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Important paints of step down chopper

→ A step-down chopper that acts as a variable resistance load can produce an output voltage from 0 to $V_s$.

→ Although a dc converter can be operated either at a fixed or variable frequency, it is usually operating at fixed frequency with a variable duty cycle.

→ The output voltage contains harmonics and a dc filter is needed to smooth out the ripples

# Generation of duty cycle:

Duty cycle K can be generated by comparing a dc reference signal $v_r$ with saw tooth carrier signal $v_{cr}$. It is shown in fig. 3 where $V_r$ is the peak value of $v_r$, and $V_{cr}$ is the peak value of $v_{cr}$. The reference signal $v_r$ is given by

$$v_r = \frac{V_r}{T} t \qquad \text{— (12)}$$

which must equal to the carrier signal

$v_{cr} = V_{cr}$ at KT. That is

$$V_{cr} = \frac{V_r}{T} \cdot KT$$

which gives the duty cycle K as

$$K = \frac{V_{cr}}{V_r} = M \qquad \text{— (13)}$$

where M is the modulation index. By varying the carrier signal $v_{cr}$ from 0 to $V_{cr}$ the duty cycle K can be varied from 0 to 1

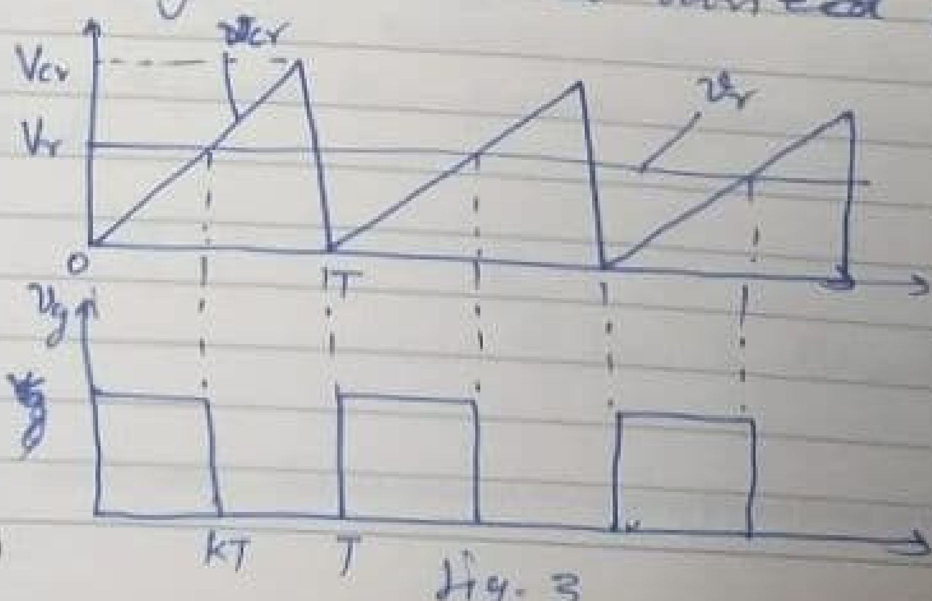


Fig. 3

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## Step down converter with RL Load:

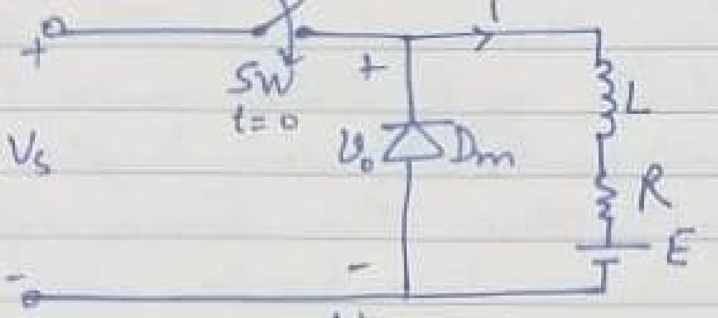
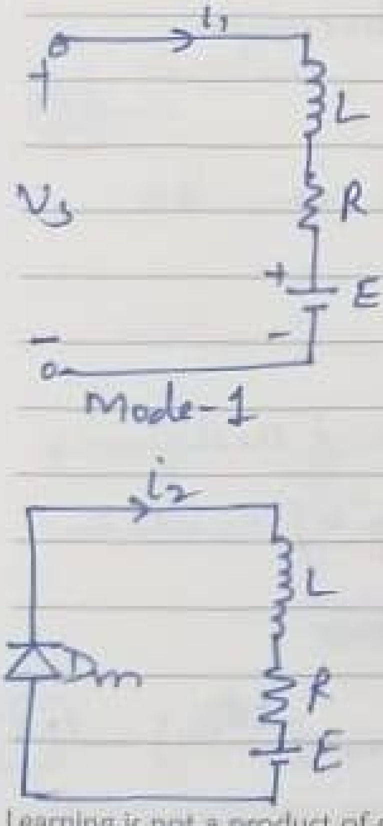
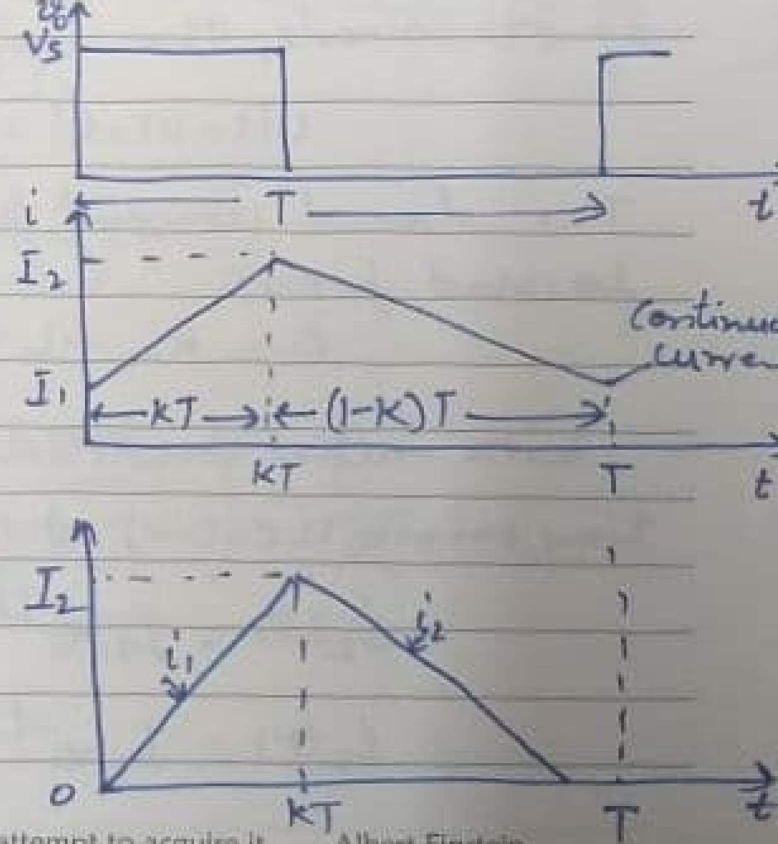



fig. 4

Converter with RL Load is shown in fig-4. Operation is devided into two modes. During mode-1, converter is switched on and the current flows from supply to load. During mode-2, the converter is switched off and the load current continues to flow through freewheeling diode Dm. The equivalent ckt and waveforms are shown in fig. 5(a) and 5(b) respectively.




(a) Equivalent ckts




(b) waveforms.

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Waveforms are drawn with the assumption that load current varies linearly. However, the current flowing through inductor rises or falls exponentially with a time constant. The load time constant ($T = \frac{L}{R}$) is much higher than the switching period T. Thus the linear approximation is valid.

The load current for mode-1

$$V_s = Ri_1 + L\frac{di_1}{dt} + E$$

with initial condition $i_1(t=0) = I_1$ gives the load current as

$$i_1(t) = I_1 e^{-tR/L} + \frac{V_s - E}{R}(1 - e^{-tR/L}) \quad \text{—(14)}$$

this mode is valid for $0 \leq t \leq t_1 (= KT)$ and at the end of this mode, the load current becomes.

$$i_1(t = KT = t_1) = I_2 \quad \text{—(15)}$$

The load current for mode-2 can be found from

$$0 = Ri_2 + L\frac{di_2}{dt} + E$$

with initial condition $i_2(t=0) = I_2$ and redefining time origin (i.e. $t=0$) at the beginning of mode 2,

$$\cancel{i_2(t) = I_2 e^{-t/R/L} + L\frac{di_2}{dt} + E}$$

$$i_2(t) = I_2 e^{-tR/L} - \frac{E}{R}(1 - e^{-tR/L}) \quad \text{—(16)}$$

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This mode is valid for $0 \le t \le t_2 [=(1-K)T]$ at the end of this mode, the load current becomes

$$i_2(t=t_2) = I_3 \quad \text{--- (17)}$$

At the end of mode 2, the converter is turned on again in the next cycle.

Under steady state condition,

$$I_1 = I_3$$

The peak to peak ripple current can be determined from eqn (14) to (17).

From eqn (14) and (15) gives

$$I_2 = I_1 e^{-KTR/L} + \frac{V_s - E}{R}\left(1 - e^{-KTR/L}\right)$$

from eqn (16) and (17) $I_3$ is given

$$I_3 = I_1 = I_2 e^{-(1-K)TR/L} - \frac{E}{R}\left(1 - e^{-(1-K)TR/L}\right)$$

Solving for $I_1$ and $I_2$

$$I_1 = \frac{V_s}{R}\left(\frac{e^{Kz} - 1}{e^{z} - 1}\right) - \frac{E}{R}$$

where $z = \frac{TR}{L}$

$$I_2 = \frac{V_s}{R}\left(\frac{e^{-Kz} - 1}{e^{-z} - 1}\right) - \frac{E}{R}$$