An Investigation of the Coupling between Extremely Compact Microstrip Patch Antennas in a Link for Biomedical Implants

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Data communication between the external and internal components for biomedical prosthetic devices has traditionally been accomplished via low frequency (1-20 MHz) inductive links between two coils. In this approach, the low frequency power carrier is modulated by an information signal. This imposes a limitation on the achievable data bandwidth, which is dependent on the power carrier frequency. In data intensive biomedical implants such as a visual prosthesis, lack of adequate bandwidth may prove to be a significant functionality constraint in the efficient operation of the entire prosthetic system. In such cases, data communication at microwave frequencies (1–3 GHz) using a pair of external and internal microstrip patch antennas is a viable alternative and can provide a much larger bandwidth.

This work addresses the design of appropriately sized patch antennas and their coupling issues for a visual prosthetic device. Two frequency bands of operation were considered at 1.35–1.45 GHz and 2.35–2.45 GHz. For both the frequency bands, the external (transmitting) antenna size was restricted to 25×25 mm. Size of the receiving antenna was to be restricted to 6×6 mm. Hence, to reduce the surface area, size reduction techniques such as shorting posts, high dielectric constant and maximizing the current path (by incorporating slits) were employed to design the receiving antennas and restrict their size to 6×6 mm for both the frequency bands. Optimal design of the antennas was carried out using an in house FDTD code and then the transmit–receive pairs were implemented to resonate at the same frequency in both the frequency bands.

A parametric analysis of the free space coupling as a function of separation, spatial relative orientation and spatial angle of orientation was carried out at both the frequency bands. Due to their eventual intended application in a retinal prosthesis, the maximum separation distance was fixed at 35 mm. Within this distance the coupling exhibits near field behavior and it is observed that the antenna performance characteristics (resonant frequency, impedance) are sensitive to their relative proximity. It is further observed that the receiver antenna which exhibits a mixed polarization characteristic (due to shorting posts and several slits), is sensitive to a particular polarization of the transmitter antenna even in the near field region. Detailed account of the antenna design issues and a comprehensive investigation of parametric analysis of the coupling between the two antennas in both the frequency bands will be presented.