Practical Realization of Broadband Reconfigurable non-Foster ENZ /MNZ/DPS Metamaterial

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All known passive materials (or metamaterials) that have either negative (ENG, MNG) or less-than-unity (ENZ, MNZ) real parts of permittivity or permeability suffer from inherent narrow operating bandwidth caused by basic energy-dispersion constraints. Recently, it has been shown possible to go around these basic constrains by the use of so-called non-Foster elements (negative capacitors and negative inductors). Typical examples include both 1D and 2D ENZ metamaterials with extremely broad bandwidth varying from four to six octaves (S. Hrabar, I. Krois, et al., *Negative capacitor paves the way to ultra-broadband metamaterials'*, Applied physics letters. Vol. 99, No. 25, 25403-1-25403-4, December 2011, S. Hrabar, *Active non-Foster Metamaterials: From Intriguing Background Physics to Real-world Application,* Proceedings on Metamaterials 2012, Sankt Petersburg, 2012, pp. 601-603). All these implementations contain electronic circuits that generate fixed ENZ values of effective permittivity.

Here, we present an improved version of active non-Foster metamaterial with reconfigurable unit cells, operating in lower RF regime (up to 300 MHz). The unit cell of this metamaterial comprises a negative capacitor, the values of which can be tuned by DC bias. In such a way, it is possible to obtain both the ENZ/DPS response. Both the single reconfigurable unit cell and the compact 1D reconfigurable metamaterial were constructed and tested. All obtained results show stable operation within a bandwidth of more than four octaves and the values of effective permittivity that can be changed continuously from approximately 0.2 to 2. Previously observed broadband superluminal phase and group velocities (S. Hrabar, I. Krois, et al *Broadband Superluminal Effects in ENZ Active Metamaterial*, Proc on IEEE AP-S 2011 Conference, pp. 661-664, Spokane, July 2011) have also been investigated in this reconfigurable metamaterial (operating in the ENZ mode), both in the frequency domain and in the time domain. The possibility of continuous transition from the ENZ to the DPS mode enabled the adjustment of both phase and group velocity within a broad range of superluminal and subluminal values.

Finally, it was attempted to extend the principle of reconfigurable unit cells to the construction of ENZ/MNZ/DPS metamaterial. Combined circuit-theory (SPICE-based) simulations and full-wave (FIT) simulations predict stable behavior with tuneability of effective relative permittivity and permeability from 0.2 to 2, within the bandwidth of more than two octaves. Practical implementation of reconfigurable ENZ/MNZ/DPS unit cell is in progress and the first preliminary experimental results will be presented at the conference.