

Integrated Circuit and Systems Sciences

Research Needs: Circuit Design

December 2011

The SRC GRC member companies are pleased to release this document that describes the research needs in the thrust of Circuit Design including that for Texas Analog Center of Excellence (TxACE). Incorporated into this document are the Grand Challenges from the International Technology Roadmap for Semiconductors (<http://public.itrs.net>) as well as needs identified through ETAB priorities, the ICSS strategic planning process, TxACE workshops and joint discussions.

Addressing the challenges in the ITRS requires the focus of circuit design research in three main areas: management and optimization of circuit power and energy, design of robust circuits, and design of high-performance circuits. These challenges are evident in both advanced processing nodes as well as circuits for particular application areas. The members have an increased focus on analog/power/RF/mixed-signal design as designing complex circuits in those areas has become more difficult than in the past. This complements the emphasis on circuit design to take advantage of technology scaling.

There are six general categories identified, which are areas of importance to the members. Each category then contains several subcategories which describe the need in more detail. Even so, these are written to be broad in nature. With the formation of the TxACE, the end applications that might take advantage of these research results are broader than they have been in the past.

The needs in the circuit design space cover a broad range of applications, including high performance processors for data centers, low power processors for mobile computing and communication, healthcare devices, and efficient energy usage and management systems. Investigators are encouraged to link the results of their work with a potential application to help describe the relevance of the proposed work.

White Papers for all the categories below will be considered for funding. Please note the categories in bold were highlighted by member companies for this 2011 solicitation as being particularly valuable to the industry.

2011 Circuit Design Needs Categories

C1	Circuit Power/Energy Management/Optimization
C1.1	Very low power digital and analog circuits
C1.2	Circuits used for power management, including regulators, DC DC converters, and controllers
C1.3	Thermal management circuitry including high accuracy compact temperature sensors
C1.4	Control/management of leakage current
C1.5	Bulk CMOS replacement for external crystals in ultra low power systems
C2	Circuit Design Robustness (Analog, Digital, RF and Memory)
C2.1	Circuits for increased tolerance and adaptability to manufacturing/process variability
C2.2	Increasing reliability by design with unreliable components, soft errors and voltage "overstress"
C2.3	Noise tolerant and aging tolerant circuits/isolation techniques, signal integrity, low capacitance robust ESD
C3	High Performance Circuits
C3.1	On-chip interconnect scaling, including high-speed signaling techniques and interconnect driven design techniques
C3.2	Circuits for high-speed communications including ultra high speed ADC (> 10 Gbps) links
C3.3	Adaptive analog, digital, and memory circuits for improved power performance efficiency
C3.4	Power efficient high performance digital circuit design
C3.5	Power efficient, high performance clocking: Scaling, low jitter, multiple clock domains, and asynchronous/GALS
C3.6	High dynamic range analog front-ends for sensors
C3.7	Configurable Modular analog and high-speed I/O architectures that improve reuse in SOC products
C3.8	Digitally enhanced analog/RF circuits
C4	Circuits in Advanced and Emerging Technologies
C4.1	Area efficient analog/RF design in scaled "digital" technologies
C4.2	Digital circuits with low I_{on}/I_{off} in low head room CMOS processes (e.g. extreme scaled CMOS or high V_t ultra low power)
C4.3	Low voltage digital and analog circuit design including near-threshold and subthreshold design with wide dynamic range
C4.4	Circuit design techniques with advanced CMOS device structures
C4.5	Reconfigurable Analog/RF design in processes with non-volatile memory bits/tunable devices
C4.6	Interface circuits for 3D integration
C4.7	Test structures that target characterization of traditional and new sources of variability
C4.8	Test structures for 3D ICs that account for manufacturing, and reliability challenges
C4.9	Emerging memory design (volatile or nonvolatile) – high performance and power tradeoffs with high reliability and/or 3D scalability
C4.10	Low power logic and circuit design utilizing emerging nonvolatile RAM memory technology
C5	Bridging Research Across Disciplines
C5.1	Semiconductor materials/processes/device and circuit design interactions/co-development, including novel non-CMOS devices
C5.2	Variation-aware device and interconnect modeling in advanced technologies
C5.3	Package and circuit interactions – high frequency, low noise, EMI management, power delivery, cost effective packaging, 3D silicon stacking
C5.4	Improved designer productivity through CAD and circuit interactions
C5.5	Mixed-signal isolation technologies for SoC, SiP and 3D
C5.6	Non-traditional application areas for silicon circuitry
C5.7	Heat and temperature management for 3D ICs
C5.8	Variation-aware and scalable analog/RF/memory/mixed-signal BIST/DFT circuits

2011 Circuit Design Needs Categories, continued

C6	Circuit Design for Emerging Applications
C6.1	Adaptive circuits that sense and take corrective action when the device approaches known or operational limits
C6.2	Non-Nyquist and other novel techniques for ADCs (e.g for compressed sensing)
C6.3	Wearable health monitors: Power efficient body sensor circuitry and/or dry skin contact sensing
C6.4	Accurate, affordable Gas Sensors for spectroscopy applications
C6.5	Efficient and affordable circuits for emerging lighting and display applications
C6.6	Reliable power efficient antenna, and wireless power transmit and receive circuits
C6.7	Low power circuits for timing and control of sleep/wake sequences
C6.8	Circuits for managing multiple energy sources that are not well behaved, such as from energy harvesting
C6.9	Energy Efficient Spectrum Sensing for cognitive radio applications
C6.10	Components for multi-band/multi-standard (cellular, connectivity or wireless sensor network)
C6.11	Low power circuits and techniques for RF synchronization and hand shaking (replacement for listen before talk)
C6.12	Signal amplification near and beyond f_{max} for millimeter wave and sub millimeter wave applications
C6.13	Energy efficient motor control and driver circuits