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Location tracking system using wearable on-body GPS antenna

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Abstract. An on-body location tracking system is developed and integrated with a wearable GPS antenna. Such system is beneficial in human location tracking of patients and elderly within a radius of 1 km. The system consists of a wearable antenna, a GPS module, a low cost microcontroller, two RF modules and a local monitoring system. A user equipped with the GPS antenna, GPS module and a RF transmitter is able send his/her location to the local monitoring system via a RF receiver. The proposed wearable antenna is validated to be safe for human use in terms of specific absorption rate (SAR). This antenna was then incorporated into the complete prototype and tested. Several suggestions for future improvements are also proposed and discussed.

1 Introduction

During the past decade, location tracking/monitoring systems have been actively developed for tracking children, elderly, disabled [1-4], vehicles and etc. Specifically, human location tracking systems are important to ensure human safety and to efficiently initiate search and rescue in the event of emergencies. Such location monitoring can be developed using different technologies such as global positioning system (GPS) [2, 5], radio frequency identification (RFID) [4, 6] and ZigBee [3]. Their selection depends on the application requirements such as coverage, cost and accuracy.

A majority of previously developed tracking systems focused on aspects such as security and privacy [4, 7], accuracy improvement [8], and body effects to the antenna used [2]. The need of developing low cost tracking system is addressed in [1]. However, these works have yet to address the issue of implementing location tracking system on?? Human body. Ref. [2] described the effect of body towards the performance of the system but did

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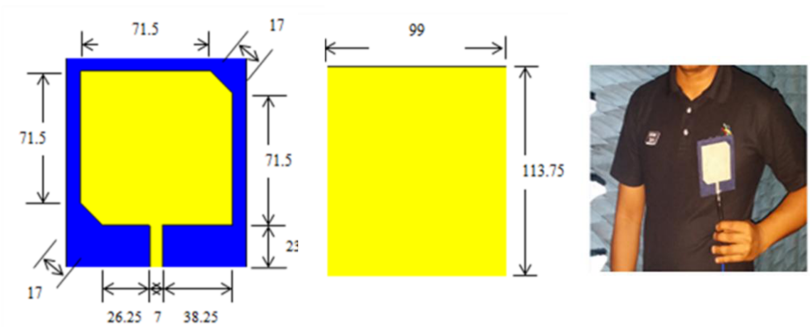
not discuss the effect of the system towards the human body. Apart from that, none of the aforementioned works adopted the use of wearable antennas, despite their attractive features and suitable properties for on-body application [9].

In this work, the issue of implementing a body-wearable antenna onto a low cost location tracking system is addressed. The wearable antenna is first designed for operation before being studied in terms of specific absorption rate (SAR) level to ensure safety for operation on body. . The rest of this paper discusses the system description and results obtained through simulations and measurements.

2 System overview

The overall location tracking system consists of a wearable, circularly-polarized GPS antenna, a microcontroller, GPS module and RF module to enable its functionality.

2.1 Antenna design



(a) (b) (c)

Fig. 1. Structure of the proposed wearable CP Antenna (a) top view of the antenna (dimensions in mm) (b) Bottom view of the antenna (dimensions in mm) (c) Fabricated antenna during on-body measurements.

As presented in [9], it is demonstrated that the existence of the full ground plane on the reverse side of the patch antenna is expected to minimize the effect of the body, resulting in very low SAR levels. Based on this, the selected circularly polarized (CP) antenna topology for this system adopts a full ground plane. It is based on a square shaped topology with corner truncations, as illustrated in Fig. 1. It operates at 1.575 GHz with a right-handed circular polarization (RHCP). Textile materials are used for the fabrication of the antenna. The substrate used is Felt with a thickness of 1.5 mm and a dielectric constant of 1.22. Similar to the work in [10], the conductive textile known as SheildIt super is used to form its patch and ground plane.

2.2 System design

The developed antenna was then incorporated with a GPS module and Arduino Mega microcontroller. The microcontroller is programmed to capture the GPS data and send it to the local monitoring system through RF modules which operate at 2.4 GHz band. The graphical user interface (GUI) for the monitoring system is developed using Visual Basic software. The overall system is illustrated in Fig. 2.

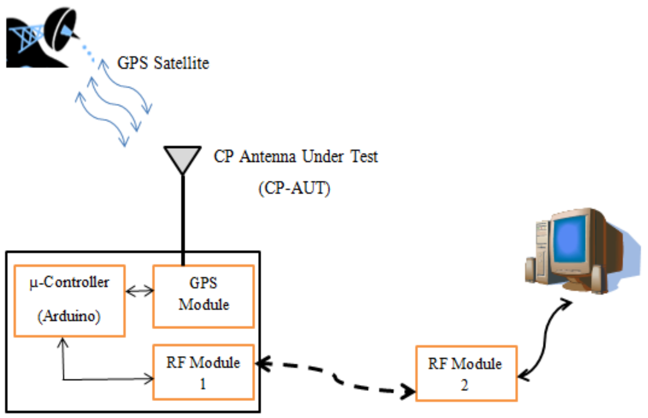


Fig. 2. Location tracking system using wearable CP antenna

3 Results

3.1 Antenna performance

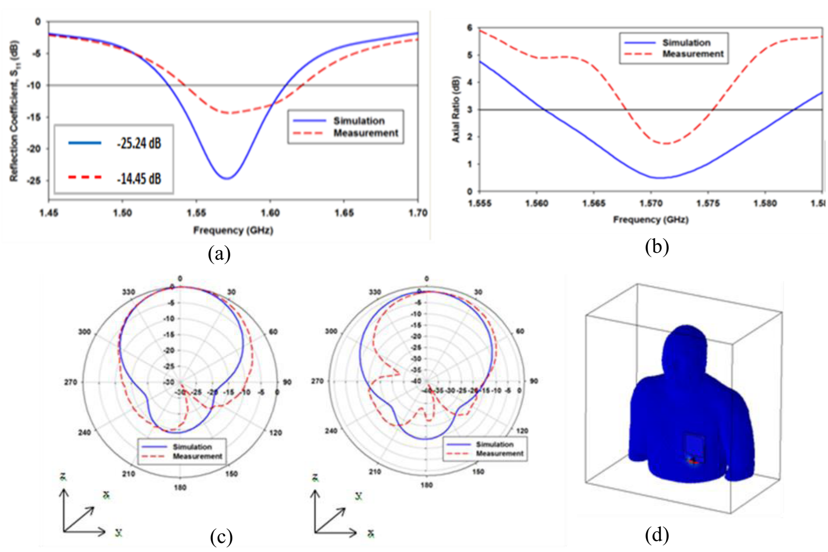


Fig. 3. Results of the antenna. (a) Reflection coefficient. (b) Axial ratio. (c) Radiation pattern (d) SAR analysis

All evaluated antenna parameters are satisfactory, as shown in Fig. 3.. Measured 10 dB impedance bandwidth indicated operation from 1.538 GHz to 1.622 GHz, while its 3 dB axial ratio from 1.568 GHz to 1.577 GHz. The antenna gain is approximately 3 dBi with a unidirectional radiation pattern. The SAR analysis conducted in proximity of a HUGO human body model resulted in values of 1.478 W/kg for averaged over a 1g of tissue, and 0.356 W/kg for 10g tissue-mass averaging.. Both values do not exceed the limit regulated by the ICNIRP guidelines [9].

3.2 GPS data processing and transmission

In this section, the developed system is tested to validate its practical usability. The designed antenna was capable in receiving the GPS signal. Meanwhile, the developed processing architecture was able to process the data and send it to the local monitoring system/data centre as depicted in Fig. 4.

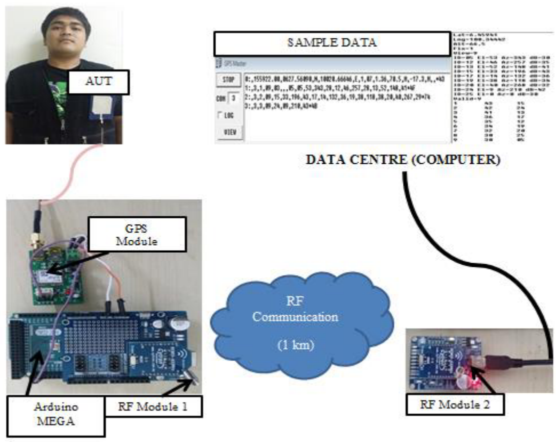


Fig. 4. Practical outdoor measurement setup using the developed location tracking system

The outdoor measurement is conducted in a free space environment. Fig. 4 shows the location tracking system in two parts, firstly, the microcontroller module and secondly, the interface module located in the data centre. Each module has its own functionality. The microcontroller module is attached to the on-body GPS antenna and GPS module to receive Global Positioning System Fixed Data (GGA) and GNSS Satellites in View (GSV) values from available GPS satellites.). Sample of such received data is shown below:

: $GPGSV,3,1,11,10,63,137,17,07,61,098,15,05,59,290,20,08,54,157,30*70
: $GPGSV,3,2,11,02,39,223,19,13,28,070,17,26,23,252,,04,14,186,14*79
: $GPGSV,3,3,11,29,09,301,24,16,09,020,,36,,,*76

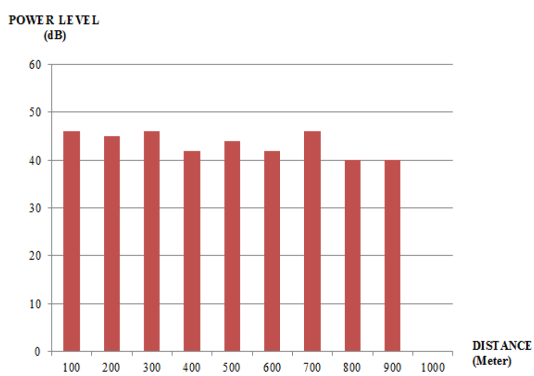


Fig. 5. Power level (dBHz) vs distance (meter).

The received power level is then extracted from the data and is illustrated in Fig. 5. It indicates the power level versus distance between the microcontroller on the human body and data centre. It can be observed that from distance 100 meter to 900 meter, the power level ranges from 40 dBHz to 46 dBHz. However, beyond the distance of 1000 meter, communication between RF module 1 and RF module 2 has ceased to exist. This result validates that the specification RF modules are able to operate up to a maximum distance of 1 km.

4 Conclusions

A low cost location tracking system using wearable GPS antenna is successfully developed and tested. The designed wearable antenna operates at 1.575 GHz with acceptable impedance and axial ratio bandwidths. The antenna is validated to be safe for on body use with SAR values of 1.478 W/kg (averaged over 1g of tissue) and 0.356 W/kg (averaged over 10g of tissue). These values do not exceed the regulatory limit specified in the ICNIRP guidelines. The system can be operated for coverage of up to 1 km of radial distance, and can be improved with the use of high gain antenna at RF modules.

References

1. D. Punetha, V. Mehta, 2014 International Conference on Advances in Computing, Communications and Informatics, 2349 (2014)
2. X.L. Chen, N. Kuster, Y.C. Tan, and N. Chavannes, 6th European Conference on Antennas and Propagation, (2012)
3. C. Park, J. Kim, 2011 Seventh International Conference, (2011)
4. J. Lee, K.E. Khatib, 2010 IEEE Second International Conference, (2010)
5. R.I. Rajkumar, P.E. Sankaranarayanan, G. Sundari, 2013 International Conference on Advanced Electronic Systems, (2013)
6. H. Rajagopalan, Y.R.Samii, 2010 IEEE Antennas and Propagation Society International Symposium, (2010)
7. C.Y. Chow, M.F. Mokbel, T. He, IEEE Transactions on Mobile Computing, 10, 94 (2011)
8. D. Rosner, R. Tataroiu, C. Ilas, A.L. Beciu, O.M. Alexandru,19th International Conference on Control Systems and Computer Science, (2013)
9. P.J. Soh, G. Vandenbosch, F.H. Wee, A.v.d. Bosch, M.M. Vazquez, D. Schreurs, IEEE Antennas and Propagation Magazine, 57, 229 (2015)
10. M.S. Shakhirul, M. Jusoh, A.H. Ismail, M.R. Kamarudin, R. Yahya, M.N.M. Yasin, IEEE Asia-Pacific Conference on Applied Electromagnetics, (2014)