Adaptive Tuning Topologies with Mechanical Tuning for Small Antennas

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As modern mobile devices are very small in size, less space is available for the antenna. Consequently, the antenna must be electrically small, requiring use of matching circuits to achieve resonance. Automatic matching circuits are available but aim to tune one or two matching conditions. For example, they may account for the human hand holding the cellphone or the body's influence. It is of interest to tune the antenna when the environment is unknown yielding unpredictable antenna loading, especially for electrically small antennas that have rapidly changing impedances. In this case, it is necessary to design an agile impedance matching network to account for all possible load impedances.

Traditional tuning techniques monitor reflected power from the antenna's terminal and adjust the tuner's electronics to minimize this reflected power (or $|S_{11}|$). While this approach works in an ideal circuit, in practice it may also maximize circuit losses. To overcome this issue we introduce tuning architectures that also monitor radiated power from the antenna in order to maximize radiation efficiency. Thus reception range is improved and battery consumption is minimized. Several tuning topologies will be presented; their performance vs complexity will be discussed.

Circuit tunability is often obtained through varactors, PIN diodes, FET switches, MEMS, etc... containing unavoidable losses. To remedy this, mechanical tuning is exploited to lower circuit losses. Mechanical tuners have very low losses over a broad bandwidth, and do not suffer from linearity problems. Further, they have the potential to handle high RF transmit power, and once a tuning state is found, DC power can be turned off extending battery life. However, they require more space to implement, and are associated with slower tuning speeds, and have high DC power consumption during tuning. Nevertheless, mechanical tuning can yield more aggressive impedance / frequency tuning agility with lower losses as compared to other tuning circuit approaches. This research will explore the use of micro-motors and other small movable mechanisms for mechanical tuning. A mechanical tuner for UHF applications will be presented and analyzed in terms of loss and tuning agility.