Variable Hardware Inductance Simulator

Nathan Shepard
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(4 min presentation)
Overview

- Pulsed alternator application
- Design requirements
- Competing designs
- Progress to date
- Conclusion
- Questions
Pulsed Alternator Application
Pulsed Alternator Application

Motor Drive → Motor Generator → Current Sensors

Summing Relays → SCR Control → Load

Control → Data Acquisition

DSP System
Pulsed Alternator Application

- The rail gun acts like an inductor with very small (<10mΩ) series resistance.
- The high current passing through the rail/armature loop is broken when the armature escapes.
Pulsed Alternator Application

- Problem: Quick break in high-current (>1kA) inductive loop
Pulsed Alternator Application

- Problem: Unused energy reduces efficiency
Pulsed Alternator Application

- Solution: Parallel current path to store energy
Design Requirements

- Variable inductance (100mH – 10H)
- 20A maximum DC current
- ±200V input pulse
- Compact, user-friendly operation
Basic Design

- Voltage integrator circuit defines current

\[
\begin{align*}
V_{\text{out}} &= -(1/RC) \int V_{\text{in}}(t) \, dt \\
I_L &= (1/L) \int V_{\text{in}}(t) \, dt \\
L_{\text{sim}} &= (I_{\text{out}}/V_{\text{out}})(1/RC)
\end{align*}
\]
Linear Transistor Design

- **Pros:** Easy to simulate and build, low noise
- **Cons:** Operating NPN transistor in linear region = significant heating (>400W)

\[
L_{\text{sim}} = (C/R_{\text{sim}})(10\text{M}/R_{\text{adj}})
\]

For \( R_{\text{sim}} = 0.01 \), \( C = 1\mu \):

\[
L_{\text{sim}} = (1\text{k}/R_{\text{adj}})
\]
Switching MOSFET Design

- **Pros**: Low on-resistance (<10m Ω) = less heating (<4W)
- **Cons**: Switching creates high-frequency noise

![Circuit Diagram]
Design Overview

- Design and simulate competing circuits
- Build a small-scale version of each
- Choose the most desirable alternative
- Implement chosen design on a large scale
Progress to Date

- Designed both linear and switching circuits
- Simulated both linear and switching
- Implemented small-scale versions of each
- Chose linear version as preferable
Problems Encountered

- Bi-polar supply too expensive
  - Design adjusted for polarized operation
- MOSFET design shorts inputs
  - Power resistor in series necessary
- MOSFET design generates noise
  - High-frequency ground plane implemented
Progress to date

- On schedule
- Large-scale linear circuit finished
- Next week:
  - Testing & application
Conclusion

- Project proceeding as planned
  - Progress is on schedule

- Final deliverable will meet specifications
  - Design criteria and component specifications are well understood
Questions?