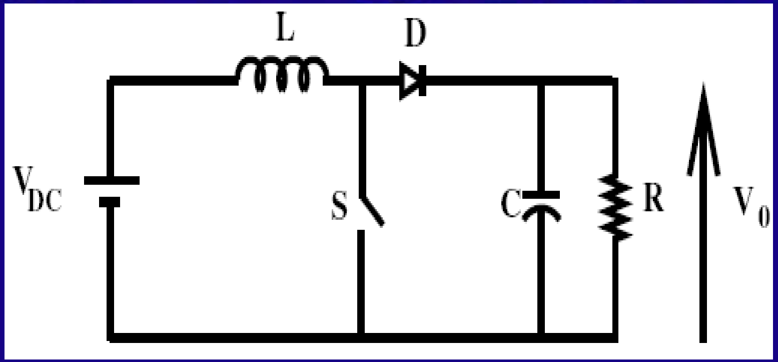
Review:

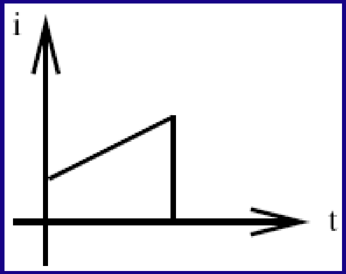
Limitations of hard switching converter

$\Rightarrow$ Device stress $\uparrow$

$\Rightarrow$ Switching loss $\uparrow$

$\Rightarrow$ EMI

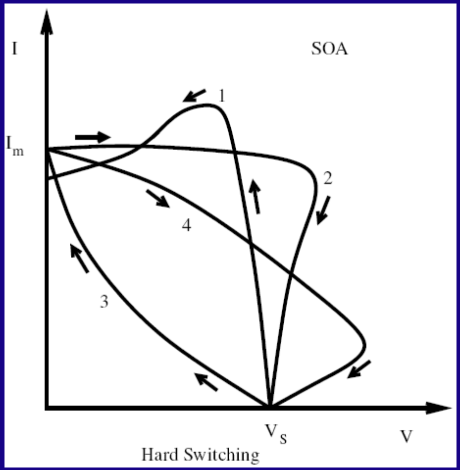


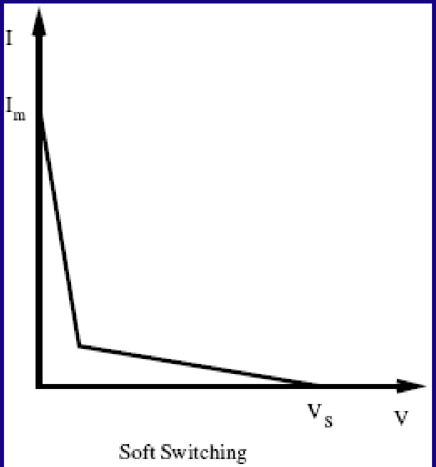


Soft switching converter

$\rightarrow$ Zero current switching

$\rightarrow$ Zero voltage switching



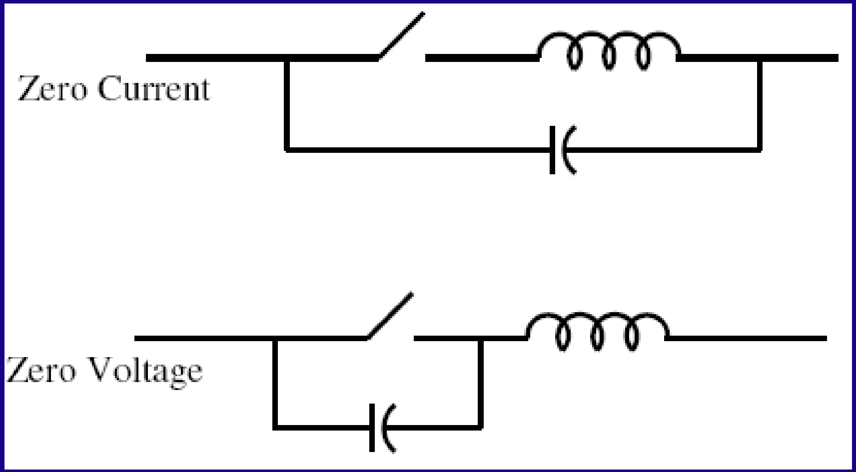


Stress on device ↑.

To reduce the converter size and weight

⇒ Switching Frequency (F_S) ↑

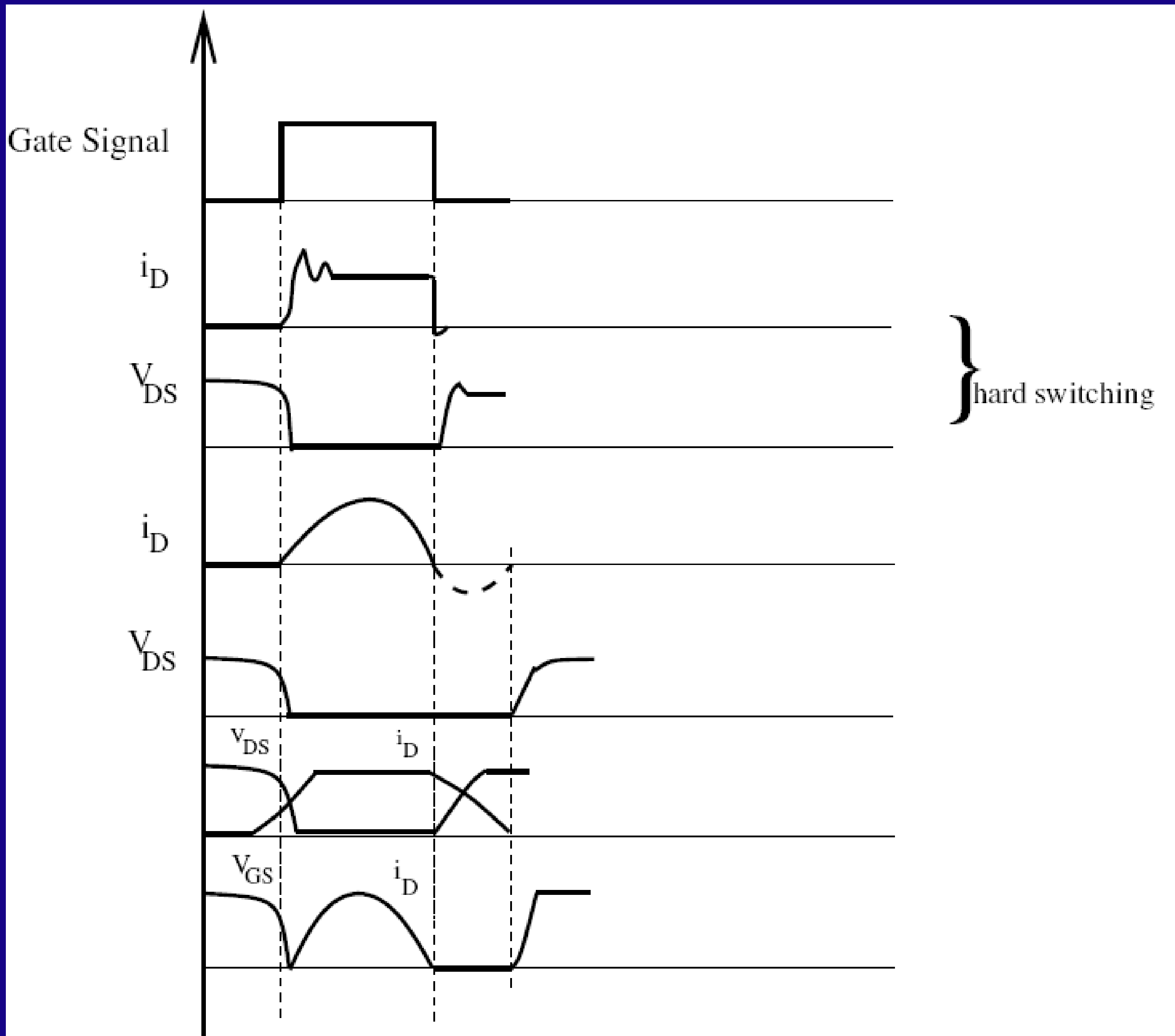
⇒ The above limitations become worse as F_S ↑



- $\Rightarrow$ Solution $\rightarrow$ Switch ON/OFF the device when the voltage across it AND/OR the current through it is ZERO.
  - $\Rightarrow$ Zero Voltage / Zero Current switching converter.
  - $\Rightarrow$ Soft switched converter
  - $\Rightarrow$ Resonant Converter
  - $\Rightarrow$ Some sort of LC resonance

⇒ Power electronic equipment which utilizes a resonant L-C circuit as a part of the power conversion process

- ⇒ Resonance frequency of L-C is very high
- ⇒ Depending upon the power level, it could be of the order of 300-500 KHz
- ⇒ Size of L & C is very small


Gate Signal
iD
VDS
hard switching
iD
VDS
VDS
iD
VGS
iD

Advantages

$\Rightarrow$ Devices stress $\downarrow$

$\Rightarrow$ Low EMI

$\Rightarrow$ Switching Losses ; 0

$\Rightarrow$ Separate L & C are required

$\Rightarrow$ parasitic elements can be enhanced than distract the circuit performance.

$\Rightarrow$ Possible to improve the diode recovery

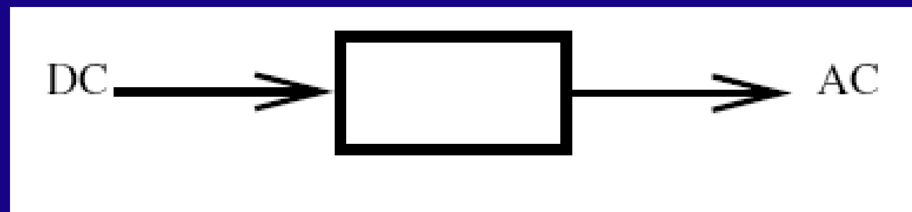
Dis-advantage

- ⇒ Circuit is complicated
- ⇒ High peak current

Applications

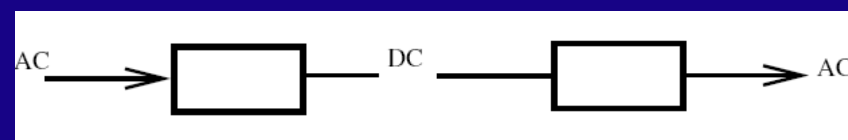
- ⇒ Power supplies
- ⇒ Induction heating

DC - AC Converters : Inverters

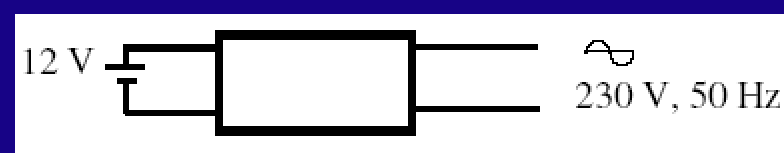


Why is there a need?

Power is generated $\rightarrow$ AC



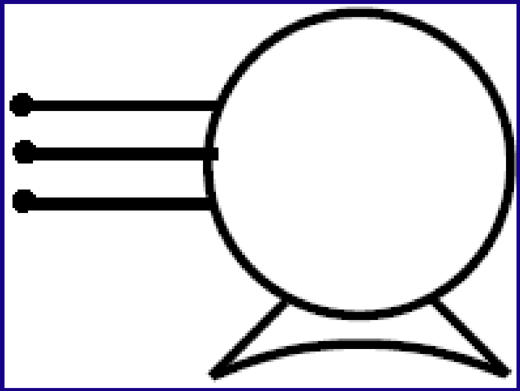
Voltage induced in the conductor rotating in a magnetic field is AC.



U.P.S $\rightarrow$ Input is 12V

Constant 'V' & constant 'F' supply is required.

Now consider a 3-Φ IM



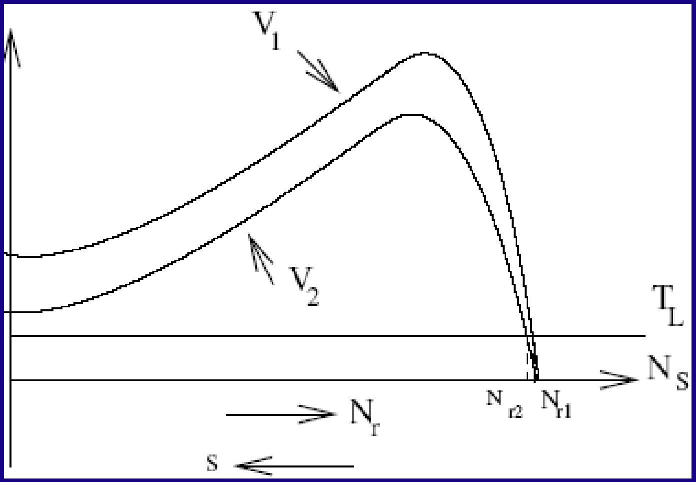
Stator field is rotating at $N_s = \dfrac{120\ F}{P}$

Rotor is stationary ($N_r = 0$)

$N_s - N_r = N_s$

$\Rightarrow$ Current in rotor $\rightarrow$ Current in stator

$\rightarrow$ supply current is very high ($\approx$ 6 I_{RATED})



Assume that 'T_L' is constant.

$\therefore$ T_L = developed torque

$\approx$ constant = $\dfrac{P_2}{2\pi n_S}$

$\Rightarrow$ Air-gap power input is constant

$\Rightarrow$ Input power is constant

$\rightarrow$ almost independent of speed

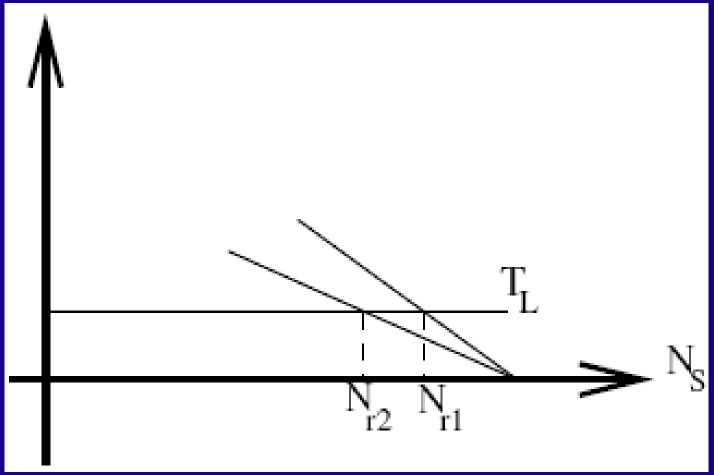
$\Rightarrow$ In order to $\downarrow$ the speed, $\downarrow$ the applied voltage (F is constant)

$T \propto V^2$

$\Rightarrow$ speed $\downarrow$ from N_{r1} to N_{r2}

$\because$ 'F' is constant, N_s is constant.

N_r has to $\downarrow$.



$\therefore$'s' $\uparrow$.

$\because$ P_2 is constant $\Rightarrow$ sP_2 has dissipated as heat.

$$\Rightarrow T_e \propto P_2 \propto \frac{I^2R}{s}$$

$$\therefore\ I \propto \sqrt{s}$$

$\Rightarrow$ Stator copper loss $\uparrow$

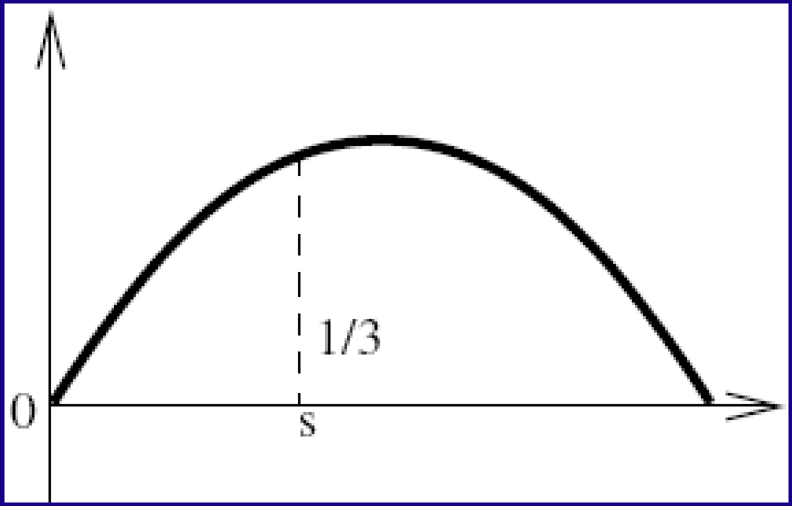
$\Rightarrow$ Heat $\uparrow$ and $\eta \downarrow$

If $T_L \propto N_r^2 \rightarrow$ Fan type of load

$$\propto (1-s)^2$$

$$T_e \propto \frac{I^2R}{s}$$

$$\therefore\ I = (1-s)s^{\frac{1}{2}}$$



If the process requires wide variation in speed

$\Rightarrow$ N_S should be changed especially for

T_L = constant

[in principle, this may not be required

for fan type of loads]

$\Rightarrow$ Even for fan type of load, it is preferred.

$$N_S = \frac{120\ F}{P}$$

$\Rightarrow$ Frequency of stator supply should

be changed