Single Phase Controlled Rectifier with Cosine Firing Scheme Scientech 2709

Learning Material
Ver 1.1

An ISO 9001:2008 company
Scientech Technologies Pvt. Ltd.
94, Electronic Complex, Pardesipura, Indore - 452 010 India,
✆ + 91-731 4211100, ✉: info@scientech.bz , : www.ScientechWorld.com

Certificate

Standard: **ISO 9001:2008**

Certificate Registr. No. **85 100 001 10182**

TÜV Rheinland India Pvt. Ltd.:

Certificate Holder: **Scientech Technologies Pvt. Ltd.**

Unit 1: 94 – 101, Electronics Complex, Pardeshi Pura,
Indore – 452 010, Madhya Pradesh, India

Unit 2: 90 – 91, Electronics Complex, Pardeshi Pura,
Indore – 452 010, Madhya Pradesh, India

Scope: **Design, Manufacture of Electronic Test & Measuring Instruments, Training Products for Electrical & Electronics Education and Providing Technology Training**

An audit was performed, Report No. 10182. Proof has been furnished that the requirements according to ISO 9001:2008 are fulfilled.

The due date for all future audits is 04-10 (dd.mm).

Validity: The certificate is valid from **2010-12-13 until 2013-12-12.**

Bangalore, 2010-12-20

The Certification Body of
TÜV Rheinland India Pvt. Ltd.

TÜV NABCB QMS 010

The validity of this certificate is subject to timely completion of Surveillance audits as agreed in the Contract. The Validity of the Certificate can be verified under WWW.tuv.com with the identification No. 9105027653

09/03/NABCB/00

www.tuv.com

TÜVRheinland®
Precisely Right.

Single Phase Controlled Rectifier with Cosine Firing Scheme

Scientech 2709

Table of Contents

Safety Instructions

Read the following safety instructions carefully before operating the instrument. To avoid any personal injury or damage to the instrument or any product connected to the instrument.

Do not operate the instrument if you suspect any damage within.

The instrument should be serviced by qualified personnel only.

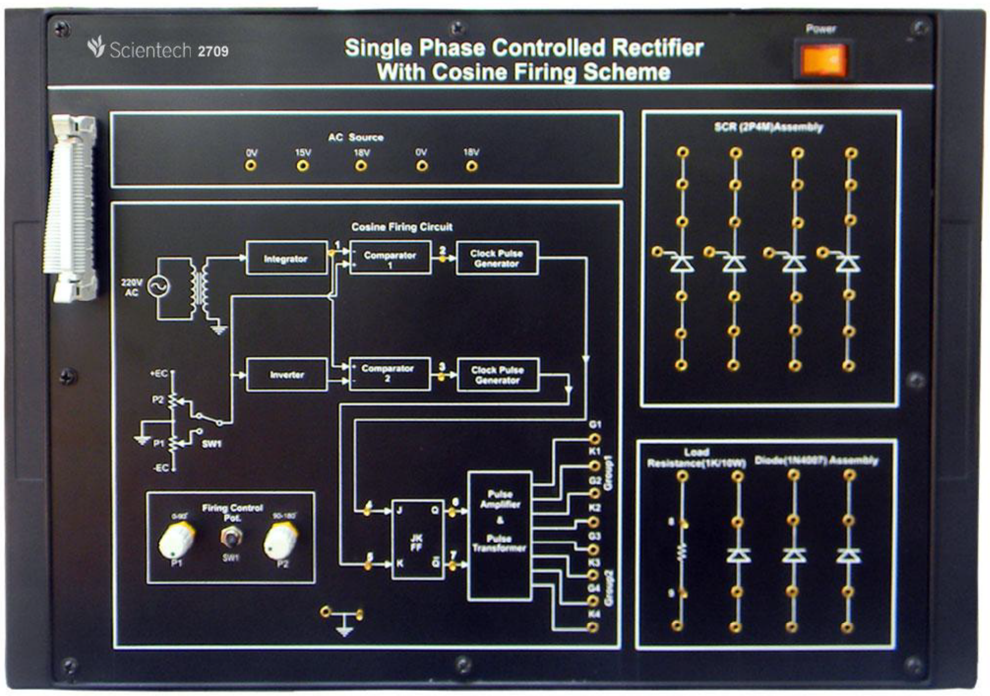
For your safety:

Use proper Mains cord	**:**	Use only the mains cord designed for this instrument. Ensure that the mains cord is suitable for your country.
Ground the Instrument	**:**	This instrument is grounded through the protective earth conductor of the mains cord. To avoid electric shock the grounding conductor must be connected to the earth ground. Before making connections to the input terminals, ensure that the instrument is properly grounded.
Observe Terminal Ratings	**:**	To avoid fire or shock hazards, observe all ratings and marks on the instrument.
Use only the proper Fuse	**:**	Use the fuse type and rating specified for this instrument.
Use in proper Atmosphere	**:**	Please refer to operating conditions given in the manual.

1. **Do not operate in wet / damp conditions.**
2. **Do not operate in an explosive atmosphere.**
3. **Keep the product dust free, clean and dry.**

Introduction

Scientech 2709 is a platform which helps Students to understand the various concepts of Cosine wave firing scheme for single phase controlled rectifiers. 2709 is also useful for Students to perform controlled rectifiers on various configurations like half wave, full wave, bridge, symmetrical & symmetrical configurations. This platform is provided with in built AC & DC power supplies, sockets for making different interconnections in the circuit and exhaustive learning material.



Features

- **In built Power Supply**
- **Easy to operate and understand**
- **Gradual firing angle control upto 180 degree**
- **Test points to observe output of different blocks**
- **On board AC sources of 15 V and 18 V**
- **More than six experiments can be performed on single board**

Technical Specifications

On board AC source	:	0 V - 15 V, 18 V - 0 V - 18 V
On board firing circuits	:	Cosine firing scheme
SCR Assembly	:	4 SCRs 2P4M, 400 V/2 A
Mains Supply	:	220V/110V, 50 Hz / 60 Hz
Test points	:	9 nos (Gold plated)
Interconnection	:	2 mm socket (Gold plated)
Dimensions (mm)	:	W 420 x D 255 x H 100
Weight	:	2 Kg (approximately)
Operating Conditions	:	0-40^0 C, 85% RH
Learning material	:	CD (Theory, procedure, reference results, etc.), Online (optional)

Theory

Earlier, DC power was obtained from motor generator sets or AC power was converted to DC power by means of mercury arc rectifiers or thyratrons. The advent of thyristors has changed the art of AC to DC conversion. Presently, Phase controlled AC to DC converters employing thyristors are extensively used for changing constant AC input voltage to controlled DC output voltage. In industry where there is a provision for modernization, mercury-arc rectifiers and thyratrons are being replaced by thyristors.

In phase controlled rectifiers, a thyristor turns off as AC supply voltage reverse biases it, provided anode current has fallen to level below the holding current. The turning off, or commutation, of a thyristor by supply voltage itself is called natural commutation. As phase controlled rectifiers need no commutation circuitry, these are simple, less expensive and are therefore widely used in industries where controlled DC power is required.

Principle of phase control:

The simplest form of controlled rectifier circuits consist of a single thyristor feeding DC power to a resistive load R. The source voltage is Vs = Vm sin ωt. An SCR can conduct only when anode voltage is positive and a gating is applied. As such, a thyristor blocks the flow of load current Io until it is triggered. At some delay angle α, a positive gate signal applied between gate and cathode turns on the SCR. Immediately, full supply voltage is applied to the load as V_o. At the instant of delay angle α, V_o rises from zero to $V_m \sin \alpha$ as shown in figure for resistive load, current i_o is in phase with V_o. Firing angle of thyristor is measured from the instant it would start conducting if it were replaced by diode. If thyristor is replaced by diode, it would begin conduction at ωt = 0,2π, 4π etc.; firing angle is therefore measured from these instants. A firing angle may thus be defined, as the angle between the instant thyristor would conduct if it were a diode and the instant it is triggered. It is also defined as the angle measured from the instant that gives the largest average output voltage to the instant it is triggered.

Once the SCR is 'On', load current flows, until it is turned-off by reversal of voltage at ωt=π, 3π, 5π etc. load current falls to zero and soon after the supply voltage reverse biases the SCR , the device is therefore, turned off. By varying the firing angle α, the phase relationship between the start of the load current and the supply voltage can be controlled.

Phase Controlled Rectifier:

There are two types of rectifier;

1. Half wave rectifier
2. Full wave rectifier

Half Wave Controlled Rectifier:

Single-phase half wave controlled rectifier means that the single SCR is used to convert the AC to DC. During the positive half cycle of the input voltage, thyristor T1 is forward biased and current flows through the load when the thyristor is fired, at $\omega t = \alpha$. The thyristor conducts only when the anode is positive with respect to cathode and a positive gate signal is applied, otherwise, it remains in the forward blocking state and blocks the flow of the load current.

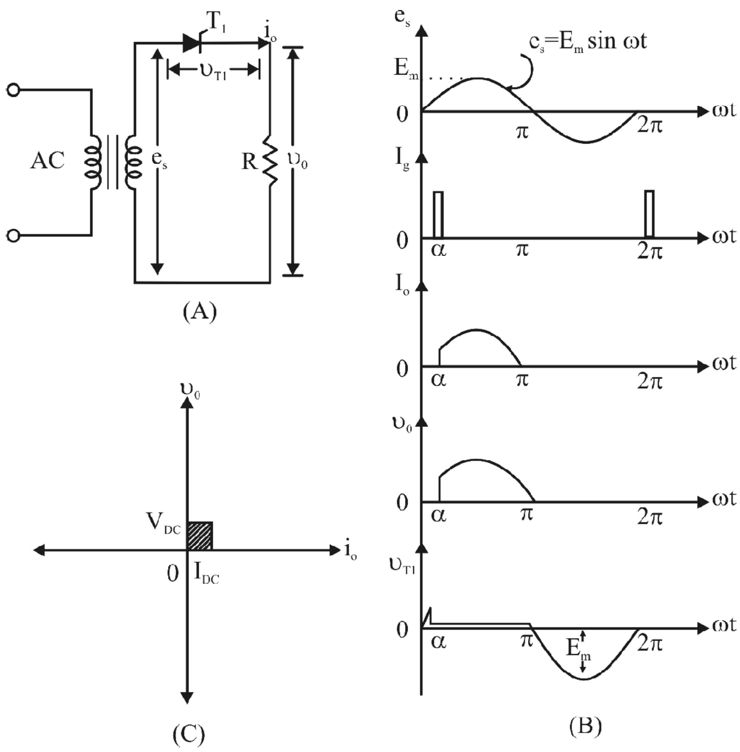


Figure 1

In the negative half cycle, i.e., at $\omega t = \pi$, the thyristor is in the reverse biased condition and no current flows through the load. Thus, varying the firing angle at which the thyristor starts conducting in positive half controls the average DC output voltage cycle. The waveforms of the above circuit are shown in figure. The output load voltage and current are positive, i.e., **they are one quadrant**; it is called a half wave semi converter.

The average DC output voltage across load is given by

$$V_{DC} = E_m (1+\cos \alpha)/2\pi \qquad \text{.............................(1)}$$

And

$$V_{DC}\,(\text{maximum}) = E_m/\pi$$

Average current is given by

$$I_{DC} = E_m (1 + \cos \alpha)/2\pi R \qquad \text{................................(2)}$$

And, the DC output power is

$$P_{DC} = V_{DC} \text{ X } I_{DC} \qquad \text{...............................(3)}$$

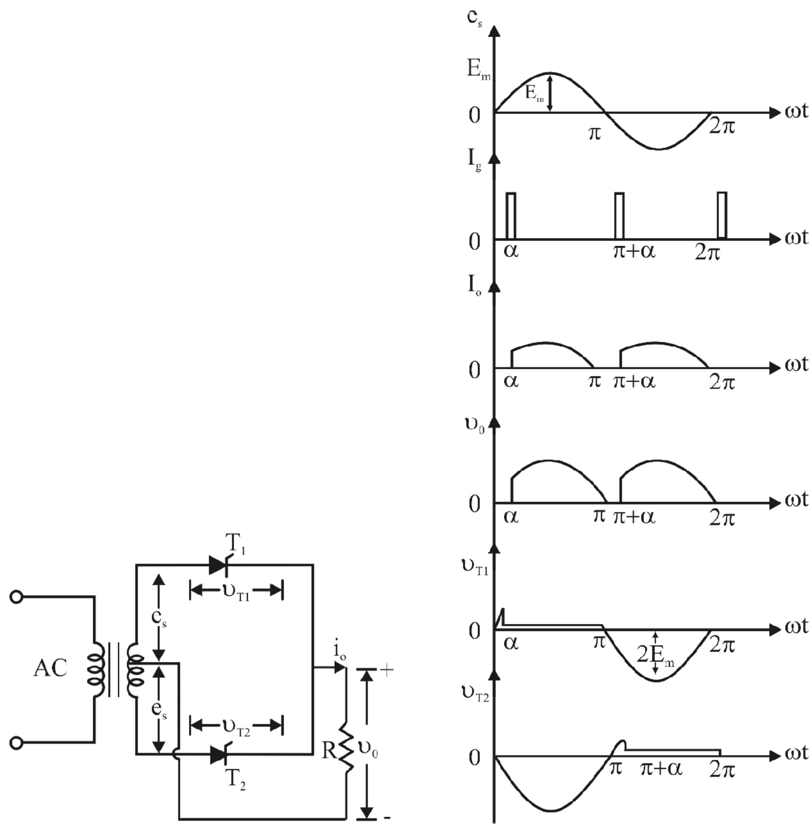
Full Wave Rectifier:

There are two types of full rectifier;

1. Mid-point configuration
2. Bridge configuration

Mid-Point Full Wave Rectifier:

The circuit diagram of a single-phase full-wave converter using center-tapped transformer is shown in figure. When terminal ‘P’ of the transformer is positive w.r.t. to terminal ‘Q’ in the positive half cycle of the supply, and if thyristor T_1 is fired at $\omega t = \alpha$, current flows from terminal ‘P’ through thyristor T_1, the load resistance R and back to the center tapped of the transformer. This current continues to flow up to 180° and when the input voltage changes its polarity, the thyristor T_1 goes from the ‘On’-state to the ‘Off’-state. In the negative half cycle, when terminal ‘Q’ is positive w.r.t. Terminal ‘P’, if thyristor T_2 is fired at $\omega t = (\pi + \alpha)$, current flows through the thyristor T2, the load resistance and back to the center tapped of the transformer. This current continues to flow up to 2π when the thyristor T_2 turns ‘Off’. Thus, there are two current pulses of the same direction across the load in one complete cycle. **Since thyristor T_1 and T_2 are forward biased during the positive and negative half cycles respectively (linking to what?).**



(A) (B)

Figure 2

The average DC voltage across load is

$$V_{DC} = E_m(1+\cos\alpha)/\pi \qquad \text{……………………..(4)}$$

The average load current is

$$I_{DC} = E_m(1+\cos\alpha)/\pi R \qquad \text{……………………..(5)}$$

Therefore, the DC output power is

$$P_{DC} = V_{DC} \times I_{DC}$$

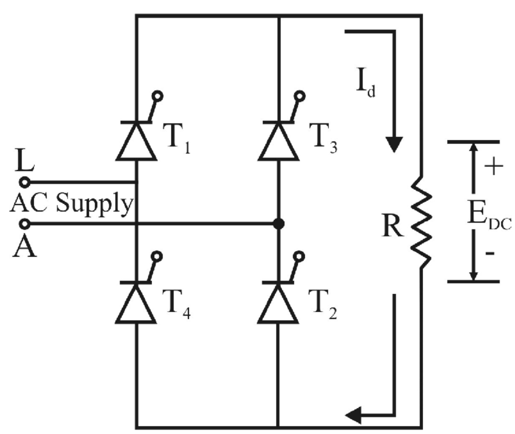
Bridge Type Full Wave Rectifier:

There are two types of bridge configuration full wave rectifier:

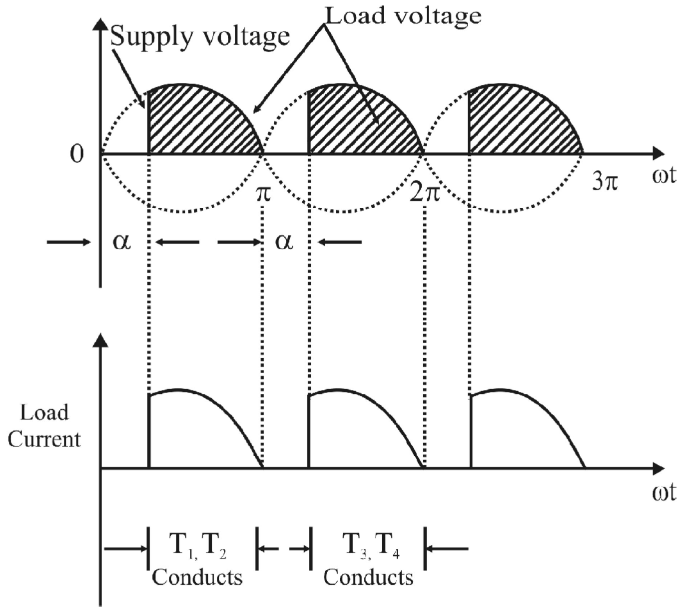
1. Fully controlled bridge rectifier
2. Half controlled bridge rectifier

Fully Controlled Bridge Rectifier:

A single-phase fully controlled bridge circuit with resistive load consists of four thyristor as shown in figure. During the positive half cycle when terminal ‘P’ is positive w.r.t.‘Q’, thyristors T_1 and T_2 are in the forward blocking state and when these thyristors fire simultaneously at $\omega t = \alpha$, the load is connected to the input through T_1 and T_2. During negative half cycle i.e., after $\omega t = \pi$, thyristor T_3 and T_4 are in the forward blocking state, and simultaneous firing of these thyristors reverse biases the previously conducting thyristors T_1 and T_2. These reverse biased thyristors turn off due to line or natural commutation and the load current transfers from T_1 and T_2 to T_3 and T_4. The voltage and current waveforms are shown in figure.



Fully-controlled bridge –circuit with resistive-load



Waveform for fully-controlled bridge with resistive-load

Figure 3

The average DC voltage across load is

$V_{DC} = E_m (1+\cos\alpha)/\pi$ ……………………… (6)

The average load current is

$I_{DC} = E_m (1+\cos\alpha)/\pi R$ …………………….. (7)

Therefore, the DC output power is

$P_{DC} = V_{DC} \text{ X } I_{DC}$

Half Controlled Bridge Rectifier:

In these configurations two thyristors are replaced by power diodes and can be connected in either arm of the bridge. Depending on the connections, these are further classified as

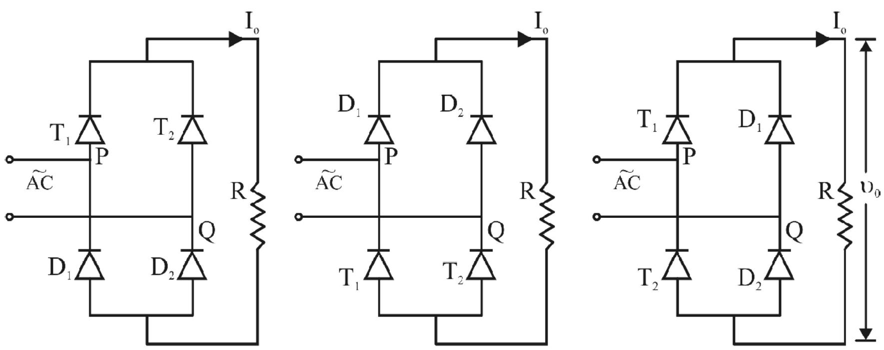
1. Symmetrical
2. Asymmetrical

Symmetrical configuration is in two types

1. Common cathode
2. Common anode

Out of these configurations, the common cathode symmetrical configuration is the most commonly used configuration, because a single trigger can be used to fire both thyristors without any electrical isolation.

During the positive half cycle, when ‘P’is more positive w.r.t. ‘Q’ and when thyristor T_1 is triggered, the load currents flows through T_1 and the diode D_2 in the circuit as shown in figure. During the negative half cycle, when ‘Q’ is more positive w.r.t. ‘P’, the thyristor T_2 and the diode D_1 constitute the load current. The waveforms of the voltage and current in relation to the input voltage are shown in figure.



(a) **(b)** **(c)**

Figure 4

Where, figure (a) is common cathode, (b) is common anode and (c) is asymmetrical configuration

Average DC voltage across load is

$$V_{DC} = E_m (1+ \cos \alpha) / \pi \quad \ldots\ldots\ldots\ldots(8)$$

And average current is

$$I_{DC} = E_m (1+ \cos \alpha) / \pi R \quad \ldots\ldots\ldots\ldots(9)$$

Average power is

$$P_{DC} = V_{DC} \times I_{DC}$$

Single Phase Converter Firing Circuit:

There are many schemes to generate firing pulses for single phase rectifier Cosine-firing scheme in which synchronized sinusoidal signal is converted in cosine wave.

Cosine Firing Scheme:

This scheme is used to fire thyristors in single phase converter. **The pulse output of this scheme synchronizes with AC supply using step down transformer supply voltage step down to an appropriate level.** Input to this transformer is taken from same source from which converter circuit is energized. The output voltage of transformer is integrated using integrator to get cosine wave V_1. The cosine signal is compared with reference voltage in comparator 1 and in comparator 2, it is compared with invert of reference voltage. The DC control voltage E_C varies from maximum positive E_{cm} to maximum negative E_{cm} so that firing angle can be varied from 0 to 180 degree. So the comparator 1 and comparator 2 give output pulses V_2 and V_3. The firing angle is governed by the intersection of V_1 and E_C. When E_C is a maximum, firing angle is zero. Thus firing angle α in terms of V_{2m} and E_c can be expressed as

$$V_{2m} \cos\alpha = E_C$$

Or

$$\alpha = \cos^{-1} (E_C / V_{2m})$$

Where V_{2m} = maximum value of cosine signal V_2.

The signals V_3, V_4 obtained from comparators are fed to clock pulse generators 1, 2 to get clock pulses V_5, V_6. These signals V_5, V_6 **energies a** JK flip flop to generate output signals **V_i and V_j**. the signal Vi is amplified through the amplifier circuit and then employed to turn 'On' the SCR's in the positive half cycle. Signal V_j, after amplification, is used to trigger SCR's in the negative half cycle.

Firing angle in time is

$$\alpha = (180 \text{ X } T) / 10\text{ms} \qquad \text{………………. (10)}$$

So,

$$T = (\alpha \text{ X } 10\text{ms}) / 180 \qquad \text{……………... (11)}$$

Where, time T in ms

And,

$$V_{RMS} = V_M / \sqrt{2} \qquad \text{………………. (12)}$$

Then,

$$V_M = \sqrt{2} \text{ X } V_{RMS} \qquad \text{………………. (13)}$$

Experiment 1

Objective:

Study of cosine firing circuit for single-phase converter

Equipments Needed:

1. Power Electronics board, **Scientech 2709**
2. Oscilloscope-Scientech 803/831, or equivalent
3. 2 mm patch cords.

Circuit diagram:

The basic cosine firing circuit block diagram is shown below in the figure 5

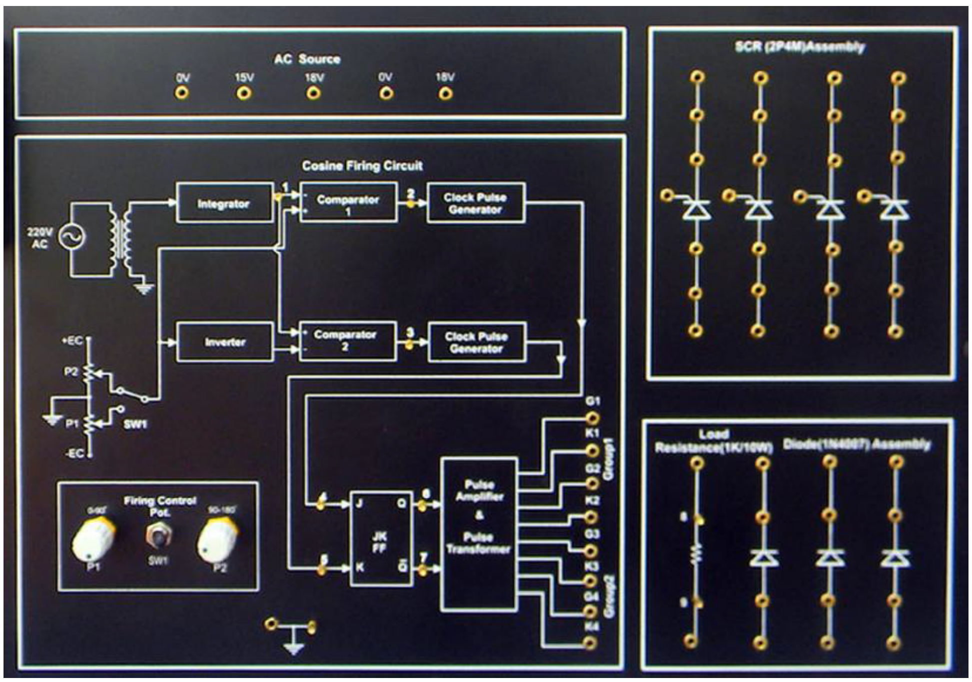


Figure 5

Procedure:

- Make sure that there should not be any connections by patch cord on the board.

1. Rotate the firing control Potentiometer 1 in fully clock wise direction and Potentiometer 2 in fully counter clockwise direction.
2. Switch 'On' the power supply.
3. Observe the sine wave AC signal between 15V and 0V and note readings of amplitude and time.
4. Observe the output waveforms of integrator point '1'w.r.t. ground and note readings of amplitude and time base.
5. Observe the output waveforms of comparator1, comparator 2 at points '2'and '3' w.r.t ground and also note readings of amplitude and time base.
6. Observe the output waveforms of clock pulse generator 1, clock pulse generator 2 at points '4'and '5'w.r.t. ground and also note readings of amplitude and time base.
7. Observe the output waveforms of gate pulse 1 gate pulse 2 points '6'and '7'w.r.t. ground and also note readings of amplitude and time base.
8. Plot the waveforms of input signal, cosine signal, comparator1 and comparator 2 outputs, clock pulse1 and 2, gate pulse 1 and 2.

S. No.	Input signal		Cosine signal		Comparator 1 output		Comparator 2 Output		Clock pulse 1 Output		Clock Pulse 2 output		Gate pulse 1		Gate pulse 2	
	A	T	A	T	A	T	A	T	A	T	A	T	A	T	A	T

Experiment 2

Objective:

Study of half wave controlled rectifier with resistive load

Equipments Needed:

1. Power Electronics board, **Scientech 2709**
2. Oscilloscope ST201 or equivalent
3. 2 mm patch cords.
4. Multimeter, ST4022 or equivalent

Circuit diagram:

The circuit diagram of basic half wave controlled rectifier is shown below in the figure 6

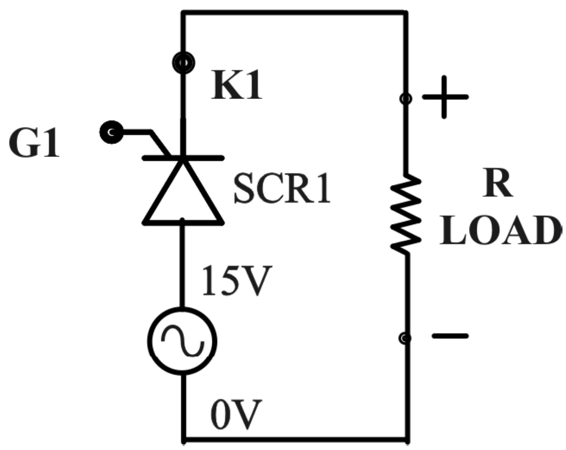


Figure 6

Procedure:

- Make sure that there should not be any connections by patch cord on the board

1. Rotate the firing control Potentiometers 1 and 2 in full counter clockwise direction and **also switch set at Potentiometer 1 side.**
2. Switch 'On' the power supply
3. Measure the AC voltage (Vrms) by voltmeter between point 0V-15V and calculate Em by Em =1.414 X Vrms.
4. Switch 'Off' the power.
5. Connect the circuit of half wave rectifier as shown figure 6 using 2 mm patch cords.
6. Switch 'On' the power supply
7. Connect the Oscilloscope and voltmeter across the load.
8. Vary the firing control Potentiometer and set on 30º, 60º, 90º, 120º and 150º firing angles using equation (11).
9. Observe the output waveforms and note the readings of voltage across load on different firing angles.
10. Observe the waveform across the SCR1 when firing angle is 90º.
11. Calculate the average load current I_{DC} and power P_{DC} from measured load voltage V_o.
12. Plot the input signal, gate pulse, and drop signal across SCR and output waveforms when firing angle is 90º.

Observation Table :

S. No.	Input AC Voltage		Firing Angle		Average Output Voltage Across Load		Average Load Current (I_{DC})		Average Output Power	
	In (V_{rms})	In (V_m)	In Deg.	In Time (ms)	Measured Voltage (V_o)	Calculated Voltage (V_{DC})	Measured (I_o) V_o / R_L	Calculated (I_{DC}) V_{DC} / R_L	Measured P_o V_o X I_o	Calculated (P_{DC}) V_{DC} X

Experiment 3

Objective:

To study the full wave controlled rectifier (mid-point configuration) with resistive load.

Equipments Needed:

1. Power Electronics board, **Scientech 2709**
2. Oscilloscope ST201 or equivalent
3. 2 mm patch cords.
4. Multimeter ST4022 or equivalent

Circuit diagram:

The circuit diagram of basic full wave controlled rectifier (mid- point configuration) is shown in the below figure 7

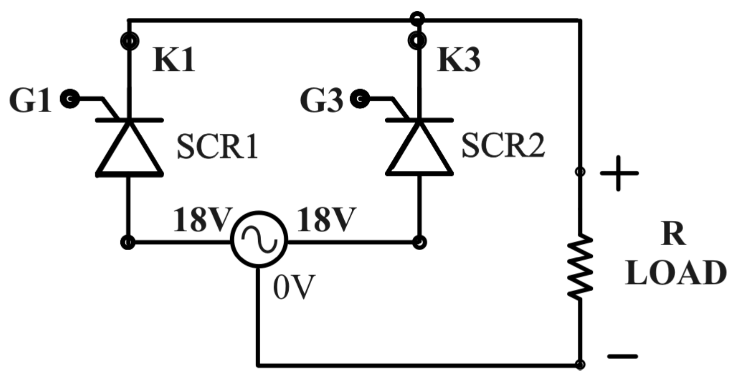


Figure 7

Procedure:

- Make sure that there should not be any connections by patch cord on the board

1. Rotate the firing control Potentiometer in full clockwise direction.
2. Switch ‘On’ the power supply
3. Measure the AC voltage (Vrms) by voltmeter between point 0V-18V and calculate Em by Em =1.414 X Vrms.
4. Switch ‘Off’ the power.
5. Connect the circuit of full wave controlled rectifier (mid-point configuration) as shown in figure 7 using 2 mm patch cords.
6. Switch ‘On’ the power supply
7. Connect the Oscilloscope and voltmeter across the load.
8. Vary the firing control Potentiometer and set on 30º, 60º, 90º, 120º and 150º firing angles using equation (11).
9. Observe the output waveforms and note the readings of voltage across load on different firing angles.
10. Connect the Oscilloscope one by one across SCR1 and SCR2 and observe the waveform when firing angle is 90º.
11. Calculate the average load current I_{DC} and power P_{DC} from measured load voltage V_o.
12. Plot the input signal, gate pulse, and drop signal across SCR and output waveforms when firing angle is 90º.

Observation Table :

S.No	Input AC Voltage		Firing Angle		Average Output Voltage Across Load		Average Load Current (I_{DC})		Average Output Power	
	In (V_{rms})	In (V_m)	In Deg.	In Time (ms)	Measured Voltage (V_o)	Calculated Voltage (V_{DC})	Measured (I_o) V_o / R_L	Calculated (I_{DC}) V_{DC} / R_L	Measured P_o V_o X I_o	Calculated (P_{DC}) V_{DC} X I_{DC}

Experiment 4

Objective:

Study of half controlled bridge rectifier (common cathode configuration) with resistive load

Equipments Needed:

1. Power Electronics board, **Scientech 2709**
2. Oscilloscope ST210 or equivalent
3. 2 mm patch cords.
4. Multimeter ST4022 or equivalent

Circuit diagram:

The circuit diagram of basic half controlled bridge rectifier (common cathode configuration) is shown in the below figure 8

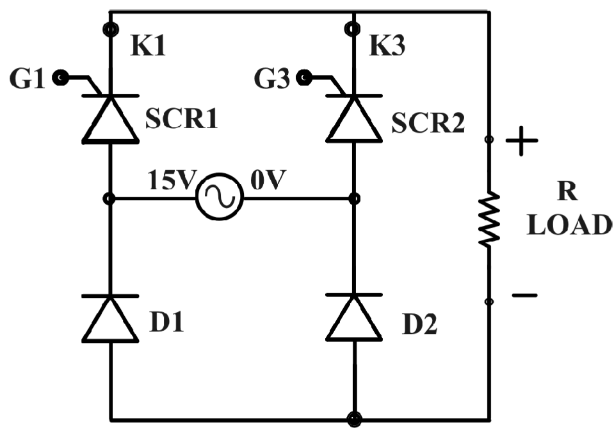


Figure 8

Procedure:

- **Make sure that there should not be any connections by patch cord on the board.**

1. Rotate the firing control Potentiometer in full clockwise direction.
2. Switch 'On' the power supply
3. Measure the AC voltage (Vrms) by voltmeter between point 0V-15V and calculate Em by Em =1.414 X Vrms.
4. Switch 'Off' the power supply
5. Connect the circuit of half controlled bridge rectifier (common cathode configuration) as shown in figure 8 using 2 mm patch cords.
6. Switch 'On' the power supply
7. Connect the Oscilloscope and voltmeter across the load.
8. Vary the firing control Potentiometer and set on 30º, 60º, 90º, 120º and 150º firing angles using equation (11).
9. Observe the output waveforms and note the readings of voltage across load on different firing angles.
10. Connect the Oscilloscope one by one across SCR1 and SCR2 and observe the waveform when firing angle is 90º.
11. Calculate the average load current I_{DC} and power P_{DC} from measured load voltage V_o.
12. Plot the input signal, gate pulse, and drop signal across SCR and output waveforms when firing angle is 90º.

[redacted]

Observation Table :

S. No.	Input AC Voltage		Firing Angle		Average Output Voltage Across Load		Average Load Current (I_{DC})		Average Output Power	
	In (V_{rms})	In (V_m)	In Deg.	In Time (ms)	Measured Voltage (V_o)	Calculated Voltage (V_{DC})	Measured (I_o) V_o / R_L	Calculated (I_{DC}) V_{DC} / R_L	Measured P_o V_o X I_o	Calculated (P_{DC}) V_{DC} X I_{DC}
[redacted]										

Experiment 5

Objective:

Study of half controlled bridge rectifier (common anode configuration) with resistive load

Equipments Needed:

1. Power Electronics board, **Scientech 2709**
2. Oscilloscope ST201 or equivalent
3. 2 mm patch cords
4. Multimeter ST4022 or equivalent

Circuit diagram:

The circuit diagram of basic half controlled bridge rectifier (common anode configuration) is shown below in the figure 9

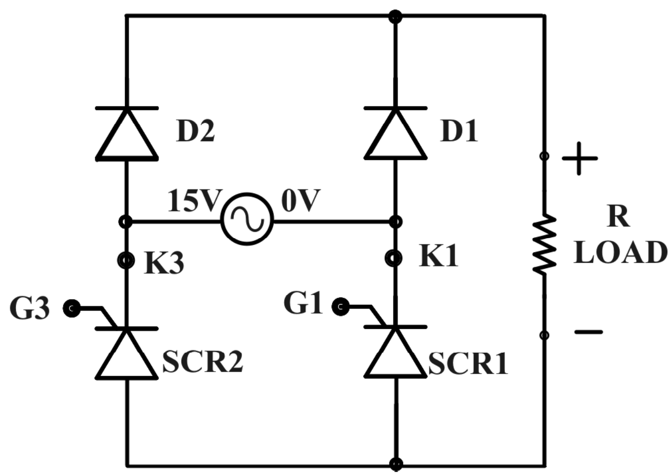


Figure 9

Procedure:

- **Make sure that there should not be any connections by patch cord on the board**

1. Rotate the firing control Potentiometer in full clockwise direction.
2. Switch 'On' the power supply
3. Measure the AC voltage (Vrms) by voltmeter between point 0V-15V and calculate Em by Em =1.414 X Vrms.
4. Switch 'Off' the power supply
5. Connect the circuit of half controlled bridge rectifier (common anode configuration) as shown in figure 9 using 2 mm patch cords.
6. Switch 'On' the power supply
7. Connect the Oscilloscope and voltmeter across the load.
8. Vary the firing control Potentiometer and set on 30º, 60º, 90º, 120ºand 150º firing angles using equation (11).
9. Observe the output waveforms and note the readings of voltage across load on different firing angles.
10. Connect the Oscilloscope one by one across SCR1 and SCR2 and observe the waveform when firing angle is 90º.
11. Calculate the average load current I_{DC} and power P_{DC} from measured load voltage V_o.
12. Plot the input signal, gate pulse, and drop signal across SCR and output waveforms when firing angle is 90º.

Observation Table :

S. No.	Input AC Voltage		Firing Angle		Average Output Voltage Across Load		Average Load Current (I_{DC})		Average Output Power	
	In (V_{rms})	In (V_m)	In Deg.	In Time (ms)	Measured Voltage (V_o)	Calculated Voltage (V_{DC})	Measured (Io) Vo / R_L	Calculated (I_{DC}) V_{DC} / R_L	Measured P_o V_o X I_o	Calculated (P_{DC}) V_{DC} X I_{DC}

Experiment 6

Objective:

Study of half controlled bridge rectifier (asymmetrical configuration) with resistive load

Equipments Needed:

1. Power Electronics board, **Scientech 2709**
2. Oscilloscope ST201 or equivalent
3. 2 mm patch cords.
4. Multimeter ST4022 or equivalent

Circuit diagram:

The circuit diagram of basic half controlled bridge rectifier (asymmetrical configuration) is shown below in the figure 10

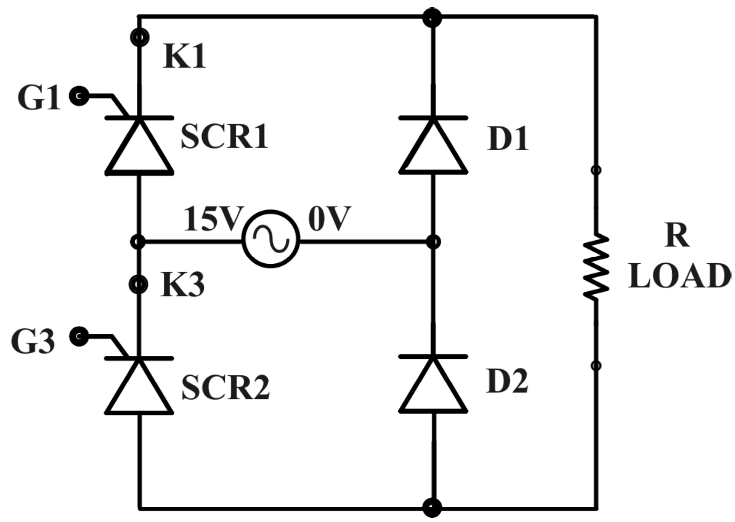


Figure 10

Procedure:

- **Make sure that there should not be any connections by patch cord on the board**

1. Rotate the firing control Potentiometer in full clockwise direction.
2. Switch ‘On’ the power supply
3. Measure the AC voltage (Vrms) by voltmeter between point 0V-15V and calculate Em by Em =1.414 X Vrms.
4. Switch ‘Off’ the power supply
5. Connect the circuit of half controlled bridge rectifier (asymmetrical configuration) as shown in figure 10 using 2 mm patch cords.
6. Switch ‘On’ the power supply
7. Connect the Oscilloscope and voltmeter across the load.
8. Vary the firing control Potentiometer and set on 30º, 60º, 90º, 120º and 150º firing angles using equation (11).
9. Observe the output waveforms and note the readings of voltage across load on different firing angle.
10. Connect the Oscilloscope one by one across SCR1 and SCR2 and observe the waveform when firing angle is 90º.
11. Calculate the average load current I_{DC} and power P_{DC} from measured load voltage V_o.
12. Plot the input signal, gate pulse, and drop signal across SCR and output waveforms when firing angle is 90º.

Observation Table :

S. No.	Input AC Voltage		Firing Angle		Average Output Voltage Across Load		Average Load Current (I_{DC})		Average Output Power	
	In (V_{rms})	In (V_m)	In Deg.	In Time (ms)	Measured Voltage (V_o)	Calculated Voltage (V_{DC})	Measured (I_o) V_o / R_L	Calculated (I_{DC}) V_{DC} / R_L	Measured Po V_o X I_o	Calculated (P_{DC}) V_{DC} X

Experiment 7

Objective:

Study of fully controlled bridge rectifier with resistive load

Equipments Needed:

1. Power Electronics board, **Scientech 2709**
2. Oscilloscope ST201 or equivalent
3. 2 mm patch cords.
4. Multimeter ST4022 or equivalent

Circuit diagram:

The circuit diagram of basic fully controlled bridge rectifier is shown in the below figure 11

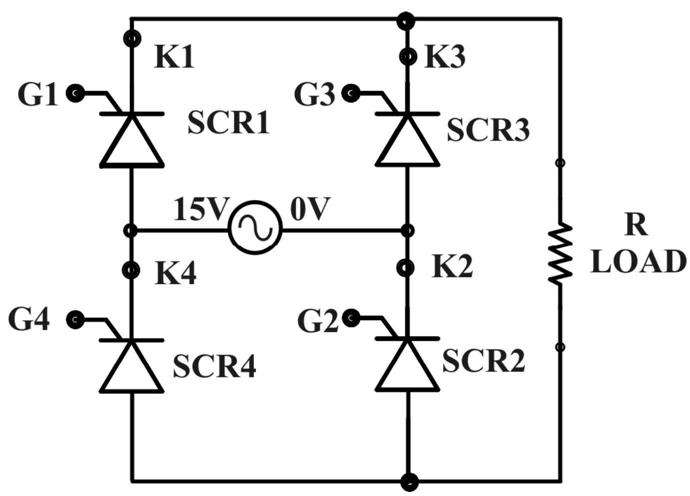


Figure 11

Procedure:

- **Make sure that there should not be any connections by patch cord on the board.**

1. Rotate the firing control Potentiometer in full clockwise direction.
2. Switch 'On' the power supply
3. Measure the AC voltage (Vrms) by voltmeter between point 0V-15V and calculate Em by Em =1.414 X Vrms.
4. Switch 'Off' the power supply
5. Connect the circuit of fully-controlled bridge rectifier as shown in figure 11 using 2 mm patch cords.
6. Switch 'On' the power supply
7. Connect the Oscilloscope and voltmeter across the load.
8. Vary the firing control Potentiometer and set on 30º, 60º, 90º, 120º and 150º firing angles using equation (11).
9. Observe the output waveforms and note the readings of voltage across load on different firing angles.
10. Connect the Oscilloscope one by one across SCR1, SCR2, and SCR3 & SCR4 and observe the waveform when firing angle is 90º respectively.
11. Calculate the average load current I_{DC} and power P_{DC} from measured load voltage V_o.
12. Plot the input signal, gate pulse, and drop signal across SCR and output waveforms when firing angle is 90º.

Observation Table :

S. No.	Input AC Voltage		Firing Angle		Average Output Voltage Across Load		Average Load Current (I_{DC})		Average Output Power	
	In (V_{rms})	In (V_m)	In Deg.	In Time (ms)	Measured Voltage (V_o)	Calculated Voltage (V_{DC})	Measured (I_o) V_o / R_L	Calculated (I_{DC}) V_{DC} / R_L	Measured P_o V_o X I_o	Calculated (P_{DC}) V_{DC} X I_{DC}

Data Sheet

NEC

THYRISTORS

2P4M, 2P5M, 2P6M

2 A(4 $A_{r.m.s.}$) PLASTIC MOLDED THYRISTOR

DESCRIPTION

The 2P4M to 2P6M are P-gate all diffused plastic molded type SCR granted average on-state current 2 Amps (T_C = 77 °C), with rated voltages up to 600 volts.

FEATURES

- Easy installation by its miniature size and thin electrode leads.
- Less holding current distribution provides free application design.
- Low cost because of mass-production.

QUALITY GRADE

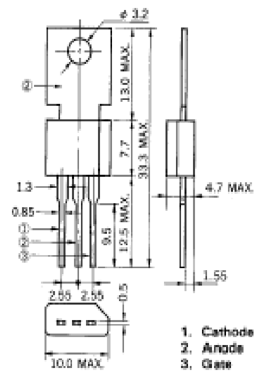
Standard

Please refer to "Quality grade on NEC Semiconductor Devices" (Document number IEI-1209) published by NEC Corporation to know the specification of quality grade on the devices and its recommended applications.

APPLICATIONS

Electric blanket, Electronic jar, Various temperature control.
Electric sewing machine, Speed control of miniature type motor.
Light display equipment, Lamp dimmer such as a display for entertainment.
Automatic gas lighter, Battery charger.
Solid state static switches etc.

PACKAGE DIMENSIONS
(in millimeters)



1. Cathode
2. Anode
3. Gate

Document No. SC-1031B
(O.D.No. SC-7523)
Date Published February 1994 M
Printed in Japan

NEC **2P4M, 2P5M, 2P6M**

ABSOLUTE MAXIMUM RATINGS (T_a = 25 °C)

CHARACTERISTIC	SYMBOL	2P4M	2P5M	2P6M	UNIT	NOTE
Non-Repetitive Peak Reverse Voltage*	V_{RSM}	500	600	700	V	R_{GK} = 1 kΩ
Non-Repetitive Peak Off-state Voltage*	V_{DSM}	500	600	700	V	R_{GK} = 1 kΩ
Repetitive Peak Reverse Voltage*	V_{RRM}	400	500	600	V	R_{GK} = 1 kΩ
Repetitive Peak Off-state Voltage*	V_{DRM}	400	500	600	V	R_{GK} = 1 kΩ
On-state Current	$I_{T(AV)}$	2 (T_c= 77 °C, θ = 180 ° Single phase (1/2 wave)			A	See Fig.3, Fig.4
Surge Non-Repetitive On-state Current	I_{TSM}	20			A	See Fig. 10
Peak Gate Power Dissipation	P_{GM}	0.5 (f ≥ 50 Hz, Duty ≤ 10 %)			W	
Average Gate Power Dissipation	$P_{G(AV)}$	0.1			W	
Peak Gate Forward Current	I_{FGM}	0.2 (f ≥ 50 Hz, Duty ≤ 10 %)			A	
Peak Gate Reverse Voltage	V_{RGM}	6			V	
Junction Temperature	T_j	−40 to + 125			°C	
Storage Temperature	T_{stg}	−55 to + 150			°C	
Weight		1.4			g	

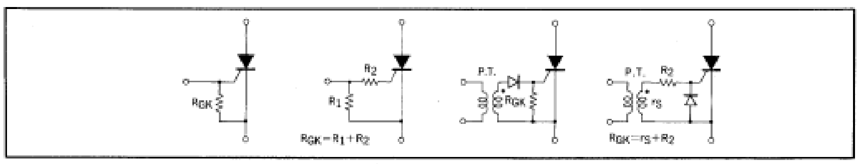
T_c: Case Temperature is measured at 1.5 mm from the neck of Tablet.

ELECTRICAL CHARACTERISTICS (T_a = 25 °C)

CHARACTERISTIC	SYMBOL	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT	NOTE
Repetitive Peak Reverse Current*	I_{RRM}	$V_{RM} = V_{RRM}$, T_j = 125 °C R_{GK} = 1 kΩ	–	–	100	μA	
Repetitive Peak Off-state Current*	I_{DRM}	$V_{DM} = V_{DRM}$, T_j = 125 °C R_{GK} =1 kΩ	–	–	100	μA	
On-state Voltage	V_{TM}	I_{TM} = 4 A	–	–	2.2	V	See Fig. 1
Gate-Trigger Current*	I_{GT}	V_{DM} = 6 V, R_L = 100 Ω R_{GK} = 1 kΩ	–	–	200	μA	See Fig. 5 Fig. 7
Gate-Trigger Voltage*	V_{GT}	V_{DM} = 6 V, R_L = 100 Ω R_{GK} = 1 kΩ	–	–	0.8	V	See Fig. 6, Fig. 8
Gate Non-Trigger Voltage*	V_{GD}	V_{DM} = 1/2 V_{DRM}, T_j = 125 °C R_{GK} = 1 kΩ	0.2	–	–	V	
Critical Rate-of-Rise of Off-state Voltage	dv/dt	V_{DM} = 2/3 V_{DRM}, T_j = 125 °C R_{GK} = 1 kΩ	10	10**	–	V/μS	** 2P5M, 2P6M
Holding Current*	I_H	V_D = 24 V, R_{GK} = 1 kΩ I_{TM} = 4 A	–	1	3	mA	See Fig. 9
Thermal Resistance	$R_{th (j-c)}$	Junction to Case	–	–	10	°C/W	See Fig. 11
	$R_{th (j-a)}$	Junction to Ambient	–	–	75		See Fig. 11

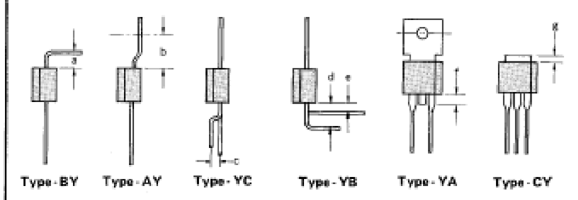
** Note: Insert a resistance less than 1 kΩ between gate and cathode, because the items indicated are guaranteed by connecting short resistance between gate and cathode (R_{GK} = 1 kΩ).

EXAMPLE OF R_{GK} INSERTION



NOTICE FOR INSTALLATION

1. Electrode leads (especially heat sink tablet) are not granted to be bent because of wet-proof. However in case it is required inevitably, a mechanical stress should not be put on mold. Fix tightly between the mold case and the area to be formed or bent.
2. Electrode leads should not to be bent more than twice over 90°. Avoid the bending within 1.5 mm from the neck of mold case.
3. Special lead and heat tab formings as indicated below are available at an additional cost.



Measurement (mm)	
a	3 ± 0.3
b	9 ± 0.2
c	2.5 ± 0.2
d	5.5 ± 0.2
e	2.5 ± 0.2
f	1.5 ± 0.3
g	1.0 ± 0.2

4. The surface of heat sink for thermal radiator is to be smooth without any foreign matter.
5. Suitable torque value is 4 to 5 kg.cm.
6. Soldering
   - ○ Recommended solder: PbSu (4 : 6) Melting point 180 °C
   - ○ Dimension from the neck of leads to dipping points . . . . 4 to 6 mm
   - ○ Soldering temperature and period
     - 250°C . . . . less than 5 s.
     - 230°C . . . . less than 10 s.

REFERENCE

Document name	Document No.
Quality control guide of semiconductor devices	MEI-1202
Assembly manual of semiconductor devices	IEI-1207