Antennas and propagation considerations for robust wireless communications in medical body area networks

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It is only relatively recently that radio communications for medical applications has enjoyed widespread attention in the research community, even though "wireless" has been used in some clinical investigations for over 50 years (the swallowable endoradiosonde capsule first appeared in the 1950s, albeit without a video camera!). Today, medical body area networks (MBAN) are seen as a key challenge for the wireless communications community (e.g., IEEE 802.15.6) who are focusing on a range of issues including security, power consumption, reliability, capacity, range error performance. Interestingly, in MBANs the antennas and propagation aspects of the problem can be shown to have a significant effect on all of these important issues. Therefore, in this paper we will present some of our current antennas and propagation research results and how they may be applied to improve the performance of MBANs.

One of the most important considerations for MBAN applications is the ability to efficiently couple two low-profile, compact nodes that do not have line-of-sight. That is, the antennas used must be designed to favorably propagate trapped surface (so called "creeping") waves present with non-perfect conductors (see Fig. 1). In this way, the body skin-air interface itself is used to guide the signal rather than rely solely on multipath reflections. Using a specially shaped numerical or physical phantom (Fig. 2) it is possible to isolate these surface wave effects from other propagation modes so that on-body antennas can be investigated and optimized. Although the MBAN restrictions on antenna dimensions (particularly height off the body surface) complicate the on-body antenna design, there are a number of potential approaches to the problem and further examples will be given in the full paper. Nonetheless, even at relatively low frequencies (such as the 868 MHz ISM band), it is also possible to improve the performance of on-body communications using simple two-branch diversity. Fig. 3(a) shows the measured received power profile (256 sa/s) and maximal ratio combining (MRC) time-series for horizontal spatial antenna diversity while the user was mobile in an open office environment. The receivers (short helicals, 4 cm spacing, 0.12λ) were positioned on the user's left anterior chest with the transmitter on the diagonally opposite back waist. Fig 3(b) shows the time series expansion between 10 and 12 s. The cdf for this system (Fig. 4) shows that gains of up to 6.4 dB are possible for on-body 2-branch diversity. (Note: SC is selection and EGC is equal gain combining).

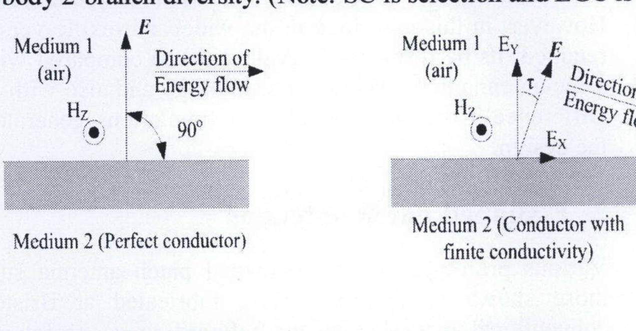

Fig. 1: Trapped surface wave formation on finite conductors

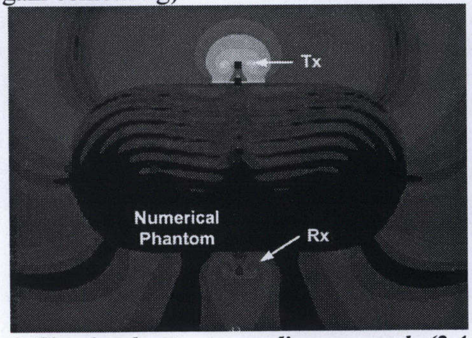

Fig. 2: Simulated antenna coupling on muscle (2.4 GHz)

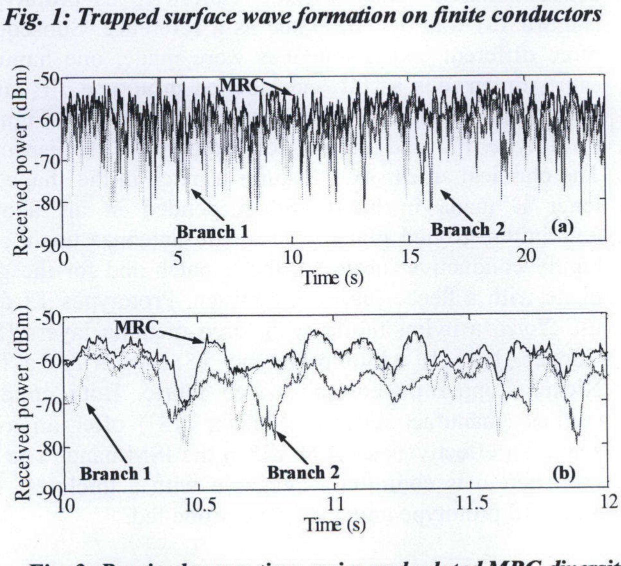

Fig. 3: Received power time-series and related MRC diversity

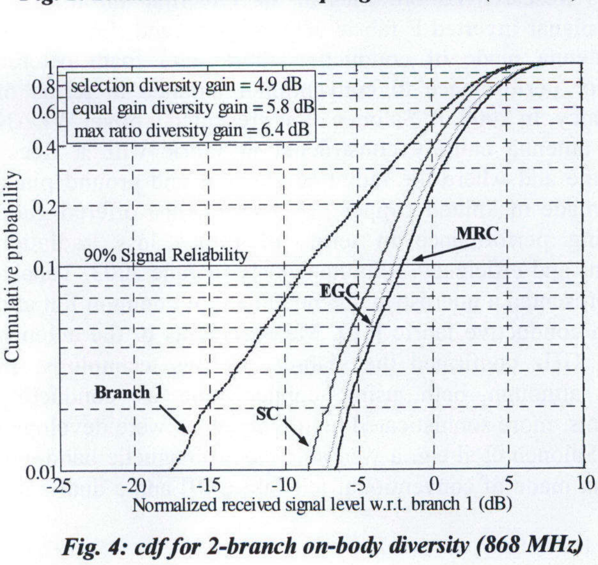

Fig. 4: cdf for 2-branch on-body diversity (868 MHz)