Topic Audio/ Design1

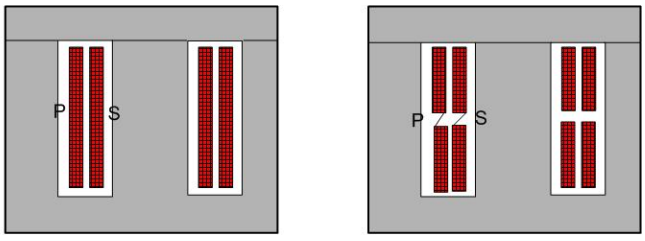
Designing the audio transformer for loudspeaker 25W, 16_Ohm

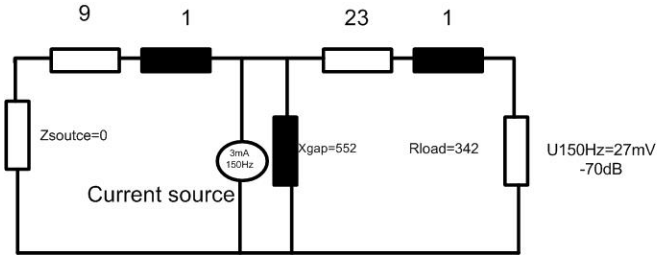
Input parameters

Input	Voltage	100V, 50-17000Hz, sine wave
	Wire	Cu, double insulated for small winding capacitance, wound outside
Output	Nominal output voltage	20V @ 50Hz, min 14.1V @ 17000Hz (-3dB)
	Nominal output current	1.25A @ 50Hz on 16 Ohm
	Wire	Cu, double insulated round wire for small winding capacitance, wound inside
Core	Steel	M6, annealed
	Assembly	Gaped EI core with 5 mil between E and I, for blocking amplifier DC bias current and the fine tuning of the resonance frequency
Bobbin	Type	Single section bobbin
Design	Criterion of design	<10% regulation

General rules

1. In order to keep the leaking reactance low normally you'll use a single section bobbin. If the resonance frequency is lower than the maxim operating frequency (in this design 17000Hz) then you can reduce the capacitance (and increase the resonance frequency) using a double section bobbin. In that case 50% of the primary and 50% of the secondary are wound in each section.£





2. For a low amount of the winding capacitance you'll use a double or heavy insulated round wire. In some cases you'll also need to use the layer insulation.
3. Typical core assembly of a loudspeaker audio transformer is gaped EI or C cores with annealed grain oriented steel. In order to avoid the output voltage distortion through the current harmonics of the magnetizing current the maximal induction should not exceed 1.3T in an annealed EI core or 1.7T in a C core. In that case the third harmonic of the magnetizing current (no load current) will not exceed 10%-15% (in our design approx. 3mA, view "Results at 50Hz without gap")

   With a gaped core assembly you can manipulate the resonance frequency changing the value of the no-load inductance. Additionally the gap will block the influence of the amplifier DC bias current.
4. At 17000Hz the output voltage is 15.85V (14.1V) and the phase delay 28.1°. If you would like to improve this operation mode then you need to reduce the eddy current losses (using litz wire) and the leaking reactance (using a long EI core with bigger Fe cross section). Note that the best results can be achieved using a toroidal core with minimum 8 sectors and one layer windings within each sector.

Results at 50Hz with gap

#*0	DIAGNOSE	Page 0
Name	:1 X EI 75/(2) 1126-0	
Steel	-:M111-0.35mm =>M6 0.014"	
Number of Sections	-:1	
max.Cu-Fill Factor	%:73.4	
max. parallel Wires	:1	
Induction on Load	T:1.301	
Max. Induction	T:1.333	
Max.Cu-Temp.rise on load	°K:34.	
Max.Cu-Temp.rise no-load	°K:22.7	
Regulation	%:9.8	
I^Inrush/I^nom-Factor	*:14.1	
Input Current No-Load	%:91.1	

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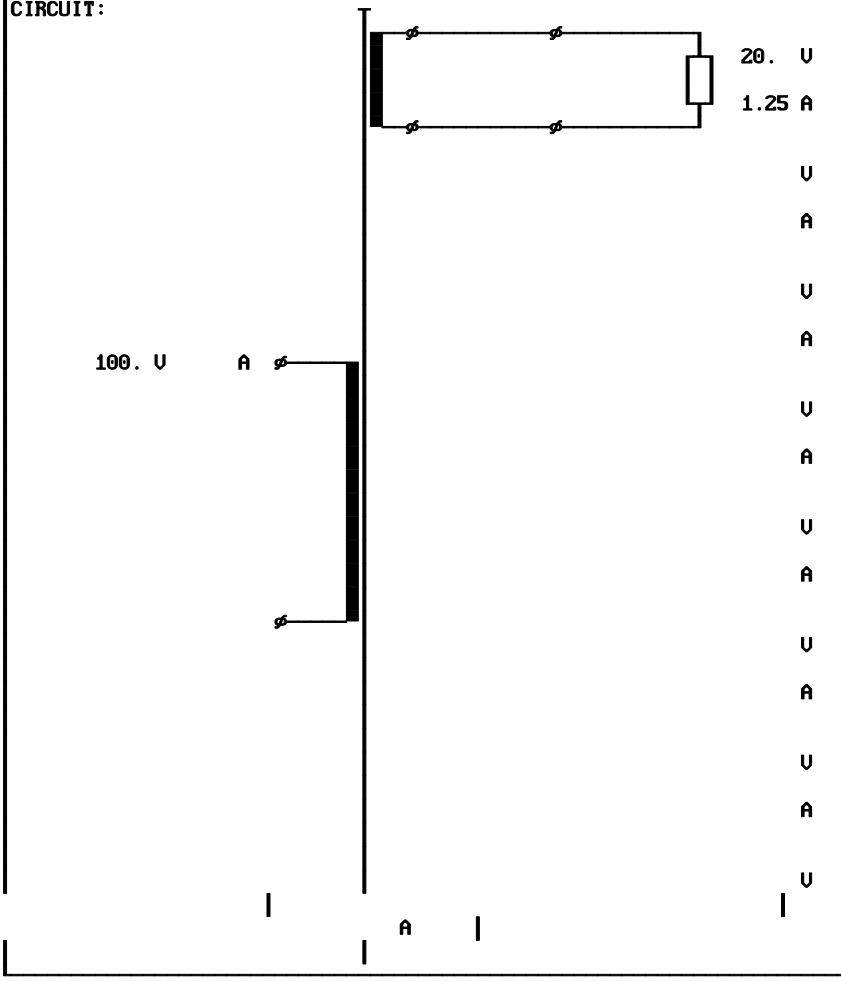
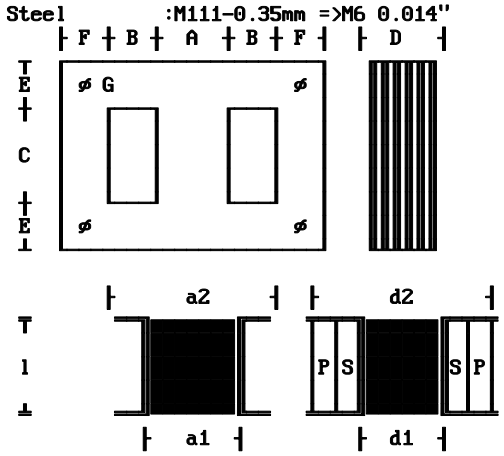
PRIMARY	U(V) I(A)	SECOND. 1--- 2--- 3--- 4--- 5--- 6--- 7--- 8---
Circuit-:1	100.	Circuit-:11
Overvlt*:1.00	.	Volta. V:20.
Wire :2.0	.	Curre. A:1.25
I/L. mil:0.	.	Wire :2
I/E. mil:10.	.	I/L mil:0.0
Formfac.:1.11	.	I/E mil:5.0
Fre.Hz:50	.	
dI/Io :100	.	

Regulat. %:8.0	Steel -:1	Cooling *:1.00	Bobbin -:1
Udiode V:1.5	Induction T:1.30	Force ft/s:0.00	P/S-Order -:2
dUdiode V:.1	Remanence *:0.35	Bracket -:1	Rac/Rdc *:1.05
Ripple %:5.	W/kg *:1.00	Radiator -:0	Space *:0.90
Tmp. Amb.°C:40	VAr/kg *:1.00	Chassis -:1.00	Vertical -:1
Tmp.rise °K:20	Gap *:5.00	Channel in:0.00	Horizontal -:1
Time 1 Min:30.0	Annealed -:1	Cu-Surface*:1.00	Impregnat. -:3
Load 1 *:1.0	Stacking *:1.00	Rth-varni.*:1.00	Spread %:0
Time 2 Min:30.0	Hole -:1	Rth-comp. *:1.00	Selection -:2
Load 2 *:1.0	Assembly -:2	Case -:0	Criterion -:1

CIRCUIT:

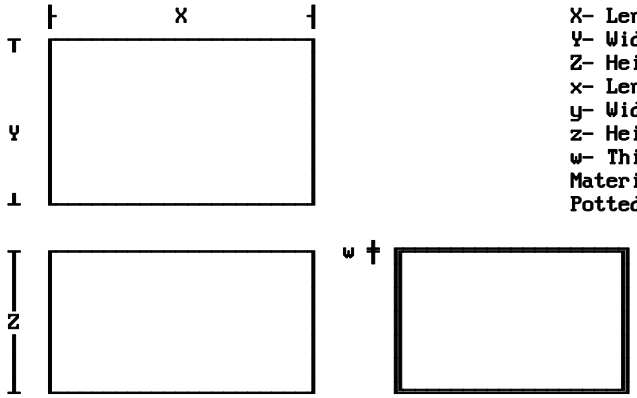


Name :1XEI 75/(2) 1126-0
Steel :M111-0.35mm =>M6 0.014"



/13.78

Weight	lb:1.82
Gap total	in:0.000
A-Limb	in:0.75
B-Width	in:0.38
C-Height	in:1.13
D-Stack	in:2.03
E-Yoke 1	in:0.38
F-Yoke 2	in:0.38
G-Hole	in:0.00
Radiator Fin	:0
Radiator Chan.	:0
a1	cm:0.84
a2	cm:1.49
d1	cm 2.10
d2	cm 2.73
l	cm:1.03
lp	cm:
ls	cm:
Margin	cm:0.05



X- Length 1	in:
Y- Width 1	in:
Z- Height 1	in:
x- Length 2	in:
y- Width 2	in:
z- Height 2	in:
w- Thickness	in:
Material	:
Potted	:

	Typ	Windun	MTI	DN	DN	Par	D/ø mil	B/ø mil	W/L	L	I/L mil	I/E mil	Weight lb	RWH %
1 2 3 4 5 6 7 8	1	356.	C02	25.5	25.5	1	16.9	16.9	49	7.2	.	10.	.172	52.
1 2 3 4 5 6 7 8	11	77.0	C02	23.5	23.5	1	21.3	21.3	40	1.9	.	5.	.053	17.
TOTAL													.225	73.

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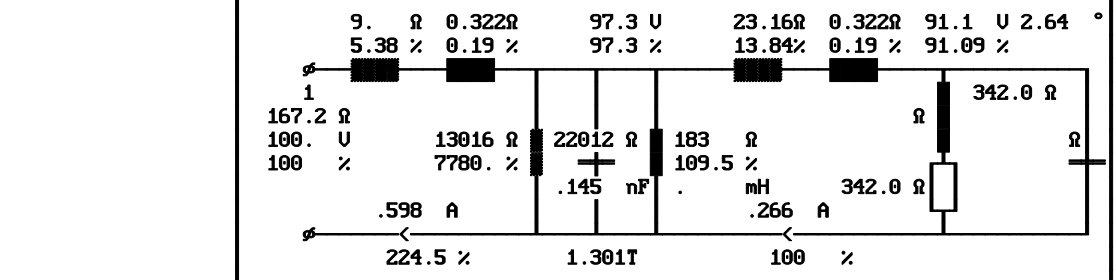
NOMINAL OPERATION at Temperature °C 72.2 and Overvoltage 1.00

Output Power on Load	W:24.26	Output Power of Transfor.	W:24.26
Cu Losses	W:4.86	Fe-Losses active	W:.73
Short-Circuit-Volt. cold	%:15.85	Regulation	%:9.79
Instantaneous pow. .5/95&	W:57.9	Efficiency of Transformer	%:81.29
dT Fe average Surface	°K:24.6	dT primary	°K:34.
dT Case aver. Surface	°K:.	dT secondary	°K:30.4



DUTY CYCLE OPERATION at Amb.Temperature °C 40. and Overvoltage 1.00

dT Fe average Surface	°K:24.5	dT primary	°K:34.
dT Gehäuse av. Surface	°K:.	dT secondary	°K:30.4

NO LOAD OPERATION at Amb.Temperature °C 40. and Overvoltage 1.00

Losses active	W:3.4	Losses reactive	VAr:54.36
Current factor	%:91.11	Induction	T:1.333
dT Fe average Surface	°K:16.2	dT primary	°K:22.7
dT Gehäuse av. Surface	°K:.	Rezonance frequency	kHz:17.3

SHORT-CIRCUIT OPERATION at Amb.Temperature °C 40. and Overvoltage 1.00

Losses active	W:375.2	Losses reactive	VAr:37.41
Current factor cold	%:630.9	Induction	T:.972
dT Fe average Surface	°K:267.2	dT primary	°K:410.2
dT Gehäuse av. Surface	°K:.	dT secondary	°K:448.3

PRIMARY (Tap:1)	1---- 2---- 3---- 4---- 5---- 6---- 7---- 8-----
Voltage Input/Output	V:100.
Out. Voltage no load	V:
Current Input/Output	A:0.598
Load on output	Ω:
Power factor of load	:
Current in segment	A:0.598
Current density A/in^2	:2665.
Icc-Current cold	A:3.77
Io -Current	A:0.545
Inrush Current peak	^A:11.89
Inrush Current rms	A:4.82
Cu-Losses	W:3.2
Resistance cold	Ω:7.406
Reactance	Ω:.3221
Eddy-Current Factor	:1.

SECONDARY	1---- 2---- 3---- 4---- 5---- 6---- 7---- 8-----
Output Voltage	V:19.7
Output Current	A:1.231
Out. Voltage no load	V:21.55
Sec. Voltage	V:19.7
Sec. Current	A:1.231
Current density A/in^2	:3455.
Sec. Voltage cold	V:19.7
Load on output	Ω:16.
Power factor of load	:1.000
Icc cold	A:17.28
Cu-Losses warm	W:1.643
Resistance cold	Ω:.9024
Reactance	Ω:.0151
Eddy-Current Factor	:1.
Capacitor	mF:.

Results at 17000Hz

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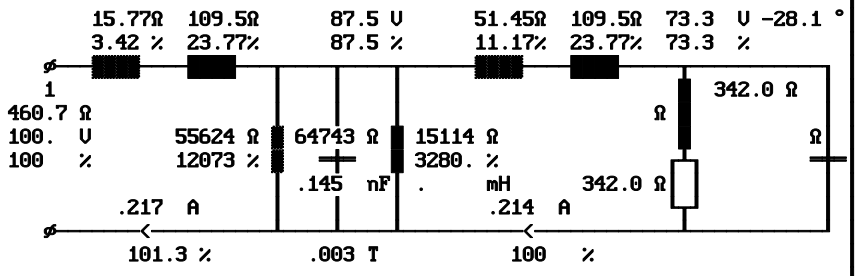
NOMINAL OPERATION at Temperature °C 59.9 and Overvoltage 1.00

Output Power on Load	W:15.71	Output Power of Transfor.	W:15.71
Cu Losses	W:3.11	Fe-Losses active	W:.14
Short-Circuit-Volt. cold	%:47.66	Regulation	%:36.43
Instantaneous pow. .5/95&	W:9.2	Efficiency of Transformer	%:82.88
dT Fe average Surface	°K:15.8	dT primary	°K:19.5
dT Case aver. Surface	°K:.	dT secondary	°K:20.3



DUTY CYCLE OPERATION at Amb.Temperature °C 40. and Overvoltage 1.00

dT Fe average Surface	°K:15.8	dT primary	°K:19.5
dT Gehäuse av. Surface	°K:.	dT secondary	°K:20.3

NO LOAD OPERATION at Amb.Temperature °C 40. and Overvoltage 1.00

Losses active	W:.18	Losses reactive	VAr:.44
Current factor	%:2.21	Induction	T:.004
dT Fe average Surface	°K:1.3	dT primary	°K:1.2
dT Gehäuse av. Surface	°K:.	Rezonance frequency	kHz:35.2

SHORT-CIRCUIT OPERATION at Amb.Temperature °C 40. and Overvoltage 1.00

Losses active	W:5.5	Losses reactive	VAr:45.21
Current factor cold	%:209.8	Induction	T:.002
dT Fe average Surface	°K:29.2	dT primary	°K:37.7
dT Gehäuse av. Surface	°K:.	dT secondary	°K:38.8

PRIMARY (Tap:1) 1---- 2---- 3---- 4---- 5---- 6---- 7---- 8-----

Voltage Input/Output	V:100.
Out. Voltage no load	V:
Current Input/Output	A:0.217
Load on output	Ω:
Power factor of load	:
Current in segment	A:0.217
Current density A/in^2	:967.7
Icc-Current cold	A:0.46
Io -Current	A:0.005
Inrush Current peak	^A:0.
Inrush Current rms	A:0.
Cu-Losses	W:.7
Resistance cold	Ω:7.406
Reactance	Ω:109.5
Eddy-Current Factor	:1.84

SECONDARY 1---- 2---- 3---- 4---- 5---- 6---- 7---- 8-----

Output Voltage	V:15.85
Output Current	A:0.991
Out. Voltage no load	V:21.52
Sec. Voltage	V:15.85
Sec. Current	A:0.991
Current density A/in^2	:2780.
Sec. Voltage cold	V:15.9
Load on output	Ω:16.
Power factor of load	:1.000
Icc cold	A:2.08
Cu-Losses warm	W:2.363
Resistance cold	Ω:.9024
Reactance	Ω:5.123
Eddy-Current Factor	:2.3
Capacitor	mF:.

Results at 50Hz withot gap

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NOMINAL OPERATION     at Temperature °C 57.7   and   Overvoltage 1.00
Output Power on Load      W:24.58    Output Power of Transfor. W:24.58
Cu Losses                 W:2.25     Fe-Losses active           W:.74
Short-Circuit-Volt. cold  %:7.36     Regulation                 %:9.06
Instantaneous pow. .5/95& W:60.6     Efficiency of Transformer  %:89.16
dT Fe average  Surface    °K:14.9    dT primary                 °K:17.4
dT Case aver.  Surface    °K:.       dT secondary               °K:18.

        8.515Ω  0.322Ω      97.6 V      22.21Ω  0.322Ω  91.7  V -0.03 °
        2.35 %  0.09 %      97.6 %      6.13 %  0.09 %  91.69 %
    ø
      1                                                  342.0 Ω
  362.1 Ω                                          Ω
  100.  V       12820 Ω   22012 Ω   6416  Ω                      Ω
  100   %       3540. %               1771. %
                          .145  nF    .     mH      342.0 Ω
           .276  A                          .268  A
    ø
           103.  %         1.307T          100   %

DUTY CYCLE OPERATION  at Amb.Temperature °C 40.  and Overvoltage 1.00
dT Fe average  Surface    °K:14.9    dT primary                 °K:17.4
dT Gehäuse av. Surface    °K:.       dT secondary               °K:18.

NO LOAD OPERATION     at Amb.Temperature °C 40.  and Overvoltage 1.00
Losses    active          W:.85      Losses    reactive         VAr:1.59
Current factor            %:6.52     Induction                  T:1.337
dT Fe average  Surface    °K:5.1     dT primary                 °K:4.7
dT Gehäuse av. Surface    °K:.       Rezonance frequency        kHz:2.9

SHORT-CIRCUIT OPERATION at Amb.Temperature °C 40.  and Overvoltage 1.00
Losses    active          W:374.8    Losses    reactive         VAr:9.59
Current factor cold       %:1357.    Induction                  T:.975
dT Fe average  Surface    °K:266.1   dT primary                 °K:403.7
dT Gehäuse av. Surface    °K:.       dT secondary               °K:447.

PRIMARY (Tap:1   )     1---- 2---- 3---- 4---- 5---- 6---- 7---- 8-----
Voltage Input/Output V:100.
Out. Voltage no load V:
Current Input/Output A:0.276
Load on output       Ω:
Power factor of load  :
Current in segment   A:0.276
Current density A/in^2:1231.
Icc-Current   cold   A:3.75
Io -Current          A:0.018
Inrush Current peak ^A:11.89
Inrush Current rms   A:4.82
Cu-Losses            W:.6
Resistance    cold   Ω:7.406
Reactance            Ω:.3221
Eddy-Current Factor   :1.

SECONDARY              1---- 2---- 3---- 4---- 5---- 6---- 7---- 8-----
Output Voltage       V:19.83
Output Current       A:1.24
Out. Voltage no load V:21.61
Sec. Voltage         V:19.83
Sec. Current         A:1.24
Current density A/in^2:3478.
Sec. Voltage cold    V:19.8
Load on output       Ω:16.
Power factor of load  :1.000
Icc            cold  A:17.31
Cu-Losses      warm  W:1.597
Resistance     cold  Ω:.9024
Reactance            Ω:.0151
Eddy-Current Factor   :1.
Capacitor           mF:.
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