Journal of Theoretical and Applied Information Technology
15th August 2017. Vol.95. No.15

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

ANALYSIS PERFORMANCE OF HYBRID SUBCARRIER MULTIPLEXED OCDMA SYSTEM BASED ON AND SUBTRACTION DETECTION AND SINGLE PHOTODIODE DETECTION

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ABSTRACT

This paper demonstrates the comparison of two detections which are; AND subtraction detection and single photodiode detection (SPD). In this work, we evaluate the performance of hybrid subcarrier multiplexing (SCM) of spectral amplitude coding optical code-division multiple-access (SAC-OCDMA) system based on these two detections. SAC-OCDMA is applied due to its capability to reduce the effects of Multiple Access Interference (MAI) by employing code sequences with fixed-in phase cross correlation. This system utilizes the Recursive Combinatorial (RC) code as a one of the SAC-OCDMA codes. A part from that, SCM scheme is efficient to promote the channel data rate of OCDMA system. Hence, the hybrid technique is expected to boost up the spectral efficiency of the OCDMA system by providing large number of simultaneous users with fewer optical channels. The maximum allowable number of concurrent users can be improved by rising the number of subcarrier without effecting the number of code lengths and SAC-OCDMA codes. The result reveals that the implementation of SPD detection gives excellent performance in hybrid SCM SAC-OCDMA system in comparison to AND subtraction detection. This is due to the fact that the effects of MAI and phase induced intensity noise (PIIN) are suppressed at the optical domain.

Keywords: *Subcarrier Multiplexing, Hybrid SCM OCDMA, AND Subtraction Detection, Single Photodiode Detection (SPD), Recursive Combinatorial (RC) Code*

1. INTRODUCTION

Currently, faster speed, trusted telecommunication and stronger data network are the main demands in access networks. Researchers and network providers' need to face huge problem to design high capacity network in order to manage the diverse and heavy data traffic. Fortunately, OCDMA technologies have the capability to overcome these constraints as it have numerous beneficial features where it can support asynchronous access network [1], secure transmission, and also support large number of users [1]. Besides that, it has the ability to permit various users with similar bandwidth and high level security to access the system concurrently. The increase demands for higher spectral efficiency in fiber optic communication systems have driven the combination of OCDMA with subcarrier multiplexed (SCM) [1].

The definition of optical subcarrier multiplexing (SCM) is that the numerous signals are multiplexed in the radio frequency (RF) domain and it will transmit by a single wavelength [2]. SCM technique is an attractive technique since it can increase the data rate while boosting the number of users and spectral efficiency of the hybrid system. By utilizing this technique, expanding number of subscribers can be done by adding the number of subcarrier without enhancing the number of SAC-OCDMA codes and codelengths [3] .

In addition, SCM techniques offer more mature usage for common microwave devices compared to

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

optical devices. Apart from that, the microwave filters are more effective rather than their optical counterparts in terms of frequency selectivity [4]. Besides that, costing for the system application are affordable. The transmission of multi-channel digital optical signals to a local area network is a good proposal [4].

However, there are various limitations affects the performance of the hybrid SCM OCDMA system. First, there are several noises such as PIIN, MAI, thermal noise, shot noise and intermodulation noise, IMD but MAI and PIIN are the primary noise sources that impact the system performance degradation. This noises occur owing to the overlapping optical spectral of various users. So that, the SAC approach with unity cross correlation was suggested [5] to diminish the MAI and PIIN noises. There are several codes have been proposed based on SAC to overcome this issue, such as Double Weight (DW) code, Enhanced Double Weight (EDW) code, Modified Double Weight (MDW) code and Modified Frequency Hopping (MFH) code but these codes suffer from various limitations such as long code length, the number of weight and variable cross correlation. Increasing the number of code length will increase the number of users and wider bandwidth. Then, more noises will be created in the system. So, it will limit the flexibility of the code parameter. Thereby, in this research we applied RC code. RC code are chosen based on some benefits such as unity cross-correlation which is one; the codelengths is smaller compare to other code and flexibility in choosing code parameters.

Another main element in OCDMA system is the detection part of the receivers. A good detection will only detect selected codes, and suppress dominant noises, thus enhancing the OCDMA system performance. The detection in OCDMA is divided into two types which are coherent and incoherent [9]. Recently, incoherent detection has numerous advantages compare to coherent detection. The system complexity is reduced as it does not require phase synchronization. On top of that, it also does not need phase information knowledge when detecting the transmitted signal. In addition, incoherent detection performed in unipolar behaviour with respect to the coding operation while coherent detection performed in bipolar detection. Thus, it can show the incoherent detection is the best approach rather than coherent detection.

In this works, we consider the AND subtraction detection and SPD detection. The performance of the hybrid SCM OCDMA system is evaluated and compared with respect to the utilization in order to monitor how each of the detection, impact on the better performance of the hybrid subcarrier multiplexed optical network.

2. TYPES OF DETECTIONS TECHNIQUES

2.1 AND Subtraction Detection Technique

AND subtraction detection is an improved method from the complementary detection method. Figure 1 specified the implementation of hybrid SCM OCDMA system by installing AND subtraction detection method. At the transmitter part, the data's are electronically modulated with different microwave subcarriers at particular frequencies. Then, the subcarriers are joined together and driven through a modulator to optically modulated onto RC code sequence generated [10]. Depends on the RC code structure, each code sequence is allocated with a different wavelength. Then, the optical combiner combined the *m* modulated code sequences and transmits it through the optical fiber.

At the receiver part where AND detection is utilized, the incoming signal is splitted into two parts which are upper part and lower part. The signal for user K was connected with its own signal on the upper part while the cross correlation taking place on the lower part. It resulting from AND operation between signal user *K* and user *L* with the signal in the upper part. Both parts will then be driven through a photo detector each. Using an electrical subtractor, the overlapping data will be eliminated from the necessary code. Hence, the interference signals from neighbouring code will be eliminated and consequently, the PIIN noise at the photo detector will be suppressed.

Journal of Theoretical and Applied Information Technology
15th August 2017. Vol.95. No.15

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

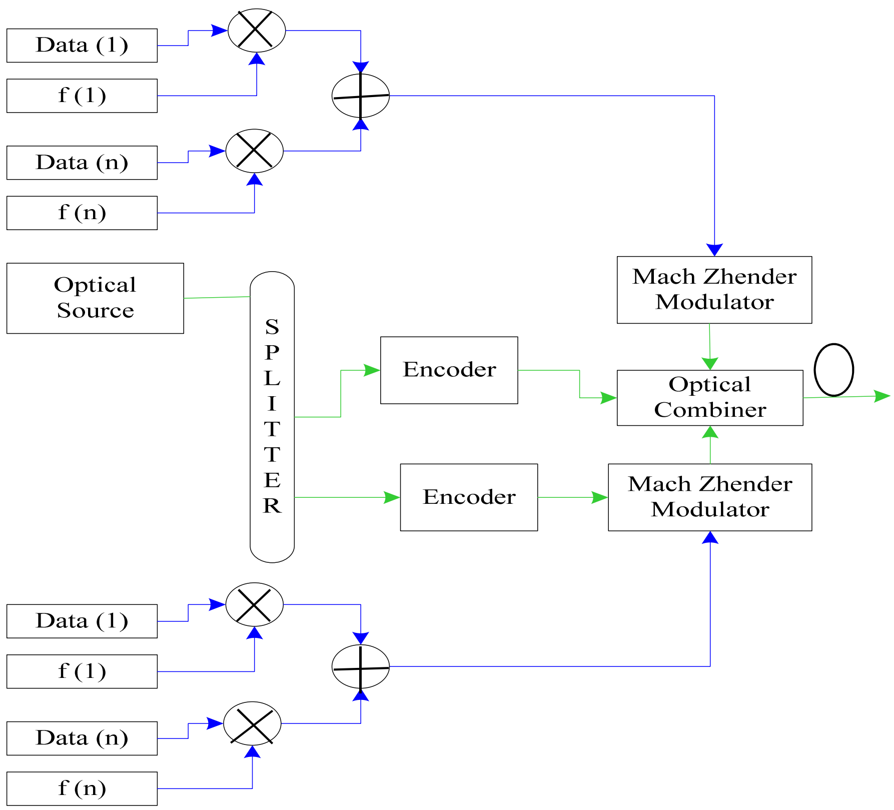

Figure 1 : The transmitter part of hybrid SCM OCDMA system.

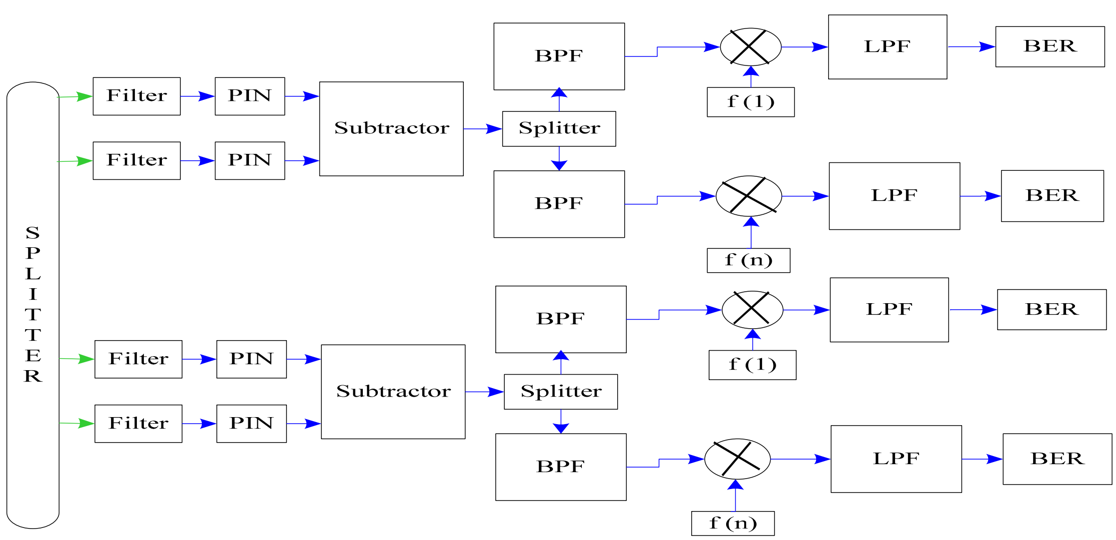

Figure 2 : The Receiver Part Of Hybrid SCM OCDMA System By Applying AND Subtraction Detection Technique.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

2.2 Single Photodiode Detection, SPD

Figure 3 illustrates the implementation of SCM OCDMA structure at the transmitter part. Here, data from users are modulated into electrical signal within different specific frequencies. These RF frequencies are then combined using electrical adder before being modulated into optical signal codes via a Mach Zhender Modulator. The optical RC codes are executed by splitting the broadband optical sources into smaller wavelengths, and encoded it back in the form of codes using an encoder. Optical combiner is then used to combine the optical codes before being transmitted via a single mode fiber.

Figure 4 depicts the implementation of SPD detection at the receiver. The structure is simple compared to other detections, such as AND detection. It only needs a couple of decoder and photo detector rather than AND subtraction detection where it requires two pairs of decoder and photo detector. By doing this, the effect of MAI is actually reduced in the optical domain. Thereby, the reduction value of optical-to-electrical conversion and shot noise are happened at the receiver side [7].

In SPD technique, the overlapping wavelengths are subtracted in the optical domain. At the photodetector, the photo diode only detects and filters the clean chips or the non-overlapping chips. Then, the effects of MAI are successfully reduced in the optical domain because there is only the required signal spectra are filtered. Then, there is no subtraction process in SPD technique. It is because; the photo detector only detects the clean optical pulses and converted into electrical domain. The electrically modulated signal is then passed through a Band Pass Filter (BPF) to remove the unwanted frequency. In order to remove the higher frequency, a low pass filter (LPF) is assigned. The original data signal is detected at the output of LPF using a BER analyser.

The main advantage of this technique is SPD technique can mitigate the effects of MAI in the optical domain. The MAI noise can limit the performance of hybrid OCDMA system instead of support the hybrid system up to hundreds of Mbps [3]. At the optical part, the elimination of the overlapping signals was occurred. It only permits a single photodiode to be adopted compared to the other detections which is allows two photodiodes [3]. Thereby, the reduction value of optical-to-electrical conversion and shot noise are happened at the receiver side [11]. Besides that, it also can be implemented with any fixed in-phase cross-correlation SAC codes with different spectral chips distribution of the s-Decoder, depending on the structure of the SAC codes itself. As observed, the design of SPD is simplified hence giving a less complex system that can support larger number of users. SPD detection also been confirmed as a good method for ultra-high speed transmission, noise suppression and cost effective [11].

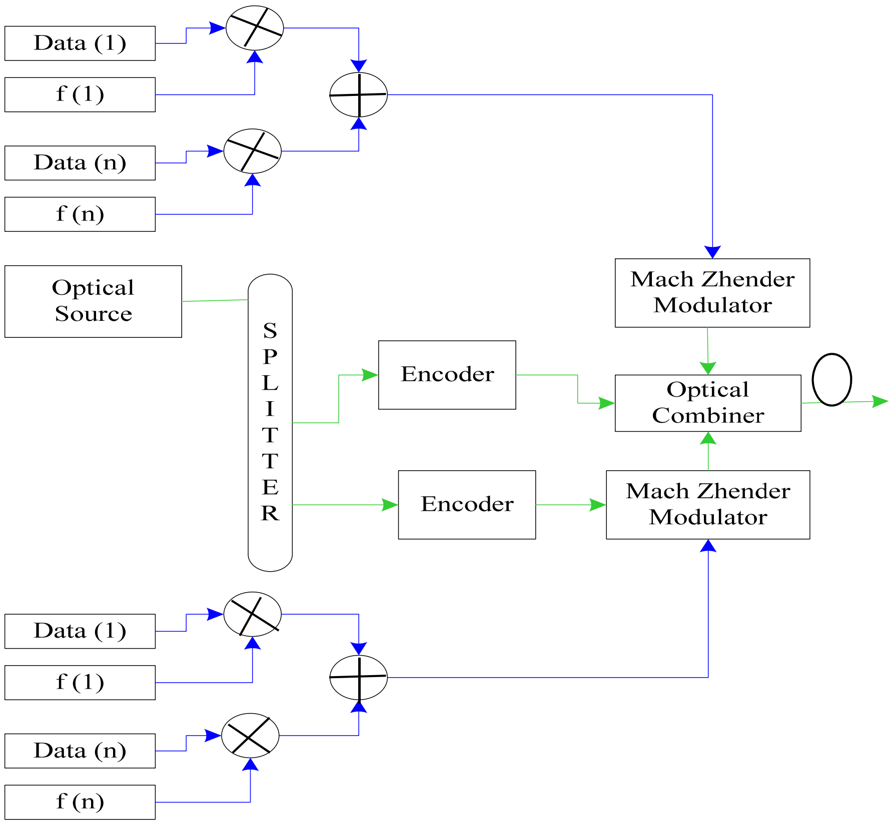

Figure 3 A block diagram of transmitter part of hybrid SCM OCDMA applying SPD technique.

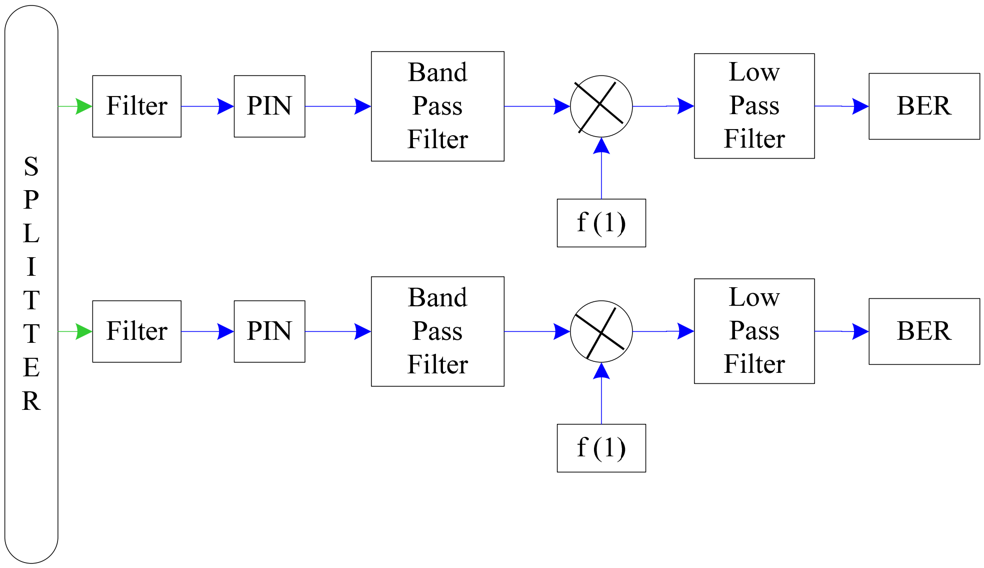

Figure 4 : Receiver part of hybrid SCM OCDMA applying SPD detection technique.

3. RECURSIVE COMBINATORIAL CODE

Recursive Combinatorial (RC) code is developed by Junita MN et al [12] in 2004. The development of RC code is the improvement of previous codes such as modified double weight code, double weight code, modified quadratic congruence code and etc. The characteristics of RC code are, it has minimum code lengths and minimum cross correlation, which equal to one. Besides that, RC code is flexible in term of choosing code parameter. The flexibility lies in adding number of users where it will not disturb the code words given to existing users [12], with the new code sequence will be added at the next available bandwidth for additional users. In addition, as the code weight increases, other existing parameters and structure are not affected. Then, it will not affect the code sequences for every existing user. Thus, increasing the code weight does not affect the chips positioning.

4. ANALYSIS OF HYBRID SCM OCDMA SYSTEM

Generally, Gaussian approximation is employed to calculate the signal noise ratio (SNR) and bit error rate (BER) of the RC code for AND subtraction detection and SPD technique. SNR can be describe as the average signal to noise power of the received signal. SNR= $\left[\frac{I^2}{\sigma^2}\right]$, which is I indicates the receive current at the photodiode meanwhile σ^2 indicates a few of different noise [13]signal which is :

$$\sigma^2 = I^2_{shot} + I^2_{PIIN} + I^2_{thermal} + I^2_{IMD} \quad (1)$$

$$= 2eBI + I^2B\tau_C + \frac{4K_bT_nB}{R_L} + \Re^2 \mathrm{m}^6_{\mathrm{n,k}}\left[\frac{\mathrm{D}_{111}}{32} + \frac{\mathrm{D}_{21}}{64}\right]$$

At the photodetector, PIN photodetector and used and dark current is assumed negligible. The incident current and source coherence time [14] are:

$$I = \Re \int_0^\infty G(v)dv \quad (2)$$

$$\tau_c = \frac{\int_0^\infty G(v)^2\,dv}{\left[\int_0^\infty G(v)dv\right]^2} \quad (3)$$

Where G(v) indicates the power spectral density (PSD) of a single sideband optical source meanwhile indicates the responsivity of photodiode.

There are some sorts of assumptions has been made to analyse the RC code. The purposes of the assumptions are it is significant for mathematical simplicity and easy to analyse the RC code. The assumptions are as follows [11]:

- Spectrum of each light source is flat over the entire bandwidth.
- It is ideally unpolarized for the light sources.
- At the receiver part, the spectral width for each optical source is same.
- At the receiver part, it will receive identical power signal for each user.

4.1 Theoretical Development of Hybrid SCM SAC OCDMA System Using AND Subtraction Technique

$C_a(i)$ Indicates the i^{th} element of the Kth RC code sequence, thereby the property of RC code based on AND subtraction detection technique can be expressed as:

$$\sum_{i=1}^{L} C_a(i)C_b(i) = \begin{cases} \left.\begin{matrix} W, for\ a = b \\ 1, for\ a \neq b \end{matrix}\right\} same\ mapping\ sector \\ 0, for\ a \neq b, not\ same\ mapping\ sector \end{cases} \quad (4)$$

and

$$\sum_{i=1}^{L} C_a(i)(C_b(i)C_b(i)) = \begin{cases} \left.\begin{matrix} W, for\ a = b \\ 1, for\ a \neq b \end{matrix}\right\} same\ mapping\ sector \\ 0, for\ a \neq b, not\ same\ mapping\ sector \end{cases} \quad (5)$$

As stated in Equation (4) and (5), the condition of a and b in the identical mapping factor indicates it is in the similar mapping sector for the two code sequences, m in equation:

$$\mathrm{M} = \begin{cases} 0\ ; when\ K = 1, 2 \\ Q\ ; K\ is\ odd \\ Q - 1\ ; when\ K\ is\ even \end{cases} \quad (6)$$

M represents the coefficient of mapping sector and Q indicates the quotient of K/2.

Thereby, it shows the AND operation for $(C_a(i)C_b(i))$ is only valid for a ≠ b meanwhile the

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

cross correlation product of $C_a(i)(C_b(i)C_a(i))$ is valid for both a = b and a ≠ b.

Based on equation (4) and (5), it represents the upper part and lower part of the decoder respectively. Then, equation (4) expressed the cross correlation of $C_a(i).C_b(i))$ is W when a = b. Besides that, the cross correlation of $C_a(i)\,(C_b(i)\,.\,C_a(i))$ is subtracted from $(C_a(i)\,.\,C_b(i))$ when a≠ b then the effects of MAI can be reduced.
Then, it can be written as:

$$\left\{\begin{matrix}\sum_{i=1}^{L} C_a(i)C_b(i) - \\ \sum_{i=1}^{L} C_a(i)(C_b(i)C_a(i)) \end{matrix}\right\} = \begin{cases} w-1\,; for\ a = b \\ 0\,; a\ \neq b \end{cases} \quad (7)$$

From equation 7, the first part indicates the upper part of the decoder while the second part represents the lower part of the decoder.

Therefore, the summation of incident power during one period at the input of photo detector PIN 1 and PIN 2 for the AND subtraction detection method are [14]:

For PIN 1:

$$\int_0^{\infty} \boldsymbol{G_1(v)dv} =$$

$$\int_0^{\infty} \frac{P_{sr}}{\Delta v} \sum_{K=1}^{K} d_k \sum_{i=1}^{L} C_a(i)C_b(i) \left\{u\left[\frac{\Delta v}{L}\right]\right\} dv$$

$$= \frac{P_{sr}}{\Delta v}\left(\frac{\Delta v}{L}\right)\left[\sum_{k=1}^{K} d_k \sum_{i=1}^{L} C_a(i)C_b(i)\right] \quad (8)$$

Based on Equation (11), it can be assume that the data transmitted only for bit "1", meanwhile bit "0", the RC code will not carry. Then, the equation becomes:

$$\left[\sum_{k=1}^{K} d_k \sum_{i=1\,;a=b}^{L} C_a(i)C_b(i)\right] = 1\,(W) = W$$

When a = b (9)

$$\left[\sum_{k=1}^{K} d_k \sum_{i=1\,;a\neq b}^{L} C_a(i)C_b(i)\right] = 1\,(1) = 1$$

When a ≠ b (10)

Then, substitute the equation (12) and (13 into equation (11), the equation becomes:

$$\int_0^{\infty} \boldsymbol{G_1(v)dv} = \frac{P_{sr}}{L}(W) + \frac{P_{sr}}{L}(1)$$

$$= \frac{P_{sr}}{L}(W+1) \quad (11)$$

For PIN 2, it same as PIN 1, then the equation becomes:

$$\int_0^{\infty} \boldsymbol{G_2(v)dv} = \frac{P_{sr}}{L}(1) + \frac{P_{sr}}{L}(1) = 2\frac{P_{sr}}{L} \quad (12)$$

Then, the difference between two photodiodes defines the signal from the desired user [13]. So, it can write as:

$$\boldsymbol{I = I_1 - I_2} \quad (13)$$

Where I_1represents the current at photodiode PIN 1 and I_2 represents the current at photodiode PIN 2. Then the current of the desired user's signal can be written as:

$$I = \Re\left[\frac{P_{sr}}{L}W + \frac{P_{sr}}{L} - \frac{2P_{sr}}{L}\right]$$

$$= \frac{\Re P_{sr}}{L}(W-1) \quad (14)$$

The shot noise power at the receiving photodiode for AND subtraction technique can be determined using (1) and (14):

$$I_{shot}^2 = 2eB\ \mathrm{I}$$

$$I_{shot}^2 = 2eB\,(I_1 + I_2)$$

$$\boldsymbol{I_{shot}^2 = 2eB\,\Re\frac{P_{sr}w}{L}(w+3)} \quad (15)$$

The noise power of PIIN can be illustrates as:

$$\boldsymbol{I_{PIIN}^2 = BI_1^2\tau_{c1} + BI_2^2\tau_{c2}}$$

Therefore, the total PIIN noise power can be illustrates as:

$$\boldsymbol{I_{PIIN}^2 = \frac{R^2BP_{sr}^2Kw^2}{L^2\Delta v}(w+3)} \quad (16)$$

The thermal noise [15] can be illustrates as:

$$\langle \mathbf{i_{thermal}^2} \rangle = \frac{\mathbf{4K_bT_NB}}{\mathbf{R_L}} \quad (17)$$

The inter-modulation noise [4] can be illustrates as:

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

$$\langle i_{IMD}^2 \rangle = \mathbf{P}_{sr}^2\, \mathfrak{R}^2 \mathbf{m}_{n,k}^6 \left[\frac{D_{111}}{32} + \frac{D_{21}}{64}\right] \quad (18)$$

Where D_{111} represents the three tone third order of inter-modulation which is can be expressed as:

$$\mathbf{D_{111}} = \frac{r}{2}(\mathbf{N} - \mathbf{r} + \mathbf{1}) + \frac{1}{4}[(\mathbf{N}-\mathbf{3})^2 - \mathbf{5}] - \frac{1}{8}[\mathbf{1} - (-\mathbf{1})^{\mathbf{N}}](-\mathbf{1})^{\mathbf{N}+\mathbf{r}} \quad (19)$$

Based on equation (19), N indicates the number of subcarrier channels; meanwhile r indicates the rth subcarrier. Then, D_{21} is the two tone third order modulation;

$$D_{2,1} = \frac{1}{2}\left\{\mathbf{N} - \mathbf{1} - \frac{1}{2}[\mathbf{1} - (-\mathbf{1})^{\mathbf{N}}](-\mathbf{1})^{\mathbf{r}}\right\} \quad (20)$$

Hence, the total SNR for the RC code using AND detection can be illustrates as:

$$SNR = \frac{\left(\frac{\mathfrak{R}P_{sr}(W-1)}{L}\right)^2 m_{n,k}^2}{eB\mathfrak{R}\frac{P_{sr}(W+3)}{L} + \frac{B\mathfrak{R}^2 P_{sr}^2 KW}{2L^2\Delta V}(W+3) + \frac{4K_b T_n B}{R_L} + P_{sr}^2\mathfrak{R}^2 m_{n,k}^6\left[\frac{D_{11}}{32} + \frac{D_{21}}{64}\right]} \quad (21)$$

4.2 Theoretical Development of Hybrid SCM SAC OCDMA System Using SPD Technique

The performance of RC code in hybrid system can be analyse by describe the properties of RC code which is the cross correlation and auto correlation function of the code take into account. In equation 22, Ca(i) indicates the ith element of Ath RC code sequence. So that, the properties of RC code based on SPD method can be written as:

$$\sum_{i=1}^{L} C_a(i) C_b(i) = \begin{cases} W ; for\ a = b \\ 1 ; for\ a \neq b \end{cases} \quad (22)$$

Where C_a and C_b represents the RC code sequences, meanwhile L represent the code length and W represent the number of the weight. At the receiver part, the photo detector only detects and decodes the non-overlapping chips. Therefore, the total incident power during one period at the input of the photo detector *PIN 1* for the SPD detection technique can be expressed by:

$$\int_0^\infty G_{dd}(v)dv = \int_0^\infty \frac{P_{sr}}{\Delta v}\sum_{k=1}^{K} d_k \sum_{i=1}^{L} C_m(i)\, C_n(i) u\left[\frac{\Delta v}{L}\right] dv \quad (23)$$

$$= \frac{P_{sr}}{\Delta v}\left[\frac{\Delta v}{L}\right]\sum_{k=1}^{K} d_k \sum_{i=1}^{l} C_a(i) C_b(i) \quad (24)$$

$$= \frac{P_{sr}}{L}(w-1) \quad (25)$$

The photodiode current, I indicate the signal from the desired user and can be illustrates as:

$$I = I_{dd} = \mathfrak{R}\int_0^\infty G_{dd}(v)dv \quad (26)$$

Then, substitute the equation (25) in (26), the equation becomes:

$$I_{dd} = \mathfrak{R}\frac{P_{sr}}{L}(w-1) \quad (27)$$

Based on equation (27), (W-1) indicates the power spectral density of the overlapping chips or cross correlation are subtracted at the received power signal. Thereby, the photodiode only detects and filters the PSD of the non-overlapping chips.

For the noise variances, there are three types of noises are considered which are shot noise, thermal noise and intermodulation noise while PIIN noise is neglected. The PIIN noise is neglected because it only appearance when the optical signal is incident more than one on the photo detector surface. The shot noise can be illustrates as:

$$I_{shot}^2 = 2eB\, I_{dd}$$

$$I_{shot}^2 = 2eB\,\mathfrak{R}\frac{P_{sr}(w-1)}{L} \quad (28)$$

The thermal noise [15] can be illustrates as:

$$I_{thermal}^2 = \frac{4K_b T_N B}{R_L} \quad (29)$$

The inter-modulation noise [4] can be illustrates as:

$$I_{IMD}^2 = \mathbf{P}_{sr}^2\,\mathfrak{R}^2\mathbf{m}_{n,k}^6\left[\frac{D_{111}}{32} + \frac{D_{21}}{64}\right] \quad (30)$$

The Signal Noise Ratio or SNR equation of the hybris SCM OCDMA using RC code using SPD method can be expressed as:

$$SNR = \frac{\left(\frac{\Re P_{sr}(W-1)}{L}\right)^2 m_{n,k}^2}{eB\Re\frac{P_{sr}(W-1)}{L} + \frac{4K_b T_n B}{R_L} + P_{sr}^2 \Re^2 m_{n,k}^6\left[\frac{D_{11}}{32} + \frac{D_{21}}{64}\right]} \quad (31)$$

5. PERFORMANCE ANALYSIS AND RESULTS

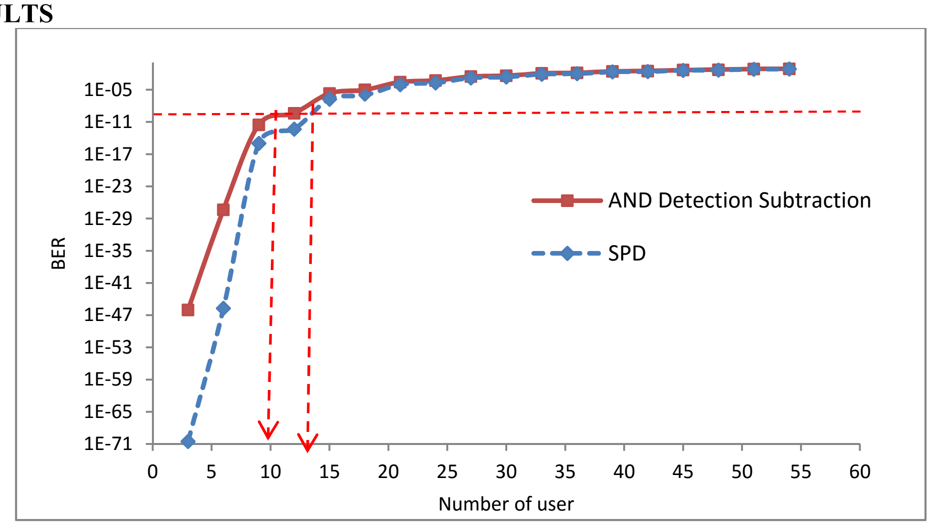

Figure 5 : The Analysis Performance Of Hybrid SCM OCDMA System With Respect The Number Of Users And BER.

Figure 5 indicates the implementation of AND subtraction detection technique and SPD detection technique on the hybrid SCM OCDMA system. Then, compare the system performance with respect to the number of users. At 10^{-9}, the system with implemented AND subtraction detection can holds 10 number of users while by using SPD detection; it can supports about 13 number of users. Then, the system with implements SPD detection showed better performance compared to AND subtraction detection. Increasing the number of user will increase the bandwidth of the system. The bandwidth for SPD detection techniques more efficient than the bandwidth for AND subtraction detection technique.

Figure 6 indicates the corresponding BER versus to the effective received power for the SPD detection and AND detection. In this analysis, the cardinality and the number of weight are fixed, while the numbers of received power are different. Based on the graph, at threshold BER value of 10^{-9}, the received power for the SPD detection is about -18 dBm and the received power for the AND detection is about -10 dBm. This result indicates that the power consumption for the SPD detection is smaller rather than AND detection. Thus, the SPD detection gives better performance sensitivity compared to AND detection for the hybrid system. It is because the SPD detection reduced the effects of MAI and PIIN in optical domain which elevates the quality of the received power.

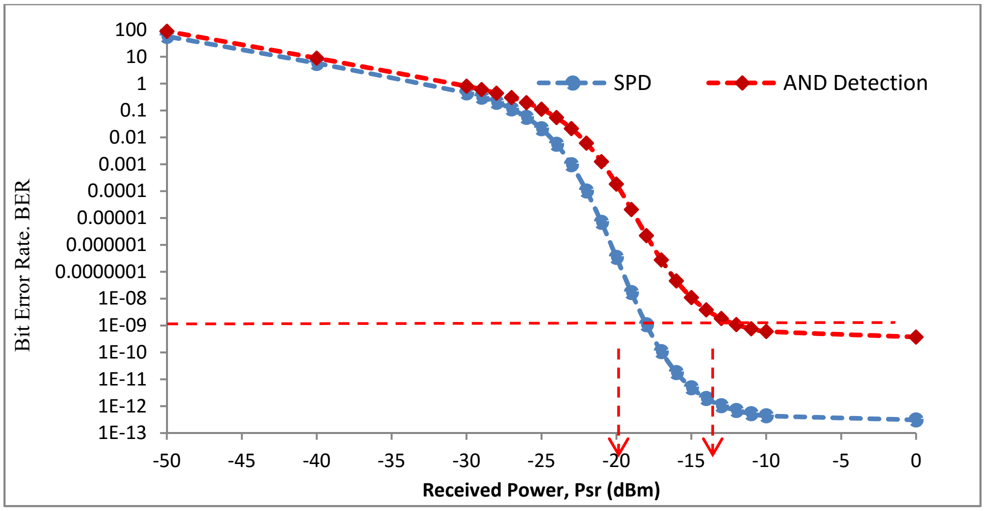

Figure 7 : The Comparison Of Performance Hybrid System With Respect The Number Of Received Power, Psr .

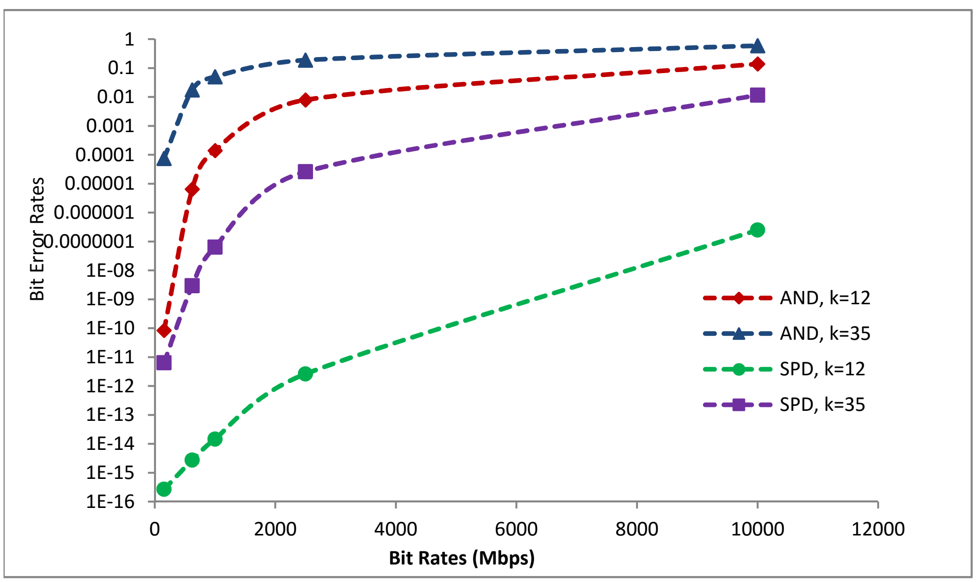

Figure 6 : The Effects Of Bit Rate On The System Performance For Simultaneous Users Equal To 12 And 13 Based On Two Detections

Figure 7 depicts how the bit rates affect the performance of the hybrid system for the simultaneous users equal to 12 and 35. Bit rates from 155 Mbps to 10Gbps are assigning for this purpose. Based on Figure 5, it can be conclude as, increase the bit rates will degrades the BER performance for both AND subtraction detection and SPD technique. When the bit rates increase, the pulse width will decrease and makes the signal more sensitive to noise. Generally, increase the bit

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

rates will increase the electrical bandwidth and thus more noise is created. A part from that, increase the bit rates also affects the regeneration circuit. It will become more complex due to higher speed requirements. Then, the performance of the hybrid system becomes worse. Nevertheless, by employing SPD technique, the system performance is better rather than the use of AND subtraction detection technique when higher number of user is involved. This is due to the effects of noise is reduced at the optical part for the SPD technique, meanwhile the AND subtraction detection at the electrical part.

6. CONCLUSION

In this paper, AND subtraction detection technique and single photodiode detection, SPD technique have been proposed, evaluated and compared for hybrid SCM OCDMA system. The performance of the hybrid SCM OCDMA system was evaluated by using Recursive Combinatorial (RC) code. Based on the theoretical results, SPD detection provides a good performance than the AND subtraction detection. It is owing to SPD detection technique reduces the effects of MAI in optical domain, while AND subtraction detection in electrical domain. Besides that, SPD detection can supports many number of users compare to AND subtraction detection at the threshold 10^{-9}. Therefore, SPD detection shows better performance rather than AND subtraction detection as is can supports large number of cardinality and its bandwidth are efficient even it supports large number of users.

7. ACKNOWLEDGEMENT

The authors would like to thank the Ministry of Higher Education (MOHE) Malaysia for the funding under the Fundamental Research Grant Scheme (FRGS).

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