Development of Capacitive Nonlinear Transmission Lines and its Performance Limits

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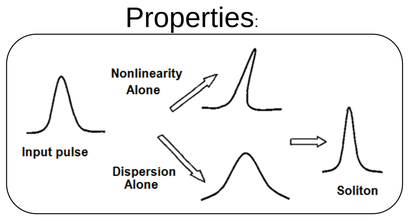
Abstract — **The generation of radiofrequency through Nonlinear Transmission Lines (NLTLs) have been investigated as an alternative way to build RF generators for application in a variety of areas such as telecommunication, medical and defensive electronic countermeasures systems. Two main configurations of NLTLs have been reported in the literature: the discrete lines that comprise a network of LC sections built with nonlinear components and gyromagnetic line that consists of a coaxial transmission line loaded with ferrite-based magnetic cores. Gyromagnetic lines produce high voltage microwave oscillations with frequency ranging from few hundred of MHz up to less than 10 GHz, however, an external magnetic polarization is required. On the other hand, discrete lines are suitable for RF generation in a lower frequency range from a few MHz to hundreds of MHz, having a better prospect for the use in compact systems. Capacitive NLTLs require the use of voltage-dependent components as a ceramic capacitor or varactor diodes. While lines built with ceramic capacitors show a maximum operating frequency around tens of MHz requiring high input voltage, the use of silicon varactors diodes allows the construction of low voltage lines. By using carbide silicon Schottky diodes, the output of capacitive NLTLs can reach a few kV. This paper presents some experimental results on the development of the capacitive NLTLs at the Plasma Laboratory (LABAP) of the National Institute for Space Research (INPE) in Brazil. The analysis of the experimental results points out that performance limits of capacitive NLTLs are closely related to the characteristics of the nonlinear component used in their construction, leading to the conclusion that an improvement of their performance requires the development of new nonlinear components that present simultaneously voltage-dependent nonlinear capacitance, low losses, and thermal stability.**

Properties:



Basic equations:

$$V_p = 1/\sqrt{LC(V)}$$

$$f_C = 1/\pi\sqrt{LC(V_{max})}$$

$$Z = \sqrt{L/C(V)}$$

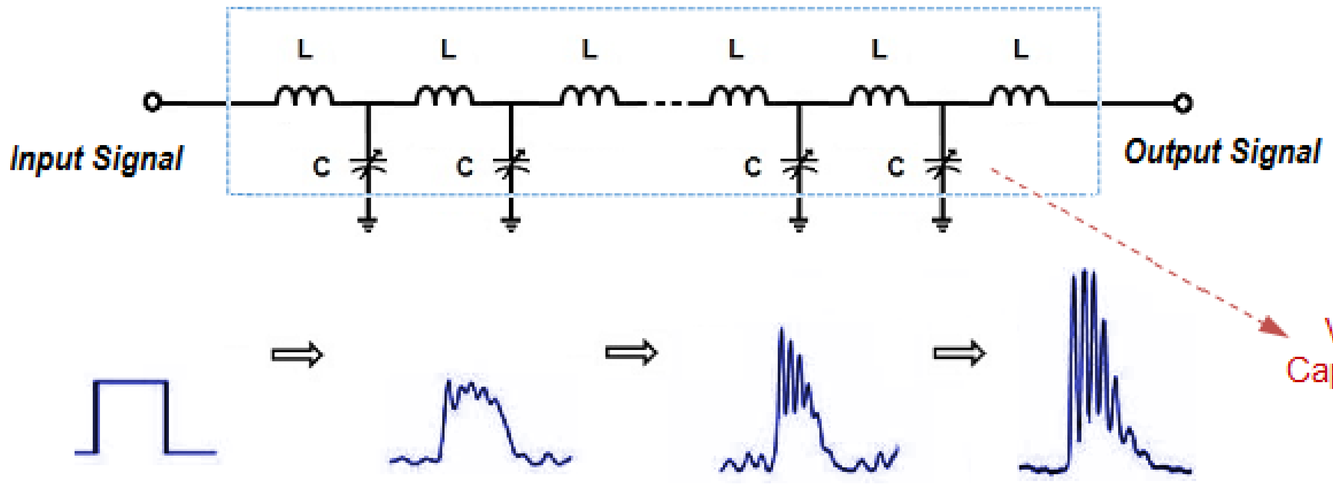
Behavior:

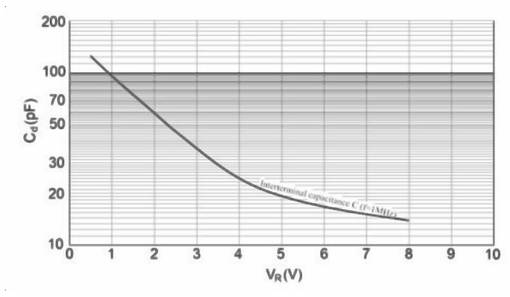
$$\Delta T = n\left(\sqrt{LC_0} - \sqrt{LC(V_{max})}\right)$$

$t_{ri} < \Delta T$ Pulse sharpening

$t_{ri} > \Delta T$ Pulse is broken into a train of solitons

Capacitive NLTL



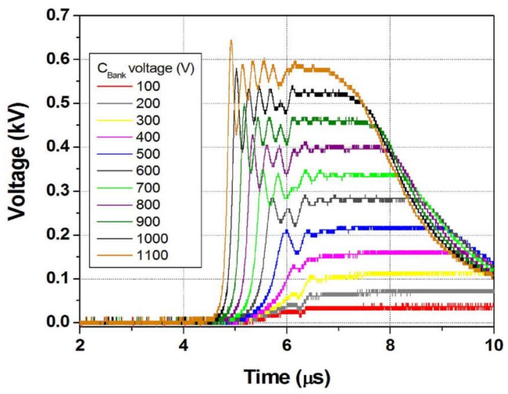


EXPERIMENTAL RESULTS

Nonlinear Element Characteristics			Output Signal	
Type	Specification	Capacitance Change	Frequency (MHz)	Peak Voltage (V)
Ceramic Capacitor	10 nF	(7,47 – 0.7) nF (90 %)	4	800
Varactor diode	BB809	(56 – 13) pF (77 %)	30	16
Varactor diode	SVC236	(155-11,5) pF (93 %)	230	14
Schottky diode	C4D05120E	(380-41,5) pF (89 %)	200	600

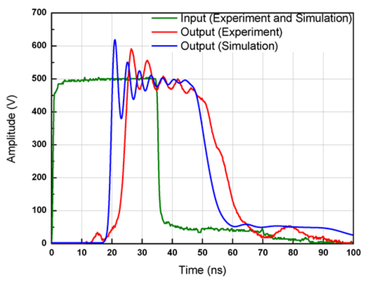
High Voltage Capacitive NLTL using ceramic capacitors

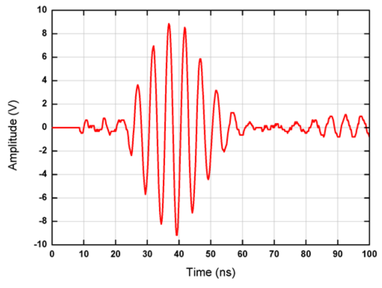
30 sections - C = 10 nF - L = 3.3 μH

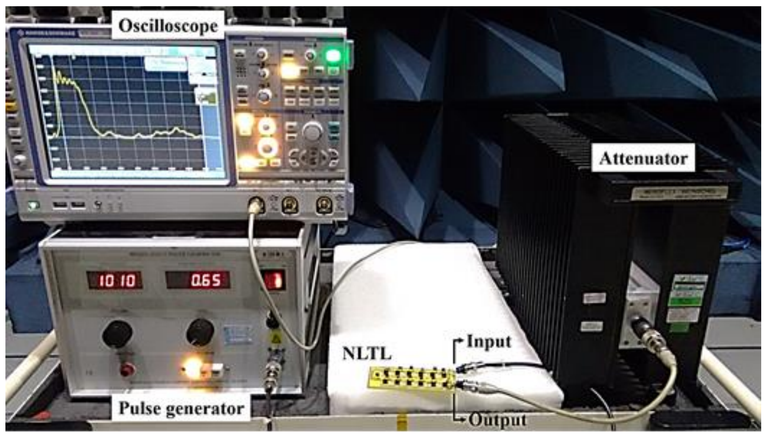


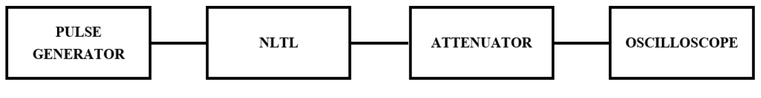
High Voltage Capacitive NLTL using Schottky diodes

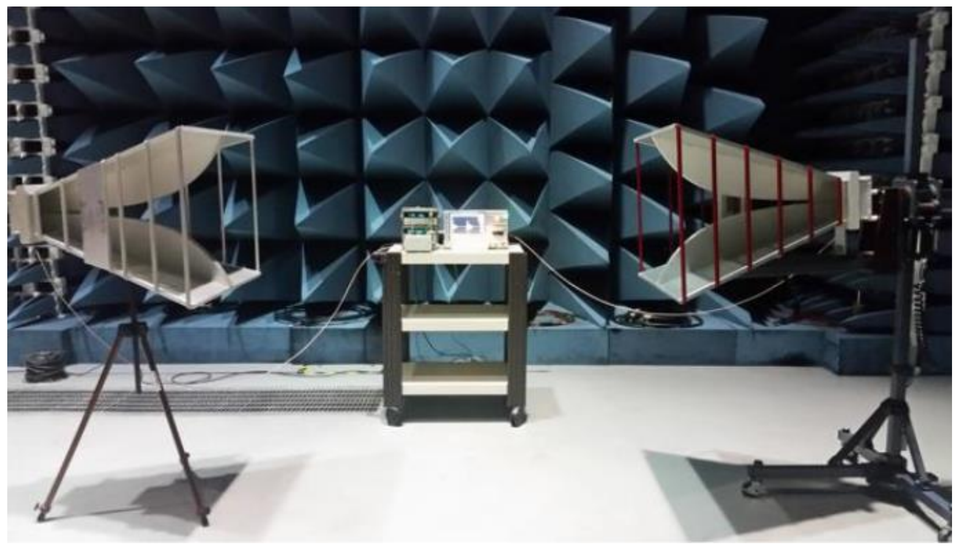
12 sections - L = 56 nH

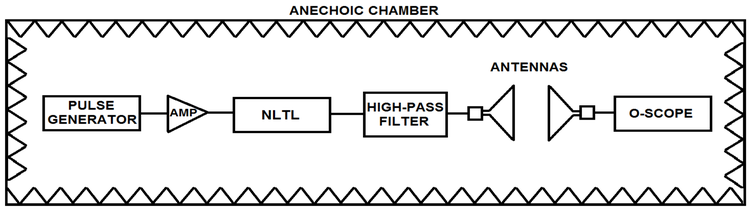






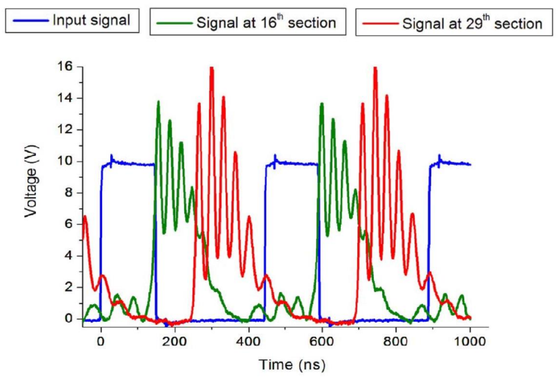






Low Voltage Capacitive NLTL using varactor diodes BB809

30 sections - L = 2.7 μH



Low Voltage Capacitive NLTL using varactor diodes BB809

20 sections - L = 100 nH