Using Transient Properties of a Tunable Narrowband Antenna to Realize a Dual-Band Antenna

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Switched antennas have been used for wireless communication in order to achieve a direct modulation. A combination of semiconductor switch and a radiating element can be employed to decouple the information bandwidth from the antenna bandwidth. This method allows the system to operate in a wideband range using small and resonant antennas instead of wideband radiators. The first attempt to use a switched antenna to increase the impedance bandwidth was done by Merenda (USA Patent 5402133, March 28, 1995) and there have been several publications afterwards. However, most designs suffer from signal ringing, spurious radiation and high switching rate requirements.

In this paper, we use the transient response of the antenna to efficiently switch between two frequency bands. A PIFA is chosen due to narrowband and small-size properties and the antenna is loaded by two switchable capacitive elements to control the radiating frequency. In the first demonstration, we feed the antenna with an RF pulse train to study the transient fields. Letting the antenna radiate in a single frequency, we measure the transient near- and far-fields to determine how energy decays when we turn off the antenna. Based on decay rate, we can decide how fast we need to turn on the antenna in order to have a continuous waveform and minimize the switching effect in the far field. In the second part, a fast RF switch with short rise and fall time is placed between the antenna and capacitive loads in order to switch between two resonant frequencies. A train pulse with %50 duty cycle is used to drive the switch. During the time that antenna operates in first resonant frequency, high Q factor of the PIFA allows enough amount of stored energy in the near field to continue radiating after the antenna is switched to the second resonance. If the switch rate is adequately fast, both frequencies can be seen in the far field simultaneously. Narrowband properties of the PIFA will also suppress the out-of-band switching frequency and therefore radiation efficiency is not affected. Harmonic balance is used to simulate the switched antenna and measurement results are used to validate the simulations.