PAPR REDUCTION OF THE POWER EFFICIENT ASYMMETRICALLY CLIPPED OFDM

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ABSTRACT

Two methods are applied to reduce the peak-to-power ratio (PAPR) of asymmetrically clipped optical OFDM transmission systems in this paper. Bit error rate (BER) performance of different methods are compared in experiment. PAPR is reduced about 4dB by using companding transform with slightly receive sensitivity decrease.

Keywords: *OFDM, PAPR, Power Efficiency*

1. INTRODUCTION

Orthogonal frequency division multiplexing (OFDM) is a promising technology in high-speed optical fiber transmission due to its high spectral efficiency and tolerance against chromatic dispersion [1], but it's not widely used practical because bipolar signal can't be used in intensity modulation, so a DC-bias is usually added to be unipolar with large optical power waste. To solve this problem asymmetrically clipped optical (ACO)-OFDM is proposed owing to its high power efficiency. According to its principle, only odd subcarriers are used in OFDM modulation and all negative values are forced to zero after inverse fast Fourier transform (IFFT), it is proved that data on odd subcarriers can be recovered while noise is spread on even ones [4]. However, ACO-OFDM has even higher peak-to-average power ratio (PAPR) than original OFDM which is the main shortcoming. A novel OFDM format called polar-OFDM (P-OFDM) is proposed to reduce the PAPR of ACO-OFDM while keep the power efficiency [6]. Also, companding transform is a traditional way to reduce the PAPR of OFDM signals [5, 6], it also can be applied in ACO-OFDM, which is usually a nonlinear function that can restrain higher peaks to reduce the PAPR finally. In this paper, complementary cumulative distribution function (CCDF) of each OFDM format is evaluated, and an intensity-modulation direct-detection (IM/DD) system is demonstrated with different OFDM signals are transmitted over 20km optical fiber link, then the bit error rate (BER) curves are tested to compare the performance of these signals.

2. PRINCIPLE

ACO-OFDM is realized based on original OFDM and has some more steps. Fig. 1 shows the process of generating different format OFDM signals offline. Original OFDM signal is made after IFFT (except inserting cyclic prefix), as is mentioned in [4], in ACO-OFDM system, only odd subcarriers are used in IFFT and negative signals are forced to zero afterwards, as the red path shows and use "odd sub" and "zero" for short. While in P-OFDM, only even subcarriers are used and then bipolar signals are transformed to unipolar via a Cartesian-to-polar function like the blue part. Companding transform is a common way to reduce PAPR in OFDM. It's essentially a function that restrains the peak value of the input signal before transmission and has no influence on the average value. So according to the algorithm of PAPR it will be reduced.

3. EXPERIMENT AND RESULT

In the research, five formats of OFDM signal are generated in matlab as the previous part says, namely

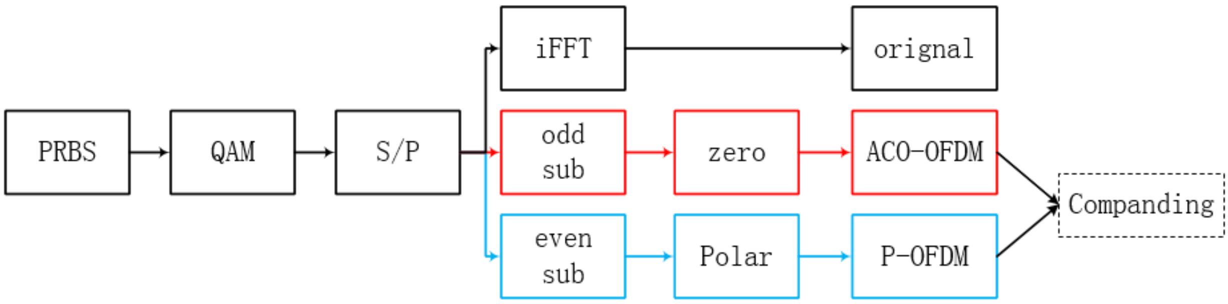

Fig. 1 Sketch map of generating different OFDM signals offline

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original OFDM with a DC-bias, ACO-OFDM, polar-OFDM and the former two after companding transformation. Before they are put into the optical link, the CCDF of each signal is figured out and shown in Fig. 2. The subscript 'c' indicates that signal is after companding transformation. The Y-axis uses logarithmic coordinates. It is seen that ACO-OFDM has the highest PAPR while original OFDM with companding the lowest. Also, the PAPR of ACO-OFDM after companding is almost the same with original OFDM but with higher power efficiency, it is proved that companding transform really gives an advantage to ACO-OFDM.

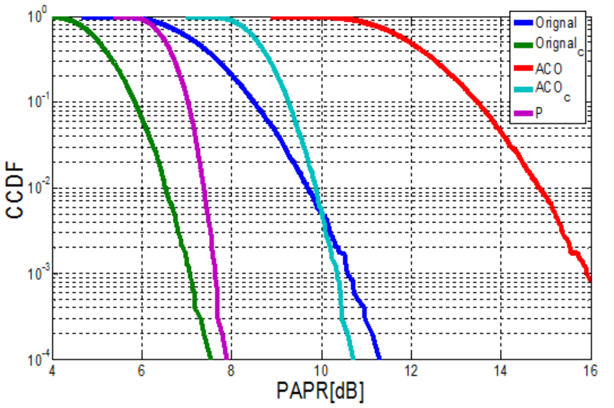

Fig. 2 CCDFs of original, asymmetrically clipped and polar OFDM signals with different colors.

The architecture of the experiment is illustrated in Fig. 3. The OFDM signal mentioned above is sent into Tektronix Arbitrary Waveform Generator (AWG) 7122B to generate electrical signal, which is then modulated onto optical domain by a Mach-Zehnder modulator (MZM). The optical signal after the Erbium-doped fiber amplifier (EDFA) passes through 20km single mode fiber (SMF) link and is received by a photodetector (PD). The signal is sampled by Tektronix Digital Phosphor Oscilloscope (DPO) 72004B and processed offline by digital signal processor (DSP) to recover the original data. For different transmitted OFDM signals, the optical power before getting into the fiber is controlled to be 11dBm, and the power before receiving varies from -1dBm to -15dBm to obtain BER curves.

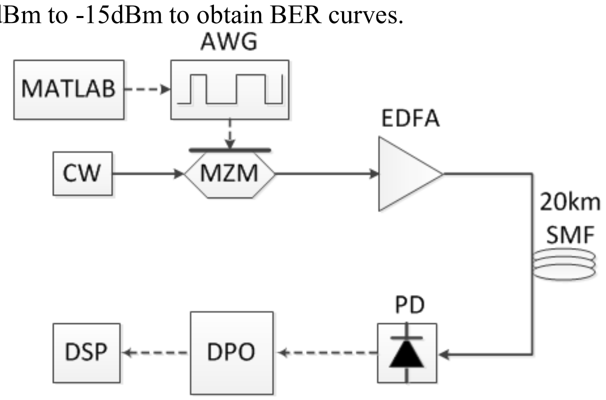

Fig. 3 Principle of the experiment system. CW: continuous wave

The performance of polar-OFDM is first studied by the constellation diagram in Fig. 4(a), compared to ACO-OFDM in Fig. 4(b) with the same receiving power. It can be seen that the points almost crowd together and some spread out while the original modulation format is 4QAM. The reason is that as the principle, the amplitude and phase are extracted and transmitted instead of the complex signal, so the noise and other distortion makes effect directly on the signal phase and amplitude more than bring in noise floor. It causes that points on the constellation diagram offset randomly. For the other four format signals, BER is calculated after data recovery and BER curves are drawn in Fig. 4(c). The X-axis represents the optical power before the photodetector. It shows that companding has about 0.5dB loss about receiving sensitivity for ACO-OFDM, but still better than original OFDM.

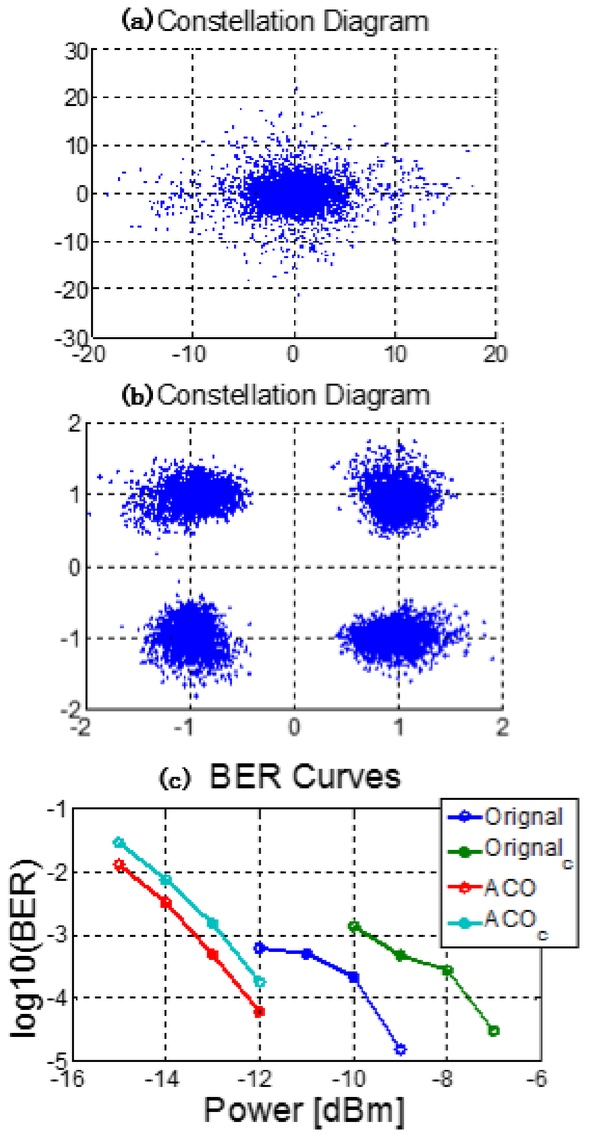

Fig. 4. Constellation diagram of the received (a) ACO-OFDM data and (b) polar-OFDM data. (c) BER curves of the other recovered OFDM data

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4. CONCLUSION

To reduce the PAPR of ACO-OFDM, two methods are applied in the transmission experiment. One of them the companding transform is firstly applied on ACO-OFDM, the result shows an obvious effect on PAPR reduction while causes a little sensitivity loss, but it is still much better than the original OFDM performance. Polar-OFDM does not work well in the experiment but it's still a promising technique and follow-up research is needed to ameliorate it.

5. ACKNOWLEDGEMENTS

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