A Robust Jitter Noise Power Reduction in Ultra-Speed Optical OFDM Systems

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Abstract. Recently, there is a tremendous growth in wireless communication networks for achieving ultra-high-speed data transmission to enhance the performance of optical communication system. In such systems, jitter is a serious drawback and will leads to impairments in transceivers that causes overall mitigation on the system performance. We used a robust noise reduction technique to minimise the jittering effect under various fading conditions of the channel such as white gaussian additives (AWGN), Rayleigh and Rician distribution to solve this problem. Extensive simulation analysis shown that the proposed approach mitigates the average jitter noise under considered channel circumstances. We also compared the channel performances in terms of sub carrier index versus power.

Keywords: orthogonal frequency division multiplexing (OFDM), jitter noise power, AWGN, Rayleigh fading channel, Rician channel distribution and subcarrier index.

1. Introduction

Every day, a communication network will require higher speed data transmission in each field. Orthogonal multiplexing frequency division (OFDM) is a network which permits high speed data transfer at higher data rate without affecting input quality. OFDM has been used in recent years by optical systems to further improve high-speed data rates (see [8] and its references) as the fiber-optical data rate is much above the RF (radio frequency) Wireless arrangements. Data rates, Jitter is a central, severe difficulty that causes ultra-data impairment in transceivers leading to low system efficiency and loss of system performance. Jitter reflects the divergence, with respect to a reference clock signal, from the actual periodicity of a probably periodic signal. It is called timing jitter in clock recovery applications [1-3]. Jitter is a critical element in the architecture of almost all contact links and typically unwelcome. Sampling clock is the key source of jitters needed in these systems with ultra-high - speed analogue to digital converters (ADCs). The problem of high frequency band pass samples is very extreme in Optical-OFDM radios [9]. The chip reduction strategies were discussed in [10] and [11-15]. The colourful low pass time jitter that is classic of schemes applying Phase lock loops (PLL), is focused on these papers. Unacceptable long test sequences for circuits with multiple random patch tolerant defects also are sufficient to obtain high fault coverage for pseudorandom checks [16]. However, the conventional schemes have been tested under AWGN channel environment with less number of symbols. Here, we utilized a robust jitter noise power mitigation scheme under various channel distributions instead of only AWGN channel. The channels considered for simulation are fading channels [4-7].
2. System Model

The OFDM block diagram was seen in Figure 1 with the symbol mapper used to map input symbols, serial to parallel converter (S / P), discrete reverse Fourier transform (IDFT) or reverse rapid Fourier transform (IFFT), internal save (GI), low-cass digital to analogue converter (LPF), and radio frequency converter (RFT) used in the optical converter. Optical link has been provided as a media which consists of fading channels such as AWGN, Rayleigh and Rician. Reverse controlled blocks, as de-mapper, DFT or FFT, analog-to - digital (A / D) and LPF, parallel-to-serial (P / S) and optical-to-RF, are included in the reception segment. Generally, the jitter can be occurred at several points in practical optical-OFDM systems. [17] But, we considered here that the jitter introduction will be at the receiver’s ADC sampler block. Figure 2 demonstrates that the definition of jitter. The OFDM signal is preferably sampled at a constant T/N interval. The standardised sampling intervals in figure 2 above were shown by dotted lines in which solid lines were the real sampling times. The deviating effect from timing jitter is a product of the divergence among the real sampling times as well as consistent sampling periods. Example $\tilde{S}_n$ Discreet timing in figure 2 is shown.

$$Y = WHX^T + N$$  \hspace{1cm} (1)

Where,

$Y$= Signal got

$X$= Signal broadcast

$N$= White Gaussian Signal Additive

$H$ is channel reply matrix as well as $W$ is the period jitter matrix

$$Y = [Y_{N/2+1} \ldots Y_0 \ldots Y_{N/2}]^T$$

![Figure 1. Block diagram of ultra-speed optical-OFDM communication system](image1.png)

![Figure 2. Definition of jitter](image2.png)
\[ X^T = \begin{bmatrix} X_{-N/2+1} & \ldots & X_0 & \ldots & X_{N/2} \end{bmatrix}^T \]

\[ H = \text{diag}(H_{-N/2+1} \ldots H_0 \ldots H_{N/2}) \]

And

\[
W = \begin{bmatrix}
\begin{array}{cccc}
-1 & -1 & \cdots & -1 \\
1 & 1 & \cdots & 1 \\
0 & 0 & \cdots & 0 \\
\vdots & \vdots & \ddots & \vdots \\
0 & 0 & \cdots & 0 \\
\end{array}
\end{bmatrix}
\]

Timing jitter allows the received signal to introduce a noise identical to the variable.

\[ Y = HX^T + (W - I)H^T + N \]

Here, \( N \) denotes the matrix of identity equally, (3), the initial term is a required term, and the next term is a fuss. The time jitter matrix of components were seen to be supported

\[
w_{l,k} = \frac{1}{N} \sum_{n=-N/2+1}^{N/2} e^{j2\pi nk \frac{n}{N}} e^{j2\pi (k-l)n} \]

Here, \( n \) represents the time indicator, \( k \) indicates the indicator of the subcontractor distributed also \( l \) denotes the indicator of a subcontractor obtained.

3. Inherent Oversampling

Now, we examine the super-sample (IOS) intrinsic and prove that it decreases the shortcomings induced by the time jitter. In order to obtain an IOS where \( M \) is an integer the obtained signal is sampled by \( MN / T \). While all \( N \)-sub-carriers are regulated, the signal bandwidth is \( N/2T \). As seen in fig.2 at the Nyquist sample interval, \( T / N \). The signal bandwidth \((N L+N U)/2T\), if rather only non-zero sub controllers with indicators from \(-N L\) to \( N U \) The sampling interval is greater than the Nyquist rate in this situation. In usual, the signal samples of signals afterwards the ADC receiver is delivered through both inherent and fractional over-sampling.

\[
y_{nM} = y \left( \frac{nMT}{NM} \right) = \frac{1}{\sqrt{N}} \sum_{k=-N L}^{N U} H_k X_k e^{j2\pi k \frac{nM}{NM}} + \eta \left( \frac{nMT}{NM} \right) \]

Here \( nM \) = the sampling time also \( \mu \) represents the AWGN index. In proposed algorithm, the \( N \)-point FFT is substituted via an over dimensional \( N M \)-point FFT. The FFT yield is a \( N M \) longitudinal vector of elements

\[
y_{lM} = \frac{1}{\sqrt{N}} \frac{1}{\sqrt{M}} \sum_{nM=-NM/2}^{NM/2} y_{nM} e^{\frac{-j2\pi nM(k)}{NM}} \]

Where the FFT performance index of \( lM \) is \( NM \)-point. The adapted coefficients for the case introduced are then received through integrating the equations (4), (5) and (6).

\[
w_{lM,k} = \frac{1}{N} \sum_{nM=-NM/2}^{NM/2} w_{lM,k-nM} e^{j2\pi nM(k-iM)nM} \]

For white jitter, we calculate the average subcarrier noise for each subcarrier. (3) and (6)),

\[
y_{lM} = H_{lM} X_{lM} + \sum_{k=-N L}^{N U} (w_{lM,k} - I_{lM,k}) H_k X_k + N(l) \]

Here the second word is the rumbling noise. In next, we assume a flat channel through a power \( H k=1 \), which means which, for each of the applied subcarrier \( E\{X k^2\} = \sigma^2 \), the power of the signal transmitted was spread uniformly through all the subcarrier. The middling noise energy, \( P(j) \) to the signal power obtained from \( l \) the subcarrier is then calculated by,

\[
\frac{P_{j(l)}}{\sigma^2} = E\left[ \frac{\sum_{k=-N L}^{N U} (w_{lM,k} - I_{lM,k})^2}{\sigma^2} \right] = \sum_{k=-N L}^{N U} E\left[ (w_{lM,k} - I_{lM,k})^2 \right] \]
SoN \( U = N \sqrt{2} \) for a device in the same number of subcarriers unused on each band edge:

Here \( N \) amount of subcontractors utilized. So the equation (9) is translated to

\[
P_j(l) = \sum_{k=-N_v/2}^{N_v/2+1} \frac{1}{NM} \left( \frac{2\pi k}{T_v} \right)^2 E\left\{ \tau_n^2 \right\}
\]

Reducing the subcontractors leads to a decrease in total data, communicated energy as well as constant bandwidth if the symbol time is unchanged. In order to compare the symbolic period, \( T_v = (N_v T_N) / N_v \) also reduced, when \( T_v \) is the sign of \( N_v \) utilized subscribers, while \( T_N \) is the symbol of \( N_v \) utilized subcarriers.

\[
P_j(l) = \sum_{k=-N_v/2}^{N_v/2+1} \frac{1}{NM} \left( \frac{2\pi k}{T_v} \right)^2 E\left\{ \tau_n^2 \right\}
\]

Using \( \sum_{k=-N_v/2}^{N_v/2+1} k^2 = \frac{1}{12} N_v (2 + N_v^2) \), we obtain

\[
P_j(l) = \frac{2}{3M} E\left\{ \tau_n^2 \right\} \left( \frac{N_v}{N} \right)^2 + \frac{1}{3M} E\left\{ \tau_n^2 \right\} \left( \frac{N_v^3}{N} \right) \left( \frac{\pi}{T_v} \right)^2
\]

From the outset of the word, (12) is very tiny, so you can ignore it. The equation is written as follows.

\[
P_j(l) = \frac{\pi^2}{3M} E\left\{ \tau_n^2 \right\} \left( \frac{N_v N}{T_N^2} \right)
\]

If cogitate which here is no oversampling then \( M=1 \) and \( N_v = N \), hence

\[
P_j(l) = \frac{\pi^2}{3M} E\left\{ \tau_n^2 \right\} \left( \frac{N^2}{T_N^2} \right)
\]

Comparing the equivalent. Inherent and fractional oversampling combinations (13) and (14) reduce the jitter noise energy through the \( N / NM \) faction.

4. Results and Discussion

We have seen the detailed simulation review in this portion of the proposed noise reduction model. For testing purpose, 2000 OFDM symbols are assumed with 512 subcarriers and a variance of jitter about \( E\{\tau_n^2\} = ((0.3T_N)N)^2 \), that shouldn’t change if oversampling employed. Figure 3 offers simulated and theoretical analyses of the typical jitter noise compared with the IOS component in various channels. This shows that there is a 3dB decrease in jitter noise energy with any copying of the rate of sampling. The variation in noise due to jitter as a purpose of the indicator of subcarriers achieved if an idle band-edge subs carrier discloses the subsidiary index and excludes subcarriers at a band-edge, uniformly minimising noise across whole subcarriers as disclosed in Figure 4-6.

![Figure 3. Performance of proposed model under AWGN channel environment](image-url)
As said above, figure 5 and 6 describes the performance of received power with the subcarrier index, where the power has distributed equally among the subcarriers. Figure 7 shows that, with the increased rate of the IOS factor, the BER is reduced as the IOS factor increases with the SNR and that the SNR values improve at the same time. This leads that the improvement in system efficiency as well as the higher data rates.
5. Conclusion
In the light of many decreasing channel requirements such as AWGN, Rayleigh and Rician distributions, this article has introduced a rigorous approach to reducing noise power. Extensive analyses of simulation found that the solution suggested mitigates mean jitter noise under channel conditions. Further, it is also compared the channel performances in terms of sub carrier index versus power.

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