Generation of Dissipative Solitons using 32nm CMOS

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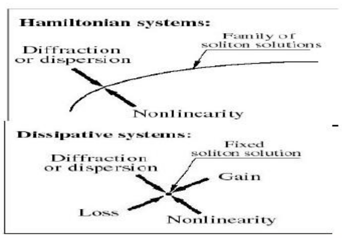
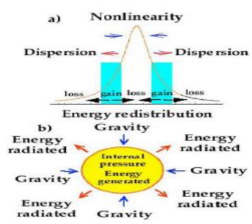
Abstract:

Dissipative solitons have successfully emerged as robust information carriers in optics and nanophotonics. In this work, we explore the nonlinearities arising due to processes and geometry in a 32nm CMOS technology to generate dissipative solitons with extremely simple circuitry. Deep submicron VLSI design and SPICE simulations are done using MicroWind followed by nonlinear data analysis. Finally the generated dissipative solitons are used as carriers in a prototype communication system. The dissipative solitons generated enable state-of-the-art CMOS technologies to relish some of the successes enjoyed by ultrafast nonlinear optical technology.

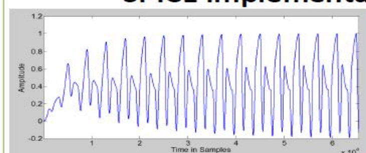
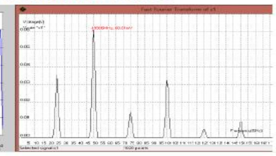
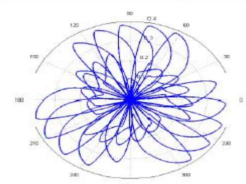
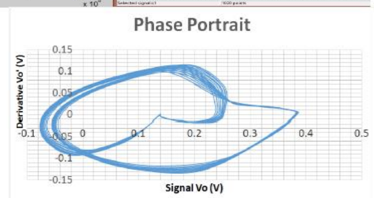
Concept of Dissipative Solitons:

Solitons – Balance of dispersion (linear) and compression (nonlinear) Solitons provide a single axis balance.
Double axis(Dispersive-Compressive + Gain-Loss)-Dissipative Solitons.

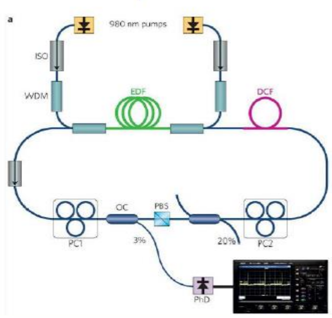


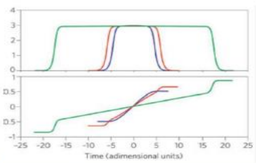


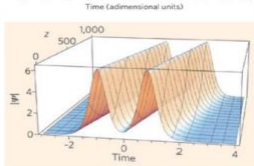
SPICE Implementation Results

Dissipative Solitons in Photonics:

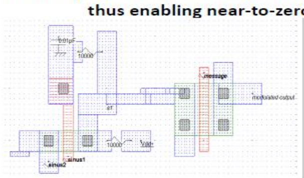
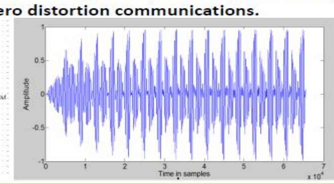




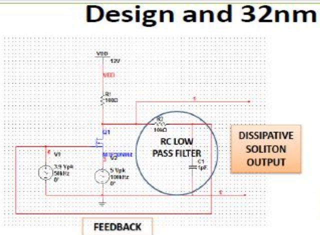


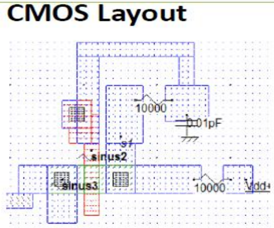
Dissipative Solitons in Communications

The generated train of dissipative solitons can be used as carrier waveforms for communication systems. The robust nature of dissipative solitons provides resilience to noise and amplitude/frequency distortions, thus enabling near-to-zero distortion communications.

Design and 32nm CMOS Layout

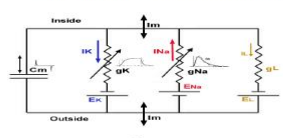


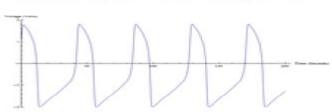


- NMOS provides I-V nonlinearity , resembling optical EDFA-DCF pair.
- Dispersion provided by RC, equivalent of PC.
- Two pumps replaced by function generators.
- Gain Loss provided by feedback through RC.

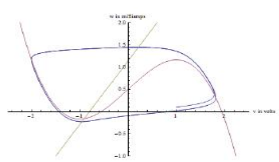
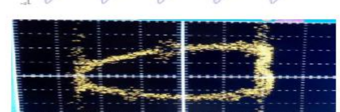
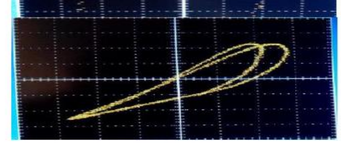
Dissipative Solitons in Neuroscience

The stabilization and nonlinear based phase space dynamics of the dissipative solitons resemble those of a spiking neuron, as described by the FitzHugh-Nagumo model, a simplified Hodgkin-Huxley Model.





$$\dot{v} = v - \frac{v^3}{3} - w + I_{\text{ext}}$$

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