TECHNIUM

*Technium Vol. 27, pp.1-6 (2025)*
*ISSN: 2668-778X*
*www.techniumscience.com*

# RLC Circuits to change the shape of electromagnetic signals

Alion Alizoti
Department of Physics, Faculty of Natural Sciences, University of Tirana, Albania
alion.alizoti@fshn.edu.al

**Abstract**

This paper introduces a research work concerning electromagnetic signals. The research has been going on for several years now, focusing mainly on developing successful public attempts to produce electromagnetic signals, and also altering them efficiently. Following notable footsteps on the history of electromagnetic evolution, the research is based on both theoretical approaches and practical experiments. Thence, affirmative conclusions about electromagnetic signals denote that, the application of RLC circuits is a good simple method to produce electromagnetic signals and, also, change some of their features, such as amplitude, frequency, or shape. Aspects of this research are introduced to class activities with regard to proper curriculum recommendations and further issued with presentations to advanced international events.

## Introduction

Electromagnetic waves theory started a new era in physics and electricity. After a few years after J. C. Maxwell's, Heinrich Hertz invented his famous set of electromagnetic antennas, one receiver and transmitter [1][2]. Later on, other distinguished physicist and engineers devoted their contribution to electromagnetism and electromagnetic based communication has become an important tool of interaction. Theoretical and practical studies have shown that electromagnetic communication should develop along with the construction of relevant electric devices according to four stages [2][3]:

1) Devices to produce electromagnetic signals
2) Antenna Devices to emit the produced electromagnetic signals
3) Antenna Devices to receive the transmitted electromagnetic signals
4) Receiving Devices that receive the electromagnetic signals

Consequently, an outnumbered of electromagnetic devices have been created, ever since, sometimes of a strictly traditional fashion, other times of extreme modern designs [4]. Therefore, simple devices to produce and study electromagnetic signals can be constructed by using traditional RLC circuits and, also, modern ones, such as transistors, or diodes [4][5]. Whatsoever, their everlasting goal is to produce, emit and receive electromagnetic signals.

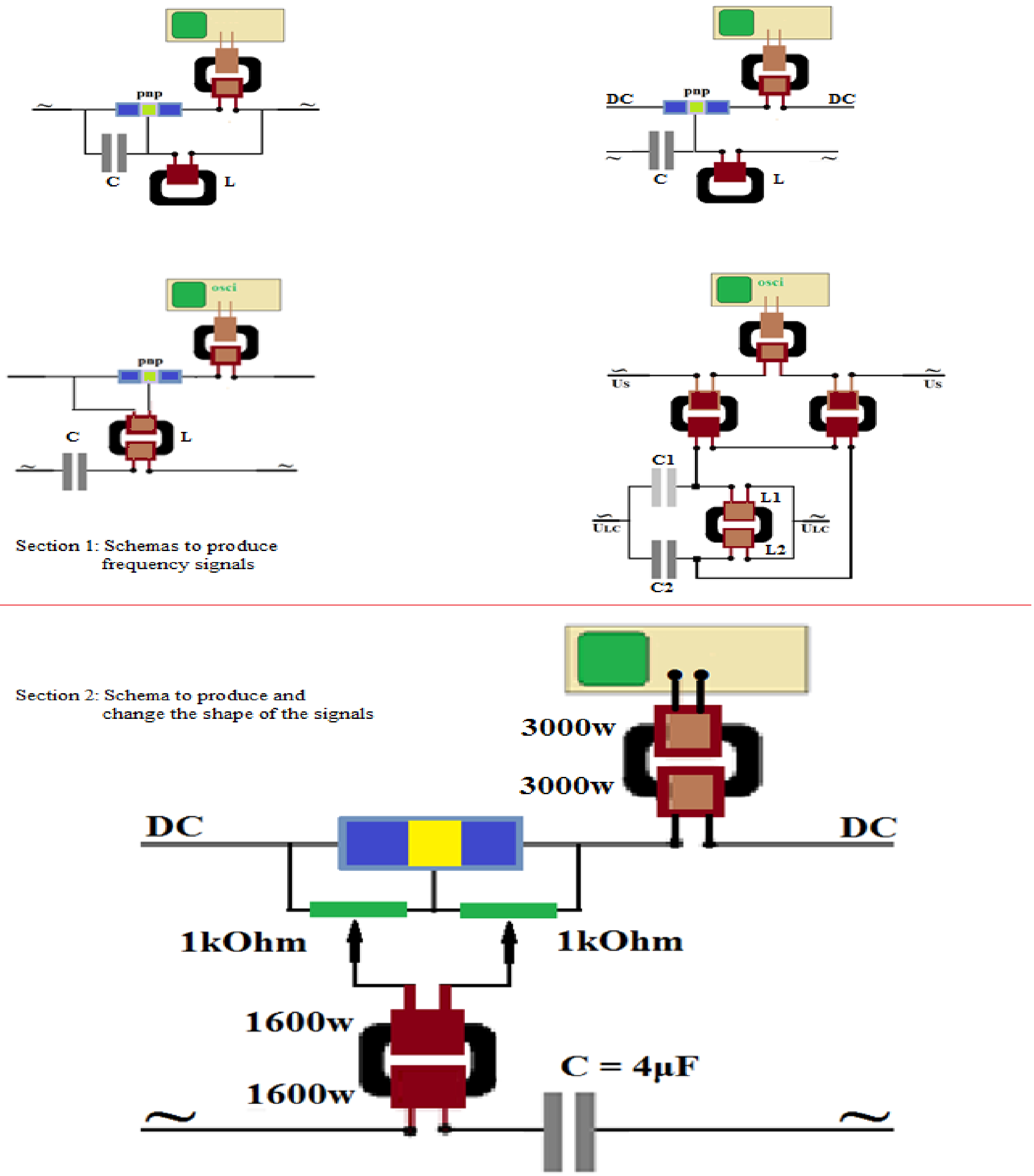


Figure 1: Schemas to produce electromagnetic signals.

As devices used to produce electromagnetic signals are the primary source of such signals, first steps are paid to design two types of schemas and, hence, build the proper circuits specifically:

1) Schemas designed mainly to produce and change the frequency of electromagnetic signals, Figure 1 – Section 1.1 i.e. [6]
2) Schemas designed mainly to produce and change the shape of electromagnetic signals, Figure 1 – Section 1.2

## Method and materials

Method: This research work is based on methods developed upon practical theories of RLC circuits in series and RLC circuits in parallel, as suggested by Kelvin & Thompson [6][7]. Kelvin – Thomson studies the ideal LC circuit, compounded by an induction coil and a capacitor. Their relevant theoretical approaches are shown in Table 1 below, with respect to practical LC connections, in series or, in parallel.

Table 1: Kelvin – Thomson theoretical approaches to succeed with practical experiments

| **LC in series** | **LC in parallel** |
|---|---|
| IL = IC | UL = UC |
| UL/XL = UC/XC | IL XL = IC XC |
| XL = ωL | XL = ωL |
| XC = 1/ωC | XC = 1/ωC |
| UL/ωL = UC ωC | IL ωL = IC/ωC |
| UL/UC = ωC ωL | ωL ωC = IC/IL |
| UL/UC = ωω LC | ωω LC = IC/IL |
| **ωω = (1/LC)(UL/UC )** | **ωω = (1/LC)(IC/IL )** |
| | |
| in series resonance of tension voltages | in parallel resonance of currents |
| UL = UC | IL = IC |
| **ωω = (1/LC)** | **ωω = (1/LC)** |
| UL: potential difference of the coil | UL: potential difference of the coil |
| IL: electric current of the coil | IL: electric current of the coil |
| XL: Ohm’s resistance of the coil | XL: Ohm’s resistance of the coil |
| L: magnetic inductance of the coil | L: magnetic inductance of the coil |
| | |
| UC: potential difference of the capacitor | UC: potential difference of the capacitor |
| IC: electric current of the capacitor’s branch | IC: electric current of the capacitor’s branch |
| XC: Ohm’s resistance of the capacitor | XC: Ohm’s resistance of the capacitor |
| C: capacity of the capacitor | C: capacity of the capacitor |

| ω: angular frequency of the circuit | ω: angular frequency of the circuit |
|---|---|

Previous experiences have demonstrated that Kelvin – Thompson approaches are quite right and denoted that, LC components can be used to control electromagnetic signals, at least, first in frequency and later ambitions later.

Therefore, to produce some kinds of electromagnetic signals, RLC circuits are to be designed and properly built to change their shapes. Figure 1 – Section 2 and Figure 2 – first image atop show a RLC circuit conceived and used to such aims. The top transformer connected to the oscilloscope is meant to merely serve observing purposes, providing an induced electromagnetic force as recommended by the oscilloscope practices. *Nonetheless, it may slightly affect the signals.*

Materials: The materials used with this research work are listed below:

1. Alternating electric source of net frequency: fo = 50 Hz (ωo = 2πfo); Uo = 2V – 6V; AC
2. Direct electric source: Uo = 2V – 6V; DC
3. Magnetic coils and Cores, Transformers: from 240wings to 3000wings
4. Set of Capacitors: 0.1μF, 1μF, 4μF, 20μF, 50μF, etc.
5. Resistors R = 1KOhm and changing controlled by handles
6. Transistors PNP – BDA, current holding.
7. Oscilloscope
8. Switches
9. Connecting wires

Naturally, all signals are observed live on the oscilloscope, at channel port one and channel port two. At channel two the source signal is the harmonic signal from the net source. At channel one the newly created signal differs in shape, but maintains almost the same frequency ω ≈ ωo. Having both signals on the same screen, any differences can easily be spotted, Figure 2. Differences can also be noticed by hearing the top transformer on the speaker, or head speakers.

Both resistors in Figure 1 – Section 2 are played by handle and, so changing, several electromagnetic signals are creatively reshaped. As studied, a specific contact switch implemented to cut off the current can be used to fun Morse the signals, while any person can pick the desired signal.

## Results and Conclusions

The application of the schema, shown in Figure 1 – Section 1 and Figure 2 – top first image, has been really successful, and producing a variety of electromagnetic signals, which accordingly are of different shapes, Figure 2 below.

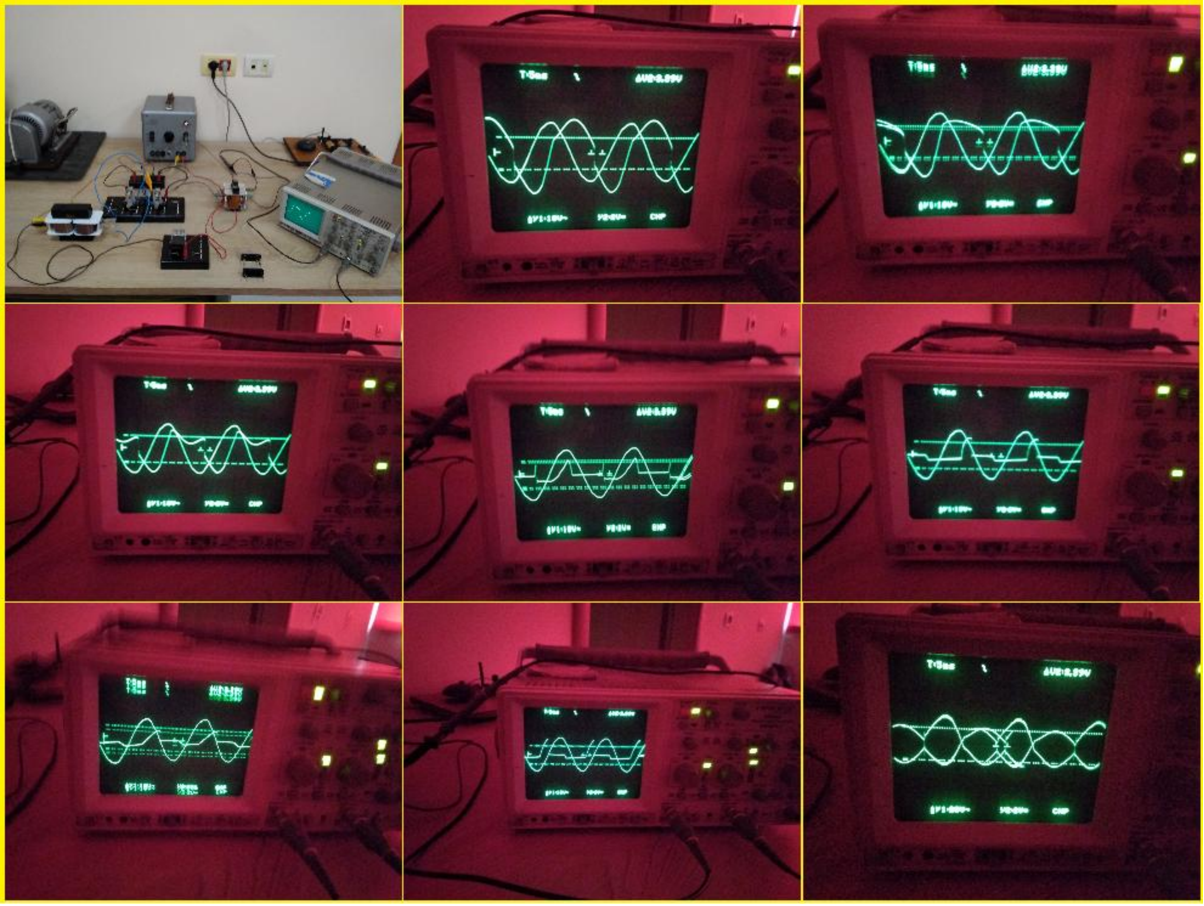

Figure 2: RLC Circuit as connected – top first image; Signals as reshaped – next 7 images; Screen Manipulation – bottom last image: All signals compared to net source signal.

From this perspective, a few conclusions and recommendations are worth suggesting. Working with Kelvin – Thomson practical theories is an efficient enterprise meaning that C - capacitors and L – inductors can be used to build simple circuits and produce different electromagnetic signals.

However, applying R – resistors enables anyone to alter the shapes of the electromagnetic signals, by playing them R – handles at will, instead of trying to combine capacitors and coils by XL equal to XC (XL = XC).

After all, we are able to build two types of RLC circuits, one to produce frequency signals; second to produce and reshape signals. Furthermore, we may combine both types and see what’s coming out. In this regard, it is important to realize that, by implementing macro devices we can beat the micro world phenomena.

Connecting channel one to the top transformer and channel two to the LC circuit's transformer, the schema displays some intriguing images on the screen, reminding concerned people of the true origin of the screen display, such as TV Screen, PC Monitor, or else Figure 2 – bottom last image.

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