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Basic Active Transmission Line Terminations

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Abstract

The electromagnetics community has paid a great deal of attention to field coupling to transmission lines. The transmission line models may be complex, but these models usually have linear terminations. Simulating the coupling of fields into real systems requires the application of active terminations. Such a model can be expanded to understand how energy stored in a target system can be applied to make that system fail.

1. Introduction

Evaluating the effects of electromagnetic fields on an electronic system requires evaluation of:

1. External interaction of the fields with the system
2. Penetration of the fields through the exterior via apertures, diffusion or cables
3. Coupling of those fields penetrating the system to components via transmission line networks
4. Showing the effects of the coupled currents and voltages on the electronic systems

Finding the response of the system cables to the penetrating fields is often done using the BLT equation [1,2,3]. The BLT formulation connects a network of multiconductor transmission lines with scattering matrices. The scattering matrices simulate the reflection and transmission and reflection among the various transmission lines. The elements of the scattering matrices are usually passive, but complex.

Systems evaluated or tested as targets for electromagnetic interference or other effects are usually active and require the use of active terminations in the scattering matrices.

In the following, we will look at field coupling to some active terminations and show the response of the transmission lines to illumination.

2. Active Terminations

2.1 Buck Converter

A Buck converter is a DC-DC voltage converter that is often used to control the voltage applied to the guidance electronics in a quadcopter. Figure 1 shows a functional schematic of a Buck converter.

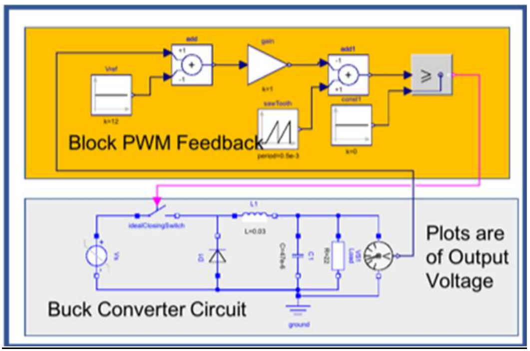


Figure 1. Functional schematic of a Buck converter showing the power and control circuits.

The power conversion circuit is in the lower grey box and takes the supply voltage and drops it to a voltage equal to the reference voltage. This circuit is controlled by the upper gold box that converts the difference between the output voltage and the reference voltage to a pulse width modulated voltage. The PWM voltage turns on the charging circuit to maintain the supply voltage at the reference voltage. Like many electronic control circuits the Buck converter easily transitions to chaos [5].

Figure 2 shows what happens when occasional transients are injected into the control circuit.

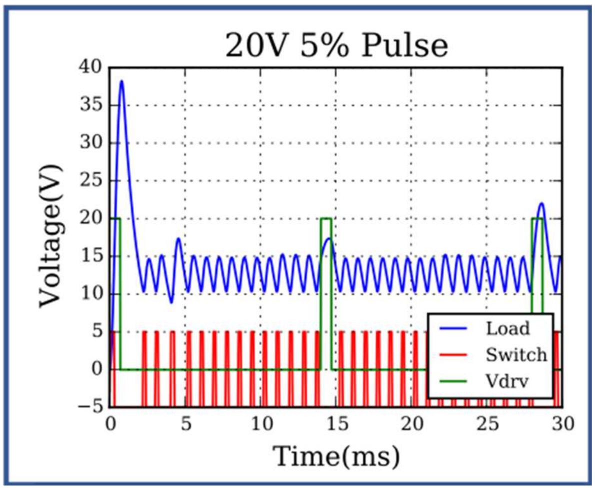


Figure 2. Transients resulting from transients injected into the supply circuit

2.2 Negative Resistor

Negative resistors are often used as linear amplifiers to restore a signal that has decayed from long propagation paths. It is also prone to chaos. Figure 3 shows a negative resistor used in a PT symmetric circuit. This PT symmetric circuit pairs two RLC circuits through a transformer. One circuit is lossy and the other has gain from a negative resistance. The two compensate and the total energy in the circuit remains constant as shown in Figure 4 [6].

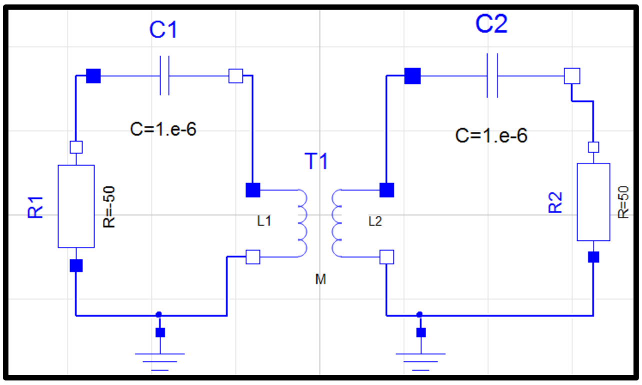
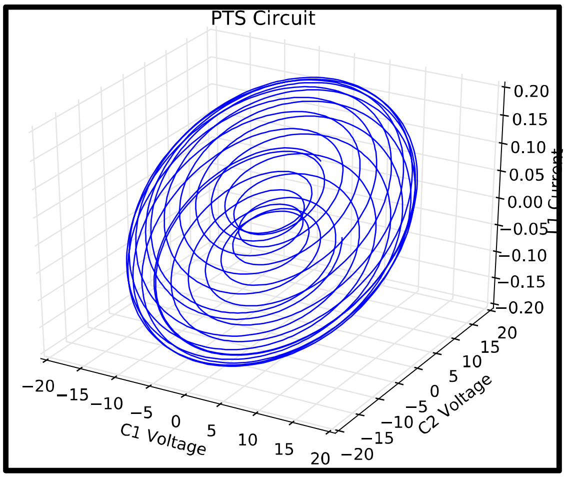


Figure 3. PT symmetric RLC circuit



3. Coupling to Transmission Lines

We made several example calculations of fields coupling to the 3-wire model in Figure 5. The coupling simulation was performed using the Agrawal model [1].

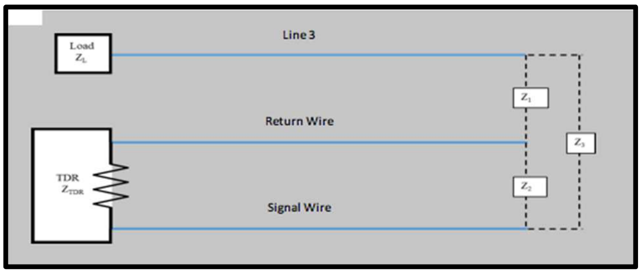


Figure 5. 3-line example transmission line**5. Figures and Tables**

For the first example, we injected a short pulse onto one line using linear, passive terminations and observed the pulse evolution on the other line. The pulse amplitude rapidly decayed.

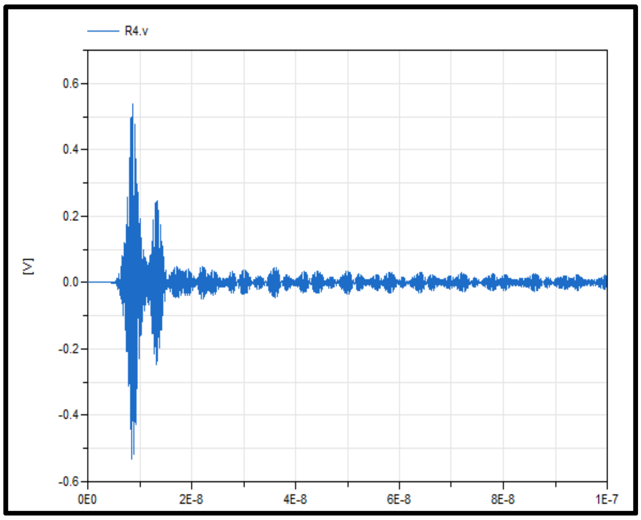


Figure 6. Linear termination example.

In the next example, we injected the short pulse onto one line and terminated the other line in the negative resistor shown in Figure 7.

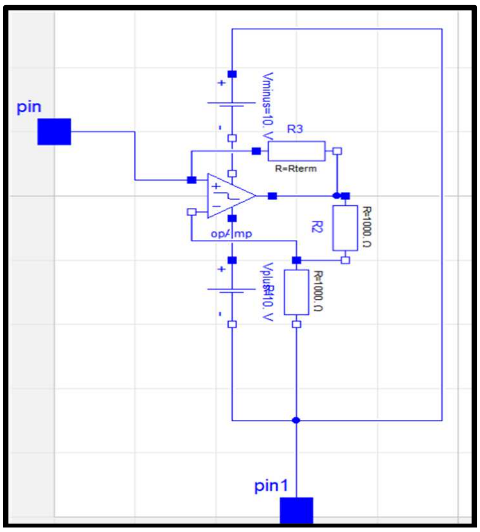


Figure 7. Negative impedance converter

The injected short pulse is shown in red in Figure 8. Since the pulse is amplified with each reflection, the pulse grows in amplitude as shown in blue in Figure 8. The operational amplifier supply voltage imposes a limit on the growth, but the pulses can still be quite a bit larger than those that result from the coupled fields.

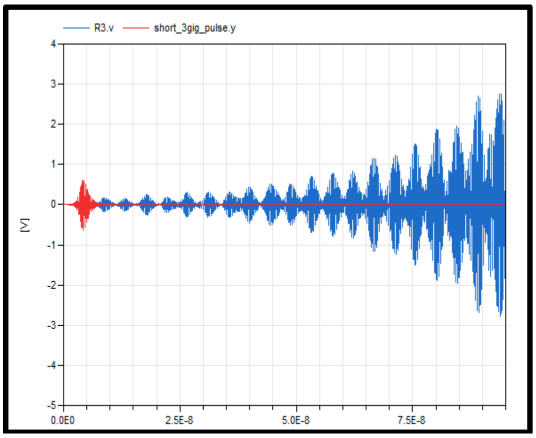


Figure 8. Increasing pulse voltage from reflections from the negative resistor termination

4. Conclusion

In this type of coupling the energy that can generate effects in the electronics is much larger than the energy available just from the fields. In a sense this type of coupling takes energy from the electronic system itself to upset or otherwise affect the electronic system.

5. References

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