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Buck-Derived Converters

Presented by

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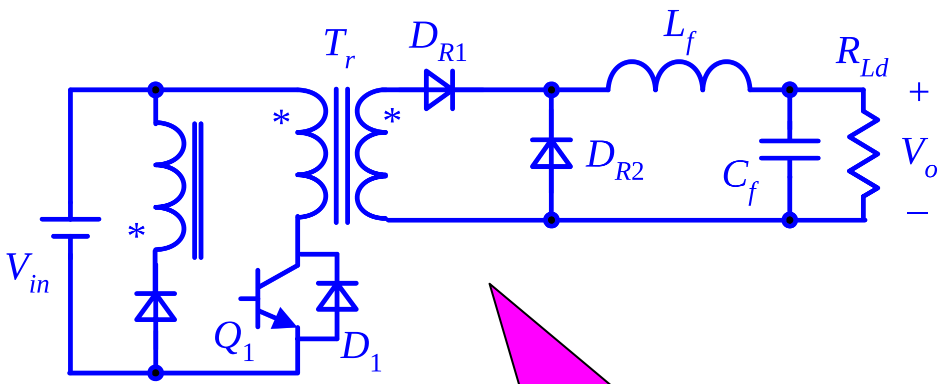
Forward Converter



It is suited for the low power and low input voltage applications

Advantages:

☺ Simple topology;

☺ **No direct-short problem**.

Disadvantages:

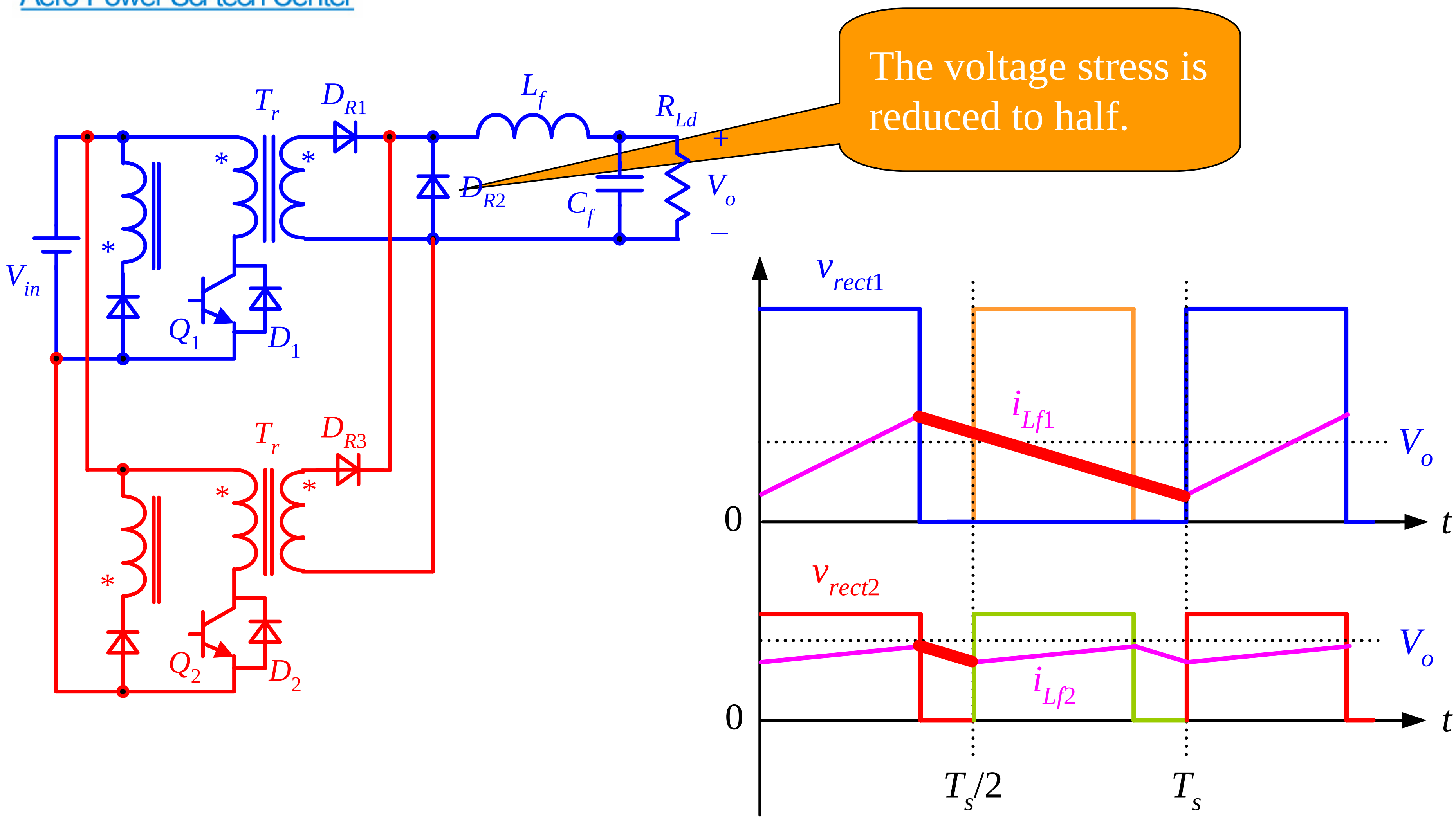
☹ The duty cycle is limited to 0.5;

☹ The transformer is unidirectional magnetic, so it is very large;

☹ The filter inductance is large;

☹ The voltage stress of the rectifier diodes is high.

Double Forward Converter (1)



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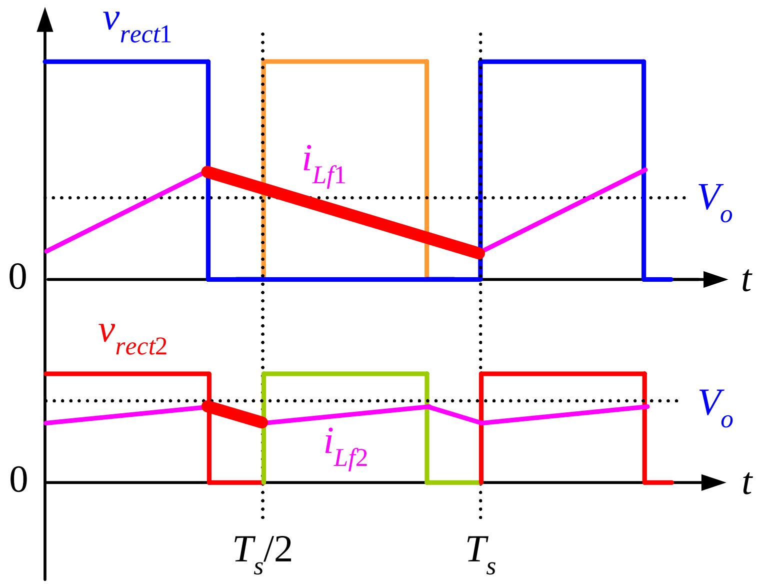
Double Forward Converter (2)



$$V_o = L_f \frac{\Delta i_{Lf}}{T_{off}} \quad \Rightarrow \quad \Delta i_{Lf} = \frac{V_o}{L_f} \bullet (1-D) \bullet T_s$$

<u>Given D_{max}=0.45 for single Forward converter.</u>

$$V_o = 0.45 \bullet \frac{V_{in\min}}{K}$$

$$D = \frac{KV_o}{V_{in}} = 0.45 \bullet \frac{V_{in\min}}{V_{in}}$$

$$\Delta i_{Lf} = \frac{V_o}{L_f} \bullet \left(1 - 0.45 \bullet \frac{V_{in\min}}{V_{in}}\right) \bullet T_s$$

$$\Delta i_{Lf}^* = \frac{1 - 0.45 \bullet \frac{V_{in\min}}{V_{in}}}{1 - 0.45}$$

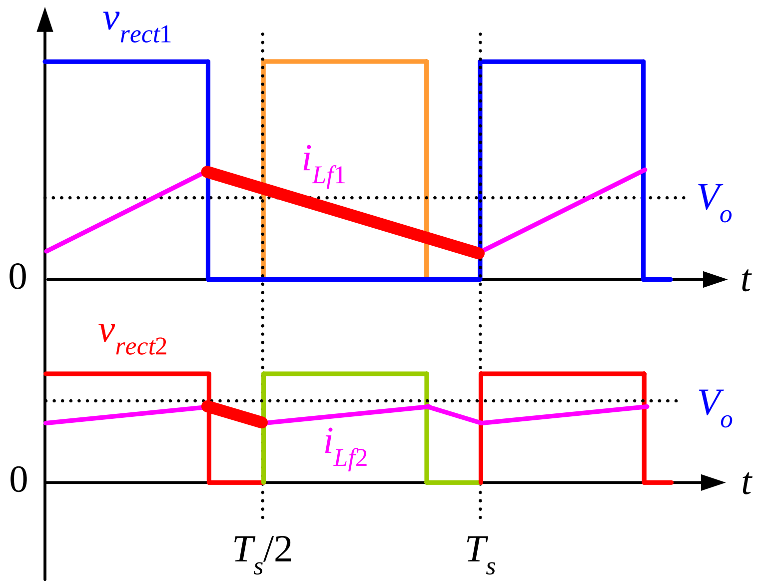
$$V_o = 0.9 \bullet \frac{V_{in\min}}{K}$$

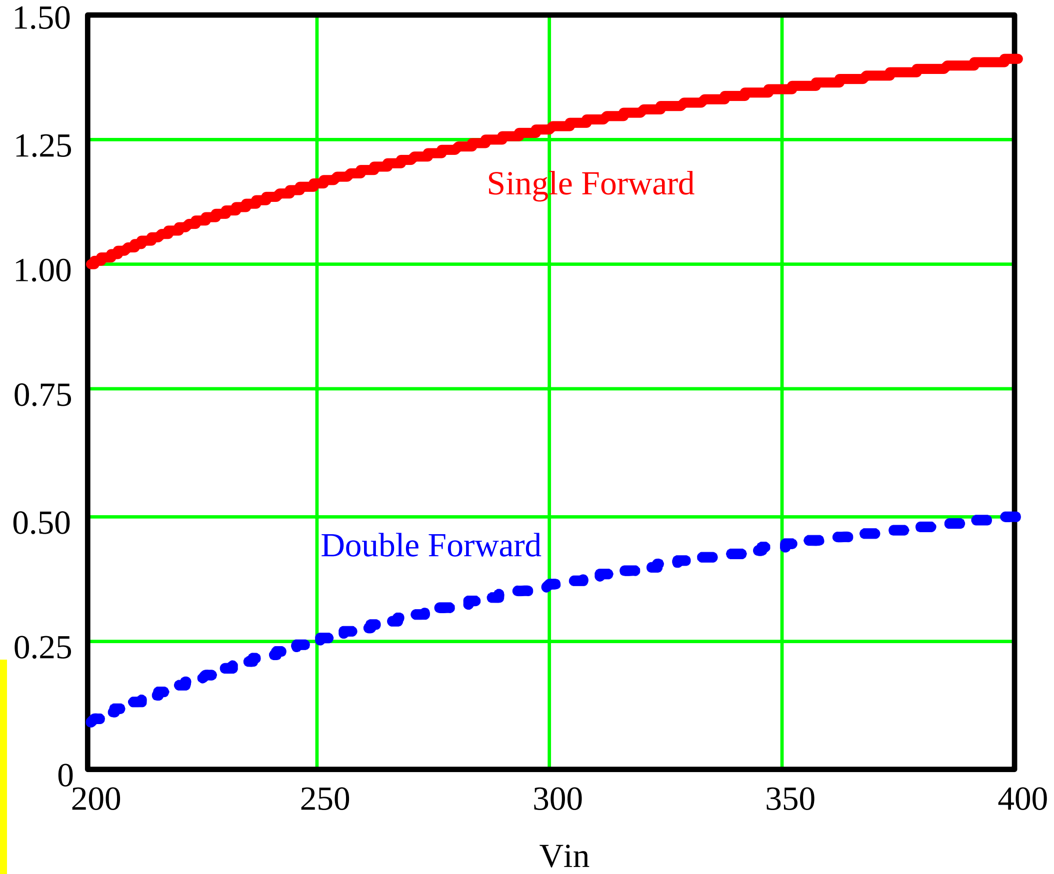
$$D = \frac{KV_o}{V_{in}} = 0.9 \bullet \frac{V_{in\min}}{V_{in}}$$

$$\Delta i_{Lf} = \frac{V_o}{L_f} \bullet \left(1 - 0.9 \bullet \frac{V_{in\min}}{V_{in}}\right) \bullet \frac{T_s}{2}$$

$$\Delta i_{Lf}^* = \frac{1 - 0.9 \bullet \frac{V_{in\min}}{V_{in}}}{(1 - 0.45) \times 2}$$

Double Forward Converter (3)





The reasons for the reduction of L_f

- The magnitude of the secondary voltage is reduced to half;
- The ripple frequency is doubled.

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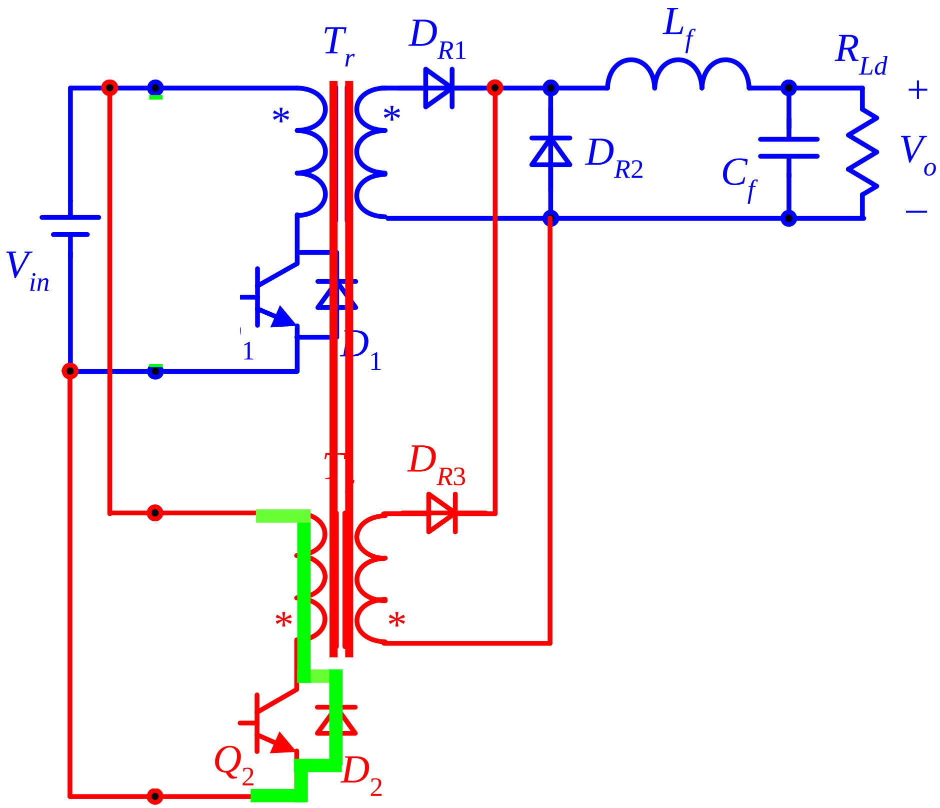
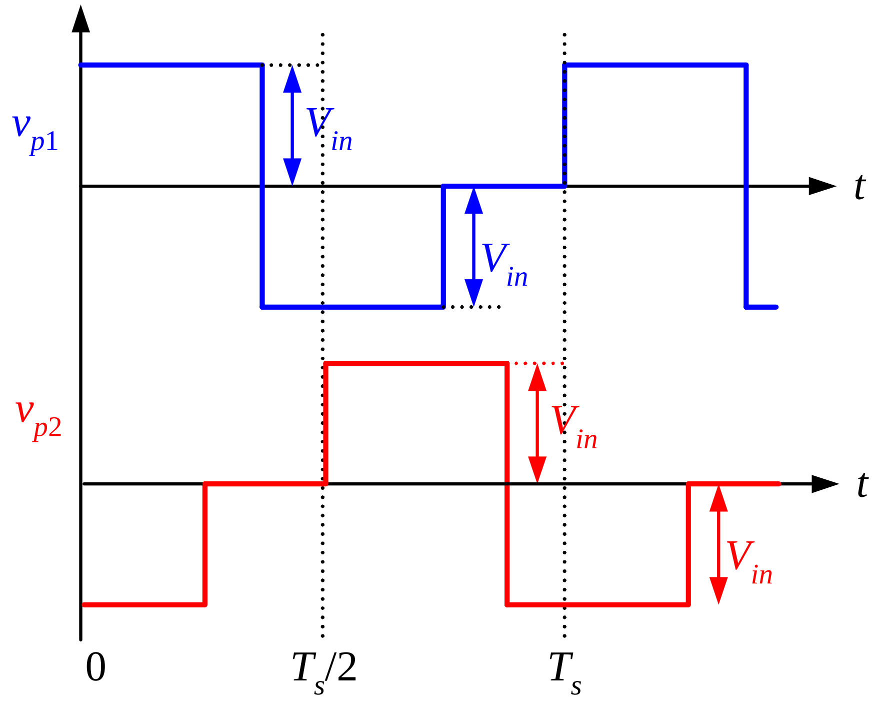
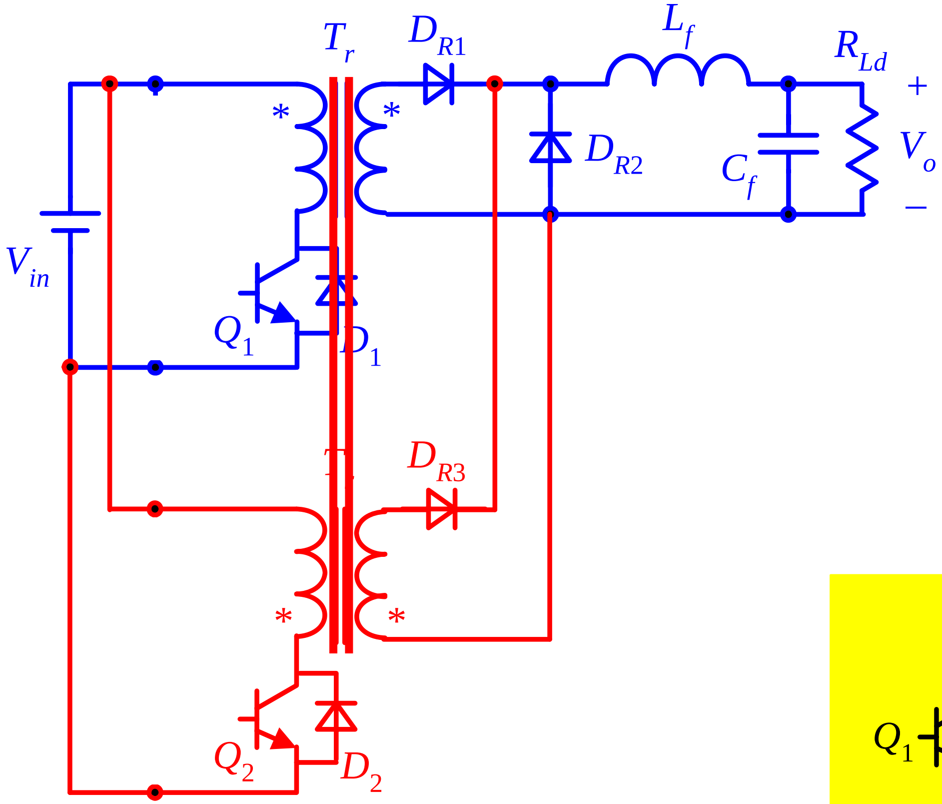
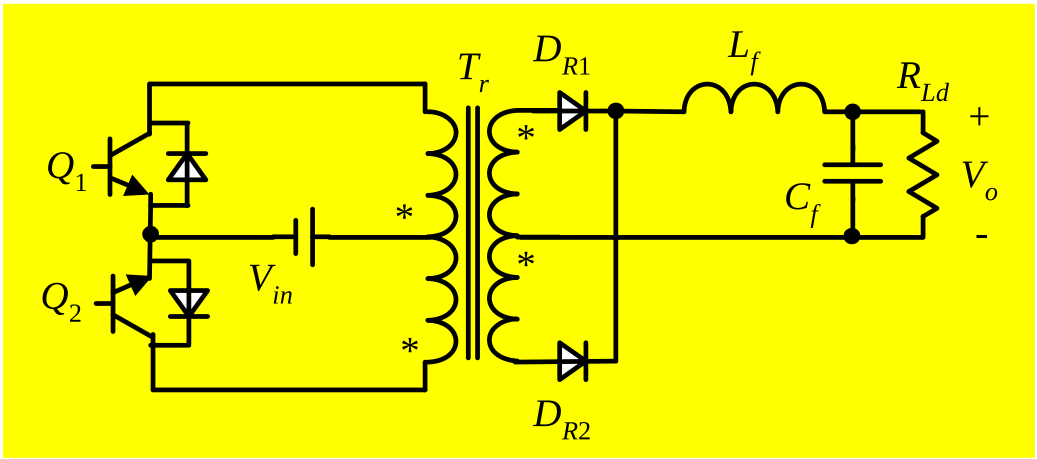
Derivation of Push-Pull Converter (1)



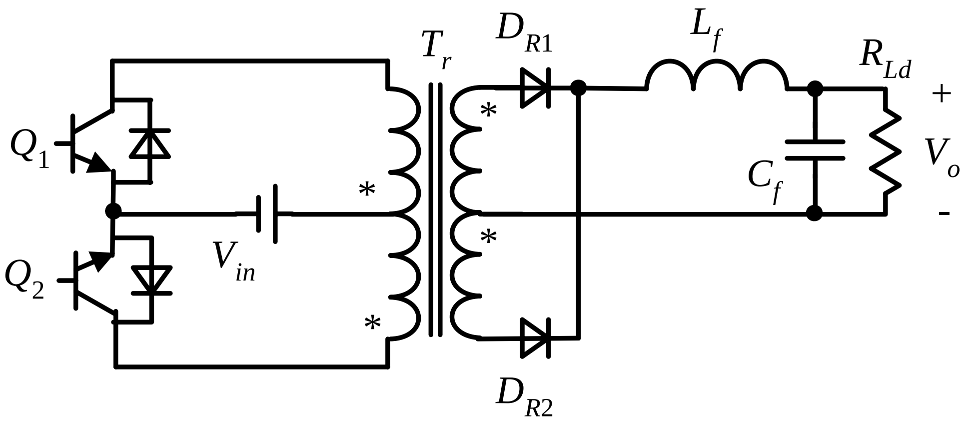


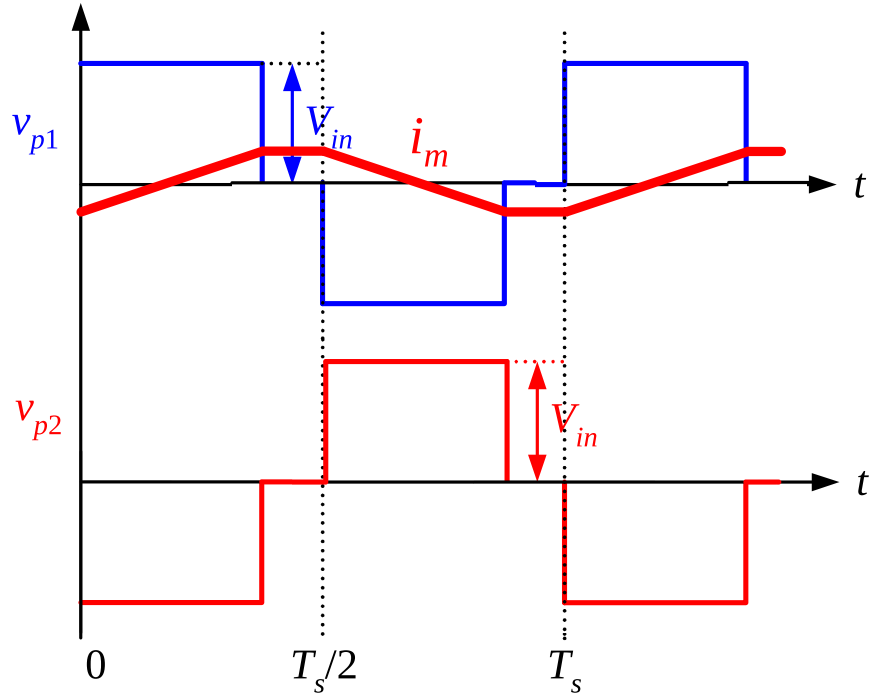
Derivation of Push-Pull Converter (2)



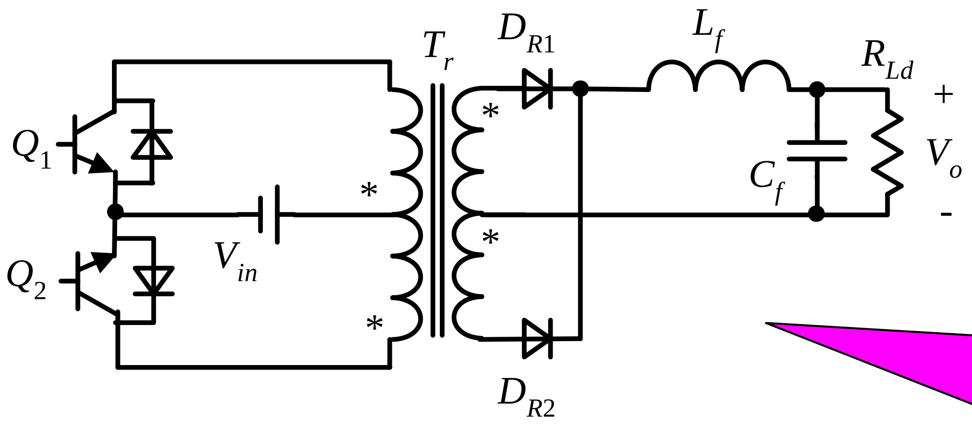


Magnetic Reset of Push-Pull Converter





Push-Pull Converter



It is suited for the low input voltage applications

Advantages:

☺ Bi-directional magnetic, leading to small transformer;

☺ The duty cycle can be extended to be 1.0, leading to reduced filter inductance and lower voltage stress of the rectifier diodes.

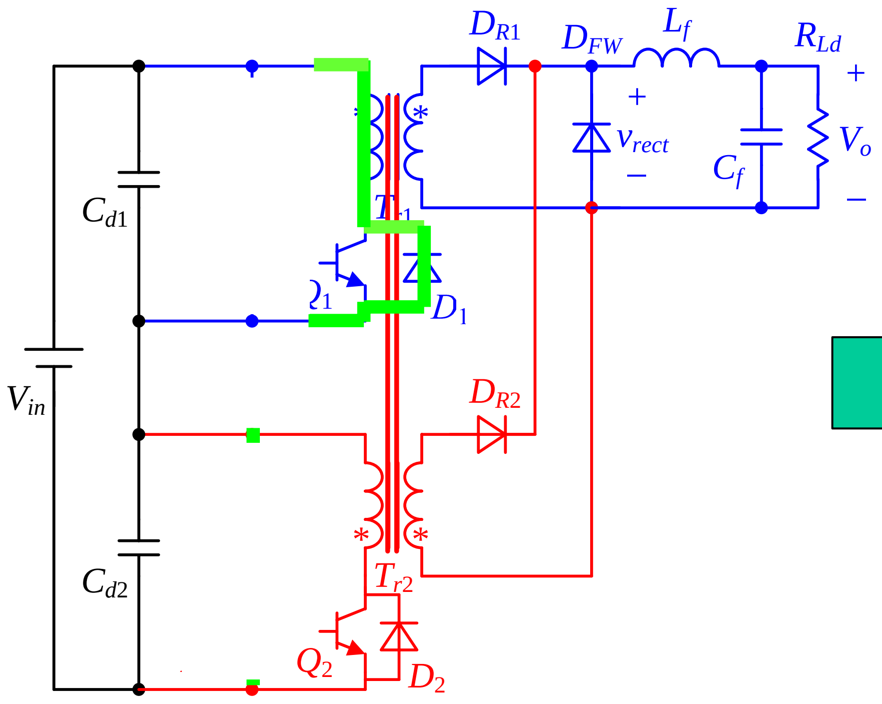
Disadvantages:

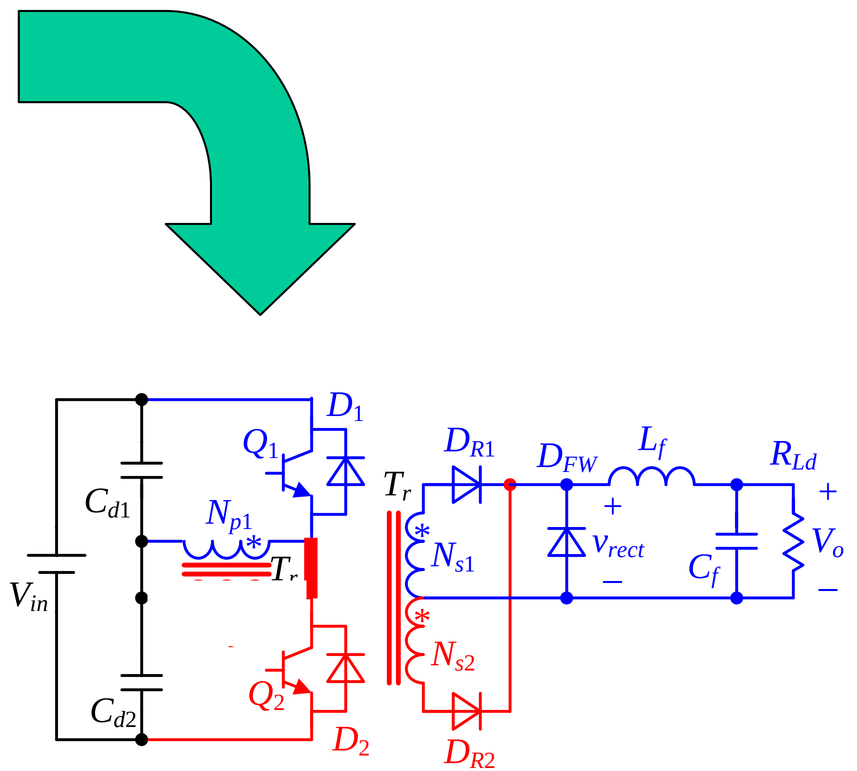
☹ The switches sustain twice of the input voltage;

☹ The leakage inductance results in large voltage spike across the switches;

☹ There is a risk of saturation of the transformer due to the dc component.

Derivation of Half-Bridge Converter





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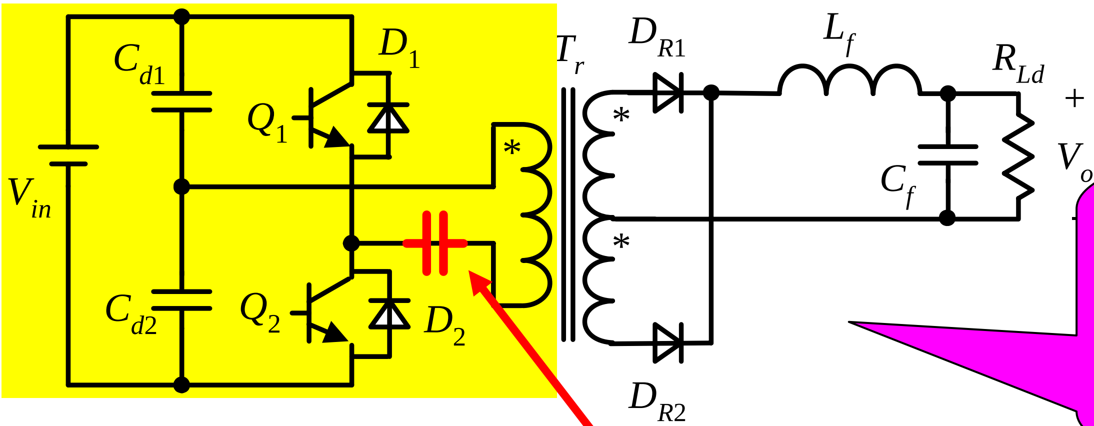
Half-Bridge Converter



It is suited for the low input voltage applications

medium

Advantages:

☺ Bi-directional magnetic, leading to small transformer;

☺ The duty cycle can be extended to be 1.0, leading reduced filter inductance and lower voltage stress of the rectifier diodes.

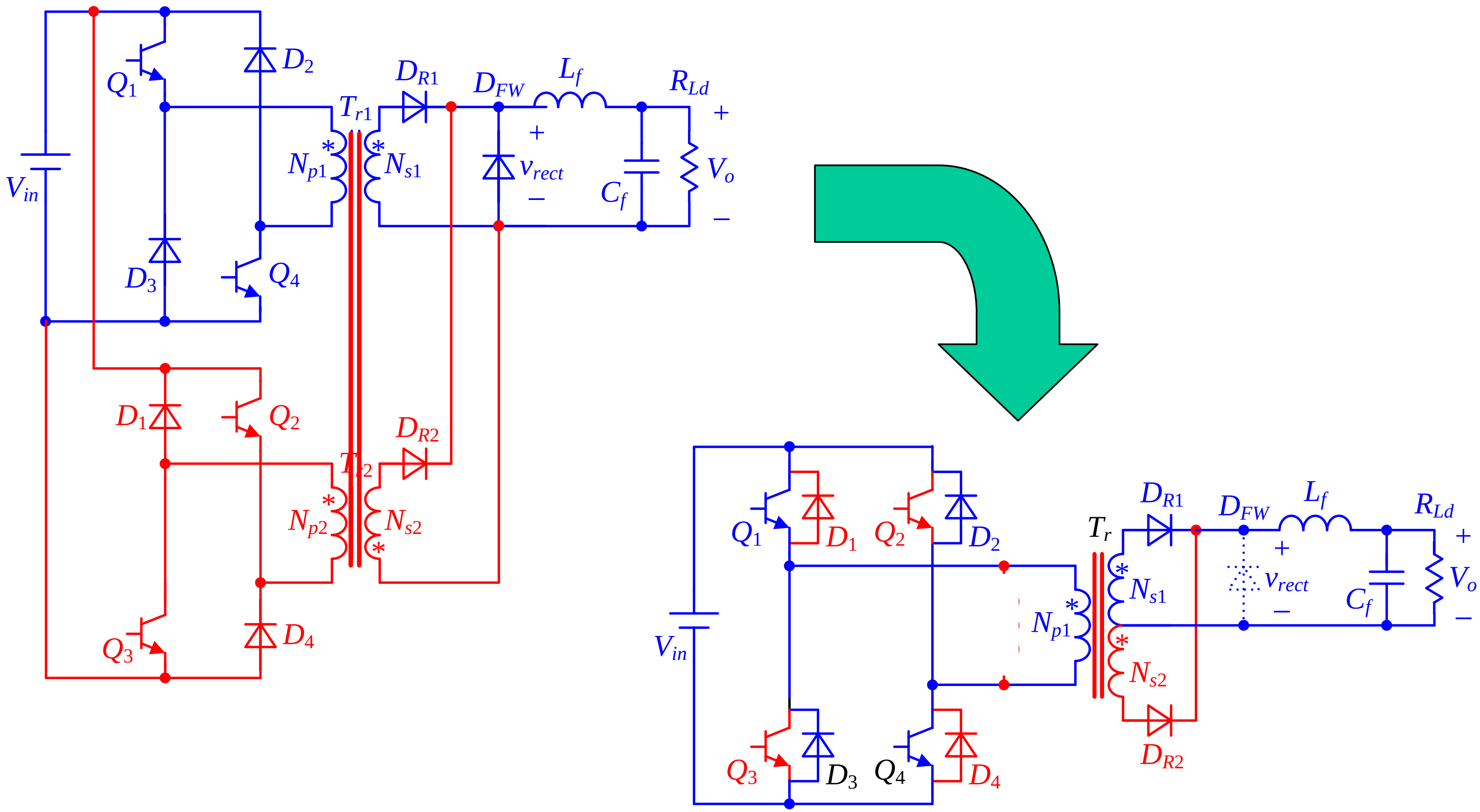
Disadvantages:

☹ The switches sustain ~~twice of~~ the input voltage;

~~☹ The leakage inductance results in large voltage spike across the switches;~~

☹ There is a risk of saturation of the transformer due to the dc component.

Derivation of Full-Bridge Converter



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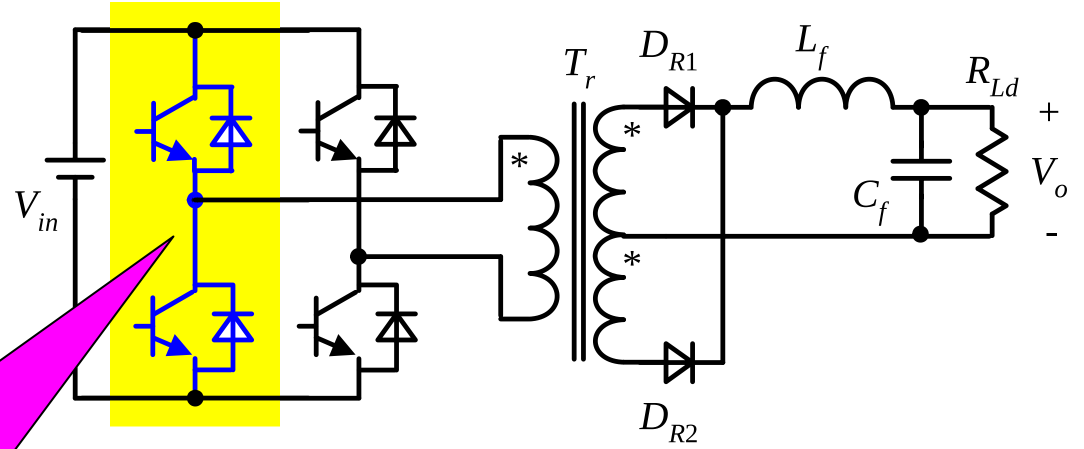
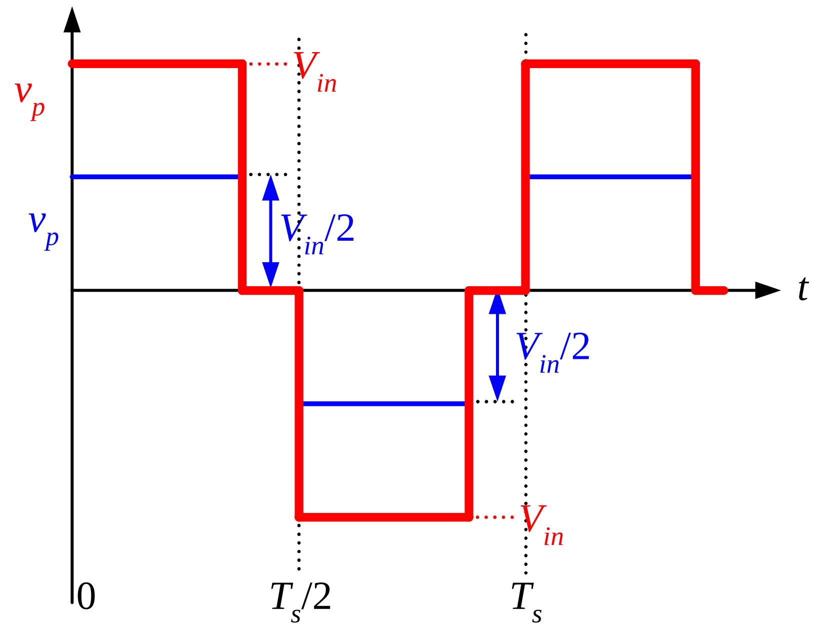
Full-Bridge Converter



The current stress of the switches reduces to be half compared with HB



Comparison of the Converters

Design a DC/DC converter

- Input Voltage: V_{in}
- Output Voltage: V_o
- Output Current: I_o

Given the duty cycle of all the switches be 0.5

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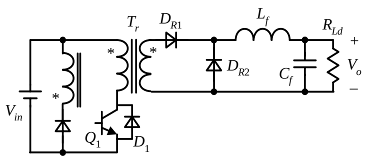
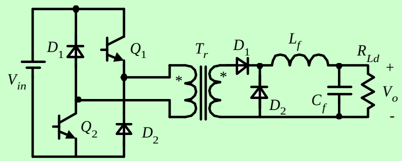
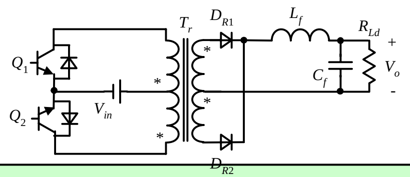
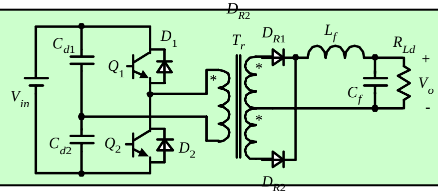
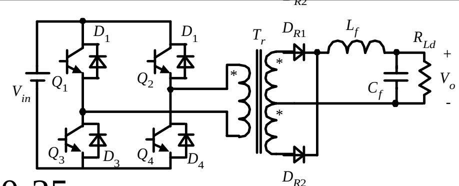
Comparison of the Converters

Converter	Topology	Winding Ratio	Current Stress	Voltage Stress	No of Switches	Total Power of Switches
Single-Switch Forward		K_0	I_o/K_0	$2V_{in}$	1	$2V_{in}I_o/K_0$
Dual-Switch Forward		K_0	I_o/K_0	V_{in}	2	$2V_{in}I_o/K_0$
Push-Pull		$2K_0$	$I_o/(2K_0)$	$2V_{in}$	2	$2V_{in}I_o/K_0$
Half-Bridge		K_0	I_o/K_0	V_{in}	2	$2V_{in}I_o/K_0$
Full-Bridge		$2K_0$	$I_o/(2K_0)$	V_{in}	4	$2V_{in}I_o/K_0$

Thanks for your attention !

Questions? / Answer!