Pulse Area Modulation for High-Efficiency Power Amplifier

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The pulsed power amplifier (pulsed PA) is one of the practical solutions to high-efficiency linear amplification. The 'pulsed PA' amplifies the RF pulse train that the RF input signal is modulated into, and the original RF input signal is restored by a high-Q band pass filter. The technique was suggested to overcome drawbacks of EER [1]-[3]. Fig. 1 shows a schematic of the pulsed PA. The isolator in Fig.1 is necessary in order to maintain good linearity, but it decreases the efficiency of the pulsed PA by dissipating upconverted switching harmonics reflected by the band pass filter.

This paper presents a new modulation scheme and its implementation for improving the efficiency of the pulsed PA. Instead of a pulse width modulation (PWM), a pulse area modulation (PAM) is proposed for the pulsed PA. Unlike PWM, the proposed method has at least two different pulse amplitude levels. PAM modulates an input signal so that it can be represented by the pulse whose area is proportional to the amplitude of the input signal. In the PAM technique, the different pulse amplitude level is selected depending on the range of the input signal so that the duty ratio of the pulse can be larger for small input signal. For example, the lower pulse amplitude level is selected for a small input signal. Fig.2 shows waveforms of the PWM and PAM according to an input signal. Though both waveforms have same pulse areas, the PAM waveform has fewer harmonic components than that of the PWM.

A schematic of the proposed pulsed PA employing PAM is shown in Fig. 3. The proposed pulsed PA differs from the conventional pulsed PA in that two class E-PAs with different sizes are combined in parallel though $\lambda/4$ transmission lines. When the envelope of a RF input exceeds a reference level, the large-sized class E-PA turns on and the small-sized class E-PA turns off. On the contrary, when the envelope of the RF input is lower than the reference level, only the small-sized class E-PA turns on. In this case, the duty ratio of the input RF pulse train is to be increased to maintain linearity performance. Thus, the pulsed PA using PAM generates relatively small upconverted switching harmonics, which results in improving the efficiency of the conventional pulsed PA. Also, the proposed technique has good linearity because its output is determined only by the on-time duration and the pulse amplitude.

Fig. 4 shows the ideal instantaneous efficiencies of the various power amplifiers. It is assumed that the pulsed PAs using PWM and PAM have only one pulse amplitude level (1) and two pulse amplitude levels (1, 2) respectively. Though the efficiency of the pulsed PA using the PAM is the same as that using PWM when an input signal is high, the PAM technique has higher efficiency when the input signal is lower than a reference level which is a 6dB back-off point from the maximum power. Simulation results show that the PAM technique can enhance the efficiency of the conventional pulsed PA by more than 40% for the IS-95 signal.

REFERENCE

[1] Yuanxun Wang, "An Improved Kahn Transmitter Architecture Based on Delta-Sigma Modulation", *2003 IEEE MTT-S Int. Microwave Symp.* Dig., pp.1327-1330

[2] Young-Sang Jeon, Hoe-Sung Yang, and Sangwook Nam, "A novel high-efficiency linear transmitter using injection-locked pulsed oscillator;" *IEEE Microwave and Wireless Components Letters,* vol. 15, pp. 214–216, April 2005

[3] Young-Sang Jeon, Hoe-Sung Yang, and Sangwook Nam, "A power re-use Technique for improved efficiency of the pulsed oscillating amplifier;" *IEEE Microwave and Wireless Components Letters,* vol. 10, pp. 567- 569, October 2006

< Figures >

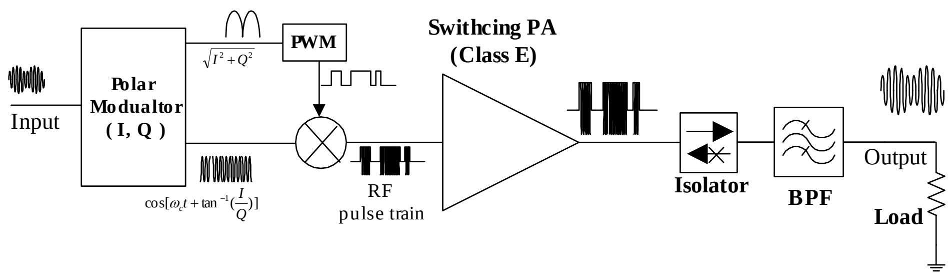

Fig. 1 Schematic of conventional pulsed PA

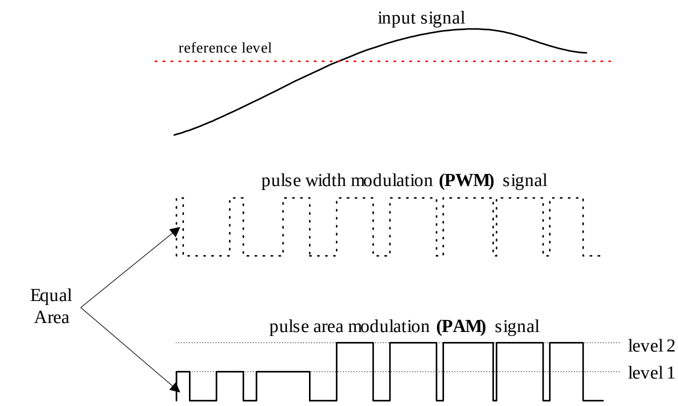

Fig. 2 waveforms of PWM and PAM according to input signal

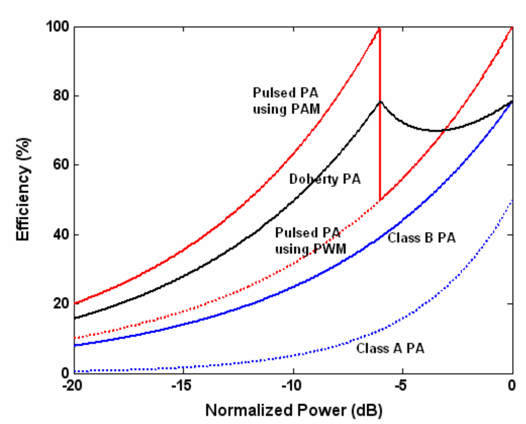

Fig. 4 Ideal instantaneous efficiencies of the various power amplifiers

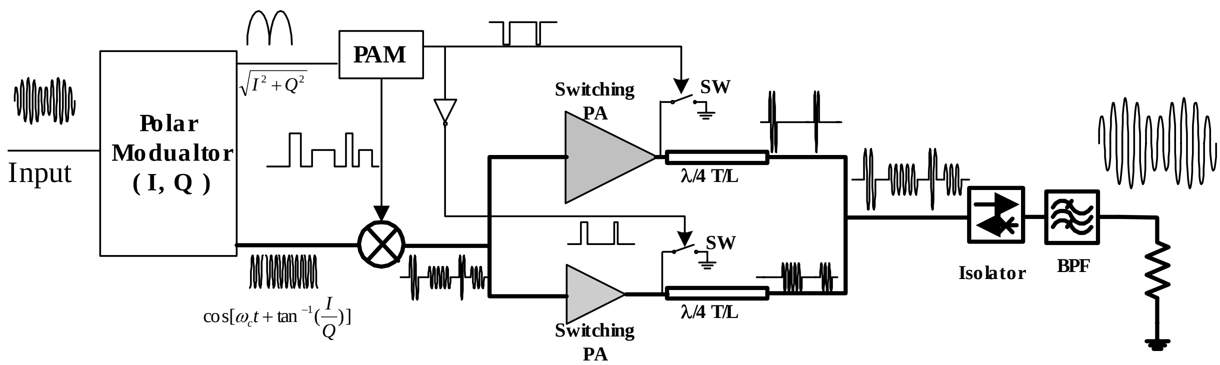

Fig. 3 Schematic of proposed pulsed PA using PAM