1	***Hiper_PFS-5_Boost_051923; Rev.1.2; Copyright Power Integrations 2023***	***INPUT***	***INFO***	***OUTPUT***	***UNITS***	***Discontinuous Mode Boost Converter Design Spreadsheet***
2	Enter Application Variables					Design Title
3	Input Voltage Range	Universal		Universal		Input voltage range
4	VACMIN	170		170	VAC	Minimum AC input voltage. Spreadsheet simulation is performed at this voltage. To examine operation at other votlages, enter here, but enter fixed value for LPFC_ACTUAL.
5	VACMAX	265		265	VAC	Maximum AC input voltage
6	VBROWNIN		Info	82	VAC	Brown-IN voltage has been modified since the V-pin ratio is no longer 100:1
7	VBROWNOUT		Info	71	VAC	Brown-OUT voltage has been modified since the V-pin ratio is no longer 100:1
8	VO	380	Info	380	VDC	Brown IN/OUT voltage has changed due to modifications in the V-pin ratio from 100:1. Recommend Vpin ratio= FB pin ratio for optimized operation. Check the PF, input current distortion, brown in/out and power delivery
9	PO	145		145	W	Nominal Output power
10	fL			50	Hz	Line frequency
11	TA Max			40	°C	Maximum ambient temperature
12	Efficiency Estimate			0.9500		Enter the efficiency estimate for the boost converter at VACMIN. Should approximately match calculated efficiency in Loss Budget section
13	VO_MIN			361	VDC	Minimum Output voltage
14	VO_RIPPLE_MAX	10		10	VDC	Maximum Output voltage ripple
15	T_HOLDUP			20	ms	Holdup time
16	VHOLDUP_MIN			304	VDC	Minimum Voltage Output can drop to during holdup
17	I_INRUSH			40	A	Maximum allowable inrush current
18	Forced Air Cooling	Yes		Yes		Enter "Yes" for Forced air cooling. Otherwise enter "No". Forced air reduces acceptable choke current density and core autopick core size
19						
20	KP and INDUCTANCE					
21	LPFC_MIN (0 bias)			169	uH	Minimum PFC inductance value
22	LPFC_TYP (0 bias)	175		175	uH	LPFC value used for calculations. Enter value to hold constant (also enter core selection) while changing VACMIN to examine brownout operation.
23	LPFC_MAX (0 bias)			180	uH	Maximum PFC inductance value
24	LP_TOL	3.0		3.0	%	Tolerance of PFC Inductor Value (ferrite only)
25	LPFC_PEAK			175	uH	Inductance at VACMIN and maximum bias current. For Ferrite, same as LPFC_DESIRED (0 bias)
26	KP_ACTUAL			1.35		Actual KP calculated from LPFC_DESIRED
27						
28	Basic Current Parameters					
29	IAC_RMS			0.90	A	AC input RMS current at VACMIN and Full Power load
30	IL_RMS			1.47	A	Inductor RMS current (calculated at VACMIN and Full Power Load)
31	IO_DC			0.38	A	Output average current/Average diode current
32						
33						
34	PFS Parameters					
35	PFS Package			F		HiperPFS package selection
36	PFS Part Number	PFS5277F	Warning	PFS5277F		Peak power rating for the device has been exceeded. Output might droop. Change the input voltage range, enter higher output power selection factor, or select a larger device.
37	Self-Supply Feature	No		No		Device self-supply feature. Select "Yes" to select device with self-supply feature or "No" for device without self-supply
38	PS_FACTOR	0.7		0.7		Programmable output power selection factor
39	PO_MAX_DEV			130	W	Maximum output power of the device
40	IOCP min			5.37	A	Minimum Current limit
41	IOCP typ			4.00	A	Typical current limit
42	IOCP max			6.24	A	Maximum current limit
43	IP			3.64	A	MOSFET peak current
44	IRMS			1.04	A	PFS MOSFET RMS current
45	RDSON			0.29	Ohms	Typical RDSon at 100 'C
46	FS_PK			140.5	kHz	Estimated frequency of operation at crest of input voltage (at VACMIN)
47	FS_AVG			125.5	kHz	Estimated average frequency of operation over line cycle (at VACMIN)
48	PCOND_LOSS_PFS			0.316	W	Estimated PFS Switch conduction losses
49	PSW_LOSS_PFS			0.111	W	Estimated PFS Switch switching losses
50	PFS_TOTAL			0.427	W	Total Estimated PFS Switch losses
51	TJ Max			100	deg C	Maximum steady-state junction temperature
52	Rth-JS			2.80	°C/W	Maximum thermal resistance (Junction to heatsink)
53	HEATSINK Theta-CA			137.66	°C/W	Maximum thermal resistance of heatsink

54						
55						
56	INDUCTOR DESIGN					
57	Material and Dimensions					
58	Core Type			Ferrite		Ferrite core
59	Core Material	Auto		PC44/PC95		Select the core material
60	Core Geometry	ATQ		ATQ		Select the core geometry
61	Core	ATQ25/16		ATQ25/16		Core part number
62	Ae			102.00	mm^2	Core cross sectional area
63	Le			40.80	mm	Core mean path length
64	AL			6700.00	nH/t^2	Core AL value
65	Ve			4.16	cm^3	Core volume
66	HT (EE/PQ/EQ/RM/POT) / ID (toroid)			3.20	mm	Core height/Height of window; ID if toroid
67	MLT			48.8	mm	Mean length per turn
68	BW			8.00	mm	Bobbin width
69	LG			0.71	mm	Gap length (Ferrite cores only)
70	Flux and MMF Calculations					
71	BP_TARGET (ferrite only)	3498		3498	Gauss	Target flux density at worst case: IOCP and maximum tolerance inductance (ferrite only) - drives turns and gap
72	B_OCP (or BP)			3446	Gauss	Target flux density at worst case: IOCP and maximum tolerance inductance (ferrite only) - drives turns and gap
73	B_MAX			1952	Gauss	Peak flux density at AC peak, VACMIN and Full Power Load, nominal inductance,minimum IOCP
77	I_TEST			4.0	A	Current at which B_TEST and H_TEST are calculated, for checking flux at a current other than IOCP or IP; if blank IOCP_typ is used.
78	B_TEST			2209	Gauss	Flux density at I_TEST and maximum tolerance inductance
80	Wire					
81	TURNS			32		Inductor turns. To adjust turns, change the BP_TARGET
82	ILRMS			1.47	A	Inductor RMS current
83	Wire type	Litz		Litz		Select between "Litz" or "Magnet" for double coated magnet wire
84	AWG			40	AWG	Inductor wire gauge
85	Filar			59		Inductor wire number of parallel strands. Leave blank to auto-calc for Litz
86	OD (per strand)			0.079	mm	Outer diameter of single strand of wire
87	OD bundle (Litz only)			0.85	mm	Will be different than OD if Litz
88	DCR			0.121	ohm	Choke DC Resistance
89	P AC Resistance Ratio			0.55		Ratio of total copper loss, including HF AC, to the DC component of the loss
90	J		Info	5.12	A/mm^2	Current density is low. If copper loss is low, you can use thinner wire or fewer strands
91	Layers			3.57		Estimated layers in winding
92	Auxiliary Winding					
93	N_AUX			121		Recommended auxiliary winding number of turns to ensure the supply to the VS pin
94	V_VS_MAX			0.88	V	Maximum voltage across the auxiliary winding
95	V_VS_MIN			-1417.09	V	Minimum voltage across the auxiliary winding
96	RVS			10.00	kohm	Recommended series resistor to the VS pin. Place as close as possible to the VS pin of Hiper-PFS5
97	Loss Calculations					
98	BAC-p-p			2465	Gauss	Core AC peak-peak flux excursion at VACMIN, peak of sine wave
99	LPFC_CORE_LOSS			0.235	W	Estimated Inductor core Loss
100	LPFC_COPPER_LOSS			0.299	W	Estimated Inductor copper losses
101	LPFC_TOTAL_LOSS			0.533	W	Total estimated Inductor Losses
102						
103						
104	PFC Diode					
105	PFC Diode Part Number	STTH8L06		STTH8L06		PFS Diode Part Number
106	Type / Part Number			Ultrafast		PFC Diode Type / Part Number
107	Manufacturer			ST		Diode Manufacturer
108	VRRM			600.0	V	Diode rated reverse voltage
109	IF			8.00	A	Diode rated forward current
110	Qrr			900.0	nC	Qrr at High Temperature
111	VF			1.05	V	Diode rated forward voltage drop
112	PCOND_DIODE			0.516	W	Estimated Diode conduction losses
113	PSW_DIODE			0.000	W	Estimated Diode switching losses
114	P_DIODE			0.516	W	Total estimated Diode losses
115	TJ Max			100.0	deg C	Maximum steady-state operating temperature
116	Rth-JS			2.50	degC/W	Maximum thermal resistance (Junction to heatsink)
117	HEATSINK Theta-CA			113.17	degC/W	Maximum thermal resistance of heatsink
118	IFSM			120.0	A	Non-repetitive peak surge current rating. Consider larger size diode if inrush or thermal limited.

119						
120						
121	Output Capacitor					
122	COUT	150		150	uF	Minimum value of Output capacitance
123	VO_RIPPLE_EXPECTED			8.5	V	Expected ripple voltage on Output with selected Output capacitor
124	T_HOLDUP_EXPECTED			26.9	ms	Expected holdup time with selected Output capacitor
125	ESR_LF			1.11	ohms	Low Frequency Capacitor ESR
126	ESR_HF			0.44	ohms	High Frequency Capacitor ESR
127	IC_RMS_LF			0.34	A	Low Frequency Capacitor RMS current
128	IC_RMS_HF			0.85	A	High Frequency Capacitor RMS current
129	CO_LF_LOSS			0.125	W	Estimated Low Frequency ESR loss in Output capacitor
130	CO_HF_LOSS			0.323	W	Estimated High frequency ESR loss in Output capacitor
131	Total CO LOSS			0.447	W	Total estimated losses in Output Capacitor
132						
133						
134	Input Bridge (BR1) and Fuse (F1)					
135	I^2t Rating			10.53	A^2*s	Minimum I^2t rating for fuse
136	Fuse Current rating			2.60	A	Minimum Current rating of fuse
137	VF			0.90	V	Input bridge Diode forward Diode drop
138	IAVG			1.62	A	Input average current at VBROWNOUT.
139	PIV_INPUT BRIDGE			375	V	Peak inverse voltage of input bridge
140	PCOND_LOSS_BRIDGE			1.455	W	Estimated Bridge Diode conduction loss
141	CIN	1.00		1.00	uF	Input capacitor. Use metallized polypropylene or film foil type with high ripple current rating
142	CIN_DF			0.001		Input Capacitor Dissipation Factor (tan Delta)
143	CIN_PLOSS			0.019	W	Input Capacitor Loss
144	RT1			9.37	ohms	Input Thermistor value. Adjust I_INRUSH to get the closest standard thermistor value
145	D_Precharge			1N5407		Recommended precharge Diode
146						
147						
148	PFS5 Small Signal Components					
149	RVS			10.0	kOhms	VS pin resistor for valley sensing. This resistor should be optimized such that proper delay is introduced from the instant the voltage on the sense winding goes below the Vvs2 threshold to the instant when the cascode turns-on (valley sensing). Must be tested on the bench
150	RPS			FALSE	kOhms	Power programmability resistor. Leaving PS pin short to G node is acceptable
151	RV1			4.0	MOhms	Line sense resistor 1
152	RV2			6.0	MOhms	Line sense resistor 2
153	RV3			6.0	MOhms	Typical value of the lower resistor connected to the V-PIN. Use 1% resistor only!
154	RV4			161.6	kOhms	Description pending, could be modified based on feedback chain R1-R4
155	C_V			0.495	nF	V pin decoupling capacitor (RV4 and C_V should have a time constant of 80us) Pick the closest available capacitance.
156	C_VCC			1.0	uF	Supply decoupling capacitor
157	C_C			100	nF	Feedback C pin decoupling capacitor
158	Power good Vo lower threshold VPG(L)			333	V	Vo lower threshold voltage at which power good signal will trigger
159	PGT set resistor			337.4	kohm	Power good threshold setting resistor
160						
161						
162	Feedback Components					
163	RFB_1			4.00	Mohms	Feedback network, first high voltage divider resistor
164	RFB_2			6.00	Mohms	Feedback network, second high voltage divider resistor
165	RFB_3			6.00	Mohms	Feedback network, third high voltage divider resistor
166	RFB_4			155.5	kohms	Feedback network, lower divider resistor
167	CFB_1			0.514	nF	Feedback network, loop speedup capacitor. (R4 and C1 should have a time constant of 80us) Pick the closest available capacitance.
168	RFB_5			39.2	kohms	Feedback network: zero setting resistor
169	CFB_2			1000	nF	Feedback component- noise suppression capacitor
170						
171						
172	Loss Budget (Estimated at VACMIN)					
173	PFS Losses			0.427	W	Total estimated losses in PFS
174	Boost diode Losses			0.516	W	Total estimated losses in Output Diode
175	Input Bridge losses			1.455	W	Total estimated losses in input bridge module
176	Input Capacitor Losses			0.019	W	Total estimated losses in input capacitor
177	Inductor losses			0.533	W	Total estimated losses in PFC choke
178	Output Capacitor Loss			0.447	W	Total estimated losses in Output capacitor

179	EMI choke copper loss			0.081	W	Total estimated losses in EMI choke copper
180	Total losses			3.479	W	Overall loss estimate
181	Efficiency			97.66	%	Estimated efficiency at VACMIN, full load.
182						
183						
184	Function					
185	Total Series Resistance (Rcapzero1+Rcapzero2)			0.730	MOhms	Maximum total series resistor value to discharge X-capacitors with time constant of 1 second. Resistors must be connected to D1 and D2 pins of the HiperPFS-5 part for integrated CAPZero function
186						
187						
188	EMI Filter Components Recommendation					
189	CX2			470	nF	X-capacitor after differencial mode choke and before bridge, ratio with Po
190	LDM_calc			172	uH	Estimated minimum differential inductance to avoid <10kHz resonance in input current
191	CX1			470	nF	X-capacitor before common mode choke, ratio with Po
192	LCM			10.0	mH	Typical common mode choke value
193	LCM_leakage			30	uH	Estimated leakage inductance of CM choke, typical from 30~60uH
194	CY1 (and CY2)			220	pF	typical Y capacitance for common mode noise suppression
195	LDM_Actual			142	uH	cal_LDM minus LCM_leakage, utilizing CM leakage inductance as DM choke.
196	DCR_LCM			0.070	Ohms	Total DCR of CM choke for estimating copper loss
197	DCR_LDM			0.030	Ohms	Total DCR of DM choke(or CM #2) for estimating copper loss
198						
199	Note: CX2 can be placed between CM choke and DM choke depending on EMI design requirement.					
200						