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Error Rate Performance through Body Surface to Body Surface Human Body Area Channel

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ABSTRACT: The bit error rate performance evaluation has been done for Human body area channel model CM3 by comparing the efficient rake receiver structures for UWB for different signaling techniques. The BER has been obtained over the power delay profile using M- ary signaling schemes i.e. MPPM (M-ary pulse phase modulation) and M-ary BOK (bi-orthogonal keying) and thus with the results obtained, performance evaluation for different rake receivers structures has been performed. Through simulative investigations, it has been analyzed that MBOK is more suitable for UWB CM3 and for rake structures, all-Rake is the best rake structure but it's an ideal rake receiver and cannot be practically implemented whereas S-rake receiver gives better performance over P-Rake for optimum number of taps.

KEYWORDS: HBAC, power delay profile, bi-orthogonal keying, pulse position modulation, rake receiver.

1 INTRODUCTION

IEEE 802.15.6 has provided an international standard for a short range i.e. human body range, low power and highly reliable wireless communication with high QoS, data rate and least interference to be used in, on and around human body for addressing the best applications **[1], [2].** This communication link setup was thus titled as "Human Body Area Channel".

This concept of body area networks was given by Zimmermann in 1996. The IEEE 802.15 Working group developed the IEEE 802.15.6 standard to operate low power devices and to communicate on and around the body. This standard was approved in 2012 for wireless communication in HBAC. In comparison to classical wireless communications, for body area communication, the human body serves as a communication medium either passively or favorably. The required knowledge about BAN extended its area from wireless communications to bio-electromagnetics. The first author in body area communications had mobile communications and personal computer communication as strong areas that led to research on body area networks in 2005. It was analyzed that channel modeling is the most prior step to explore and analyze HBAC **[3].**

As described in **[4],[5],** HBAC is a special wireless communication network designed and developed for human body to supervise, monitor and communicate different signs like temperature, blood pressure and ECG etc. and these signs can be monitored by installing sensors on human skin or clothes. A cellular phone can be employed to monitor the communication to and from the human body to the external world. It has been used for many services like user identification, wireless headphone, medical treatment including cancer, diabetes, asthma treatment etc. **[6]**. The agencies like NICT, IMEC, ETRI and NIST are involved in the formulation of HBAC empirical models whose measurement results are considered as a base for obtaining new results and parameters.

The motivation of our work is to evaluate the performance metrics of UWB CM3 in terms of BER with rake reception. The contribution to this paper is obtaining the bit error rate for different signaling schemes on UWB channel model and thus analyzing the efficient technique for the same.

The paper has been organized by introducing to HBAC model in the next section. Following it is the results and observations sections which describes the performance metrics of the channel model. And in the last section, the paper is concluded with the overall performance evaluation of the same.

2 HBAC Model

Channel modeling is one of the biggest challenges for HBAC. Transmitter and receiver are the integral parts of HBAC models. Based on the positions of nodes, different channel models are formulated for different frequency bands that are contributed by IEEE 802.15 group. The signaling schemes are used as the performance parameters for the channel models by evaluating their BER respectively. The important digital methods for modulation include amplitude shift keying (ASK), frequency shift keying (FSK) and phase shift keying (PSK) and these are well suitable for MICS, ISM or HBC band communication.

IR-UWB and multi-band orthogonal frequency division multiplexing (MB-OFDM) are the two technologies for UWB and the UWB receivers are usually based on pulse energy detection or correlation demodulation with template waveform. MIMO (Multiple inputs multiple outputs) can be combined with UWB for providing good performance. Modulations like OOK, M-PSK and BPPM are employed to analyze UWB band **[3], [6], [7]**. Different signaling schemes have been used to develop an efficient and reliable system**.** Signaling schemes like GFSK for MICS and WMTS bands **[1]**, whereas in case of SC-UWB, OOK, PPM, PSK, and BPPM have been used for improving BER and to lessen the power consumption. Techniques like pulsed-chirp UWB, CO-UWB, DS-UWB have been proposed for UWB. Also MIMO+UWB can be best suitable for SNR performance **[8]**.

To counter the effects of fading, rake reception is used. The multiple correlators in rake receiver multiples received signal with the time shifted versions of locally generated code sequence. The rake receiver take advantage of MPC's to improve SNR.

The model presented in this paper is a statistical model based on measurements carried out by NICTA for UWB band.

The UWB range is for 3.1-10.6 GHz and this range of frequency is operable for low data rate as well as high data rate communication. Basically two channel models can be designed for this band i.e. CM3 which is for body surface to body surface communication and CM4 that is for body surface to external communication **[3], [9].** This paper presents the CM3 performance metrics in terms of BER for different signaling schemes. UWB employs very narrow and short duration pulses as modulation signal thus covering large bandwidth.

3 Results and Observations

In this paper performance evaluation for UWB channel model CM3 has been performed and the rake reception has been performed over each signaling scheme. The first step performed is to obtain the power delay profile of the channel model. The model parameters are considered from NICTA's measurements as in **[9]**. In this paper, the power delay profile is generated with 100 channel realizations. On an average 53 multipath components (delay bins) are produced from the channel realizations of the power delay profile. The figure shows the generated power delay profile. It fluctuates as a function of number of paths for each realization.

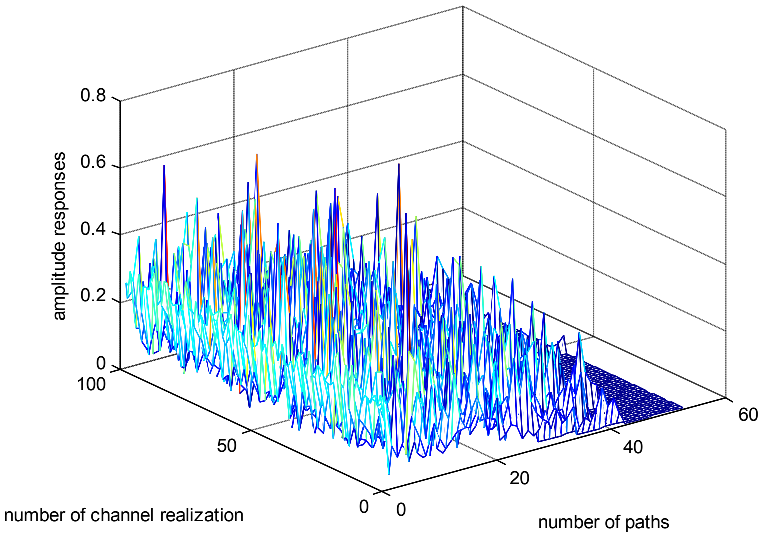

Fig. 1. Power delay profile for CM3

The modulation is performed over the generated power delay profile and BER has been obtained for the same with the rake receiver. The signaling schemes that are applied over the CM3 PDP here are M-PPM and M-BOK modulations.

The Rake receivers that could be employed for the given channel model are A-Rake, S-Rake and A-Rake receivers. The S-Rake and P-Rake are used with 2, 16 taps for obtaining an efficient system. The results that are obtained could be shown in the figure.

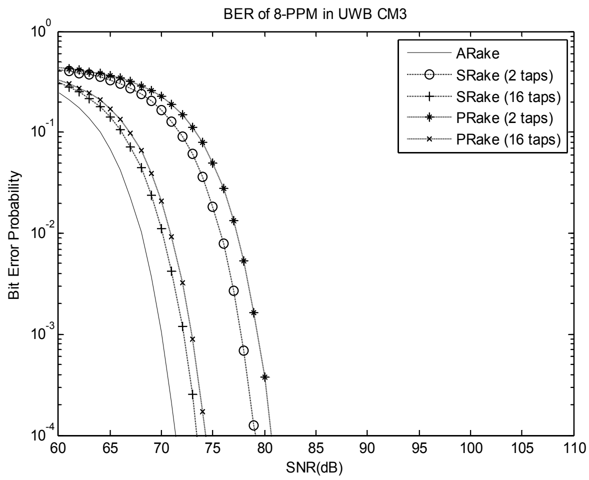

Fig. 2. BER v/s SNR for 8-PPM

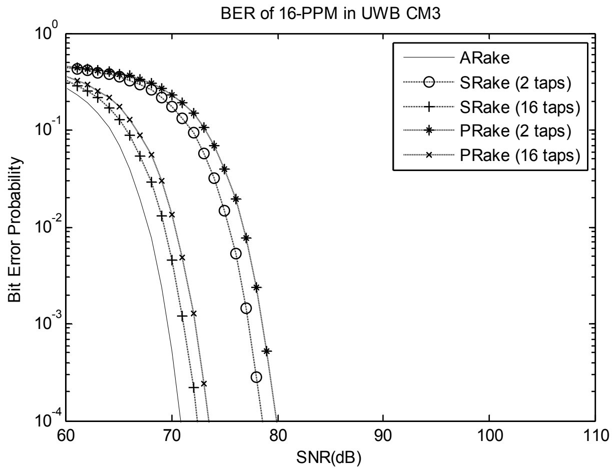

Fig. 3. **BER v/s SNR for 16-PPM**

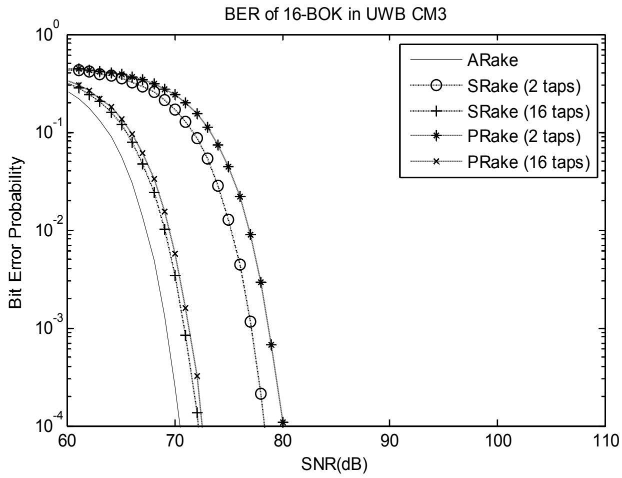

Fig. 4. **BER v/s SNR for 16-BOK**

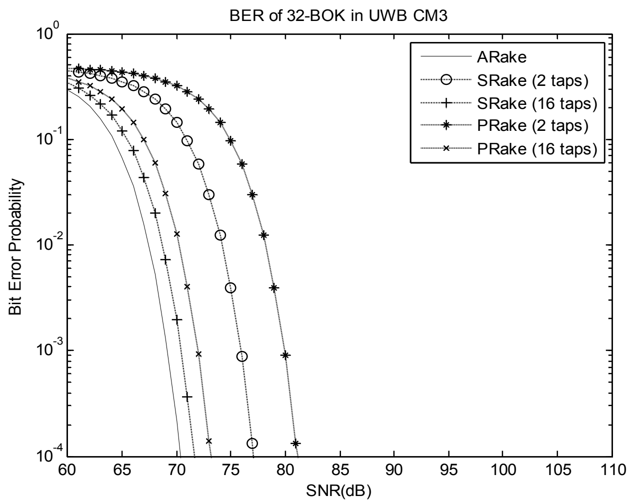

Fig. 5. **BER v/s SNR for 32-BOK**

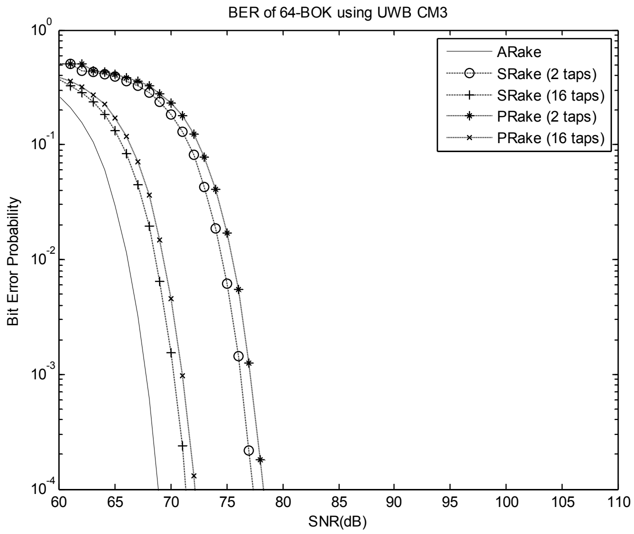

Fig. 6. BER v/s SNR for 64-BOK

Through the simulative investigations, it can be analyzed from all the figures above that, all rake shows the best results among other rakes. A-Rake structure is an ideal structure and cannot be brought into implementation. Thus it can be set as a benchmark for the performance evaluation for the other rakes.

Table.1. Error Rate Analysis for M-PPM

		8-PPM		16-PPM	
Target BER	**No. of taps**	**S-rake**	**P-Rake**	**S-rake**	**P-Rake**
10^{-1}	**2**	71.82dB	73.3dB	71.73dB	72.9dB
	16	66dB	67dB	65.7dB	66.7dB
10^{-3}	**2**	77.88dB	79dB	77dB	78.5dB
	16	72dB	73dB	71.22dB	72.3dB

Considering the M-PPM technique, the results have been evaluated considering the target BER. From the above table, it can be evaluated that S-Rake shows better results than P-Rake structures and 16-PPM is more efficient than 8-PPM. Thus, as the value of M increases, the performance becomes better. Also, it can be observed that with the increase in number of taps of Rake receiver, the SNR falls by approximately 6dB to achieve the same BER.

Now the same analysis has been performed for M-BOK i.e. M-ary bi orthogonal keying. It's an efficient coding/signaling scheme for UWB channel models. This has been performed for M= 16, 32 and 64 with S-Rake and P-rake. M=2 BOK is similar to BPSK.

Table.2. Error rate analysis for M-BOK

		16-BOK		32-BOK		64-BOK	
Target BER	**No. of taps**	**S-rake**	**P-Rake**	**S-rake**	**P-Rake**	**S-Rake**	**P-Rake**
10^{-1}	**2**	71.93dB	74dB	71.47dB	73.12dB	71.55dB	72.8dB
	16	65.74dB	66.1dB	65.69dB	65.74dB	65.54dB	66.48dB
10^{-3}	**2**	77dB	79.6dB	76.4dB	78.19dB	76.3dB	77.5dB
	16	71.13dB	71.63dB	70.5dB	70.6dB	70dB	71dB

Thus the observations made from the above table are that the same happens as in case of M-PPM that S-Rake is better than P-Rake but increasing the number of fingers degrades the performance. It can be analyzed from the above results that 64-BOK is best amongst the ones with low values of M. M-Bok provides better signaling than M-PPM.

4 CONCLUSION

The bit error rate performance evaluation has been performed on HBAC model UWB- CM3 using M-ary signaling schemes i.e. M-PPM and M-BOK. The results have been analyzed using rake receivers with A-Rake, S-Rake and P-Rake structures using 2 and 16 taps/ fingers. It has been analyzed from the results that performance of S-Rake is suitable for all signaling schemes than P-Rake with optimum number of fingers. 16-PPM is better than 8-PPM and 64-BOK shows better performance over others. Concluding this M-BOK gives better performance than M-PPM.

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