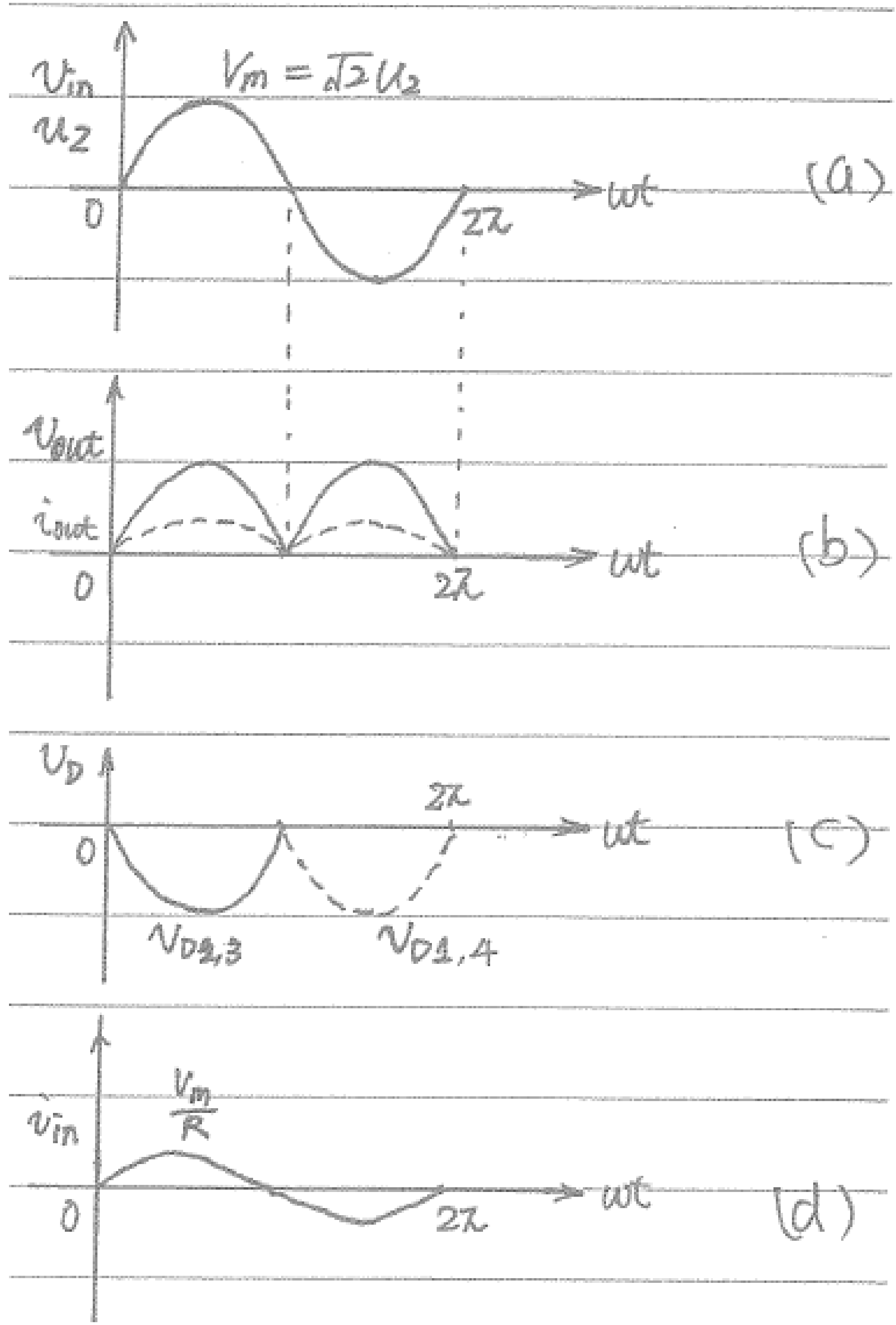
EEE213 Power Electronics and Electromechanism

Tutorial 1

Problem 2.1

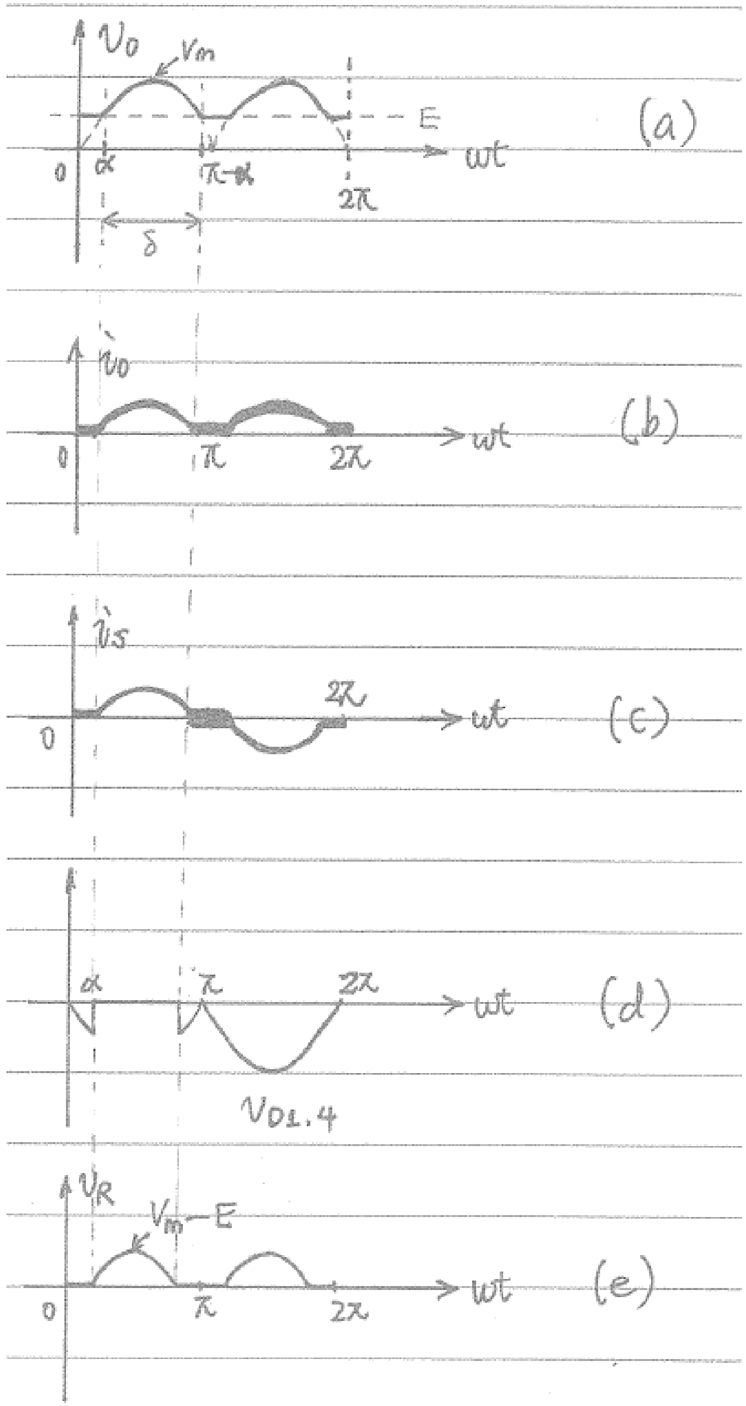
- A single-phase bridge rectifier is required to supply an average voltage of 110V to a resistive load R=10 Ω. The main supply is 220V RMS. Determine
  - 1)The rms value of the input voltage for the rectifier and then the turns ratio of the transformer;
  - 2)The voltage and current ratings of the diodes;
  - 3)The power rating of the transformer;
  - 4)The power consumed by the load;
  - 5)The THD of the line current.



v_{in}
u_2
$V_m = \sqrt{2}U_2$
0
2π
ωt
(a)
v_{out}
i_{out}
0
2π
ωt
(b)
V_D
0
2π
ωt
$v_{D2,3}$
$v_{D1,4}$
(c)
i_{in}
$\frac{V_m}{R}$
0
2π
ωt
(d)

Problem 2.2

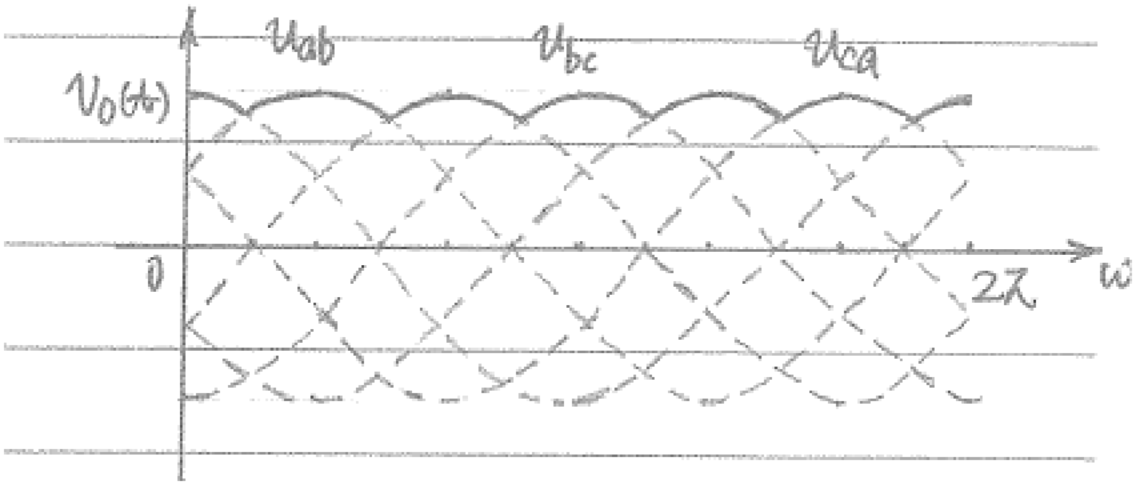
- A battery charger is supplied by a single-phase bridge rectifier. The battery voltage is E=20V and the capacity is 10Ah. The current-limiting resistor is 10ohm. The input voltage is 30V RMS. Draw the waveforms and then calculate
  - 1)The conduction angle of a diode;
  - 2)The average charging current;
  - 3)The charging time;
  - 4)The power dissipated on R;
  - 5)The peak reverse voltage across a diode.



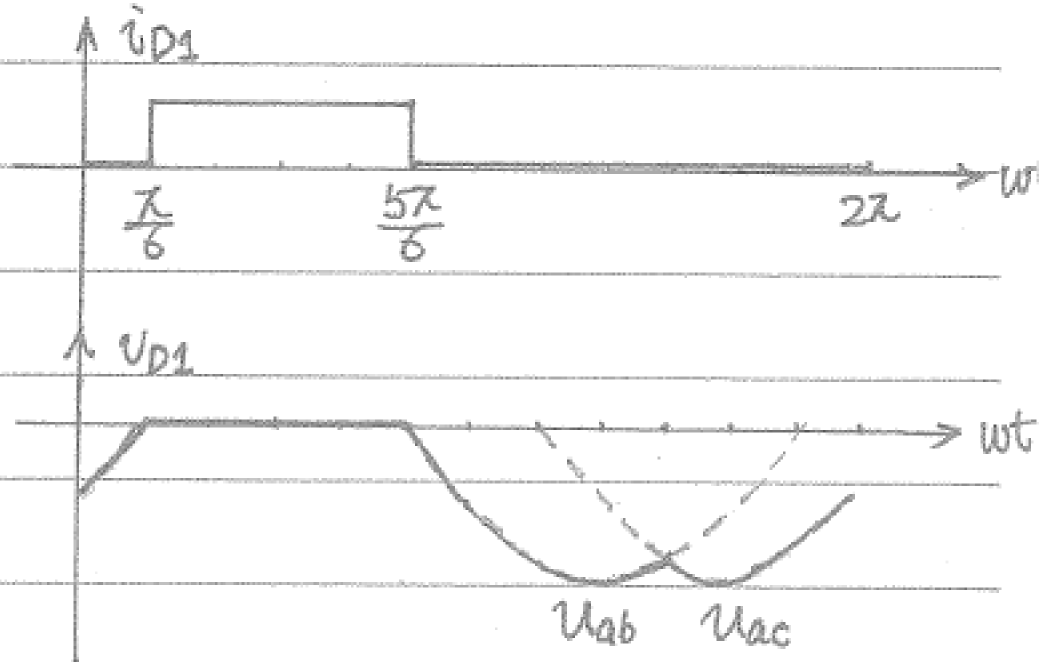
vo
Vm
E
ωt
(a)
0
α
π-α
2π
δ
io
π
(b)
is
(c)
(d)
vD1,4
vR
Vm-E
(e)

Problem 3.1

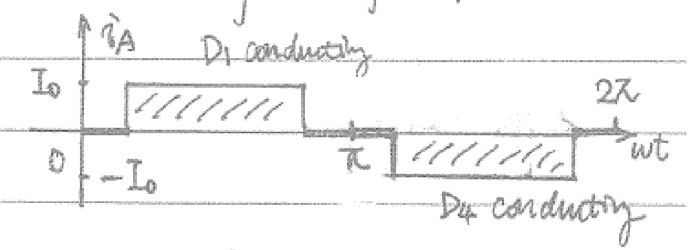
- A three-phase bridge rectifier supplies a ripple-free current I_0=10A and an average voltage V_0=110V to the load. Assume $v_A=V_m\sin\omega t$.
  – 1)Determine the rms value of the phase voltage;
  – 2)Draw the current and voltage waveforms for D1, D3, D5;
  – 3)Draw the current waveform for phase A and determine the rms value;
  – 4)Determine the diode ratings.



2)

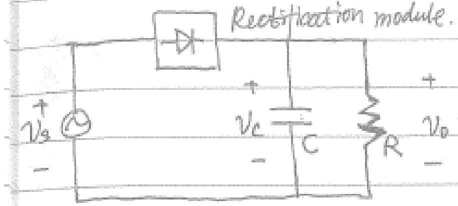


3). Current waveform for phase A:



Problem 3.2

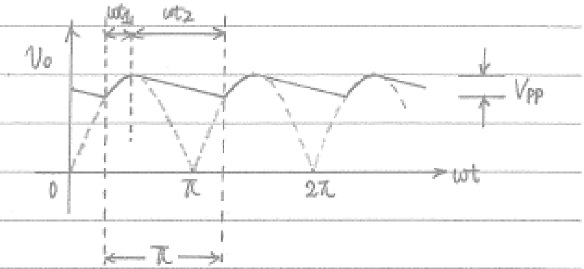
- The single phase bridge rectifier is supplied from a 120V, 60Hz source. The load resistance is R=500ohm.
  - a) Design a capacitive filter so that the ripple factor of the output voltage is less than 5%;
  - b) With the value of capacitor C in part a), calculate the average load voltage V_{dc}.



Single phase, bridge, rectification.

$V_s = 120V$. $f = 60Hz$.

$R = 500\Omega$.



First, analyse the discharge procedure.

$t_1 \longrightarrow t_1 + t_2$

$* \quad t_1 + t_2 = T/2.$

$\omega t_1 + \omega t_2 = \pi.$

$$\frac{1}{C}\int i_o(t)dt + v_c(t_1) + R\, i_o(t) = 0$$

$$\Rightarrow i_o(t) = \frac{v_c(t_1)}{R} e^{-\frac{t-t_1}{RC}}$$

$v_c(t_1) = V_m$, the peak voltage.

$$\Rightarrow v_o(t) = i_o(t)\cdot R$$

$$= V_m e^{-\Delta t/RC}. \quad (\Delta t = t - t_1)$$

The peak-to-peak ripple is

$$V_{pp} = V_o(t_1) - V_o(t_1+t_2)$$

$$= V_m(1 - e^{-\frac{t_2}{RC}})$$

Based on the power series of e^{-x}

$$e^{-x} \approx 1 - x$$

$$\Rightarrow V_{pp} = V_m \cdot \frac{t_2}{RC}$$

Assume the capacitor is large enough, then $t_1 \to 0$, $t_2 \to T/2$.

So $V_{pp} \approx V_m \cdot \frac{T/2}{RC} = \frac{V_m}{2fRC}$

$$V_{dc} = V_m - \frac{V_{pp}}{2}.$$

$$V_{ac} \approx \frac{1}{\sqrt{2}} V_{pp}$$

$$\Rightarrow f_R = \frac{V_{ac}}{V_{dc}} = \frac{\frac{1}{\sqrt{2}} \cdot \frac{V_m}{2fRC}}{(4fRC - 1)\cdot \frac{V_m}{2fRC}} = 5$$

$\Rightarrow C = 126.2\mu F.$

2). With $C = 126.2\mu F$.

$$V_{dc} = V_m\left(1 - \frac{1}{4fRC}\right)$$

$$= 158.5V.$$