Negative Capacitor for Electrically Small Antennas

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Electrically small antennas (ESAs) are more and more necessary in a lot of communication system where available space is limited. This includes commercial mobile wireless antennas, military handheld, body-wearable radios and aircraft antennas. However, because of their compact size, ESAs are generally not efficient radiators and they have narrow bandwidths, as expressed by the fundamental limit individuated by Wheeler, Chu and Harrington. In other words, the input impedance of ESA is characterized by a high reactive part X_a and a small radiation resistance R_r; for this reason, there is a strong mismatch between the antenna and transmission line which it is connected. In transmit application, most of the incident power is reflected by the antenna with a decrease the radiated power that forces the transceiver to increase the power in order to compensate the reduction. This leads to an increase of the power consumption, lower battery life and transmission quality deterioration. Instead, in receive application; this impedance mismatch leads in poor signal-to-noise ratio (SNR). For this reason it is necessary add an external matching network to increase the power transfer between the generator and antenna in both transmit and receive application. However, if we use a passive matching network (also known as Foster circuits), the achievable matching bandwidth is limited by another fundamental gain-bandwidth limitation derived by Bode and Fano. A possible way to overcome the fundamental gain-bandwidth limit is the use of active components in the antenna or in the matching network. On this basis, the employment of non-Foster circuits (NFCs) in the matching network of antennas has been proposed in order to achieve a broadband ESA for high-data-rate applications. These NFCs do not follow Foster's reactance theorem, indeed it provide a negative slope reactance X versus frequency f ($dX/df<0$). This property, on the Smith chart, is transformed in a counterclockwise motion of the reflection coefficient Γ and the phase increases with the frequency. Negative capacitor and negative inductor are example of non-Foster elements. These NFCs can be implemented by used of 2-port active circuit, called negative impedance converter (NIC) or negative impedance inverter (NII), that contain a feedback circuits that convert a passive capacitor or inductor to a negative capacitor or inductor. In general, the input impedance can be scaled by a k factor as well. In recent years, some published paper, used this NFCs to broaden the bandwidth of parasitic arrays or enhance the bandwidth of artificial magnetic conductors (AMCs). Moreover, when transmission line are periodically loaded with negative capacitor or inductor, fast low-dispersion transmission lines can be obtained; afterwards these fast transmission lines have been suggested for squint-free broadband leaky-wave antenna application. Although NFCs can be very useful, there are many issues involved in the design of these circuits, such stability, losses and linearity. At first it was designed a variable negative capacitor with a Linvill's open circuit stable (OCS) NIC to match the model of electrically small printed monopole antenna (single capacitor). Moreover, several prototypes with different sizes have been designed and investigated. The topology of these circuits comprises two back to back n-p-n bipolar-junction transistors (BJTs), a variable capacitor C_L connected between two collectors with the base of one transistor connected to the collector of the other one (feedback circuits). The evaluation of the linearity and the level of the distortion introduced by the active matching network is currently under study.