Commutated Networks for Phase Conjugation and Time Reversal

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Time modulation of linear networks has been the subject of extensive research in recent years. A good portion of the work on time modulated structures has been focusing on breaking Lorentz reciprocity, which is of great interest for high-channel capacity in new wireless communication systems, enabling full-duplex communications.

Another substantial component in modern wireless systems, and in particular for Internet of Things (IoT) applications, is the phase conjugation device, which provides interesting functionalities to leverage the channel capacity through spatial multiplexing. Yet, phase conjugation devices are difficultly implemented without employing complex, energy-consuming and slow digital techniques, and they have not been explored yet in the context of time modulated media. Initial designs for phase conjugation devices have been based on highly nonlinear, inefficient, noisy and bulky RF mixers, not compatible with the recent trends in communication systems.

Here we show the potential of commutated networks realized through arrays of CMOS switches to implement a new form of phase conjugating devices. In particular, we show that the N-path filter platform (Franks, L.E. and Sandberg, I.W., Bell System Technical Journal, 39(5), pp.1321-1350, 1960) with suitably modified switching scheme can implement low-loss, broadband and inherently linear phase conjugation functionality in an all-analog fashion. The properties of our phase conjugating device are ideally suited for modern wireless and communication systems, and open interesting opportunities also for photonic and metasurface technologies.