UCC25630x DESIGN CALCULATOR TOOL

TI Literature Number:SLUC634 **Version: B**

UCC25630x Enhanced LLC Resonant Controller

Please enter design parameters into the shaded cells;
Recommended Component Values will be in RED

Be sure to *ENABLE EDITING* before attempting to use this design calculator

This spreadsheet guides the user through the design process of an LLC resonant DC/DC CONVERTER using the UCC25630x. User interaction is required in order to get the best possible results. Enter the desired specification where prompted, the highlighted cells are for user inputs; calculations for the design are based upon the inputs.

WHERE APPLICABLE, A RECOMMENDED VALUE IS GIVEN THAT WILL BE THE BEST CHOICE TO MEET THE GIVEN SPECIFICATION. IT IS IN THE BEST INTEREST OF THE USER TO USE A VALUE AS CLOSE AS POSSIBLE TO THE SUGGESTED RECOMMENDED VALUE. FOR ACCURATE RESULTS, THE USER MUST ENTER THE ACTUAL VALUE USED IN THE APPROPRIATE CELL.

Select Which Device You Are Using		UCC256302	

OUTPUT			
Output Voltage	V_{OUT}	5	V
Maximum Output Power	P_{OUT}	98	W
Full Load Output Current	I_{OUT}	19.6	A
Maximum Output Voltage Ripple	$V_{OUT(pk-pk)}$	100	mV
Target Efficiency	η	0.93	

INPUT			
Nominal Input Voltage	V_{BLK}	390	V
Maximum V_{BLK} Ripple (2 x Line Frequency)	$V_{BLK(ripple)target}$	30	V_{PP}
Maximum DC Input Voltage	$V_{BLK(max)}$	410	V
Minimum DC Input Voltage	$V_{BLK(hu)}$	260	V

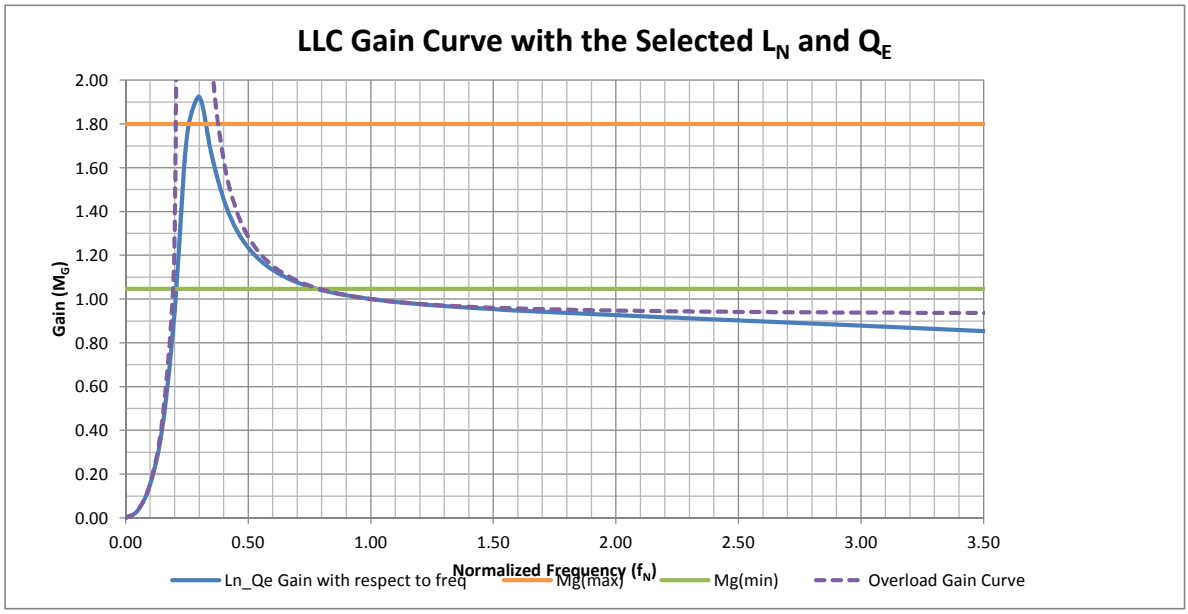
LLC STAGE			
Nominal LLC Switching Frequency	f_{LLC}	100	kHz
LLC Transformer			
Recommended Primary/Secondary Turns Ratio	$N_{PS(recommended)}$	39	
Actual Primary/Secondary Turns Ratio	N_{PS}	39.00	
Recommended Primary/Bias Turns Ratio	$N_{PB(recommended)}$	13.00	
Actual Primary/Bias Turns Ratio	N_{PB}	13.00	
LLC Effective Load Resistance at 110% Full Load	R_E	285.9	Ω
LLC Effective Load Resistance at Full Load	$R_{E(full\ load)}$	314.5	Ω
LLC Gain Range			
Minimum LLC Gain	$M_{G(min)}$	1.046	
Maximum LLC Gain Including Losses	$M_{G(max)}$	1.800	
Predicted Voltage Drop Due to Losses	V_{LOSS}	0.500	V
Select L_N and Q_E			

From the figure on the right, $M_{G(peak)}$ Vs Q_E with respect to L_N, select a point on an Ln curve that has an Ln and Q_E point that corresponds to an Attainable $M_{G(PEAK)}$ value that is greater than $M_{G(max)}$. Enter the selected values in the L_N and Q_E cells below.

For example, if $M_{G(max)}$, calculated above and shown by the horizontal line, was calculated to be 1.4, then using Ln = 5 and Q_E = 0.35 would result in an attainable $M_{G(PEAK)}$ = 1.52 (interpolated from Ln = 5 curve) which satisfies the requirement that the Attainable $M_{G(PEAK)}$ > $M_{G(max)}$

Selected Primary Inductance Ratio	$L_{N(selected)}$	13.500	
Selected Quality Factor for Resonant Network	$Q_{E(selected)}$	0.150	
Gain Required at No-Load	$M_{G(noload)}$	0.931	
f_N at Maximum Switching Frequency	$f_{N(max)}$	3.50	

The selected L_N and Q_E values should result in an LLC Gain Curve, shown below, that intersects with the $M_{G(min)}$ and $M_{G(max)}$ traces. The Gain curve from an overload condition is also plotted, showing the minimum gain at maximum frequency.



Parameters of the LLC Resonant Circuit			
Recommended Resonant Capacitor Value	$C_{R(recommended)}$	0.034	uF
Actual Total Value of Resonant Capacitor Used	C_R	0.0338	uF
Recommended Resonant Inductor Value	$L_{R(recommended)}$	74.942	uH
Actual Resonant Inductor Value Used	L_R	61.5	uH
Recommended Transformer Magnetizing Inductance	$L_{M(recommended)}$	830.25	uH
Actual Transformer Magnetizing Inductance Used	L_M	532	uH
Resultant Series Resonant Frequency	f_0	110.4	kHz
No Load Resonant Frequency	f_P	35.5	kHz
Resultant Inductance Ratio	L_N	**8.65**	
Resultant Quality Factor at Full Load	Q_E	**0.14**	
f_N at $M_{G(max)}$	$f_{N(Mg\_max)}$	0.52	
f_N at $M_{G(min)}$	$f_{N(Mg\_min)}$	1.15	
Maximum Switching Frequency	$f_{SW(max)}$	126.9	kHz
Minimum Switching Frequency	$f_{SW(min)}$	57.4	kHz
LLC Primary Side Currents			
Primary Side RMS Load Current	I_{OE}	0.614	A
RMS Magnetizing Current at $f_{SW(min)}$	I_M	0.915	A
Total Current in Resonant Circuit	I_R	1.102	A
LLC Secondary Side Currents			
Secondary RMS Current	$I_{OE(S)}$	23.947	A
Current in Each Center Tapped Winding	I_{WS}	16.933	A

LLC Resonant Inductor			
Terminal AC Voltage Across Resonant Inductor	V_{Lr}	24.442	V
Inductance	L_R	61.500	uH
Rated Current	I_R	1.102	A

LLC Resonant Capacitor			
AC Voltage Across Resonant Capacitor	V_{CR}	90.4	V
RMS Voltage Across Resonant Capacitor	$V_{CR(rms)}$	224.0	V
Peak Voltage AC Voltage Rating for Resonant Capacitor	$V_{CR(peak)}$	332.8	V
Valley Voltage on Resonant Capacitor	$V_{Cr(valley)}$	77.2	V
Rated Current of Resonant Capacitor	I_R	1.102	A
If Using Split Resonant Capacitors			
Value of EACH Resonant Capacitor If Using Split Resonant Capacitors	$C_{R(split)}$	0.017	uF

LLC Primary Side MOSFETs			
Minimum Voltage Rating of LLC MOSFETs	$V_{QLLC(peak)}$	615.0	V
RMS Current Rating of LLC MOSFETs	I_{QLLC}	1.212	A

LLC Output Rectifier Diodes/Synchronous rectifiers			
Minimum Voltage Rating for LLC Output Diodes	V_{DB}	12.615	V
Minimum Current Rating for LLC Output Diodes	I_{SAV}	10.780	A

LLC Output Capacitors, C_{OUT}			
Rectifier's full wave output current	I_{RECT}	21.770	A
C_{OUT} Minimum Voltage Rating	V_{LLCcap}	10	V
C_{OUT} RMS Ripple Current Rating at resonant frequency	$I_{C(out)}$	9.475	A
C_{OUT} Maximum ESR	ESR_{max}	3.248	mΩ

BLK			
BLK Pin Start Threshold	$V_{BLKpinstart}$	3.05	V
BLK Pin Stop Threshold	$V_{BLKpinstop}$	2.20	V
BLK Pin OV Rise Threshold	$V_{BLKpinOVrise}$	4.03	V
BLK Pin OV Fall Threshold	$V_{BLKpinOVfall}$	3.76	V
Desired Bulk Start Voltage	$V_{BLKStart}$	260	V
Actual Bulk Start Voltage	$V_{BLKStart}$	330	V
Nominal Bulk Voltage	V_{BLK}	390	V
Bulk Stop Voltage	$V_{BLKstop}$	238	V
Bulk OV Rise Voltage	$V_{BLKOVrise}$	436	V
Bulk OV Fall Voltage	$V_{BLKOVfall}$	407	V
Resistor Divider Ratio	k_{BLK}	85	
Resistor Divider Power Consumption Budget	P_{BLKsns}	0.01	W
Total BLK Sense Resistor Value	R_{BLKsns}	15.21	MΩ
Recommended Upper BLK Sense Resistor Value	$R_{BLKupper}$	15.03	MΩ
Actual Upper BLK Sense Resistor Value	$R_{BLKupper}$	15	MΩ
Recommended Lower BLK Sense Resistor Value	$R_{BLKlower}$	178.43	kΩ
Actual Lower BLK Sense Resistor Value	$R_{BLKlower}$	140	kΩ

VCR			
Peak Resonant Current at Full Load	$I_{res(peak)}$	1.56	A
Peak to Peak Resonant Capacitor Voltage at Full Load	$V_{cr(pk-pk)}$	255.664	V
Maximum Working Voltage Range of VCR Pin	$V_{VCRpin(pk-pk)}$	2.2	V
Common Mode Voltage of VCR Pin	V_{CM}	3.02	V
Maximum VCR Voltage	V_{VCRmax}	4.12	V
Minimum VCR Voltage	V_{VCRmin}	1.92	V
Ratio of I_{Ramp} vs. the Peak Current in Capacitor Divider	$k_{VCRramp}$	0.35	
Compensation Ramp Current Source Value	I_{Ramp}	1.84	mA
Total Capacitance of the Capacitor Divider	C_{VCRsns}	114.4	pF
Capacitor Divider Ratio	k_{CapDiv}	116.21	
Recommended Capacitor Divider Value - Upper Cap	$C_{VCRupper}$	115.4	pF
Actual Capacitor Divider Value - Upper Cap	$C_{VCRupper}$	118.0	pF
Recommended Capacitor Divider Value - Lower Cap	$C_{VCRlower}$	13293.9	pF
Actual Capacitor Divider Value - Lower Cap	$C_{VCRlower}$	13300.0	pF
The above are estimated capacitor values without considering I_{ramp}'s contribution to VCR			
Now consider I_{ramp}, calculate FB voltage at full load	Vcompfullload	2.54	V
Calculate FB voltage at resonant frequency	Vcompresonant	0.92	V
Calculate Vcr pin voltage	Vcrpeak	2.96	V

SS			
SS Internal Reference Voltage	V_{ref}	7	V
SS Current Source Value	I_{SSUp}	25.8	µA
Required Soft Start Time at Full Load	T_{SS}	40	ms
Actual Soft Start Time at Full Load	T_{SS}	40.7	ms
Recommended SS Capacitance Value	C_{SS}	147.4	nF
Actual SS Capacitance Value	C_{SS}	150	nF

LL (this section may be ignored for initial design and populated once hardware is available)			
Required Burst Mode Threshold - Percentage of Full Load	k_{Burst}	10	%
Required Burst Mode Threshold - Load Current	$I_{BurstLoad}$	1.96	A
Re Value		10	KΩ
Voltage on Re at $I_{BurstLoad}$ and Maximum Input Voltage		0.757	V
Internal Current Source on FB Pin		80.5	uA
FB Pin Voltage at $I_{BurstLoad}$ and Maximum Input Voltage	V_{LL1}	0.48	V
BLK Pin Voltage at Maximum Input Voltage	$V_{BLKPin1}$	3.79	V
Voltage on Re at $I_{BurstLoad}$ and Minimum Input Voltage		0.70	V
FB Pin Voltage at $I_{BurstLoad}$ and Minimum Input Voltage	V_{LL2}	1.09	V
BLK Pin Voltage at Minimum Input Voltage	$V_{BLKPin2}$	2.40	V
Recommended LL Resistor Divider Upper Resistor Value	$R_{LLupper}$	1399.5	KΩ
Actual LL Resistor Divider Upper Resistor Value	$R_{LLupper}$	OPEN	KΩ
Recommended LL Resistor Divider Lower Resistor Value	$R_{LLlower}$	957.3	KΩ
Actual LL Resistor Divider Lower Resistor Value	$R_{LLlower}$	402.0	KΩ
Internal LL Resistor Value	R_3	250	KΩ

BW			
Desired OVP Threshold Percentage of Nominal V_{out}	η_{OVP}	115	%
Actual OVP Threshold Percentage of Nominal V_{out}	η_{OVP}	138.2	%
OVP Threshold	V_{BWOVP}	-3.97	V
BW Pin Voltage at Nominal V_{out}	$V_{BWpinNom}$	-3.45	V
Bias Winding Nominal Voltage	$V_{BiasWindingNom}$	15.0	V
Bias Winding Resistor Divider Ratio	k_{BW}	4.345	
Actual Bias Winding Lower Resistor Value	$R_{BWlower}$	10	KΩ
Recommended Bias Winding Upper Resistor Value	$R_{BWupper}$	33.45	KΩ
Actual Bias Winding Upper Resistor Value	$R_{BWupper}$	42.2	KΩ
BW Filter Capacitor Needed so That the Bandwidth is 50 Times the Resonant Frequency		3.57	pF
Actual BW Filter Capacitor		3.90	pF

ISNS			
OCP3 Threshold		0.64	V
OCP2 Threshold		0.84	V
OCP1 Threshold		4.03	V
Desired OCP3 Threshold (Percentage of Full Load at Nominal Input Voltage)		150	%
Calculated OCP2 Level (Percentage of Full Load at Nominal Input Voltage)		196.9	%
Sensed Average Input Current Level at Full Load		0.43	V
Current Sense Ratio	k_{ISNS}	1.58	
Select a Current Sense Capacitor	C_{ISNS}	150	pF
Recommended Current Sense Resistor	R_{ISNS}	356	Ω
Actual Current Sense Resistor	R_{ISNS}	357	Ω
Peak V_{ISNS} at Full Load		2.47	V
Ires peak at OCP1 Level		2.54	A
Isec peak at OCP1 Level		99.20	A