On-Chip Power Management: Core Stacking and RF Power Recovery

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The implementation of circuits and systems in deeply scaled CMOS processes is increasingly limited by power delivery, dissipation, and efficiency requirements. This work explores the development and applications of analog and RF integrated circuits aimed at enabling new approaches to on-chip power distribution and enhancing energy efficiency through power recycling.

In the power distribution area, series stacking of processing and/or memory blocks in large multiple processor core integrated circuits has the potential to dramatically decrease the metal dedicated to the power distribution system in deeply scaled CMOS technologies. An example of what is proposed is shown in Figure 1 below. Substantial blocks of logic or memory are operated with common VDDlocal and GNDlocal values. However, N (N would be 2, 3, 4 or even more) blocks are operated in series. Shunt regulators around each of them ensure that reasonably constant voltages are maintained for VDDlocal and GNDlocal in the face of time varying currents demand by the N blocks in a stack.

In the power efficiency area (with Professor David Ricketts), on-chip resonant AC-DC converters are utilized to recycle wasted power in LINC power amplifier architectures back to the power supply, thereby improving the power added efficiency of the overall system. LINC power amplifier architectures overcome the efficiency-linearity tradeoff by separating an incoming signal into two phase-modulated, constant-envelope signals, which are then individually amplified at optimal efficiency. The signals are combined at the output by a Wilkinson or Chireix combiner, resulting in highly efficient and highly linear power amplification. One drawback of LINC topologies is that power is wasted in the combiner when the amplifiers are operated out-of-phase. As part of this work, RF resonant rectifiers are designed with THz capable Schottky barrier diodes to recycle this lost power back to the supply, and resistance compression networks are utilized to insulate the power amplifiers from variations in loading conditions.

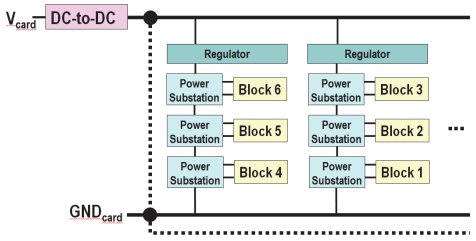

Fig. 1: Core stacking power distribution architecture.

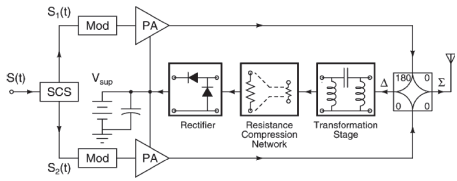

Fig 2: RF power recovery for LINC power amplifiers.