boost
Basic Equations

$$I_{ref}(\theta) = \frac{P_o}{V_{pk}} \tag{1}$$

$$\delta_Q(\theta) = 1 - \frac{V_{pk}}{V_o} \tag{2}$$

$$\delta_D(\theta) = \frac{V_{pk}}{V_o} \tag{3}$$

$$\tag{4}$$

Bilateral Triangle Δ^B
A = triangle peak-to-peak
DT = time of triangle peak

$$\Delta^B_{rms}(A, B, D, T) = \frac{\sqrt{\int_0^{DT} \left(-\frac{A}{2} + \frac{At}{DT}\right)^2 dt + \int_0^{T(1-D)} \left(-\frac{A}{2} + \frac{At}{T(1-D)}\right)^2 dt}}{\sqrt{T}} \tag{5}$$

$$\Delta^B_{rms}(A, B, D, T) = \frac{A}{2\sqrt{3}} \tag{6}$$

$$\Delta^B_{avg}(A, B, D, T) = \frac{\int_0^{DT} \left(-\frac{A}{2} + \frac{At}{DT}\right) dt + \int_0^{T(1-D)} \left(-\frac{A}{2} + \frac{At}{T(1-D)}\right) dt}{T} \tag{7}$$

$$\Delta^B_{avg}(A, B, D, T) = 0 \tag{8}$$

$$\tag{9}$$

Elevated Right Triangle Δ^R
B = Tri Y Midpoint
A = triangle height

DT = time of triangle peak

$$\Delta^R_{rms}(A,B,D,T) = \frac{\sqrt{\int_0^{DT} \left(-\frac{A}{2} + \frac{At}{DT} + B\right)^2 \, dt}}{\sqrt{T}} \tag{10}$$

$$\Delta^R_{rms}(A,B,D,T) = \frac{\sqrt{D}\sqrt{A^2 + 12B^2}}{2\sqrt{3}} \tag{11}$$

$$\Delta^R_{avg}(A,B,D,T) = \frac{\int_0^{DT} \left(-\frac{A}{2} + \frac{At}{DT} + B\right) \, dt}{T} \tag{12}$$

$$\Delta^R_{avg}(A,B,D,T) = BD \tag{13}$$

$$\tag{14}$$

Inductor rms simple

$$I_{ref,rms} = \frac{\sqrt{\int_0^{\pi} \frac{P_o^2}{V_{pk}^2} \, d\theta}}{\sqrt{\pi}} \tag{15}$$

$$I_{ref,rms} = \frac{P_o}{V_{pk}} \tag{16}$$

$$I_{L,rms} = I_{ref,rms} \tag{17}$$

$$\tag{18}$$

Inductor rms with ripple

$$\Delta i_{L,pp}(\theta) = v_{In}(\theta)\frac{\delta_Q(\theta)}{Lf} \tag{19}$$

$$\Delta i_{L,pp}(\theta) = \frac{V_{pk}\left(1-\frac{V_{pk}}{V_o}\right)}{Lf} \tag{20}$$

$$\Delta i_{L,rms,t}(\theta) = \Delta^B_{rms}(A = i_{LR,pp}) \tag{21}$$

$$\Delta i_{L,rms,t}(\theta) = \frac{V_{pk}\left|V_o - V_{pk}\right|}{2\sqrt{3}LV_o f} \tag{22}$$

$$\Delta I_{L,rms} = \frac{\sqrt{\int_0^\pi \frac{V_{pk}^2\left(V_o-V_{pk}\right)^2}{12L^2V_o^2f^2}\,d\theta}}{\sqrt{\pi}} \tag{23}$$

$$\Delta I_{L,rms} = \frac{V_{pk}\left|V_o - V_{pk}\right|}{2\sqrt{3}LV_o f} \tag{24}$$

$$I_{L,rms} = \sqrt{I_{ref,rms}^2 + \Delta I_{L,rms}^2} \tag{25}$$

$$I_{L,rms} = \frac{\sqrt{12L^2P_o^2V_o^2f^2 + V_o^2V_{pk}^4 - 2V_oV_{pk}^5 + V_{pk}^6}}{2\sqrt{3}LV_oV_{pk}f} \tag{26}$$

$$\tag{27}$$

Bridge rms simple

$$I_{B,rms} = I_{L,rms} \tag{28}$$

$$I_{B,rms} = \frac{P_o}{V_{pk}} \tag{29}$$

$$\tag{30}$$

Bridge rms with ripple

$$I_{B,rms} = I_{L,rms} \tag{31}$$

$$I_{B,rms} = \frac{\sqrt{12L^2P_o^2V_o^2f^2 + V_o^2V_{pk}^4 - 2V_oV_{pk}^5 + V_{pk}^6}}{2\sqrt{3}LV_oV_{pk}f} \tag{32}$$

$$\tag{33}$$

Bridge avg

$$I_{B,avg} = \frac{\int_0^{\pi} \frac{P_o}{V_{pk}}\, d\theta}{\pi} \tag{34}$$

$$I_{B,avg} = \frac{P_o}{V_{pk}} \tag{35}$$

$$\tag{36}$$

Switch rms simple

$$i_{Q,rms,t}(\theta) = \Delta^R_{rms}\big(B = i_{ref}, A = 0, D = \delta_Q\big) \tag{37}$$

$$i_{Q,rms,t}(\theta) = \frac{P_o\sqrt{V_o - V_{pk}}}{\sqrt{V_o}V_{pk}} \tag{38}$$

$$I_{Q,rms} = \frac{\sqrt{\int_0^{\pi} \frac{P_o^2\left(V_o - V_{pk}\right)}{V_o V_{pk}^2}\, d\theta}}{\sqrt{\pi}} \tag{39}$$

$$I_{Q,rms} = \frac{P_o\sqrt{V_o - V_{pk}}}{\sqrt{V_o}V_{pk}} \tag{40}$$

$$\tag{41}$$

Switch rms with ripple

$$i_{Q,rms,t}(\theta) = \Delta^R_{rms}\big(B = i_{ref}, A = i_{LR,pp}, D = \delta_Q\big) \tag{42}$$

$$i_{Q,rms,t}(\theta) = \frac{\sqrt{\left(V_o - V_{pk}\right)\left(12L^2P_o^2V_o^2f^2 + V_o^2V_{pk}^4 - 2V_oV_{pk}^5 + V_{pk}^6\right)}}{2\sqrt{3}LV_o^{\frac{3}{2}}V_{pk}f} \tag{43}$$

$$I_{Q,rms} = \frac{\sqrt{\int_0^{\pi} \frac{\left(V_o - V_{pk}\right)\left(12L^2P_o^2V_o^2f^2 + V_o^2V_{pk}^4 - 2V_oV_{pk}^5 + V_{pk}^6\right)}{12L^2V_o^3V_{pk}^2f^2}\, d\theta}}{\sqrt{\pi}} \tag{44}$$

$$I_{Q,rms} = \frac{\sqrt{\left(V_o - V_{pk}\right)\left(12L^2P_o^2V_o^2f^2 + V_o^2V_{pk}^4 - 2V_oV_{pk}^5 + V_{pk}^6\right)}}{2\sqrt{3}LV_o^{\frac{3}{2}}V_{pk}f} \tag{45}$$

$$\tag{46}$$

Switch avg

$$i_{Q,avg,t}(\theta) = \Delta^{R}_{avg}\big(B = i_{ref}, D = \delta_Q\big) \tag{47}$$

$$I_{Q,avg,t} = \frac{P_o\left|V_o - V_{pk}\right|}{V_o V_{pk}} \tag{48}$$

$$I_{Q,avg} = \frac{\int_0^{\pi} \frac{P_o\left(1-\frac{V_{pk}}{V_o}\right)}{V_{pk}}\, d\theta}{\pi} \tag{49}$$

$$I_{Q,avg} = \frac{P_o\left|V_o - V_{pk}\right|}{V_o V_{pk}} \tag{50}$$

$$\tag{51}$$

Switch switching loss timings

$$t_{IR} = t_2 - t_1 = R_g C_{iss,test} \ln\left(\frac{V_{gs,max} - V_{th}}{V_{gs,max} - V_{gp}}\right) \tag{52}$$

$$t_{VF} = t_3 = \frac{R_g Q_{gd,test} V_{ds,max}}{V_{ds,test}(V_{gs,max} - V_{gp})} \tag{53}$$

$$t_{VR} = t_5 = \frac{R_g Q_{gd,test} V_{ds,max}}{V_{ds,test} V_{gp}} \tag{54}$$

$$t_{IF} = t_6 = R_g C_{iss,test} \ln\left(\frac{V_{gp}}{V_{th}}\right) \tag{55}$$

$$t_{ON} = t_{IR} + t_{VF} \tag{56}$$

$$t_{OFF} = t_{IF} + t_{VR} \tag{57}$$

$$\tag{58}$$

Switch switching loss simple

$$P_{Q,sw,t}(\theta) = \frac{V_o f}{2} I_{ref}(\theta)(t_{ON} + t_{OFF}) \tag{59}$$

$$P_{Q,sw,t}(\theta) = \frac{P_o V_o f\,(T_{OFF} + T_{ON})}{2V_{pk}} \tag{60}$$

$$P_{Q,sw} = \frac{\int_0^{\pi} \frac{P_o V_o f (T_{OFF}+T_{ON})}{2V_{pk}}\, d\theta}{\pi} \tag{61}$$

$$P_{Q,sw} = \frac{P_o V_o f\,(T_{OFF} + T_{ON})}{2V_{pk}} \tag{62}$$

$$\tag{63}$$

Switch switching loss with ripple

$$P_{Q,sw,t}(\theta) = \frac{V_o f}{2}\Bigg(\big(I_{ref}(\theta) - \Delta i_{L,pp}(\theta)\big)t_{ON} + \big(I_{ref}(\theta) + \Delta i_{L,pp}(\theta)\big)t_{OFF}\Bigg) \tag{64}$$

$$P_{Q,sw,t}(\theta) = \frac{V_o f\left(T_{OFF}\left(\frac{P_o}{V_{pk}} + \frac{V_{pk}\left(1-\frac{V_{pk}}{V_o}\right)}{2Lf}\right) + T_{ON}\left(\frac{P_o}{V_{pk}} - \frac{V_{pk}\left(1-\frac{V_{pk}}{V_o}\right)}{2Lf}\right)\right)}{2} \tag{65}$$

$$P_{Q,sw} = \frac{\int_0^{\pi} \frac{V_o f\left(T_{OFF}\left(\frac{P_o}{V_{pk}} + \frac{V_{pk}\left(1-\frac{V_{pk}}{V_o}\right)}{2Lf}\right) + T_{ON}\left(\frac{P_o}{V_{pk}} - \frac{V_{pk}\left(1-\frac{V_{pk}}{V_o}\right)}{2Lf}\right)\right)}{2}\, d\theta}{\pi} \tag{66}$$

$$P_{Q,sw} = \frac{\left|2LP_oT_{OFF}V_o f + 2LP_oT_{ON}V_o f + T_{OFF}V_oV_{pk}^2 - T_{OFF}V_{pk}^3 - T_{ON}V_oV_{pk}^2 + T_{ON}V_{pk}^3\right|}{4LV_{pk}} \tag{67}$$

$$\tag{68}$$

Switch switching loss output capacitance

$$P_{Q,sw,c}(\theta) = \frac{C_{oss}V_o^2 f}{2} \tag{69}$$

$$P_{Q,sw,c} = \frac{\int_0^{\pi} \frac{C_{oss}V_o^2 f}{2}\, d\theta}{\pi} \tag{70}$$

$$P_{Q,sw,c} = \frac{C_{oss}V_o^2 f}{2} \tag{71}$$

$$\tag{72}$$

Boost Diode simple

$$i_{D,rms,t}(\theta) = \Delta^R_{rms}\big(B = i_{ref}, A = 0, D = \delta_D\big) \tag{73}$$

$$i_{D,rms,t}(\theta) = \frac{P_o}{\sqrt{V_o}\sqrt{V_{pk}}} \tag{74}$$

$$I_{D,rms} = \frac{\sqrt{\int_0^\pi \frac{P_o^2}{V_o V_{pk}}\, d\theta}}{\sqrt{\pi}} \tag{75}$$

$$I_{D,rms} = \frac{P_o}{\sqrt{V_o}\sqrt{V_{pk}}} \tag{76}$$

$$\tag{77}$$

Boost Diode with ripple

$$i_{D,rms,t}(\theta) = \Delta^R_{rms}\big(B = i_{ref}, A = i_{LR,pp}, D = \delta_D\big) \tag{78}$$

$$i_{D,rms,t}(\theta) = \frac{\sqrt{12L^2P_o^2V_o^2f^2 + V_o^2V_{pk}^4 - 2V_oV_{pk}^5 + V_{pk}^6}}{2\sqrt{3}LV_o^{\frac{3}{2}}\sqrt{V_{pk}}f} \tag{79}$$

$$I_{D,rms} = \frac{\sqrt{\int_0^\pi \frac{12L^2P_o^2V_o^2f^2+V_o^2V_{pk}^4-2V_oV_{pk}^5+V_{pk}^6}{12L^2V_o^3V_{pk}f^2}\, d\theta}}{\sqrt{\pi}} \tag{80}$$

$$I_{D,rms} = \frac{\sqrt{12L^2P_o^2V_o^2f^2 + V_o^2V_{pk}^4 - 2V_oV_{pk}^5 + V_{pk}^6}}{2\sqrt{3}LV_o^{\frac{3}{2}}\sqrt{V_{pk}}f} \tag{81}$$

$$\tag{82}$$

Boost Diode avg

$$i_{D,avg,t}(\theta) = \Delta^R_{avg}\big(B = i_{ref}, D = \delta_D\big) \tag{83}$$

$$I_{D,avg,t} = \frac{P_o}{V_o} \tag{84}$$

$$I_{D,avg} = \frac{\int_0^\pi \frac{P_o}{V_o}\, d\theta}{\pi} \tag{85}$$

$$I_{D,avg} = \frac{P_o}{V_o} \tag{86}$$

$$\tag{87}$$

Boost Diode switching loss timings

$$K_Q = \frac{I_{rr,0} T_{rr,0}}{2\sqrt{I_{F,0}}} \tag{88}$$

$$S = \frac{T_{rr,0} \frac{dI_{D,0}}{dt}}{I_{rr,0}} - 1 \tag{89}$$

$$I_{rr} = \sqrt{\frac{2\frac{dI_D}{dt} K_Q \sqrt{I_F}}{1+S}} \tag{90}$$

$$T_a = \frac{I_{rr}}{\frac{dI_D}{dt}} \tag{91}$$

$$T_b = S T_a \tag{92}$$

$$E_Q = V_{DS}\big(\frac{I_{rr}}{2} T_a + \frac{I_{rr}}{4} T_b\big) \tag{93}$$

$$E_D = \frac{V_R I_{rr}}{4} T_b \tag{94}$$

$$\tag{95}$$

Boost Diode switching loss reverse recovery simple

$$I_F = \frac{P_o}{V_{pk}} \tag{96}$$

$$\frac{dI_D}{dt} = \frac{P_o}{T_{IR} V_{pk}} \tag{97}$$

$$I_{rr} = \frac{\sqrt{2}\sqrt{K_Q} P_o^{\frac{3}{4}}}{\sqrt{T_{IR}} V_{pk}^{\frac{3}{4}} \sqrt{S+1}} \tag{98}$$

$$T_a = \frac{\sqrt{2}\sqrt{K_Q}\sqrt{T_{IR}}\sqrt[4]{V_{pk}}}{\sqrt[4]{P_o}\sqrt{S+1}} \tag{99}$$

$$T_b = \frac{\sqrt{2}\sqrt{K_Q} S \sqrt{T_{IR}}\sqrt[4]{V_{pk}}}{\sqrt[4]{P_o}\sqrt{S+1}} \tag{100}$$

$$E_{Qrr} = \frac{K_Q \sqrt{P_o} V_o \left(S+2\right)}{2\sqrt{V_{pk}}\left(S+1\right)} \tag{101}$$

$$E_{Drr} = \frac{K_Q \sqrt{P_o} S V_o}{2\sqrt{V_{pk}}\left(S+1\right)} \tag{102}$$

$$P_{D,sw,rr}(\theta) = \frac{K_Q \sqrt{P_o} V_o f}{\sqrt{V_{pk}}} \tag{103}$$

$$P_{D,sw,rr} = \frac{\int_0^{\pi} \frac{K_Q \sqrt{P_o} V_o f}{\sqrt{V_{pk}}}\, d\theta}{\pi} \tag{104}$$

$$P_{D,sw,rr} = \frac{K_Q \sqrt{P_o} V_o f}{\sqrt{V_{pk}}} \tag{105}$$

$$\tag{106}$$

Boost Diode switching loss reverse recovery with ripple

$$I_F = \frac{P_o}{V_{pk}} - \frac{V_{pk}\left(1 - \frac{V_{pk}}{V_o}\right)}{2Lf} \tag{107}$$

$$\frac{dI_D}{dt} = \frac{\frac{P_o}{V_{pk}} - \frac{V_{pk}\left(1-\frac{V_{pk}}{V_o}\right)}{2Lf}}{T_{IR}} \tag{108}$$

$$I_{rr} = \frac{\sqrt{2}\sqrt{K_Q}\sqrt{\left(\frac{P_o}{V_{pk}} - \frac{V_{pk}\left(1-\frac{V_{pk}}{V_o}\right)}{2Lf}\right)^{\frac{3}{2}}}}{\sqrt{T_{IR}}\sqrt{S+1}} \tag{109}$$

$$T_a = \frac{\sqrt{2}\sqrt{K_Q}\sqrt{T_{IR}}\sqrt{\left(\frac{P_o}{V_{pk}} - \frac{V_{pk}\left(1-\frac{V_{pk}}{V_o}\right)}{2Lf}\right)^{\frac{3}{2}}}}{\sqrt{S+1}\left(\frac{P_o}{V_{pk}} - \frac{V_{pk}\left(1-\frac{V_{pk}}{V_o}\right)}{2Lf}\right)} \tag{110}$$

$$T_b = \frac{\sqrt{2}\sqrt{K_Q}S\sqrt{T_{IR}}\sqrt{\left(\frac{P_o}{V_{pk}} - \frac{V_{pk}\left(1-\frac{V_{pk}}{V_o}\right)}{2Lf}\right)^{\frac{3}{2}}}}{\sqrt{S+1}\left(\frac{P_o}{V_{pk}} - \frac{V_{pk}\left(1-\frac{V_{pk}}{V_o}\right)}{2Lf}\right)} \tag{111}$$

$$E_{Qrr} = \frac{\sqrt{2}K_Q\sqrt{V_o}\,(S+2)\sqrt{2LP_oV_of - V_{pk}^2\,(V_o - V_{pk})}}{4\sqrt{L}\sqrt{V_{pk}}\sqrt{f}\,(S+1)} \tag{112}$$

$$E_{Drr} = \frac{K_QSV_o\sqrt{\frac{P_o}{V_{pk}} - \frac{V_{pk}\left(1-\frac{V_{pk}}{V_o}\right)}{2Lf}}}{2\,(S+1)} \tag{113}$$

$$\tag{114}$$

$$P_{D,sw,rr}(\theta) = \frac{\sqrt{2}K_Q\sqrt{V_o}\sqrt{f}\sqrt{2LP_oV_of - V_{pk}^2\left(V_o - V_{pk}\right)}}{2\sqrt{L}\sqrt{V_{pk}}} \tag{115}$$

$$P_{D,sw,rr} = \frac{\int_0^{\pi} \frac{\sqrt{2}K_Q\sqrt{V_o}\sqrt{f}\sqrt{2LP_oV_of - V_{pk}^2\left(V_o - V_{pk}\right)}}{2\sqrt{L}\sqrt{V_{pk}}}\, d\theta}{\pi} \tag{116}$$

$$P_{D,sw,rr} = \frac{K_Q\sqrt{V_o}\sqrt{f}\sqrt{2LP_oV_of - V_oV_{pk}^2 + V_{pk}^3}}{\sqrt{2}\sqrt{L}\sqrt{V_{pk}}} \tag{117}$$

$$\tag{118}$$

Boost Diode switching loss junction capacitance

$$P_{D,sw,c}(\theta) = \frac{C_jV_{D,bl}^2(\theta)f}{2} \tag{119}$$

$$P_{D,sw,c}(\theta) = \frac{C_jV_o^2f}{2} \tag{120}$$

$$P_{D,sw,c} = \frac{\int_0^{\pi} \frac{C_jV_o^2f}{2}\, d\theta}{\pi} \tag{121}$$

$$P_{D,sw,c} = \frac{C_jV_o^2f}{2} \tag{122}$$

$$\tag{123}$$

Cap rms simple

$$I_{C,rms} = \sqrt{I_{D,rms}^2 - (\frac{P_o}{V_o})^2} \tag{124}$$

$$I_{C,rms} = \frac{P_o\sqrt{V_o - V_{pk}}}{V_o\sqrt{V_{pk}}} \tag{125}$$

$$\tag{126}$$

Cap rms with ripple

$$I_{C,rms} = \sqrt{I_{D,rms}^2 - (\frac{P_o}{V_o})^2} \tag{127}$$

$$I_{C,rms} = \frac{\sqrt{(V_o - V_{pk})\left(12L^2P_o^2V_of^2 + V_oV_{pk}^4 - V_{pk}^5\right)}}{2\sqrt{3}LV_o^{\frac{3}{2}}\sqrt{V_{pk}}f} \tag{128}$$

$$\tag{129}$$