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NLTL Frequency Chirp Through Dynamic Bias of Inductor Cores

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Objective

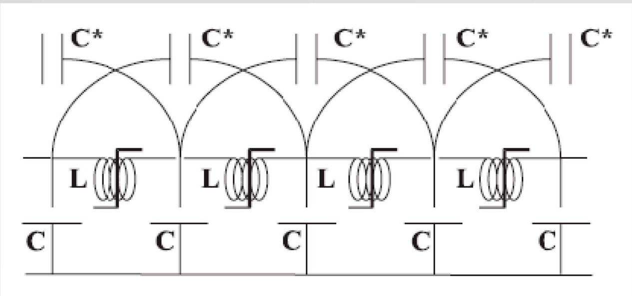
- Using a synchronous wave NLTL, vary the bias in the inductor ferrites to vary the shock velocity along the length of the line and yield RF output with a chirp frequency characteristic
- Low power NLTL used to prototype the circuit and idea

NLTL Overview

- RF generated with shock propagation in a dispersive line
- Nonlinear material is ferrite
- High amplitude input pulse drives ferrites into saturation and results in electromagnetic shock wave
- High frequency content generated at the shock front can couple into an RF wave with phase velocity equal shock velocity
- Tunable with varying initial bias on the inductor cores

System Overview

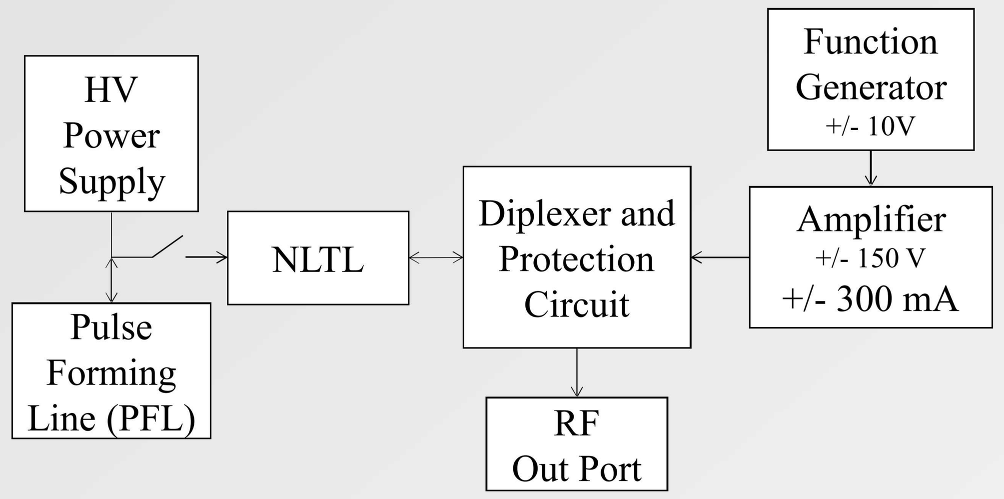
- Prototype low power NLTL made of COTS capacitors and ferrite core inductors



Equivalent Circuit for NLTL

Prototype Low Power NLTL

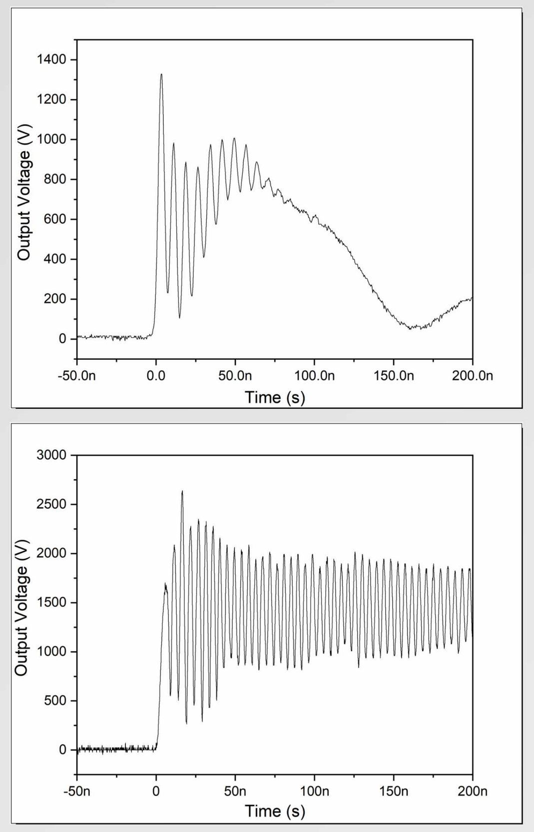
- NLTL driven with PFL charged to 1 kV – 3 kV
- Dynamic bias drives NLTL with 250 Vpp from amplifier



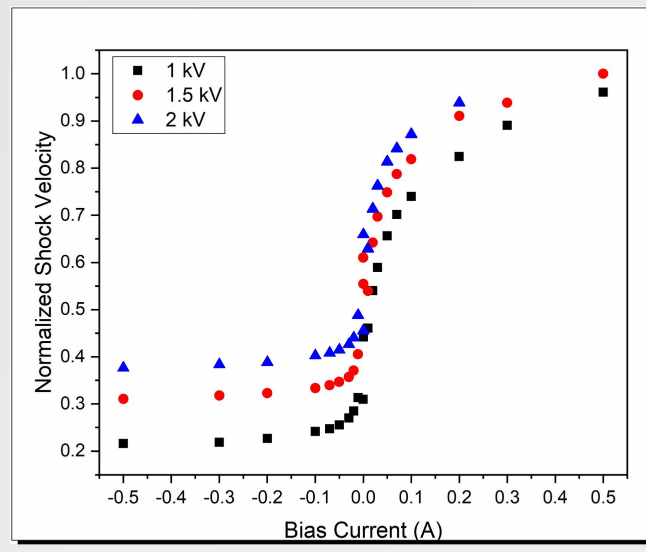
Test System Block Diagram

Characterizing the Nonlinear Transmission Line

- DC bias of inductor cores
- Measured output frequency and delay through NLTL
- Bias current varies NLTL shock velocity and RF phase velocity
- Group velocity determines forward vs backward wave



Forward and Backward Wave Time Waveforms
FW: 132 MHz, BW: 221 MHz

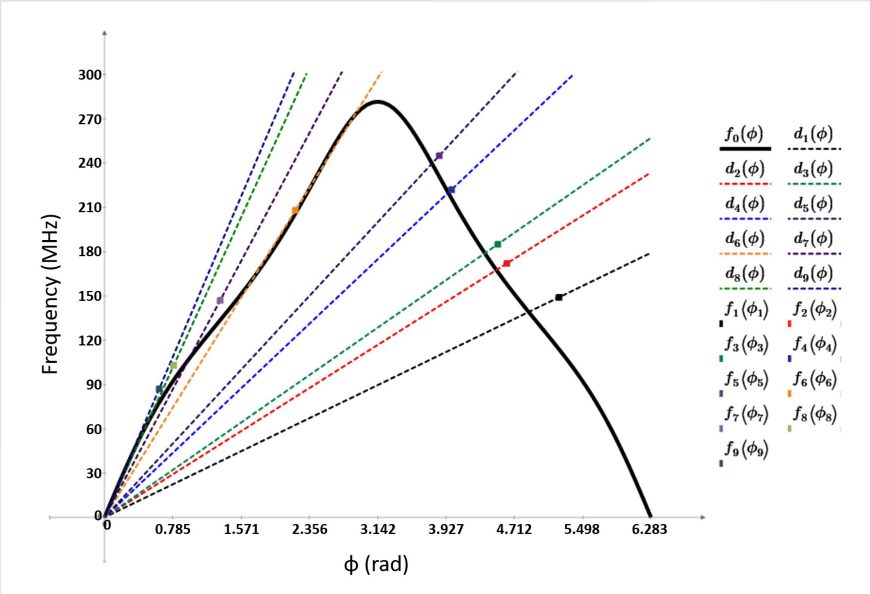


Bias Current Effect on Shock Velocity

Comparing Experimental to Analytical Results

- First order dispersion curve equation to match experimental data to analytical solution

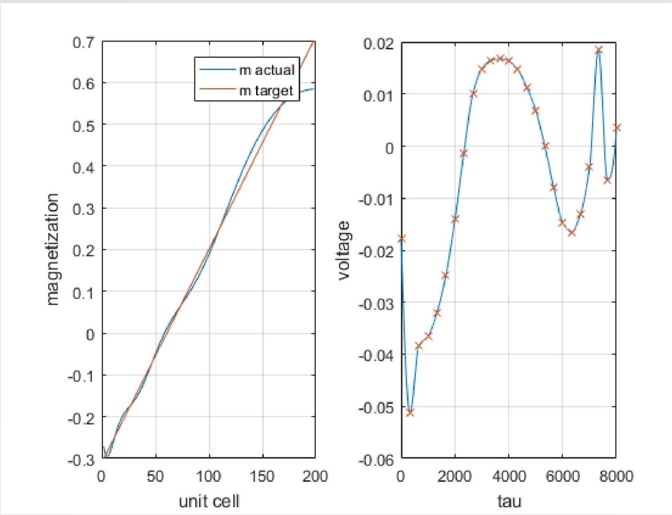
$$\omega_0(\phi) = \frac{\sin\left(\frac{\phi}{2}\right) * \omega_c}{\sqrt{1 + 4 * \gamma * \sin(\phi)^2}} \qquad f_0(\phi) = \frac{\omega_0(\phi)}{2 * \pi}$$



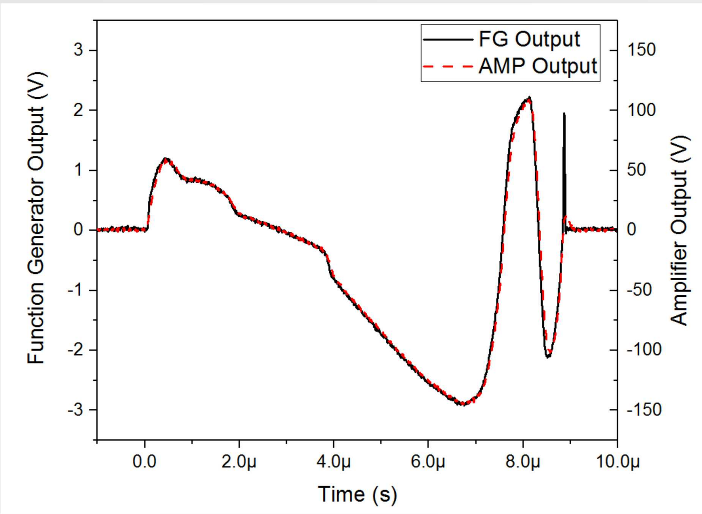
Experimental Data vs Analytical Solution

Dynamic Bias of Inductor Cores

- MATLAB used to optimize dynamic bias waveform for linear bias of inductor cores
- Amplifier used to achieve approx. 250 Vpp bias to NLTL
- Diplexer utilized to protect the amplifier and ensure the bias pulse is coupled to the NLTL



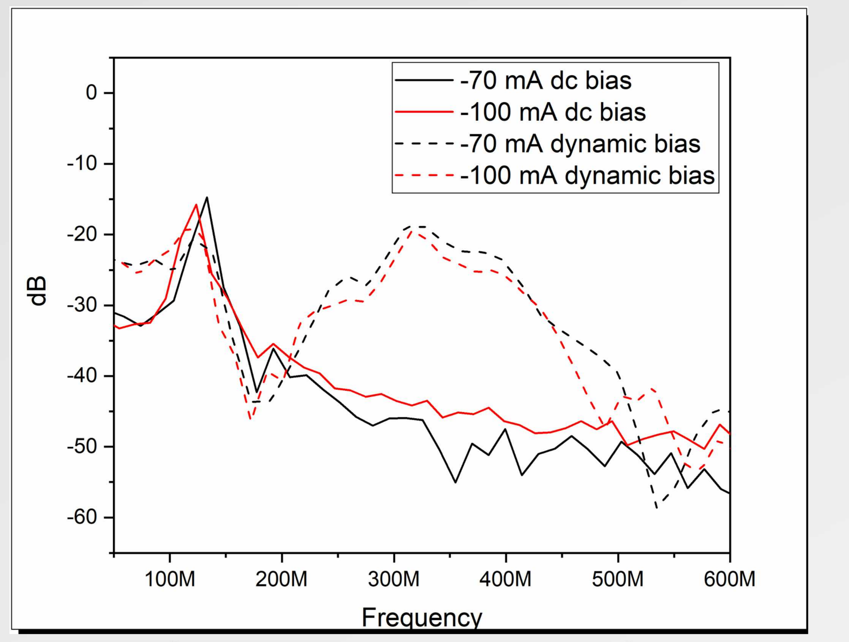
MATLAB Output for Dynamic Bias



Dynamic Bias output from Function Generator and Amplifier

Frequency Chirp Results

- Initial results maintain fundamental frequency with added broad spectrum higher frequency content in RF wave
- Fundamental frequency around 130 MHz with broad spectrum content between 275 MHz and 425 MHz



FFT for DC vs Dynamic Bias of NLTL Forward Wave Mode

Future Work

- Further study into phenomenon
- Implementation in backward wave mode (more RF cycles)
- Designs for implementation in high power synchronous wave NLTLs

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