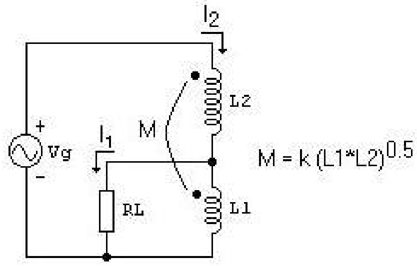
Useful Calculations for better understanding the use of
The Bogen T-725 Autotransformer

Consider a lossless autotransformer driven by a voltage source Vg supplying power to a resistor R_L. See figure below.



Lossless autotransformer with resistive load

Mesh equations describing the above network can be writtten as:

$$V_g = jw(L_2 + M)I_2 + jw(L_1 + M)(I_2 - I_1) \qquad ...(1)$$

$$I_1 = \frac{1}{R_L}\left[jwL_1(I_2 - I_1) + jwMI_2\right] \qquad ...(2)$$

From the above equation:

$$(R_L + jwL_1)I_1 = jw(L_1 + M)I_2$$

Then,

$$I_1 = \frac{jw(L_1 + M)}{R_L + jwL_1} I_2 \qquad ...(3)$$

Eq. (1) may be arranged as:

$$V_g = jwI_2(L_1 + L_2 + 2M) - jwI_1(L_1 + M)$$

Substituting eq. (3) into the above expression:

$$V_g = jwI_2(L_1 + L_2 + 2M) + \frac{w^2(L_1 + M)^2}{R_L + jwL_1} I_2$$

$$= \frac{jwI_2(L_1+L_2+2M)R_L - w^2L_1I_2(L_1+L_2+2M) + w^2(L_1+M)^2 I_2}{R_L + jwL_1}$$

$$= \frac{jwI_2(L_1+L_2+2M)R_L + w^2I_2(M^2 - L_1L_2)}{R_L + jwL_1}$$

The mutual inductance M of L_1 and L_2 is given by $M = k\,(L_1L_2)^{0.5}$, where k is the coupling coefficient. For values of k very close to unity, M^2-L_1L_2 nearly vanishes and :

$$V_g = \frac{jwI_2(L_1+L_2+2M)R_L}{R_L + jwL_1}$$

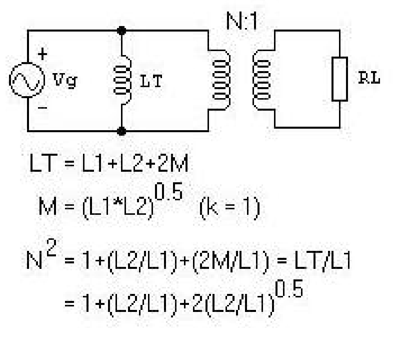
The input admittance of the autotransformer network is computed as:

$$\frac{I_2}{V_g} = \frac{R_L + jwL_1}{jw(L_1+L_2+2M)R_L}$$

$$= \frac{1}{jw(L_1+L_2+2M)} + \frac{L_1}{(L_1+L_2+2M)R_L}$$

$$= \frac{1}{jw(L_1+L_2+2M)} + \frac{1}{\left(1+\frac{L_2}{L_1}+\frac{2M}{L_1}\right)R_L}$$

which suggests the following transformer-like network equivalent:



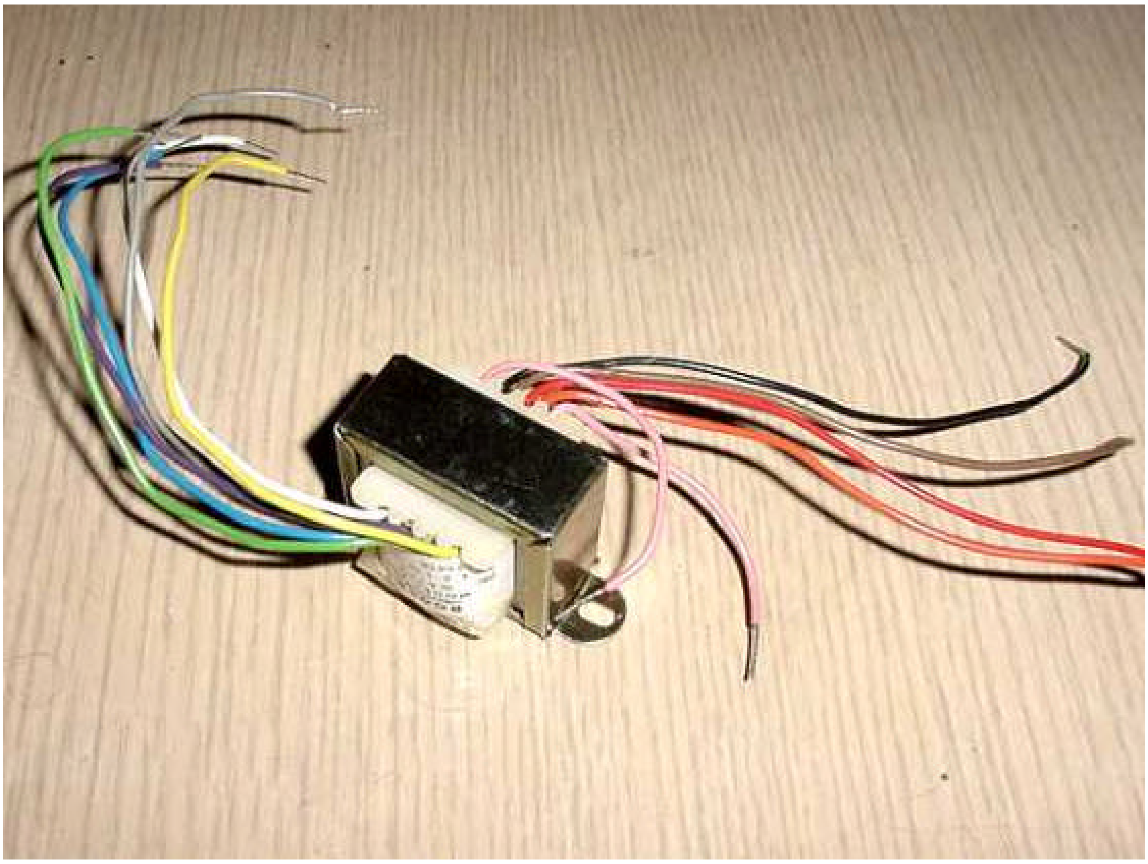
Transformer-like network equivalent of the autotransformer loaded by a resistive load RL.

$L_T = L_1+L_2+2M$ is the measured inductance of the whole winding and L_1 is the inductance measured from the tap to the lower end of the winding.

Impedance transformation ratios are then $N^2 = L_T / L_1$ for each tap. The impedance ratio at 300 Hz or whatever frequency in the autotransformer´s pass band is approximately equal (for k ~1) to the inductance ratio. Each tap is recognized by its impedance. I find it useful to calculate things at 300Hz and then scale the figures to the desired frequency. If it is desired 40k ohms to be the maximum impedance point, then it is a simple matter of calculating $40*L_1 / L_T$ in kohms to find the corresponding impedance for the selected tap.

This is the methodology for determining the corresponding impedances assigned to each tap in the Bogen T-725 autotransformer (and for any other useful autotransformer for audio applications).

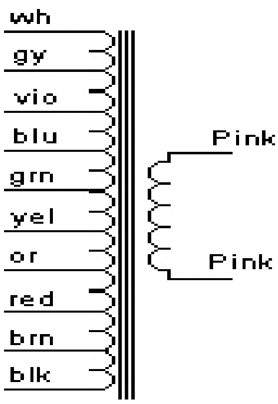
The Bogen T-725 Autotransformer

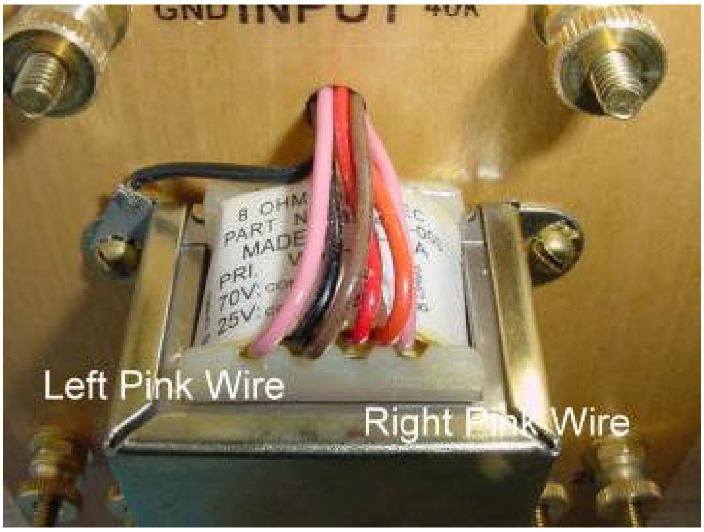


Bogen Specs.

All values are relative to the black (blk) tap.

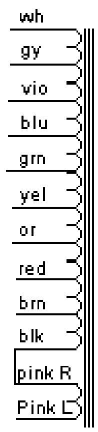
Color	Resistance	Inductance	XL @ 300 hz	Rounded Value
White (WH)	1424.3 ohms	24 H	45.239k ohms	40k ohms
Gray (GRY)	886.4 ohms	12.04 H	22.694k ohms	20k ohms
Violet (VIO)	516.5 ohms	6.06 H	11.423k ohms	10k ohms
Blue (BLU)	260.1 ohms	3.04 H	5.730k ohms	5k ohms
Green (GRN)	81.8 ohms	1.565 H	2.950k ohms	2.5k ohms
Yellow (YEL)	56 ohms	787 mH	1.483k ohms	1.2k ohms
Orange (OR)	38.2 ohms	398 mH	750.2 ohms	600 ohms
Red (RED)	26 ohms	197 mH	371.3 ohms	300 ohms
Brown (BRN)	18.2 ohms	98 mH	184.7 ohms	150 ohms
Pink to Pink	0.5 ohms	5.23 mH	9.86 ohms	8 ohms





All values are relative to the left side pink tap.

Color	Impedance @ 300Hz
White	40k ohms
Gray	20k ohms
Violet	10k ohms
Blue	5k ohms
Green	2.5k ohms
Yellow	1.5k ohms
Orange	900 ohms
Red	500 ohms
Brown	250 ohms
Pink (R)	8 ohms



References

1. Schmarder, Dave "Uses for the Bogen T-725 Audio Transformer" http://www.schmarder.com/radios/misc-stuff/t-725.htm

2. Schmarder, Dave "Simple Matching Circuit Using Bogen Transformer" http://www.schmarder.com/radios/misc-stuff/transformer.htm

3. Bringhurst, Steve "S-T-M Calrad / Bogen 'Select to Match' Impedance Matching Circuit" http://www.crystalradio.net/soundpowered/matching/index.shtml

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