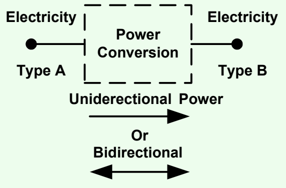
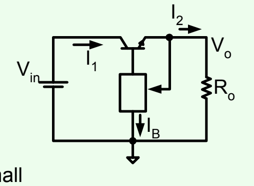
The problem of Power Conversion



- AC-DC Rectifier
- DC-DC Power converter
- DC-AC Inverter
- AC-AC Cycloconverter

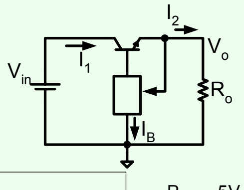
This course will concentrate on DC-DC converters

Linear Regulator



- $I_B \rightarrow$ Small
- $I_1 \approx I_2$
- Power lost depends on voltage drop on regulator
- Regulator needs a minimum of 3 volts
- Low Drop Regulators ~min(V_{in}-V_o)=1V
- But: V_{in}-V_o Variations ~3V

Example (Cont.)



<u>100W, 5V power supply</u>

Assume:

$(V_{in} - V_o)_{nominal} \approx 3V$

$(V_{in} - V_o)_{max} \cong 5V$

$$\frac{P_{loss}}{P_o} = \frac{5V}{5V} = 1; \quad \rightarrow \quad P_{loss} = 100W$$

$$\eta\% = \frac{100}{200} \cdot 100 \approx 50\%$$

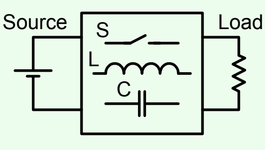
Example (Cont.)

The problem is not $\eta\% = 50\ \%$ **It is 100W !**

- Battery -> efficiency
- Line operation -> heat dissipation
- Cooling -> size, expense

Modern Power Conversion Systems Requirements

- High efficiency
- Small size
- Cost

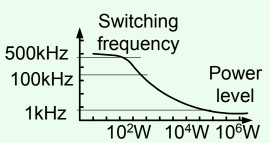


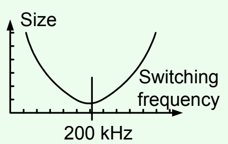
L, C: Reactive elements
S: "On" Resistance →0
"Off" Resistance → ∞

→ **Low Losses**

Disadvantages

- More Expensive (in general)
- Noisy
- Less Reliable
- Switching Losses

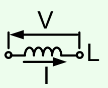




PWM

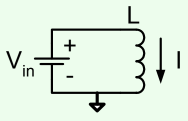
Inductor_1

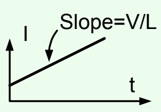
$$\frac{dI}{dt} = \frac{V}{L}$$



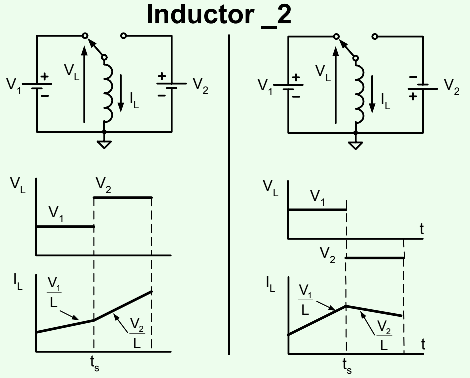
In most Power Electronics cases V=constant over time period of interest

$$\frac{\Delta I}{\Delta t} = \frac{V}{L}; \qquad \Delta I = \frac{V}{L}\Delta t;$$

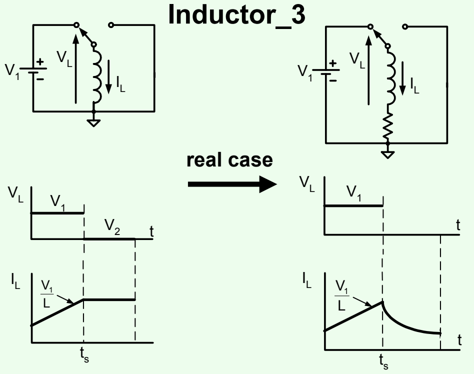




Inductor _2



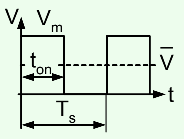
Inductor_3



Average Signals

Most important equation in Power Electronics: $\frac{dI}{dt} = \frac{V}{L}$

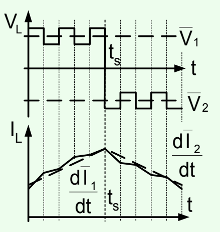
Correct for average too: $\frac{d\bar{I}}{dt} = \frac{\bar{V}}{L}$



$\bar{X} = \frac{1}{T}\int_0^T X dt$

$\bar{X}$ - average

$\bar{V} = \frac{V_m \cdot t_{on}}{T_s} = V_m D_{on}$



Implication

For any practical system in steady state:
Average voltage on inductor $\bar{V}_L = 0$

Proof:

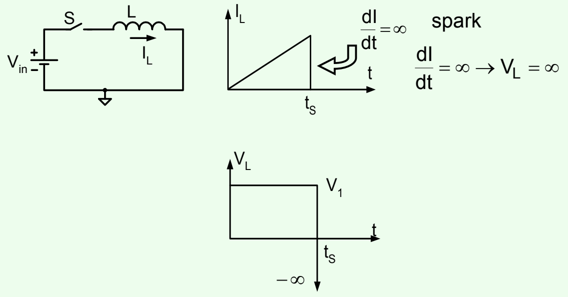
If $\bar{V}_L \neq 0$ then $\bar{I}_L \to \infty$

That is:

System must be designed such that:

$$\bar{V}_L = 0$$

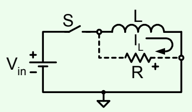
Inductor current interruption



Inductor current interruption

What is the polarity?

The imaginary resistor method



Current continuity