Adaptive Matching Circuitry for Compensation of Finger Effect on Handset Antennas

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In this paper we evaluate the effect that the hand has on the performance of the terminal antenna and discuss a method to compensate for the impedance mismatch. The presence of the hand is the primary cause of detuning the antenna resonance frequency and impedance, whereas the head contributes mainly to the absorptive losses. The impedance mismatch of the antenna causes losses, due increased reflected power, which the power amplifier (PA) tries to compensate for by increasing its output power[1]. This increase in output power then results not only in an increased level of harmonic spurious emissions from the PA, but also higher current consumption from the battery hence reducing the talk-time of the mobile terminal.

Circulators or isolators are used to protect the PA from the excessive reflected power, caused due to antenna mismatch. A solution that addresses this problem and reduces this degradation in performance would be to introduce an adaptive impedance compensation for the antenna.

In this study we propose a dynamic antenna matching (DAM) technique that can improve the total efficiency of the antenna by 2 – 4dB compared to the mismatched cases. It is done by improving the matching at both the low and high bands.

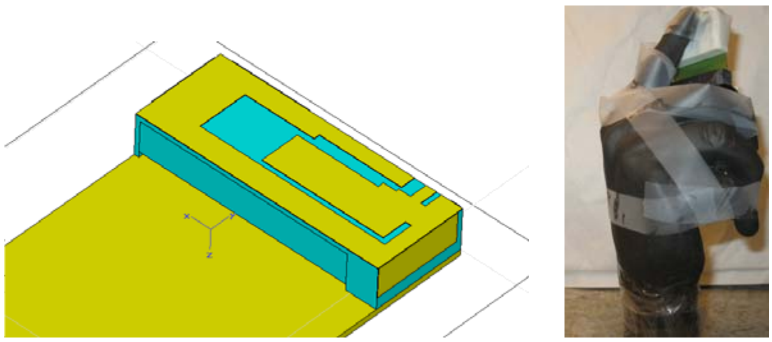

Figure 1*(a).Implemented dual band PIFA (b) DUT with phantom hand*

A dual band PIFA(42mm x 16mm x 6mm) [2] for the GSM800 and 1800 bands was designed and built on a 100x42mm PCB (see figure 1a). The efficiency of the antenna at both bands was then measured with and without an artificial phantom hand holding the device under test (figure 1b). The efficiency was measured in Satimo Stargate64, chamber and the results are presented in figure 2.

As can be seen the efficiency as a function of frequency is heavily reduced in both bands when the hand is introduced (compare LB_Freespace & LB_Detuned for the low band, and HB_Freespace & HB_Detuned for the high band). Observed reduction in efficiency caused by the hand was 2-5.5dB in the low band and 2-4dB in the high band.

In order to compensate for this reduction in efficiency we introduce a tuning circuit (see figure 3). To cover most of the mismatch conditions on the smith chart, a “pi” configuration comprising of two “L” type networks is designed. The circuit can be used effectively for mismatch compensation. This type of network can be utilized to get a good enough matching criterion for the entire band. The number of combinations required to match each frequency point ideally back to 50 ohm for different mismatch conditions is very high. But for practical purposes, considering the impedance shift of the antenna for different extents of detuning, the number of topologies of matching network required is not too high.

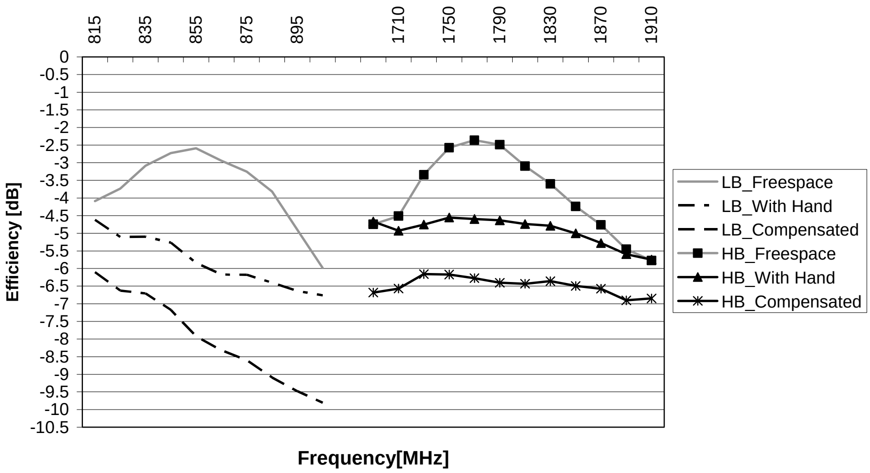

Figure 2*. Efficiency of the measured adaptive antenna in freespace, with hand and compensated states*

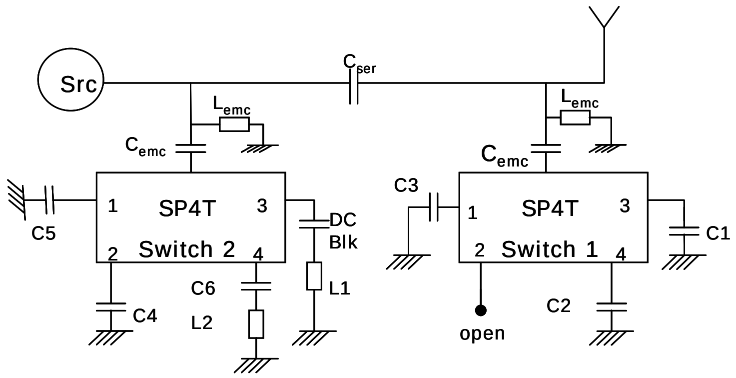

Figure 3*. Implementation of Dynamic Antenna Matching Circuitry*

In order to compensate for the mismatch the antenna impedance state for the detuned case is noted from Vector Network Analyzer. This information is used to design the matching network. As stated earlier, the circuit shown in figure 3 can be used to compensate for any mismatch of the antenna in the Smith chart. Using the information from the VNA the most appropriate topology of the matching circuit is selected and the efficiency of the resulting antenna configuration was measured and is presented in figure 2. As you compare the LB_Detuned state (antenna in the presence of hand) and LB_Compenstated (antenna in the presence of hand and matching circuit used to re-match it back to 50-ohm), we can see an improvement in efficiency of 2-4dB for the low-band. Similarly for high band, comparing HB_Detuned with HB_compensated, it can be observed that improvement in efficiency after compensation is about 2dB, thus indicating that the method works well (The return loss graphs will be provided in the complete paper).

Since the real mobile phones continuously monitors the VSWR of the antenna, it also implies that by making use of that information it is easily possible to implement a feedback loop to control the switch state of the circuit. Hence, an adaptively matched antenna to compensate for hand and finger effects can easily be designed.

References:

[1] Michael A. Jensen, Yahya Rahmat-Samii, "Electromagnetic interaction between biological tissue and antenna on a Transceiver Handset", Volume 1, 20-24 June 1994

[2] S. Tarvas and A. Isohatala, "An Internal Dual-Band Mobile Phone Antenna," *IEEE Antennas and Propagation Symp. Dig.*, Salt Lake City, UT, pp. 266–269, July 2000