

Characterization of a pulse-recharge circuit for PuFF

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Overview

One insufficiently developed aspect of the Pulsed Fission-Fusion (PuFF) space propulsion system is the magnetic nozzle subsystem (in red, below)

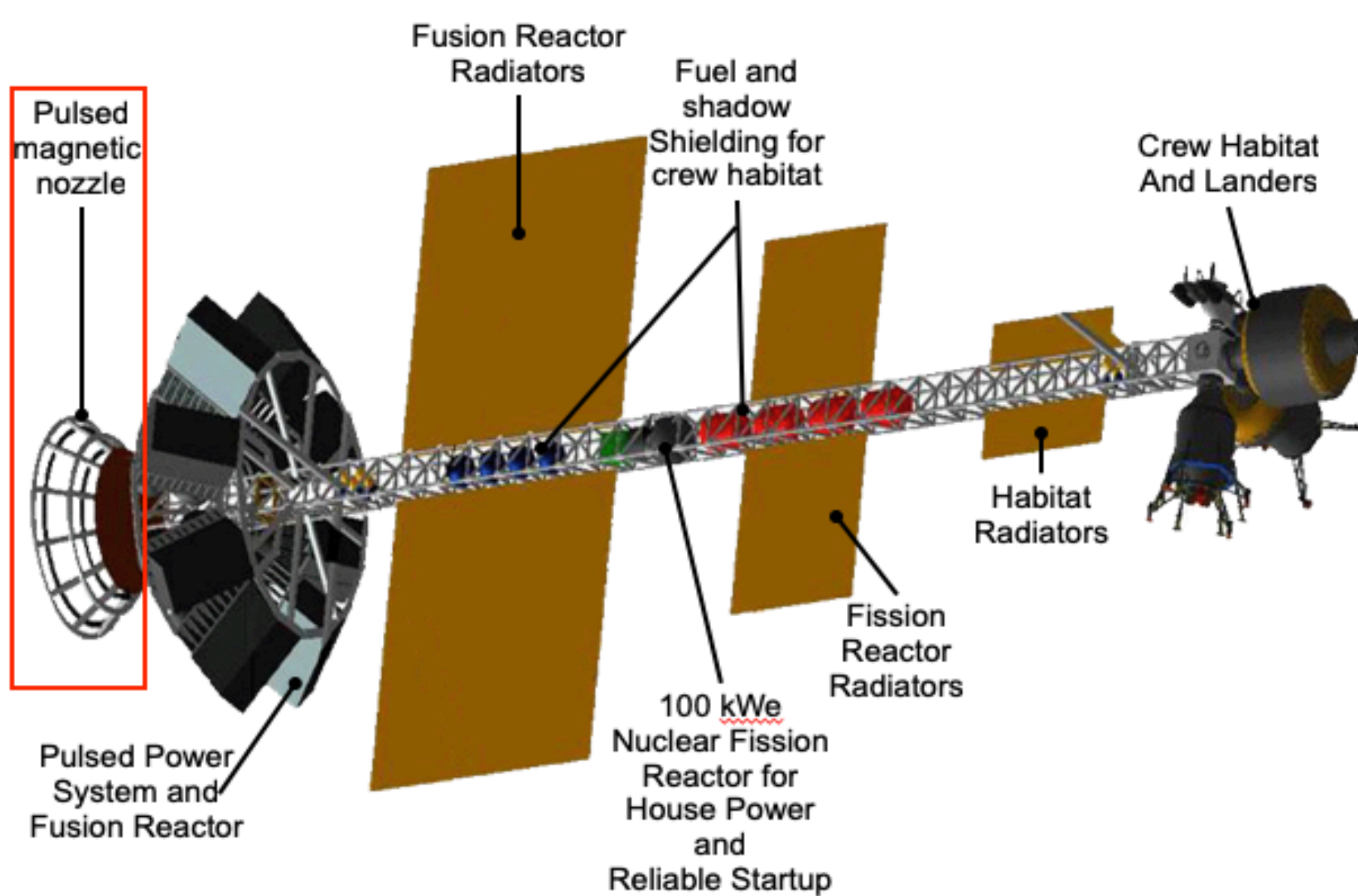


Fig. 1. PuFF vehicle overview

This subsystem is unique in that in addition to accelerating flow, is also must convert some exhaust energy to electrical energy to run itself.

Impact

Development of a pulse-recharge magnetic nozzle will allow for deep-space travel that is faster, and less expensive.

Explanation

This subsystem is modeled with the variable inductor circuit below. This model allows for impacts to thrust and specific impulse to be determined.

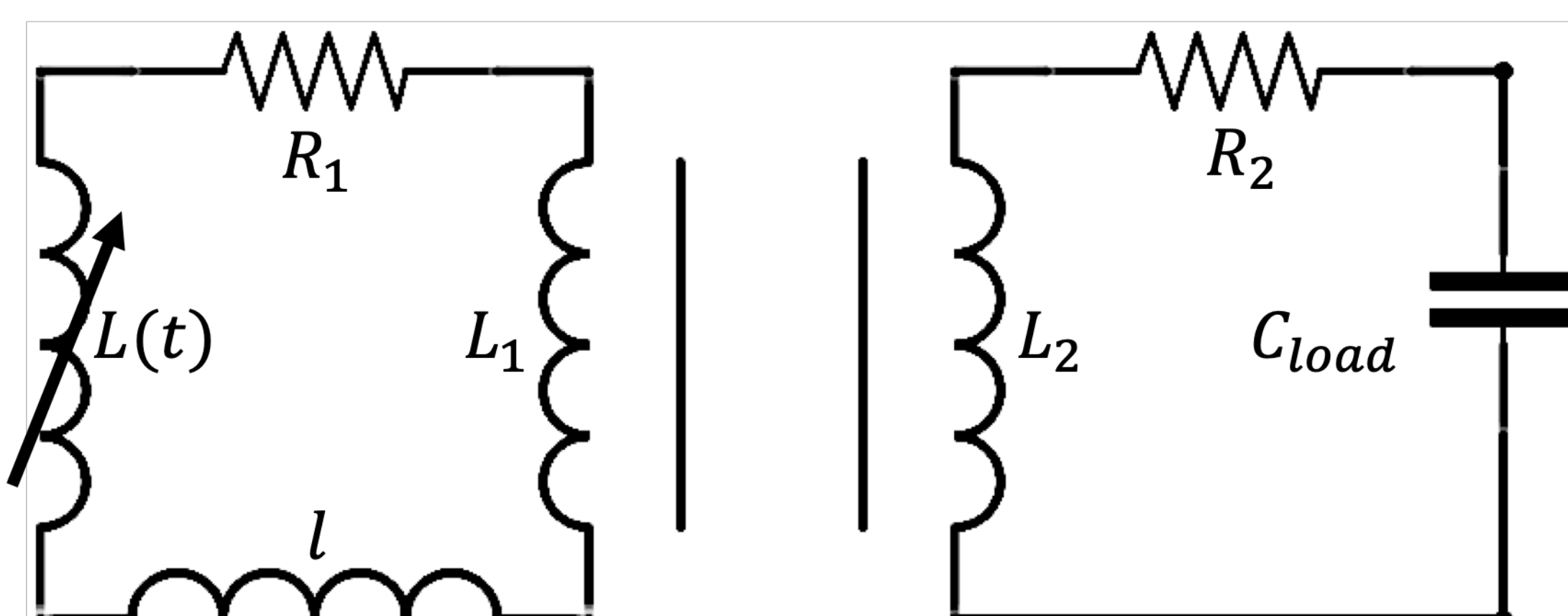


Fig. 2. Pulse-recharging circuit model

Key Findings/Results

The $L(t)$ term captures the inductive coupling as the plasma expanding against the magnetic nozzle coils. It is given below

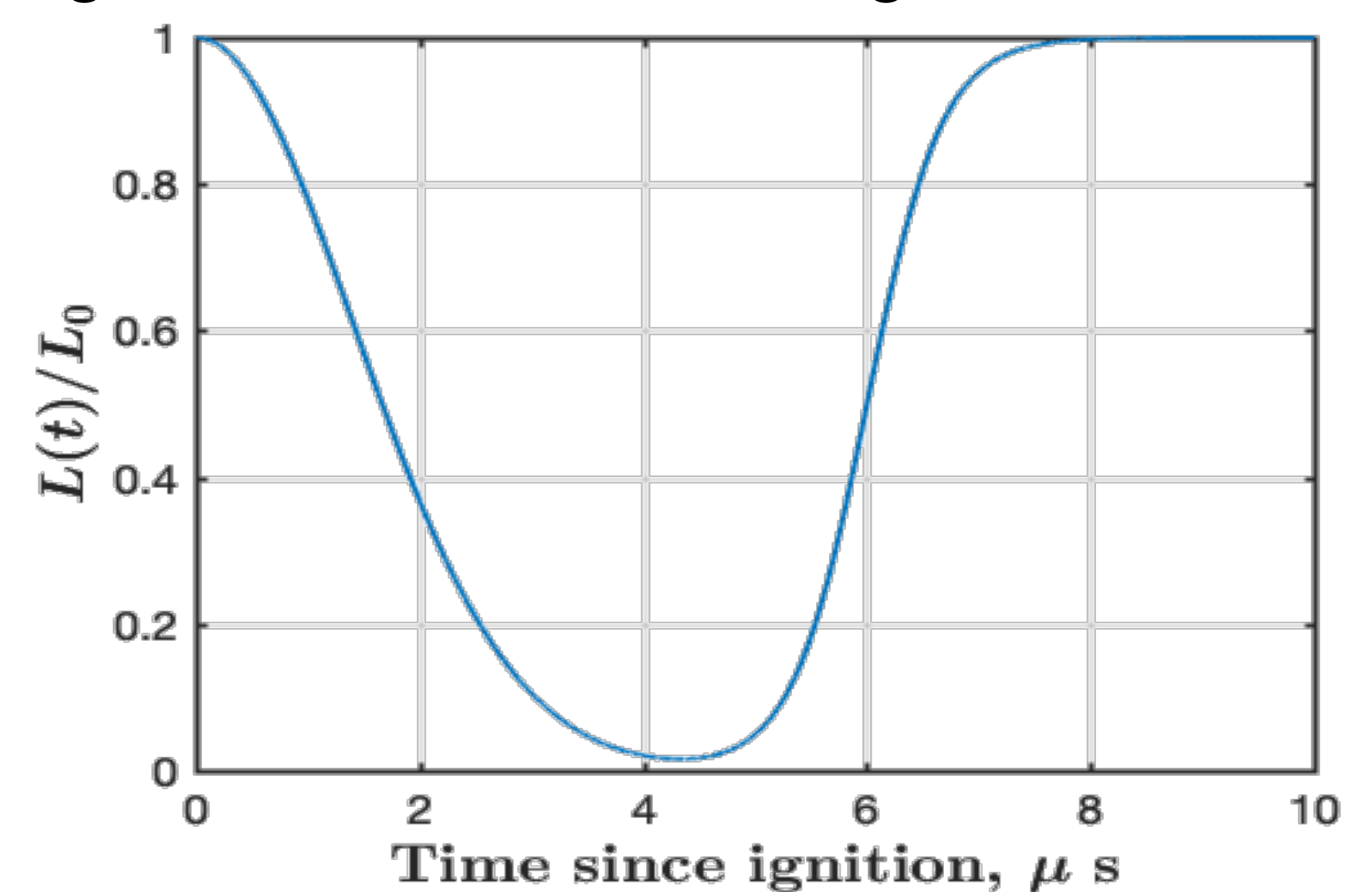


Fig. 3 Normalized $L(t)$ vs. Time since ignition.

With this $L(t)$, a parametric analysis was done to find the optimal transformer design for energy transfer across the circuit.

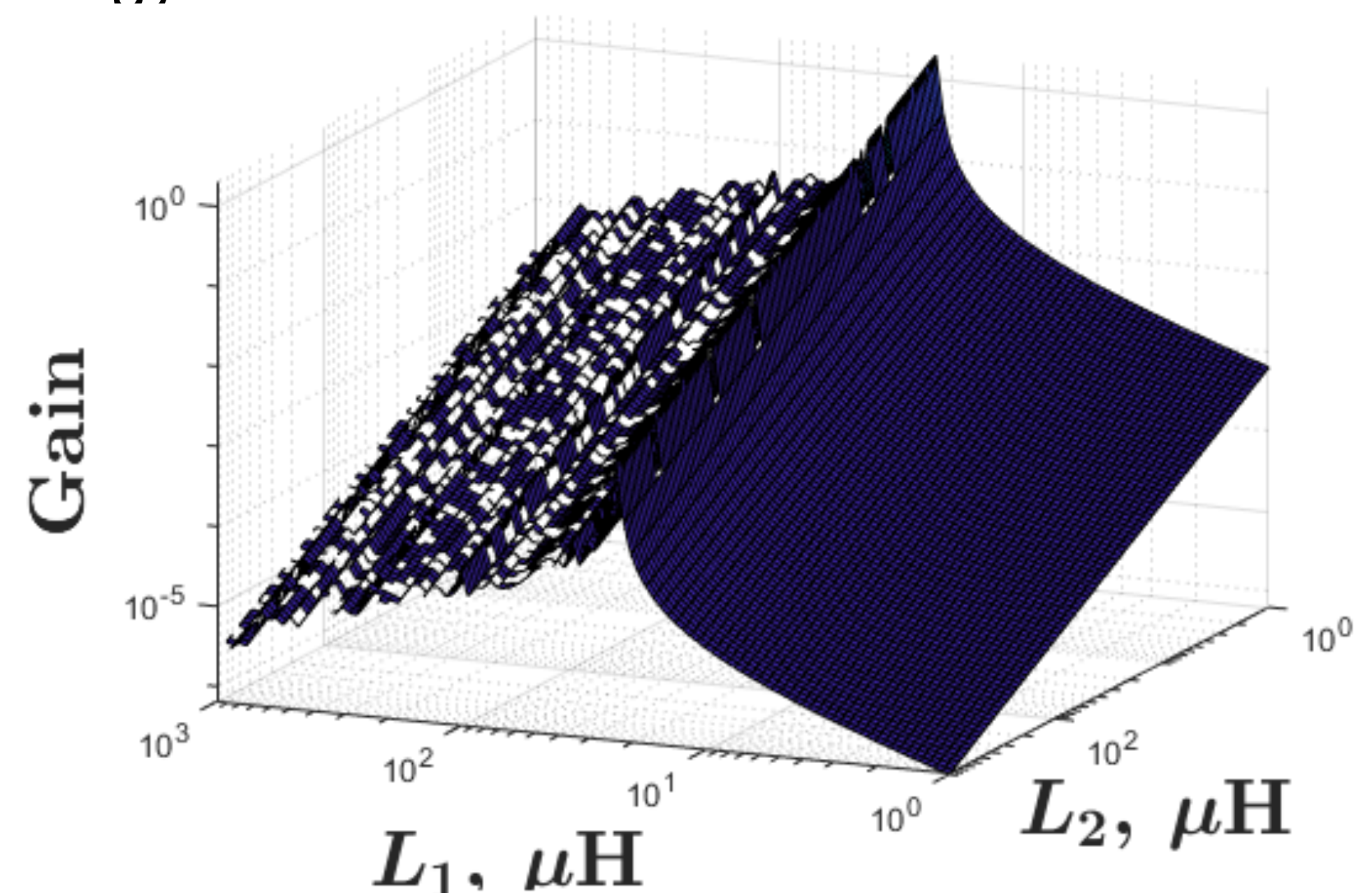
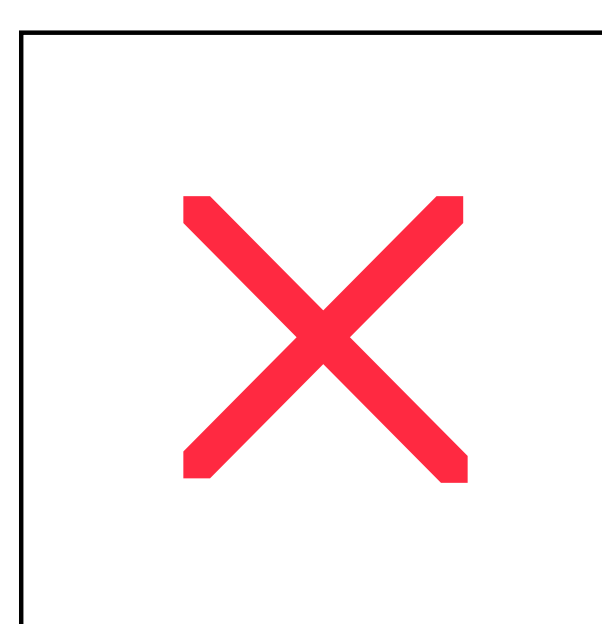


Fig. 4 Parametric analysis results.

The parametric analysis shows an optimal transformer with $L_1=20 \mu\text{H}$ and $L_2=1 \mu\text{H}$. Next, a parametric design of the seed nozzle coils was undertaken. This results in $L_0=350\mu\text{H}$ and $I_{10}=0.25\text{MA}$ for a target with 10 MJ of initial energy. These parameters result in a gain of 0.8. However, this takes more energy out of the target and reduces specific impulse from 1500 sec to 900 sec and thrust from 1.5 MN to 0.63 MN

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