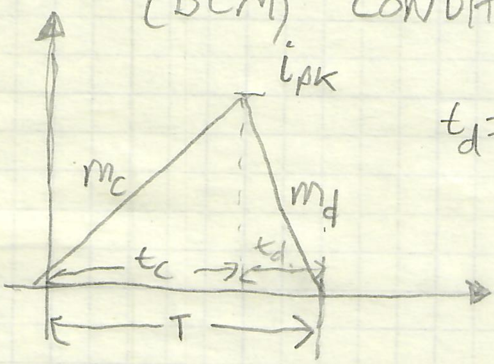
BOUNDARY CONDUCTION MODE (BCM) CONDITION



$t_d = T - t_c$

$$m_c t_c = m_d (T - t_c) \qquad t_c = \frac{i_{pk}}{m_c}$$

$$m_c t_c = m_d T - m_d t_c$$

$$t_c (m_c + m_d) = m_d T$$

$$t_c = \frac{m_d T}{m_c + m_d}$$

$$\frac{i_{pk}}{\cancel{m_c}} = \frac{m_c m_d T}{(m_c + m_d)} = \frac{\frac{V_{CG}}{L} \frac{V_{DG}}{L}}{\frac{V_{CG}}{L} + \frac{V_{DG}}{L}} T = \frac{\frac{V_{CG}}{L} \frac{V_{DG}}{L}}{V_{CG} + V_{DG}}$$

$$\boxed{i_{pk} = \frac{V_{CG} V_{DG}}{V_{CG} + V_{DG}} \frac{T}{L}}$$

PEAK CURRENT DURING BCM OPERATION (1)

$$i_{CG} = \frac{L}{2TV_{CG}} i_{pk}^2 \qquad i_{DG} = \frac{L}{2TV_{DG}} i_{pk}^2$$

$$\frac{2\cancel{TV_{CG}}}{\cancel{L}} i_{CG} = \left(\frac{\cancel{V_{CG}} V_{DG}}{(V_{CG} + V_{DG})} \frac{T}{\cancel{L}} \right) \frac{V_{CG} V_{DG}}{V_{CG} + V_{DG}} \left(\frac{T}{L} \right)$$

$$2 i_{CG} = \frac{T}{L} \frac{V_{DG}^2 V_{CG}}{(V_{CG} + V_{DG})^2}$$

$$\boxed{i_{CG} = \frac{T}{2L} \frac{V_{DG}^2 V_{CG}}{(V_{CG} + V_{DG})^2}}$$

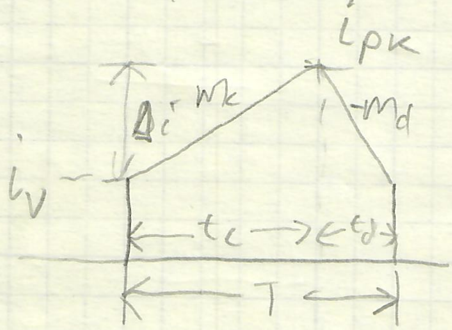
AVERAGE CHARGING CYCLE CURRENT DURING BCM OPERATION (2)

$$\frac{2\cancel{T}\,\cancel{V_{DG}}}{\cancel{L}}\, i_{DG} = \left(\frac{V_{CG}\,\cancel{V_{DG}}}{V_{CG}+V_{DG}}\right)\left(\frac{\cancel{T}}{\cancel{L}}\right)\left(\frac{V_{CG}\,V_{DG}}{V_{CG}+V_{DG}}\right)\left(\frac{T}{L}\right)$$

$$\boxed{i_{DG} = \frac{T}{2L}\,\frac{V_{CG}^2\,V_{DG}}{(V_{CG}+V_{DG})^2}}$$

AVERAGE DISCHARGING CYCLE CURRENT DURING BCM OPERATION (3)

CONTINUOUS CONDUCTION MODE (CCM)
STEADY-STATE CONDITIONS



$$m_c t_c = m_d\,(T - t_c)$$

$$t_c = \frac{m_d T}{m_c + m_d}$$

$$i_{pk} - i_v = t_c\, m_c$$

$$t_c = \frac{i_{pk} - i_v}{m_c}$$

$$\frac{m_d T}{m_c + m_d} = \frac{i_{pk} - i_v}{m_c}$$

$$i_{pk} - i_v = \frac{m_c m_d T}{m_c + m_d} =$$

$$i_{DG} = \frac{L}{2T V_{DG}}\left(i_{pk}^2 - i_v^2\right)$$

$$i_{pk} - i_v = \frac{V_{CG}\,V_{DG}}{V_{CG}+V_{DG}}\,\frac{T}{L}$$

$$\boxed{\Delta i = \frac{V_{CG}\,V_{DG}}{V_{CG}+V_{DG}}\,\frac{T}{L}}$$ (4) Δi

$$i_{pk} = \frac{V_{CG}\,V_{DG}}{V_{CG}+V_{DG}}\,\frac{T}{L} + i_v$$

$$i_{pk}^2 = \left(\frac{V_C V_D}{V_C + V_D}\frac{T}{L} + i_V\right)\left(\frac{V_C V_D}{V_C + V_D}\frac{T}{L} + i_V\right)$$

$$\frac{V_C^2 V_D^2}{(V_C+V_D)^2}\left(\frac{T}{L}\right)^2 + 2\,\frac{V_C V_D}{V_C+V_D}\frac{T}{L}\,i_V + i_V^2$$

$$i_{pk}^2 - i_V^2 = \frac{(V_C V_D)^2}{(V_C+V_D)^2}\left(\frac{T}{L}\right)^2 + \frac{2T}{L}\,\frac{V_C V_D}{V_C+V_D}\,i_V$$

VALLEY CURRENT AS FUNCTION OF DISCHARGE CURRENT

$$\frac{2T\,V_D}{L}\,i_D = \frac{(V_C V_D)^2}{(V_C+V_D)^2}\left(\frac{T}{L}\right)^2 + \frac{2T}{L}\,\frac{V_C V_D}{V_C+V_D}\,i_V$$

$$\frac{(V_C+V_D)L}{V_C V_D\,2T}\left[\frac{2T\,V_D}{L}\,i_D - \frac{(V_C V_D)^2}{(V_C+V_D)^2}\left(\frac{T}{L}\right)^2\right] = \left[\frac{2T}{L}\,\frac{V_C V_D}{V_C+V_D}\,i_V\right]\frac{L}{2T}\,\frac{(V_C+V_D)}{V_C V_D}$$

$$\frac{V_D(V_C+V_D)}{V_C V_D}\,i_D - \frac{V_C V_D}{V_C+V_D}\,\frac{T}{2L} = i_V$$

$$\boxed{i_V = \frac{V_{CG}+V_{DG}}{V_{CG}}\,i_{DG} - \frac{V_{CG}V_{DG}}{V_{CG}+V_{DG}}\,\frac{T}{2L}}$$

VALLEY CURRENT AS FUNCTION OF DISCHARGE CYCLE CURRENT

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CHECK VALLEY CURRENT AT BCM

e.g. $i_V = 0$ (DISCHARGING)

$$\frac{V_{CG}+V_{DG}}{V_{CG}} i_{DG} - \frac{V_{CG}V_{DG}}{V_{CG}+V_{DG}} \frac{T}{2L} = 0$$

$$i_{DG} = \frac{V_{CG}}{V_{CG}+V_{DG}} \left(\frac{V_{CG}V_{DG}}{V_{CG}+V_{DG}} \right) \frac{T}{2L}$$

$$i_{DG} = \frac{T}{2L} \frac{V_{CG}^2 V_{DG}}{(V_{CG}+V_{DG})^2} \quad 6 = 3$$

CHECK

DISCHARGE CURRENT FOR BCM

6 CHECK (3)

VALLEY CURRENT AS FUNCTION OF CHARGE CURRENT

$$\frac{2T V_{CG}}{L} i_{CG} = \frac{(V_C V_D)^2}{(V_C+V_D)^2} \left(\frac{T}{L}\right)^2 + \frac{2T}{L} \frac{V_C V_D}{V_C+V_D} i_V$$

$$\frac{L}{2T} \frac{V_C+V_D}{V_C V_D} \left[\frac{2T V_C}{L} i_{CG} - \frac{(V_C V_D)^2}{(V_C+V_D)^2} \left(\frac{T}{L}\right)^2 \right] = \left(\frac{2T}{L} \frac{V_C V_D}{V_C+V_D} i_V \right) \frac{L}{2T} \frac{V_C+V_D}{V_C V_D}$$

$$\frac{V_C+V_D}{V_D} i_{CG} - \frac{T}{2L} \frac{V_C V_D}{V_C+V_D} = i_V$$

$$\boxed{i_V = \frac{V_{CG}+V_{DG}}{V_{DG}} i_{CG} - \frac{T}{2L} \frac{V_{CG}V_{DG}}{V_{CG}+V_{DG}}}$$

VALLEY CURRENT AS FUNCTION OF CHARGING CYCLE AVERAGE CURRENT

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CHECK VALLEY CURRENT AT BCM (CHARGING)

$$\frac{V_{CG}+V_{DG}}{V_{DG}}\, i_{DG} = \frac{T}{2L}\,\frac{V_{CG}V_{DG}}{V_{CG}+V_{DG}}$$

$$\boxed{i_{DG} = \frac{T}{2L}\,\frac{V_{DG}^2 V_{CG}}{(V_{CG}+V_{DG})^2}}$$

(8) = (2) CHECK

CHARGE CURRENT FOR BCM

(8) CHECK (2)

CCM PEAK CURRENT AS FUNCTION OF i_{CG}, i_{DG}

$$\Delta i = \frac{V_{CG}V_{DG}}{V_{CG}+V_{DG}}\,\frac{T}{L} \quad \text{FROM (4)}$$

$$i_{pk} = i_v + \Delta i$$

$$\boxed{i_{pk} = \frac{V_{CG}+V_{DG}}{V_{DG}}\, i_{CG} + \frac{T}{2L}\,\frac{V_{CG}V_{DG}}{V_{CG}+V_{DG}}}$$

AS FUNCTION OF CHARGING CYCLE CURRENT (9)

$$\boxed{i_{pk} = \frac{V_{CG}+V_{DG}}{V_{CG}}\, i_{DG} + \frac{T}{2L}\,\frac{V_{CG}V_{DG}}{V_{CG}+V_{DG}}}$$

AS FUNCTION OF DISCHARGING CYCLE CURRENT (10)

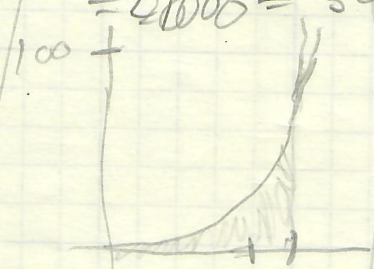
UNRELATED

$$\int_0^{10} x^2\, dx$$

$$\left[\frac{1}{\cancel{2}3}x^3\right]_0^{10}$$

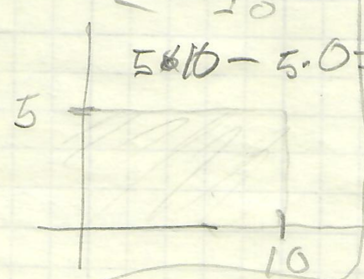
$$\frac{1}{3}\,2\cdot 10 - 2\cdot 0$$

$$= \frac{1}{2}\,1000 = 500$$



$$\int_0^{10} 5\, dx = \left[5x\right]_0^{10}$$

$$5\cdot 10 - 5\cdot 0 = 5\cdot 10 = 50$$



CHECK

$$\frac{V_{CG} + V_{DG}}{V_{CG}} i_{DG} = \frac{V_{CG} + V_{DG}}{V_{DG}} i_{CG}$$

$$V_{DG} \, i_{DG} = V_{CG} \, i_{CG}$$

POWER OUT = POWER IN

CHECK