ABSTRACT

The immensely growing miniaturization of electronic devices along with enormous development in wearable computer technology, are leading to the production of components and devices that can be carried by people in their pockets or even be attached on their body as part of their clothing. For seamless communication to take place, wearable antennas incorporated into clothing have also become indispensable. Wearable electronics and in particular wearable antennas are a perfect wedding of textile and technology.

For the design and implementation of a wearable antenna four aspects need to be addressed. Of foremost importance is the antenna working as the intended radiator when worn as part of clothing and close to the human body. Variations or rather deviations in the operation of these wearable antennas when working in proximity to the body tissues must be kept very less to ensure effective and efficient communication. However making an antenna truly wearable introduces additional constraints. One is that compared with conventional antennas, textile antennas must be drapable. Drapability means that something can be bent in all directions at the same time. Use of innovative materials or techniques can make the wearable antenna truly drapable. Finally if these wearable antennas are to become a revolution in the commercial market complete integration of these components into the textiles at the point of production is needed.

The key aim of this dissertation is to deal with the above mentioned aspects of wearable antenna design. Various studies were performed to learn about the effects of the human body that is present close to the radiator. Detuning effects and changes in directivity are studied in detail. In a novel
design additional resonance is introduced into the wearable antennas making it operate at two different frequency bands. This is achieved through simple configurations of slots and slits in the radiating element. This dual band antenna is then put under rigorous examination by studying its performance under bent and crumpled conditions. Assessment of the working of the antenna when it is exposed to moisture conditions is also carried out.

Questions have been raised repeatedly in the past as to whether frequent usage of such antennas which radiates electromagnetic field onto the human body tissues is unsafe. Specific Absorption Rate (SAR) computation is also performed as part of this thesis using a three layered heterogeneous rectangular human body model comprising of skin, fat and muscle layers.

After establishing basic inferences regarding the working of antennas integrated as part of the clothing, the research is extended to ensure increased efficiency of the same. To quantify the effect of every deformation thorough statistical scrutiny of wearable antennas and the significant deformations that affect the working of the same was performed. The experimentation was based on Taguchi’s method performed on a novel dual band planar wearable antenna under three deforming variables namely stretching/compression, bending and shear of the fabric. The extent to which these deformations affect the performance of the antenna is carried out using Analysis Of Variance (ANOVA) analysis. A meticulous examination brings out the deforming variable that has the largest impact on the textile antenna’s performance.

The next part of this thesis is aimed at improving the performance of these antennas through the usage of Electromagnetic Band Gap (EBG) structures. A new design of dual band monopole type radiator employing fractal geometry is designed for this part of the research. A dual band EBG plane is kept below the designed antenna and the performance is studied.
Remarkable improvement in the performance is noticed in the working of the antenna.

After addressing aspects related to the satisfactory working of wearable antennas, research is carried forward to improve its wearability. An extensive study on materials that could be used to increase the drapability of the antenna is studied and their performance is evaluated. For the conductive portions of the patch various materials like conductive foil, coated fabrics, coating on substrates and woven conductive fabrics are used and studied. However all these techniques require the use of separate assembling and fastening of the components of the wearable antenna on a conformal substrate. Hence in order to bring about complete integration at the point of production a unique multilayer woven wearable antenna is proposed using specially set up table loom. A novel multilayer woven fully textile antenna made from conductive and non-conductive threads is presented. The developed prototype eliminates the need for any fastening component like adhesives, tapes etc., and hence becomes an entirely integrated textile antenna.