

The following Mathcad Sheet is based on TI's MathCAD file Rev A, available on the UCC3818 webpage. To reduce confusion, every attempt was made to match the reference designators of the UCC3818 data sheet reference design, but it is still best to correlate with USCi's schematic and board layout.

This sheet is provided to ease the parameter calculations and should be used in parallel with TI's UCC3818 data sheets and Application Notes

General Specifications

$$V_{inmin} := 90 \text{ V} \quad V_{out} := 800 \text{ V} \quad \eta_1 := 0.98 \quad V_{ovp} := 450 \cdot \text{volt}$$

$$V_{inmax} := 260 \text{ V} \quad P_{out} := 1000 \text{ W} \quad f_s := 50 \cdot 10^3 \cdot \text{Hz}, (100 \cdot 10^3) \cdot \text{Hz}, (150 \cdot 10^3) \cdot \text{Hz}$$

$$V_{rmsmin} := 3 \text{ V} \quad V_{rmsmax} := 10 \text{ V} \quad V_{ref} := 7.5 \text{ V}$$

$$V_{eamin} := 0.5 \text{ V} \quad V_{eamax} := 5.5 \text{ V}$$

$$V_p := 4 \text{ V}$$

Calculate maximum Duty Cycle

$$D := \frac{V_{out} - \sqrt{2} \cdot V_{inmin}}{V_{out}}$$

$$D = 0.841$$

$$I_{dc} := \frac{P_{out}}{V_{out}} \quad \text{PFC DC Output Current}$$

$$I_{dc} = 1.25 \text{ A}$$

$$V_F := 1.1 \cdot \text{volt}$$

$$P_{diode} := V_F \cdot I_{dc}$$

$$P_{diode} = 1.375 \text{ W} \quad \text{PD on Diode}$$

Boost Inductor

$$I_{pk} := \sqrt{2} \cdot \frac{\frac{P_{out}}{\eta_1}}{V_{inmin}}$$

$$I_{pk} = 16.034 \text{ A}$$

$$dI := 0.2 \cdot I_{pk}$$

$$dI = 3.207 \text{ A} \quad \text{ripple current}$$

Calculate Inductance

$$L1(fs) := \frac{V_{inmin} \cdot \sqrt{2} \cdot D}{dI \cdot fs}$$

$$L1(45000 \cdot \text{Hz}) = 7.417 \cdot 10^{-4} \text{ H} \quad L1(100000 \cdot \text{Hz}) = 3.338 \cdot 10^{-4} \text{ H} \quad L1(125000 \cdot \text{Hz}) = 2.67 \cdot 10^{-4} \text{ H}$$

R1 and C1 Timing Passives

$$C1 := 220 \cdot 10^{-12} \cdot \text{farad}$$

C1

$$R1(fs) := \frac{0.6}{C1 \cdot fs}$$

$$R1(25000 \cdot \text{Hz}) = 1.091 \cdot 10^5 \ \Omega \quad R1(100000 \cdot \text{Hz}) = 2.727 \cdot 10^4 \ \Omega \quad R1(150000 \cdot \text{Hz}) = 1.818 \cdot 10^4 \ \Omega$$

$$R1 := 27 \cdot 10^3 \cdot \text{ohm}$$

R1

Boost Output Capacitor

Select Boost Capacitor

$$\text{tholdup} := 5 \cdot 10^{-3} \cdot \text{s}$$

$$V_{pfc_Droop} := 30 \cdot \text{volt}$$

Minimum Capacitance Required

$$C12 := \frac{2 \cdot \frac{P_{out}}{\eta I} \cdot \text{tholdup}}{V_{out}^2 - (V_{out} - V_{pfc_Droop})^2}$$

$$C12 = 2.166 \cdot 10^{-4} \text{ F}$$

$$C12 := (220 \cdot 10^{-6} \cdot \text{farad})$$

C12

Setting IAC

$$I_{acmax} := 500 \cdot 10^{-6} \text{ A}$$

$$R_{iacmax} := V_{inmax} \cdot \frac{\sqrt{2}}{I_{acmax}}$$

$$R_{iacmax} = 7.354 \cdot 10^5 \Omega$$

$$R_{IAC_max_4} := \frac{R_{iacmax}}{4}$$

$$R_{IAC_max_4} = 1.838 \cdot 10^5 \Omega$$

$$R_{21A} := (178 \cdot 10^3 \cdot \text{ohm})$$

R21

$$R_{21B} := (178 \cdot 10^3 \cdot \text{ohm})$$

$$R_{13A} := (178 \cdot 10^3 \cdot \text{ohm})$$

R13

$$R_{13B} := (178 \cdot 10^3 \cdot \text{ohm})$$

$$R_{iac} := R_{21A} + R_{21B} + R_{13A} + R_{13B}$$

$$R_{iac} = 7.12 \cdot 10^5 \Omega$$

$$I_{acmax} := \frac{V_{inmax} \cdot \sqrt{2}}{R_{iac}} \quad I_{ac_min} := V_{inmin} \cdot \frac{\sqrt{2}}{R_{iac}}$$

$$I_{acmax} = 5.164 \cdot 10^{-4} \text{ A}$$

$$I_{ac_min} = 1.788 \cdot 10^{-4} \text{ A}$$

Feed Forward

$$R_{vff} := \frac{1.4 \text{ V}}{\frac{V_{inmin}}{R_{iac} \cdot 2} \cdot 0.9}$$

$$R_{vff} = 2.461 \cdot 10^4 \Omega$$

$$R_{vff} := 17.4 \cdot 10^3 \cdot \text{ohm}$$

$$R_6 := R_{vff}$$

R6

$$f_p := 2.6 \cdot \text{Hz}$$

$$C_{vff} := \frac{1}{2 \cdot \pi \cdot R_{vff} \cdot f_p}$$

$$C_{vff} = 3.518 \cdot 10^{-6} \text{ F}$$

$$Cvff := 3.9 \cdot 10^{-6} \cdot F$$

$$C6 := Cvff$$

$$C6 = 3.9 \cdot 10^{-6} \text{ F}$$

C6

$$fp1 := \frac{1}{2 \cdot 3.14159 \cdot Rvff \cdot Cvff}$$

$$fp1 = 2.345 \text{ Hz}$$

Rsense Calculation

$$Rsense := \frac{1 \text{ V}}{Ip_k + 0.5 \cdot dI}$$

$$Rsense = 0.057 \text{ } \Omega$$

$$Rsense := 0.03 \cdot \text{ohm}$$

$$R14 := Rsense$$

R14

Multiplier

$$Km := \frac{1}{V}$$

$$V = 1 \text{ V}$$

$$Imomax := \frac{Iac_min \cdot (Veamax - 1 \text{ V})}{Km \cdot Vrmsmin^2}$$

$$Imomax = 8.938 \cdot 10^{-5} \text{ A}$$

$$Plimit := \frac{Pout \cdot 1.2}{\eta 1}$$

$$Vrs := \frac{Plimit \cdot \sqrt{2}}{Vinmin} \cdot Rsense$$

$$Vrs = 0.577 \text{ V}$$

$$Rmout := \frac{Vrs}{Imomax}$$

$$Rmout = 6.458 \cdot 10^3 \text{ } \Omega$$

$$R_{mout} := 6.34 \cdot 10^3 \cdot \text{ohm}$$

$$R9 := R_{mout}$$

R9

$$R10 := R_{mout}$$

R10

Peak Current Limit

$$I_{limit} := \frac{P_{out} \cdot 1.3 \cdot \sqrt{2}}{\eta_1 \cdot V_{inmin}} + 0.5 \cdot dI$$

$$I_{limit} = 22.448 \text{ A}$$

$$V_{rs} := I_{limit} \cdot R_{sense}$$

$$V_{rs} = 0.673 \text{ V}$$

R11

$$R11 := 10 \cdot 10^3 \cdot \text{ohm}$$

$$R12 := \frac{V_{rs} \cdot R11}{V_{ref}}$$

$$R12 = 897.913 \cdot \text{ohm}$$

R12

$$R12 := 1.2 \cdot 10^3 \cdot \text{ohm}$$

Current Loop

$$f_c := 10 \cdot 10^3 \cdot \text{Hz}$$

$$Gid_{75k} := \frac{V_{out} \cdot R_{sense}}{2 \cdot \pi \cdot f_c \cdot L1(75000 \cdot \text{Hz}) \cdot V_p} \quad id_{100k} := \frac{V_{out} \cdot R_{sense}}{2 \cdot \pi \cdot f_c \cdot L1(100000 \cdot \text{Hz}) \cdot V_p} \quad Gid_{125k} := \frac{V_{out} \cdot R_{sense}}{2 \cdot \pi \cdot f_c \cdot L1(125000 \cdot \text{Hz}) \cdot V_p}$$

$$Gid_{75k} = 0.215$$

$$Gid_{100k} = 0.286$$

$$Gid_{125k} = 0.358$$

$$Gea_{75k} := \frac{1}{Gid_{75k}}$$

$$Gea_{100k} := \frac{1}{Gid_{100k}}$$

$$Gea_{125k} := \frac{1}{Gid_{125k}}$$

$$Gea_{75k} = 4.66$$

$$Gea_{100k} = 3.495$$

$$Gea_{125k} = 2.796$$

$$R_i := R_{mout}$$

$$R_{f_75k} := R_i \cdot G_{ea_75k}$$

$$R_{f_100k} := R_i \cdot G_{ea_100k}$$

$$R_{f_125k} := R_i \cdot G_{ea_125k}$$

$$R_{f_75k} = 2.954 \cdot 10^4 \Omega$$

$$R_{f_100k} = 2.216 \cdot 10^4 \Omega$$

$$R_{f_125k} = 1.773 \cdot 10^4 \Omega$$

$$R_{8_75k} := R_{f_75k}$$

$$R_{8_100k} := 22.0 \cdot 10^3 \cdot \text{ohm}$$

$$R_{8_125k} := R_{f_125k}$$

R8

$$C_p(\text{fs}) := \frac{1}{2 \cdot \pi \cdot R_{8_75k} \cdot \left(\frac{\text{fs}}{2}\right)}$$

$$C_p(\text{fs}) := \frac{1}{2 \cdot \pi \cdot R_{8_100k} \cdot \left(\frac{\text{fs}}{2}\right)}$$

$$C_p(\text{fs}) := \frac{1}{2 \cdot \pi \cdot R_{8_125k} \cdot \left(\frac{\text{fs}}{2}\right)}$$

$$C_p(75000 \cdot \text{Hz}) = 2.394 \cdot 10^{-10} \text{ F}$$

$$C_p(100000 \cdot \text{Hz}) = 1.796 \cdot 10^{-10} \text{ F}$$

$$C_p(125000 \cdot \text{Hz}) = 1.437 \cdot 10^{-10} \text{ F}$$

$$C_{8_75k} := C_p(75000 \cdot \text{Hz})$$

$$C_{8_100k} := C_p(100000 \cdot \text{Hz})$$

$$C_{8_125k} := C_p(125000 \cdot \text{Hz})$$

$$C_{8_75k} = 2.394 \cdot 10^{-10} \text{ F}$$

$$C_{8_100k} = 1.796 \cdot 10^{-10} \text{ F}$$

$$C_{8_125k} = 1.437 \cdot 10^{-10} \text{ F}$$

$$C_{8_100k} := 220 \cdot 10^{-12} \cdot \text{F}$$

C8

$$C_{z_75k} := \frac{1}{2 \cdot \pi \cdot f_c \cdot R_{8_75k}}$$

$$C_{z_100k} := \frac{1}{2 \cdot \pi \cdot f_c \cdot R_{8_100k}}$$

$$C_{z_125k} := \frac{1}{2 \cdot \pi \cdot f_c \cdot R_{8_125k}}$$

$$C_{z_75k} = 5.387 \cdot 10^{-10} \text{ F}$$

$$C_{z_100k} = 7.234 \cdot 10^{-10} \text{ F}$$

$$C_{z_125k} = 8.978 \cdot 10^{-10} \text{ F}$$

$$C_{9_75k} := C_{z_75k}$$

$$C_{9_125k} := C_{z_125k}$$

$$C_{9_100k} := 820 \cdot 10^{-12} \cdot \text{F}$$

C9

Voltage Amplifier Loop

$$v_{opk} := \frac{P_{out} \cdot \frac{1}{\eta_1}}{2 \cdot \pi \cdot 120 \cdot \text{Hz} \cdot C_{12} \cdot V_{out}}$$

$$v_{opk} = 7.69 \text{ V}$$

$$v_{opp} := v_{opk} \cdot 2$$

$$v_{eapk} := 0.015 \cdot (V_{eamax} - V_{eamin})$$

$$v_{eapk} = 0.075 \text{ V}$$

$$G_{vea} := \frac{v_{eapk}}{v_{opp}}$$

$$G_{vea} = 4.877 \cdot 10^{-3}$$

$$R_{in} := 4 \cdot 249 \cdot 10^3 \cdot \text{ohm} \quad \text{Input resistance to be 1.0MEG}$$

Set Output Voltage

$$R2A := 249 \cdot 10^3 \cdot \text{ohm}$$

$$R2B := 249 \cdot 10^3 \cdot \text{ohm}$$

R2

$$R19A := R2A$$

$$R19B := R2B$$

R19

$$R_{in} := 2 \cdot R2A + 2 \cdot R19A$$

$$R_{in} = 9.96 \cdot 10^5 \Omega$$

$$R_d := \frac{V_{ref} \cdot R_{in}}{V_{out} - V_{ref}}$$

$$R_d = 9.426 \cdot 10^3 \Omega$$

$$R_d := 9.31 \cdot 10^3 \cdot \text{ohm}$$

R3 Actual resistor

R3

$$R3 := R_d$$

$$C_f := \frac{1}{2 \cdot \pi \cdot 120 \cdot \text{Hz} \cdot G_{vea} \cdot R_{in}}$$

$$C_f = 2.731 \cdot 10^{-7} \text{ F}$$

$$C7 := 0.27 \cdot 10^{-6} \cdot \text{F}$$

C7

$$G_{ps_fc} := \frac{P_{out}}{(V_{eamax} - V_{eamin}) \cdot V_{out} \cdot 2 \cdot \pi \cdot C12}$$

$$G_{ps_fc} = 180.858 \text{ Hz}$$

$$G_{\text{veal_75k}} := \frac{1}{2 \cdot \pi \cdot R_{\text{in}} \cdot C_{\text{p}}(75000 \cdot \text{Hz})} \quad G_{\text{veal_100k}} := \frac{1}{2 \cdot \pi \cdot R_{\text{in}} \cdot C_{\text{8_100k}}} \quad G_{\text{veal_125k}} := \frac{1}{2 \cdot \pi \cdot R_{\text{in}} \cdot C_{\text{p}}(125000 \cdot \text{Hz})}$$

$$G_{\text{veal_75k}} = 667.43 \text{ Hz}$$

$$G_{\text{veal_100k}} = 726.337 \text{ Hz}$$

$$G_{\text{veal_125k}} = 1.112 \cdot 10^3 \text{ Hz}$$

$$T_{\text{v_75k}} := G_{\text{ps_fc}} \cdot G_{\text{veal_75k}}$$

$$T_{\text{v_100k}} := G_{\text{ps_fc}} \cdot G_{\text{veal_100k}}$$

$$T_{\text{v_125k}} := G_{\text{ps_fc}} \cdot G_{\text{veal_125k}}$$

$$T_{\text{v_75k}} = 1.207 \cdot 10^5 \cdot \text{Hz}^2$$

$$T_{\text{v_100k}} = 1.314 \cdot 10^5 \cdot \text{Hz}^2$$

$$T_{\text{v_125k}} = 2.012 \cdot 10^5 \cdot \text{Hz}^2$$

$$f_{\text{c_75k}} := \sqrt{T_{\text{v_75k}}}$$

$$f_{\text{c_100k}} := \sqrt{T_{\text{v_100k}}}$$

$$f_{\text{c_125k}} := \sqrt{T_{\text{v_125k}}}$$

$$f_{\text{c_75k}} = 347.433 \text{ Hz}$$

$$f_{\text{c_100k}} = 362.441 \text{ Hz}$$

$$f_{\text{c_125k}} = 448.535 \text{ Hz}$$

$$R_{\text{f_75k}} := \frac{1}{2 \cdot \pi \cdot f_{\text{c_75k}} \cdot C_{\text{p}}(75000 \cdot \text{Hz})} \quad R_{\text{f_100k}} := \frac{1}{2 \cdot \pi \cdot f_{\text{c_100k}} \cdot C_{\text{p}}(100000 \cdot \text{Hz})} \quad R_{\text{f_125k}} := \frac{1}{2 \cdot \pi \cdot f_{\text{c_100k}} \cdot C_{\text{p}}(125000 \cdot \text{Hz})}$$

$$R_{\text{f_75k}} = 1.913 \cdot 10^6 \ \Omega$$

$$R_{\text{f_100k}} = 2.445 \cdot 10^6 \ \Omega$$

$$R_{\text{f_125k}} = 3.057 \cdot 10^6 \ \Omega$$

$$R_{\text{7_75k}} := R_{\text{f_75k}}$$

$$R_{\text{7_100k}} := 0.909 \cdot 10^6 \cdot \text{ohm}$$

$$R_{\text{7_125k}} := R_{\text{f_125k}}$$

$$R_{\text{7_75k}} = 1.913 \cdot 10^6 \ \Omega$$

$$R_{\text{7_100k}} = 9.09 \cdot 10^5 \ \Omega$$

$$R_{\text{7_125k}} = 3.057 \cdot 10^6 \ \Omega$$

R7

$$C_{\text{z_75k}} := \frac{1}{2 \cdot \pi \cdot \frac{f_{\text{c_75k}}}{10} \cdot R_{\text{f_75k}}}$$

$$C_{\text{z_100k}} := \frac{1}{2 \cdot \pi \cdot \frac{f_{\text{c_100k}}}{10} \cdot R_{\text{f_100k}}}$$

$$C_{\text{z_125k}} := \frac{1}{2 \cdot \pi \cdot \frac{f_{\text{c_125k}}}{10} \cdot R_{\text{f_125k}}}$$

$$C_{\text{z_75k}} = 2.394 \cdot 10^{-9} \text{ F}$$

$$C_{\text{z_100k}} = 1.796 \cdot 10^{-9} \text{ F}$$

$$C_{\text{z_125k}} = 1.161 \cdot 10^{-9} \text{ F}$$

$$C_{\text{15_75k}} := C_{\text{z_75k}}$$

$$C_{\text{z_100k}} = 1.796 \cdot 10^{-9} \text{ F}$$

$$C_{\text{15_125k}} := C_{\text{z_125k}}$$

$$C_{\text{15_75k}} = 2.394 \cdot 10^{-9} \text{ F}$$

$$C_{\text{15_100k}} := 2.0 \cdot 10^{-9} \text{ F}$$

$$C_{\text{15_125k}} = 1.161 \cdot 10^{-9} \text{ F}$$

C15

Set up UnderVoltage Lockout Divider

$$V_UVLO := 1.9 \cdot \text{volt}$$

$$Vo_set := 105 \cdot \text{volt}$$

$$R5 := 10 \cdot 10^3 \cdot \text{ohm}$$

R5

$$R_{top} := \frac{R5 \cdot (Vo_set - V_UVLO)}{V_UVLO}$$

Under Voltage
R5.... R4/R20

$$R_{top} = 5.426 \cdot 10^5 \Omega$$

$$R_{top_4} := \frac{R_{top}}{4}$$

$$R_{top_4} = 1.357 \cdot 10^5 \Omega$$

$$R4A := 137 \cdot 10^3 \cdot \text{ohm}$$

$$R4B := R4A$$

$$R20A := R4A$$

$$R20B := R4A$$

$$R4B = 1.37 \cdot 10^5 \Omega$$

$$R20A = 1.37 \cdot 10^5 \Omega$$

$$R20B = 1.37 \cdot 10^5 \Omega$$

R4AB and R20AB

Set up Over Voltage Divider

$$V_UVLO := 2.7 \cdot \text{volt}$$

$$Vo_set := 450 \cdot \text{volt}$$

$$R51 := 7.87 \cdot 10^3 \cdot \text{ohm}$$

R51

$$R_{top} := \frac{R51 \cdot (Vo_set - V_UVLO)}{V_UVLO}$$

Under Voltage
R5.... R4/R20

$$R_{top} = 1.304 \cdot 10^6 \Omega$$

$$R_{top_4} := \frac{R_{top}}{4}$$

$$R_{top_4} = 3.259 \cdot 10^5 \Omega$$

$$R50A := 320 \cdot 10^3 \cdot \text{ohm}$$

$$R50B := R50A$$

$$R50C := R50A$$

$$R50D := R50A$$

$$VOVP := V_{o_set} \cdot \left(\frac{R51}{4 \cdot R50A} \right)$$

$$VOVP = 2.767 \text{ V}$$

R50A,B,C,C

$$R50B = 3.2 \cdot 10^5 \Omega$$

$$R50C = 3.2 \cdot 10^5 \Omega$$

$$R50D = 3.2 \cdot 10^5 \Omega$$

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$$VDD := 14 \cdot \text{volt}$$

$$Vz := 2.7 \cdot \text{volt}$$

$$Iz := 0.007 \cdot \text{amp}$$

$$Rz := \frac{(VDD - Vz)}{Iz}$$

$$Rz = 1.614 \cdot 10^3 \Omega$$

$$Pd := \frac{(VDD - Vz)^2}{Rz}$$

$$Pd = 0.079 \text{ W}$$

Device Summary

$R11 = 1 \cdot 10^4 \Omega$	peak current limit	$C6 = 3.9 \cdot 10^{-6} \text{ F}$	Feed Forward
$R12 = 1.2 \cdot 10^3 \Omega$	peak current limit	$R6 = 1.74 \cdot 10^4 \Omega$	Feed Forward
$C1 = 2.2 \cdot 10^{-10} \text{ F}$	timing capacitor	$C8_{100k} = 2.2 \cdot 10^{-10} \text{ F}$	current amp pole
$R1 = 2.7 \cdot 10^4 \Omega$	timing resistor	$C9_{100k} = 8.2 \cdot 10^{-10} \text{ F}$	current amp zero
$C4 := 0.01 \cdot 10^{-6} \text{ F}$	soft start capacitor	$R8_{100k} = 2.2 \cdot 10^4 \Omega$	current amp zero
$R5 = 1 \cdot 10^4 \Omega$		$C7 = 2.7 \cdot 10^{-7} \text{ F}$	voltage amp pole
$R4A = 1.37 \cdot 10^5 \Omega$		$C15_{100k} = 2 \cdot 10^{-9} \text{ F}$	voltage amp zero
$R4B = 1.37 \cdot 10^5 \Omega$		$R7_{100k} = 9.09 \cdot 10^5 \Omega$	voltage zero
$R20A = 1.37 \cdot 10^5 \Omega$	UVL - Enable Divider	$R14 = 0.03 \Omega$	current sense resistor
$R20B = 1.37 \cdot 10^5 \Omega$		$R9 = 6.34 \cdot 10^3 \Omega$	current sense feed
$R2A = 2.49 \cdot 10^5 \Omega$		$R10 = 6.34 \cdot 10^3 \Omega$	current sense feed
$R2B = 2.49 \cdot 10^5 \Omega$		$R51 = 7.87 \cdot 10^3 \Omega$	
$R19A = 2.49 \cdot 10^5 \Omega$	Voltage Set Divider	$R50A = 3.2 \cdot 10^5 \Omega$	
$R19B = 2.49 \cdot 10^5 \Omega$		$R50B = 3.2 \cdot 10^5 \Omega$	OVP Divider
$R3 = 9.31 \cdot 10^3 \Omega$		$R50C = 3.2 \cdot 10^5 \Omega$	
$R21A = 1.78 \cdot 10^5 \Omega$		$R50D = 3.2 \cdot 10^5 \Omega$	
$R21B = 1.78 \cdot 10^5 \Omega$			
$R13A = 1.78 \cdot 10^5 \Omega$	Setting IAC		
$R13B = 1.78 \cdot 10^5 \Omega$			

