Designer's Corner

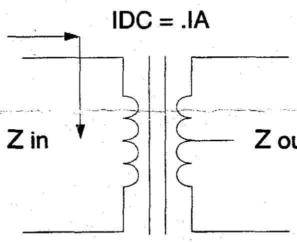
BY LOWELL QUIST

Designing a Broadband Audio, 20 Watts thru, Single Ended...

20 to 20,000 Hz ± .75 db

Zin= 1500Ω
Zout = 8Ω tap at 4Ω

IDC Primary = 100 ma



$$Lp = \frac{1500 \text{ x } 1.2}{2\pi \text{ x } 20} = 14.3 \text{ Henries; call it 15}$$

After a couple of trys with smaller cores, I'm going to select an EI-138, and a larger than square stack. Say ~2.00"

A_C	= 1.375 x 2 = 2.75 in^2	... core area
A_W	= 1.418 in^2	... window area
l_i	= 20.96 cm	... path length in cm

1/4 window (for 295 pri) = 1.418/4 = .3545 in²

A_C $\quad I_{pri} = \sqrt{\frac{20}{1500}} = .115$ amps

TOTAL $\quad I_{pri} = \sqrt{.115^2 + .10^2} = .152$ amps

A_C $\quad E_{pri} = .115 \text{ x } 1500 = 173$ volts

#29 awg = 127 cml/.152 amps = 836 cml/amp
d 29 single = .0126 inch

If I use ~2250 turns on pri
2250 x $.0126^2$ = .3572... pretty close to .3545 in²

In order to get 15H with 2250 turns the μeff needs to be $\mu eff = Lli/1.256 \text{ } N^2 \text{ } Ac \text{ } K \text{ x } 10^{-8}$
$= 15 \text{x} 20.96/1.256 \text{x} 2250^2 \text{x} 2.75 \text{x} 6.45 \text{x}.95 \text{ x } 10^{-8}$
= 293

$$la = \left[\frac{1}{293} - .001\right] \text{x} 20.96 = .0505 \text{ total gap in cm}$$

$$.0505 \text{ x} \frac{1}{2} \text{x} \frac{1}{2.54} = .010 \text{ inches, gap spacers}$$

$$1.256 \text{ NI} = li\text{Hdc} + la\text{Bdc}$$

$$B_{dc} = (1.256 \text{x} 2250 \text{x}.1 - 2)/.0505 = 5556 \text{ gauss dc}$$

$$B_{ac} = \frac{3.5 \text{ x} 10^6 \text{ x } 173\text{V}}{20 \text{ x } 2.75 \text{x}.95 \text{ x } 2250} = 5150 \text{ gauss ac}$$

$$N_{s8\Omega} = 2250\sqrt{8/1500} = 164 \text{ turns}$$

$$N_{s4\Omega} = 2250\sqrt{4/1500} = 116 \text{ turns}$$

$$I = \sqrt{20/4} = 2.23 \text{ amps}$$

Use #18 on whole sec for simplicity

$$\text{MTL} = 1.375 \text{x} 2 + 2 \text{x} 2 + \pi \text{x} \frac{.6875}{2} \text{x}.85 = 8.586 \text{ in}$$

$$DCR_{pri} = 8.586 \text{x} 2250 \text{x} 81.84/12\text{K} = 132\Omega$$

$$DCR_{sec} = 8.586 \text{x} 164 \text{x} 6.385/12\text{K} = .75\Omega$$

$$I^2R_{pri} = .152^2 \text{x} 132 = 3.04 \text{ watts}$$

$$I^2R_{sec} = 2.23^2 \text{x}.75 = 3.73 \text{ watts}$$

$$\text{M6 core loss} = 6.0\# \text{ x } .5\frac{\text{w}}{\#} = 3.0 \text{ watts}$$

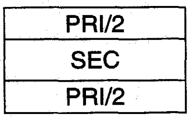
Total losses ~ 9.77 watts

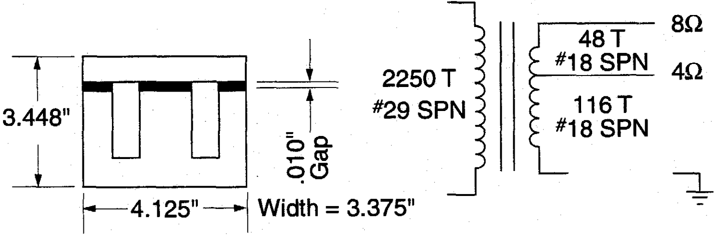
$A_s \cong 70 \text{ in}^2$; surface area

$$\Delta T = \frac{9.77}{70} \text{x} 160 = 23°\text{C temp rise}$$

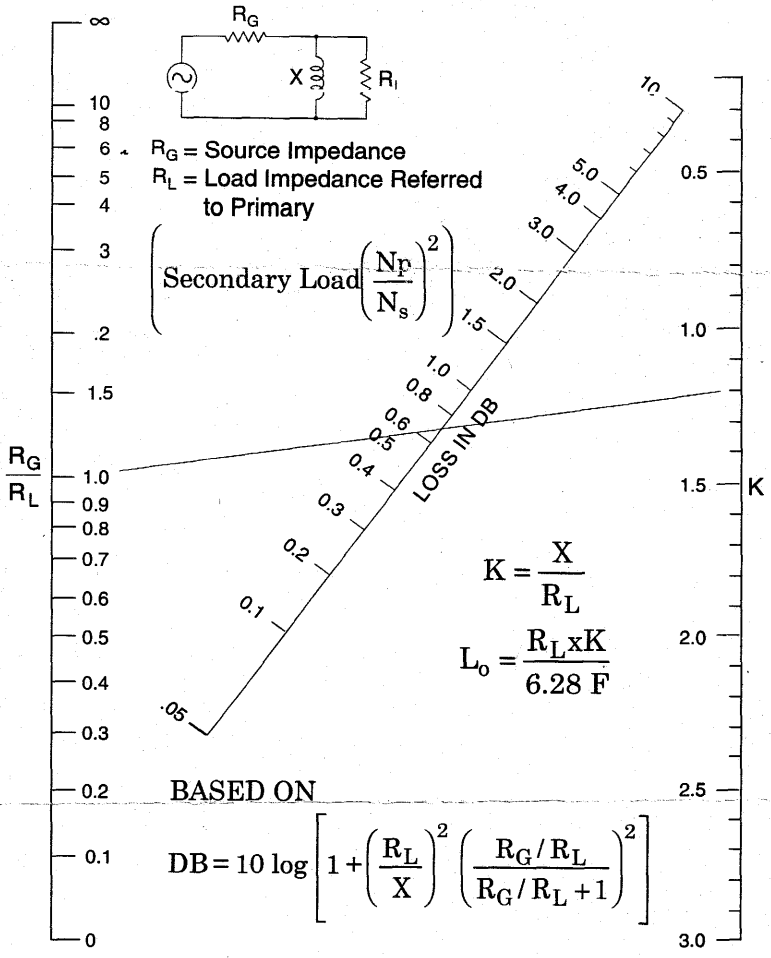
Wire Wt = $1.3^{\#}$
Cor Wt = $6.0^{\#}$
Total = $7.3^{\#}$
WO Impr, Brackets, Etc.

Interleave
to Reduce
L_L by 4





DB Loss Prediction Chart for Low Freqencies



R_G = Source Impedance
R_L = Load Impedance Referred to Primary

$$\left(\text{Secondary Load}\left(\frac{N_P}{N_s}\right)^2\right)$$

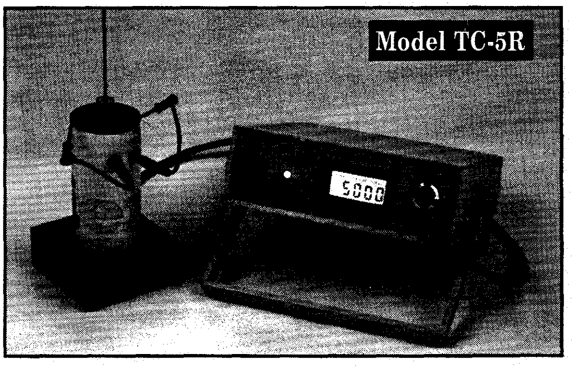
$$K = \frac{X}{R_L}$$

$$L_o = \frac{R_L x K}{6.28\ F}$$

BASED ON

$$DB = 10 \log\left[1 + \left(\frac{R_L}{X}\right)^2 \left(\frac{R_G/R_L}{R_G/R_L + 1}\right)^2\right]$$

Ref. "*An Analysis of Audio Frequency Response Charts*"
By H. Holobow in Communications, Oct. 1942.



R is for Rogowski

Count turns of large diameter coils and motor windings quickly and safely! The new TC-5R uses digital technology and a lightweight Rogowski Coil to measure coils without awkward fixturing and high voltage levels. Contact us for details.

WE ALSO OFFER A COMPLETE LINE OF COIL TEST SYSTEMS DESIGNED TO YOUR SPECIFICATION. CONTACT US FOR MORE INFORMATION.

iem

International Electro-Magnetics, Inc.
350 N. ERIC DRIVE, PALATINE, ILLINOIS 60067 USA
TEL: (847) 358-4622 FAX: (847) 358-4623
1-800-227-4323

www.iemmag.com

Mark 208 on inquiry card

SOURCES DIRECTORY
http://www.woundmagnetics.com

Ferrite Core Transformers Weights and Measures

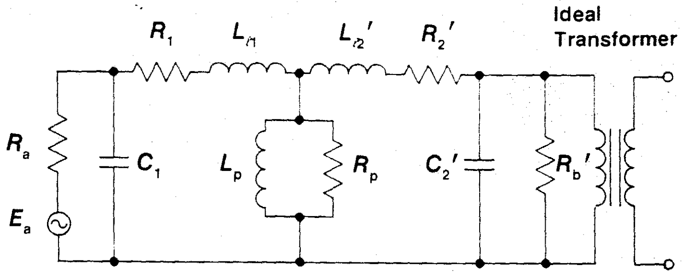


Figure 2 Lumped equivalent circuit of a transformer.

E_a = source EMF
R_a = source resistance
C_1 = primary winding capacitance
R_1 = resistance of primary winding
L_{l1} = primary leakage inductance
L_p = open circuit inductance of primary winding
R_p = shunt resistance that represents loss in core

Secondary parameters reflected to the primary side.

C_2' = secondary winding capacitance
R_2' = resistance of secondary winding
L_{l2}' = secondary leakage inductance
R_b' = load resistance

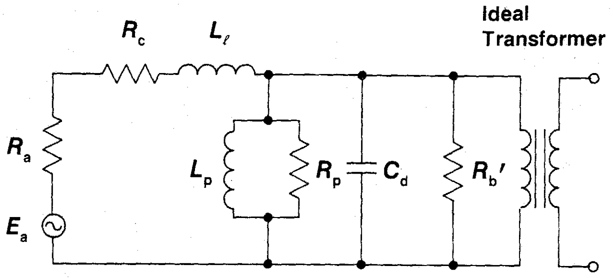


Figure 3 Simplified equivalent transformer circuit.

$C_d = C_1 + C_2'$
$R_c = R_1 + R_2'$
$L_l = L_{l1} + L_{l2}'$

For other circuit parameters see Figure 2.

reactance X_{LP}, with a negligible contribution of the equivalent shunt loss resistance R_p. The insertion loss may therefore be expressed in terms of the shunt inductance:

$$A_i = 10 \log_{10} \left(1 + \left(\frac{R}{\omega L_p}\right)^2\right) \text{ dB}$$

Where $R = R_a \times R_b' / R_a + R_b'$

For most ferrite broadband transformer designs, the only elements that are likely to effect the transmission at the mid-band frequency range are the winding resistances. The insertion loss for the mid-band frequency region due to the winding resistance may be expressed as:

$$A_i = 20 \log_{10} \left(1 + \frac{R_c}{R_a + R_b'}\right) \text{ dB}$$

Where $R_c = R_1 + R_2'$

In the higher frequency region the transmission characteristics are mainly a function of the leakage inductance or the shunt capacitance. It is often necessary to consider the effect of both of these reactances, depending upon the circuit impedance. In a low impedance circuit the high frequency droop due to leakage inductance is:

$$A_i = 10 \log_{10} \left(1 + \left(\frac{\omega L_l}{R_a + R_b'}\right)^2\right) \text{ dB}$$

This high frequency droop in a high impedance circuit, due to the shunt capacitance, is as follows:

$$A_i = 10 \log_{10} \left(1 + \left(\omega C R\right)^2\right) \text{ dB}$$

Reviewing the insertion loss characteristics for the three frequency regions, it can be concluded that the selection of ferrite material and core shape should result in a transformer design that yields the highest inductance per turn at the low frequency cutoff f_1. This will result in the required shunt inductance for the low frequency region with the least number of turns. The low number of turns are desirable for low insertion loss at the mid-band region and also for low winding parasitics needed for good response at the high frequency cutoff f_2.