Synthesis of stable radiofrequency non-Foster system for predetermined set of passive loads

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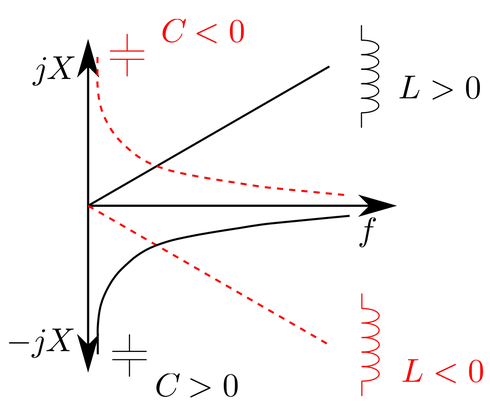
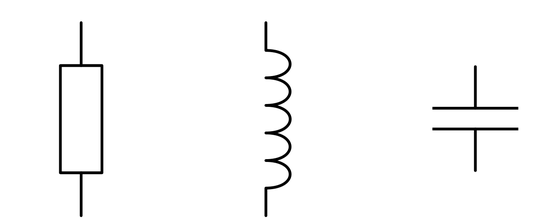
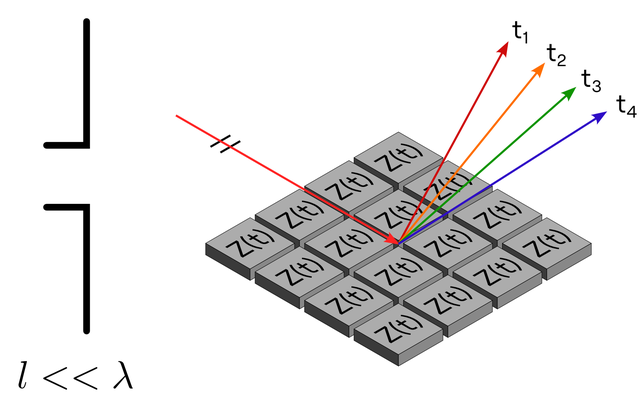
1. Introduction

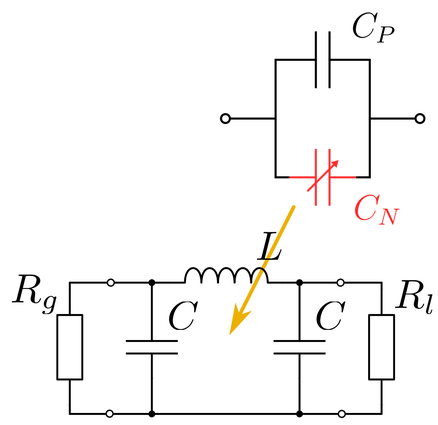
In circuit theory, Foster's reactance theorem states that a network constructed of passive reactive elements without losses (capacitance and inductance) has a reactance whose value increases with frequency. However, non-Foster elements behave in the opposite way to the Foster theorem, i.e., their reactance or susceptance decreases with increasing frequency. These elements are necessarily active and include negative capacitances and negative inductances [1]. If we include negative resistances and conductances, we obtain a class of negative elements that find a wide range of applications.





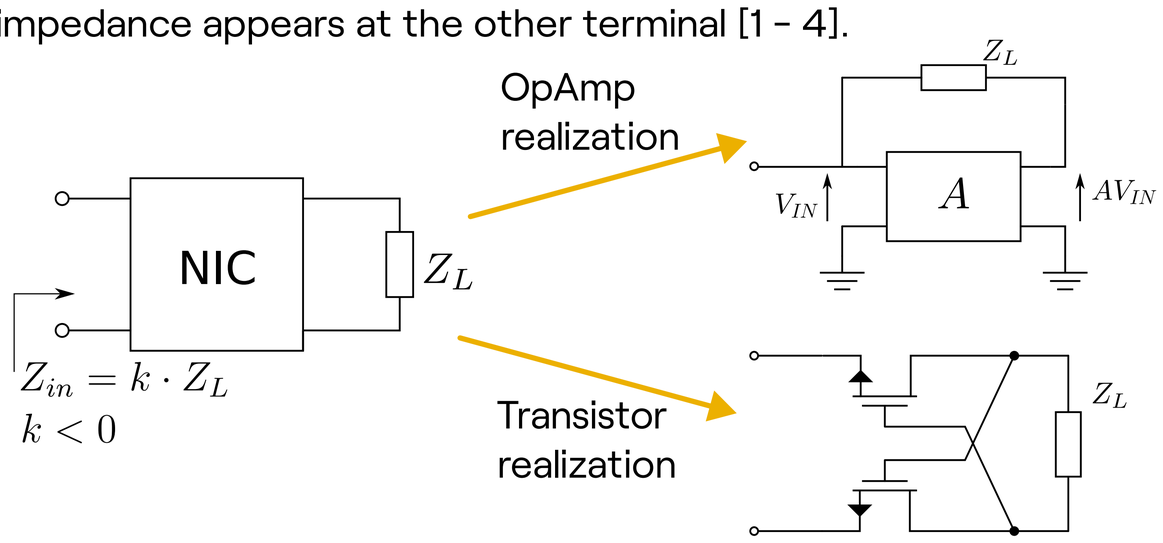
Applications of negative elements include broadband matching of electrically small antennas, active metamaterials and metasurfaces, distributed amplifiers, broadband phase shifters, power dividers, voltage-controlled oscillators, and self-oscillating antennas [1].





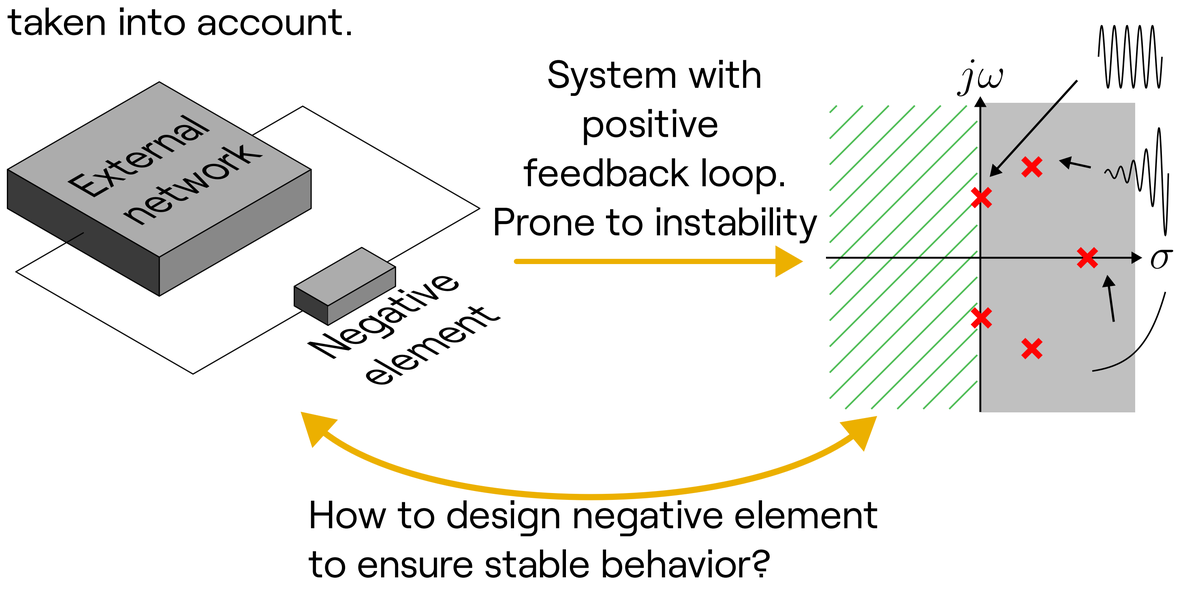
2. Construction of negative elements

The basic idea of negative elements is to superimpose two signals (voltage or current), resulting in a change in the polarity of the input signal and giving the appearance of negative impedance. Negative Impedance Converters (NICs) are active circuits that accomplish this task. Ideally, when one terminal is loaded with an impedance, a "negative image" of the same impedance appears at the other terminal [1 - 4].



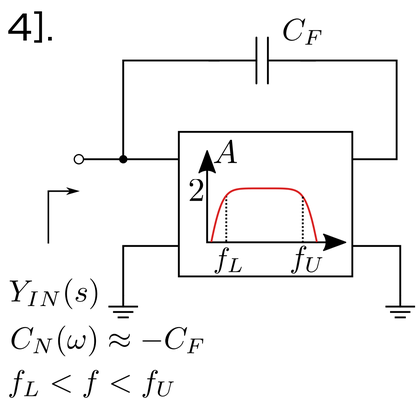
3. Problems with use of negative elements

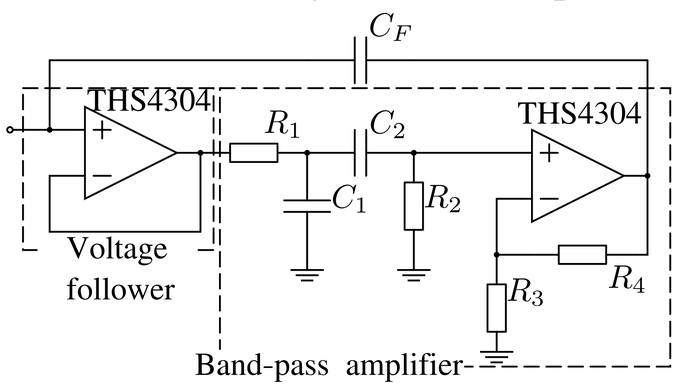
The main problem with the use of negative elements is the inherent instability caused by the inevitable use of a positive feedback loop in their realization. In addition, an external network connected to the input terminals of the negative element alters the stability characteristics, so this must also be taken into account.

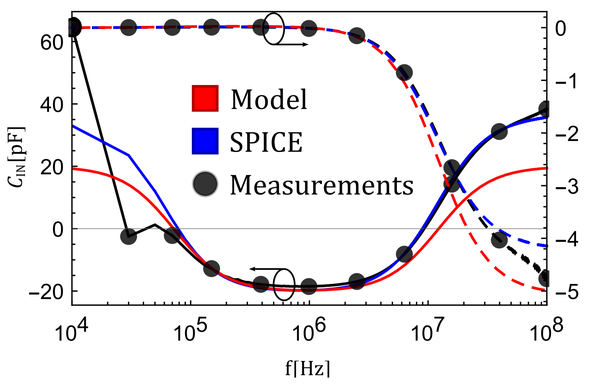


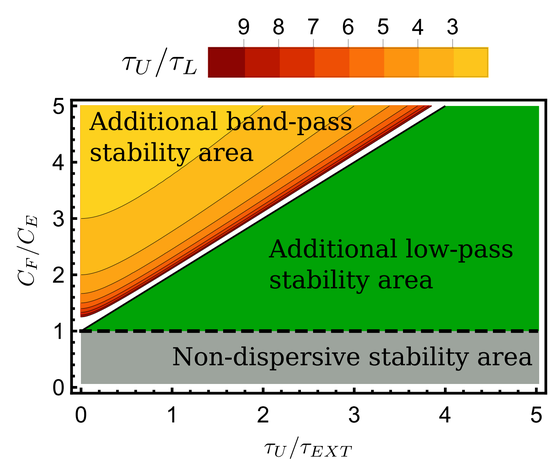
4. Proposed solution

By enforcing band-pass behavior of amplifier with constraint on the lower operating frequency, we open up an additional stable region that allows for greater net negative capacitance with stable behavior. There is an inherent tradeoff between stability and bandwidth that should be considered in practical designs [2, 4].

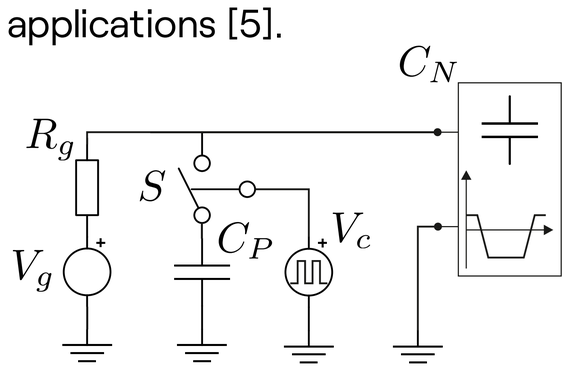


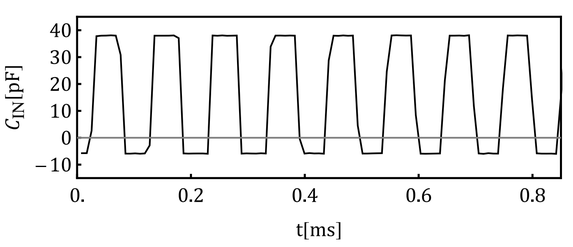






This approach has proven useful in developing stable positive/ negative capacitances for use in switching and time-varying applications [5].





Acknowledgements

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References

[1] S. Hrabar, "First ten years of active metamaterial structures with "negative" elements"
[2] S. Hrabar, I. Krois and D. Zanic, "Improving Stability of Negative Capacitors for use in Active Metamaterials and Antennas"
[3] D. Zanic, A. Brizic, E. Iakovenko, N. Kalmykov, D. Kholodnyak and S. Hrabar, "Equivalent Circuit of OCS Negative Capacitor based on Linvill's Floating NIC,"
[4] D. Zanic, I. Krois and S. Hrabar, "Comparison of Stability Properties of Different Implementations of Negative non-Foster Capacitor" - Review pending
[5] S. Hrabar, D. Zanic and I. Krois, "Stable Positive/negative Capacitor for use in Active Artificial Structures"