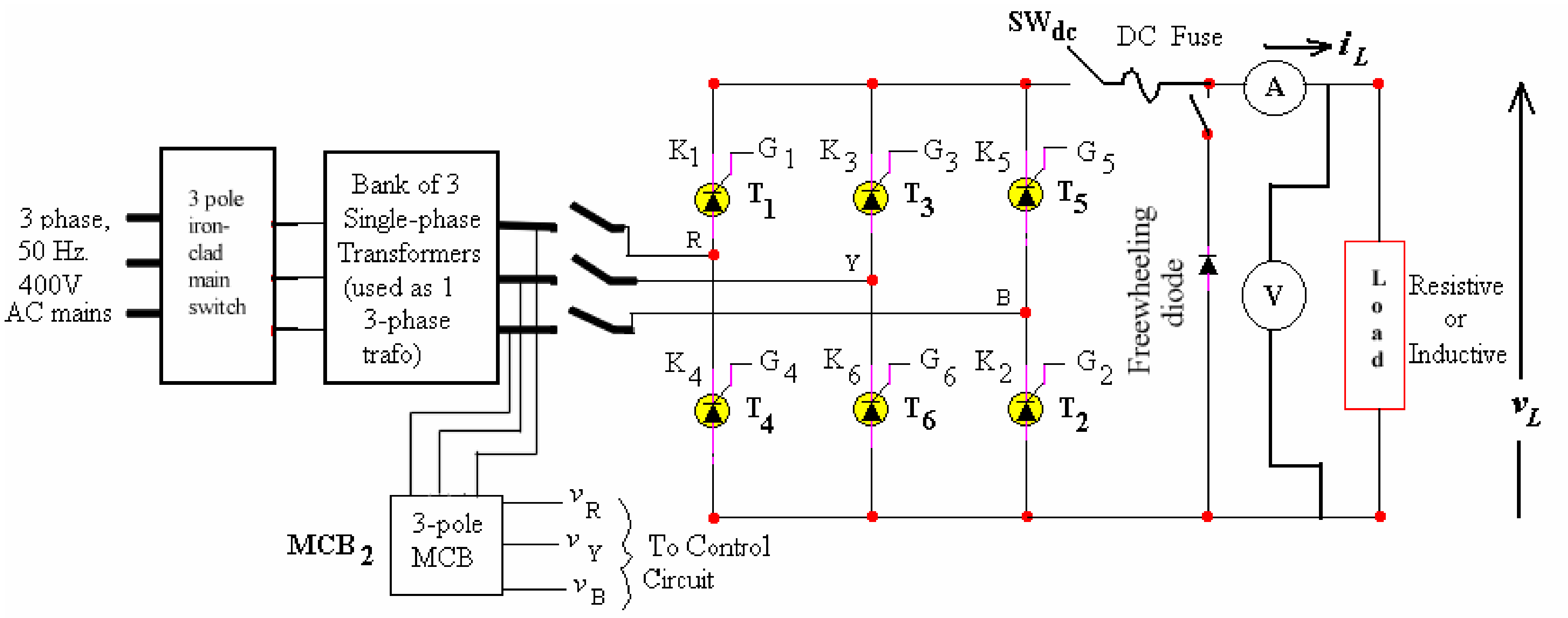


Fig. 2.1. Power Circuit Diagram of the thyristorized three phase full-controlled rectifier, with different types of loads.

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Industrial Electronics Laboratory 8th Semester, Electrical

Expt. No 851-PE/3 Experiment no:-3

Study of Power Circuit of a Single Phase Thyristorized A.C. Voltage Controller

A) Preparatory notes:-

i. Equip yourself with the theory of the 1-ϕ thyristorized AC to AC voltage controller from 'Suggested readings', as given in iii. below.

ii. A particular student will be allowed to conduct the experiments only after she/he has made a detailed survey of the working of the circuits and made investigations on certain pertinent points. As an example, the following points should be clear:
   - a) What is the need for providing transformers in the power and control circuits?
   - b) How do you decide on the voltage ratios and relative polarities of the transformers employed in the control circuit and the power circuit?
   - c) How does an AC voltage controller differ from a variac?
   - d) Does the load parameters of the power circuit have any influence on the above?

   The students can approach the teachers to clarify any doubt before the day of the experiment.

   The students may be prevented from conducting experiments or let off with **fail/simple pass** grade in case the teacher is not satisfied with the level of preparation.

iii. Suggested Readings:
   - a) Power Electronics by M. H. Rashid
   - b) Thyristorized Power Controllers by G. K. Dubey, S. R. Doradla, Joshi and Sinha
   - c) Power Electronics by Cyril W. Lander
   - d) Power Electronics by B. W. Williams
   - e) Principles of Alternating Circuits by Kerchner and Corcoran

   (for calculation of Fourier coefficients from oscilloscope plots)

B) Objective: -

i) **To study** the principle and details of operation of the 1-phase ac voltage controller

ii) **To analyse** the performance of the a.c. voltage controller with different types of loads

iii) **To evaluate** the harmonic content in such a converter.

C) Set under test:-

i. A laboratory-built 1-ϕ thyristorized AC-AC voltage controller along with its logic and gate driver circuits.

D) Apparatus (Prepare apparatus list in the format given in Expt. #1):-

i. Power scope
ii. Ammeter
iii. Voltmeter
iv. Different loads namely:
   a) **Resistance** (Take the given 8 no.s 25W@230V resistors and 8 no.s 50W@ 230V resistors)
   b) **Resistance-inductance** (use from above resistors & the given choke)
   c) **Resistance-capacitance** (use from above resistors & the given capacitance, 2 no.s, each 8μF, paralleled to yield 16 μF for the purpose)

E) Circuit Diagram:-

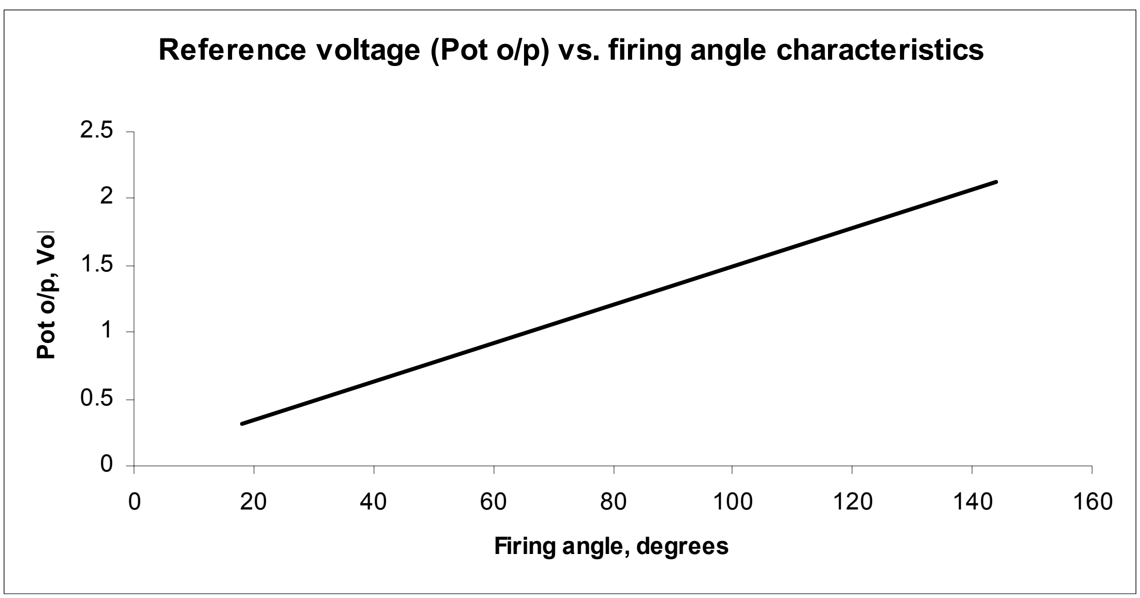
Refer to Figs. 3.1 for understanding power circuit of the converter.

F) Procedure and Results: -

DO NOT SWITCH ON THE POWER CIRCUIT WITHOUT CONSULTING YOUR TEACHER.

RUN-I:- STUDY OF CONTROL CIRCUIT

a) Identify the manual switch powering the control circuit, on the front panel. Identify the logic circuit potentiometer responsible for varying the firing angle of the thyristors. Identify the control (logic) circuit ground. The reference voltage (pot. Output vs. firing angle characteristics is given below:



RUN-II:- STUDY OF POWER CIRCUIT

a) Try to relate the power circuit, as drawn on the front panel of the converter, with the circuit diagrams of Fig. 3.1 given in this instruction sheet. Identify the nodes G_1, K_1, ….G_2,

K_2 on the front panel. Identify the manual switch powering the power circuit on the front panel.

RUN-III:- PERFORMANCE OF POWER CIRCUIT

First, switch on the control circuit and then the power circuit.

a) WITH RESISTIVE LOAD: Complete the wiring of the power circuit with resistive load as per Fig. 3.1. **(8 no.s 25W, 230V and 8 no.s 50W, 230V wall-mounted loading resistors are all to be connected in parallel and one by one to be switched on, if loading is to be increased.)** Power up the control circuit and then power up the power circuit. Keeping the load resistance constant, now vary the firing angle, α. Fill up table 3.1 (All columns except the column marked 'calculated') for three values of firing angles, α_1, α_2 and α_3.
For any one firing angle setting (ask the teacher), take the following waveforms from the **dual channel** power scope:
   1) Load voltage (v_L), load current (i_L)
   2) Load current (i_L), voltage across thyristor T_1 (v_{AK})

b) WITH INDUCTIVE LOAD: Repeat the same steps, for the same 3 sets of firing angles, α_1, α_2 and α_3 as above (RUN IIIa), **but with inductive load** (Keep the same value of resistance as that for RUN IIIa. Use the choke given for the purpose). Fill up table 3.1 (All columns except the column marked 'calculated') and take power scope waveforms as outlined in RUN IIIa.

c) WITH CAPACITIVE LOAD: Repeat the same steps, for the same 3 sets of firing angles, α_1, α_2 and α_3 as above (RUN IIIa), **but with capacitive load** (Take the same value of resistance as that for RUN IIIa and the given paralleled capacitance marked 16 μF for the purpose). Fill up table 3.1 (All columns except the column marked 'calculated') and take power scope waveforms as outlined in RUN IIIa.
All waveforms must have voltage and time scales specified. They must be properly captioned, with proper legends. Ground line must be marked.

Table-3.1

Type of load	Firing angle (degrees)	I_L (A)		V_L (V)	
		Measured	Calculated	Measured	Calculated
Resistive Load (R = Ω)					
Inductive Load (R = Ω, L = mH)					
Capacitive Load (R = Ω, C = μF)					

F) Report: -

i. Fill up the columns marked 'Calculated' in Table 3.1 after finding them out **from proper waveforms** taken in the related 'Run'. (Show **at least one** sample calculation for each type of load.)

ii. Find out the Fourier coefficients of the load current and load voltage waveforms **graphically** from your waveform data for **any one** value of firing angle for each type of load, i.e. R, R-L and R-C load. Follow Kerchner and Corcoran's book named "Principles of Alternating Current Machinery for graphically calculating the Fourier coefficients.

iii. Answer the following questions:
   a) Are the readings of the voltmeter and ammeter representing true rms, fundamental rms or something else? Justify your answer.
   b) The loads you are using are all linear. Then why is the quantity voltage/current not constant for different values of firing angle, for the same load?
   c) Discuss any special observation that you might have made while doing this experiment.

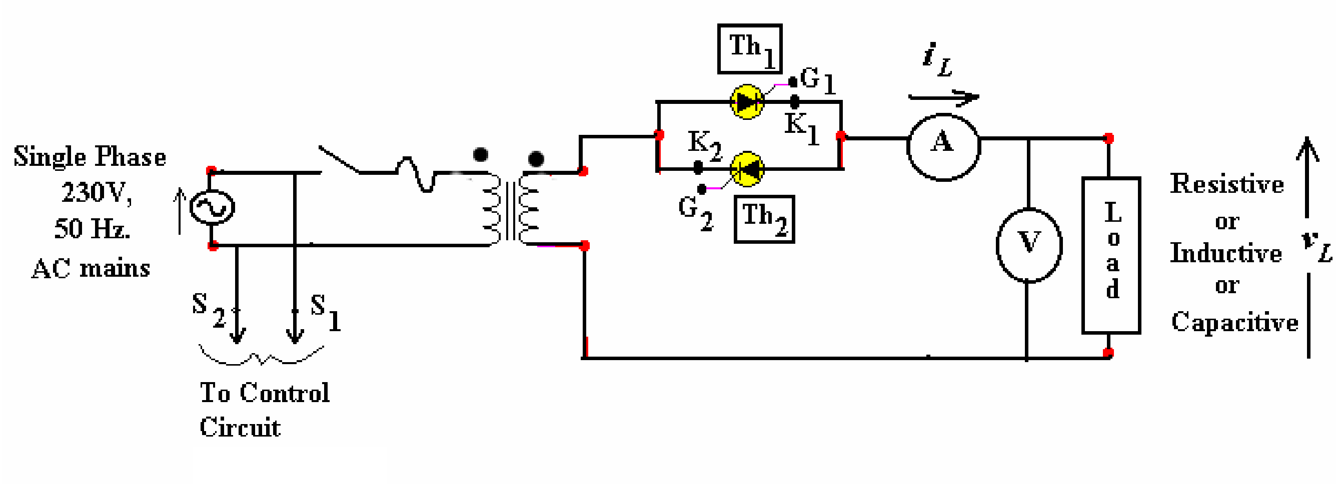


Fig. 3.1: Power Circuit Diagram of the Single-phase thyristorized AC-AC voltage controller, with proper metering and different types of loading.

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Industrial Electronics Laboratory **8^{th} Semester, Electrical**

Expt. No 851-PE/4 Experiment no:-4

Study of the power circuit of a Three Phase Transistorised Inverter

A) Preparatory notes:-

i. Equip yourself with the theory of the 3-ϕ transistorised inverter operating under 120^0 and 180^0 conduction modes from 'Suggested readings', as given in iii. below.

ii. A particular student will be allowed to conduct the experiments only after she/he has made a detailed survey of the working of the circuits and made investigations on certain pertinent points. As an example, the following points should be clear:
   a) What is meant by 180^0 conduction of a 3-phase inverter?
   b) What is meant by 120^0 conduction of a 3-phase inverter?
   c) Get acquainted with the harmonic spectrum of the phase voltages and the line voltages of a 3-phase inverter, when it is operated under (i) 120^0 conduction (ii) 180^0 conduction.
   d) What is the need for providing transformers in the power and control circuits?
   e) How a transistor-diode combination is equivalent to a 2-quadrant switch?
   f) What are the differences between a thyristorized inverter and a transistorised inverter?
   g) How do we choose the ratings of the power devices of an inverter?
   h) Why do we generally need a rectifier at the input of the inverter?

The students can approach the teachers to clarify any doubt before the day of the experiment.

The students may be prevented from conducting experiments or let off with **fail/simple pass** grade in case the teacher is not satisfied with the level of preparation.

iii. Suggested Readings:
   a) Power Electronics by M. H. Rashid
   b) Power Electronics by Cyril W. Lander
   c) Power Electronics by B. W. Williams
   d) Power Electronics by Philip T. Krein
   e) Principles of Alternating Circuits by Kerchner and Corcoran

   (for calculation of Fourier coefficients from oscilloscope plots)

B) Objective: -

i) **To study** the principle and details of operation of the 3-phase 3 leg inverter

ii) **To analyse** the performance of the 3-phase inverter with different types of loads (R, R-L)

iii) **To evaluate** the harmonic content in the output of such a converter.

C) Set under test:-

i. A 3-ϕ transistorized (MOSFET-based) inverter along with its control (logic) and gate driver circuits.

ii. Different loads namely:

a) **Resistance** (use the given 3 no.s 25W@230V tungsten filament lamp for the 3 phases)

b) **Resistance-inductance** (use the above lamps & the 3 given chokes, given for the purpose)

D) Apparatus (Prepare Apparatus list as per format given in Expt. #1):-

i. Power scope

ii. Voltmeter

iii. Multimeter

E) Circuit Diagram:-

Refer to Figs. 4.1 for understanding power circuit and Fig. 4.2 for details of the connection diagram of the load of the inverter.

F) Procedure and Results: -

DO NOT SWITCH ON THE POWER CIRCUIT WITHOUT CONSULTING YOUR TEACHER.

KEEP POWER CIRCUIT AND CONTROL CIRCUIT OFF INITIALLY.

RUN-I:- STUDY OF CONTROL CIRCUIT

a) Identify the power cord for powering up the control circuit. Identify the manual switch for powering the control circuit, on the front panel. Identify the manual switch for selecting the mode, i.e. whether 120^0 conduction or 180^0 conduction.

RUN-II:- STUDY OF POWER CIRCUIT

a) Try and identify the power cord for powering up the power circuit. Identify the push button based START and STOP switches on the front panel of the inverter, meant for energizing and de-energizing the power circuit respectively. Identify the electrical switchboard, on which the load (R, R-L) is wired up. Identify the already-housed chokes and the spaces, where the resistances (25W@230V Tungsten filament lamps) are to be fitted. Spot the 3 given lamps. Identify the given cable for connecting the load with the inverter. Identify the plug-in wires for connecting each phase resistance with the required tapping of that particular phase inductance.

b) Study the switchboard (on which load wired up) from the given circuit diagram of Fig. 4.2a and 4.2b. Note the changeover switch for changing the load connection from ‘STAR’ to ‘DELTA’. Note how to choose a particular tap of the given inductors.

RUN-III:- PERFORMANCE OF POWER CIRCUIT

a) Connect the cable connecting the load and the inverter.

b) Fit the 25W tungsten filament lamps.

c) For taking readings for resistive load only, connect such that choke is bypassed. For taking readings for inductive loads, plug in the given jumpers to put inductance in series with the resistance. Choose full available inductance, i.e. choose endmost tap positions for the given chokes.

d) Set the load connection in 'STAR' mode initially. (Later change it to 'DELTA' when required)

e) Connect the power cords, powering up the power circuit and the control circuit of the inverter. **Please note that directly, 230V, 50 Hz. mains supply should <u>not</u> be given to the front-end diode bridge rectifier, but, should be given through a 230V/0-270V, 4A single phase variac. <u>The variac output should be set at zero initially</u>. After powering up the control circuit and then the power circuit, slowly, the variac output should be increased to a voltage of 100V rms.**

<u>(i) FOR 120 DEGREE CONDUCTION OF INVERTER:</u> Set the manual switch for selecting 120^0 conduction mode in the control circuit of the inverter. Power up the control circuit. Next, power up the power circuit by pressing the 'START' push button on the front panel of the inverter. Note load voltages, AC mains voltage from the meter readings and fill up the relevant columns of Table 3.1.

Take **one representative phase voltage** waveform and **one representative line voltage** waveform using the given dual channel power scope (in cut-out transparency). This should be done individually for star-connected resistive load, star connected inductive load, delta connected resistive load and delta connected inductive load.

By means of the oscilloscope, identify the phase sequence of the 3-phase voltage generated by the inverter at its output nodes marked as 'R', 'Y' and 'B'. Prove by taking and presenting proper waveforms.

<u>(ii) FOR 180 DEGREE CONDUCTION OF INVERTER:</u> Set the manual switch for selecting 180^0 conduction mode in the control circuit of the inverter. Repeat similar steps as given above (Run III(i)). Take similar meter readings and fill up relevant columns of Table 3.1. Take similar waveforms as outlined in Run III(i), here also, using the dual channel power scope.

By means of the oscilloscope, identify the phase sequence of the 3-phase voltage generated by the inverter at its output nodes marked as 'R', 'Y' and 'B'. Prove by taking and presenting proper waveforms.

All waveforms must have voltage and time scales specified. They must be properly captioned, with proper legends. Ground line must be marked.

Table-3.1

Mode of inverter conduction	AC mains voltage (V)	*Load in star*				*Load in delta*	
		Phase voltage (V)		Line voltage (V)		*Phase voltage = line voltage (V)*	
		R-load	R-L load	R-load	R-L load	R-load	R-L load
120 degree							
180 degree							

G) Report: -

i. Work out the Fourier coefficients of the experimental load phase and line voltage waveforms for 120^0 and 180^0 conduction **individually.** Are the readings of the voltmeter and ammeter representing true R.M.S, fundamental R.M.S or something else? Justify your answer utilising the Fourier coefficients and comparing the predicted value with the meter readings.

ii. Answer the following questions:

1) Justify the need for the use of the reverse connected diode across each transistor of the inverter.
2) Why are there some spikes sometimes in the output voltage waveforms at every 60^0 transistion?
3) In case an inverter output voltage is defined as a space vector as

$$v_{inv} = v_a + a\, v_b + a^2 v_c, \text{ where } a = \text{the unit vector, } 1\angle 120^0$$

plot the voltage vectors to a uniform scale corresponding to the different switching configurations for (i) 120^0 conduction and (ii) 180^0 conduction.

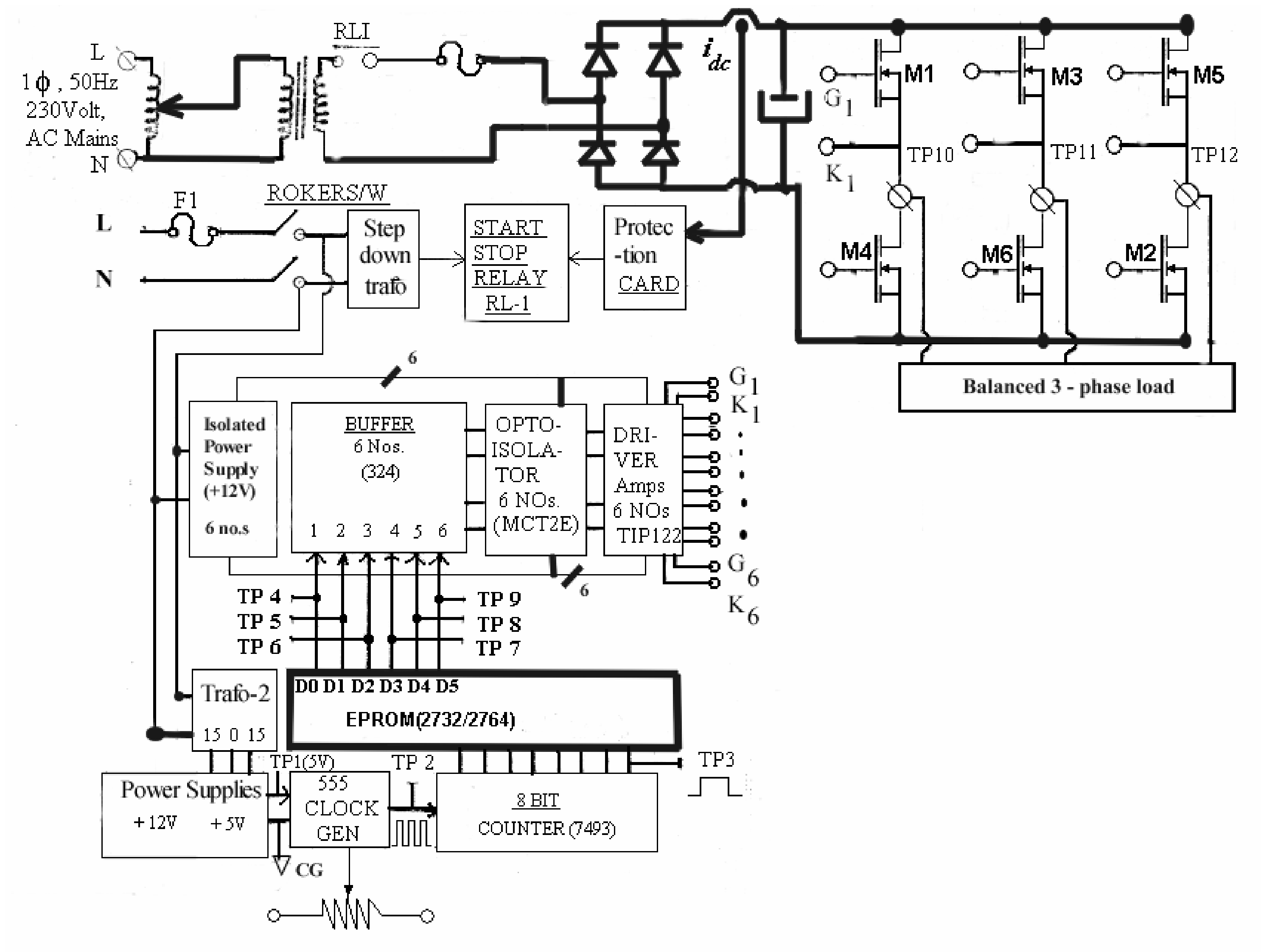
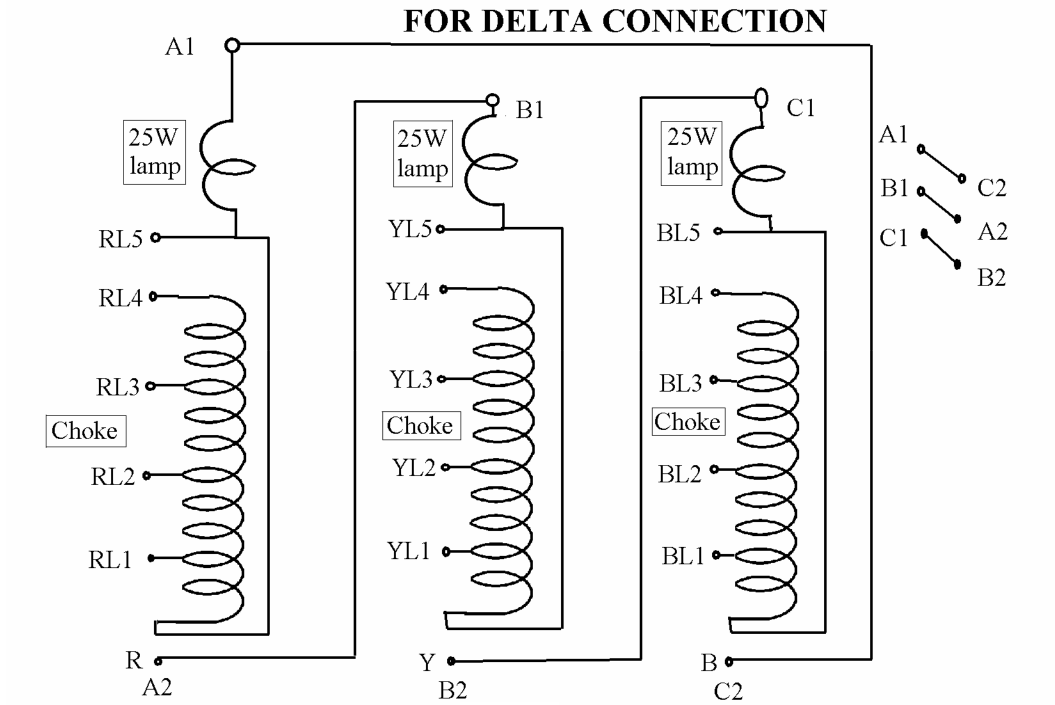
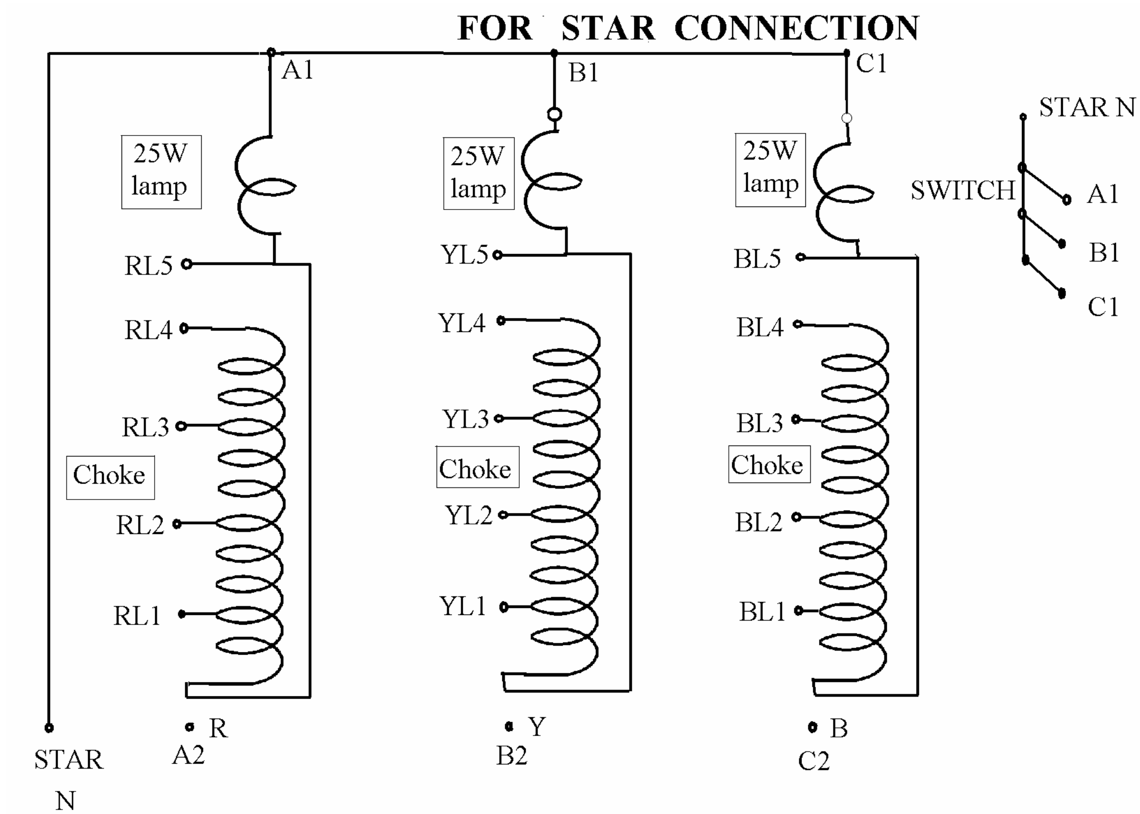


Fig. 4.1: **Power Circuit Diagram** (with load) and **Control Circuit Diagram** of the 3-phase MOSFET-based bridge inverter panel (For details of the load connection, refer to Figure 4.2).



(a)



(b)

Fig. 4.2: Connection details of the load of the 3-phase transistorized inverter on the given electrical switchboard.

DEPARTMENT OF ELECTRICAL ENGINEERING
BENGAL ENGINEERING AND SCIENCE UNIVERSITY, SHIBPUR

Electric Drives Laboratory, 8th Semester Electrical

Expt. No. 805-2/1 : Familiarisation with Motor Control Devices

Familiarisation with different electromagnetic devices used in Motor Control Logic Units such as : Contactors, Overload relay, time delay relay etc.

Expt.No. 805-2/2 : Starting and Reversing of Induction Motor

Design the logic circuit for starting and reversing an induction motor. The controller should have two separate push buttons one for forward and other for reverse rotation while a single stop button will stop the motor in both direction of motion. The motor should be protected against overload and there will be interlock between forward & reverse operation.

Fabricate the circuit and run the motor.

Expt. No. 805-2/3 : Sequential Motor Control

Design the logic controller for controlling two induction motors operating in sequence as detailed below. The motor 1 should start immediately as the START push button is pressed and the motor 2 will automatically start after a pre-assigned time delay. When STOP button is pressed the motor 2 stops immediately while the motor 1 stops after a pre-assigned time delay. The system will follow the stop sequence if any of the motors is overloaded.

Fabricate the circuit and test the operation.

Expt. No. 805-2/4 : Automatic Star-delta Starter

Design an automatic star-delta starter for a 6-terminals sequence cage induction motor. The motor will be protected against overload.

Fabricate and test the circuit.