AIM 10/6/15.

E 4532: Power Electronics & Drives
Tutorial 1, Diode & Thyristor (devices) characteristics

1.1 A power diode is carrying a forward current of 35 A. Under the influence of the external circuit, this current turns off at a constant rate of 15 A/μs to a peak reverse current I_{rr} of 22 A. The reverse current subsequently recovers to zero with a softness factor of 0.6 while the diode is eventually reverse biased at 40 V.

(a) Sketch the diode current and voltage for the situation described.
(b) Compute the reverse recovery time t_{rr}, and the reverse recovery charge Q_{rr}

[t_{rr} =2.35μs , Q_{rr} =25.85μC]

1.2 To share a high imposed voltage of 5kV, two diodes are connected in series as shown in the figure for series connection of your lecture note. The reverse leakage currents of the two respective diodes D1 & D2 are, I_{S1}= 30mA, and I_{S2}=35mA. Find:

a) Diode voltages, if the voltage sharing resistances are equal R_1= R_2 =R = 100kΩ.

b) The voltage sharing resistances R_1, R_2, if the diode voltages are equal.

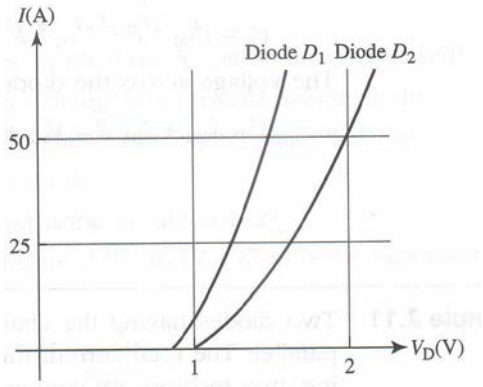
[Ans: 2750V, 2250V, R_1=100kΩ, R_2=125kΩ]

1.3 In order to balance the diode currents in two parallel branches under steady state condition, two resistors are connected as shown in your lecture note Fig. for parallel connection. The V-I characteristics of the two diodes are given in the adjacent Fig. The total current (i) through both the diodes is 50A. Find:

a) The resistances of the current sharing resistors so that the current in any diode is no more than 55% of total current.

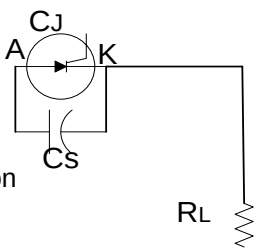
b) The total power loss in the resistors

c) The voltage across the diode-resistor combination



[Ans: R=0.06Ω, 75.8 W, 2.95V]

1.4 A capacitor (C_S) is connected across a Diode/thyristor switch to increase its effective dv/dt rating. The junction capacitance of the Diode/thyristor (C_J) is 15pF. The limiting value of the charging current to turn the thyristor on is 15mA. The critical dv/dt of the thyristor is 200 V/μS. Determine the minimum value of the capacitance (C_S) so that the thyristor wont be turned on due to the imposed dv/dt.



[Ans=60pF]

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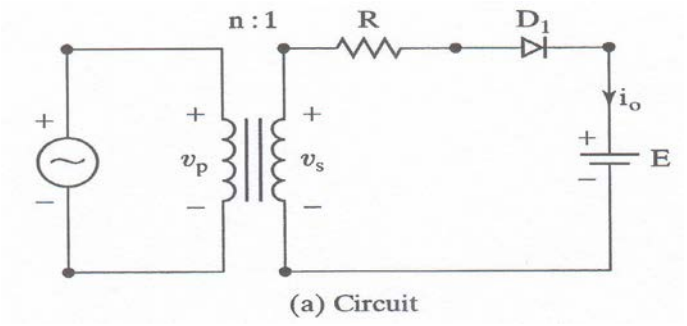
E 4532: Power Electronics & Drives
Tutorial 2, Diode Circuits and characteristics

2.1 The battery voltage of the battery charger circuit shown below is E=12V and its capacity is 100Wh.The average charging current I_{dc}= 5A. The primary input voltage is V_P= 120V, 60Hz, and the transformer has a turns ratio of n=2:1. Calculate:

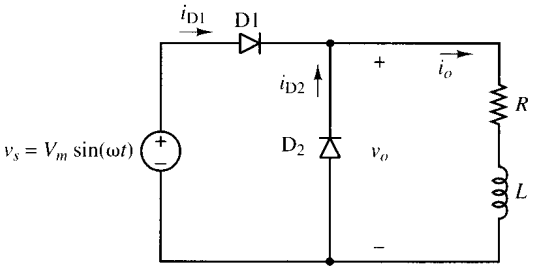
a) The diode conduction angle, δ
b) The current limiting resistance, R
c) The power rating P_R of R
d) The charging time in hours
e) The rectifier efficiency
f) The diode peak inverse voltage



(a) Circuit

[Ans. 163.74^0, 4.26 Ω, 286.4W, 1.66Hr, 17.3%, 96.85V]

2.2 The adjacent Fig. illustrates a single phase diode rectifier with a free-wheeling diode. Sketch:
(a) Its equivalent circuits during the positive and negative cycles of the input voltage
(b) The output voltage and current and the diode currents
(c) Calculate the average output voltage and current and the average diode current if v_m= 100V, R=2 Ω.

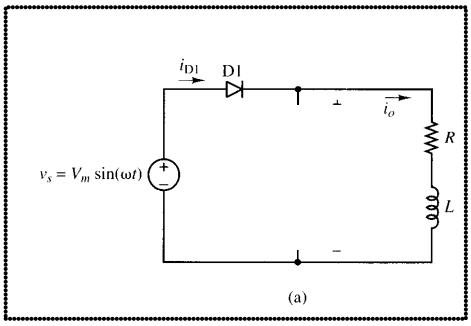


(a)

[Ans: 31.8V, 15.9A, 7.95A]

2.3 A power diode is connected between a 230V rms 50Hz supply and a resistive load as shown in the adjacent Fig.. The resistor has a value of 10Ω. A large inductor is added in series with the resistor. Sketch:

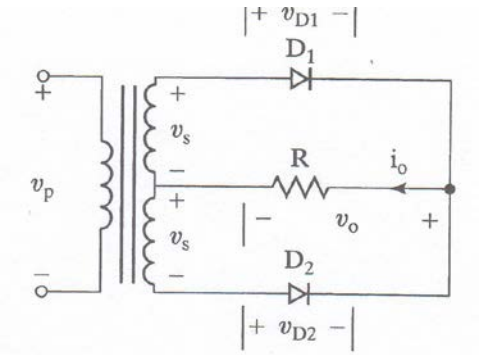
- Steady state converter input and output voltage and current waveforms.
- Compare the waveforms with those of an RL load connected to an ac source.
- If capacitor is connected in parallel with the load, sketch the current waveform through the diode along with the output voltage waveforms.



(a)

2.4 The single phase full wave diode rectifier shown in the adjacent figure has a purely resistive load. Find:

a) The efficiency
b) The RF
c) The TUF
d) Diode PIV
e) The PF



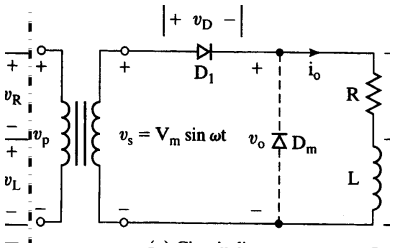
[Ans: 81%, 48.2%, 57.3%, 2V,0.707]

E 4532: Power Electronics & Drives
Tutorial 3, Diode Rectifiers & Characteristics

3.1 The single phase half wave rectifier shown in the adjacent Fig. has a freewheeling diode and an average ripple free load current of Io_ave.

(a) Draw the waveforms of the currents in D1, Dm and also the transformer primary.

(b) Determine the rectifier input **PF** and the **THD** of the input current under a unity transformer turns ratio.

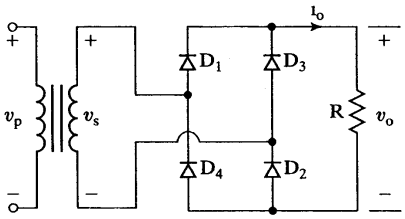


[Ans: (b) 0.63, 1.21]

3.2 The single phase full bridge diode rectifier shown in the adjoining Fig. is required to supply an average load voltage Vd=400V to a load resistance R=10Ω.

(a) Sketch the load voltage/current and the voltage across the diodes. How would the waveforms change if the load becomes highly inductive?

(b) Determine the voltage/current ratings of the diodes and also the supply transformer.



[Ans: 444V, 44. 4A, 19.74kVA]

3.3 A three phase bridge rectifier has an R-L load and the Supply is wye connected voltage source with V_m = 311 V, frequency, f = 50 Hz, and the per phase line inductance is 5mH. The load resistance Is 50 Ohms and inductance is 100mH.

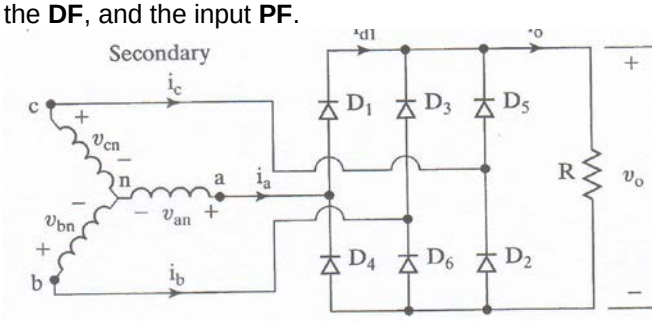
(a) Calculate the reduction of rectifier output voltage due to the effect of line inductances.

(b) Draw & show the magnitudes of the load V & I waveforms when the rectifier load is ;
(I) purely resistive,
(ii) Highly inductive.

(c) Sketch the rectifier input current waveform when the;
(I) Line inductance is present,
(ii) Line inductance is absent.

[Ans: (a) about 3% reduction]

3.4 The load current of a three phase diode rectifier as shown In the Fig. below is continuous with negligible ripple content. Express the rectifier input current in Fourier series and determine the **THD** of the input current, the **DF**, and the input **PF**.



[Ans: [THD=31%, DF=1, PF=0.95]

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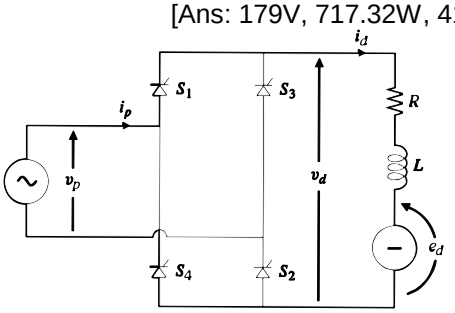
E 4532: Power Electronics & Drives
Tutorial 4, Single Phase Thyristor Rectifiers & Characteristics

4.1 A single-phase fully controlled bridge rectifier as shown in next Fig. is used to obtain a regulated dc output voltage. The rms input voltage is 230V, and the delay angle α is 30^0, yielding an output current of 4A.

(a) Sketch the input voltage and current showing their relative positions. Also show the fundamental component of the input current.

(b) Calculate the dc output voltage and the active and reactive input power at fundamental frequency, under e_D=0.

[Ans: 179V, 717.32W, 414.15VA]



4.2 The bridge rectifier shown above is connected to a 230 V rms 50 Hz supply is used to charge a rechargeable battery bank of 40 V with an internal resistance of 0.45Ω. A **large inductance** is connected in series with the battery to suppress current ripples.

(a) Draw a circuit diagram to illustrate the above arrangement

(b) Determine the required firing angle for a charging current of 16 A

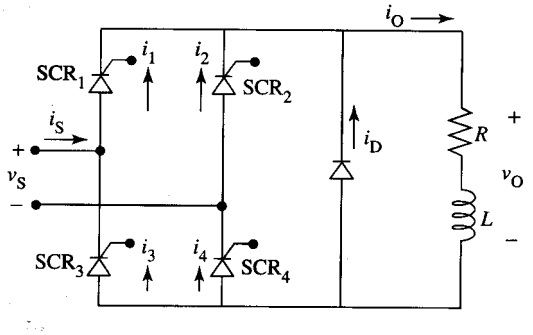
(c) Sketch the supply voltage, supply current, load voltage and load current waveforms

(d) What is the rectifier input power factor?

[Ans.: α=76.8^0, PF=0.21]

4.3 A full-wave bridge rectifier with a freewheeling diode shown in the adjacent Fig. supplies an RL load. The source voltage is 120V rms, and the resistive portion of the load is 10Ω. Sketch the input/output voltage/current waveforms (i_S, v_O , i_O , i_D). If the delay angle α = 30^0.

a) find the average load voltage , b) the average & rms load current, (c) Power to the load.



[Ans: (a) 100.9V(b) 10.1A, (c) 1018W]

4.4 A Single phase full converter shown above is supplied from a 120V 60 Hz supply. The load current with an average value of I_a is continuous and ripple free. Transformer turns ration is unity. Converter delay angle $\alpha = \pi/3$. Calculate:

(a) Input current harmonic factor (THD)

(b) Input current Displacement factor (DF)

(c) Rectifier input power factor (PF) [Ans: 48.3%, 0, 0.45 lagging]

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E 4532: Power Electronics & Drives
Tutorial 5, Three Phase Controlled & PWM Rectifiers

5.1 A three-phase half-wave converter presented in your lecture note is operated from a three-phase Y-connected 220-V, 60-Hz supply and the load resistance is R = 10Ω. If it is required to obtain an average output voltage of 25% of the maximum possible output voltage, calculate:

(a) the Delay angle,
(b) the Rms and average output currents,
(c) the Average and rms thyristor currents,
(e) the **TUF**, and
(f) the input **PF**

[Ans: 94.5^0, 3.71A, 6.21A, 1.24A 3.59A, 1.24A, 10%, 0.2822 lagging]

5.2 A three phase full-converter described in your lecture note is supplied from a three phase wye connected 220V, 60 Hz supply and the load resistance of 10Ω. If the average output voltage is 25% of the maximum possible output voltage; Calculate:

(a) Converter delay angle (α)
(b) **Average & RMS** output currents
(c) **Average and rms** thyrsitor currents
(e) Transformer utilization factor
(f) Converter input power factor

[Ans: 75.5^0, 11.56A, 6.67A, 0.1533, 0.3717 lagging]

5.3 The single-phase ac-dc converter described in your lecture note is operated with **uniform PWM** control, and the supply is Vs= 220V rms. There are two pulses per half cycle and the pulses are positioned symmetrically with respect to quarter wave and are detailed as follows:
$\alpha_1=30^0$, $\delta_1= 30^0$.

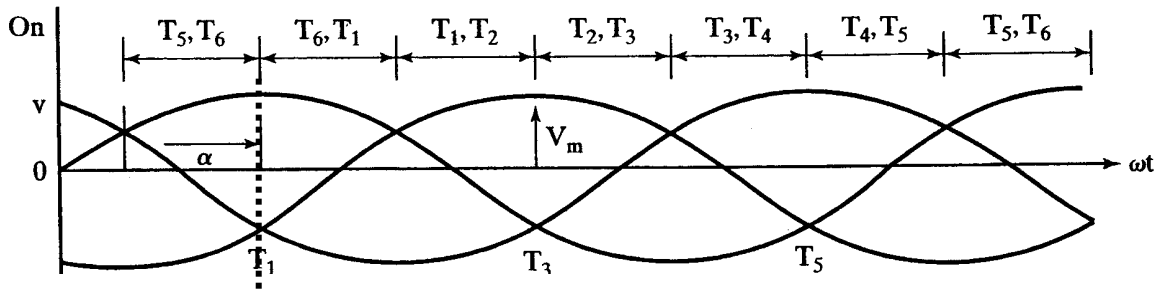
Draw the pulse positions. Calculate:

(a) Average output voltage V_{dc}

[Ans. 72.4V]

Instead of uniform PWM, if you are asked to employ sinusoidal PWM, explain the necessary changes, and how would you approach to solve.

5.4 The latching current of thyristors of the three-phase full-converter described in your lecture note is I_H=200mA, and the delay time t_D=2.5μS (refer to thyristor turn-on Fig.). The converter is supplied from a three phase wye connected rms line to line voltage of 208V, 60 Hz supply as shown below, and has a load of R=2Ω , L=8mH. The converter operates under a delay angle $\alpha=60^0$. Determine the **minimum gate pulse** required to turn the thyristors on.



α=60⁰, Thyristor fired here

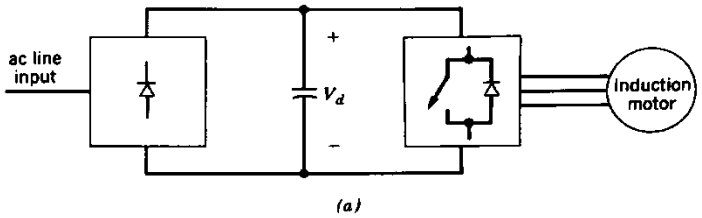
[Ans: 7.39μS]

EE4532, Part B
Tut-6
Drives

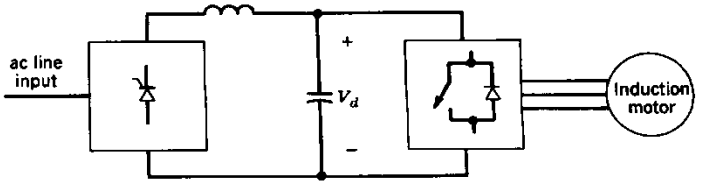
1) A 240-V, 50-Hz, 4-pole, 3-phase induction motor has a full load speed of 1425 rpm. Calculate (a) its synchronous speed (b) the slip, and (c) the rotor frequency.

2) Using the Motor Torque vs. Speed characteristic, establish the importance of v/f characteristic of Induction motors.

3) The adjacent schematic shows Converters for Driving Induction Motor which include a front-end rectifier, dc link filter and DC-AC inverter. List the advantages disadvantages of both the topologies in terms of:

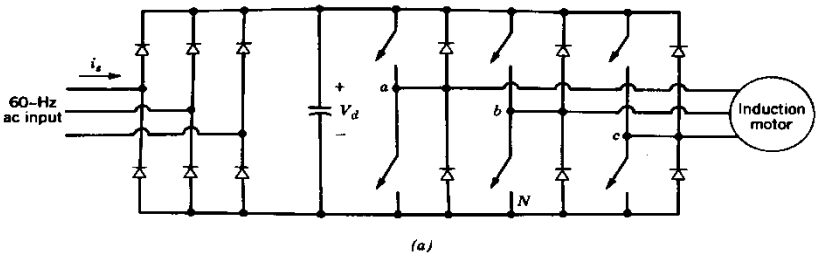


(a)

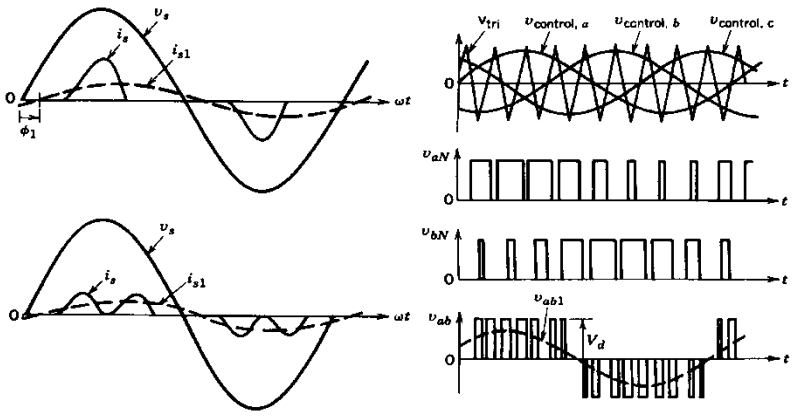


   a) Input Power Factor
   b) Flexibility of Power Flow
   c) Instantaneous Motor Torque/speed control
   d) Input Current THD

4) The following Fig Presents the Schematic for an AC motor drive applying the PWM Inverter. Tabulate the advantages disadvantages of both the topologies in terms of:



(a)



   1. Input Power Factor
   2. Flexibility of Power Flow
   3. Instantaneous Motor Torque/speed control
   4. Input Current THD