Appendix A: Coupled Inductor Calculation

	Symbol	Equations	36/22 no gap	36/22 150µm	36/22 250µm	36/22 430µm	36/22 730µm
Switching Frequency	f	given	100000	100000	100000	100000	100000
Period	T	given	0.00001	0.00001	0.00001	0.00001	0.00001
1/2 Period	0.5T	given	0.000005	0.000005	0.000005	0.000005	0.000005
Duty Ratio	D	given	0.500000	0.500000	0.500000	0.500000	0.500000
Efficieny Rating	eta	given	1.1	1.1	1.1	1.1	1.1
Input Voltage	Vin	given	108.0	108.0	108.0	108.0	108.0
Output Voltage	Vout	given	25	25	25	25	25
Input Current	Iin	given	3	3	3	3	3
Output Current	Iout	given	10.0	10.0	10.0	10.0	10.0
Primary Turns	N1	given	44	44	44	44	44
Secondary Turns	N2	given	10	10	10	10	10
Bsat	Bsat	given	0.3	0.3	0.3	0.3	0.3
Permiability of Free Space	µ0	given	1.25664E-06	1.25664E-06	1.25664E-06	1.25664E-06	1.25664E-06
Effective permeability (unitless)	µe	given	2260	335	210	132	84
Core Permeability (H/m)	µ	µe*µ0	0.00284	0.000420973	0.000263894	0.000165876	0.000105558
Effective length (m)	le	given	0.0532	0.0532	0.0532	0.0532	0.0532
Effective Area	Ae	given	0.000202	0.000202	0.000202	0.000202	0.000202
Inductance/turn	Al	given	1.08E-05	1.60E-06	1.00E-06	6.30E-07	4.00E-07
Core reluctance (1/H)	CRel	le/(µAe)	92734.63345	625612.751	998001.2933	1587729.33	2495003.233
Primary Core Inductance	L1	N1^2/CRel	0.020876774	0.003094566	0.001939877	0.001219351	0.000775951
Secondary Core Inductance	L2	N2^2/CRel	0.001078346	0.000159843	0.0001002	6.2983E-05	4.00801E-05
Required Volt-second rating	V-s req	N1*Bsat*Ae	0.002666	0.002666	0.002666	0.002666	0.002666
Volt-second rating	V-s	Vmax*0.5T	0.000845	0.000845	0.000845	0.000845	0.000845
Critical Inductance Primary	Lcritp	2Vout*Eta*T*D/Iout	9.16667E-05	9.16667E-05	9.16667E-05	9.16667E-05	9.16667E-05
Critical Inductance secondary	Lcrits	2Vout*Eta*T*D/Iout	0.0000275	0.0000275	0.0000275	0.0000275	0.0000275
Critical Turns	Turns_crit	Lcrit/Al	2.55	17.19	27.50	43.65	68.75

	Symbol	Equations	36/22 no gap	36/22 150µm	36/22 250µm	36/22 430µm	36/22 730µm
Primary Side Energy Balance Test							
Primary Energy	Vin*Iin*0.5T		0.001620	0.001620	0.001620	0.001620	0.001620
Inductor Storage Energy Primary		<.5*L*Iin^2	0.093945484	0.013925547	0.008729448	0.005487081	0.003491779
Secondary Side Energy Balance Test							
Secondary Energy	Vout*Iout*0.5T		0.00125	0.00125	0.00125	0.00125	0.00125
Inductor Storage Energy Primary		<.5*L*Iin^2	0.053917289	0.007992164	0.005010014	0.003149151	0.002004005
Primary Amp-turns Test							
Magnetomotive force: MMF (A*turns)	N1*Iin		132	132	132	132	132
		< Bsat*Ae*CRel	5.619718787	37.91213271	60.47887837	96.21639741	151.1971959
Secondary Amp-turns Test							
Magnetomotive force: MMF (A*turns)	N2*Iout		100	100	100	100	100
		< Bsat*Ae*CRel	5.619718787	37.91213271	60.47887837	96.21639741	151.1971959
Primary Volt-second Rating Test							
Volt-second rating	Vdc(in)*D*T		0.00054	0.00054	0.00054	0.00054	0.00054
		< Bsat*N1*Ae	0.00267	0.00267	0.00267	0.00267	0.00267
Secondary Volt-second Rating Test							
Volt-second rating	Vdc(out)*D*T		0.000125	0.000125	0.000125	0.000125	0.000125
		< Bsat*N2*Ae	0.00061	0.00061	0.00061	0.00061	0.00061

Appendix A: Coupled Inductor Calculation

	36/22 970µm	42/29 no gap	42/29 190µm	42/29 340µm	42/29 580µm	42/29 990µm	42/29 1320µm	26/16 no gap
Switching Frequency	100000	100000	100000	100000	100000	100000	100000	100000
Period	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001
1/2 Period	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005
Duty Ratio	0.500000	0.500000	0.500000	0.500000	0.500000	0.500000	0.500000	0.500000
Efficieny Rating	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Input Voltage	108.0	108.0	108.0	108.0	108.0	108.0	108.0	108.0
Output Voltage	25	25	25	25	25	25	25	25
Input Current	3	3	3	3	3	3	3	3
Output Current	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Primary Turns	44	44	44	44	44	44	44	44
Secondary Turns	10	10	10	10	10	10	10	10
Bsat	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Permiability of Free Space	1.25664E-06	1.25664E-06	1.25664E-06	1.25664E-06	1.25664E-06	1.25664E-06	1.25664E-06	1.25664E-06
Effective permeability (unitless)	66	2370	330	206	130	82	65	685
Core Permeability (H/m)	8.2938E-05	0.00297823	0.00041469	0.000258867	0.000163363	0.000103044	8.16814E-05	0.000860796
Effective length (m)	0.0532	0.0686	0.0686	0.0686	0.0686	0.0686	0.0686	0.037600
Effective Area	0.000202	0.000265	0.000265	0.000265	0.000265	0.000265	0.000265	0.000094
Inductance/turn	3.15E-07	1.15E-05	1.60E-06	1.00E-06	6.30E-07	4.00E-07	3.15E-07	2.15E-06
Core reluctance (1/H)	3175458.661	86920.06286	624244.0878	1000002.665	1584619.608	2512201.817	3169239.215	465180.8385
Primary Core Inductance	0.000609676	0.022273339	0.003101351	0.001935995	0.001221744	0.000770639	0.000610872	0.004161822
Secondary Core Inductance	3.14915E-05	0.001150482	0.000160194	9.99997E-05	6.31066E-05	3.98057E-05	3.15533E-05	0.00021497
Required Volt-second rating	0.002666	0.003498	0.003498	0.003498	0.003498	0.003498	0.003498	0.001239
Volt-second rating	0.000845	0.000845	0.000845	0.000845	0.000845	0.000845	0.000845	0.000845
Critical Inductance Primary	9.16667E-05	9.16667E-05	9.16667E-05	9.16667E-05	9.16667E-05	9.16667E-05	9.16667E-05	9.16667E-05
Critical Inductance secondary	0.0000275	0.0000275	0.0000275	0.0000275	0.0000275	0.0000275	0.0000275	0.0000275
Critical Turns	87.30	2.39	17.19	27.50	43.65	68.75	87.30	12.79

	36/22 970µm	42/29 no gap	42/29 190µm	42/29 340µm	42/29 580µm	42/29 990µm	42/29 1320µm	26/16 no gap
Primary Side Energy Balance Test								
Primary Energy	0.001620	0.001620	0.001620	0.001620	0.001620	0.001620	0.001620	0.001620
Inductor Storage Energy Primary	0.002743541	0.100230024	0.013956079	0.008711977	0.005497849	0.003467874	0.002748925	0.0187282
Secondary Side Energy Balance Test								
Secondary Energy	0.00125	0.00125	0.00125	0.00125	0.00125	0.00125	0.00125	0.00125
Inductor Storage Energy Primary	0.001574576	0.057524119	0.008009687	0.004999987	0.003155331	0.001990286	0.001577666	0.010748508
Primary Amp-turns Test								
Magnetomotive force: MMF (A*turns)	132	132	132	132	132	132	132	132
	192.4327948	6.910144998	49.62740498	79.50021186	125.9772588	199.7200444	251.9545176	13.10414422
Secondary Amp-turns Test								
Magnetomotive force: MMF (A*turns)	100	100	100	100	100	100	100	100
	192.4327948	6.910144998	49.62740498	79.50021186	125.9772588	199.7200444	251.9545176	13.10414422
Primary Volt-second Rating Test								
Volt-second rating	0.00054	0.00054	0.00054	0.00054	0.00054	0.00054	0.00054	0.00054
	0.00267	0.00350	0.00350	0.00350	0.00350	0.00350	0.00350	0.00124
Secondary Volt-second Rating Test								
Volt-second rating	0.000125	0.000125	0.000125	0.000125	0.000125	0.000125	0.000125	0.000125
	0.00061	0.00080	0.00080	0.00080	0.00080	0.00080	0.00080	0.00028

	26/16 510µm	26/16 890µm	26/16 1630µm	30/19 no gap	30/19 170µm	30/19 290µm	30/19 480µm	30/19 640µm
Switching Frequency	100000	100000	100000	100000	100000	100000	100000	100000
Period	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001
1/2 Period	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005
Duty Ratio	0.500000	0.500000	0.500000	0.500000	0.500000	0.500000	0.500000	0.500000
Efficieny Rating	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Input Voltage	108.0	108.0	108.0	108.0	108.0	108.0	108.0	108.0
Output Voltage	25	25	25	25	25	25	25	25
Input Current	3	3	3	3	3	3	3	3
Output Current	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Primary Turns	44	44	44	44	44	44	44	44
Secondary Turns	10	10	10	10	10	10	10	10
Bsat	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Permiability of Free Space	1.25664E-06	1.25664E-06	1.25664E-06	1.25664E-06	1.25664E-06	1.25664E-06	1.25664E-06	1.25664E-06
Effective permeability (unitless)	80	51	32	2180	263	165	105	83
Core Permeability (H/m)	0.000100531	6.40885E-05	4.02124E-05	0.002739469	0.000330496	0.000207345	0.000131947	0.000104301
Effective length (m)	0.037600	0.037600	0.037600	0.045200	0.045200	0.045200	0.045200	0.045200
Effective Area	0.000094	0.000094	0.000094	0.000137	0.000137	0.000137	0.000137	0.000137
Inductance/turn	2.50E-07	1.60E-07	1.00E-07	8.30E-06	1.00E-06	6.30E-07	4.00E-07	3.15E-07
Core reluctance (1/H)	3983110.929	6248017.144	9957777.323	120434.6653	998279.7352	1591197.396	2500453.051	3163223.739
Primary Core Inductance	0.000486052	0.000309858	0.000194421	0.016075106	0.001939336	0.001216694	0.00077426	0.000612034
Secondary Core Inductance	2.5106E-05	1.60051E-05	1.00424E-05	0.000830326	0.000100172	6.28458E-05	3.99928E-05	3.16133E-05
Required Volt-second rating	0.001239	0.001239	0.001239	0.001808	0.001808	0.001808	0.001808	0.001808
Volt-second rating	0.000845	0.000845	0.000845	0.000845	0.000845	0.000845	0.000845	0.000845
Critical Inductance Primary	9.16667E-05	9.16667E-05	9.16667E-05	9.16667E-05	9.16667E-05	9.16667E-05	9.16667E-05	9.16667E-05
Critical Inductance secondary	0.0000275	0.0000275	0.0000275	0.0000275	0.0000275	0.0000275	0.0000275	0.0000275
Critical Turns	110.00	171.88	275.00	3.31	27.50	43.65	68.75	87.30

	26/16 510µm	26/16 890µm	26/16 1630µm	30/19 no gap	30/19 170µm	30/19 290µm	30/19 480µm	30/19 640µm
Primary Side Energy Balance Test								
Primary Energy	0.001620	0.001620	0.001620	0.001620	0.001620	0.001620	0.001620	0.001620
Inductor Storage Energy Primary	0.002187235	0.001394362	0.000874894	0.072337977	0.008727013	0.005475122	0.003484169	0.002754152
Secondary Side Energy Balance Test								
Secondary Energy	0.00125	0.00125	0.00125	0.00125	0.00125	0.00125	0.00125	0.00125
Inductor Storage Energy Primary	0.0012553	0.000800254	0.00050212	0.041516286	0.005008616	0.003142288	0.001999638	0.001580666
Primary Amp-turns Test								
Magnetomotive force: MMF (A*turns)	132	132	132	132	132	132	132	132
	112.2042349	176.0066429	280.5105872	4.949864744	41.02929712	65.39821298	102.7686204	130.0084957
Secondary Amp-turns Test								
Magnetomotive force: MMF (A*turns)	100	100	100	100	100	100	100	100
	112.2042349	176.0066429	280.5105872	4.949864744	41.02929712	65.39821298	102.7686204	130.0084957
Primary Volt-second Rating Test								
Volt-second rating	0.00054	0.00054	0.00054	0.00054	0.00054	0.00054	0.00054	0.00054
	0.00124	0.00124	0.00124	0.00181	0.00181	0.00181	0.00181	0.00181
Secondary Volt-second Rating Test								
Volt-second rating	0.000125	0.000125	0.000125	0.000125	0.000125	0.000125	0.000125	0.000125
	0.00028	0.00028	0.00028	0.00041	0.00041	0.00041	0.00041	0.00041

	30/19 840µm	66/56 no gap
Switching Frequency	100000	100000
Period	0.00001	0.00001
1/2 Period	0.000005	0.000005
Duty Ratio	0.500000	0.500000
Efficieny Rating	1.1	1.1
Input Voltage	108.0	108.0
Output Voltage	25	25
Input Current	3	3
Output Current	10.0	10.0
Primary Turns	44	44
Secondary Turns	10	10
Bsat	0.3	0.3
Permiability of Free Space	1.25664E-06	1.25664E-06
Effective permeability (unitless)	66	2490
Core Permeability (H/m)	8.2938E-05	0.003129026
Effective length (m)	0.045200	0.123000
Effective Area	0.000137	0.000717
Inductance/turn	2.50E-07	1.82E-05
Core reluctance (1/H)	3977993.49	54824.76069
Primary Core Inductance	0.000486678	0.035312512
Secondary Core Inductance	2.51383E-05	0.001823993
Required Volt-second rating	0.001808	0.009464
Volt-second rating	0.000845	0.000845
Critical Inductance Primary	9.16667E-05	9.16667E-05
Critical Inductance secondary	0.0000275	0.0000275
Critical Turns	110.00	1.51

	30/19 840µm	66/56 no gap
Primary Side Energy Balance Test		
Primary Energy	0.001620	0.001620
Inductor Storage Energy Primary	0.002190049	0.158906302
Secondary Side Energy Balance Test		
Secondary Energy	0.00125	0.00125
Inductor Storage Energy Primary	0.001256915	0.091199668
Primary Amp-turns Test		
Magnetomotive force: MMF (A*turns)	132	132
	163.4955324	11.79280602
Secondary Amp-turns Test		
Magnetomotive force: MMF (A*turns)	100	100
	163.4955324	11.79280602
Primary Volt-second Rating Test		
Volt-second rating	0.00054	0.00054
	0.00181	0.00946
Secondary Volt-second Rating Test		
Volt-second rating	0.000125	0.000125
	0.00041	0.00215