Modifed T-coil Network

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The interface between two amplifiers or circuits can often lead to bandwidth limiting. Figure 1 shows a typical situation where the output current of an amplifier is converted to a voltage by a load resistance and the input capacitance of the following stage. The -3dB bandwidth is given by

$$f_{3dB} = \frac{1}{2pR_L C_L}.$$

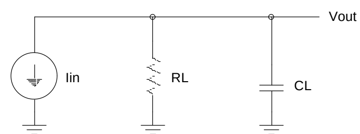

Figure 1. Typical RC network.

Many years ago Tektronix developed an interface network called a bridged T-coil which has some outstanding properties. When the component values are chosen appropriately, the input impedance is perfectly resistive (R_L) at all frequencies — no more capacitive loading on the driving amplifier. In addition, output bandwidth is increased by a factor of 2.5 over the circuit of Figure 1. The difficulty with T-coil design is the construction of the transformer formed by L_1 and L_2. The fractional magnetic coupling must be set precisely for proper operation. Design equations from Tektronix are given as

$$L_1 = \frac{C_L}{4}\left[1+\frac{1}{4z^2}\right](R_L+R_S)^2 - R_L R_S C_L - L_S$$

$$L_2 = \frac{C_L}{4}\left[1+\frac{1}{4z^2}\right](R_L+R_S)^2 - L_S$$

$$M = \frac{C_L}{4}\left[R_L^2 - R_S^2 - \frac{1}{4z^2}(R_L+R_S)^2\right] + L_S$$

$$C_B = \frac{C_L}{16z^2}\left[\frac{R_L+R_S}{R_L}\right]^2$$

$$k = \frac{M}{\sqrt{L_1 L_2}}.$$

It is desireable to have no magnetic coupling. Then simple low cost fixed value inductors can be used in place of the transformer. The author's modified T-coil adds a series resistance R_{comp} which is determined by setting M to zero. R_S and L_S model the interconnection parasitics. The new circuit is given in Figure 2.

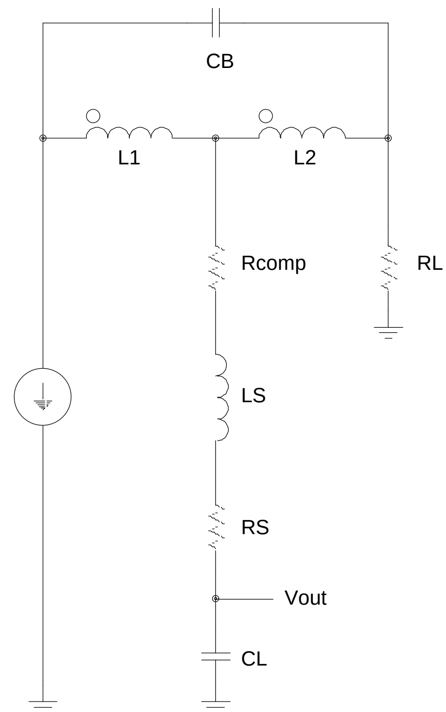

Figure 2. Modified T-coil network.

The solution for R_{comp} is

$$R_{comp} = \left(\frac{\sqrt{R_L^2 - (1+4z^2)\left[R_L^2(1-4z^2) - \left(\frac{16z^2 L_S}{C_L}\right)\right]} - R_L}{(1+4z^2)}\right) - R_S.$$

The equations for L_1, L_2, and C_B are the same as before but with R_S replaced by the quantity (R_S+R_{comp}). Unfortunately, under some conditions R_{comp} may calculate as negative or imaginary in which case the modification is not realizable□