X-Band Isolated Outphasing GaN MMIC PA with Transistor Rectifier for Power Recycling

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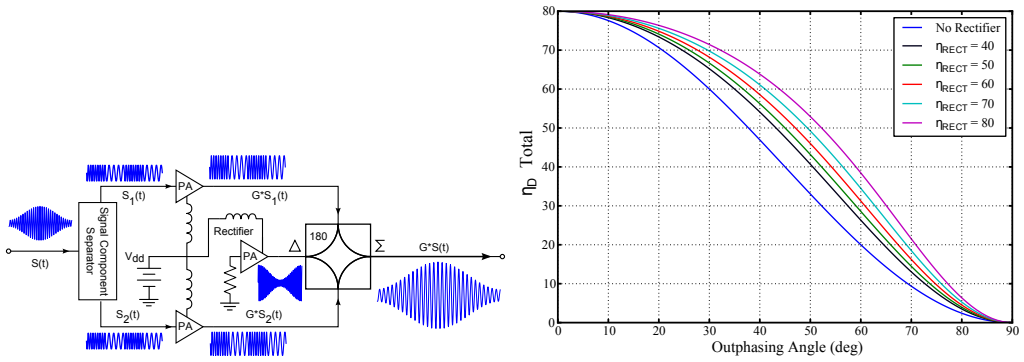
The outphasing method of power amplification, introduced by Henri Chireix in 1935, is one of several architectures which (ideally) provides both linearity and efficiency. In the realization of such an amplifier, though, efficiency and linearity are still traded off through the choice of combiner. A non-isolated combiner will provide high efficiency (as long as the power amplifiers can operate under complex loading), but sacrifices linearity. On the other hand, an isolated combiner provides perfect linearity, while reducing efficiency due to the power lost in the isolated port termination (A. Birafane et al., "Analyzing Linc Systems", *Microwave Magazine*, vol. 11, 2010). Rather than dissipating power in the isolated port of the combiner, this power can be rectified (e.g. R. Langridge et al., "A Power Re-use Technique for Improved Efficiency of Outphasing Microwave Power Amplifiers", *Microwave Theory and Techniques*, vol. 47, 1999) to obtain DC power, thereby reducing the DC power consumption from the power supplies and increasing efficiency. This work utilizes diode networks while presenting a near constant impedance to the isolated combiner. We propose an improvement to this method, by utilizing an RF power amplifier as a rectifying element for an improved efficiency in the isolated outphasing architecture (M. Roberg et al., "High-Efficiency Harmonically Terminated Diode and Transistor Rectifiers", *Microwave Theory and Techniques*, vol. 60, 2012).

A MMIC outphasing amplifier was designed utilizing this new concept on TriQuint's $0.15\mu m$ GaN process. Figure 1(b) shows the theoretical efficiency improvement for various rectification efficiencies. This assumes that the PAs are identical, the combiner is lossless and provides perfect isolation, and the rectification efficiency is constant. Because these are idealized assumptions, our design attempts to account for the real performance, where the combiner will be de-tuned by the varying impedance of the rectifier along with its varying conversion efficiency. The simulated performance predicts a peak power above 5 watts is expected with a PAE greater than 55 %.



(a) (b)

Figure 1: Block diagram of isolated outphasing power amplifier with PA rectifier and theoretical system efficiencies for various rectification efficiencies.