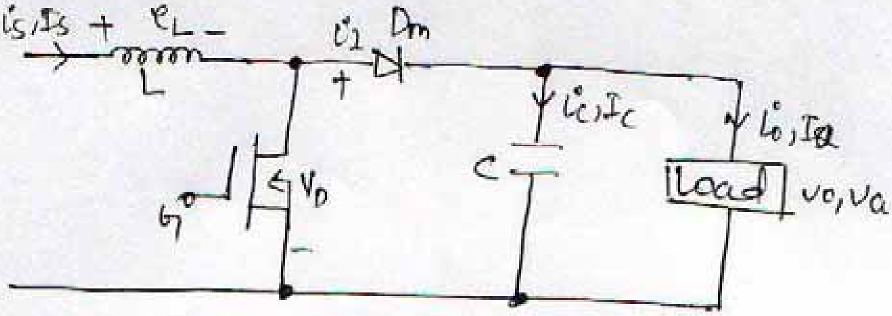
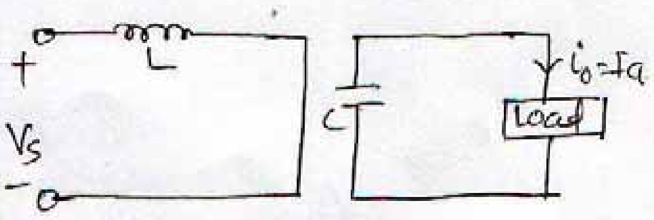
Boost Converter

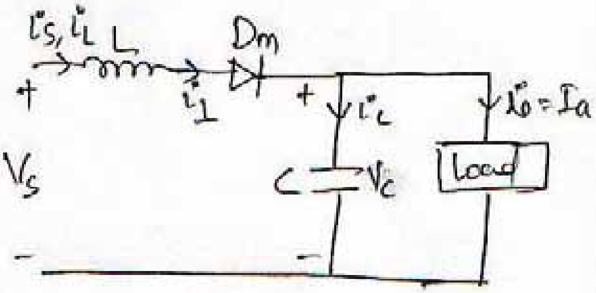


Circuit Diagram

Equivalent Circuits



Mode-1.



Mode-2.

Mode-1

$$v_s = e_L = L\frac{di_L}{dt}$$

or, $$\int_0^{t_1} v_s\,dt = \int_{I_1}^{I_2} L\,di_L$$

or, $$t_1 \cdot V_s = L(I_2 - I_1)$$

or, $$t_1 = \frac{L(I_2 - I_1)}{V_s}$$

$$\therefore t_1 = \frac{L\Delta I}{V_s} \quad \text{—— (i)}$$

Mode-2

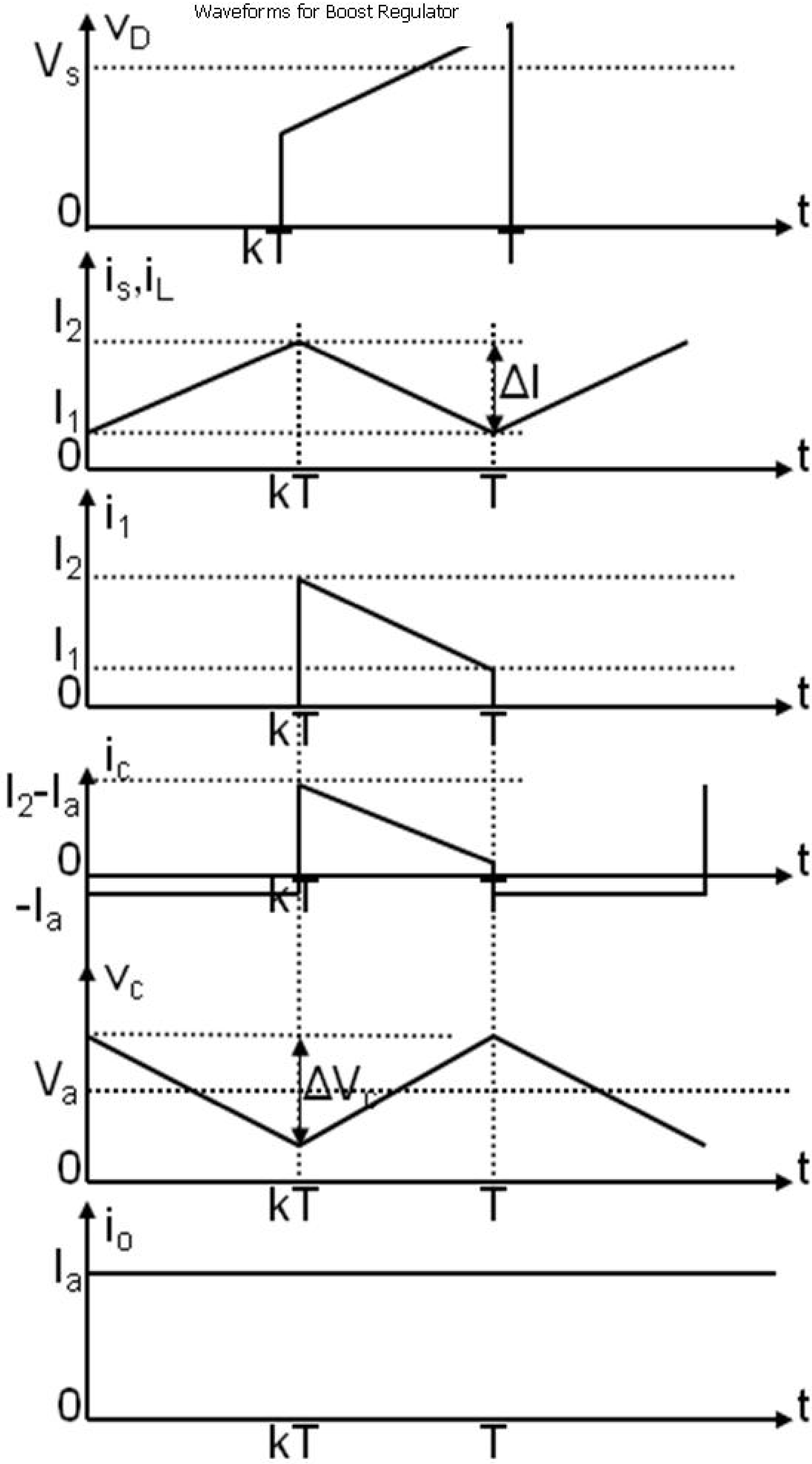
$$V_s - V_a = e_L = L\frac{di_2}{dt}$$

or, $$\int_0^{t_2} (V_s - V_a)\,dt = \int_{I_2}^{I_1} L\,di_L$$

or, $$(V_s - V_a)\,t_2 = L(I_1 - I_2)$$

or, $$t_2 = \frac{L(I_1 - I_2)}{V_s - V_a} = \frac{L(I_2 - I_1)}{V_a - V_s} = \frac{L\Delta I}{V_a - V_s} \quad \text{—— (ii)}$$

Waveforms for Boost Regulator



From eqⁿs (i) and (ii),

$$T = t_1 + t_2$$

$$T = \frac{V_a L \Delta I}{V_s (V_a - V_s)} \quad \text{—— (iii)}$$

Further,

$$K = \frac{t_1}{T} = \frac{t_1}{t_1 + t_2} = \frac{(L\Delta I / V_s)}{\frac{L\Delta I}{V_s} + \frac{L\Delta I}{V_a - V_s}} = \frac{1}{1 + \frac{V_s}{V_a - V_s}} = \frac{V_a - V_s}{V_a} = 1 - \frac{V_s}{V_a} \quad \text{—— (iv)}$$

From (iv),

$$1 - K = \frac{V_s}{V_a}$$

$$\therefore \boxed{V_a = \frac{V_s}{1-K}} \quad \text{for, } K < 1, \; V_a > V_s$$

The transfer function of Boost regulater $\left(\frac{V_a}{V_s}\right) = \frac{1}{1-K}$

from eqⁿ (iii)

$$\Delta I = \frac{T(V_a - V_s)V_s}{V_a L}$$

$$= \frac{T V_s \cancel{V_a}\left(1 - \frac{V_s}{V_a}\right)}{L \cancel{V_a}}$$

$$= \frac{T V_s \left[1 - (1-K)\right]}{L}$$

$$= \frac{T V_s \left[\cancel{1} - \cancel{1} + K\right]}{L}$$

$$\boxed{\Delta I = \frac{V_s K}{f L}} \quad \text{—— (V)}$$

When the transister is on, the capacitor supplies the load current for $t = t_1$. The average capacitor current during time t_1 is $I_c = I_a$ and the peak to peak ripple voltage of capacitor is,

$$\Delta V_c = v_c - v_c\Big|_{t=0} = \frac{1}{C}\int_0^{t_1} I_c \, dt = \frac{1}{C}\int_0^{t_1} I_a \, dt = \frac{I_a t_1}{C} \quad \text{—— (VI)}$$

Subtituting the value of t_1 from eqⁿ (i),

$$\Delta v_c = \frac{I_a}{C}\left(\frac{L\Delta I}{V_s}\right) = \frac{I_a}{\bullet}\left(\frac{V_a - V_s}{V_a f C}\right) = \frac{I_a \cancel{V_a}\left(1 - \frac{V_s}{V_a}\right)}{\cancel{V_a} f C} = \frac{I_a(\cancel{1} - \cancel{1} + K)}{fC} = \frac{I_a K}{fC} \quad \text{—— (VII)}$$

Condition for Continuous Inductor current and capacitor Voltage.

If I_L is the average inductor current, the inductor ripple current

$$\Delta I = 2I_L$$

$$\text{or, } \frac{V_s K}{fL} = 2I_a$$

$$\text{or, } \frac{V_s K}{fL} = 2 \cdot \frac{V_a}{R}$$

$$\text{or, } \frac{\cancel{V_s} K}{fL} = 2 \cdot \frac{\cancel{V_s}}{(1-K) R}$$

Which gives the critical value of inductor L_c as

$$\boxed{L_c = L = \frac{K(1-K)R}{2f}}$$

If V_c is the average capacitor voltage, the capacitor ripple voltage $\Delta V_c = 2V_a$.

$$\text{or, } \frac{I_a K}{fC} = 2V_a$$

$$\text{or, } \frac{\cancel{I_a} K}{fC} = 2\cancel{I_a} R$$

Which gives the critical value of capacitor C_c as.

$$\boxed{C_c = C = \frac{K}{2fR}}$$

Numerical

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