Power Converters

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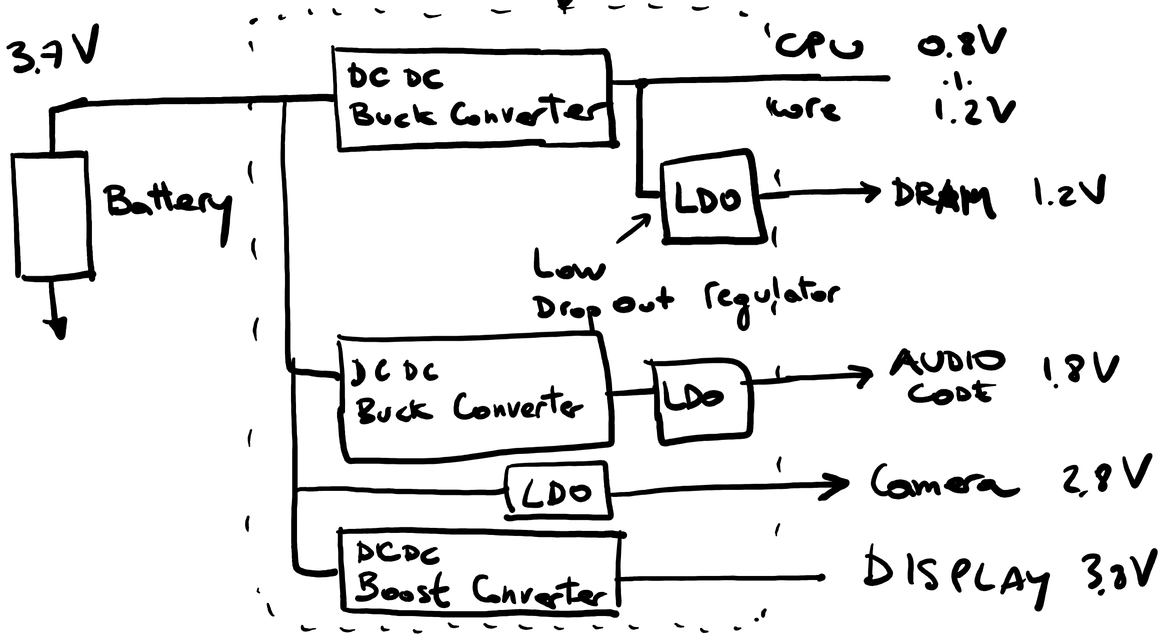
- Power delivery network

1 PMIC

"Power Management IC"



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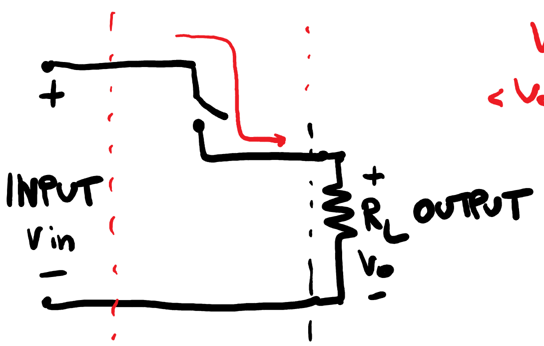
Buck Converter

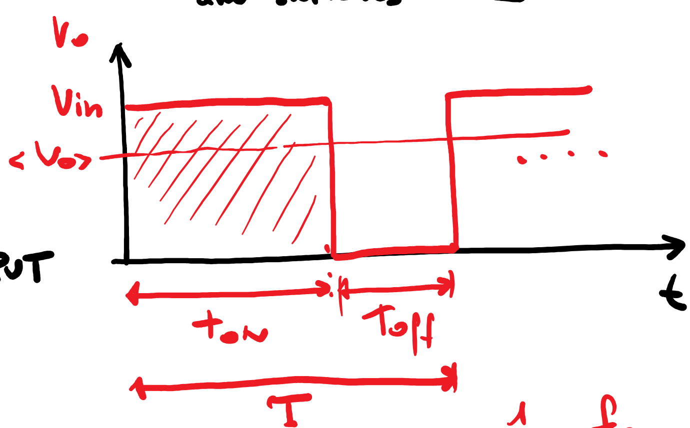
(Step Down)

[Switching Regulator]

only reactive elements L, C

and switches





$$\langle V_o \rangle = V_{in} \frac{T_{on}}{T} = D$$

$$\frac{1}{T} = f_s$$

switching frequency

BUCK CONVERTER

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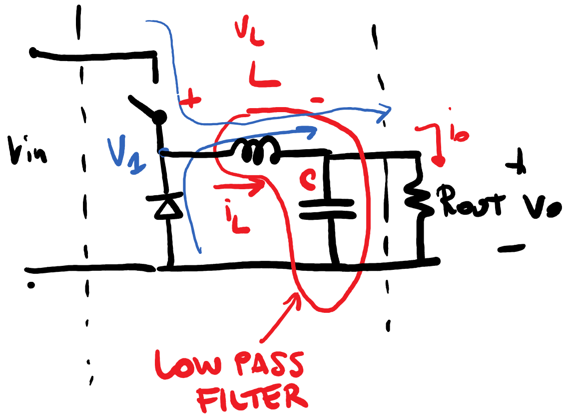
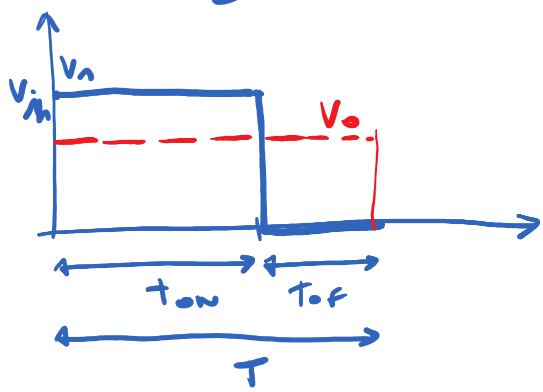


$$\langle V_o \rangle = \underbrace{\frac{T_{on}}{T}}_{D} V_{in} = V_o$$



$$f_s \gg f_c = \frac{1}{2\pi\sqrt{LC}}$$

cut off frequency

$$V_L = L \frac{di_L}{dt}$$

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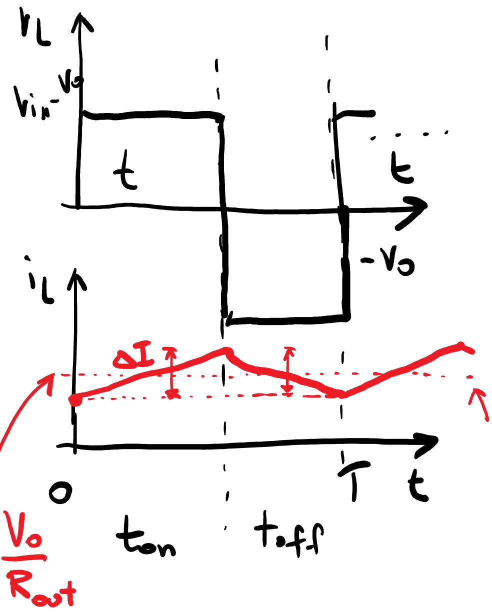
$$T_{on}: \quad V_L = V_{in} - V_o \Rightarrow \frac{di_L}{dt} = \frac{V_L}{L} = \frac{V_{in} - V_o}{L}$$

$$T_{off}: \quad V_L = -V_o \rightarrow \frac{di_L}{dt} = \frac{V_L}{L} = \frac{-V_o}{L}$$

$$\underbrace{\frac{V_{in} - V_o}{\cancel{L}} \cdot T_{on}}_{\Delta I} = +\frac{V_o}{L} t_{off} = \frac{V_o}{\cancel{L}}(T - T_{on})$$

$$\boxed{V_o = \frac{T_{on}}{T} V_{in}}$$



Limit of continuous conduction

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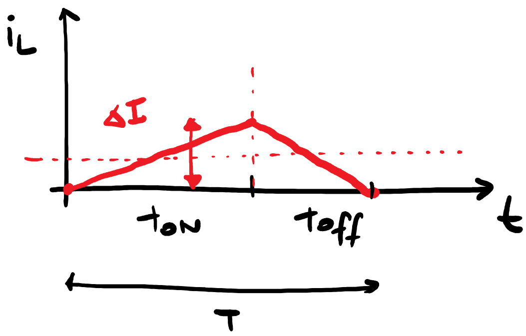


in the limit

$$\Delta I = 2 i_o$$

$$\frac{V_{in} - V_o}{L} t_{on} = 2 i_o \qquad t_{on} = DT$$

$$V_o = \frac{t_{on}}{T} V_{in} \qquad \frac{t_{on}}{T} = D$$

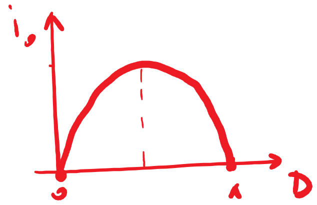
$$\frac{V_{in}(1-D)DT}{L} = 2 i_o$$

current at the limit of continuous conduction

$$\rightarrow i_o = \frac{V_{in} T}{2L} D(1-D)$$

$$i_o = i_{o\,max} \, 4D(1-D)$$

$$i_{o\,max} = \frac{V_{in} T}{8L}$$



Discontinuous conduction

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