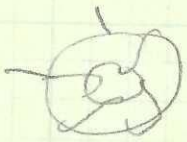
low frequency

Introduction To RF Transformers

Toroidal Inductors &

~~Coreless~~ toroid L



Toroid made of Powered iron & Ferrite

- Concentrate & confine magnetic flux
- Increase inductance (by factor equal to relative permeability)

$$L = kN^2 \Rightarrow k = \frac{L}{N^2}$$

Why?

$V = N\frac{d\phi}{dt}$

But $\phi \propto NI$

So $V \propto N^2\frac{dI}{dt}$

or $V = kN^2\frac{dI}{dt}$

compare with $V = L\frac{dI}{dt}$

$\Rightarrow L = kN^2$

Example 1 T37-2 core (.37 OD) # 2 powdered iron material 1-30 MHz

From table $k = 40\ \mu H$ for 100 turns

$\Rightarrow k = 4\ nH/turn^2$ ←!

10 turns = 400 nH

Example 2 (F) T37-67 core (0.3700, #67 material)

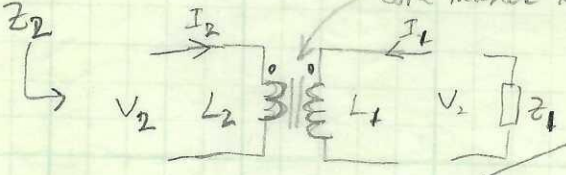
$L = 17.7$ "mH / 1000 turns" ← Bad terminology

$k = \frac{17.7m}{1000^2} = 17.7\ nH/t^2$

10 turns = 1.8 μH

Transformers

core makes ϕ in $L_1 \approx \phi$ in L_2



IV characteristics

Ideal: $L_1 \to \infty$, $L_2 \to \infty$

$V_2 = \frac{N_2}{N_1}V_1$

$Z_2 = \left(\frac{N_2}{N_1}\right)^2 Z_1$

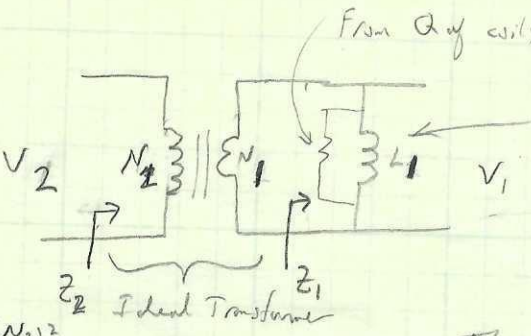
Practical: $V_1 = j\omega L_1 I_1 + j\omega M I_2$

$V_2 = j\omega L_2 I_2 + j\omega M I_1$

where $M = k\sqrt{L_1 L_2}$

↑ coupling coeff (Frac of flux from L_1 that links L_2)

If $k \approx 1$, then model simplifies to:



$Z_2 = \left(\frac{N_2}{N_1}\right)^2 Z_1$ ——— This reduces to L_2 if unloaded

SKIP

Ideal Transformer Behavior

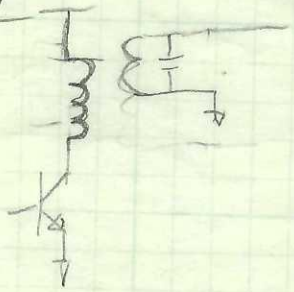
$$\left.\begin{aligned} V_2 &= \frac{N_2}{N_1} V_1 \\ I_2 &= \left(\frac{N_2}{N_1}\right)^{-1} I_1 \end{aligned}\right\} \text{ why? } \quad V_2 I_2 = \frac{N_2}{N_1} V_1 \left(\frac{N_2}{N_1}\right)^{-1} I_1 = V_1 I_1$$

Power conservation!

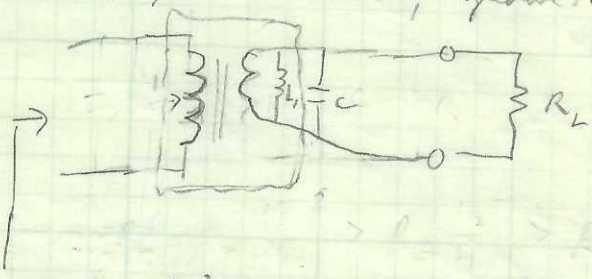
$$Z_2 = \frac{V_2}{I_2} = \left(\frac{N_2}{N_1}\right)^2 \frac{V_1}{I_1} = \left(\frac{N_2}{N_1}\right)^2 Z_1$$

Applications

Matching



Tuned Ckts (OPT) w/ DC isolation & Impedance Transformation

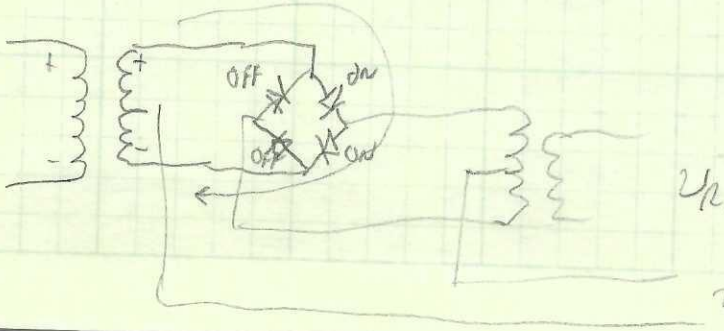


$$Z_L' = \left(\frac{N_2}{N_1}\right)^2 \left((j\omega L \,//\, \frac{1}{j\omega C}) \,//\, R_L \right) \simeq \left(\frac{N_2}{N_1}\right)^2 R_L$$

@ f_0

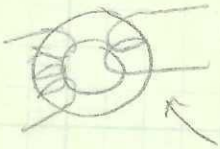
Show RX Diagram open at f_0

Mixers



Transformer Realizations

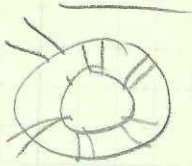
BAD



High Permeability Ferrite Core s

OR

GOOD

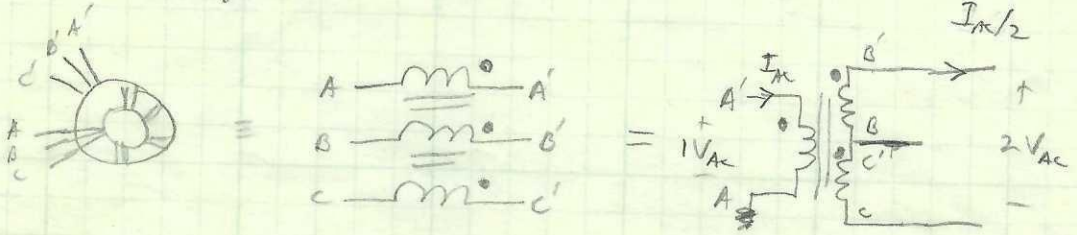


TX - Line construction
(Broader Bandwidth)
Better flux linkage

Model:

$\approx$

2:1 Center Tapped TX Line construction

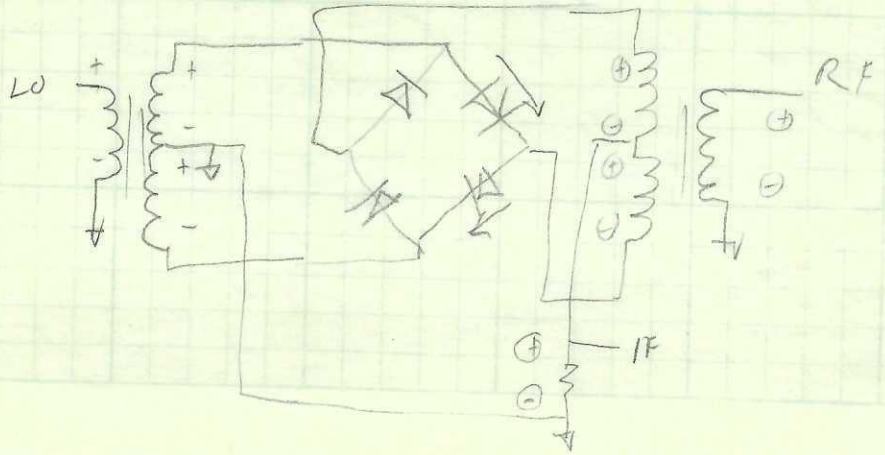


2:1 Voltage, 4:1 Z transformation

Application:

mixer!

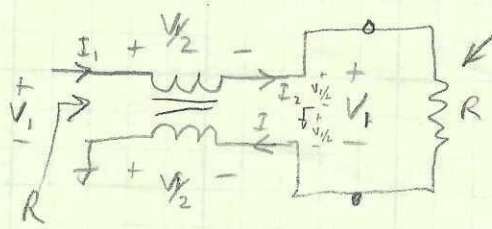
Goal: Pass RF to IF with polarity reversals every half cycle of LO



Additional applications

Balun

Eg. 75Ω dipole antenna



$I_2 = I_1 \Rightarrow V_2 = V_1$

But V_2 is "balanced"

4:1 Z