(紅色字體爲輸入參數欄)

Power Supply Input

Minimum AC Input Voltage	Vacmin	Volts	80				
Maximum AC Input Voltage	Vacmax	Volts	130				
AC Main Frequency	FL	Hertz	60				
Bridge Rectifier Conduction Time Estimate	Tc	mseconds	3				
Loss Allocation	Z		0.54	驗証：	0.538		
Efficiency Estimate	η		85%				

Power Supply Output

Output Voltage	Vos	Volts	42.00	24.00	15.00	5.00	6.60
Power Supply Output Current	Ios	Amps	1.700	0.100	0.200	0.100	0.200
Bias Voltage	VB	Volts	20.00				
Bias Current	IB	Amps	0.100				

Device Variables

Device Name	Device		TNY246Y				
Total Output Power	PO	Watts	80.6200				
Maximum Drain VoltageEstimate(Includes Effect of Leakage Inductance)	VDRAIN	Volts	489.27	(不超過700V)			
Device On-State Drain to Source Voltage	VDS	Volts	6.75				
Device Switching Frequency	FS	Hertz	132000				
Ripple to Peak Current Ratio (連續式/0.4~<1.0, 不連續式/1.0 (一般0.92) ,迭代時使Ipk≦0.9*I_{LIMIT}(min))	KRPKDP		0.67	驗証：	0.670		
External Current Limit, Ratio (0.4 ~ 1.0)	KI		0.40				
外部限流電阻(RIL≦6.5KΩ時,KI=1.0)	RIL	KΩ	25.03				
Device Current Limit, External Mimimum	ILIMITEXT	Amps	1.160				
Device Current Limit, Minimum	ILIMITMIN	Amps	2.900				
Device Current Limit, Maximum	ILIMITMAX	Amps	3.700				
Peak Primary Current	IP	Amps	2.6704				
Primary RMS Current	IRMS	Amps	1.441				
Minimum Duty Cycle	Dmin		0.425				
Maximum Duty Cycle (Dmax ≦ #N/A)	Dmax		0.607				

Power Supply Components Selection

Input Filter Capacitor	Cin	uFarads	200.00				
Minimum DC Input Voltage	VminDC	Volts	88.0				
Maximum DC Input Voltage	VmaxDC	Volts	183.8				
Clamp Zener Voltage	VCLO	Volts	203.9				
Estimated primary Zener Clamp Loss	PZ	W	0.50				
Bias Winding Diode Forward Voltage Drop	V_{DFB}	Volts	0.700				
Bias Rectifier Maximum Peak Inverse Voltage	PIVB	Volts	48.00				

Power Supply Output Parameters

Output Winding Diode Forward Voltage Drop	V_{DF}	Volts	0.700	0.700	0.700	0.700	0.700
Output Rectifier Maximum Peak Inverse Voltage	PIVSX	Volts	99.76	57.41	36.24	12.71	16.47
Peak Secondary Current	ISPX	Amps	7.5279	0.4374	0.8603	0.3949	0.8141
Secondary RMS Current	ISRMSX	Amps	3.2682	0.1899	0.3735	0.1714	0.3534
Output Capacitor RMS Ripple Current	IRIPPLEX	Amps					

Transformer Construction Parameters

Core and Bobbin Type	Core/Bobbin		E30/15/7				
Core 材			NC-2H				
Core Manufacturing	Core Manuf		宇 瑞				
Core Initial Permeability	ui		2300.0				
Inductance Factor	AL	nH					
Resistivity	ρ	mΩ	8				
Curie Temperature	Tc	℃	230				
使用頻率范圍	f	Hz	<300KHZ				
Bs max		G	500				
Core Effective Cross Section Area	Ae	cm^2	0.6				
Gapped Core Effective Inductance	Alg	nH/N^2	43.75				
Effective Permeability	ue		38.9				
Gap Length	Lg	mm	2.906				
Maximum Operating Fiux Density	Bm	Gauss	1400	0.14000			
Peak Fiux Density(Bp<4200)	Bp	Gauss	776				
DC Fiux Density for Core Curves	Bdc	Gauss	830.1				
AC Fiux Density for Core Curves	Bac	Gauss	433.0				
Bobbin Manufacturing	Bobbin Manuf						
Primary Inductance	LP	uHenries	226.2				
Primary Winding Number of Turns	NP	T	71.89				
Number of Primary Layers	L		2.66				
Primary Wire Gauge	CWG	mm	0.360				
Primary Wire Strands	Strands		2.01				
Primary Winding Current Capacity	CMA	Cmils/A	614.40				

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Bias Winding Number of Turns	NB	T	10.95				
Reflected Output Voltage	VOR	Volts	135.92	(不超過150V)			
Bobbin Physical Winding Width	Bw	mm	13.90				
Safety Margin Width	M	mm	3.20				
Estimated Transformer Primary Leakage Inductance	Lkg	uH	21.60	(最大不超過:	6.7846	uH)	

Secondary Parameters

Seconday Winding Number of Turns	Nsx	T	22.59	13.07	8.30	3.02	3.86
Seconday Wire Gauge	CWG	mm	0.400	0.200	0.290	0.200	0.290
Seconday Wire Strands	Strands		4.00	1.00	1.00	1.00	1.00

反激式設計

輸入最大電壓 Vinmax(V):	183.85						
中心輸入電壓 Vin(V):	135.92				Np-Ns-Np ↓		
輸入最小電壓 Vinmin(V):	87.99	SEC 1 :	SEC 2 :	SEC 3 :	SEC 4 :	SEC 5 :	Bias :
輸出電壓 Vo(V):		42.00	24.00	15.00	5.00	6.60	20.00
輸出電流 Io(A):		1.700	0.100	0.200	0.100	0.200	0.100
管壓降 V_{DF}(V) :		0.700	0.700	0.700	0.700	0.700	0.700
工作週期 D(us):	0.5	或 導通時間 Ton(us) :	3.788				
大電流.低電壓輸出線路壓降倍數 :	1	(適合10V以下,50A以上)					
繞線形式 M:	2	(Np-Ns / 1, Np-Ns-Np / 2, Np-Ns-Np-Ns / 3)					
絕緣厚度 C :mm	0.10	總絕緣厚度:	0.3	cm			
本設計是否考慮效率 :	1	(考慮 / 1 , 不考慮 / 2)					
最大溫升Δt (℃):	50						
使用Core材 : 70	3	POT Core(罐狀) / 1 , 金屬疊片 / 2 , 鐵粉芯 / 3					

環境溫度: 25 ℃

計算結果:

Ap計算值:	0.468717	cm^4	留50%的裕度	0.70308				計算得 α :	1.39 %
	PRI	SEC 1	SEC 2	SEC 3	SEC 4	SEC 5	Bias	效率 η :	0.973
圈數(T):	71.89	22.59	13.07	8.30	3.02	3.86	10.95	Lp =	0.2262 mH
線徑 (mm):	0.5466	0.823	0.198	0.278	0.189	0.271	0.198	Lkg =	21.598 uH
線徑修正mm:	0.510	0.800	0.200	0.290	0.200	0.290	0.200	磨中柱:lg =	2.906 mm
銅線重量(g):	7.27	4.92	0.20	0.27	0.05	0.14	0.19	Δt (℃):	55.1
銅阻 (Ω):	0.3315	0.0370	0.3791	0.1194	0.0947	0.0599	0.3704	占積率 :	35.39 %,不超過45%.
膚股效應:	d < 0.361	mm						Pcu (W):	1.1375
線徑修正mm:	0.360	0.400	0.200	0.290	0.200	0.290	0.200	Pfe (W):	1.0642
股數:	2.01	4.00	1.00	1.00	1.00	1.00	1.00		

參考文文獻 :

Weight1	Weight2	Weight3	Weight4	Weight5	Weight6	Weight7	Kf	Ku	G
0.01873	0.04608	0.00288	0.00605	0.00288	0.00605	0.00288	4.44	0.40	1.94
column c1	column c2	column c3	column c4	column c5	column c6	column c7	Wtfe	AS	Kj
836.79	340.07	5441.19	2587.96	5441.2	2588.0	5441.19	0.0179	27.50	590
Ap	Ac	MLT	Wc	Vol	δ 溫度系數	Lm	bw	lw	X
0.7159	0.6	5.71	99.64	4.0200	1.02	6.70	13.90	3.72	-0.12

計算步驟:

STEP NO.1 : 計算輸出交流電壓

	Eo1	Eo2	Eo3	Eo4	Eo5	Bias	
Eo =K* Vo + Vd =	42.70	24.70	15.70	5.70	7.30	20.70	V

Eo總 = 116.80 V

STEP NO.2 : 計算輸出功率

	Ps1	Ps2	Ps3	Ps4	Ps5	Bias	
Po=Vo*Io=	71.400	2.400	3.000	0.500	1.320	2.000	VA

Po總 = 80.62 VA

STEP NO.3 : 計算輸入功率

Pin = Po / η = 94.847 VA

STEP NO.4 : 計算總功率

Pt = Po+Pin = 175.467 VA

STEP NO.5 : 計算鐵芯表面積

Ap=[(Pt*10^4)/(Ku*Kj*f*Bm)] = 0.386348 cm^4 留50%的裕度 0.57952

Ap=[(Lp*Ipk2*10^4)/(*Ku*J*Bm)] = 0.468717 cm^4 留50%的裕度 0.70308

Ap=[(Lp*Ipk2*10^4)/(*Ku*Kj*Bm)]$^{1.143}$ = 0.440311 cm^4 留50%的裕度 0.66047

STEP NO.6 : 計算工作週期 D

Dmin =Dmax/((1-Dmax)*K+Dmax) = 0.425 us

Dmax =K*Dmin/(Dmin(K-1)+1) = 0.607 us

STEP NO.7 : 計算初級峰值電流

Ippk = Po/(η Vinmin*Dmax(1-K_{RP}/2)) = 2.6704 A

不考慮效率及KRP時的圈數 :

Ippk = 2Po/(Vinmin*Dmax) = 3.0189 A

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本設計 Ippk = 2.6704 A

STEP NO.8 : 計算初級有效電流

$Ip_{RMS}= Ipk*(Dmax*(K_{RP}^2/3-K_{RP}+1))^{0.5}$ = 1.441 A

STEP NO.9 : 計算L電感

$Lp = Po/(Ipk^2*K_{RP}*f*(1-K_{RP}/2)*(Z(1-\eta)+\eta)/\eta$ = 0.2105 mH

或 Lp = Vinmin*Dmax/(Ippk*f*Krp) = 0.226 mH

不考慮效率及KRP時的圈數 :

Lp = Vinmin*Dmax/(Ippk*f) = 0.152 mH

本設計 Lp = 0.2262 mH

STEP NO.10 : 計算初級圈數

$Np=Lp*Ipk/(Ac*B)*10^4$ = 71.9 T

不考慮效率及KRP時的圈數 :

$Np=Lp*Ipk/(Ac*B)*10^4$ = 48.2 T

$Np = Vinmin*Dmax/(Bm*Ac*f)*10^4$ = 48.2 T

本設計 Np = 71.9 T

STEP NO.12 : 計算次級圈數

Ns1 = Np*Eo/Vinmin*(1-Dmax)/Dmax =	22.6	T				或 Ns1=Np/n =	22.587	T
Ns2 = Np*Eo/Vinmin*(1-Dmax)/Dmax =	13.1	T					13.065	T
Ns3 = Np*Eo/Vinmin*(1-Dmax)/Dmax =	8.3	T					8.305	T
Ns4 = Np*Eo/Vinmin*(1-Dmax)/Dmax =	3.0	T					3.015	T
Ns5 = Np*Eo/Vinmin*(1-Dmax)/Dmax =	3.9	T					3.861	T
Bias = Np*Eo/Vinmin*(1-Dmax)/Dmax =	10.9	T					10.950	T

STEP NO.13 : 計算初級與次級匝比

	NP/NS1:	NP/NS2:	NP/NS3:	NP/NS4:	NP/NS5:	NP/Bias:
n =Np/Ns = (Vinmin/Eo)*(Dmax/(1-Dmax))	3.183	5.503	8.657	23.845	18.619	6.566

STEP NO.14 : 計算空氣隙 lg"

$lg" = 0.4\pi*Lp*Ipk^2/(\Delta B^2*Ac)$ = 1.7233 mm

或 $lg" = 0.4\pi*10^{-8}*Ac*Np^2/Lp-1/AL$ = 1.7004 mm

STEP NO.15 : 計算磁通邊緣因素 F

$F = 1+lg/Ac^{0.5}*Ln(2G/lg)$ = 1.6866

STEP NO.16 : 計算有效空氣隙 lg (磨中柱)

磨中柱 : $lg = 0.4\pi*F*10^{-8}*Ac*Np^2/Lp-1/AL$ = 2.8836 mm

或 $lg = 0.4\pi*F*Lp*Ipk^2/(\Delta B^2*Ac)$ = 2.9064 mm

本設計 lg = 2.9064 mm

MYL片(兩側): lg = 1.4532 mm

STEP NO.17 : 計算電流密度

$J=Kj*Ap^{-0.12}$ = 614.40 A/cm²

STEP NO.18 : 計算初級線徑

$dp = 11.287(Ip_{RMS}/J)^{1/2}$ = 0.5466 mm 輸入修正值 : 0.510 mm

STEP NO.19 : 計算次級峰值電壓

$Vspk1 = Vo+(V_{INMAX}*Ns/Np)$ =	99.7581	V
$Vspk2 = Vo+(V_{INMAX}*Ns/Np)$ =	57.4104	V
$Vspk3 = Vo+(V_{INMAX}*Ns/Np)$ =	36.2366	V
$Vspk4 = Vo+(V_{INMAX}*Ns/Np)$ =	12.7101	V
$Vspk5 = Vo+(V_{INMAX}*Ns/Np)$ =	16.4743	V
$VBaispk = Vo+(V_{INMAX}*Ns/Np)$ =	47.9999	V

STEP NO.20 : 計算次級峰值電流

$Ispk1 = Po*Np/(\eta*Vmin*Dmax*(1-K_{RP}/2)*Ns)$ =	7.52794	A
$Ispk2 = Po*Np/(\eta*Vmin*Dmax*(1-K_{RP}/2)*Ns)$ =	0.43744	A
$Ispk3 = Po*Np/(\eta*Vmin*Dmax*(1-K_{RP}/2)*Ns)$ =	0.86026	A
$Ispk4 = Po*Np/(\eta*Vmin*Dmax*(1-K_{RP}/2)*Ns)$ =	0.39491	A
$Ispk5 = Po*Np/(\eta*Vmin*Dmax*(1-K_{RP}/2)*Ns)$ =	0.81406	A
$IspkBias = Po*Np/(\eta*Vmin*Dmax*(1-K_{RP}/2)*Ns)$ =	0.43498	A

STEP NO.21 : 計算次級RMS電流

$Isrms1=Ispk*((1-Dmax)*(K_{RP}^2/3-K_{RP}+1)^{0.5}$ =	3.268	A
$Isrms2=Ispk*((1-Dmax)*(K_{RP}^2/3-K_{RP}+1)^{0.5}$ =	0.190	A
$Isrms3=Ispk*((1-Dmax)*(K_{RP}^2/3-K_{RP}+1)^{0.5}$ =	0.373	A
$Isrms4=Ispk*((1-Dmax)*(K_{RP}^2/3-K_{RP}+1)^{0.5}$ =	0.171	A
$Isrms5=Ispk*((1-Dmax)*(K_{RP}^2/3-K_{RP}+1)^{0.5}$ =	0.353	A
$IsrmsBias=Ispk*((1-Dmax)*(K_{RP}^2/3-K_{RP}+1)^{0.5}$ =	0.189	A

STEP NO.22 : 計算次級線徑

$ds1 = 11.287(Isrms1/J)^{1/2}$ =	0.823	修正值爲	0.800	mm
$ds2 = 11.287(Isrms2/J)^{1/2}$ =	0.198	修正值爲	0.200	mm
$ds3 = 11.287(Isrms3/J)^{1/2}$ =	0.278	修正值爲	0.290	mm
$ds4 = 11.287(Isrms4/J)^{1/2}$ =	0.189	修正值爲	0.200	mm
$ds5 = 11.287(Isrms5/J)^{1/2}$ =	0.271	修正值爲	0.290	mm
$dBias = 11.287(IsrmsBias/J)^{1/2}$ =	0.198	修正值爲	0.200	mm

STEP NO. 23 : 銅線占窗面積 :

繞線面積 : $N\Phi^2=Np*\Phi_1^2+Ns*\Phi_2^2$ = 35.260 cm

$N\Phi^2/Wc$ = 35.39 %

要求: $N\Phi^2/Wc < 45\%$

STEP NO.24 : 計算繞線高度

$h 1 = Nd^2/bw$ = 1.494794 ==> 1.8000 ==> 0.1900 cm

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h 2 = $Nd^2/bw+C$ =	1.155516	==>	1.2000	==>	0.1300	cm	
h 3 = $Nd^2/bw+C$ =	0.041776	==>	0.2000	==>	0.0300	cm	
h 4 = $Nd^2/bw+C$ =	0.055829	==>	0.2900	==>	0.0390	cm	
h 5 = Nd^2/bw +C=	0.009641	==>	0.2000	==>	0.0300	cm	
h 6 = $Nd^2/bw+C$ =	0.012347	==>	0.2900	==>	0.0390	cm	
h 7 = $Nd^2/bw+C$ =	0.035011	==>	0.2000	==>	0.0300	cm	

STEP NO.25 : 計算各繞組MLT

	Np-Ns		Np-Ns-Np		Np-Ns-Np-Ns		
MLTp=Lw+π h_1 =	繞線	4.3169	繞線	5.4023	繞線	4.8400	cm
MLTs1=Lw+2π (h_1+0.5h_2) =		5.3222		4.7253		4.7253	cm
MLTs2=Lw+2π (h_1+h_2+0.5h_3) =		5.8249		5.2280		5.2280	cm
MLTs3=Lw+2π (h_1+h_2+h_3+0.5h_4) =		6.0416		5.4447		5.4447	cm
MLTs4=Lw+2π (h_1+h_2+h_3+h_4+0.5h_5) =		6.2584		5.6615		5.6615	cm
MLTs5=Lw+2π (h_1+h_2+h_3+h_4+h_5+0.5h_6) =		6.4752		5.8783		6.4752	cm
MLTBias=Lw+2π (h_1+h_2+h_3+h_4+h_5+h_6+0.5h_7) =		6.6919		6.0950		6.6919	cm

本設計	MLTp	MLTs1	MLTs2	MLTs3	MLTs4	MLTs5	MLTBias	
	5.4023	4.7253	5.2280	5.4447	5.6615	5.8783	6.0950	cm

MLT平均 : 5.4907 cm

STEP NO.26 : 計算次級總圈數

Ns = 129.5 T

STEP NO.27 : 計算漏電感 Lkg

Np-Ns :	Lkg=1.2MLTNp^2/bw*(C總+(h1+...+hn)/3)*10^{-6} =	117.8099 uH
Np-Ns-Np :	Lkg=0.22MLTNp^2/bw*(C總+(h1+...+hn)/3)*10^{-6} =	21.5985 uH
Np-Ns-Np-Ns :	Lkg=0.14MLTNp^2/bw*(C總+(h1+...+hn)/3)*10^{-6} =	13.7445 uH

本設計 Lkg : 21.5985 uH

STEP NO.28 : 計算初級銅阻

	Np-Ns	Np-Ns-Np	Np-Ns-Np-Ns	
Rp=MLT*Np*Column C1*δ*10^{-6} =	0.265	0.332	0.332	Ω

STEP NO.29 : 次級銅阻

Rs1=MLT*Ns1*Column C2*δ*10^{-6} =	0.0417	0.0370	0.0370	Ω
Rs2=MLT*Ns2*Column C3*δ*10^{-6} =	0.4224	0.3791	0.3791	Ω
Rs3=MLT*Ns3*Column C4*δ*10^{-6} =	0.1324	0.1194	0.1194	Ω
Rs4=MLT*Ns4*Column C5*δ*10^{-6} =	0.1047	0.0947	0.0947	Ω
Rs5=MLT*Ns5*Column C6*δ*10^{-6} =	0.0660	0.0599	0.0599	Ω
RsBias=MLT*NBias*Column C7*δ*10^{-6} =	0.4067	0.3704	0.3704	Ω

本設計	Rp	Rs1	Rs2	Rs3	Rs4	Rs5	Rbias	
D.C.R :	0.3315	0.0370	0.3791	0.1194	0.0947	0.0599	0.3704	Ω

STEP NO.30 : 計算初級銅損

Pcu初 = Ip^2*Rp = 0.6883 W

STEP NO.31 : 次級銅損

Pcu次1 = $Io1^2$*Rs1 =	0.3954	W
Pcu次2 = $Io2^2$*Rs2 =	0.0137	W
Pcu次3 = $Io3^2$*Rs3 =	0.0166	W
Pcu次4 = $Io1^2$*Rs4 =	0.0028	W
Pcu次5 = $Io2^2$*Rs5 =	0.0075	W
PcuBias = $IoBias^2$*RBias =	0.0132	W
Pcu次總 =	0.44923	W

STEP NO.32 : 總銅損

Pcu=Pcu初+Pcu次 = 1.1375 W

STEP NO .33 : 電壓調整率驗算

α =Pcu/(Po+Pcu)*100 = 1.39 %

STEP NO.34 :效率驗算

η =(1- α)/(1+ α) = 0.973

STEP NO.35 :允許總損耗

P_Σ=Po/ η -Po = 2.275 W

STEP NO.36 :允許鐵芯損耗

Pfe = P_Σ-Pcu = 1.1375 W

STEP NO.37 :實際鐵芯損耗

	Pfe=0.165*10^{-3}*$f^{1.41}$*$B^{1.77}$ *Wtfe =	1.5101	W	推挽式
或:	Pfe=0.287*$f^{1.448}$*$(10*B)^2$ *10^{-3}*Vol =	1.0642	W	鐵粉芯 Core
或:	Pfe=0.262*$f^{1.39}$*$B^{2.19}$ *10^{-3}* Wtfe =	0.3318	W	POT Core(灌狀)
或:	Pfe=5.97*$f^{1.26}$*$Bac^{1.73}$ *10^{-3}* Wtfe =	0.5296	W	硅鋼片
	(Bac=(Vmin-VDF)*Dmax*10^8/(2*f*Ac*Np) =	0.0433	)	

本設計線路 : Pfe= 1.06418

STEP NO.38 :實際總損耗

P_Σ=Pcu+Pfe =	2.202	W	
或P_Σ=2*Pcu =	2.275	W	(灌形 或 金屬疊片)
$P_{\Sigma本設計}$ =	2.20170	W	

STEP NO.39.銅線重量

W_{G1}=MLT*Np*Weight1 =	7.2734	g
W_{G2}=MLT*Ns1*Weight2 =	4.9179	g
W_{G3}=MLT*Ns2*Weight3 =	0.1967	g
W_{G4}=MLT*Ns3*Weight4 =	0.2738	g
W_{G5}=MLT*Ns4*Weight5 =	0.0492	g

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W_{G6}=MLT*Ns5*Weight6 = 0.1374 g

W_{G7}=MLT*NsBias*Weight7 = 0.1922 g

STEP NO.40.溫升計算.

$\Delta t = (P_{\Sigma}/(As*0.0005))^{0.79}$ = 55.15 ℃

STEP NO.41.膚股效應.

d < $2*65.5/f^{0.5}$ = 0.36 mm

STEP NO.42.線圈股數.

PRI : $n = (d/d_{MIN})^2$ = 2.01

SEC1 : $n = (d/d_{MIN})^2$ = 4.00

SEC2 : $n = (d/d_{MIN})^2$ = 1.00

SEC3 : $n = (d/d_{MIN})^2$ = 1.00