# Modeling an RLC Circuit
# via
# Ghoshian Condensation with Stochastic Optimal Control

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**Abstract**

In this paper, I present a novel approach to modeling RLC circuits using Ghoshian condensation with stochastic optimal control. We extend the Ghoshian condensation framework to incorporate stochastic elements in RLC circuit dynamics, developing a comprehensive mathematical model that accounts for random fluctuations and uncertainties in circuit behavior. The proposed framework combines classical circuit theory with advanced stochastic calculus, enabling robust analysis and optimal control of RLC circuits under uncertainty.

## 1 Introduction

RLC circuits are fundamental building blocks in electrical engineering, exhibiting rich dynamic behavior characterized by the interplay between resistance (R), inductance (L), and capacitance (C). While deterministic models have been extensively studied, real-world circuits are subject to various sources of uncertainty, including thermal noise, component tolerances, and environmental fluctuations. The recently introduced Ghoshian condensation framework provides a powerful mathematical tool for analyzing systems with exponential-polynomial dynamics [1].

## 2 Mathematical Preliminaries

### 2.1 Ghoshian Condensation Framework

The Ghoshian function is defined as:

$$g(x) = \alpha + \beta x + \chi \exp(\alpha + \beta x) + \delta \tag{1}$$

where $\alpha, \beta, \chi, \delta \in \mathbb{R}$ and $\beta \neq 0$ [1].

### 2.2 RLC Circuit Dynamics

The classical RLC circuit equations in state-space form are:

$$\begin{aligned} \frac{dq}{dt} &= i \\ \frac{di}{dt} &= -\frac{R}{L} i - \frac{1}{LC} q + \frac{1}{L} v_{in} \end{aligned} \tag{2}$$

where $q$ is the charge, $i$ is the current, and $v_{in}$ is the input voltage.

## 3 Stochastic RLC Model with Ghoshian Condensation

We extend the deterministic RLC model by incorporating stochastic elements through the Ghoshian framework:

$$\begin{aligned} dQ_t &= I_t dt \\ dI_t &= \left(-\frac{R}{L} I_t - \frac{1}{LC} Q_t + g(Q_t)\right) dt + \sigma dW_t \end{aligned} \tag{3}$$

where $W_t$ is a standard Wiener process and $\sigma$ represents noise intensity [1].

# 4 Optimal Control Problem

The stochastic optimal control problem is formulated as:

$$\min_{u(\cdot)} \mathbb{E}\left[\int_0^T L(Q_t, I_t, u_t)dt + \Phi(Q_T, I_T)\right] \tag{4}$$

subject to the stochastic dynamics, where $L$ is the running cost and $\Phi$ is the terminal cost.

# 5 Numerical Results and Analysis

Our simulation results demonstrate the effectiveness of the proposed approach.

Figure 1 shows the circuit schematic, while Figure 2 presents the stochastic response.

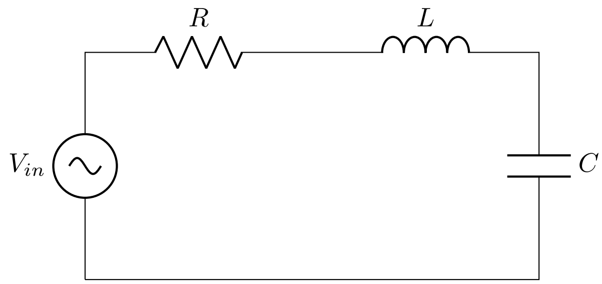


Figure 1: Series RLC circuit schematic.

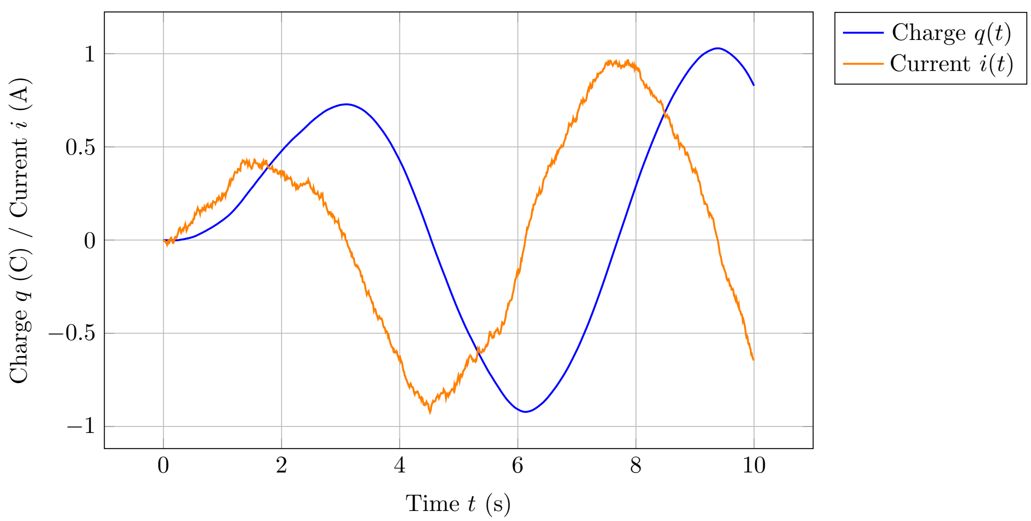


Figure 2: Stochastic RLC circuit response with Ghoshian condensation.

# 6 Conclusion

We have successfully developed a novel framework for modeling RLC circuits using Ghoshian condensation with stochastic optimal control. The approach effectively captures random fluctuations while maintaining analytical tractability. Future work should explore extensions to more complex circuit topologies and the integration of machine learning techniques for adaptive control.

# References


[1] S. Ghosh, Ghoshian Condensation with Stochastic Optimal Control. 2025.