

GENERALIZED LC MULTIPLE RESONANCE NETWORKS

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ABSTRACT

This paper generalizes the idea of "multiple resonance networks" to energy transfers between inductors and between capacitors and inductors, extending the theory about this class of LC lossless circuits. The networks discussed have the property of transferring all the energy initially stored in a particular capacitor or inductor in an LC network to another element in the network, through a linear transient.

1. INTRODUCTION

The concept of "multiple resonance networks" [1] generalizes the concepts of the "double resonance" and "triple resonance" networks found in the literature [2][3]. In these references, the networks are composed of lossless inductors, transformers, and capacitors, and designed in such a way that all the energy initially stored in a capacitor is, at the closing of a switch, transferred to another capacitor in the circuit through a linear transient. At a certain instant, all the energy is concentrated in this other capacitor, and can be used for some purpose. Networks with this function can be found in pulsed power systems for physics research, where the energy is transferred from a large capacitance charged at low voltage to a small capacitance, that becomes charged at high voltage, with the same energy. The double resonance case is long known [2], having been used in early radio transmitters, electrotherapeutic devices, and in the generation of high voltages for demonstrations about electricity, as the "Tesla coil". The usual system is shown in fig. 1.



Fig. 1. Double resonance network with a transformer.

The secondary capacitor is usually formed by the distributed capacitance of the secondary windings of the transformer and the distributed capacitance of a terminal electrode. From the formulation in [1], the relations for

optimum design can be obtained as:

$$\begin{aligned} L_1 C_1 &= L_2 C_2 \\ k_{12} &= \frac{l^2 - k^2}{l^2 + k^2} \end{aligned} \quad (1)$$

The constants k and l are two positive integers, with $l-k$ odd, that define the operation "mode". They determine the two natural oscillation frequencies of the network with the switch closed, that appear as:

$$\omega_1 = k\omega_0; \quad \omega_2 = l\omega_0; \quad \omega_0 = \frac{1}{kl} \sqrt{\frac{k^2 + l^2}{2L_2 C_2}} \quad (2)$$

The triple resonance system [3] was developed more recently, for pulsed power applications, as a solution for the insulation problem caused by the transformer in the double resonance system. As shown in fig. 2, a third inductor and another capacitor were added, with the result being that at the end of the energy transfer transient all the output voltage is over the third inductor, with no voltages or currents in the transformer.



Fig. 2. Triple resonance network with a transformer and additional inductor and capacitor.

The design formulas for the triple resonance network [1][4] can be arranged in convenient way as:

$$\begin{aligned} L_1 C_1 &= (L_2 + L_3) C_2 \\ \frac{L_2}{L_3} &= \frac{(l^2 - m^2)(k^2 - l^2)}{2k^2 m^2} \\ k_{12} &= \sqrt{\frac{L_2}{L_2 + L_3}} \\ \frac{C_2}{C_1} &= \frac{2l^4}{(l^2 - m^2)(k^2 - l^2)} \end{aligned} \quad (3)$$

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