SMPS

SMPS the transistor operates in the switch mode in very high freq. (Cut off region is used for off state & saturation region is used for ON state).

At such an high freq. we can reduce the size of filter as well as Xmer.

* Here we use Ferrite core for high freq. Xmer used in SMPS.
* With the availability of high speed device like power MOSFET SMPS is populary used in now a days.
* SMPS is highly efficient & compact in size.
* In linear power supply the transistor operates in the active region & therefore it is not efficient power supply & it occupy more space & weight (because we use 50 Hz Xmer in linear power supply)

Types of SMPS →

(1) Flyback Converter → * It is derived from Buck-Boost Converter.
* It is also known as isolated Buck-Boost

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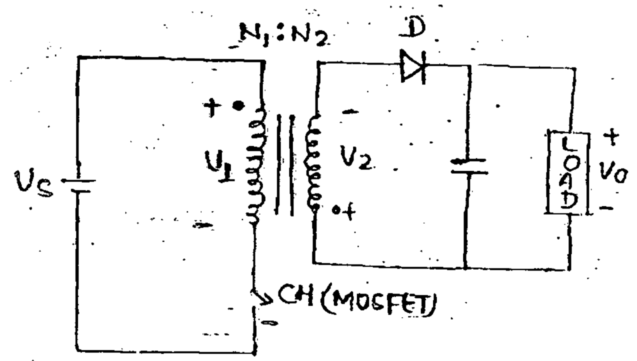
* Here in place of the indctor we are use Xmer here because both stores megnatic energy.



mode (1) → $0 \le t \le T_{ON}$

CH → ON

Xmer stores energy in the form of megnatic field

$V_1 = V_S$

$V_2 = \frac{N_2}{N_1} V_1$

$V_2 = a V_S$

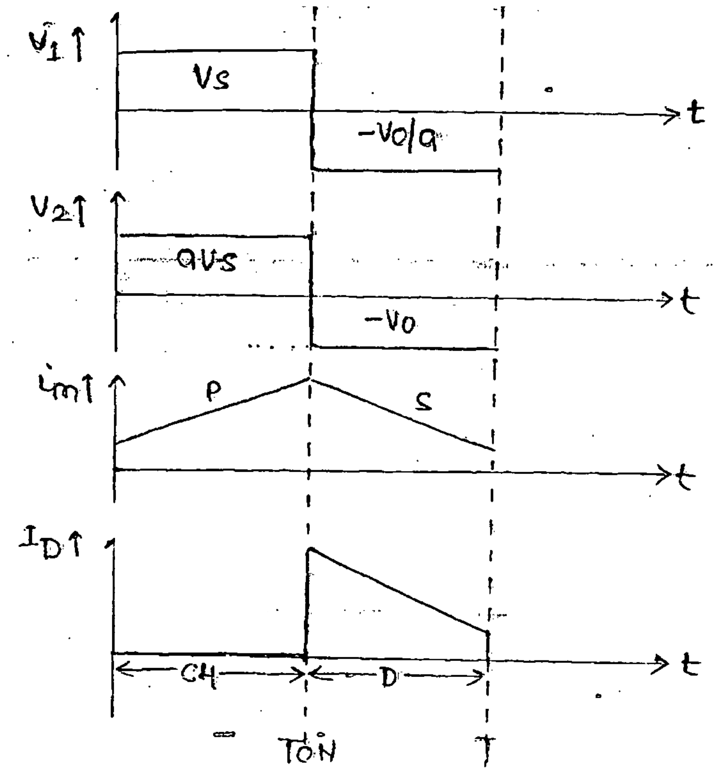
mode (2) → $T_{ON} \le t \le T$

CH → OFF, D → ON

$V_2 = -V_0$

$V_1 = \frac{N_1}{N_2} V_2$

$V_1 = -\frac{V_0}{a}$



$$\boxed{V_0 = \frac{a.\alpha V_s}{(1-\alpha)}}$$

The peak forward blocking voltage of CH switch $= V_s + \frac{V_0}{a}$

Note:- The o/p voltage of front end rectifier without voltage doubling $= V_m$

V_m (Peak value of ac i/p vol.)

o/p voltage of front end rectifier with voltage doubling $= 2V_m$

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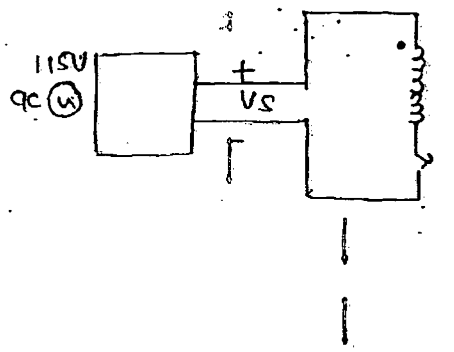


$V_s = 115\sqrt{2}$ (peak)

$V_0 = a.\frac{\alpha V_s}{1-\alpha}$

$35 = \frac{a \times 0.3 \times 115\sqrt{2}}{(1-0.3)}$

$a = 0.5$

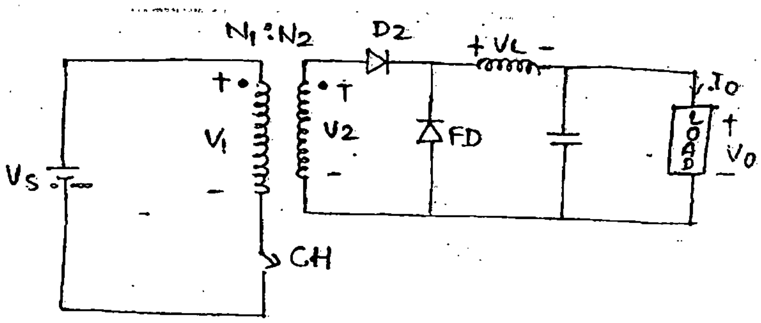
Forward blocking Vol. $= V_s + \frac{V_0}{a} = 115\sqrt{2} + \frac{35}{0.3}$

$= 232.6V$

(2) Forward converter → * It is derived from Buck Conr.

case (1) → Ideal Xmer;

→ $I_m = 0$
→ No Losses
→ No leakage inductance

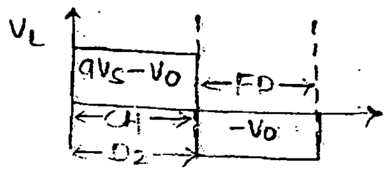


mode (1) → $0 \le t \le T_{ON}$

CH → ON

$V_1 = V_s$; $V_2 = \frac{N_2}{N_1} V_1$

$V_2 = a V_s$



171 Applying KVL;

$-V_2 + V_L + V_0 = 0$

$V_L = V_2 - V_0$

$V_L = aV_s - V_0$

mode (2) → $T_{ON} \le t \le T$

CH → OFF, D_2 → OFF

FD → ON

$+V_L + V_0 = 0$

$V_L = -V_0$

$(V_L)_{avg} = 0$

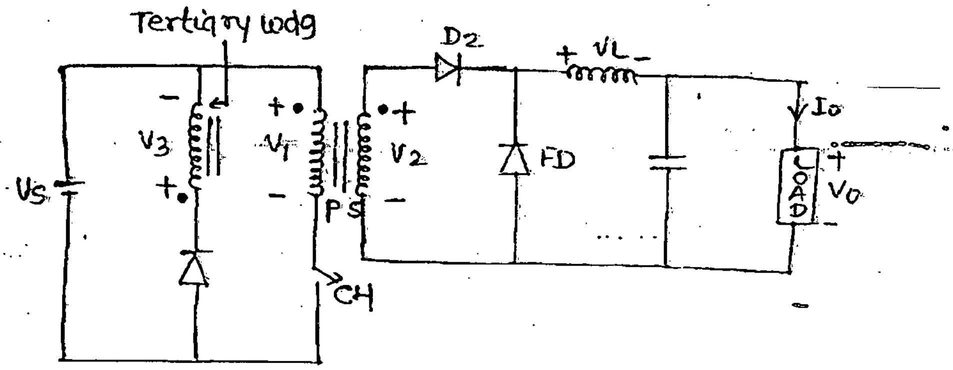
$(aV_s - V_0) T_{ON} - V_0 T_{OFF} = 0$

$aV_s T_{ON} = V_0 T$

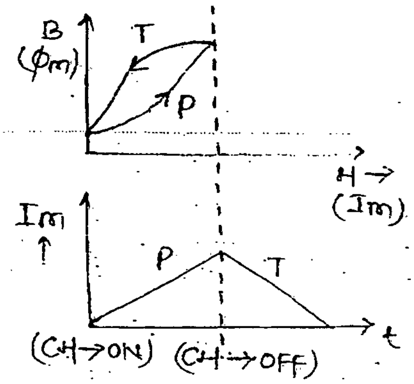
$V_0 = a \cdot \frac{T_{ON}}{T} \cdot V_s$

$$\boxed{V_0 = a\alpha \cdot V_s}$$

Case(2) → For non-ideal Xmer
→ $I_m \neq 0$



* Tertiary wdg is used to provide a path to magnetising current when the CH switch becomes OFF.
* Here Xmer megnatises through 1° wdg & demegnatises through 3° wdg.



* In Flyback & Forward Converters the Xmer is excited only in one dirn.
It is called unidirectional core excitatation.

(3.) Push-Pull Converter → * In this conr the Xmer core is excited bi-directionaly.
Therefore it is called bidirectional core excitation.
Fig is que (5/59).

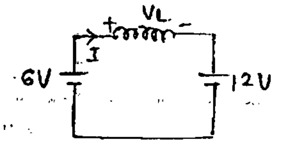
$$V_0 = 2 \cdot a \alpha V_S$$

$$V_0 = 2 \cdot \frac{N_2}{N_1} \cdot \frac{T_{ON}}{T_{ON} + T_{OFF}} \cdot V_S$$

Chopper Question

1/52 0 to T_{ON}

$V_{dc} = 60V$



KVL →

$$-60 + V_L + 12 = 0$$

$$V_L = 48$$

$$L\frac{dI}{dt} = 48$$

$$\int_{I_{min}}^{I_{max}} dI = \frac{48}{L}\int_0^{T_{ON}} dt \qquad \Delta I = \frac{48}{L}T_{ON} = 0.48A.$$

2/52 $I_0 = \frac{\alpha V_S}{R} = \frac{0.8 \times 100}{10} = 8A$

$$(I_D)_{avg} = I_0\left(\frac{T_{OFF}}{T}\right) = I_0(1-\alpha) = 8(1-0.8) = 1.6A$$

3/52 $(t_{OFF})_{min} = \cancel{\frac{CV_S}{R}} = \cancel{1\times10^{-6}\times250} \qquad \pi\sqrt{LC} = 140\mu s.$

4/52 $V_0)_{min} = V_S\frac{(T_{ON})_{eff}}{T} = 47.5V$

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5/52 $(i_m)_{max} = I_0 + V_S\sqrt{\frac{C}{L}} = 12A, \; (i_A)_{max} = I_0 = 10A$

Conventional question →

(a.) (i) $(T_{ON})_{eff} = T_{ON} \cancel{+ 2t_{cm}}$

$= 1075\mu s$

(ii) $t_{cm} = \frac{CV_S}{I_0} = 137.5\mu s$

(b.) $(i_m)_{max} = I_0 + V_S\sqrt{\frac{C}{L}}$; & $(i_A)_{max} = I_0$

(c.) $t_{cA} = \frac{\pi}{2}\sqrt{LC} = 49\mu s$ & $t_{cm} = \frac{CV_S}{I_0}$

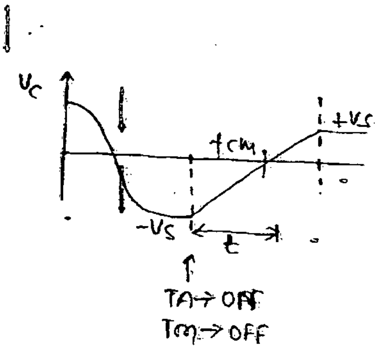
(d.) $2t_{cm} = 275\mu s$

(e.)

$$V_C = \frac{V_S}{t_{cm}}t - V_S$$

$$= \frac{220}{137.5}(150) - 220$$

$$V_C = 20V$$



(8.) $T_{ON}' = T_a \ln\left[1 + m\left(e^{T/\tau_a} - 1\right)\right]$

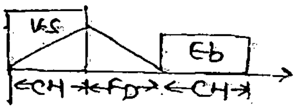
(10.) $t_{min} \le t \le t_{max}$

$\pi\sqrt{LC} \le t \le \frac{3\pi}{2}\sqrt{LC}$

$50\mu s \le t \le 75\mu s$

(11) $I_o + I_p \sin\omega t$

(12.)



$V_o = \frac{V_s t_r + E_b t_r}{t_r + t_f + t_o}$

(13.) $I_{max} = I_o + \frac{\Delta I_c}{2}$

$= 5 + \frac{1.6}{2}$

$= 5.8A$

1-ϕ Half wave Rectifier

Rectifier Load	V_o	V_{or}	t_c	I_o	Other
R	$\frac{V_m}{2\pi}(1+\cos\alpha)$	$\frac{V_m}{2\sqrt{\pi}}\left[(\pi-\alpha)+\frac{1}{2}\sin 2\alpha\right]^{1/2}$	$\frac{\pi}{\omega}$	$(I_s)_{avg}=\frac{V_m}{2\pi R}(1+\cos\alpha)$	$I_{sr}=I_{or}=\frac{V_{or}}{R}$ $V_{sr}=\frac{V_m}{\sqrt{2}}$
R-L	$\frac{V_m}{2\pi}(\cos\alpha-\cos\beta)$	$\frac{V_m}{2\sqrt{\pi}}\left[(\beta-\alpha)+\frac{1}{2}(\sin 2\alpha-\sin 2\beta)\right]^{1/2}$	$\frac{2\pi-\beta}{\omega}$	$i_o=\frac{V_m}{\lvert Z\rvert}\sin(\omega t-\phi)+Ke^{-t/\tau}$	$K=\frac{-V_m}{\lvert Z\rvert}\sin(\alpha-\phi)e^{\frac{-R\alpha}{\omega L}}$
RL+FD	$\frac{V_m}{2\pi}(1+\cos\alpha)$	$\frac{V_m}{2\sqrt{\pi}}\left[(\pi-\alpha)+\frac{1}{2}\sin 2\alpha\right]^{1/2}$	$\frac{\pi}{\omega}$		$PF=\frac{P_o}{V_{sr}.I_{sr}}$
RE	$(V_o)_{avg}=\frac{1}{2\pi}\left[V_m(\cos\alpha-\cos\theta_2)+E(2\pi+\alpha-\theta_2)\right]$		$\frac{\pi+2\theta_1}{\omega}$	$\frac{1}{2\pi R}\left[V_m(\cos\alpha-\cos\theta_2)-E(\theta_2-\alpha)\right]$	(1.) $PF=\frac{I_{or}^2R+EI_o}{V_{sr}I_{sr}}$ (2.) $I_{or}=\left[\frac{1}{2\pi}\int_{\alpha}^{\theta_2}\left(\frac{V_m\sin\omega t-E}{R}\right)^2\right]^{1/2}$ (3.) PIV of thy. $=V_m+E$ $\theta_1=\sin^{-1}\left(\frac{E}{V_m}\right)$ $\theta_2=\pi-\theta_1$

1-ϕ Fully Controlled Conr

Rectifier load	V_0	V_{or}	t_c	Other
R load	$\frac{V_m}{\pi}(1+\cos\alpha)$	$\frac{V_m}{\sqrt{2\pi}}\left[(\pi-\alpha)+\frac{1}{2}\sin 2\alpha\right]^{1/2}$	$\frac{\pi}{\omega}$	(1.) $PF=\frac{1}{\sqrt{\pi}}\left[(\pi-\alpha)+\frac{1}{2}\sin 2\alpha\right]^{1/2}$ (2.) Mid pt. Recr PIV $=2V_m$ Bridge PIV $=V_m$
RL (discontineous)	$\frac{V_m}{\pi}(\cos\alpha-\cos\beta)$	$\frac{V_m}{\sqrt{2\pi}}\left[(\beta-\alpha)+\frac{1}{2}(\sin 2\alpha-\sin 2\beta)\right]^{1/2}$	$\frac{2\pi-\beta}{\omega}$	— —
RL (contineous)	$\frac{2V_m}{\pi}\cos\alpha$	$\frac{V_m}{\sqrt{2\pi}}\left[\pi\right]^{1/2} \cancel{+\tfrac{1}{2}} = \frac{V_m}{\sqrt{2}} = V_{sr}$	$\frac{\pi-\alpha}{\omega}$	(1.) $I_{sr}=I_0$ High inductive load (1.) Condn angle of thy. $=\pi$ rad's $(I_T)avg=\frac{I_0}{2}$, $(I_T)_{Rms}=\frac{I_0}{\sqrt{2}}$
RE	$\frac{1}{\pi}\left[V_m(\cos\alpha-\cos\theta_2)+E(\pi+\alpha-\theta_2)\right]$		$\frac{\pi+2\theta_1}{\omega}$	(1.) $I_0=\frac{1}{\pi R}\left[V_m(\cos\alpha-\cos\theta_2)-E(\theta_2-\alpha\right.$ (2.) $i_0=\frac{V_m\sin\omega t-E}{R}$
RLE contineous	$\frac{2V_m}{\pi}\cos\alpha$	$PF=\frac{2\sqrt{2}}{\pi}\cos\alpha$, $THD=0.4834$ $P=\frac{2V_m}{\pi}I_0\cos\alpha=V_0I_0$ $Q=V_0I_0\tan\alpha$ $FF=\frac{\pi}{2\sqrt{2}}\cdot\frac{1}{\cos\alpha}$		$I_{sR}=I_0$ $I_{s1}=\frac{2\sqrt{2}I_0}{\pi}$, $FDF=\cos\alpha$ $g=\frac{2\sqrt{2}}{\pi}$, $I_{sn}=\frac{2\sqrt{2}I_0}{n\pi}$
RLE Discontineous	$\frac{1}{\pi}\left[V_m(\cos\alpha-\cos\beta)+E_b(\pi+\alpha-\beta)\right]$			

1φ semiconverter

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★ $V_0 = \frac{V_m}{\pi}(1+\cos\alpha)$

★ $V_{or} = \frac{V_m}{\sqrt{2\pi}}\left[(\pi-\alpha)+\frac{1}{2}\sin 2\alpha\right]^{1/2}$

Cond^n angle of each thy $= \pi-\alpha$

★ $(I_T)_{avg} = I_0\left(\frac{\pi-\alpha}{2\pi}\right)$

★ $(I_T)_{Rms} = I_0\left(\frac{\pi-\alpha}{2\pi}\right)^{1/2}$

Cond^n angle of FD $= \alpha$

★ $(I_{FD})_{avg} = I_0\left(\frac{\alpha}{\pi}\right)$

★ $(I_{FD})_{Rms} = I_0\left(\frac{\alpha}{\pi}\right)^{1/2}$

★ $I_{sr} = I_0\left(\frac{\pi-\alpha}{\alpha}\right)^{1/2}$

with dc motor (RLE load)

Discontineous Cond^n:-

(1.) $\beta < \pi$;

★ $V_0 = \frac{1}{\pi}\left[(\cos\alpha-\cos\beta)V_m + E_b(\pi+\alpha-\beta)\right]$

(2.) $\beta > \pi$;

★ $V_0 = \frac{1}{\pi}\left[V_m(1+\cos\alpha)+E_b(\pi+\alpha-\beta)\right]$

Contineous cond^n →

★ $V_0 = \frac{V_m}{\pi}(1+\cos\alpha)$

★ $I_{sr} = I_0\left(\frac{\pi-\alpha}{\pi}\right)^{1/2}$

★ $I_{SN} = \frac{2\sqrt{2}}{n\pi} I_0 \cos\frac{n\alpha}{2}$

★ $I_{S1} = \frac{2\sqrt{2}}{\pi} I_0 \cos\frac{\alpha}{2}$

★ $FDF = \cos\frac{\alpha}{2}$

★ $g = \frac{2\sqrt{2}\cos\alpha/2}{\sqrt{(\pi-\alpha)\pi}}$

★ $PF = \frac{\sqrt{2}(1+\cos\alpha)}{\sqrt{\pi(\pi-\alpha)}}$

★ $THD = \left[\frac{\pi(\pi-\alpha)}{8\cos^2\alpha/2}-1\right]^{1/2}$

★ $P = V_{sr} I_{sr} \cdot \cos\alpha/2$

★ $Q = V_0 I_0 \tan\frac{\alpha}{2}$

Spec.	1ϕ-full converter	1-ϕ semi-converter	3-ϕ full conv.
i_s	$\frac{4I_o}{n\pi}\sin(n\omega t+\phi_n)$	$\frac{4I_o}{n\pi}\cos\frac{n\alpha}{2}\sin(n\omega t+\phi_n)$	$\frac{4I_o}{n\pi}\sin\frac{n\pi}{2}\sin(n\omega t+\phi_n)$
I_{s1}	$\frac{2\sqrt{2}}{\pi}I_o$	$\frac{2\sqrt{2}}{\pi}I_o\cos\frac{\alpha}{2}$	$\frac{2\sqrt{2}}{\pi}I_o\sin\frac{\pi}{3}=\frac{\sqrt{6}}{\pi}I_o$
FDF	$\cos\alpha$	$\cos\frac{\alpha}{2}$	$\cos\alpha$
g	$\frac{2\sqrt{2}}{\pi}$	$\frac{2\sqrt{2}\cos\alpha/2}{\sqrt{\pi(\pi-\alpha)}}$	$\frac{3}{\pi}$
PF	$\frac{2\sqrt{2}}{\pi}\cos\alpha$	$\frac{\sqrt{2}(1+\cos\alpha)}{\sqrt{\pi(\pi-\alpha)}}$	$\frac{3}{\pi}\cos\alpha$
THD	48.34%	$\left[\frac{\pi(\pi-\alpha)}{8\cos^2\frac{\alpha}{2}}-1\right]^{1/2}$	31%

Specifi:	Current Commutated chopper (class B)	Voltage Commutated Chopper (Class D)
$(I_{Tm})_{peak}$	I_o	$I_o + I_p = I_o + V_s\sqrt{\frac{C}{L}}$
$(I_{TA})_{peak}$	$I_p = V_s\sqrt{\frac{C}{L}}$	I_o
* Cond^n time of the TA	$\pi\sqrt{LC}$	$2t_{cm}$
* t_{cm}	$\frac{V_R C}{I_o}$	$\frac{V_s C}{I_o}$ $RC\ln 2$ (with R load)
* total Time req. to turn off Tm after TA is ON	$t_1 + t_2 = \pi\sqrt{LC} + \sqrt{LC}\sin^{-1}\left(\frac{I_o}{I_p}\right)$	
* $(T_m)_{min}$ = $t_{min}(min)$ time req. to turn off the Tm after TA ON	$\pi\sqrt{LC}$	
* t_{max}	$\frac{3\pi}{2}\sqrt{LC}$	
* Reverse vol.	$V_R = V_s\cos\left[\sin^{-1}\left(\frac{I_o}{I_p}\right)\right]$	
* $(T_{ON})_{min}$		$\pi\sqrt{LC}$
* PIV of FD		$2V_s$
* PIV of Tm		V_s
* t_{cA}		$\frac{\pi}{2}\sqrt{LC}$
* commutation interval		$2t_{cm}$
* $(T_{ON})_{eff}$		$T_{ON} + 2t_{cm}$
* V_o		$V_s \frac{(T_{ON})_{eff}}{T}$
* $(V_o)_{min}$		$V_s(\pi\sqrt{LC} + 2t_{cm})f$