Master internship offer 2020

Simulation and design of Signal Component Separator for outphasing modulator for switched mode power amplifier

Subject orientation : Research in mixed analog/digital/RF design ; possible extension for PhD thesis

Supervisors:

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1 Context

In wireless communication systems, the radio-frequency (RF) power amplifier (PA) is one of the most critical components in the design of wireless transmitters. In all wireless applications, the design and manufacturing of the PA requires the engineer to address several concurrent, and often conflicting, requirements on power efficiency, linearity, cost per watt and size.

Recent trends in efficient and linear PA research have begun focusing more on the use of two-branch amplifier systems and away from the classical single-ended amplifier topology combined with the use of digital predistortion techniques. Among these dual-branch systems, the most popular are the Doherty amplifier; the envelope elimination and restoration (EER) technique and variations thereof; the linear amplification with nonlinear components (LINC) technique; and the modified implementation of the LINC concept (MILC) technique [1].

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It is possible to avoid envelope variations in a PA by decomposing a variable-envelope signal into two constant-envelope waveforms. Called "outphasing" or "linear amplification with nonlinear components" (LINC), the idea is that a band-pass signal can be expressed as the sum of two phase-modulated components.

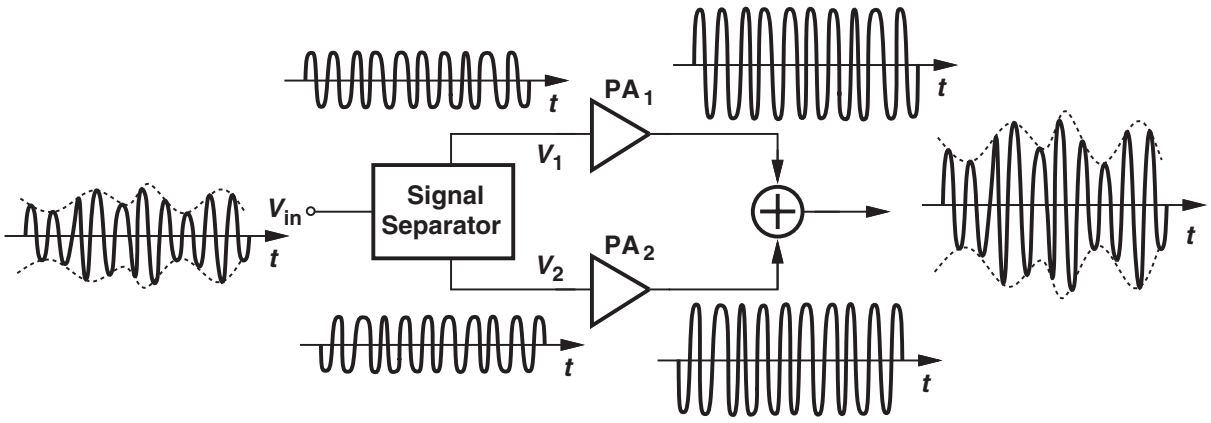

Figure 12.60 *Basic outphasing.*

Figure 1: Figure from: [2]

The generation of two components constant-envelope waveforms from the initial signal requires substantial complexity, primarily because their phase must be modulated, which itself is a nonlinear function of the envelope of the signal.

Due to their high efficiency switch mode PAs, and class-E amplifiers in particular, have been effectively applied as branch amplifiers for outphasing PAs [3]. Indeed, since two outphasing signals have constant envelope, they can theoretically, be amplified with a high level of linearity with switch mode amplifiers.

The generation of the RF switch mode signal starting from the baseband digital representation requires a specialized analog and mixed signal block which is critical for the performance of the whole system.

2 Subject positioning and objective

While some analog signal component separation implementations have been proposed, it is the digital implementation that offers the flexibility required to exert a control over the precision of calculations, as well as to implement correction algorithms to compensate for any residual imbalance in the analog sections. The use of a lookup table technique, the bit resolution of the computations, the memory resources required, the required computation speed (largely determined by the modulation bandwidth), the choice of digital to analog

converters, etc., are all issues that must be addressed when using a digital implementation of the signal component separation block [1].

The aim of this internship is to design the signal component separation block and some of its subsequent analog stages.

3 Work Plan (6 months)

The research work plan is the following:

- State of the art of signal component separation blocks and phase modulators (1.5 months)
- Matlab level simulation and electrical simulation of a complete ideal outphasing modulator (2.5 month)
- Design of a phase modulator, report & publication (2 months)

4 Required skills & tools to be used

- Skills in programming (Matlab/Octave)
- Skills in analog and RF circuit design

References

[1] A. Birafane, M. El-Asmar, A. B. Kouki, M. Helaoui, and F. M. Ghannouchi. Analyzing LINC Systems. *IEEE Microwave Magazine*, 11(5):59–71, Aug 2010.

[2] Behzad Razavi. *RF Microelectronics*. Prentice Hall Press, 2nd edition, 2011.

[3] A. Ghahremani, A. Annema, and B. Nauta. Outphasing Class-E Power Amplifiers: From Theory to Back-Off Efficiency Improvement. *IEEE Journal of Solid-State Circuits*, 53(5):1374–1386, May 2018.