IIT ROORKEE

NPTEL ONLINE CERTIFICATION COURSE

Charging Infrastructure

Lecture-10

Single-phase Boost PFC Converter-II

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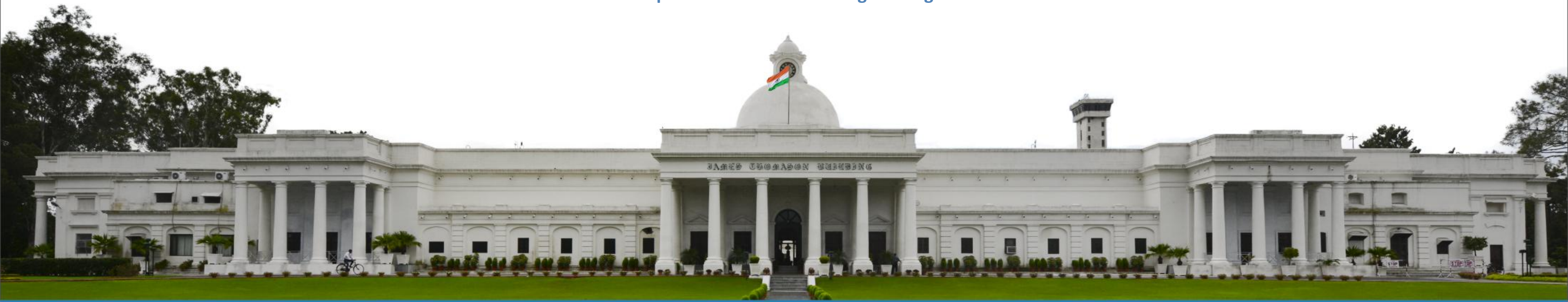
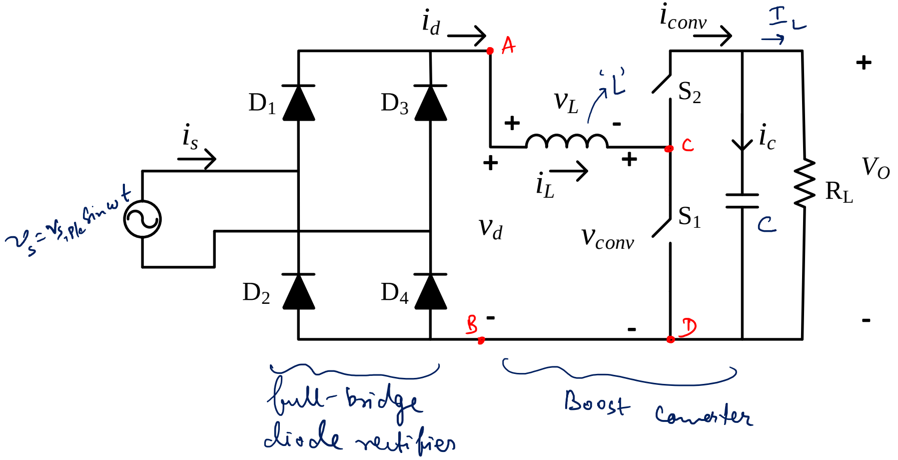


Recap

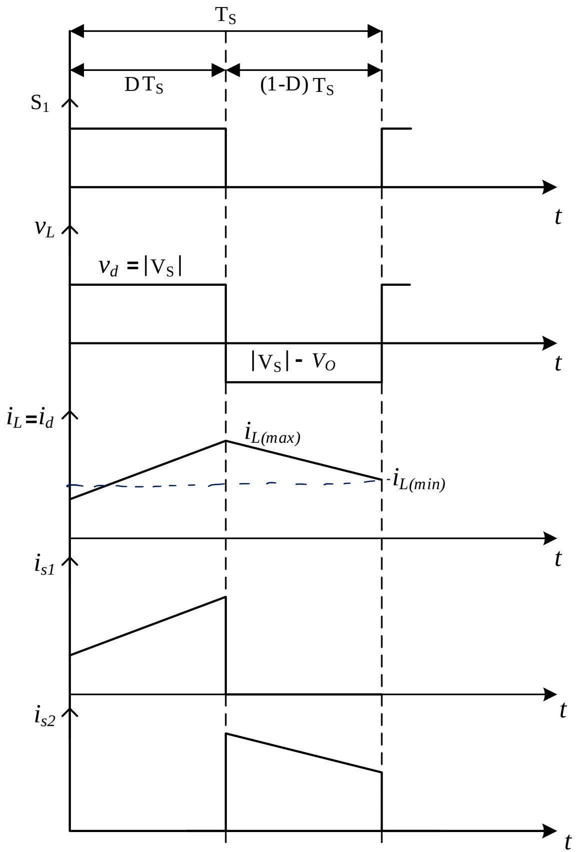


$v_d = |v_{s,pk} \sin\omega t|$

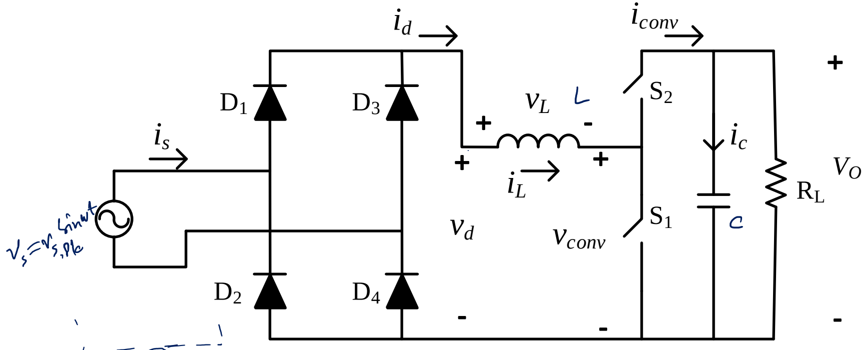
$f_{sw} >> f_s \rightarrow 50\,Hz$

$\Downarrow$

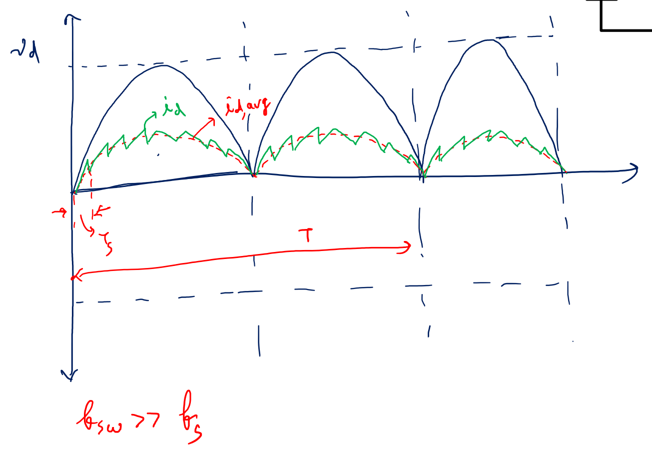
Boost PFC



T_S
DT_S
$(1-D)T_S$
S_1
v_L
$v_d = |V_S|$
$|V_S| - V_O$
$i_L = i_d$
$i_{L(max)}$
$i_{L(min)}$
i_{s1}
i_{s2}
t



i_d
i_{conv}
D_1
D_3
D_2
D_4
v_L
L
S_2
S_1
i_s
i_c
i_L
V_O
R_L
v_d
v_{conv}
C
$v_s = v_{s,pk} \sin \omega t$



v_d
i_d
$i_{d,avg}$
T_s
T
$f_{sw} >> f_s$

if, $d(t)$ is the duty ratio that is varying with time

$v_d = |v_s(t)|$

$$\int_0^{T/2} \left[|v_s(t)| \cdot d(t) T_s + \left(|v_s(t)| - v_o \right) (1-d(t)) T_s \right] \cdot dt = 0$$

$$\Rightarrow \quad |v_s(t)| \, d(t) T_s + \left(|v_s(t)| - v_o \right) (1-d(t)) T_s = 0$$

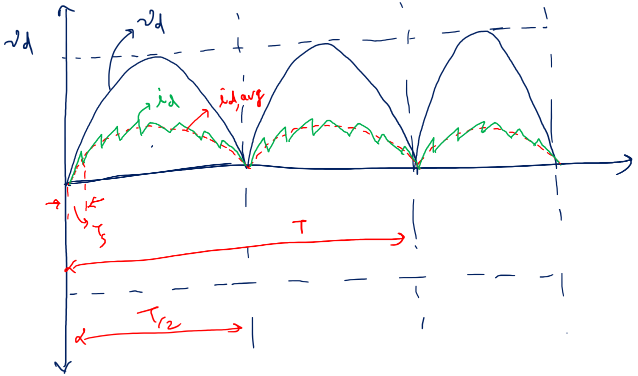
$$\Rightarrow \quad |v_s(t)| \cdot d(t) + \left(|v_s(t)| - v_o \right) (1-d(t)) = 0$$

$$\Rightarrow \quad \cancel{|v_s(t)| \cdot d(t)} + |v_s(t)| - v_o - \cancel{|v_s(t)| d(t)} + v_o d(t) = 0$$

$$\Rightarrow \quad |v_s(t)| = v_o (1 - d(t))$$

$$\Rightarrow \quad d(t) = 1 - \frac{|v_s(t)|}{V_o}$$

$$\Rightarrow \quad d(t) = 1 - \frac{|V_{s,pk} \sin \omega t|}{V_o}$$



$f_{sw} >> f_s$

$$d(t) = 1 - \frac{|v_{s,pk} \sin\omega t|}{V_o}$$

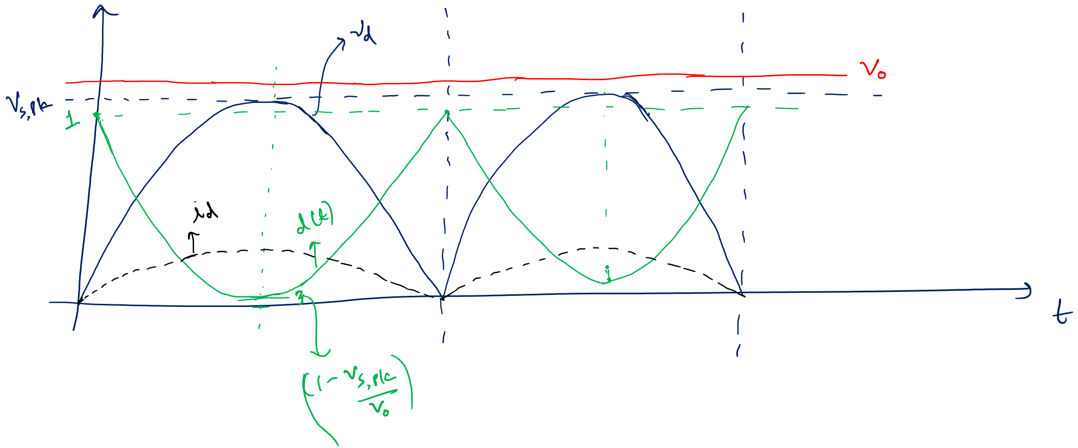
if $V_o > V_{s,pk}$, $0 < d(t) < 1$

if $V_o < V_{s,pk}$, $d(t) < 0$ (-ve) $\Rightarrow$ Not possible

Thus, with Boost PFC converter, always $V_o > V_{s,pk}$

$230V \rightarrow 325 \Rightarrow V_o > 325V$

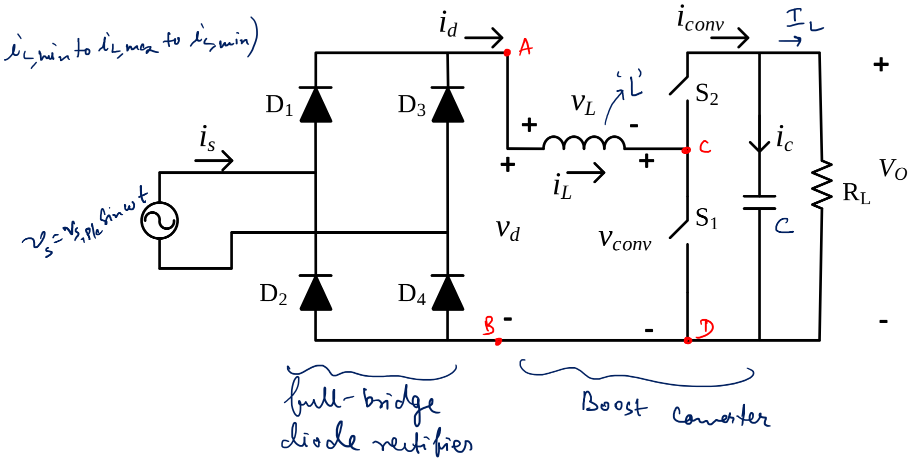
$\approx V_o = 400V$



Sizing the inductance 'L'

$$\Delta i_L = i_{L,max} - i_{L,min}$$

(Assume, the i_L goes from $i_{L,min}$ to $i_{L,max}$ to $i_{L,min}$)



During $d(t)T_s$,

$$|v_s(t)| = \frac{L \Delta i_L}{d(t) T_s}$$

$$\Rightarrow d(t) T_s = \frac{L \Delta i_L}{|v_s(t)|} \longrightarrow (1)$$

During $(1-d(t))T_s$

$$|v_s(t)| - v_o = \frac{-L \Delta i_L}{(1-d(t)) T_s}$$

$$\Rightarrow (1-d(t)) T_s = \frac{L \Delta i_L}{v_o - |v_s(t)|} \longrightarrow (2)$$

Add Eq. (1) & (2)

$$\Rightarrow T_s = \frac{L \Delta i_L}{|v_s(t)|} + \frac{L \Delta i_L}{v_o - |v_s(t)|}$$

$$\Rightarrow \quad T_s = L \Delta i_L \left[\frac{V_0 - \cancel{|v_s(t)|} + \cancel{|v_s(t)|}}{|v_s(t)| \left(V_0 - |v_s(t)| \right)} \right]$$

$$T_s = \frac{L \Delta i_L V_0}{|v_s(t)| \left(V_0 - |v_s(t)| \right)}$$

$$\Rightarrow \quad \Delta i_L = \frac{\left(V_0 - |v_s(t)| \right) |v_s(t)|}{L f_{sw} V_0} \qquad \left(T_s = \frac{1}{f_{sw}} \right) \longrightarrow 3$$

we get $\Delta i_{L,max}$, by $\dfrac{d(\Delta i_L)}{d(|v_s(t)|)} = 0$

$$\Rightarrow \quad \frac{d}{d(|v_s(t)|)} \left[V_0 |v_s(t)| \right] - \frac{d|v_s(t)|^2}{d(|v_s(t)|)} = 0$$

$$\Rightarrow \quad V_0 - 2|v_s(t)| = 0$$

$$\Rightarrow \quad |v_s(t)| = \frac{V_0}{2} \longrightarrow 4$$

Put 4 in 3

$$\Rightarrow \Delta i_{L,max} = \frac{\left(V_o - \frac{V_o}{2}\right)\left[\frac{V_o}{2}\right]}{L f_{sw} V_o}$$

$$\Rightarrow \Delta i_{L,max} = \frac{V_o}{4 L f_{sw}}$$

$$\Rightarrow \boxed{L = \frac{V_o}{4 \Delta i_{L,max} f_{sw}}}$$

$\Delta i_{L,max} \leq 10\%$ of $I_{s,pk}$

Thank You