A HYBRID DISCRIMINATOR-DECISION MULTI-CHIPS SECTIONS ULTRA-WIDEBAND RECEIVER [+]

تصميم مستقبل للنظام ذو الحزمة العريضة جدا يستند على وحدات المميز والمقرر

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Abstract:

In this paper, a suboptimal Ultra-wideband Rake receiver is proposed and simulated to decrease the multi-user interference in multi-path channel. The proposed receiver is based on detecting a single pulse alone in the Rakes' fingers and supplying it to a decision or discriminator devices. After that, another discriminator unit is placed after the maximum ratio combining section to discriminate the metric value of the received bit. The obtained simulated results show that the proposed Rake receiver has the best performance in terms of achieving Low Bit Error Rates (BERs) as compared with the conventional Rake that does not include neither decision nor discriminator except the decision unit that decide the estimated bit. The proposed Rake receiver and the obtained results are simulated using Matlab 7 and the network simulator package ver. 2 (NS2).

المستخلص:

في هذا البحث ، تم تصميم و تمثيل مستلم شبه مثالي نوع Rake لنظام ال Ultra-wideband لتقليل التداخل الناتج بسبب تعدد المستخدمين (المشتركين) في القناة المتعددة الطرق . إن المستلم المقترح مستند على اكتشاف نبض و حيده في أصابع ال Rake ويجهز إلى وحدة المميز . بعد ذلك، وحدة مميز أخرى موضوعة بعد وحدة نسبة الدمج القصوى maximum ratio combining لتمييز القيمة المترية للقطعة المستلمة ال bit . توضح النتائج التي تم الحصول عليها، أن مستلم ال Rake المقترح له أفضل أداء من ناحية انجاز نسب خطا القطعة المنخفضة BERs مقارنة بال Rake التقليدي الذي لا يتضمن لا وحدة قرار و لا مميز ما عدا وحدة القرار التي تقرر القطعة المخمنة ال Estimated bit . إن مستلم ال Rake المقترح و النتائج التي تم الحصول عليها تم برمجتها و تمثيلها باستخدام برنامج ال Matlab 7 و محاكي الشبكة NS2 ver.2.

Introduction:

High-capacity, high-data rate, simple, power-efficient, low-cost, and small UWB receivers design is a challenging task . There are several receivers proposed for UWB communication . A fully coherent receiver like optimal matched filtering , which is employed by Rake reception , performs well but at the expense of extremely high computational and hardware complexity . In general , a coherent receiver requires several parameters concerned with the received signal, radio channel, and interference characteristics. Multipath delays, channel coefficients for each delayed MPCs, and distortion of the pulse shape need to be estimated for optimal coherent reception. Note that, in UWB channel, the number of multipath components is very large (can be a few hundred). Also, the transmitted power and the power in each of these MPCs will be very low. Therefore, estimating the delays and coefficients from the received MPCs is an extremely challenging task.

[+] **Received on 25/8/2010 , Accepted on 10/7/2011 .**

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Noncoherent (or lightly coherent) like the Transmit Reference receiver designs for UWB systems relax the amount of information that needs to be estimated accurately for the detection of the transmitted bits. In other words, the synchronization, channel estimation, and pulse shape estimation is not as stringent as in the case of the fully coherent [1].
However, in this paper a coherent Rake ultra-wideband receiver is proposed and simulated that will be used in indoor Wireless Personal Area Network (WPAN).

UWB Receiver Options:

A general UWB receiver structure is shown in Figure (1) [1,2]. The optimal matched filtering implemented as Rake with a simple single correlator receivers correlate the received signal with a local template. The local template can be a pulse template or a frame template. In either case, the template needs to be estimated locally based on the received signal by transmitting some training sequences. This type of receiver, which correlates the received signal with a template, is often referred as "locally generated reference" systems or simply as "correlation" receivers (switch at point 2). Alternatively, the received signal can be correlated by itself, which leads to "autocorrelation" receiver structures (switch at point 1) i.e., the TR receiver.

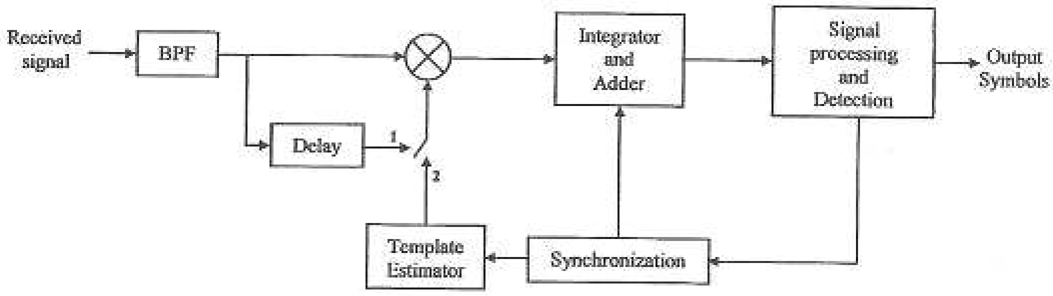


Figure (1): A general UWB receiver structure [1]

Note that in Rake reception often each possible finger can be implemented in parallel branches and these fingers are combined after the integrator. Alternatively, the local template might include all the finger elements [1].

1- UWB Rake Receiver

The Rake receiver is promising candidate to reduce the required SNR. The robustness of UWB signals to multipath fading is due to their fine delay resolution, which - in combination with a Rake receiver - leads to a high multipath diversity gain. MPCs having delays of the order of nanoseconds (approximately equal to the inverse of the spreading bandwidth) are resolved by the Rake [3]. However, in order to fully take advantage of this high delay resolution, the Rake receiver must be able to capture most of the energy carried by a very large number of different multipath signals [4,5].

2- Types of Rake Receivers

Depending on the number of MPCs that can be captured by Rake receiver, there are three types of Rake receivers. These are: all Rake (ARake), selective Rake (SRake), and partial Rake (PRake) receivers.

The All Rake (ARake)

The ideal Rake receiver structure captures all of the received signal power by having a number of fingers equal to the number of MPCs. To achieve this, it requires L_r — $T_{md}JT_c$ taps. The so called All Rake (ARake) is such a receiver. The problem with this approach is the need for an infinite number of Rake branches, which also means an infinite number of correlators. Providing a receiver with a large number of correlators, however, increases the receiver complexity too much [1,5].

The Selective Rake (SRake)

In practice, non-perfect Rake receivers are considered. Non-perfect Rake receivers do not receive all MPCs and the number of fingers is less than the number of arrived components. Two main non-perfect Rake receiver structures proposed for UWB systems are the Selective Rake (SRake) and Partial Rake (PRake) receivers [1,5]. The SRake only uses the L_r strongest propagation paths. Information on the channel impulse response is required in order to use the SRake. This type of Rake will be used in this research.

The Partial Rake (PRake)

The PRake receiver is a simplified approximation to the SRake. The PRake involves combining the L_r first propagation paths. The principle behind this approach is that the first MPCs will typically be the strongest and contain the most of the received signal power [1,5].

<u>Chip Discriminator Rake Receiver:</u>

The chip discriminator technique is a one of the solutions to mitigate the system performance loss due to strong interferer signals in the indoor multipath environment. This is done through the application of a chip discriminator device to the demodulator output that compares the energy collected from a demodulated received chip to a threshold. If the demodulation metric exceeds the threshold, it is discarded; otherwise, the received chip contributes to the bit estimate.

Assuming there is a relatively large near-to-far power ratio. This technique applies an acceptance level threshold to each chip sample prior to summing for symbol decisions. Without this discrimination a chance hit in the narrow chip correlation window by a very strong pulse can erroneously bias the symbol decision. By discarding large level chips from the N_s sum, much of the performance can be recovered [6].

Chip discriminator Rake receiver presented in [7] is shown in Figure (2). In which a single chip discriminator device is located at each Rake finger output that selectively removes finger demodulation metrics based on the product of a constant threshold level T_{in} and the channel tap coefficient a_s. Each resolved MPC that exceeds the chip discriminator threshold is discarded from the bit decision process. Otherwise a large demodulated Rake finger metric continues to corrupt the estimated metric for entire bit duration.

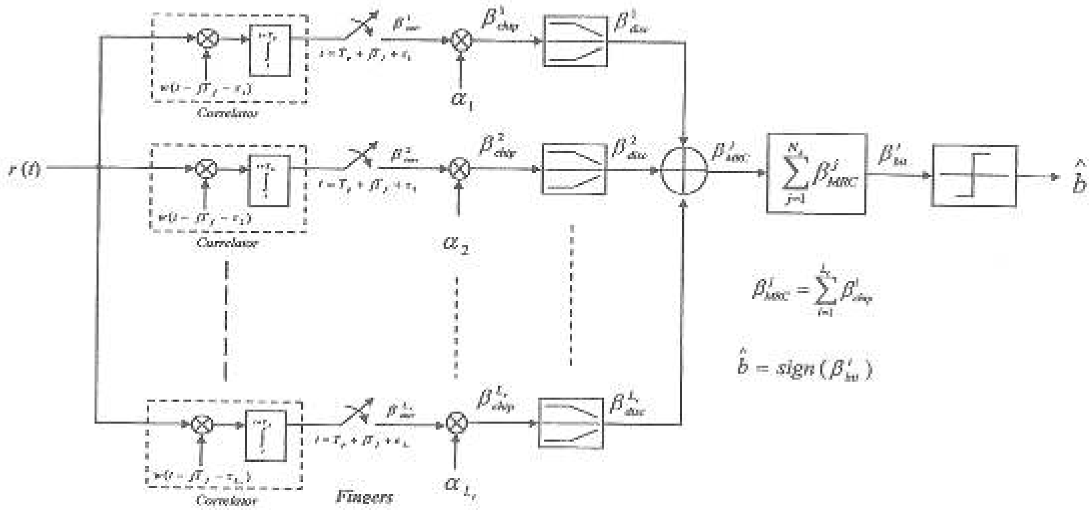


Figure (2): The chip discriminator Rake receiver [7]

This method is simply an increase in complexity to the MRC of the conventional Rake receiver, where the chip discriminator device given in Figure (3) restricts demodulated MPCs that exceed a certain threshold from contributing to the bit estimate metric β'_{bit} .

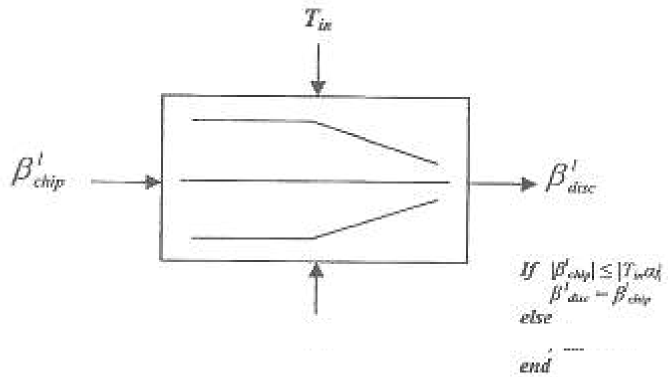


Figure (3): The chip discriminator [7]

The β'_{chip} whose magnitude exceed the input threshold level $TL_{in} = |T_{in}\alpha_1|$ is assumed to be corrupted by an interferer collision and is discarded such that the discriminator output β'_{disc} becomes zero and contributes nothing to the current quantity β'_{bjt} that is used for estimating the bit. If β'_{chjp} is within the threshold boundary then the finger output is uncorrupted and it is passed
to the combiner unaltered. As seen in Figure (3), each Rake finger output β'_{corr} is weighted by the estimated channel tap coefficient α_l to create the chip discriminator input metric β'_{chjp} as in ordinary MRC; the resulting magnitude β'_{disc} is then calculated as:

$$\beta^{l}_{disc} = \begin{cases} 0 & for \quad \left|\beta^{l}_{chip}\right| > \left|T_{in}\alpha_{l}\right| \\ \beta^{l}_{chip} & for \quad \left|\beta^{l}_{chip}\right| \le \left|T_{in}\alpha_{l}\right| \end{cases} \qquad \text{……………………………………….. (1)}$$

<u>The Proposed Ultra-Wideband Receiver:</u>

In the conventional Rake receiver, a single decision block is placed at the output of the correlation stage in each finger, i.e., the decision is based on the single chip (finger) not on bit decision. So, a threshold detection device is placed directly after the correlation process before the omitted MRC section. This would again decide whether a chip pulse β'_{chjp} is detected true or wrong. The decisions in these cases take the values {-1 , +1}. Summing unit is placed then to sum these L_r decisions. The result is repeated and summed N_s times again to enforce a final decision unit which decides the estimated bit $b^{\wedge}$.

The proposed Rake receiver in this paper is shown in Figure (4). It has one discriminator in each finger. The proposed receiver thri 5 ; and small near-far power ratios; *I/S* is very large, where *I* and *S* are the interfere. ... ...er of interest signal respectively with fixed SNR. If the SNRs are increased, *S* will increase β'_{corr}, and cause increasing the metric value of *β'chip* which in this case exceed the threshold level very largely. According to equation (1), most of the uncorrupted chips would be discarded and caused BER degradation that makes the system completely fail in large and moderate SNRs.
The discarded pulse (chip) is lost in this case and this degrades the performance of the estimated bit. Hence, a part of the received pulse energy is probed.
To deal with this problem, another discriminator unit is put after the summation unit that sums the metric values of the bits that relate to a certain symbol. This will enhance the performance of the proposed Rake receiver especially in large interferer power. Another summation unit is inserted after the discriminator section, which is responsible to sum the metric values of the total number of frames that are assigned to each symbol. The output bit is estimated using a decision unit.

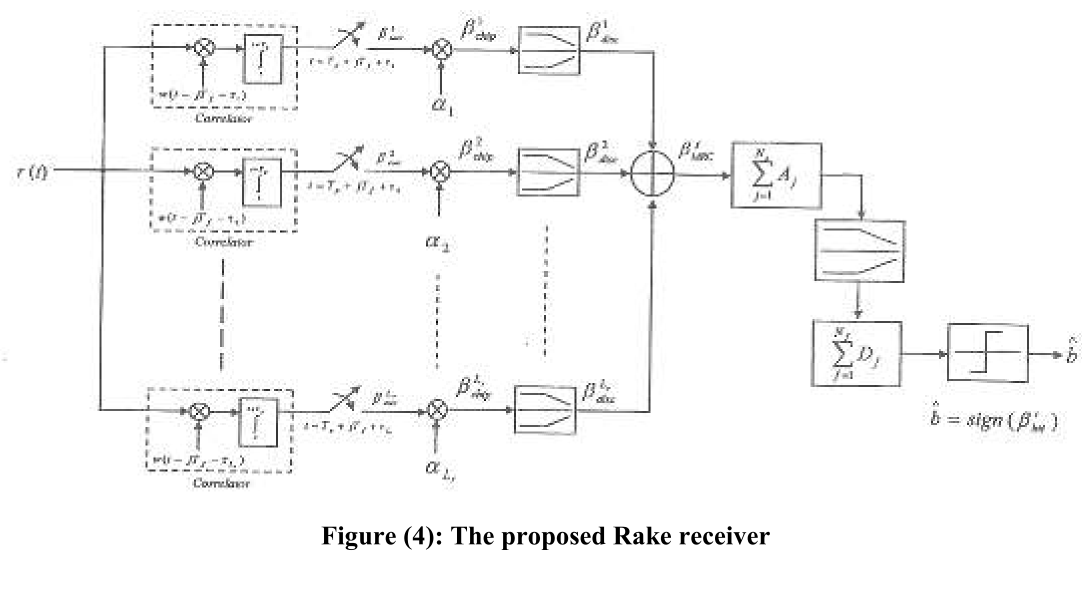
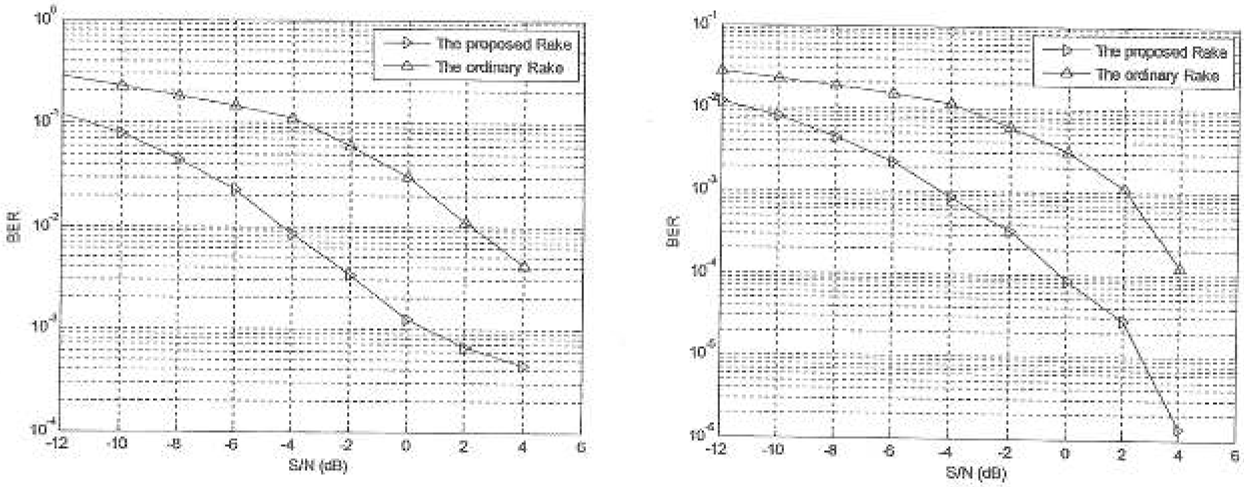


Figure (4): The proposed Rake receiver

Performance of the Proposed Receiver

With Single User

A simulation is done to study the performance of the proposed receiver as a function of the received S/N per frame at the receiver input for a number of frames N_f = 8. Figure (5a) shows the performance without the effects of inter-frame interference and inter-symbol interference for a single user (N_u = 1). The T_g is chosen to be 60 bins. In this case the channel response to the transmitted pulse is completely died out before the transmission of the next pulse. It's clear from the result of the simulation that the proposed Rake receiver outperforms the conventional Rake receiver. The reasons for this result are the using of multi-discriminator units before and after the maximum ratio combining section. Figure (5b), shows the performance of the proposed receiver when N_f is increased to 12. Again, the proposed Rake receiver is outperformed the conventional one in all values of BER. Also, its noticed that the BER values are decreased as compared with Figure (5a).

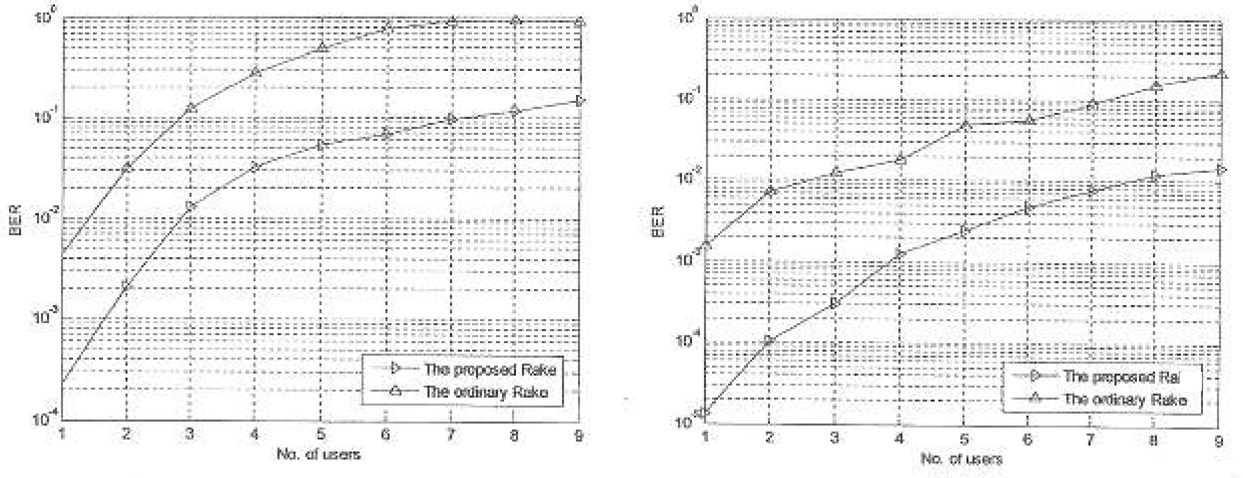


(a) $N_f = 8$ *(b)* $N_f = 12$

Figure (5): BER as a function of S/N

With Multi Users

A random scenario for the movements of the interferer users is used in this part of the simulation. The interferer user can be represented with slow movements relative to the fixed desired user. In each transmitted bit for all users, the interferer user has a different location that cause different channel realization. The powers of the interferers' users can be received by the desired user have also different values. The simulation results for transmitted power of the desired user *PT1* = - 95 dBm/Hz is now presented. The number of frames N_f is set to 8. From Figure (6a), it's clearly noticed the degradation in the BER values is because of the random d_{int} which is $0 < d_{int} < 8$ m. In addition to the previous reason, the small *PT1* value cause large BERs degradations for both receivers as shown in Figure (6b). In anyway, it's obvious that the proposed receiver has the best performance for all values N_u.



(a) $N_f = 8$ (b) $N_f = 12$

Figure (6): BER as a function of no. of users with PT1= -95 dBm/Hz.

If N_f is now increased to 12 resulting in a very low BER values that enhanced the performance of the proposed Rake receiver as shown in Figure (6b). It is clearly observed that the proposed Rake receiver outperforms the conventional Rake receiver.

Conclusions:

The aim of this research is to propose and design an Ultra-wideband Rake receive and is capable to decreased the multi-user interference and enhance the BER performance as compared with the ordinary Rake. So, many concluded point are arise in this paper. The proposed Rake receiver makes a multi discriminator decisions before the maximum ration combining section that enhanced the summation process due the preserving of the chip energy. In other words, the energy of the chips are largely does not be lost. The discriminator unit after the maximum ratio combining section is also prevents the metric of the symbol to be lost. This would also enhance the BER performance as compared with the conventional Rake. It's also shown that the performance of the proposed receive is outperformed the performance of the ordinary Rake in multi user case.

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