Compensation Networks to Improve Performance of Non-Foster Circuits

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Non-Foster circuits (NFC) can be implemented with negative impedance converters (NIC) and/or Inverters (NII). This class of active circuits can violate Foster's Reactance Theorem, which is applicable to passive lossless circuits, and produce a reactance that has a negative slope with frequency. NFC are usually implemented with active transistor-based circuits. Non-Foster impedance circuit components can be very attractive for microwave and antenna applications since they are not restricted by the gain-bandwidth product. However, there are many issues involved in the design of these circuits, including stability, losses, linearity, and achieving higher operating frequencies into the gigahertz range.

A basic negative impedance circuit (NIC or NII) consists of two cross-coupled transistors, which forms a positive feedback network. That means that the phase shift between the input and output signals is ideally 360 degree. However, when implementing NFC, transmission lines such as Microstrip lines (MTL) are used which can cause the phase difference to be different from 360°. This unfortunately degrades the performance of these circuits as the operating frequency increases. Another well-known problem with non-Foster circuits is stability. In other words, NFC tends to be unstable due to the presence of positive feedback. This implies that NFC can have negative resistance that can potentially cause unwanted oscillations.

Therefore, a detailed analysis of NFC will be done, including the phase shift effects of the transmission lines (TL). Of course, TL not only produce phase shift, but also have loss which causes signal amplitude variations. It is therefore necessary to add compensating networks to counteract the negative effects of the TL, and thus improve the performance of NFC. Analysis as well as simulated results will be shown to demonstrate the performance of compensated NFC. Another issue that will be discussed is the advantages/disadvantages of implementation of NFC with integrated circuits