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UCC38050 Mathcad Design Tool
Origianl Rev. 11/04/02
Revision 7/26/04

This Mathcad design tool was developed to use with the UCC38050 application note SLUU138.

Design Variables	Definition
$fline := 60Hz$	Line Frequency
$Vinmin := 85V$	Minimum Input Voltage
$Vinmax := 265V$	Maximum Input Voltage
$Pout := 100W$	Maximum Output Power
$Vout := 400V$	Output Voltage
$fs := 25 \cdot 10^{3} Hz$	Minimum Switching Frequency
$tholdup := 16.7 \cdot 10^{-3} s$	Period of one Line Cycle
$Vdrop := 85V$	Amount of holdup voltage

1. Inductor Size Selection and Turns Ratio (N)

$\eta := 0.95$ Predicted Efficiency

$$L1 := \frac{\left(Vout - \sqrt{2} \cdot Vinmin\right) \cdot \eta \cdot Vinmin^{2}}{2 \cdot fs \cdot Vout \cdot Pout}$$

$$L1 = 9.602 \times 10^{-4} H$$

$$N := \frac{\left(Vout - Vinmax \cdot \sqrt{2}\right)}{2 \cdot V}$$

$$N = 12.617$$

2. Boost Switch Selection (Q1)

a. The power budget for Q1 was selected to < 2.5W. A IRF840 N-Channel FET was chosen to meet these design requirements.

b. Critical FET Data Sheet Specifications

$Qgate := 63 \cdot 10^{-9} C$ $Coss := 250 \cdot 10^{-12} F$ $tr := 46 \cdot 10^{-9} s$ $Rdson := 0.85 ohm$ $Vgate := 12V$

$$Irms\_fet := \frac{Pout \cdot 2 \cdot \sqrt{2}}{\eta \cdot Vinmin} \cdot \sqrt{\frac{1}{6} - \frac{4 \cdot \sqrt{2} \cdot Vinmin}{9 \cdot \pi \cdot Vout}} \qquad Irms\_L1 := \frac{Pout}{\eta \cdot Vinmin \cdot \sqrt{2}}$$

$$Pgate := Qgate \cdot Vgate \cdot fs \qquad Pcoss := \frac{1}{2} \cdot Coss \cdot Vout^{2} \cdot fs \qquad Pcond\_fet := Rdson \cdot Irms\_fet^{2}$$

$$Pfet\_tr := \frac{1}{2} \cdot Vout \cdot Irms\_L1 \cdot tr \cdot fs$$

$$Pq1 := Pgate + Pcoss + Pcond\_fet + Pfet\_tr$$

$Pq1 = 2.015\,W$ Total FET loss is < 2.5W

$$Ipeak := \frac{Pout \cdot 2 \cdot \sqrt{2} \cdot 1.3}{\eta \cdot Vinmin}$$

$$Ipeak = 4.554\,A$$

3. Diode D1 selection

a. The power budget for D1 was selected to < 2.5W.
b. A HFA08TB60S was chosen to meet these design requirements.
c. Critical Boost Diode Data Sheet Specifications

$Vf := 1.4V$ $\quad\quad Cdiode := 25 \cdot 10^{-12} F$

$$Irms\_diode := \frac{Pout \cdot 2 \cdot \sqrt{2}}{\eta \cdot Vinmin} \cdot \sqrt{\frac{4 \cdot \sqrt{2} Vinmin}{9 \cdot \pi \cdot Vout}}$$

$Pcond\_diode := Vf \cdot Irms\_diode$ $\quad\quad Pdiode\_cap := \frac{Cdiode}{2} \cdot Vout^2 \cdot fs$

$$Pdiode := Pcond\_diode + Pdiode\_cap$$

$Pdiode = 1.061\,W$ Diode loss is < 2.5W and meets the power budget.

4. Calculate the Minimum Holdup Capacitance Required and the RMS Current Going Through the Boost Capacitor

$$C3 := 2 \cdot Pout \cdot \frac{tholdup}{Vout^2 - (Vout - Vdrop)^2}$$

$$C3 = 5.496 \times 10^{-5} F$$

$$Irms\_C3 := \frac{Pout}{Vout} \cdot \sqrt{\frac{16 \cdot Vout}{3 \cdot \pi \cdot Vinmin \cdot \sqrt{2}} - 1}$$

$$Irms\_C3 = 0.539\,A$$

$C3 := 220 \cdot 10^{-6} F$ Choose a standard value capacitor to meet the design requirements.

5. Calculate Minimum Input Holdup Capacitance Required

$$ton := \frac{2 \cdot L1 \cdot Pout}{\eta \cdot Vinmin^2}$$

$$C5 := \frac{\frac{Pout \cdot ton}{\eta \cdot 2}}{\left(Vinmin \cdot \sqrt{2}\right)^2 - \left(Vinmin \cdot \sqrt{2} - Vdrop\right)^2}$$

$$C5 = 1.115 \times 10^{-7} F$$

$C5 := 560 \cdot 10^{-9} F$ Choose a standard value capacitance.

6. Select a Current Sense Resistor

Datasheet

$$0.67 \cdot 1.3 \cdot \left(\sqrt{2}\right.$$

$$R7 := \frac{1.7V}{\frac{Pout \cdot 2 \cdot \sqrt{2} \cdot 1.3}{\eta \cdot Vinmin}}$$

$$R7 = 0.373\,\Omega$$

$R7 := 0.4ohm$ Choose a standard value resistor.

7. Multiplier Setup

$$k := \frac{0.65}{V} \qquad Veamax := 5V$$

$$Vr3 := \frac{1V \cdot 0.9}{k \cdot (Veamax - 2.5V)} - 0.075V$$

$$R5 := 1.1 \cdot 10^6 ohm$$

$$R8 := R5$$

$$Vr3 = 0.479\,V$$

$$R3 := \frac{(R8 + R5) \cdot Vr3}{Vinmin - Vr3}$$

$$R3 = 1.246 \times 10^4\,\Omega$$

$R3 := 15 \cdot 10^3 ohm$ Choose a standard value

8. Voltage Loop Compensation

$Vref := 2.5V \quad gm := 100 \cdot 10^{-6} \cdot \frac{A}{V} \quad fc := 10Hz \quad H(s) := \frac{Vref}{Vout}$

$Comp := 2.5V \quad \%THD := 1.5$

$$R13 := 4 \cdot Vout^2 \cdot \pi \cdot fc \cdot C3 \cdot R7 \cdot \frac{(R3 + R8 + R5)}{\left(k \cdot Vref \cdot Vinmax^2 \cdot R3 \cdot gm\right)}$$

$R13 = 2.29 \times 10^4 \Omega$

$R13 := 11.5 \cdot 10^3 ohm$ Choose a standard value

$$C9 := \frac{1}{2 \cdot \pi \cdot fc \cdot R13}$$

$C9 = 1.384 \times 10^{-6} F$

$C9 := 1 \cdot 10^{-6} F$ Choose a standard value

$$Vpp := \frac{\frac{Pout}{\eta}}{2\pi \cdot (2 \cdot fline) \cdot C3 \cdot Vinmin}$$

$Vpp = 7.466 V$

$$Gvea := \frac{\%THD \cdot Comp}{Vpp \cdot 100}$$

$$C11 := H(s) \cdot \frac{gm}{Gvea \cdot 2\pi \cdot (2fline)}$$

$C11 = 1.65 \times 10^{-7} F$

$C11 := 120 \cdot 10^{-9} F$ Choose a standard value

9. Graphicaly Check Voltage Loop Compensation

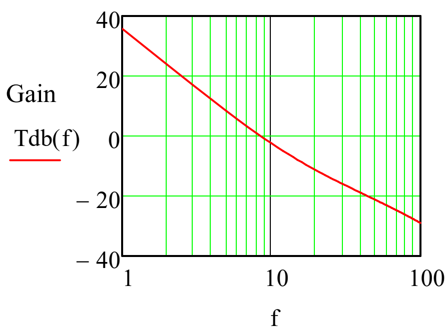
$f := 1\text{Hz}, 2\text{Hz}..\ 100\text{Hz}$ $k1 := \dfrac{R3}{R3 + R8 + R5}$

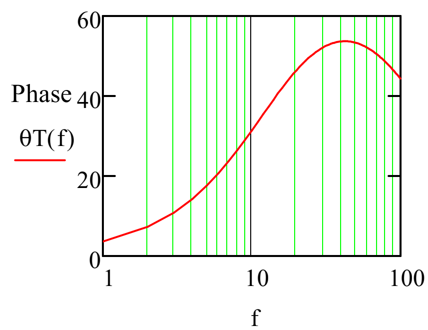
$s(f) := 2j\cdot\pi\cdot f$

$$T(f) := \frac{k\cdot \text{Vinmax}^2\cdot k1}{(s(f)\cdot C3)\cdot \text{Vout}\cdot R7\cdot 2}\cdot\left[\frac{\text{Vref}}{\text{Vout}}\cdot gm\cdot\left[\frac{s(f)\cdot R13\cdot C9 + 1}{s(f)\cdot(C9 + C11)\cdot\left(\dfrac{s(f)\cdot R13\cdot C9\cdot C11}{C9 + C11} + 1\right)}\right]\right]$$

$\text{Tdb}(f) := 20\cdot\log(|T(f)|)$

$\theta T(f) := \arg(T(f))\cdot\dfrac{180}{\pi} + 180$





Note the loop has roughly 45 degrees of phase margin at crossover.

10. Input Filter Design

$L2 = L3$ $fp := 30\cdot 10^3\text{Hz}$

$$L2 := \frac{\left[\left(\text{Vinmin}\cdot\sqrt{2} - \text{Vdrop}\right)\cdot\text{ton}\right]}{\dfrac{\text{Pout}\cdot\sqrt{2}}{\text{...min}}}$$

$L2 = 5.625\times 10^{-4}\text{H}$

$C4 = C8$

$$C4 := \frac{1}{(2\cdot\pi\cdot fp)^2\cdot L2}$$

$C4 = 5.004\times 10^{-8}\text{F}$

$C4 := 47\cdot 10^{-9}\text{F}$ Choose a standard value

$$\frac{\cdot\dfrac{15}{15+1100+1100}-0.075\Big)}{2\cdot\sqrt{2}\cdot\dfrac{Pout}{Vinmin}}=-0.017\frac{1}{A}$$