

Link-budgets with body implanted nodes: can we obtain simple analytical approximate models that are useful?

Anja K. Skrivervik⁽¹⁾, Mingxiang Gao⁽²⁾, Jiajun Li⁽¹⁾, and Zvonimir Sipus⁽³⁾

(1) EPFL, CH-1015 Lausanne, Switzerland (anja.skrivervik@epfl.ch)

(2) IT'IS Foundation, CH-8004 Zurich, Switzerland (gao@itis.swiss)

(3) FER, University of Zagreb, Zagreb, Croatia (zvonimir.sipus@fer.hr)

Wireless Communication with a body implanted device (e.g., medical sensor) represents a challenge, for three reasons: First, the antenna used for the link has to be highly miniaturized. Second, biological tissues have high losses, and thus will attenuate any wireless signal. Finally, as the implant is placed in a living host, levels of powers that may be used for a wireless link are heavily limited by regulations, in order to protect the host from exposure to electromagnetic fields. Thus, such wireless links should be designed in a way achieving the best possible efficiency in order to be viable. To this aim, good propagation models for electromagnetic fields through biological tissues are a good help in the design process. They should be precise enough to enable a good link budget at the planning stage of a project, and simple enough to enable an easy use. One of the major difficulties in establishing such models is that in the case of wireless communication with a device located in a lossy medium, it is not always possible to decouple the channel (i.e., the propagation in the medium) from the antenna characteristics, as the near field generated by the antenna can couple to the lossy medium. If we consider the scenario depicted in Fig. 1, the link budget between implanted and outside nodes can be written as:

$$P_r|_{\text{dB}} = P_{\text{tr}}|_{\text{dB}} + G_{\text{tr}}(d_0)|_{\text{dB}} - PL_{\text{body}}|_{\text{dB}} - L_{\text{reflections}}|_{\text{dB}} - L_{\text{refraction}}|_{\text{dB}} - PL_{\text{free space}}|_{\text{dB}} + A_r|_{\text{dB}} \quad (1)$$

P_r is the antenna received at the outer node, $G_{\text{tr}}(d_0)$ is the gain of the implanted antenna computed at a distance d_0 within the body, PL_{body} is the path-loss in the body (starting at a distance d_0 from the antenna), $L_{\text{reflections}}$ and $L_{\text{refraction}}$ represent the losses due to reflections and refraction at the body free space interface taking into account size of the body effective aperture. $PL_{\text{free space}}$ is the path loss between the host body and the receiving antenna, and A_r is the effective aperture of the receiving node antenna. In this contribution, approximate analytical models, their limits of application and accuracy will be discussed for the different terms appearing in this model.

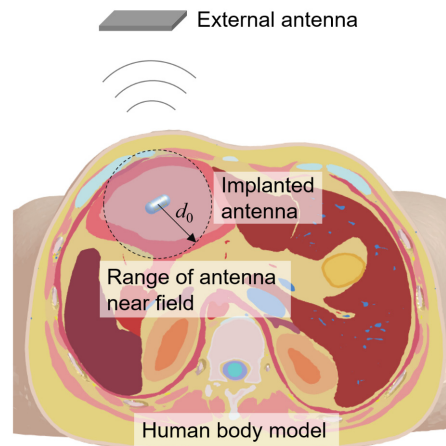


Figure 1. Wireless communication with an implanted node. The anatomical human model used stems from the Virtual Population, IT'IS Foundation.