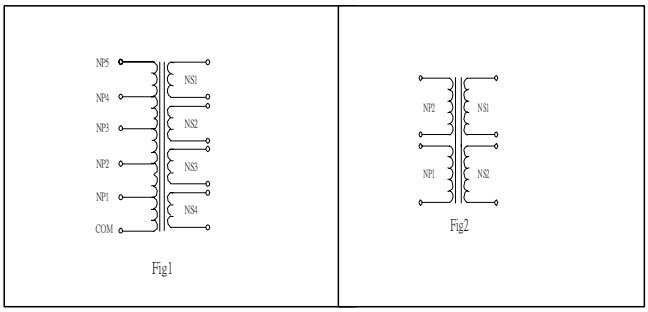
Low FrequencyTransformer Design Equations



使用說明 :

★ 紅色字體爲輸入參數 .

★ 注意單/雙層的變換, Fig1 / Fig2的變換 .

★ 以Fig1設計時, 适用於單組或以上線圈串聯輸入 .Np爲一組時輸入11, ~ Np爲5五組時輸入15 .Ns最多5組 .

★ 以Fig2設計時, 輸入22,PRI限於2組線圈并聯輸入,如:DST, A41,14A, DPC及LP系列機種 .Ns最多5組 .

★ 沒用到的繞組參數輸入0 .

★ 計算時調整輸入之α與計算之α相等 .

環境溫度: 28 ℃

請輸入 :

本設計采用骨架:	2	(單層/1, 雙層/2, 4層/4)				Z11*0.35A/ 1	H18*0.35A/ 2	EI-19/ 2	EI-66/ 11	UI-29/ 20	
本設計電路形式:	22	(Fig1/11~15, Fig2/22)				H18*0.50A/ 3	H20*0.50A/ 4	EI-24/ 3	EI-76/ 12	U-I38/ 21	
Ep1 (V):	115	Eo1 (V):	28.00	Io1(A):	3.600	H50*0.50A/ 5	H50*0.50N/ 6	EI-25.4/ 4	EI-86/13	UI-43/ 22	
Ep2 (V):	115	Eo2 (V):	0.00	Io2(A):	0.000	Bm :	1.29	EI-28/ 5	EI-96/14	UI-48/ 23	
Ep3 (V):	0	Eo3 (V):	0.00	Io3(A):	0.000	α (%):	8.01	EI-35/ 6	EI-105/ 15	UI-57/ 24	
Ep4 (V):	0	Eo4 (V):	0.00	Io4(A):	0.000	f(hz) :	60	EI-41/ 7	EI-114/ 16		
Ep5 (V):	0	Eo5 (V):	0.00	Io5(A):	0.000	T(℃):	50.0	EI-48/ 8	EI-1332/ 17		
使用鐵芯:	3	需求規格:	EI-76*38					EI-54/ 9	EI-162/ 18		
		修改規格爲:	1	EI-86*28.5	*** (EI = 1, UI = 2)			EI-57/ 10	EI-228/ 19		

計算結果:

Ap需求值:	47.441 cm^4	占積率(初1):	0.599	計算得 α 1:	8.01 %
Ap實值:	50.004 cm^4	占積率(初2):	0.000	$W_{片E+I}$ =	8.111 g 修改公式尾數
I(X1)mA:	99.49 REF(輸入Np1)	占積率(次1):	0.596	鐵芯重量:	462.3 g
ΔT(℃):	54.1	占積率(次2):	0.000		

	PRI1	PRI2	PRI3	PRI4	PRI5	SEC1	SEC2	SEC3	SEC4	SEC5
圈數(T):	410	410	0	0	0	108	1	1	1	1
線徑(mm):	0.4431	0.4431	#DIV/0!	#DIV/0!	#DIV/0!	1.1719	0.0062	0.0062	0.0062	0.0000
線徑修正(mm):	0.400	0.400	1.100	1.100	0.450	1.100	0.120	0.120	0.900	0.100
銅線重量(g):	64.82	78.18	0.0	0.0	0.0	142.58	0.02	0.0	1.0	0.0
銅阻(Ω):	7.90	9.53	0.00	0.00	0.00	0.303	0.000	0.000	0.000	0.000

參考文獻

Weight1	Weight2	Weight3	Weight4	Weight5	Weight6	Weight7	Weight8	Weight9	Weight10	
0.0115	0.0115	0.0871	0.0871	0.0146	0.0871	0.0010	0.0010	0.0583	0.0007	
column c1	column c2	column c3	column c4	column c5	column c6	column c7	column c8	column c9	column c10	
1360.3	1360.3	179.9	179.9	1074.8	179.9	15114.4	15114.4	268.7	21764.8	
E鐵芯銅窗寬度	d 鐵芯疊厚	b鐵片厚度	Ks	膠芯外周長	L絕緣層數	AT安匝	Pw_C繞線寬度	Sw_C繞線寬度	Pw繞線面積	D鐵芯側寬
1.43	2.9	0.05	41.3	12.34	2	3.279	1.8018	1.8018	2.190	1.43
F鐵芯銅窗長度	Ac(cm^2)	C舌寬	lm	Kf	Ku	δ	Kj	X	Sw繞線面積	H鐵芯I寬
4.29	8.151	2.9	17.16	4.44	0.40	1.03	534	-0.12	2.190	1.43

設計步驟

STEP NO.1 計算輸出功率

$Po=Eo_1*Io_1+\ldots+Eo_n*Ion$ = 100.8 VA

STEP NO.2 計算效率

$\eta=(100-\alpha)/(100+\alpha)$= 0.852

STEP NO.3 計算 輸入功率

$P_{IN}=Po/\eta$ = 118.4 VA

STEP NO.4 計算總功率

$Pt=P_{IN}+Po$= 219.2 VA

STEP NO.5 計算鐵芯表面積

$Ap=[(Pt*10^4)/(Kf*Ku*Kj*f*Bm)]^{1/(1+X)}$ = 47.441 cm^4

STEP NO.6 計算初級圈數

$Np_1=(Ep_1*10^4)/(Kf*Bm*f*Ac)$=	410	T
$Np_2=(Ep_2*10^4)/(Kf*Bm*f*Ac)-Np1$=	410	T
$Np_3=(Ep_3*10^4)/(Kf*Bm*f*Ac)-Np1-Np2$ =	0	T
$Np_4=(Ep_4*10^4)/(Kf*Bm*f*Ac)-Np1-Np2-Np3$ =	0	T
$Np_5=(Ep_5*10^4)/(Kf*Bm*f*Ac)-Np1-Np2-Np3-Np4$ =	0	T

STEP NO.7 計算初級電流

$Ip_1 = P_{IN}/Ep_1$ =	0.515	A
$I_{P2} = P_{IN}/Ep_2$ =	0.515	A
$Ip_3 = P_{IN}/Ep_3$ =	#DIV/0!	A
$I_{P4} = P_{IN}/Ep_4$ =	#DIV/0!	A
$I_{P5} = P_{IN}/Ep_5$ =	#DIV/0!	A

STEP NO.8 計算電流密度

$J=Kj*Ap^X$ = 333.94 A/cm^2

STEP NO.9 計算初級線徑

			修正值:			標稱外徑	
$dp_1 = 11.287*(Ip_1/J)^{1/2}$ =	0.4431	mm	修正值:	0.0400	cm	0.0440	cm
$dp_2 = 11.287*(Ip_2/J)^{1/2}$ =	0.4431	mm	修正值:	0.0400	cm	0.0440	cm
$dp_3 =11.287* (Ip_3/J)^{1/2}$ =	#DIV/0!	mm	修正值:	0.1100	cm	0.1210	cm
$dp_4 = 11.287*(Ip_4/J)^{1/2}$ =	#DIV/0!	mm	修正值:	0.1100	cm	0.1210	cm
$dp_5 =11.287* (Ip_5/J)^{1/2}$ =	#DIV/0!	mm	修正值:	0.0450	cm	0.0495	cm

STEP NO.10 計算初級銅阻

$h_{初1}=Np_1*dp_1^2/Wc$=	0.4405	cm
$h_{初2}=Np_2*dp_2^2/Wc$=	0.4405	cm
$h_{初3}=Np_3*dp_3^2/Wc$=	0.0000	cm
$h_{初4}=Np_4*dp_4^2/Wc$=	0.0000	cm
$h_{初5}=Np_5*dp_5^2/Wc$=	0.0000	cm
$MLT_{初1}=Lw+\pi h_{初1}$=	13.723	cm
$MLT_{初2}=Lw+2\pi(0.005*L+h_{初1}+0.5h_{初2})$ =	16.553	cm
$MLT_{初3}=Lw+2\pi(0.005*L+h_{初1}+h_{初2}+0.5h_{初3})$ =	17.936	cm
$MLT_{初4}=Lw+2\pi(0.005*L+h_{初1}+h_{初2}+h_{初3}+0.5h_{初4})$ =	17.936	cm
$MLT_{初5}=Lw+2\pi(0.005*L+h_{初1}+h_{初2}+h_{初3}+h_{初4}+0.5h_{初5})$ =	17.936	cm

$Rp_1=MLT_{初1}*Np_1*$Column $C_1*\delta*10^{-6}$ =	7.90	Ω
$R_{P2}=MLT_{初2}*Np_2*$Column $C_2*\delta*10^{-6}$ =	9.53	Ω
$R_{P3}=MLT_{初3}*Np_3*$Column $C_3*\delta*10^{-6}$ =	0.00	Ω
$R_{P4}=MLT_{初4}*Np_4*$Column $C_4*\delta*10^{-6}$ =	0.00	Ω
$R_{P5}=MLT_{初5}*Np_5*$Column $C_5*\delta*10^{-6}$ =	0.00	Ω

STEP NO.11 計算初級銅損

$Pcu初1=I_{P1}^2*Rp1$=	2.09	W
$Pcu初2=Ip_2^2*(Rp1+Rp2)$ =	2.52	W
$Pcu初3=Ip_3^2*(Rp1+Rp2+Rp3)$ =	#DIV/0!	W
$Pcu初4=Ip_4^2*(Rp1+Rp2+Rp3+Rp4)$ =	#DIV/0!	W
$Pcu初5=Ip_5^2*(Rp1+Rp2+Rp3+Rp4+Rp5)$ =	#DIV/0!	W

STEP NO.12 計算次級圈數

$Ns_1=(Np_1*Eo_1)/Ep_1*(1+\alpha/100)$ = 107.82 T

$Ns_2=(Np_1*Eo_2)/Ep1*(1+\alpha/100)$ = 0.00 T

$Ns_3=(Np_1*Eo_3)/Ep1*(1+\alpha/100)$ = 0.00 T

$Ns_4=(Np_1*Eo_4)/Ep1*(1+\alpha/100)$ = 0.00 T

$Ns_5=(Np_1*Eo_5)/Ep1*(1+\alpha/100)$ = 0.00 T

STEP NO.13 計算次級線徑

							標稱外徑	
$ds_1=11.287*(Io_1/J)^{0.5}$=	1.1719	mm	修正值爲	0.110	cm	0.1210	cm
$ds_2=11.287*(Io_2/J)^{0.5}$ =	0.0062	mm	修正值爲	0.012	cm	0.0132	cm
$ds_3=11.287*(Io_3/J)^{0.5}$ =	0.0062	mm	修正值爲	0.012	cm	0.0132	cm
$ds_4=11.287*(Io_4/J)^{0.5}$ =	0.0062	mm	修正值爲	0.090	cm	0.0990	cm
$ds_5=11.287*(Io_5/J)^{0.5}$ =	0.0000	mm	修正值爲	0.010	cm	0.0110	cm

STEP NO. 14 銅線占窗面積

Nd^2初=Np*dp^2 = 1.3120 cm

Nd^2次=Ns*ds^2 = 1.3046 cm

(Nd^2初+Nd2次)/Sw = 0.00

Nd^2初/Sw = 0.60

Nd^2初/Sw = 0.00

Nd2次/Sw = 0.60

Nd2次/Sw = 0.00

要求: NΦ2/Sw=55~65%

STEP NO.15 次級銅阻

$h_{次1}$ = Ns_1ds1^2/Wc = 0.876 cm

$h_{次2}$ = Ns_2ds2^2/Wc = 0.000 cm

$h_{次3}$ = $Ns3ds_3^2/Wc$ = 0.000 cm

$h_{次4}$ = $Ns4ds4^2/Wc$ = 0.000 cm

$h_{次5}$ = $Ns5ds5^2/Wc$ = 0.000 cm

$MLT_{次1}=Lw+2\pi(0.005*L+h初+0.5h次1)$ = 15.15 cm

$MLT_{次2}=Lw+2\pi(0.005*L+h初+h_{次1}+0.5h_{次2})$ = 17.90 cm

$MLT_{次3}=Lw+2\pi(0.005*L+h初+h_{次1}+h次2+0.5h_{次3})$ = 17.90 cm

$MLT_{次4}=Lw+2\pi(0.005*L+h初+h_{次1}+h次2+h次3+0.5h_{次4})$ = 17.90 cm

$MLT_{次5}=Lw+2\pi(0.005*L+h初+h_{次1}+h次2+h次3+h次4+0.5h_{次5})$ = 17.90 cm

$Rs_1=MLT_{次1}*Ns_1*$Column C6$*\delta*10^{-6}$ = 0.303 Ω

$Rs_2=MLT_{次2}*Ns_2*$Column C7$*\delta*10^{-6}$ = 0.000 Ω

$Rs_3=MLT_{次3}*Ns_3*$Column C8$*\delta*10^{-6}$ = 0.000 Ω

$Rs_4=MLT_{次4}*Ns_4*$Column C9$*\delta*10^{-6}$ = 0.000 Ω

$Rs_5=MLT_{次5}*Ns_5*$Column C10$*\delta*10^{-6}$ = 0.000 Ω

STEP NO.16 次級銅損

$Pcu次1=Io_1^2*Rs_1$= 3.931 W

$Pcu次2=Io_2^2*Rs_2$= 0.000 W

$Pcu次3=Io_3^2*Rs_3$= 0.000 W

$Pcu次4=Io_4^2*Rs_4$= 0.000 W

$Pcu次5=Io_5^2*Rs_5$= 0.000 W

STEP NO.17 總銅損

P_{CU1} = Pcu初+Pcu次 = 8.545 W

P_{CU2} = Pcu初+Pcu次 = 8.545 W

P_{CU3} = Pcu初+Pcu次 = #DIV/0! W

P_{CU4} = Pcu初+Pcu次 = #DIV/0! W

P_{CU5} = Pcu初+Pcu次 = #DIV/0! W

STEP NO .18 電壓調整率驗算

$\alpha 1$ = Pcu1/(Po+Pcu1)*100 = 8.01 %

$\alpha 2$ = Pcu2/(Po+Pcu2)*100 = 8.01 %

$\alpha 3$ = Pcu3/(Po+Pcu3)*100 = #DIV/0! %

$\alpha 4$ = Pcu4/(Po+Pcu4)*100 = #DIV/0! %

$\alpha 5$ = Pcu5/(Po+Pcu5)*100 = #DIV/0! %

STEP NO.19.效率驗算

$\eta 1$ = (100-$\alpha 1$)/(100+$\alpha 1$) = 0.852

η 2 = (100- α 2)/(100+ α 2) =	0.852	
η 3 = (100- α 3)/(100+ α 3)=	#DIV/0!	
η 4 = (100- α 4)/(100+ α 4) =	#DIV/0!	
η 5 = (100- α 5)/(100+ α 5)=	#DIV/0!	

STEP NO.20.輸入功率

P_{IN1} = Po/ η 1 =	118.35	W
P_{IN2} = Po/ η 2 =	118.35	W
P_{IN3} = Po/ η 3 =	#DIV/0!	W
P_{IN4} = Po/ η 4 =	#DIV/0!	W
P_{IN5} = Po/ η 5 =	#DIV/0!	W

STEP NO.21.總損耗

$P_{\Sigma 1}$ = P_{IN1}-Po或2Pcu =	17.555	W
$P_{\Sigma 2}$ = P_{IN2}-Po =	17.555	W
$P_{\Sigma 3}$ = P_{IN3}-Po =	#DIV/0!	W
$P_{\Sigma 4}$ = P_{IN4}-Po =	#DIV/0!	W
$P_{\Sigma 5}$ = P_{IN5}-Po =	#DIV/0!	W

STEP NO.22.鐵芯損耗

Pfe1 = $P_{\Sigma 1}$-Pcu1 =	9.010	W
Pfe2 = $P_{\Sigma 2}$-Pcu2 =	9.010	W
Pfe3 = $P_{\Sigma 2}$-Pcu3 =	#DIV/0!	W
Pfe4 = $P_{\Sigma 2}$-Pcu4 =	#DIV/0!	W
Pfe5 = $P_{\Sigma 2}$-Pcu5 =	#DIV/0!	W

STEP NO.23.激磁電流

AT_{OF}=AT*lm=	56.263	AT
Iol1=AFoo/($2^{0.5}$*Np1)=	0.09703	A
Iow1=Pfe1/Np1=	0.02197	A
Iox1=(Iow1^2+Iol1^2)$^{0.5}$=	0.09949	A
Iox2=AFoo/($2^{0.5}$*Np1+Np2) =	0.04852	A
Iox3=AFoo/($2^{0.5}$*Np1+Np2+Np3) =	0.04852	A
Iox4=AFoo/($2^{0.5}$*Np1+Np2+Np3+Np4) =	0.04852	A
Iox5=AFoo/($2^{0.5}$*Np1+Np2+Np3+Np4+Np5) =	0.04852	A

STEP NO.24.次級圈數調整

Ns_1=(Np_1*Eo_1)/Ep_1*(1+K* α /100) =	108	T
Ns_2=(Np_1*Eo_2)/Ep_1*(1+K* α /100) =	1	T
Ns_3=(Np_1*Eo3)/Ep_1*(1+K* α /100) =	1	T
Ns_4=(Np_1*Eo_4)/Ep_1*(1+K* α /100) =	1	T
Ns_5=(Np_1*Eo_5)/Ep_1*(1+K* α /100) =	1	T

STEP NO.25.輸出空載電壓

Vo_1=N_{S1}*E_P/N_P=	30.293	V
Vo2=N_{S2}*E_P/N_P=	0.280	V
Vo3=N_{S3}*E_P/N_P=	0.280	V
Vo4=N_{S4}*E_P/N_P=	0.280	V
Vo5=N_{S5}*E_P/N_P=	0.280	V

STEP NO.26.輸出負載電壓

E_{S1}=N_{S1}*E_P/(N_P*(1+ α %))=	28.046	V
E_{S2}=N_{S2}*E_P/(N_P*(1+ α %))=	0.260	V
E_{S3}=N_{S3}*E_P/(N_P*(1+ α %))=	0.260	V
E_{S4}=N_{S4}*E_P/(N_P*(1+ α %))=	0.260	V
E_{S5}=N_{S5}*E_P/(N_P*(1+ α %))=	0.260	V

STEP NO.27.銅線重量

W_{G1}=$MLT_{初1}$*Np_1*$Weight_1$ =	64.8	g
W_{G2}=$MLT_{初2}$*Np_2*$Weight_2$ =	78.2	g
W_{G3}=$MLT_{初3}$*Np3*$Weight_3$ =	0.0	g
W_{G4}=$MLT_{初4}$*Np_4*$Weight_4$ =	0.0	g
W_{G5}=$MLT_{初5}$*Np_5*$Weight_5$ =	0.0	g
W_{G6}=$MLT_{次1}$*Ns_1*Weight6 =	142.6	g
W_{G7}=$MLT_{次2}$*Ns_2*Weight7 =	0.0	g

$W_{G8}=MLT_{次3}*Ns_3*Weight8$ = 0.0 g

$W_{G9}=MLT_{次4}*Ns_4*Weight9$ = 1.0 g

$W_{G10}=MLT_{次5}*Ns_5*Weight10$ = 0.0 g

STEP NO.28溫升計算

EI $_{CORE:}$ At = 2((d+2E)(d+2E+2D)-4ED+(F+2H)(d+2E)-4FH+(F+2H)(d+2E+2D) 269.355 cm^2

UI $_{CORE:}$ At = 2((F+2H)(d+E)-2ED+(F+2H)(2E+2D)-2ED+(d+E)(2E+2D)) = 175.604 cm^2

或 $At=Ks*Ap^{0.5}$= 292.047 cm^2

本設計 At = 269.355 cm^2

$\Psi 1=K_8*P_{\Sigma 1}/At$= 0.078 w/cm^2

$\Psi 2=K_8*P_{\Sigma 2}/At$= 0.078 w/cm^2

$\Psi 3=K_8*P_{\Sigma 3}/At$= #DIV/0! w/cm^2

$\Psi 4=K_8*P_{\Sigma 4}/At$= #DIV/0! w/cm^2

$\Psi 5=K_8*P_{\Sigma 5}/At$= #DIV/0! w/cm^2

$\Delta t1 = (\Psi/0.0005)^{0.79}$ = 54.1 ℃

$\Delta t2 = (\Psi/0.0005)^{0.79}$ = 54.1 ℃

$\Delta t3 = (\Psi/0.0005)^{0.79}$ = #DIV/0! ℃

$\Delta t4 = (\Psi/0.0005)^{0.79}$ = #DIV/0! ℃

$\Delta t5 = (\Psi/0.0005)^{0.79}$ = #DIV/0! ℃

STEP NO.29 絕緣膠紙每圈用量

$S_{L初1}=1.1L(2\pi h_{初1}+Lw)$ = 16.62 cm

$S_{L初2}=1.1L[2\pi (h_{初1}+h_{初2}+0.005L)+Lw)$ = 19.73 cm

$S_{L初3}=1.1L[2\pi (h_{初1}+h_{初2}+h_{初3}+0.005L)+Lw)$ = 19.73 cm

$S_{L初4}=1.1L[2\pi (h_{初1}+h_{初2}+h_{初3}+h_{初4}+0.005L)+Lw)$ = 19.73 cm

$S_{L初5}=1.1L[2\pi (h_{初1}+h_{初2}+h_{初3}+h_{初4}+h_{初5}+0.005L)+Lw)$ = 19.73 cm

$S_{L次1}=1.1L[2\pi (h_{初1}+h_{初2}+h_{初3}+h_{初4}+h_{初5}+h_{次1}+0.005L)+Lw)$ = 25.78 cm

$S_{L次2}=1.1L[2\pi (h_{初1}+h_{初2}+h_{初3}+h_{初4}+h_{初5}+h_{次1}+h_{次2}+0.005L)+Lw)$ = 25.78 cm

$S_{L次3}=1.1L[2\pi (h_{初1}+h_{初2}+h_{初3}+h_{初4}+h_{初5}+h_{次1}+h_{次2}+h_{次3}+0.005L)+Lw)$ = 25.78 cm

$S_{L次4}=1.1L[2\pi (h_{初1}+h_{初2}+h_{初3}+h_{初4}+h_{初5}+h_{次1}+h_{次2}+h_{次3}+h_{次4}+0.005L)+Lw)$ = 25.78 cm

$S_{L次5}=1.1L[2\pi (h_{初1}+h_{初2}+h_{初3}+h_{初4}+h_{初5}+h_{次1}+h_{次2}+h_{次3}+h_{次4}+h次_5+0.005L)+Lw)$ = 25.78 cm

STEP NO.30.鐵芯用量

$Wt=(d/b)*W_{片E+I}$ = 462 g