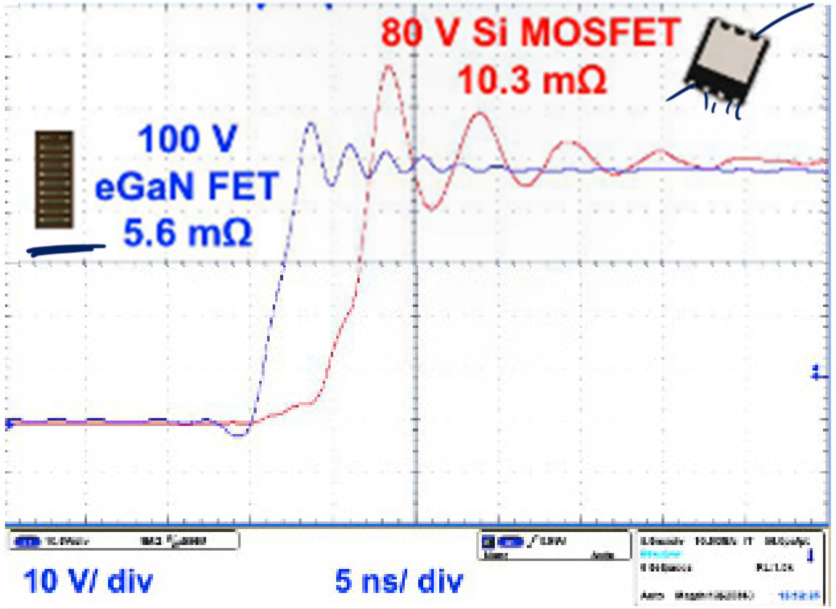
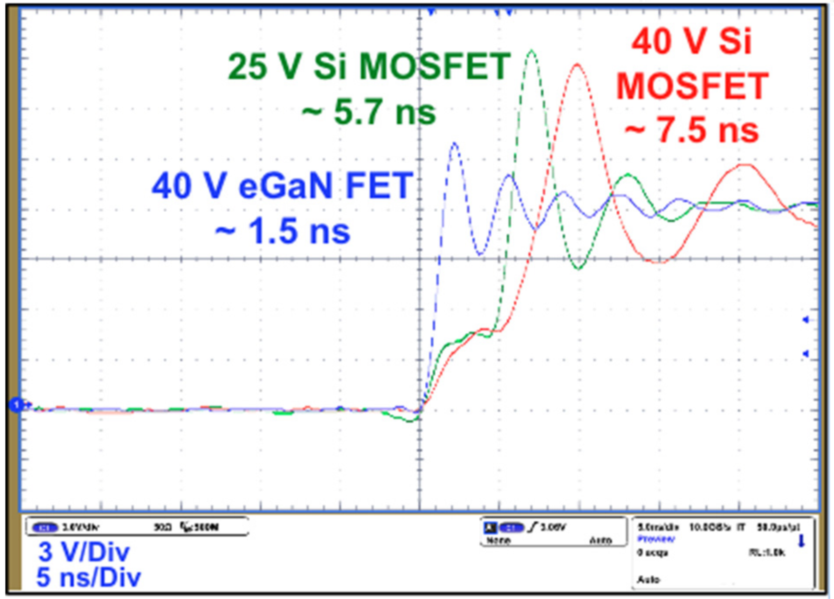
Designing with GaN

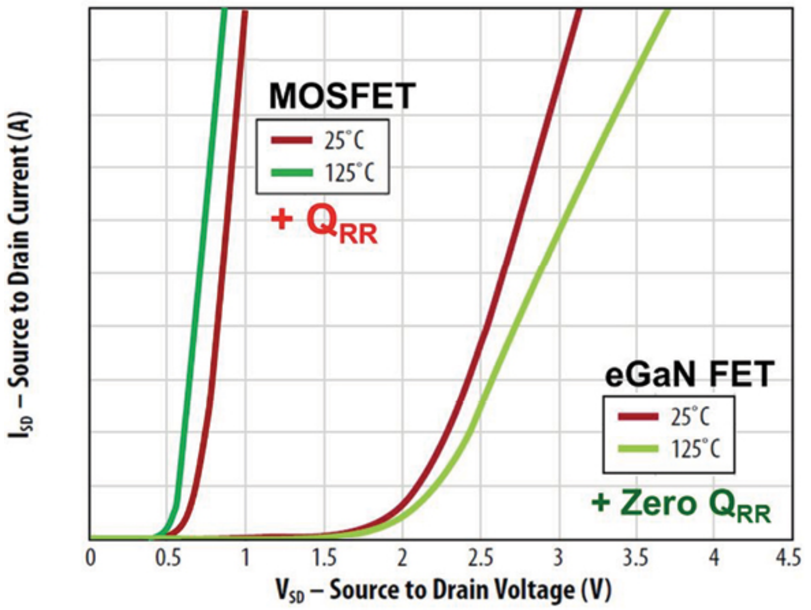
- Because of high electric breakdown field and high electron velocity, GaN devices with comparable R_{on} can be significantly smaller and switch must faster.
- Need **very** good layout to prevent ringing from causing overvoltage and device failure.

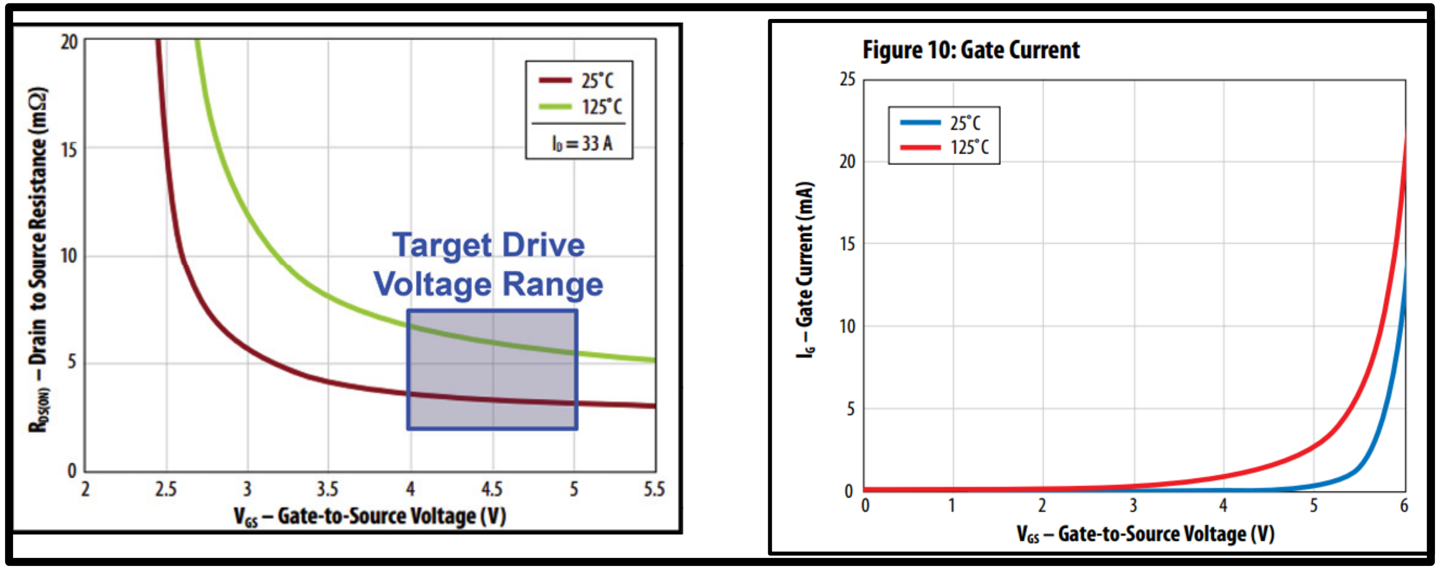


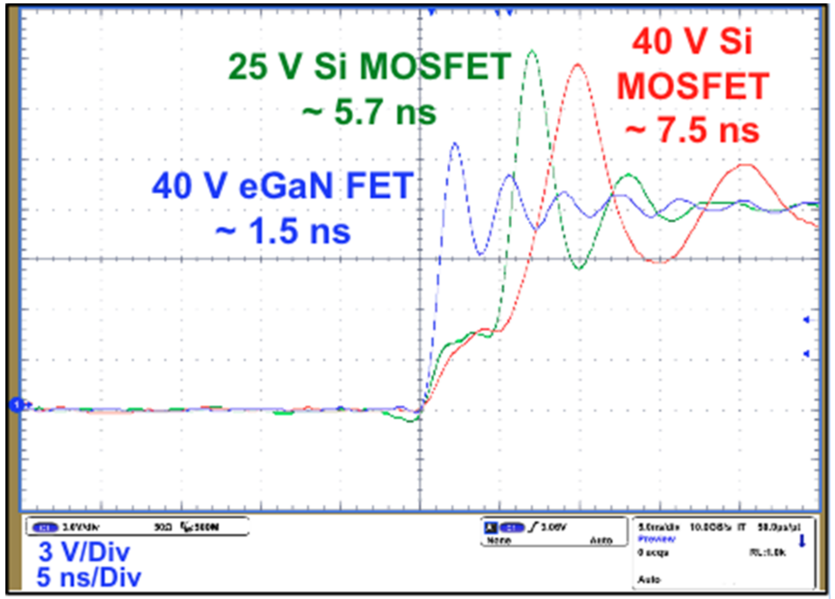


GaN Design Issues

1. Reverse conduction mechanism
2. Sensitivity to parasitics
3. Gate robustness
4. Small size -> Thermal limitations







Converter Efficiency Vs. f_s

$$P_{loss} = P_{cond} + P_{sw} + P_{fixed}$$

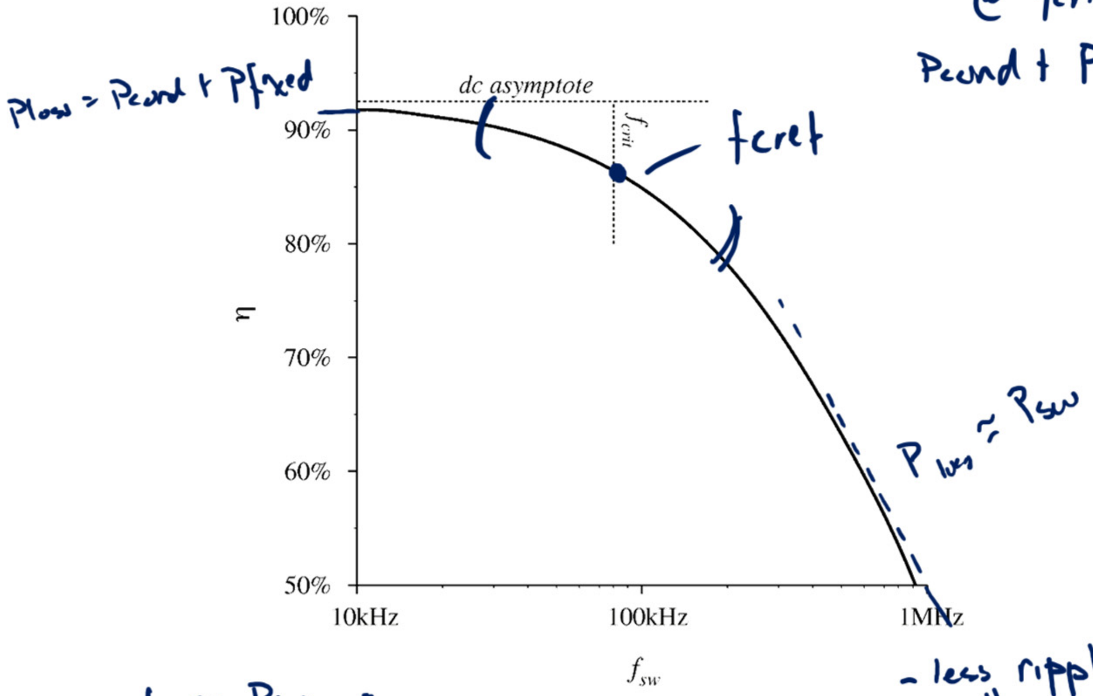
$$P_{cond} \propto I \text{ or } I^2$$

$$P_{sw} \propto f_s$$

$$\left(P_{loss} = P_{cond} + P_{fixed}\right) + W_{tot} f_{sw}$$

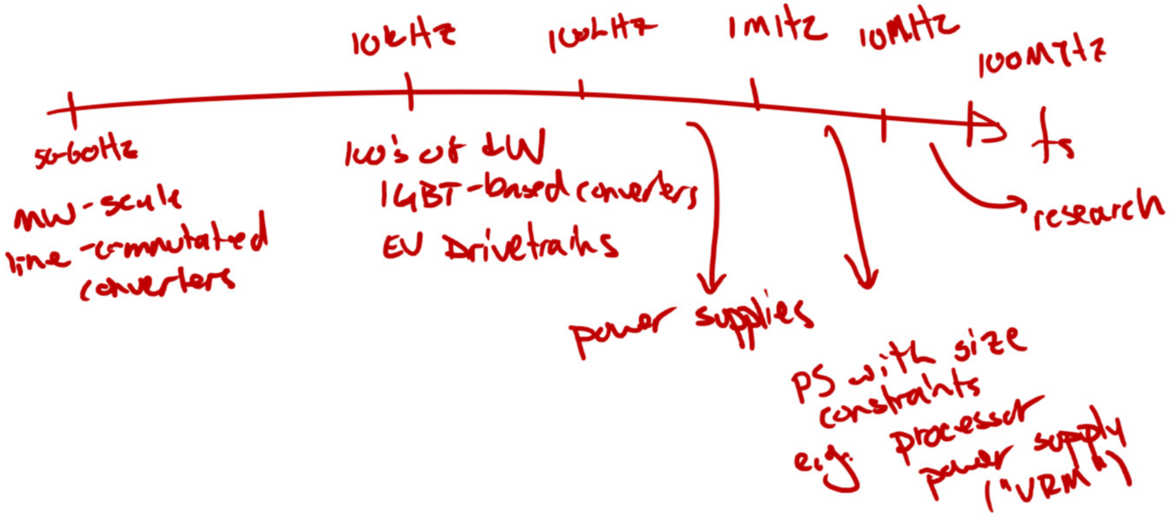
@ f_{crit}

$$P_{cond} + P_{fixed} = P_{sw}$$

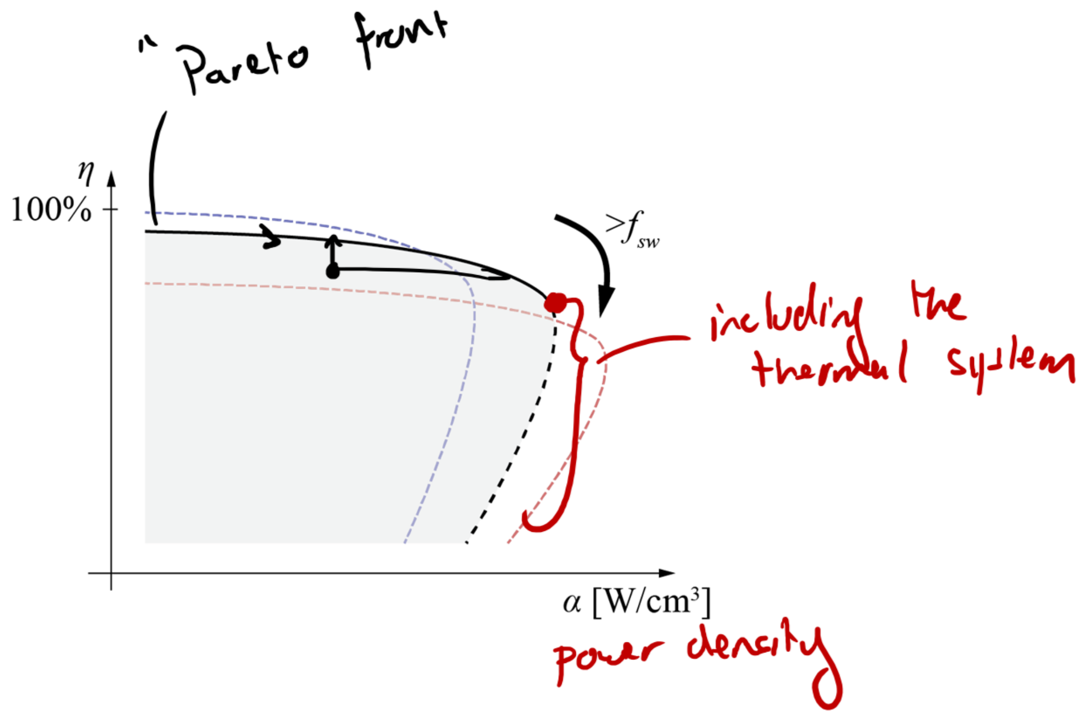


- lower P_{sw}
- lower "high" frequency EMI

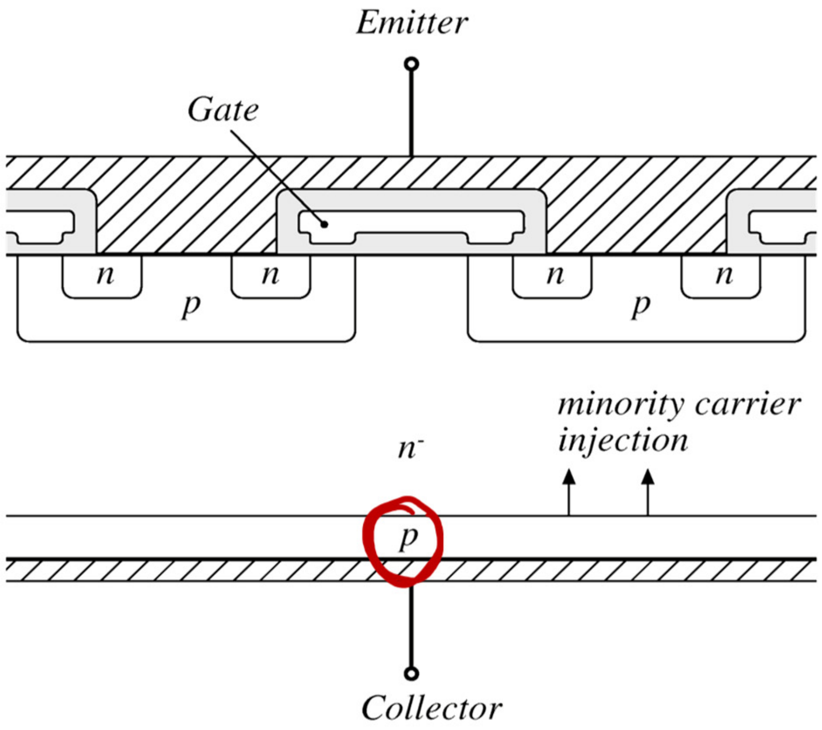
- less ripple
- smaller passives
- faster control bandwidth



Converter Optimization

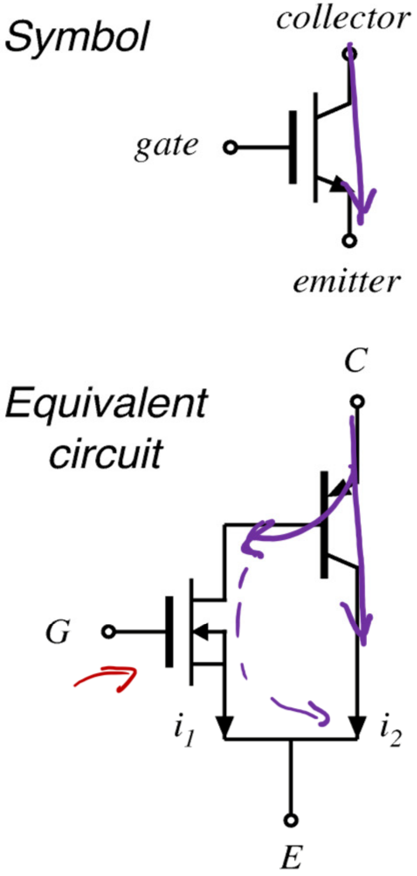


Insulated Gate Bipolar Junction Transistor



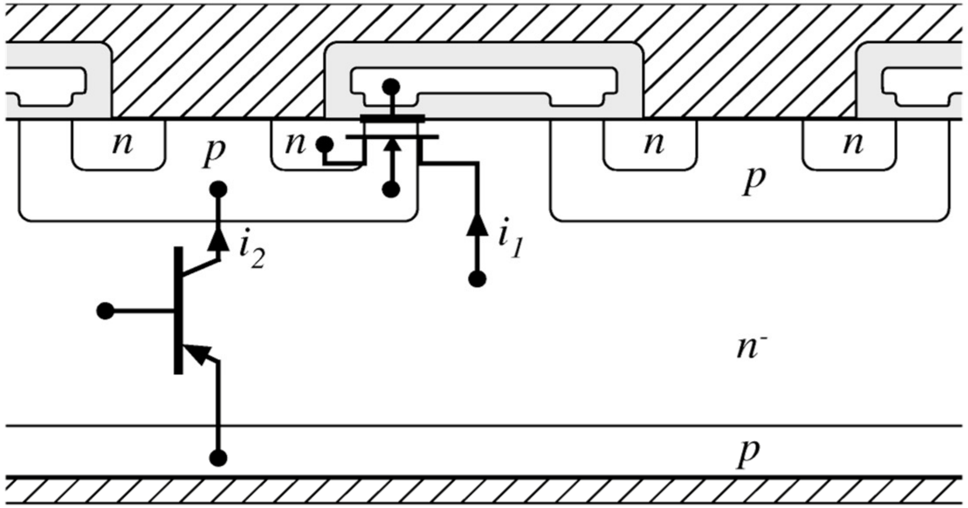
- A four-layer device
- Similar in construction to MOSFET, except extra p region
- On-state: minority carriers are injected into n^- region, leading to conductivity modulation
- compared with Si MOSFET: slower switching times, lower on-resistance, useful at higher voltages (up to 1700V)

The IGBT


Symbol

Equivalent circuit

Location of equivalent devices



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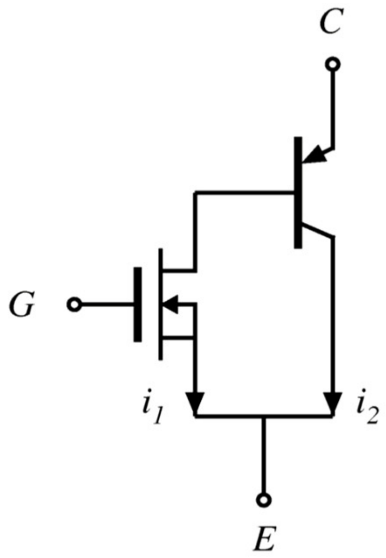
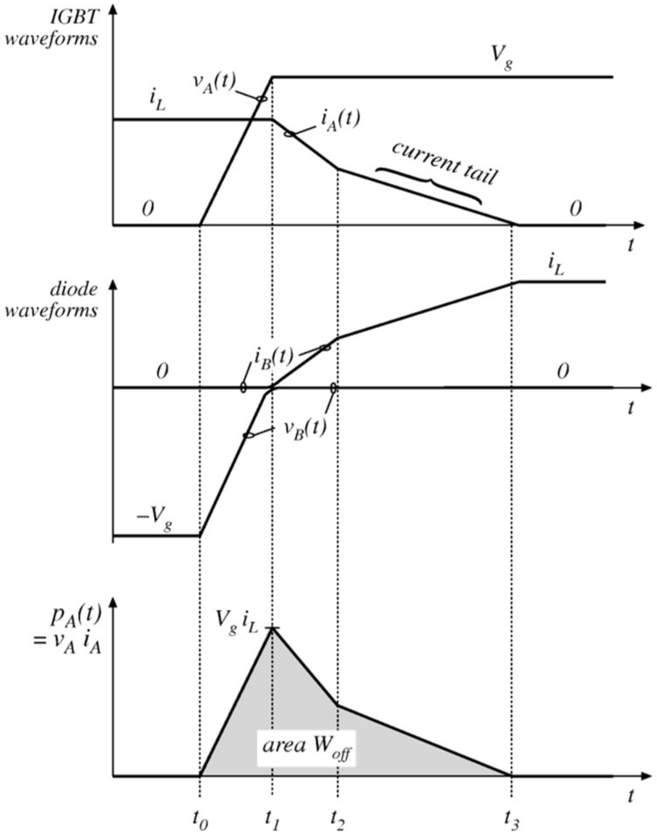
IGBT: Current Tailing





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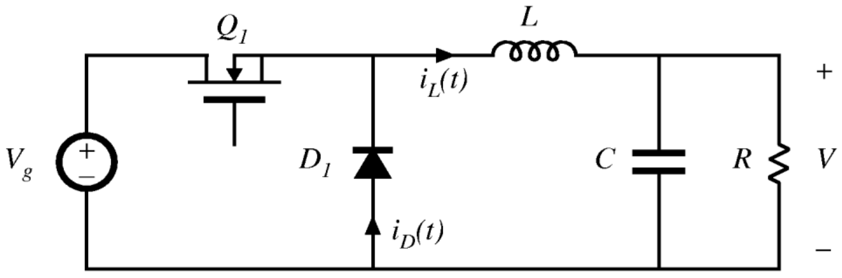
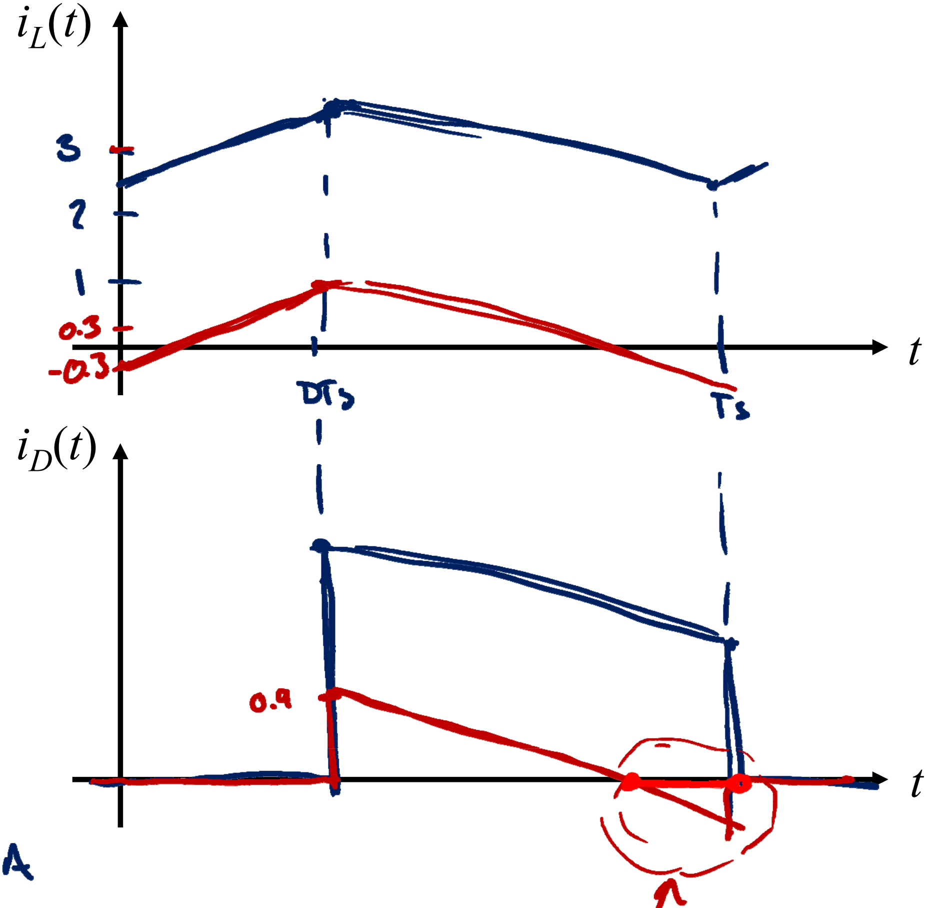
Chapter 5

THE DISCONTINUOUS CONDUCTION MODE

Buck Converter Example





X cannot happen

Ideal

$V = DV_g$

$I_L = \frac{V}{R}$

$2\Delta i_L = \frac{V_g - V}{L} DT_s$

ex/ $V_g = 12V$, $V = 3V$, $L = 100\mu H$, $f_s = 20kHz$, $T_s = 50\mu s$

① $R = 1\Omega \rightarrow D = \frac{1}{4}$, $I_L = 3A$, $\Delta i_L = 0.6A$

② $R = 10\Omega \rightarrow D = \frac{1}{4}$, $I_L = 0.3A$, $\Delta i_L = 0.6A$