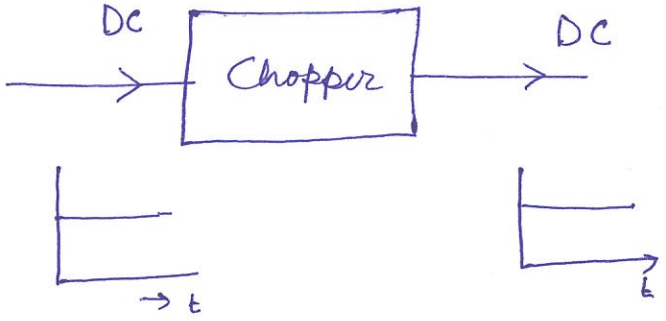
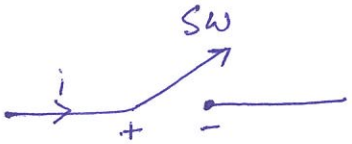
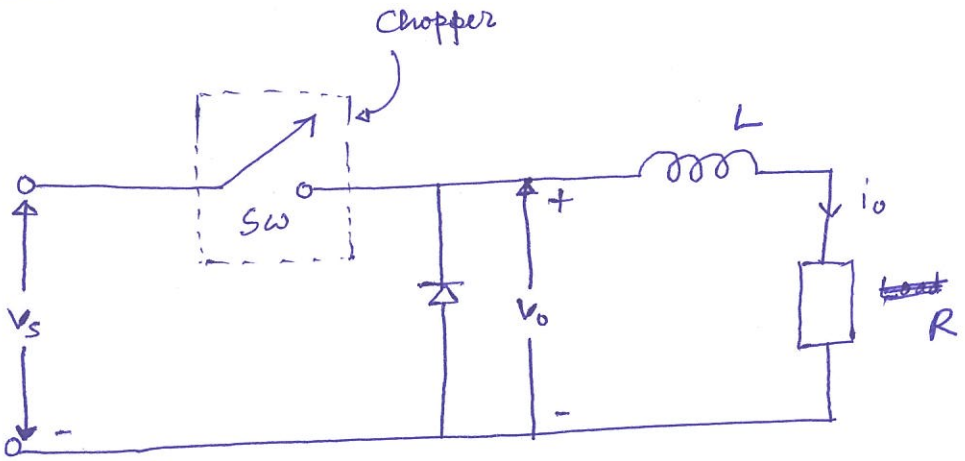
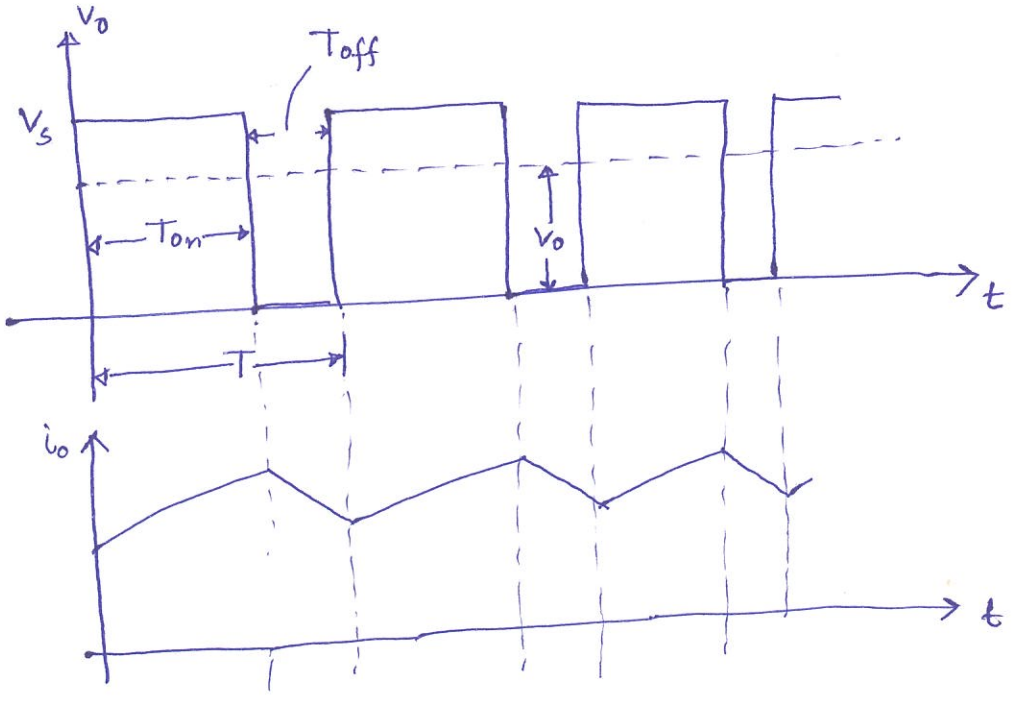
DC-DC Converters (Choppers)





Step down Chopper: (Buck Converter)





$$V_0 = \frac{T_{on}}{T_{on} + T_{off}} V_s = \frac{T_{on}}{T} V_s = \alpha V_s$$

T_{on} = on-time T_{off} = off-time

$T = T_{on} + T_{off}$ = chopping period

$\alpha = \frac{T_{ON}}{T}$ = duty cycle

$V_0 = f \cdot T_{ON} \cdot V_s$ $f = \frac{1}{T}$ = chopping frequency

Control Strategy:

Constant frequency System:

T_{ON} is varied but f is kept constant.

↓

adjustment of pulse width → pulse-width-modulation (PWM)

Variable frequency System

Chopping frequency f is varied.

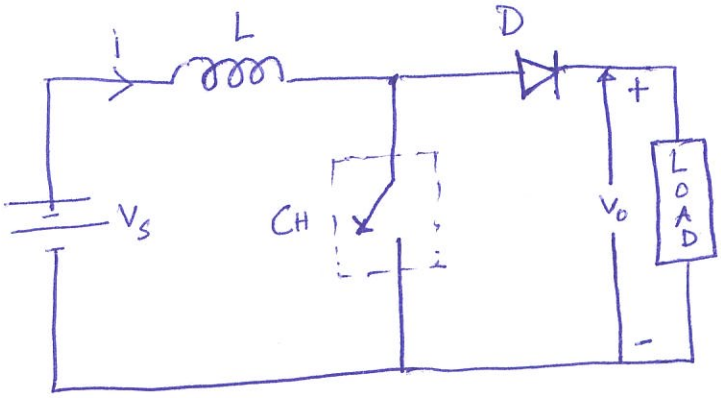
Or
- T_{ON} is kept constant
- T_{off} " " "

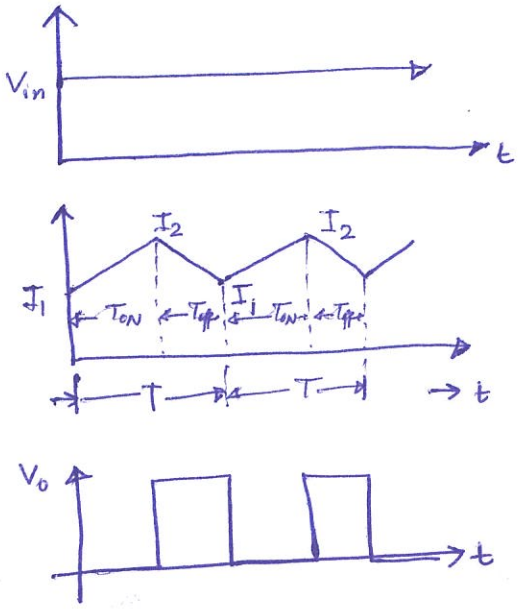
→ frequency modulation.

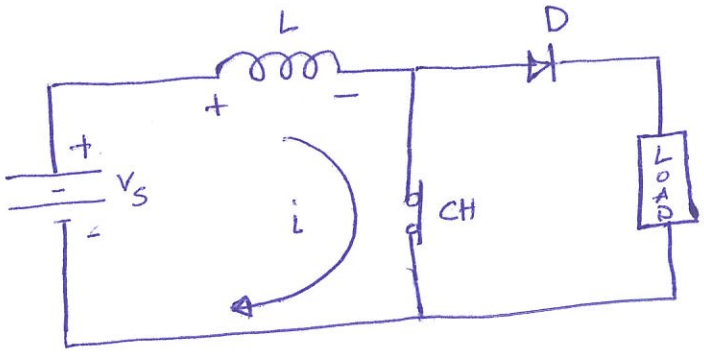
PWM Vs FM

- Filter design is difficult
- Possibility of interference with signalling and telephone lines.
- Large off-time in frequency modulation scheme may make the load current discontinuous which is undesirable.

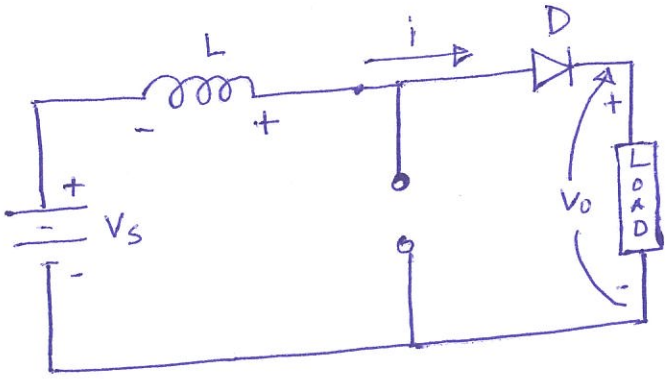
Step-up Choppers:







$\rightarrow \begin{cases} V_L = V_s \\ V_o = 0 \end{cases}$



$\rightarrow \begin{cases} V_L = V_o - V_s \\ V_o = V_s + L\left(\frac{di}{dt}\right) \end{cases}$

Assuming linear variation of output current, the energy input to the inductor from the source, during the period T_{on} is

$$W_{in} = (\text{Voltage across } L) \cdot (\text{average current through } L)\ T_{on}$$

$$= V_s \left(\frac{I_1 + I_2}{2}\right) T_{ON}$$

During the time T_{off}, the chopper is off, the energy released by inductor to the load is

$$W_{off} = (\text{Voltage across } L)\ (\text{average current through } L)\ T_{off}$$

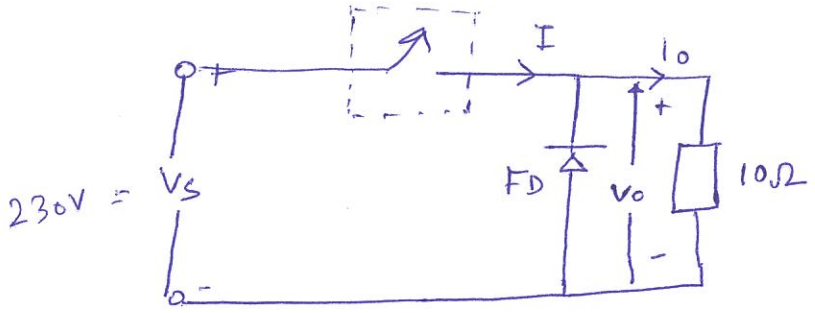
$$= (V_o - V_s) \left(\frac{I_1 + I_2}{2}\right) T_{off}$$

Considering the system to be lossless,

$$V_S\left(\frac{I_1+I_2}{2}\right)T_{ON} = (V_o - V_S)\left(\frac{I_1+I_2}{2}\right)T_{off}$$

$$V_o = V_S \frac{T}{T-T_{ON}} = V_S \frac{1}{1-\alpha}$$

Q.



Consider voltage drop of 2V across chopper when it is on, for a duty cycle of 0.4, Calculate

(a) average and rms values of output voltage

(b) chopper efficiency

Q. A step-up chopper has input voltage of 220V and output voltage of 660V. If the non-conducting time of thyristor-chopper is 100μs, compute the pulse width of output voltage.

In case pulse width is halved for constant frequency operation, find the new output voltage.