Half Bridge Controlled Rectifier using SCR and Arduino

Supriya Mane and G V V Sharma*

Contents

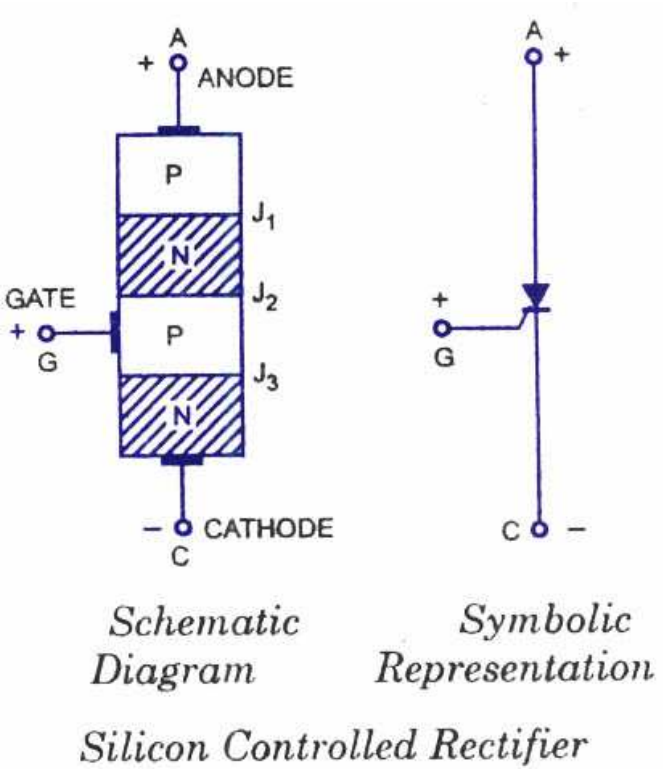
***Abstract*—This manual provides the design of a DC-DC Boost-Converter.**

1 Components

Component	Value	Quantity
Arduino uno		1
SCR-2N6509G		1
Optocoupler-PC817		2
Diode-IN4007		2
Resistor	10kΩ	1
Resistor	1kΩ	2
Resistor	200Ω	1
Resistor	10 W	1
Potentiometer	10kΩ	1
Transformer	12-0-12	1
Breadboard		1
Jumper Wire		20

2 Circuit Operation

The SCR (thyristor) is a three-terminal device (Anode, Cathode and Gate) with four layers of alternating p- and n-type material. The gate terminal is used to control the SCR, the anode (A) and cathode (K) are connected in series with the load. The SCR is just a controlled diode. The Thyristor and transistor analogy of SCR is shown in Fig. 1 and Fig. 2.



3 Working

In single-phase half-wave rectifier, only one thyristor is used to control the load voltage. The thyristor will conduct (ON state) when the voltage V_t is positive ($V_t > 0$) and a firing current pulse I_g is applied to the gate terminal. Delaying the firing pulse by an angle 'α' does the control of the load voltage. In the figure below the angle 'α' is measured from the zero crossing point of the supply voltage V_s .

The load is resistive and therefore current i_d has the

*The author is with the Department of Electrical Engineering, Indian Institute of Technology, Hyderabad 502285 India e-mail: gadepall@iith.ac.in.

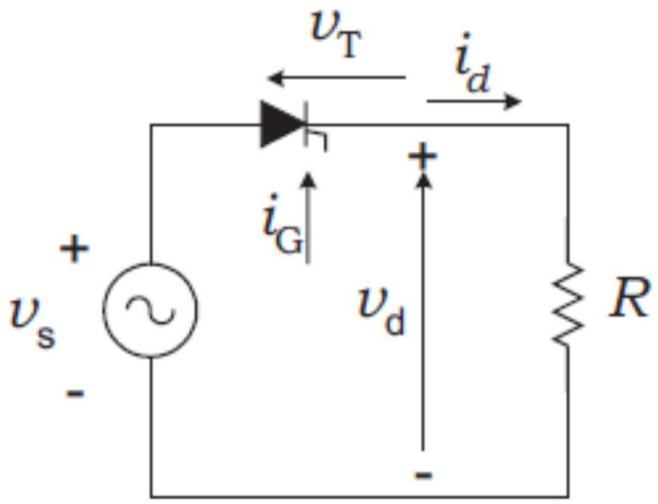


Fig. 1: Operation of Thyristor

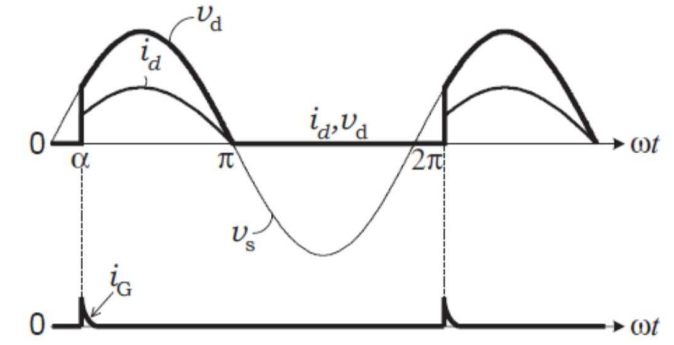


Fig. 2: Transistor Analogy

same waveform as the load voltage. The thyristor goes to the non-conducting condition (OFF state) when the load voltage and, consequently, the current try to reach a negative value.

4 Connections

1) All grounded terminals are connected together.
2) In the circuit there are two optocouplers, optocoupler-1 to detect the zero crossing of the AC voltage signal and optocoupler-2 for firing the SCR.
3) The optocouplers are used to isolate the Arduino (control circuit) from the power circuit.
4) Diodes D1 and D2 are with the same type (1N4007), D1 is used to protect optocoupler-1 from reverse voltage and D2 to feed the SCR gate with positive current.
5) Optocoupler-1 collector pin is connected to Arduino pin 2 which is external interrupt pin, so optocoupler-1 interrupts the Arduino when there is a zero crossing event(when the AC signal goes from positive to negative).
6) When the AC voltage is positive, optocoupler-1 is ON and therefore the collector pin is connected to ground.
7) Here we used the 10kΩ resistor as pull-up resistor for Arduino pin 2 because we've an open collector output (optocoupler-1).
8) The 10k ohm potentiometer is used to control firing angle.
9) We got the 12V AC (50Hz) using a step down transformer (220V to 12V).

5 Calculation

Let, the input voltage v_i be a sinusoidal voltage of amplitude Vm and frequency f Hz and let be given by,

$$V_i = V_m \sin \omega t = V_m \sin \theta \tag{5.0.1}$$

Where ω is the angular frequency in radians/second and equals $2\,\pi f$.

Let, α be the firing angle i.e. the angle at which conducting begins. The SCR conducts from α to π radians during the positive half cycle and does not conduct during the negative half cycle.

Then the average output voltage V_{av} is given by,

Eqn. 5.0.2shows integration

$$V_{av} = \frac{1}{2\pi}\int_{\alpha}^{pi} V_m \sin\theta d\theta = \frac{V_m}{2\pi}(1+\cos\alpha) \tag{5.0.2}$$

Average current is given by:-

$$I_{av} = \frac{V_{av}}{RL} = \frac{V_m}{2\pi RL}(1+\cos\alpha) \tag{5.0.3}$$

Thus as α increases from 0 to $\frac{\pi}{2}$ radians, $(1+\cos\alpha)$ reduces and I_{av} reduces. Hence, by varying resistor R. we may control the gate current, control the firing angle and hence control V_{av} and I_{av}.

Problem 5.1. Program the Arduino to generate the output voltage and the zero crossing detector to know the function of SCR.

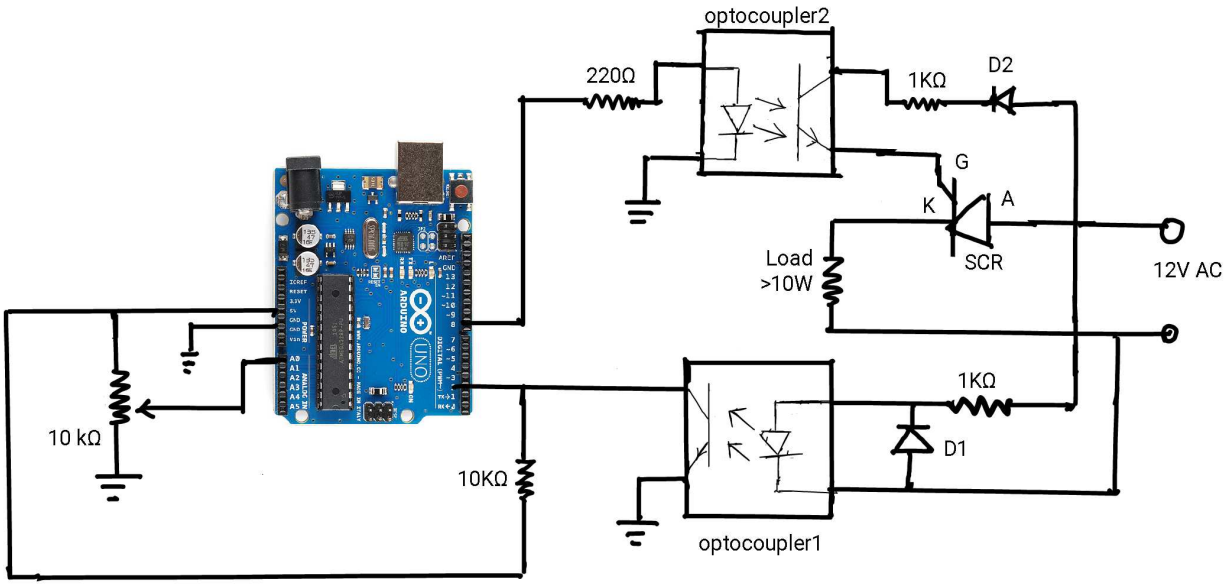


Fig. 3: Circuit Operation