

ABSTRACT

Wearable antenna is a fast developing field in research. For processing and detecting purposes, antenna might be integrated in textiles which increase the comfort and security to the users. The wearable antenna plays a significant role in WBAN. This kind of antenna gives a consistent data about the individual's health condition by transmitting and monitoring the bio signals of the individual. Hence, the textile antenna is utilized as transmitting and receiving antenna instead of a metal antenna. The accessibility of conductive materials is considered as electro-textiles. The textile may not perform efficiently in the harsh atmosphere conditions in which firefighters frequently work (i.e., high humidity and/or high temperatures). The closeness of the human body to the antenna and the consistent distortion may alter the substrate dielectric constant, which may further influence the radiation characteristics such as return loss, VSWR, radiation pattern, directivity and gain of an antenna. It may be limited by utilizing various textile antennas. Textile antenna has recently been proposed with great performance. This textile antenna should not alter its properties when utilized for crumbling or bending conditions. In this research work, the rectangular shaped microstrip patch antenna using textile substrate material embedded with conductive textile and non-textile materials was proposed to improve the textile antenna characteristics and to study the conductive material behaviour to diminish the losses.

The microstrip patch antenna is made up of three layers such as substrate, patch and ground plane. The substrate layer consists of textile dielectric components such as denim, cotton, flannel, jeans, polycotton, twill weave and polyster. The patch and ground layer consists of conductive non-textile materials such as copper sheet, CFTCA and conductive textile materials such as PCPTF, NCRSF and ShielditTM super. The dielectric

material selection depends on the parameters such as thickness of the material, permittivity and loss tangent. Using the air wedge method, the thickness of the textile material is determined by locating interference fringes. The conductive materials are required to contain short and steady resistance with the intention of diminishing the losses. So the conductive material selection was carefully noted based on the conductive properties such as surface resistivity, conductivity and material thickness. The radiating patch is intended in the form of rectangular and inset feed lines are installed on the substrate. The rectangular shaped microstrip patch textile antenna was designed by the design parameter such as patch length, patch width, ground plane length, ground plane width, length of inset feed, the gap of inset feed, feed length and feed width using design formulae. The textile antenna was designed and simulated using ADS 2013.06 software and various performance parameters such as return loss, VSWR, impedance, directivity and gain were obtained.

The various textile antennas were fabricated using different conductive materials. Normally Sub miniature version A (SMA) connector is fixed using typical soldering techniques with special care to avoid the physical damage. But in this work, the glue is used for the connection to get the best result. To measure the parameters such as return loss, VSWR and impedance, the fabricated antenna was measured using the network analyzer (N9926A 14 GHz Field Fox Handheld vector model). The textile antenna measurement was taken at both OFF body and ON body mode. The OFF body mode provides the link between the wearable devices and the network in a stationary environment. In this mode, the antenna measurement was taken in the room environment. The ON body mode provides a link between the wearable devices on the human body and the network in the dynamic environment. In this mode, the antenna is located on the human arm and human chest and the measurement was taken. The simulation and

measurement were done at 2.4 to 2.45 GHz (ISM band). The comparative study was taken between simulation and measurement results to choose the best kind in the various textile antennas, which are highlighted in the bold case based on the performance parameters as return loss nearly and above -14 dB, minimum VSWR, impedance nearly 50Ω . Additionally the fractional bandwidth, Q factor was calculated using the formulae for the selected textile materials. Furthermore, the partial and fully textile antenna was classified for selected material based on the substrate and conductive material combination. This research work provides good minimum return loss, VSWR as one, impedance as 50Ω , better fractional bandwidth, nominal Q factors, great directivity and accepted gain, which makes the maximum signal transmission without any loss compared to conventional antennas.

The performance parameters of the various textile antennas with different conductive textile and non-textile materials follow as the antenna made up of denim substrate textile with CFTCA gives fractional bandwidth of 34.4 MHz, Q factor of 29.30, a gain of 5.34 and directivity of 5.34. The antenna made up of cotton substrate textile with copper sheet gives fractional bandwidth of 6.25MHz, Q factor of 158.53, a gain of 2.35 and directivity of 7.79. The antenna made up of flannel substrate textile with copper sheet gives fractional bandwidth of 6.09MHz, Q factor of 164.5, a gain of 0.17 and directivity of 7.88. The antenna made up of jeans substrate textile with CFTCA gives fractional bandwidth of 6.83MHz, Q factor of 145, a gain of 3.29 and directivity of 8.19. The antenna made up of polycotton substrate textile with copper sheet gives fractional bandwidth of 9.23MHz, Q factor of 109.2, a gain of 1.84 and directivity of 7.96. The antenna made up of twill weave substrate textile with copper sheet gives fractional bandwidth of 8.05MHz, Q factor of 123.75, a gain of 3.12 and directivity of 7.08. The antenna made up of polyster substrate textile with copper sheet gives fractional bandwidth of 7.11MHz, Q factor of 140.11, a gain of -2.15 and

directivity of 7.96. From this research work, it is understood that wearable textile antenna such as denim and jeans with conductive non-textile materials as CFTCA are more suitable for partial textile antenna design. Similarly, wearable textile antenna such as cotton, flannel, polycotton, twill weave and polyester with conductive non-textile material as copper sheet are also compatible for partial textile antenna design. The antenna made up of denim substrate textile with NCRSF gives fractional bandwidth of 96.7MHz, Q factor of 10.33, a gain of 5.11 and directivity of 5.10. The antenna made up of cotton substrate textile with NCRSF fractional bandwidth of 9.06MHz, Q factor of 107.9, a gain of 1.52 and directivity of 7.78. The antenna made up of flannel substrate textile with NCRSF gives fractional bandwidth of 6.10MHz, Q factor of 164.1, a gain of -1.12 and directivity of 7.85. The antenna made up of jeans substrate textile with NCRSF gives fractional bandwidth of 10.4MHz, Q factor of 98.9, a gain of 2.44 and directivity of 8.19. The antenna made up of polycotton substrate textile with NCRSF gives fractional bandwidth of 7.64MHz, Q factor of 129.21, a gain of 0.70 and directivity of 7.94. The antenna made up of twill weave substrate textile with NCRSF gives fractional bandwidth of 8.04MHz, Q factor of 123.55, a gain of 2.32 and directivity of 7.06. The antenna made up of polyester substrate textile with NCRSF gives fractional bandwidth of 4.14MHz, Q factor of 244.2, a gain of -4.13 and directivity of 7.94. From this research work, the wearable textile antenna such as denim, cotton, flannel, jeans, poly cotton, twill weave and polyester with conductive textile material as NCRSF is more suitable for fully textile antenna design. This research work also analyzed the variation of the performance characteristics based on the change of different conductive textile and non-textile material usage. The partial and fully wearable textile antenna is well operated in both OFF body and ON body environment successfully. On the whole, this research work provides a new idea for upcoming textile antenna designers to select the suitable best kind textile antenna for various wearable applications.