Data Acquisition System for Body-to-body Radio Communication Channel

H. A. Rahim[1], **F. Malek**[1], **K. K. Goh**[1], **V. Ganesan**[1], **F. A. A. Fuad**[1], **N. A. A. Talib**[2], **and F. S. Abdullah**[2]

[1]Embedded, Network and Advanced Computing Research Cluster (ENAC)
School of Computer and Communication Engineering, Universiti Malaysia Perlis
P. O. Box 77, d/a Pejabat Pos Besar, Kangar, Perlis 01000, Malaysia
[2]School of Electrical System Engineering, Universiti Malaysia Perlis
P. O. Box 77, d/a Pejabat Pos Besar, Kangar, Perlis 01000, Malaysia

Abstract— This paper presents a data acquisition system (DAS) for body-to-body radio communication channel by using Labview. In order to analyze the characteristics of channel fading on body-to-body radio communication channel, a real time DAS must be utilized. The software will be integrated in the measurement system that uses an Agilent Vector Network Analyzer (VNA) (model PNA E8362B),desktop and an interface buses (GPIB)-USB cable from National Instrument (NI). A computer connected to VNA will carry out the acquisition of large data. The measurement data, S_{21}-parameter, will be recorded and stored for offline processing usage. In addition, by using this software, it is more convenient and easier to collect a large data set. This software is also able to capture rapid changes of S-parameter values in dynamic human body motions that requires for further investigation. The comparison of data acquisition between without and with the integrated software is analyzed. The results demonstrate that DAS satisfies the requirement to obtain real-time data with minimum error up to 0.02 dB for magnitude and almost 0 degree for phase of S_{11}-parameter.

1. INTRODUCTION

Body-centric wireless communications (BCWC) defines as human-self and human-to-human networking with the use of wearable and implantable wireless sensors. It is a subject area combining wireless body-area networks (WBANs), Wireless Sensor Networks (WSNs) and Wireless Personal Area Networks (WPANs) [1]. In body-to-body radio communication channel experiment involving dynamic movements, data collection is very critical as a slight movement will cause changes on the output results. Therefore, to ensure the efficiency and reliability of the system, there are several requirements need to be properly investigated. Especially, for those dealing with physical layer issues and the one related to medium access and network layers [2]. Due to this reason, the significant section of the current studies on body centric networks has been focusing on the characterization and modeling of the propagation characteristics as well as the transmission channel [3]. According to the research, a variety of investigations has concerned on the characterization of the on-body channel and described how the current human body affects the communication between two or more devices laced on it [4, 5]. However, limited studies have been done on body-to-body channel [6]. The aim of this work is to design and analyze performance of DAS for data collection in dynamic body-to-body radio propagation channel investigation.

2. CHANNEL MEASUREMENT SETUP

The channel measurement system that will consist of an Agilent E8362B vector network analyzer (VNA), textile monopole antennas (TM) and computer with Lab-VIEW™ 7 software as a controller to collect the data. The transfer function measurement mode will be operated in a VNA, where port 1 is the transmitting port and port 2 is the receiving port. This corresponds to a S_{21}-parameter measurement set-up (see Figure 2). The sweep time of the network analyzer, depending on the number of frequency points within the sweep band, will be automatically adjusted by VNA. The frequency band that will be used in the measurement is from 2 GHz to 3 GHz. Two TM antennas will be required, antenna1 will be attached on the subjectA (SubA) which is the transmitter, Tx and the antenna 2 will be attached on the subjectB (SubB) as the receiver, Rx. The experiment will be carried out in a controlled indoor environment at Embedded Computer Research Cluster, Universiti Malaysia Perlis.

No other people will be present when the measurement is running, except two student subjects and the data collectors. The placement of the transmitter (Tx) will be fixed at the right side of upper arm on the SubA and the placement of receiver (Rx) will be fixed at the left side of upper arm on the SubB. The antenna to body separation for both subjects is 10 mm air gap. Two 4 meter low loss semi-rigid coaxial cables will be used in the measurement campaign, manufactured by Huber-Suhner. At first, both of the subjects will be in a static movement for calibration purpose. During the measurement, SubA will be static and SubB will be having dynamic movement. Figure 1 shows the measurement setup utilizing TM antennas worn on two subjects' bodies in the indoor environment.

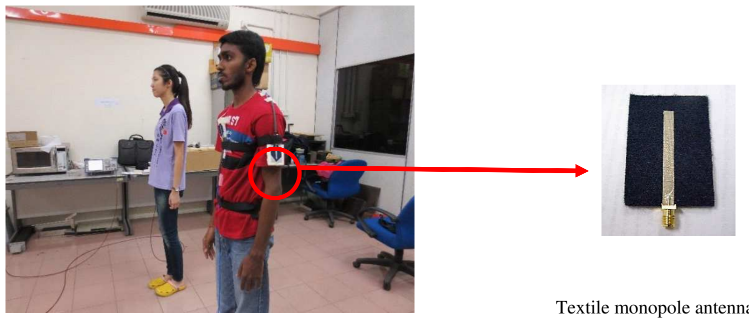

Figure 1: Measurement setup utilizing TM antennas worn on two subjects' bodies in indoor environment.

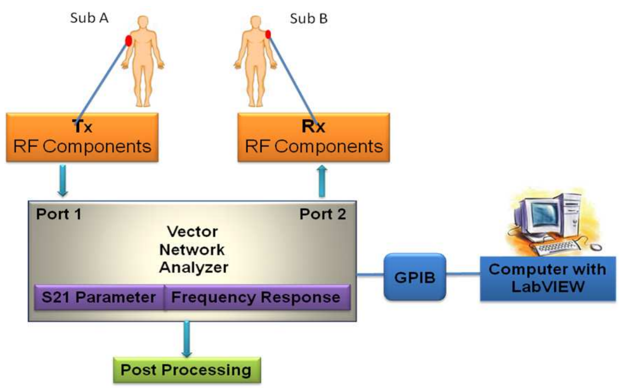

Figure 2: Measurement setup flow diagram.

3. RESULT AND ANALYSIS

The layout is created on the control panel of Labview. The graphical user interface for DAS is used to setup the instrument by using LabView interface through the GPIB card to VNA. The VISA section is the option to select the instrument model to connect with. File path is used to select the particular file location that user wants to save the data. Measurement type consists of four S-parameters; S_{11}, S_{12}, S_{21} and S_{22}, options to choose. The power level is used to select the required power to use for the particular measurement. For display trace there are two options either display phase or magnitude of S-parameter. The default setting of sweep point for this experiment is 1601 points. Besides, the frequency range setup is on the start and stop frequency. Next, the sweep time is the time range requirement to measure and collect the data. The analyzer display shows the sinusoidal graph flow of the result as shown on the screen of VNA (see Figure 3).

Table 1 presents the comparison of measured S_{11} between without and with DAS. The VNA is calibrated before the measurement starts. To validate measurement result, data is taken without DAS. First, frequency range, sweep point and sweep time are configured manually. Second, when the measuring process stops, *Save* button on PNA is pressed to save the data inside the PNA network analyzer. Finally, USB thumb drive is used to save S_{11} parameter from the instrument by connecting to the USB port of PNA and data is transferred to PC for further analysis. Data is saved as *s2p* file. On the other hand, by using DAS, the data is automatically transferred from PNA to the PC. Figure 4 indicates the differences between PNA and DAS data. The S_{11} initial values from frequency of zero to 0.5 GHz are almost equal according to the line graph showin Figure 4.

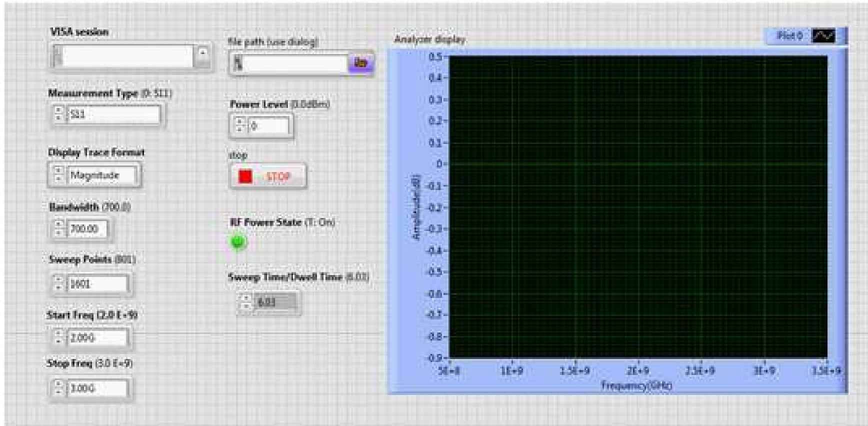

Figure 3: GUI (graphic user interface) of DAS.

The S_{11} magnitude at frequency of 0.5 GHz the PNA is 0.218359 dB and in DAS magnitude is 0.268300 dB. Both data has minor difference of 0.05 dB. The PNA magnitude is −0.011856 dB and DAS magnitude is 0.017873 dB with small difference of 0.006 dB at 1.1 GHz.

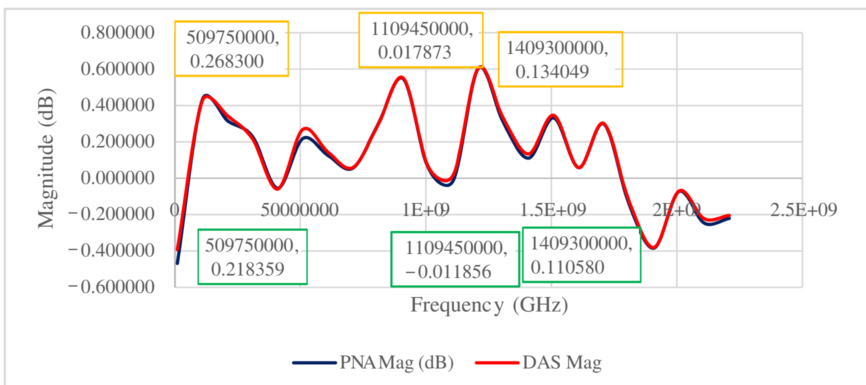

Figure 4: Comparison of PNA and DAS magnitudes in dB.

There is a small mismatch between PNA and DAS magnitudes around 0.02 dB at 1.41 GHz. In general, the overall magnitude results collected from the PNA and DAS are equal. This proves that the DAS satisfies the requirement to obtain real time data with minimum error. Figure 5 shows the phase data in degree. It is observed that there is very small variation between DAS and PNA results. All the data with very small difference can be eliminated after round off the decimal place. This graph also clearly shows that the phase data collected using DAS achieves the requirement by attaining almost equal results. This proves that the data acquisition system

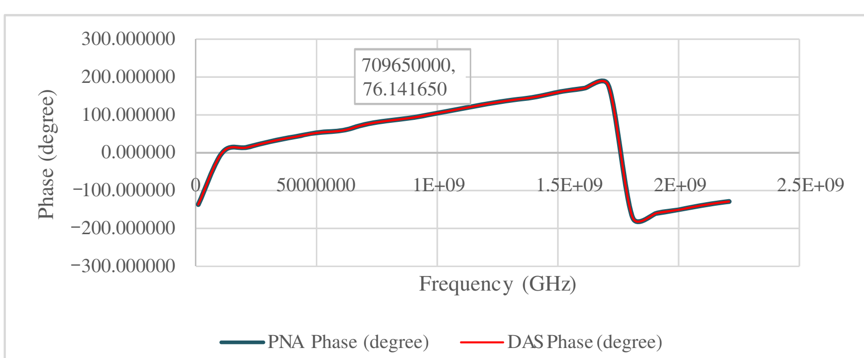

Figure 5: Comparison of PNA and DAS phase in degree.

Table 1: Comparison of measured S_{11} between without and with DAS.

Frequency (Hz)	**Without DAS**		**With DAS**	
	Magnitude (dB)	Phase (degree)	Magnitude (dB)	Phase (degree)
10000000	−0.467869	−136.450500	−0.392691	−136.505100
109950000	0.432964	0.774235	0.427213	0.634953
209900000	0.315940	14.332120	0.343037	13.643520
309850000	0.229078	30.035230	0.215615	29.792090
409800000	-0.054616	42.314820	-0.059438	42.060970
509750000	0.218359	53.683180	0.268300	53.363010
609700000	0.126100	59.233550	0.144890	58.931260
709650000	0.055836	76.379070	0.059058	76.141650
809600000	0.296493	85.646070	0.293478	85.445640
909550000	0.547233	94.204190	0.551720	94.053250

achieves the requirement and it is reliable and valid to be used for. This concludes that DAS can synchronize with the measurement data in the PNA.

4. CONCLUSION

This paper discusses a design of DAS for dynamic body-to-body radio communication channel using Labview software. The comparison of data acquisition between without and with the integrated software is analyzed. From the obtained results, it is shown that DAS satisfies the requirement to acquire real-time data with minimum error up to 0.02 dB for magnitude and almost 0 degree for phase of S_{11} parameter. As DAS will be employed for data collection in dynamic body-to-body radio channel, this software is capable of capturing rapid changes of S-parameter values in dynamic motions. Hence, this software is very potential to be used in the evaluation of channel fading of dynamic body-to-body radio propagation channel. Further work will be carried out to measure S_{21}-parameter for dynamic body-to-body radio communication channel using DAS.

REFERENCES

1. Hao, Y., "Antennas and propagation for body centric wireless communications," *2011 IEEE Int. Conf. on Microwave Technology & Computational Electromagnetics (ICMTCE)*, Beijing, China, May 22–25, 2011.
2. Ullah, S., H. Higgins, B. Braem, B. Latre, C. Blondia, I. Moerman, S. Saleem, Z. Rahman, and K. S. Kwak, "A comprehensive survey of wireless body area networks," *J. Med. Systs.*, Vol. 36, No. 3, 1065–1094, 2012.
3. Errico, R. D. and L. Ouvry, "A statistical model for on-body dynamic channels," *Int. Jof. Wireless Inf. Networks*, Vol. 17, 92–104, 2010.
4. Liu, L., D. Doncker, and C. Oestges, "Fading correlation measurement and modeling on the front side of a human body," *3rd European Conference on Antennas and Propagation (EuCAP) 2009*, 969–973, Berlin, Germany, Mar. 23–27, 2009.
5. Fort, A., C. Desset, J. Ryckaert, P. De Doncker, L. Van Biesen, and P. Wambacq, "Characterization of the ultra wideband body area propagation channel," *2005 IEEE Int. Conf. on Ultra-Wideband (ICU 2005)*, Sep. 5–8, 2005.
6. Rosini, R., R. D. Errico, and R. Verdone, "Body-to-body communications: A measurement-based channel at 2.45 GHz," *2012 IEEE 23rd Int. Symp. on Personal Indoor and Mobile Radio Communications (PIMRC)*, 1763–1768, Sydney, Australia, Sep. 9–12, 2012.