Chapter-9

Wearable Body Worn Antenna-the Beginning of New Era

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Recent days with the fast growing of the wireless communication, antenna technology has taken a quantum leap towards the development of wearable antenna. The need of convenient in carrying the communication gadgets and devices, made researchers to think of about the wearable devices which is portable and user friendly. The need of achieving portability in terms of voice communication, data transfer, positioning, and entertainment leads to the development of wearable communication. With the requirement of the specific need in different application varying from medical, rescue and security services, sports, entertainment even in fashion applications, today's communication achieving highest level of portability.

1. AN INTRODUCTION TO WEARABLE ANTENNA

In recent years the rapid growing of wireless communication technology achieving the significant goal of portability. With the increasing demands for the high data rates, voice and video transmission with miniaturized

portable devices and wireless technology, high performance devices and applications are now vital requirement for everyday life. Now a day's the mobility and wearability of devices and gadgets integrated in the clothes or mounted on the body offers significant comfort and freedom to the wearer in their daily activities [1-6].

With the wearable well designed wireless systems, mobiles and other wearable products brings the feasibility to the peoples ease of access to effective communication, sharing of information's, data transfer and globally connect to each other without heading towards a particular location. Peoples can get access to all these systems with the advent of wearable technology. However, in these wearable communications systems has different sub part where antenna plays a major role in transmitting and receiving of data's or signals to the short and long range wireless communication system [1-6].

Antennas are the 'eyes and ears' of wireless communication. They are the most visible components of communications systems. With the introduction of mobile wireless communications, and in particular cellular telephony, antenna technology has emerged in the last two decades as one of the most critical components in the advancement of wireless communication. Now with the introduction of smart phones, iPad, and other wireless mobile devices, who perform numerous functions which few years ago were impossible and unthinkable, it has become a 'horse race' as to which device will provide the most multifunctional capabilities and reliable services [7].

Advancement in communication and electronic technology puts forwards in the development of miniaturized wearable antennas for body centric

wireless communications. Recent years, wearable antennas finding potential utility in many areas like, satellite communication, military communication, WLAN, WBAN, healthcare monitoring system, telemedicine, RFID, rescue systems, fire-fighters, recreation e.t.c [1-6]. Wearable antennas captivating a quantum leap towards the design and development of low profile, light weight, low cost, miniaturized flexible antennas for body worn applications [1-6]. As in some cases handheld devices may be too cumbersome and the communications devices has to be integrated with the other systems like clothing which finds a potential solution for antennas to be used as body worn applications. This provides a space for the antenna to be integrated into clothing and worn on the user's body.

2. A GLIMPSE OF BACKGROUND HISTORY OF ANTENNA

The early days of radio starting in 1873, are well known, with the Maxwell's theory, that an electromagnetic wave exists when the changing magnetic field causes a changing electric field and vice versa. However, Maxwell's theory was just that, a theory. Heinrich Hertz applied Maxwell's theories to the production and reception of radio waves/ electromagnetic waves in the late 1880's Hertz realized that, according to the theory, if electromagnetic waves were spreading from the oscillator sparks, they would induce a current in the loop that would send sparks across the gap. Hertz built the first spark gap generator as a source (about 100 MHz) and combined this with a detecting loop with small air gap that sparked when excited. When turned on the experiment produced the first transmission and reception of electromagnetic waves. [8] The history of antenna technology dates back to

the days of Marconi when in 1901, he developed an antenna for transmitting signals from Poldhu and received at Signal Hill, St. Hohn's, Newfoundland [9].

In the early 1920s most of the antennas, were of the wire type, especially those installed in ships, which hanged on masts, primarily as single elements. The array technology was born with the Yagi and Uda's classic design on antenna where a number of wire elements placed horizontal and parallel to each other. The Yagi-Uda antenna was the very popular TV antenna as we had seen a few years back before the present dish antenna (reflector antenna/ parabolic antenna).

Figure 1: Yagi-Uda antenna

Figure 2: TV dish antenna

The need of the wearable antenna first came into picture by the demand for the military applications. The whip antenna carried by the military personnel faces lots of difficulties while moving and can be easily identified by the enemy in a squad. The limitations were overcome by incorporating the antenna into the uniform and add benefit of eliminating clumsy devices and bring comfort level to the wearer. This led to the design and development of RF helmet antenna [10] and an RF vest antenna [11]. Both

these antennas were constructed of textile material with conductive cloth. The first with polyester interwoven with nickel and copper fibers and later with canvas and Flectron.

Other relevant research work has been proposed and took a rapid development in the wearable antenna technology in military applications.

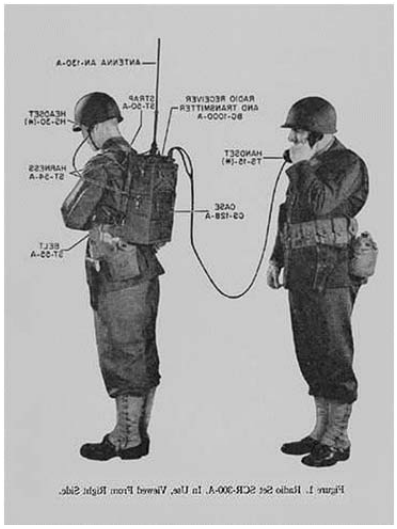

Figure 3: Whip antenna carried by military personnel

3. CURRENT STATE OF ANTENNA TECHNOLOGY

With the development of microstrip antenna in 1970, the antenna technology found a new path to step forward to the design and development of advance antenna systems. Starting from the year 1990 to present, focused on the integration of new materials to enhance and optimize the performance of the radiating element of the antenna. Different types of conductive polymers, carbon nanotubes, graphene and conductive textiles and fabrics have been employed for the radiating element [12-14].

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Metamaterials became an integral part of antenna design. This class of materials captivated the interest of many leading researchers and practitioners, scientists and engineers, from academia, industry and government. When electromagnetic waves interact with such materials, they exhibit some unique and intriguing characteristics and phenomena that can be used, for example, to optimize the performance of antennas and other electromagnetic devices. In this period, there was a renewed interest in smart antennas, including Multiple Input Multiple Output (MIMO) configurations to improve the performance and data capacity of the systems. Reconfigurable antennas designs also received a lot of attention and popularity, in being able to control the resonant frequency, pattern, input impedance, and other antenna radiation characteristics. Basic designs of fractal antennas were also introduced in order to reduce the overall size of the antenna while making them electrically long to be used at even lower frequencies. The advancement in mobile wireless communications stirred a lot of interest in the design of multi-band antennas, including the popular Planar inverted 'F' antenna (PIFA) and U slot, to handle the enormous activity and competition in wireless communication [7-9, 12-15].

In recent days stretchable and flexible (or conformal) microstrip antennas finds potential utility in many millimeter wave applications, like, automotive radars, security and surveillance systems, high-data-rate wireless communication systems , harsh environmental conditions and also in health care monitoring systems [16-18]. Wireless communication ranging from megahertz to millimetre-wave frequencies has become an important integral part of defense and consumer based technologies such as cellular

communications, wireless local area networks (WLAN), wireless personal area networks (WPAN) and medical applications[19,20].

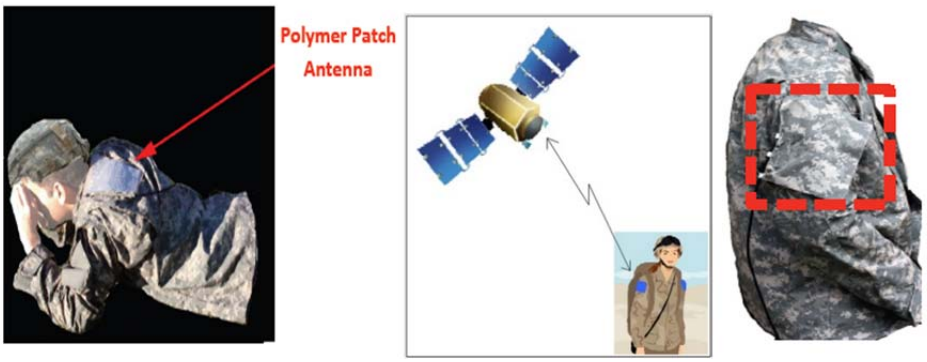

Figure 4: Wearable antenna

The extensive military, space and medical applications, have led to the need for development of antenna systems which are flexible, light weight, low-cost, ultra-miniaturization and reconfigurable. The strechability in antennas offer a new dimension of reconfigurable antennas, which can be mounted within limited and nonplanar spaces. Mechanical compliancy of flexible wearable antennas adding comfort levels for the soldiers in combat or harsh conditions and also prompt monitoring and diagnoses of the medical condition of the personals and mapping the topography of the area through wireless personal area network (WPAN)[21,22].

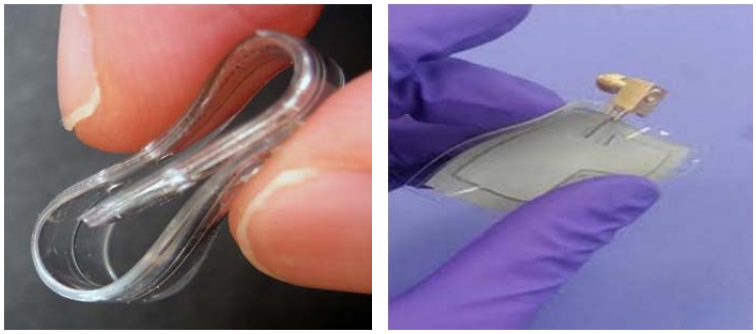

Figure 5: Stretchable flexible antenna

Body worn systems endowed with sensing, processing, actuation, communication and energy harvesting and storage abilities are emerging as a solution to the challenges of ubiquitous monitoring of people in applications such as healthcare, lifestyle, protection and safety. Recent advances in wireless body area network (WBAN) communication using the body worn equipment's are the major assets for monitoring personnel in military and medical health care systems. With the advances in body worn antenna technology personnel's can be monitored from a long distance particularly in medical health care monitoring systems and also in military. The antenna can be implanted within the patient's body to observe the health condition and monitor from long distance [23-25].

As long as wireless communication continues to expand at a rapid pace, research on the integration of new materials with antenna design especially in reducing the size and optimizing their performance promising very bright future for antenna technology to continue to flourish and contribute to the society's needs.

REFERENCES

[1] Hall, P. S. and Hao, Y., *Antennas and Propagation for Body-Centric Wireless Communications,* 2nd ed., Artech House Inc., Norwood, MA, USA, 2012.

[2] Khaleel, H., Wit Press, Southampton, Boston, UK, 2014.

[3] Gupta, B., Sankaralingam, S. and Dhar, S., IEEE 10th Mediterranean Microwave Symposium (MMS' 2010), Guzelyurt, 251-267.

[4] Rais, N. H. M., Soh, P. J., Malek, F., Ahmad, S., Hashim, N. B. M. and Hall, P. S., IEEE Antennas and Propagation Conference, (LAPC' 2009), Loughborough, 225-228.

[5] Matthews, J. C. G. and Pettitt, G., IEEE 3rd European Conference on Antennas and Propagation (EuCAP' 2009), Berlin, 273-277.

[6] Nepa, P. and Rogier, H., *IEEE Antennas and Propag. Magazine,* **57**(5), 30-52, 2015.

[7] Constantine A. Balanis, Antenna Technology: Past, Present and Future.

[8] C.G.Parini, Millimetrewave Antennas- Past, Present and Future, *Loughborough Antennas and Propagation Conference,* 2007.

[9] J. W. Klooster, Icons of Invention: the makers of the modern world from Gutenberg to Gates.

[10] Lebaric, J. and Tan, A. T., IEEE 21st Century Military Communications Conference Proceedings (MILCOM' 2000), Los Angeles, CA, 591-594.

[11] Kohls, E. C., Abler, A., Siemsen, P., Hughes, J., Perez, R. and Widdoes, D., IEEE Antennas and Propagation Society International Symposium, 2004, 447-450.

[12] J. W. Klooster, Icons of Invention: the makers of the modern world from Gutenberg to Gates.

[13] S. Silver, Microwave Antenna Theory and Design, McGraw-Hill, New York, 1949 (MIT Radiation Lab. Series, vol. 12).

[14] R. E. Munson, *IEEE Trans. Antennas Propagat*., **AP-22** (1), 74-78, 1974.

[15] Rita Salvado , Caroline Loss , Ricardo Gonçalves and Pedro Pinho, *Sensors* **12**, 15841-15857, 2012.

[16] N. Tiercelin, P. Coquet, V. Senez, R. Sauleau, H. Fujita, *J. Micromech. Microeng.,* **16**, pp. 2389-2395, 2006.

[17] J. H. So, J. Thelen, A. Qusba, G. J. Hayes, G. Lazzi, and Michael D. Dickey, *Adv. Funct. Mater.,* **19**, 3632–3637, 2009.

[18] H. J. Kim, T. Maleki, P. Wei, and B. Ziaie, *J. Microelectromech. Syst.,* **18**, 138– 146, 2009.

[19] S. Cheng, A. Rydberg, K. Hjort, and Z. Wu, *Appl. Phys. Lett.,* **94** (14), 144103–144103-3, 2009.

[20] B. A. Cetiner, H. Jafarkhani, J. Y. Qian, H. J. Yoo, A. Grau, F. De Flaviis, *IEEE Comm. Mag*., **42** (12), 62, 2004.

[21] N. Tiercelin, P. Coquet, R. Sauleau, V. Senez, H. Fujita, J. Micromech. Microeng., **16**, 2389-2395, 2006.

[22] I. Locher, M. Klemm, T. Kirstein, and G. Tröster, *IEEE Transactions on Advanced Packaging,* **29** (4), 777-788, 2006.

[23] Lingnan Song, Amanda C. Myers, Jacob J. Adams, and Yong Zhu, *ACS Appl. Mater. Interfaces* **6**, 4248−4253, 2014.

[24] P. S. Hall, Y. Hao, Antennas and Propagation for Body-Centric Wireless Communications (Artech house, 2006)

[25] V. K. Palukuru, K. Sonoda, R. Surendran, and H. Jantunen, *Progress In Electromagnetics Research C,* **16**, 195-205, 2010.