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Optimum Timing Acquisition for High Efficiency OFDM System in Wireless Communications

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Abstract

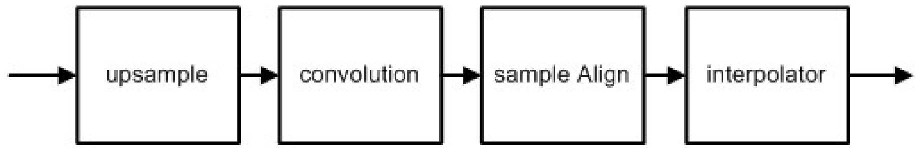
In the wireless transmission systems based on orthogonal frequency division multiplexing (OFDM), timing offset exists between the transmitter and the receiver. As the transmission speed increases the greater the influence of the timing offset. This paper examines the estimation of a timing error detector that carries out offset detection (i.e., estimation) and compensation in the receiver.

Keywords: clock offset, timing recovery, timing acquisition, estimation, OFDM

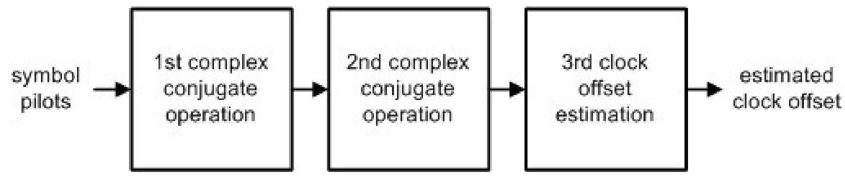
1 Introduction

OFDM that adopts higher-order quadrature amplitude modulation (QAM) is a popular method for high data rate wireless transmission. In OFDM-based transmission systems, timing offset occurs due to the sampling clock mismatch of the oscillators in the transmitter and the receiver [1]. As the transmission speed increases the greater the influence of the timing offset. The receiver thus includes a timing error detector (TED) that estimates and compensates for the offsets [2].

This paper proposes a timing error generator and a TED so as to analyze the impact of sampling clock offsets on the receivers performance [3]. The effectiveness of the proposed schemes is examined through simulations.



(a) Timing Error Generator



(b) Timing Error Detector

Figure 1: System Model.

2 System Model and Methods

The timing error generator and timing error detector presented in Figure 1 insert the sampling frequency and phase errors (offsets) into the transmitted signal and passes it to the TED.

As shown in Figure 1, the TED uses the continual pilots (CPs) of the two adjacent OFDM symbols in order to compensate for the sampling clock offsets due to the difference between transmitter and receiver oscillators. The CPs appear in certain subcarriers of each and every OFDM symbol, so the CPs of the adjacent OFDM symbols are utilized in offset compensation [4],[5].

Figure 2 illustrates how the TED works. The first operational block performs the complex conjugate of the CPs of the two adjacent OFDM symbols. The second block then performs the complex conjugate of the neighboring CPs resulting from the first block. After these two complex conjugate operations, the estimation block computes the average of the outputs of the second block, denoted as $b_{m,1} \sim b_{m,n}$, and performs $\tan^{-1}$ on the average. In this way, the TED produces an offset estimate that is then used for actual offset correction [6],[7].

3 Simulation Results

Figure 3 and Figure 4 show the change of each u_k and m_k for the operation of the interpolator when the offset is generated, in positive ppm and negative ppm.

Figure 5 shows the TED outputs of a single frame. When the TED operates

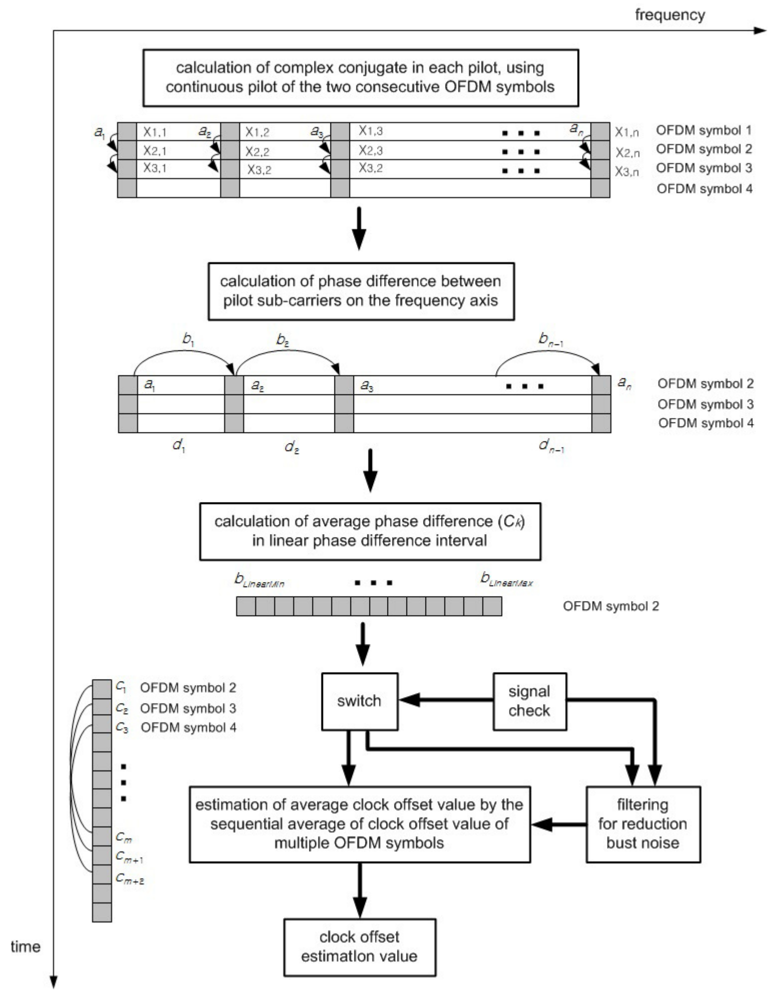


Figure 2: TED's Operational Flow.

with OFDM symbols in a single frame, its outputs (i.e., estimated clock offsets) are distributed around the sampling clock offset of 0.01 ppm. The simulation results also show that the difference between the minimum and maximum estimates made by the TED is small.

4 Conclusions

For clock offset compensation in a higher-order OFDM-based wireless system, this paper generates a sampling clock offset via the timing error generator and compares it with the clock offset estimates produced by the TED. The simulation results showed that the TED can correct the offset caused by the difference in sampling clocks of the transmitter and receiver when the sam-

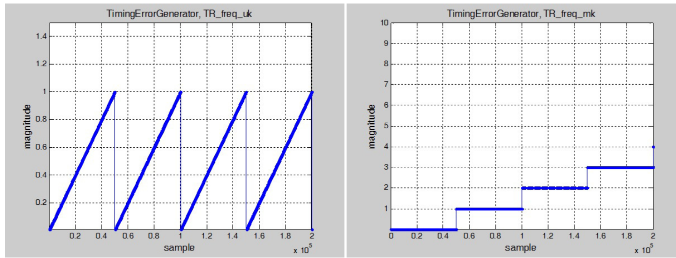


Figure 3: u_k and m_k Output of the Timing Error Generator in +ppm.

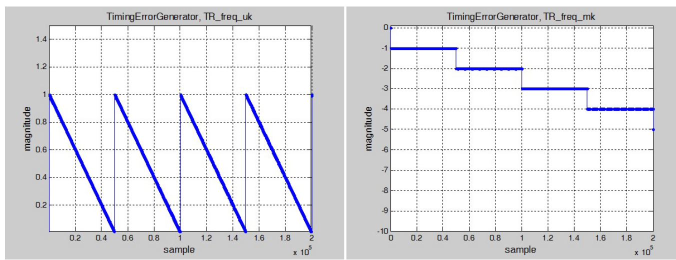


Figure 4: u_k and m_k Output of the Timing Error Generator in -ppm.

pling clock offset is set at +10 ppm in the timing error generator. The TED outputs for a single frame were centered around the sampling clock offset of 0.01 ppm. This shows that the proposed TED can make an accurate clock offset estimation, and thus it can be useful in other communications technologies with timing offsets.

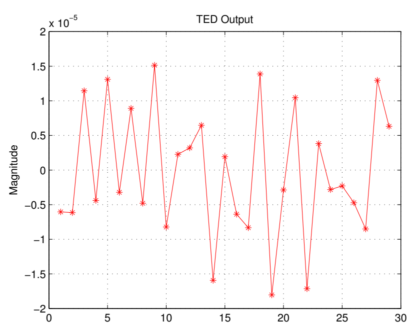


Figure 5: TED Outputs for a Single Frame.

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