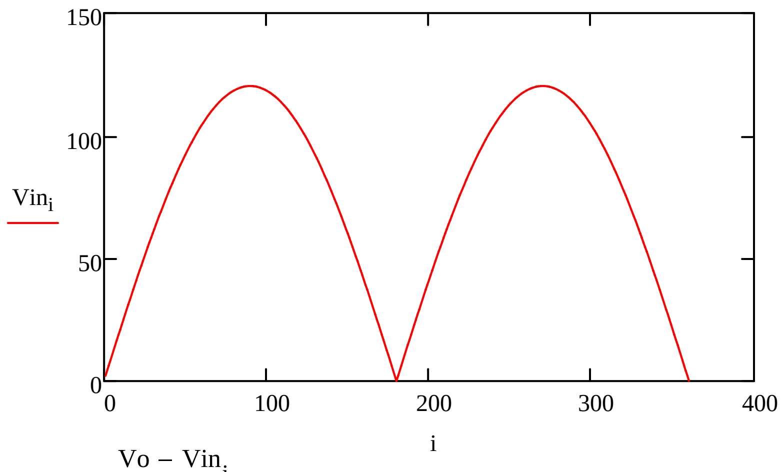
PFC Boost Inductor Calculations
CCM Mode

$Vac := 85$	Minimum Input Voltage
$Vo := 385$	Boost Voltage
$Po := 700$	Output Power
$\eta := .92$	Efficiency
$Pin := \frac{Po}{\eta}$	$Pin = 760.87$
$i := 1 .. 360$	1-360 Degrees
$\omega_i := \frac{i \cdot 2 \cdot \pi}{360}$	Convert to Radians
$\beta m := 0.3200$	maximum Operating Flux density
$Ku := 0.4$	Fill Factor
$Kj := 403$	Current Density Coefficient
$f := 65 \cdot 10^3$	Swithcing frequency
$Kf := 4$	Waveform Coefficient 4=square wave 4.44=sin
$Vinmax := 265 \cdot \sqrt{2}$	Maximum Input VAC voltage
$Vinmax = 374.767$	
$OVP := 16.5$	Overvoltage Protection setpoint
$\alpha := 2$	% Regulation
$Vfdr := 1$	Forward Voltage drop of the bridge rectifier
$fline := 50$	AC Mains Frequency
$thold := \frac{1}{fline}$	AC line single cycle holdup time
$thold = 0.02$	
$Vomin := 350$	Min Vo voltage for the output DC/DC to work at
$CbulkTol := 0.2$	Output Bulf Capacitor Tolerance

$Vin_i := Vac \cdot \sqrt{2} \cdot \left| \sin(\omega_i) \right|$

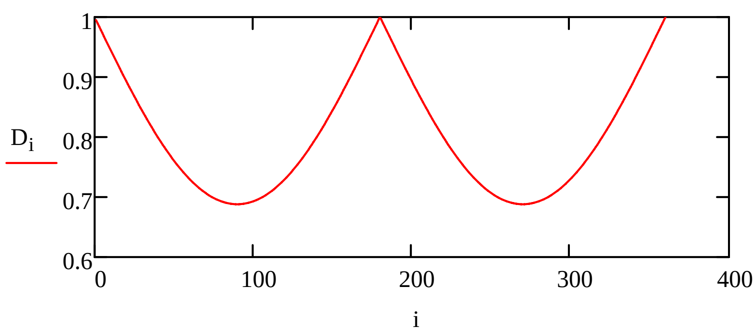
Rectified Voltage Waveform



$D_i := \frac{Vo - Vin_i}{Vo}$

Duty Cycle

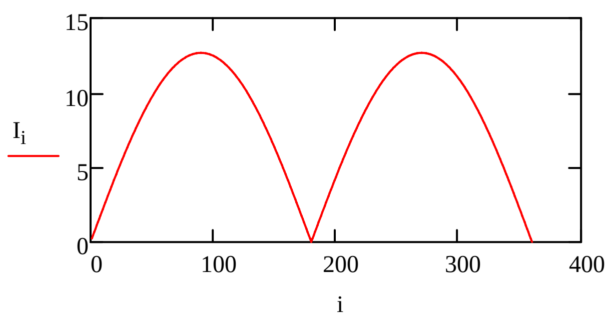
$Dmax := D_{90}$ $\quad Dmax = 0.688$



$I_i := \frac{Vin_i \cdot Pin}{Vac^2}$

Alternativey

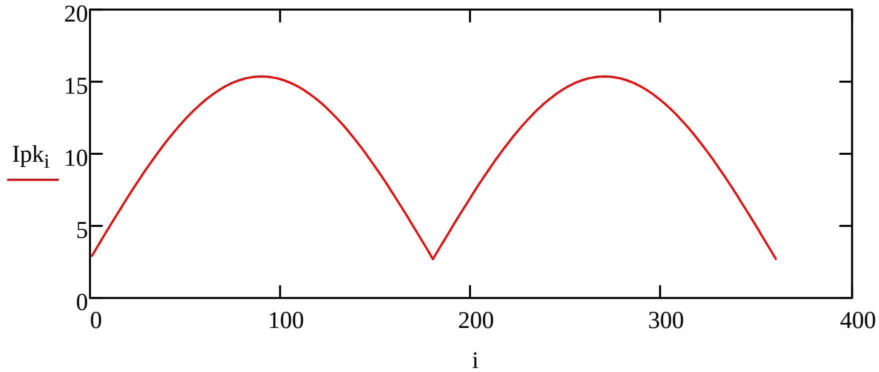
$Io := \frac{Pin \cdot \sqrt{2}}{Vac}$ $\quad Io = 12.659$



$I_{90} = 12.659$

$\Delta I := 0.42539 \cdot Io$ ripple current to the inductor and force it into continuous mode

$Ipk_i := I_i + \frac{\Delta I}{2}$ Alternatively $Ipeak := Io + \frac{\Delta I}{2}$ $Ipeak = 15.352$



$\Delta I = 5.385$ $Ipk_{180} = 2.693$

$Ts := \frac{1}{f}$ Time Period

Inductor Calculations

$L := \frac{\sqrt{2} \cdot Vac \cdot Dmax \cdot Ts}{\Delta I}$ Inductance needed

$L = 2.362 \times 10^{-4}$

$Energy := \frac{L \cdot Ipeak^2}{2}$ Watt-Seconds

$Ap := \left(\frac{2 \cdot Energy \cdot 10^4}{.3 \cdot Ku \cdot Kj}\right)^{1.14}$

$Ap = 16.205$ Choose a Ap near here

PQ3535 PC-44 Core TDK Core

MFG: TDK

$Ht := 3.475$ cm Core Height

$Wth := 4.365$ cm Core Width

$Lt := 3.51$ cm Core Length

$G := 2.5$ cm Core Window Length

$MPL := 8.8$ cm Mean Magnetic Path Length

$Wtfe := 73$ grams Weight

$Wtcu := 59$ grams Copper weight using a 40% fill

$MLT := 7.5$ cm Mean Length Per Turn

$Ac := 1.96$ cm^2 Iron Area

$Wa := 2.206$ cm^2 Window Area

$Ap := 4.324$ cm^4 Area Product Wa*Ac

$Kg := 0.451091$ cm^5 Core Geometry

$At := 60.7$ cm^2 Surface Area

$\mu := 2300$ Permeability

$AL := 4860$ Core mH/1000 turns

$Volfe := 17.26$ Ferrite core Volume cm^3

$Ki := 0.0388$ Gap Loss Coefficient

$Ku := 0.32$ Window utilization factor use 40% for most cases

$Kf := 4$ Waveform coefficient use 4 for a square wave or 4.4 for a sinewave

$Kj := 4$ Use 403 for powder core

$BobbinWidth := 2.24$ Length of the winding area mm

$BobbinHeight := 0.71$ windign Stack Height in mm

$\Delta\beta m := \beta m$ $\quad fs := f$ $\quad \Delta\beta m := 0.318965$

$Lm := L$ $\quad Ipk := Ipeak$

$$Np := \frac{Ipk \cdot Lm}{\Delta\beta m \cdot Ac} \cdot 10^4$$

This equation is compensated for Dmax

$Np = 58$

Number of turns on the primary side neglecting the fringing flux. Iterate Np upwards until you get the NP below this gives you the gap needed to support the number of turns

$Np := 82$

$$Lug := \frac{0.4 \cdot \pi \cdot Np^2 \cdot Ac \cdot 10^{-8}}{\left(\frac{MPL}{\mu}\right)}$$

Ungapped Inductance. This is needed in order to calculate the gap

$lg := \frac{MPL}{\mu} \cdot \left(\frac{Lug}{Lm} - 1 \right)$ $lg = 0.697$ Gap length required in cm $\frac{lg}{2.54} = 0.275$ gap length in in

$L := Lm$

$F := 1 + \frac{lg}{\sqrt{Ac}} \cdot \ln\left(\frac{2 \cdot G}{lg} \right)$ $F = 1.981$ Fringing Flux Factor

$Np := \sqrt{\frac{L \cdot \left(lg + \frac{MPL}{\mu} \right)}{0.4 \cdot \pi \cdot Ac \cdot F \cdot 10^{-8}}}$ $Np = 58.257$ Number of turns after compensating for the fringing flux

$Lm := \frac{0.4 \cdot \pi \cdot Np^2 \cdot F \cdot Ac \cdot 10^{-8}}{lg + \frac{MPL}{\mu}}$ $Lm = 2.362 \times 10^{-4}$ Verify loaded gapped inductance

$Bmax := \frac{0.4 \cdot \pi \cdot Np \cdot F \cdot (Ipk) \cdot 10^{-4}}{lg + \frac{MPL}{\mu}}$ $Bmax = 0.318$ Tesla

$Bac := \frac{0.4 \cdot \pi \cdot Np \cdot F \cdot \left(\frac{\Delta I}{2} \right) \cdot 10^{-4}}{lg + \frac{MPL}{\mu}}$

$Vbias := 13$ Bias rail voltage

$Bac = 0.056$ AC Flux density

$Tw := 100$ Wire temperature

$thold := 0.01$

$Leakage\% := 2\%$ Percentage of the primary side inductance you expect the leakage to be 2% is a good target 5% would be a relatively high leakage, 10% would be very high

$Kcoupling := \sqrt{1 - Leakage\%}$ this is defined as sqrt(1-Lk/Lp)

$Kcoupling = 0.99$

Constants

$\rho := 1.68 \cdot 10^{-6}$ Electrical Resistivity Ωcm

$\alpha := 0.0039$ Temperature coefficient for Cu

$\rho e := \rho \cdot [1 + \alpha \cdot (Tw - 20)]$ Temperature compensation

$\rho e = 2.204 \times 10^{-6}$

Skin Depth

$Kcu := \sqrt{\frac{\rho e}{\rho}}$

$\delta := \frac{6.62}{\sqrt{fs}} \cdot Kcu$

$\delta = 0.03$ cm Skin depth at the switching frequency.

$WireDia := 2\cdot\delta$ Choose a wire Diameter less than or equal too this value in cm

$WireDia = 0.059$ cm This would be 0.5mm wire

$Awbmax := \pi\cdot\delta^2$

$Awbmax = 2.779 \times 10^{-3}$ Wires with this crossectional (or smaller) will use all of the wire for conducting current at the fundamental frequency or 28AWG

$Energy\cdot fs = 1.809 \times 10^{3}$ Max Power available at that frequency and inductance

$$ALe := \frac{Lm}{Np^2\cdot 1\cdot 10^{-9}}$$

$ALe = 69.595$ Effective gapped mH/1000 turns

$$H := \frac{0.4\cdot\pi\cdot Np\cdot Ipk}{MPL}$$ Oersteds

$H = 127.712$ Oersteds

$J := 300$ assign a current density of 300 amps/cm^2

$$Iprms := \sqrt{\left[Ipk^2 + Ipk\cdot(Ipk - \Delta I) + \Delta I^2\right]\cdot\frac{Dmax}{3}}$$

$Iprms = 9.786$

$Aw := \frac{Iprms}{J}$ $Aw = 0.033$ cm^2 Bare Copper cross sectional Area

$MaxWireDia := \frac{BobbinWidth}{Np}$ $MaxWireDia = 0.038$

Uses 0.13mm Wire with a split winding and 2 layers stacked

$Nps := 10$ Number of stacked layers primary side

$Wdia := 0.045$ cm

$Awb := \pi\cdot\left(\frac{Wdia}{2}\right)^2\cdot Nps$ $Awb = 0.016$

$Rcu := \frac{\rho e}{Awb}$ ohms/cm Cu resistence

$$Rp := MLT\cdot\frac{Rcu}{Nps}\cdot Np$$

$Rp = 6.055 \times 10^{-3}$ Copper resistance at 100C

$Pp := Iprms^2 \cdot Rp$

$Pp = 0.58$ W copper loss on the primary side

$Pg := Ki \cdot G \cdot lg \cdot fs \cdot Bac^2$ Gap Loss

$Pg = 13.639$

$Ploss := Pg + Pp$

$Ploss = 14.219$