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: research innovation application :

Power Amplifiers for 4G and beyond - managing the efficiency, bandwidth and linearity tradeoff

Industry brief

Strategic Business Relevance:

Applying novel techniques in the design of basestation power amplifiers (PA), based on the Class-J mode of operation, can yield high efficiency coupled with significant bandwidth and good linearity. Simplified design flow for the design of "hybrid" Class-J PAs delivers state of the art efficiency and bandwidth while significantly reducing design complexity for the amplifier engineer.

Power amplifiers are the main energy consumers in modern base stations (BST) as seen in Fig.1. Moreover their inefficiency is transformed into heat, creating the need for active cooling of the devices, further increasing overall power consumption. Consequently, high PA efficiency is essential for the reduction of Operational Expenses (OpEx) for mobile networks operators, as it can reduce the power consumed and the need for cooling.

The proposed approach is based on Class-J design principles for the design of efficient, wideband and quasi-linear PAs. Wideband PAs can enable multi-mode and multi-standard operation that reduces the complexity and size of the modules. It could also allow equipment sharing between operators in the BST, thereby reducing infrastructure costs.

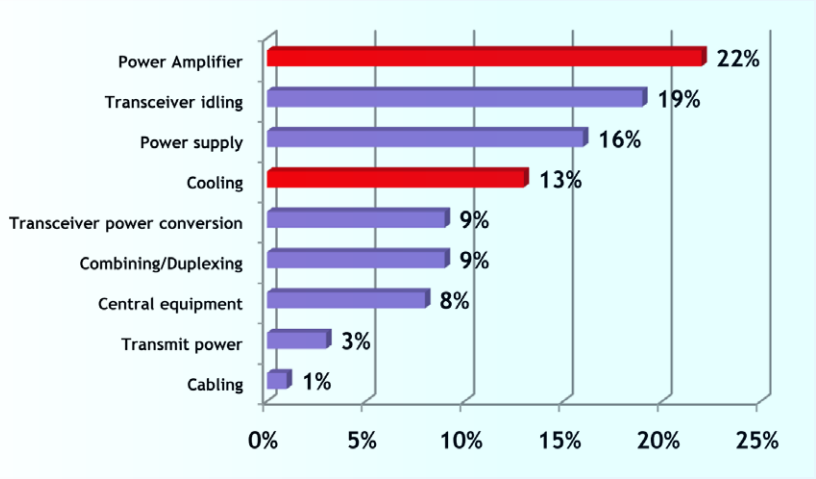

Fig.1:
Base station power consumption breakdown
(Globecomm 2010, P. Grant and S. Fletcher, MVCE doc. O-GR-0053

Core 5: Green Radio

Through the perspectives of both architecture and state of the art techniques, the Core5 Green Radio research programme is discovering innovative ideas to significantly reduce the power consumption of radio access networks.

The Techniques element spans the protocol stack and when optimally combined seeks to address the aspiration of 100x power reduction.

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Key aspects of Class-J amplifier design

Industry brief

Efficiency

Class-J PAs can be designed to achieve up to 80% efficiency at high compression. This is comparable to switching Class PAs(E/F*/F) at maximum output power. The advantage of Class-J is the graceful transition to Class-B performance at back-off, beneficial for the average efficiency under high PAPR signals. This is demonstrated by the narrowband Class-J prototype shown in Figures 2, 3.

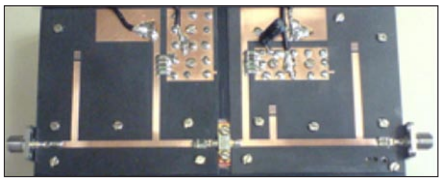

Fig.2: Highly efficient, narrowband Class-J PA.

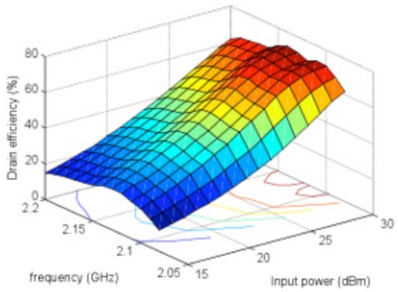

Fig.3: Performance over frequency and input power.

Bandwidth

Commonly, high efficiency PAs (Class E/F*/F) require very specific impedance terminations (10% bandwidth). Class-J theory removes this constraint by utilising combinations of impedances at fundamental and harmonic frequencies to sustain efficiency and output power. This key attribute is used to achieve wideband operation.

Linearity

The combination of impedance terminations for Class-J operation is chosen in such a way that highly non linear behaviour is avoided. This simplifies the characterisation procedure and minimises the linearisation effort.

Design methodology

We have developed a matching network synthesis and evaluation technique which based on Class-J operation and pre-defined design specifications, assists the engineer to meet the design targets. This methodology maximises the achievable efficiency/ bandwidth/ power/ linearity product for a given matching network architecture. Based on this methodology an ultra-wideband PA was designed. The photo and measurements of the PA can be seen in Figures 4 and 5 respectively.

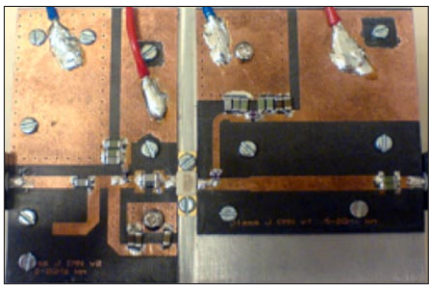

Fig.4: Highly efficient ultra-wideband Class-J covers 0.5GHz to 1.8GHz.

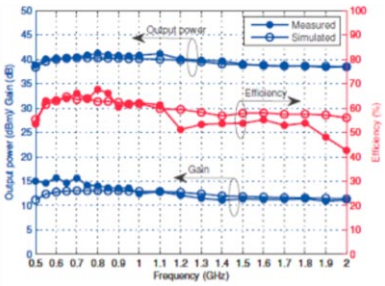

Fig.5: Efficiency, output power and gain over frequency below the 2dB compression point.

Summary

Class-J PAs can significantly contribute to reduce power consumption in basestations. Moreover, their wideband capability can enable multi-mode/multi-standard designs and allow equipment sharing between operators in the basestation. We have demonstrated a high efficiency narrowband and an ultra wideband Class-J amplifier based on a step-by-step design procedure.

Key Points

- High peak efficiency and good back-off efficiency compared to other classes (E/F*/F)
- Wideband operation
- Simplified design methodology
- Enabling technology for multi-band/multi-standard designs

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