A New LINC Architecture with Efficiency Enhancement for OFDM Signal

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In these days, wireless communication requires higher data rate as mobile applications conduct multiple functions. Also, power consumption has become a hot issue in mobile communication research for longer battery life-time. For spectral and power efficiency, orthogonal frequency division multiplexing (OFDM) and linear amplification with nonlinear components (LINC) can be the strongest candidate for a highly efficient communication system [1],[2]. However, there is a trade-off between two properties — linearity and power efficiency, and it is very difficult to satisfy both requirements at the same time. In this work, a new LINC architecture is proposed to enhance the power efficiency without linearity deterioration, especially for OFDM signal.

Conventional LINC decomposes input signal $S(t)$ into two phase modulated signals $S_1(t)$ and $S_2(t)$ with constant envelope and amplifies them using highly efficient nonlinear amplifiers. After amplification, linearity is restored in combiner where $S_1(t)$ and $S_2(t)$ are added. In spite of highly efficient amplification, LINC power efficiency is reduced when the system runs at a low-level input signal. This reduction is dominated when high PAPR signal such as OFDM signal is applied.

The proposed mixed-mode LINC architecture consists of a conventional LINC system and an auxiliary linear power amplifier. The operation is determined depending on the input signal level. Equations (1)-(6) describe the creation of each signal. For low-level signals, it operates in the identical manner with the conventional LINC system as shown in Fig. 1 (a). For high-level signals which exceed boundary level r_0, signal $S(t)$ is decomposed into three components — $S_1(t)$, $S_2(t)$ and $S_3(t)$ as drawn in Fig. 1 (b). $S_1(t)$ and $S_2(t)$ go towards conventional LINC and $S_3(t)$ heads to the auxiliary amplifier (Fig. 2). In equation (5), $S_3(t) = 0$ means that the auxiliary amplifier is turned-off to reduce power dissipation when it does not operate.

Fig. 3 shows the efficiency curves according to the input signal magnitude, assuming that switching amplifiers have 100% efficiency and the auxiliary amplifier has 50% efficiency. When the input signal level increases, efficiency increases rapidly and reaches a peak value at r_0. However, at the auxiliary amplifier operating point (slightly higher than r_0) efficiency drops drastically due to poor linear amplifier efficiency for low-level $S_3(t)$ signals. Nevertheless, the degree of efficiency improvement is much larger than the efficiency degeneration region, because of the signal magnitude distribution feature of the OFDM modulated signal. This proposed new LINC architecture shows an efficiency enhancement 8% to 31% with 802.16e signal (Fig. 4). Compared to Chireix combiner, this scheme does not need ideal voltage source such as overdrive class-B or class-D amplifier. Therefore conventional highly efficient class-E amplifiers can be used.

For measurement, two CMOS class-E amplifiers and one GaAs class-A amplifier were used. Test result shows PAE improvement from 5.3% to 20.2% with 21.5dBm output power, applying 802.16e signal at 2.3GHz with 8.75MHz bandwidth. This scheme satisfies the given spectrum mask as shown in Fig. 5.

A new LINC architecture is proposed to enhance the efficiency for high PAPR signal. These results will provide an useful power-efficient transmitter architecture for next-generation communication.

Acknowledgement

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References

[1] D.C. Cox, "Linear amplification with nonlinear components," *IEEE Trans. Commun.*, vol. 22, pp. 1942-1945, Dec. 1974.
[2] F. H. Raab, "Efficiency of outphasing RF power-amplifier system," *IEEE Trans. Commun.*, vol. 33, no. 2, pp. 1094-1099, Oct. 1985.

$$S(t) = A(t)\angle\phi(t) \tag{1}$$

$$S_{1,2} = \begin{cases} \frac{1}{2}S(t)[1 \pm je'(t)], & r \le r_0 \\ \frac{1}{2}S'(t), & r > r_0 \end{cases} \tag{2}$$

$$e'(t) = \sqrt{r_0^2 / r(t)^2 - 1} \tag{3}$$

$$S'(t) = r_0\angle\phi(t) \tag{4}$$

$$S_3 = \begin{cases} 0, & r \le r_0 \\ S(t) - S'(t), & r > r_0 \end{cases} \tag{5}$$

$$S(t) = S_1(t) + S_2(t) + S_3(t) \tag{6}$$

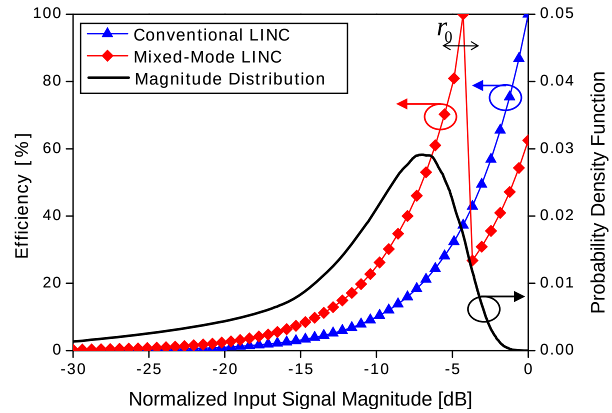

Fig. 3. Efficiency curves with signal distribution of the OFDM-modulated signal.

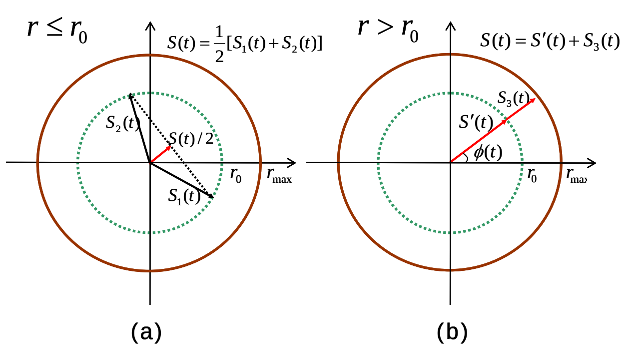

Fig. 1. Signal decomposition of mixed-mode LINC.

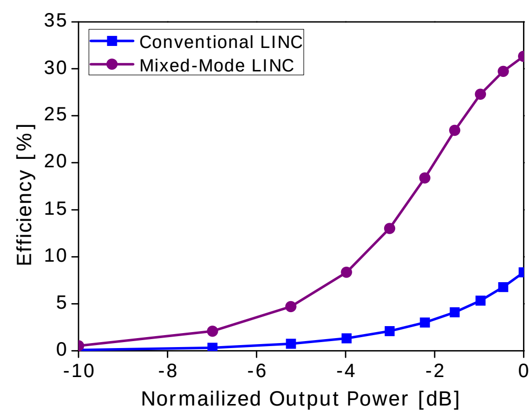

Fig. 4. Efficiency comparison with modulated signals.

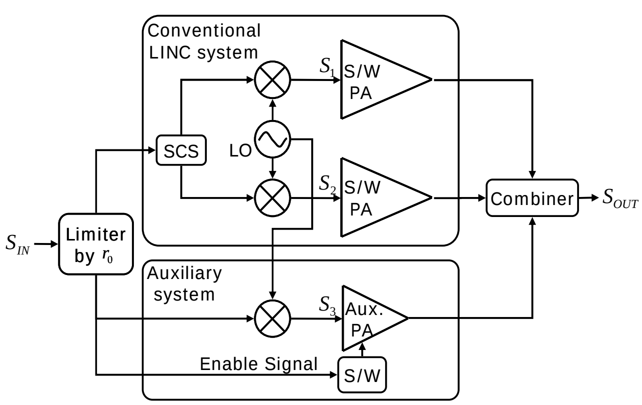

Fig. 2. Mixed-mode LINC scheme.

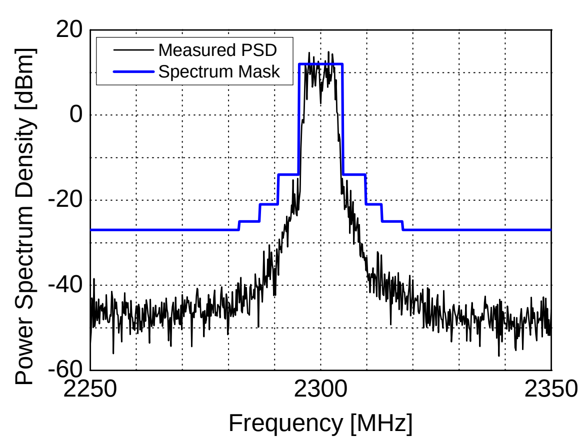

Fig. 5. Measured output spectrum of mixed-mode LINC system.