Influence of NIC Accuracy on Properties of Self-oscillating Antennas and Metasurfaces

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Recently, the self-oscillating broadly tunable non-Foster radiating structures have been introduced experimentally (S. Hrabar, A. Kiricenko, I. Krois, APS/URSI 2017, APS/URSI 2018). These are unstable active structures, an impedance of which is a 'negative image' of the antenna impedance (Fig. 1). In this way, it is possible to achieve a tunable and perfectly matched transmitter-antenna system, or even a metasurface-based transmitting array across the 1:10 bandwidth.

Above concept presumes an ideal conversion of the antenna impedance into its 'negative image' via appropriate negative impedance converter (NIC). In reality, every NIC comprises an amplifier with a finite delay, which inevitable introduces the conversion error. It can be shown this error is particularly pronounced in the case of high Q loads such as a small antenna or a subwavelength metasurface inclusion. In this contribution, a conversion error and its influence on the properties of the non-Foster radiating structure have been analyzed for several characteristic loads. At first, it was shown that even a very small phase delay of only one degree introduces significant conversion error if a unit cell radiator is smaller than $\lambda/6$. In addition, an approximate equation that predicts the error bounds has been derived and verified by simulations and measurements of the self-oscillating radiating structures developed at University of Zagreb.

In the last step, it was attempted to modify the design of the non-Foster radiating structure in a way that minimizes the error. To this end, a novel approach based on a combination of NIC and a positive impedance converter (PIC) was proposed. The basic idea deals with simultaneous conversion of antenna impedance into its positive and negative 'image'. It was shown possible to design the circuitry that assures partial (mutual) compensation of NIC and PIC conversion errors. Preliminary simulation and experimental results reveled significant (more than an order of magnitude) decrease of the conversion error. It is believed that this approach will allow construction of practical non-Foster self-oscillating structures with highly subwavelength radiating unit cells.

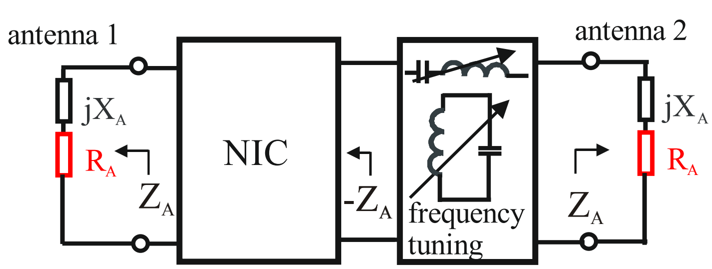

Figure 1. Basic concept of self-oscillating non-Foster structure