UCC28740 DESIGN CALCULATIONS

The Values Entered by the User on the DESIGN INPUT Page are Used in the Design Calculations

INPUT				
Input Voltage Type	AC or DC:	AC		User Input Values From Design Input Page
Minimum Input Voltage	$V_{INPUTmin}$ =	85	VAC	
Maximum Input Voltage	$V_{INPUTmax}$ =	265	VAC	
Nominal Input Voltage	$V_{INPUTnom}$ =	230	VAC	
Minimum Line Frequency	$f_{LINEmin}$ =	47	Hz	
Minimum Input Voltage for Start-Up	$V_{INPUTrun}$ =	80	VAC	
Minimum Peak Bulk Input Voltage	$V_{BULKmin}$ =	120.208	V	
Maximum Peak Bulk Input Voltage	$V_{BULKmax}$ =	374.767	V	
Nominal Peak Bulk Input Voltage	$V_{BULKnom}$ =	325.269	V	
Turn-On Peak Bulk Input Voltage	$V_{BULKstartup}$ =	113.137	V	
Line Cycle Period	t_{LINE} =	21.277	ms	
OUTPUT				
Regulated Output Voltage, Constant Voltage Mode	V_{OUT_CV} =	85	V	User Input Values From Design Input Page
Full Load Rated Output Current	I_{OUT} =	0.6	A	
Target Constant Current Mode Output Load Threshold	I_{OCC_target} =	0.6	A	
Target Minimum Output Voltage During Constant Current Regulation	V_{OUT_CC} =	30	V	
Allowable Output Voltage Drop During Load-Step Transient in Constant Voltage Mode	$V_{OUT\Delta}$ =	0.5	V	
Maximum Peak to Peak Output Voltage Ripple	V_{RIPPLE} =	30	mV	
Required Positive Load Step Transient Current	I_{TRAN} =	0.6	A	
Maximum Allowable Response Time to Load Step Transient	t_{RESP} =	20	ms	
Output Over Voltage Protection	V_{OUT_OVP} =	90	V	
Maximum Stand By Power Dissipation	$P_{SBtarget}$ =	50	mW	
Estimated Efficiency	η =	0.850		
Output Power	P_{OUT} =	51.000	W	
Estimated Input Power	P_{IN} =	60.000	W	

COMPONENT PARAMETER CALCULATIONS

INPUT CAPACITOR, C_{BULK}				
Recommended Input Bulk Capacitance	$C_{BULKrecommended}$ =	233.16	µF	
Actual Input Bulk Capacitance	$C_{BULKactual}$ =	250.000	µF	**User Input**
Input Capacitor Value Used in Calculations	C_{BULK} =	250.000	µF	
Minimum Valley Voltage on Input Bulk Capacitors	$V_{BULKvalley}$ =	101.326	V	
Minimum Input Capacitor Ripple Current Rating	$I_{CINripple}$ =	1416.812	mA	
Minimum Input Capacitor Voltage Rating	V_{Cin} =	400	V	

INPUT FUSE				
Voltage Rating	V_{FUSE} =	265	VAC	
Peak Input Current	I_{INpeak} =	3.939	A	

BRIDGE RECTIFIER				
Voltage Rating	$V_{BRIDGE\_minrating}$ =	400.000	V	
Current Rating	$I_{BRIDGE\_minrating}$ =	1.184	A	
Forward Voltage Drop	V_{F_BRIDGE} =	1.100	V	**User Input**
Full Load Power Dissipation of Bridge Rectifier	P_{BRIDGE} =	3116.985	mW	

TRANSFORMER TURNS-RATIO, N_{PS}				
Demagnetizing Duty Cycle	D_{DEMAG_CC} =	0.425		Device Parameter
Amplitude Modulation Control Ratio	K_{AMnom} =	4		Device Parameter
Maximum Desired Switching Frequency	f_{max_target} =	100.000	kHz	**User Input**
Desired Switching Period	t_{SW_target} =	10.000	µs	
Resonant Frequency During DCM Dead Time	f_{RES} =	0.500	MHz	
Time to First Resonant Valley	t_{RES} =	1.000	µs	
Estimated Maximum Duty Cycle	D_{max_target} =	0.475		

Ideal Primary to Secondary Turns Ratio	$N_{PSideal}$ =	1.3130		Ideal N_{PS}
Actual Primary to Secondary Turns Ratio	$N_{PSactual}$ =	1.321		**User Input**
Primary to Secondary Turns Ratio Used in Calculations	N_{PS} =	1.321		
Actual Flyback Voltage	$V_{FLYBACK}$ =	113.936	V	
Allowable Leakage Inductance Voltage Spike	$V_{LEAKAGE}$ =	211.297	V	
Estimated Maximum On-Time	$t_{ONestimated}$ =	4.764	µs	
Estimated Transformer Efficiency	η_{XFMR} =	0.9		

CURRENT SENSE RESISTOR, R_{CS}, PEAK PRIMARY CURRENT, I_{PP}				
Constant Current Regulation Factor, Minimum	V_{CCR_min} =	318	mV	Device Parameter
Constant Current Regulation Factor, Nominal	V_{CCR_nom} =	330	mV	Device Parameter
Constant Current Regulation Factor, Minimum	V_{CCR_min} =	343	mV	Device Parameter
Initial estimate for L_P	$L_{P\_estimate}$ =	251.721	µH	
Recommended Current Sense Resistor Value	$R_{CSrecommended}$ =	0.337	Ω	
Actual Current Sense Resistor Used	$R_{CSactual}$ =	0.374	Ω	**User Input**
Current Sense Resistor Value Used in Calculation	R_{CS} =	0.374	Ω	
Power Dissipation of R_{CS}	P_{Rcs} =	254.505	mW	
Maximum Current Sense Threshold Voltage, Minimum	V_{CSTmax_min} =	738	mV	Device Parameter
Maximum Current Sense Threshold Voltage, Nominal	V_{CSTmax_nom} =	773	mV	Device Parameter
Maximum Current Sense Threshold Voltage, Maximum	V_{CSTmax_max} =	810	mV	Device Parameter
Peak Primary Current, Minimum, Full Load	I_{PPmin} =	1.973	A	
Peak Primary Current, Nominal, Full Load	**I_{PPnom} =**	**2.067**	**A**	
Peak Primary Current, Maximum, Full Load	I_{PPmax} =	2.166	A	
Actual Output Current During Constant Current Mode	**I_{OCC_actual} =**	**0.580**	**A**	
Peak Primary Current During Light Load, FM Mode	I_{PP_FM} =	0.517	A	
Worst Case Peak Primary Current	I_{PP_WC} =	2.188	A	Assumes -1%R_{CS} and V_{CSTmax_max}
Maximum Output Current During Constant Current Mode	I_{OCCmax} =	0.614	A	Worst Case Estimate

TRANSFORMER PRIMARY INDUCTANCE, L_P				
Calculated L_P to meet f_{max_target} with chosen R_{CS}	L_{Pcalc} =	260.316	µH	
Recommended Primary Inductance to meet t_{CSLEB} with chosen R_{CS}	$L_{Precommended}$ =	260.316	µH	Ideal L_P
Actual Primary Inductance	$L_{Pactual}$ =	251.000	µH	**User Input**
Primary Inductance Used in Calculations	L_P =	251.000	µH	
Actual Maximum Nominal Switching Frequency	**f_{max} =**	**93.340**	**kHz**	
Actual Switching Period	$t_{SWactual}$ =	10.713	µs	
Actual Maximum On-Time	t_{ONmax} =	5.120	µs	
Maximum Duty Cycle	D_{MAX} =	0.478		
Demagnetization Time	t_{DEMAG} =	4.553	µs	
Primary RMS Current	I_{PRI_RMS} =	0.825	A	
Secondary Peak Current	I_{SPmax} =	2.730	A	
Secondary RMS Current	I_{SEC_RMS} =	1.028	A	
VDD Under Voltage Lock Out (UVLO) Voltage, Maximum	VDD_{OFF_max} =	8.150	V	Device Parameter
VDD Under Voltage Lock Out (UVLO) Voltage, Minimum	VDD_{OFF_min} =	7.350	V	Device Parameter
Recommended Auxiliary to Secondary Turns Ratio	$N_{ASrecommended}$ =	0.301		
Recommended Primary to Auxilliary Turns Ratio	$N_{PArecommended}$ =	4.392		
Actual Primary to Auxiliary Turns Ratio	$N_{PAactual}$ =	4.625		**User Input**
Primary to Auxiliary Turns Ratio Used in Calculations	N_{PA} =	4.625		
Nominal VDD Voltage	**VDD =**	**23.385**	**V**	
Actual Auxiliary to Secondary Turns Ratio	N_{AS} =	0.286		
Minimum On-Time, t_{CSLEB}	$t_{ONmin(limit)}$ =	280.000	ns	
Actual Minimum On-Time	$t_{ONmin(actual)}$ =	346.067	ns	
Minimum Demagnetizing Time	$t_{DEMAGmin}$ =	1.138	µs	
Minimum Output Voltage During Constant Current Mode	**V_{OUT_CCmin} =**	**28.860**	**V**	

MOSFET, Q				
Required Drain to Soure Voltage Rating , $V_{DSrated}$ =	V_{DSmin_rating} =	635.314	V	
MOSFET Rated Drain to Source Voltage	V_{DS} =	700.000	V	**User Input Values From Design Input**
Output Capacitance of Selected MOSFET	C_{OSS} =	150	pF	
Drain to Source On-Resistance of Selected MOSFET	R_{DSon} =	1.400	Ω	

MOSFET Fall Time	t_f =	52.000	ns	**Page**
MOSFET Turn Off Delay Time	t_{Doff} =	80	ns	
MOSFET Total Gate Charge	Q_g =	30.000	nC	
Actual Resonant Frequency During DCM Dead Time	f_{RES_actual} =	0.580	MHz	
Actual Estimated Time to First Resonant Valley	t_{RES_actual} =	0.862	µs	
Valley Switching Achieved?	YES or NO	YES		
MOSFET V_{DS} Derating	$V_{DSderated}$ =	0.908		
MOSFET Continuous Current Rating	I_{DRAIN} =	8.731	A	
MOSFET Pulsed Current Rating	I_{PULSED} =	21.877	A	
Estimated MOSFET Conduction Losses	$P_{FETconduction}$ =	0.953	W	
Estimated MOSFET Switching Losses	$P_{FETswitching}$ =	2.928	W	
Total Estimated MOSFET Power Loss	P_{FET} =	3.880	W	
Recommended Clamping Voltage on Drain	$V_{DRAINclamp}$ =	176.297	V	

OUTPUT DIODE, D_{OUT}				
Forward Voltage Drop of Output Rectifier, V_F =	V_F =	1.250	V	**User Input**
Minimum Required Blocking Voltage Rating	$V_{DOUT\_blocking}$ =	507.157	V	
Required Minimum Average Rectified Output Current	I_{Dout} =	1.028	A	
Power Dissipation of D_{OUT}	P_{Dout} =	0.725	W	

AUXILIARY WINDING DIODE, D_{AUX}				
Auxiliary Rectifier Forward Voltage Drop	V_{FA} =	1.250	V	**User Input**
Minimum Required Blocking Voltage Rating	$V_{DBIAS\_blocking}$ =	128.693	V	

OUTPUT INDUCTOR, L_{OUT}				
DCR of Output Inductor	DCR_{Lout} =	0	mΩ	**User Input**

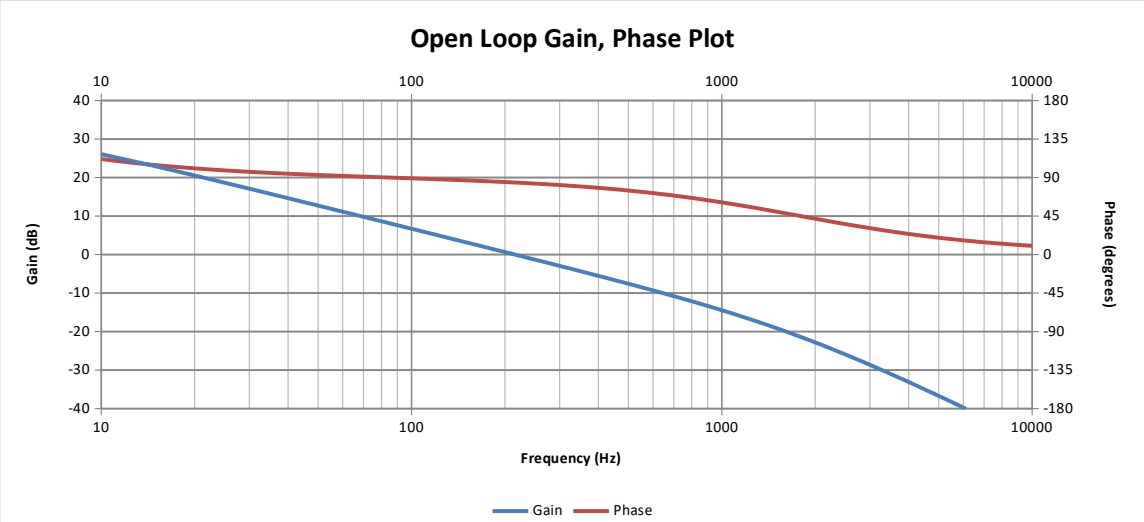
OUTPUT CAPACITOR, C_{OUT}				
Minimum Required C_{OUT} Without Opto-Coupled FeedBack	$C_{OUT\_no\_opto}$ =	24000.000	µF	The importance of using opto feedback should be noted here!
Recommended Minimum Required Output Capacitor With Opto-Coupled FeedBack	$C_{OUTrecommended}$ =	470.000	µF	
Actual Output Capacitance Used	$C_{OUTactual}$ =	540.000	µF	**User Input**
C_{OUT} Used in Calculations	C_{OUT} =	540.000	µF	
Required Minimum Ripple Current Rating	$I_{COUTrms}$ =	0.876	A	
Recommended Maximum ESR	$ESR_{Coutrecommended}$ =	10.988	mΩ	
Actual ESR of C_{OUT} Used	$ESR_{Coutactual}$ =	50.000	mΩ	**User Input**
ESR Used in Calculations	ESR_{Cout} =	50.000	mΩ	
Resultant Output Voltage Peak to Peak Ripple	**$V_{OUTripple}$ =**	**136.626**	**mV**	

VOLTAGE SENSE DIVIDER, R_{VS1}, R_{VS2}				
VS Line Sense Run Current, Minimum	I_{VSLrun_min} =	190	µA	Device Parameter
VS Line Sense Run Current, Nominal	I_{VSLrun_nom} =	225	µA	Device Parameter
VS Line Sense Run Current, Maximum	I_{VSLrun_max} =	275	µA	Device Parameter
VS Line Sense Stop Current, Minimum	$I_{VSLstop\_min}$ =	70	µA	Device Parameter
VS Line Sense Stop Current, Nominal	$I_{VSLstop\_nom}$ =	80	µA	Device Parameter
VS Line Sense Stop Current, Maximum	$I_{VSLstop\_max}$ =	100	µA	Device Parameter
Recommended Resistor Value for Minimum Start Up Line Voltage	$R_{VS1recommended}$ =	90.900	kΩ	
Actual Resistor Value Used for Minimum Start Up Line Voltage	$R_{VS1actual}$ =	93.8	kΩ	**User Input**
R_{VS1} Value Used in Calculations	R_{VS1} =	93.8	kΩ	
Resultant Turn On Voltage, Minimum	$V_{TURNONmin}$ =	58.285	VAC	
Resultant Turn On Voltage, Nominal	**$V_{TURNONnom}$ =**	**69.021**	**VAC**	
Resultant Turn On Voltage, Maximum	$V_{TURNONmax}$ =	84.359	VAC	
Resultant Input Brown Out Voltage, Minimum	$V_{BROWNOUTmin}$ =	34.825	VAC	
Resultant Input Brown Out Voltage, Nominal	**$V_{BROWNOUTnom}$ =**	**37.893**	**VAC**	
Resultant Input Brown Out Voltage, Maximum	$V_{BROWNOUTmax}$ =	44.028	VAC	
Internal VS Over Voltage Threshold, Minimum	V_{OVPmin} =	4.52	V	Device Parameter
Internal VS Over Voltage Threshold, Nominal	V_{OVPnom} =	4.600	V	Device Parameter
Internal VS Over Voltage Threshold, Maximum	V_{OVPmax} =	4.710	V	Device Parameter
Recommended Resistor Value for Desired Output Over Voltage Limit	$R_{VS2recommended}$ =	20.500	kΩ	
Actual Resistor Value Used for Desired Output Over Voltage Limit	$R_{VS2actual}$ =	17.800	kΩ	**User Input**
R_{VS2} Used in Calculations	R_{VS2} =	17.800	kΩ	
Resultant Output Over Voltage Threshold, Minimum	V_{OUT_OVPmin} =	100.468	V	
Resultant Output Over Voltage Threshold, Nominal	**V_{OUT_OVPnom} =**	**102.224**	**V**	**Actual Output Over Voltage**
Resultant Output Over Voltage Threshold, Maximum	V_{OUT_OVPmax} =	104.639	V	

LINE COMPENSATION, R_{LC}				
Line Compensation Current Ratio, Nominal	K_{LCnom} =	25	A/A	Device Parameter
Total Estimated Current Sense Delay	t_{DELAY} =	130	ns	
Recommended Resistor Value for Line Compensation	$R_{LCrecommended}$ =	2.150	kΩ	
Actual Resistor Value Used for Line Compensation	$R_{LCactual}$ =	2.000	kΩ	**User Input**
R_{LC} Used in Calculations	R_{LC} =	2.000	kΩ	
Result of R_{LC} selection	**Using a resistor value that is significantly less than that recommended will result in a higher constant current output at higher input line voltage.**			

VDD CAPACITOR, C_{VDD}				
Device Supply Current During Run Mode, Maximum	I_{RUNmax} =	2.65	mA	Device Parameter
VDD_{ON} Voltage, Maximum	VDD_{ONmax} =	23	V	Device Parameter
VDD_{OFF} Voltage, Maximum	VDD_{OFFmax} =	8.15	V	Device Parameter
Estimated Minimum Switching Frequency at No-Load	f_{SWmin} =	1.194	kHz	
Estimated Over Voltage Charge Duration	t_{OV} =	20.000	ms	
Minimum VDD Capacitor for Start UP	C_{VDD1} =	10.000	µF	
Minimum VDD Capacitor for Load Transient	C_{VDD2} =	4.700	µF	
Minimum VDD Capacitor for Target Ripple on VDD	C_{VDD3} =	2.200	µF	
Recommended Capacitor on VDD	$C_{VDDrecommended}$ =	10.000	µF	

OPTO-COUPLED FEEDBACK				
Reference Voltage of TL431 Shunt Regulator	$VREF_{431}$ =	2.5	V	**User Input**
Shunt Regulator Reference Input Current, Maximum	I_{REF431} =	4	µA	**User Input**
Recommended Bottom Resistor Value for Output Voltage Set Point	$R_{FB2recommended}$ =	44.2	kΩ	
Actual Bottom Resistor Value Used for Output Voltage Set Point	$R_{FB2actual}$ =	44.2	kΩ	**User Input**
R_{FB2} Used in Calculations	R_{FB2} =	44.2	kΩ	
Recommended Top Resistor Value for Output Voltage Set Point	$R_{FB1recommended}$ =	1470	kΩ	
Actual Top Resistor Value Used for Output Voltage Set Point	$R_{FB1actual}$ =	1540	kΩ	**User Input**
R_{FB1} Used in Calculations	R_{FB1} =	1540.02	kΩ	
Noise Injection Resistor For Loop Analysis	R_{INJ} =	20	Ω	**May be changed by User here**
Resultant Nominal Constant Voltage Output Voltage	**V_{OUT_CV} =**	**89.605**	**V**	
Minimum Current Transfer Ratio of Selected Opto-Coupler	CTR_{min} =	50	%	**User Input**
Response Fall Time of Opto-Coupler	t_{f_opto} =	3	µs	**User Input**
R_L of Specified Opto-Coupler Fall Time	R_{L_opto} =	100	Ω	**User Input**
Cut-Off Frequency of Opto-Coupler	f_{c_opto} =	80	kHz	**User Input**
Input Forward Voltage of Opto-Coupler	V_{F_opto} =	1.4	V	**User Input**
Equivalent Opto-Coupler Output Capacitance	C_{OPTO} =	4.775	nF	
Equivalent Internal UCC28740 Dynamic Reistance	R_{EQU} =	40	kΩ	
Recommended Value for External Capacitor on Opto-Coupler	$C_{EXTrecommended}$ =	0	µF	
Actual Value of External Capacitor on Opto-Coupler Used	$C_{EXTactual}$ =	0.0015	µF	**User Input**
C_{EXT} Used in Calculations	C_{EXT} =	0.0015	µF	
Recommended C_{FB}	$C_{FBrecommended}$ =	0.047	µF	
Actual C_{FB} Used	$C_{FBactual}$ =	0.047	µF	**User Input**
C_{FB} Used in Calculations	C_{FB} =	0.047		
Recommended Value For R_{FB4}	$R_{FB4recommended}$ =	22	kΩ	
Actual Value for R_{FB4} Used	$R_{FB4actual}$ =	22	kΩ	**User Input**
R_{FB4} Used in Calculations	R_{FB4} =	22	kΩ	
Opto-Coupler Emitter Current to FB Pin Current Gain	G_{FB1} =	0.355		
FB Pin Current to Control Law Voltage Gain, Full Load	G_{FB2} =	-192	kΩ	
Control Law Voltage to Power Stage Modulation Gain, FM Mode	K_{FM4} =	50.4	kHz/V	
Power Stage Modulation (FM) to Average Current Gain	G_{P4} =	6.428	µC	
Recommeded Value for Shunt Regulator Bias Resistor	$R_{TLrecommended}$ =	1.5	kΩ	
Actual Value of Shunt Regulator Bias Resistor Used	$R_{TLactual}$ =	1.5	kΩ	**User Input**
R_{TL} Used in Calculations	R_{TL} =	1.5	kΩ	
Recommended Value for Compensation Capacitor	$C_{Zrecommended}$ =	220	pF	
Actual Value Used C_Z	$C_{Zactual}$ =	1500	pF	**User Input**
C_Z Used in Calculations	C_Z =	1500	pF	


Open Loop Gain, Phase Plot
10
100
1000
10000
40
30
20
10
0
-10
-20
-30
-40
180
135
90
45
0
-45
-90
-135
-180
Gain (dB)
Phase (degrees)
Frequency (Hz)
Gain
Phase