Microelectronic Circuits Centre Ireland - MCCI Research Scope

Released

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18 June 2020

1 MCCI RESEARCH OVERVIEW

1.1 SCOPE OF MCCI WORK

MCCI will undertake research projects across a wide range of microelectronic integrated circuit design topics, spanning certain fundamental technology areas, multiple application domains, and our four research pillars.

1.2 FUNDAMENTAL TECHNOLOGY

1.2.1 ANALOGUE AND MIXED-SIGNAL IN DEEP-SUBMICRON NODES

There are significant challenges associated with Analogue, RF and mixed-signal circuits in deep-submicron nodes including reduced voltage headroom, variability, increased leakage, increased test costs and reduced scaling of power and area. MCCI is interested in new circuit architectures and topologies which address these challenges or which take advantage of increased process speed and timing resolution in 28nm CMOS and below. Digitally Assisted Analogue techniques applying pre-processing, post-processing, test, correction and calibration of Analogue circuits are of interest.

1.2.2 MORE THAN MOORE

There is a rapidly growing need for sensors and actuators across Internet of Things, Medical Technologies, Smart Food, Smart Agriculture, Smart Cities and other applications. Many of these may require the use of older or 'More than Moore' technologies. MCCI is interested in research into actuators, on-chip CMOS sensors and sensor interface circuits such as threshold or power detection. These could be application specific architectures and in almost all cases would require ultra-low power operation.

1.3 APPLICATIONS

MCCI is developing a focus on certain key applications areas. While no applications are ruled out, proposals which align with the following focus areas will be favourably received.

1.3.1 FUTURE NETWORKS, COMMUNICATIONS & IOT

- Beyond 5G cellular infrastructure & handsets
- Satellite, mmWave
- OptoElectronics, PICs

- Ultra-low Power Radio

1.3.2 MEDICAL DEVICES & TECHNOLOGIES AND CONNECTED HEALTH

- Biosensing, neuromodulation
- On-body wearable and in-body implantable
- Point of care, imaging, robustness
- RF sensing (depth, distance, composition)

1.3.3 SMART AGRI, INDUSTRIAL & AUTOMOTIVE

- Smart Agri, animal diagnostics
- Sustainability, water quality
- Green Energy - battery monitoring, health, charging
- Machine monitoring, fault tolerance
- Radar, antenna

1.3.4 PROCESSING

- Quantum, cryogenic
- Artificial intelligence & machine learning, edge processing
- Security / cryptographic technologies
- Robotics navigation, sequencing engines, annealing processors

1.4 FUNDAMENTAL RESEARCH PILLARS

MCCI has built capability in four research pillars based on fundamental building blocks. Proposals addressing the key challenges and trends in these areas are of interest:

1) High Speed Transceivers
2) Power Management
3) Precision Circuits
4) Digital

1.4.1 HIGH-SPEED TRANSCEIVERS

- Beyond 100GHz, mmWave and terahertz
    - RFCMOS, phased-array Rx and beam-forming.
    - Very wideband RF - digital processing
    - Linearity, power improvements, interference mitigation
    - MEMS switching
- RF Systems
    - Low power RF - wakeup, sensing, immunity, rejection
    - Emerging architectures (polar receiver, N-path)
    - Performance - sensitivity, blocking, power
    - Sensing and imaging at THz or sub-mmWave frequencies
- Direct RF sampling
    - Trend towards ADC/DAC based transceiver architectures
    - Power linearity & noise improvements
- Optical Communications
    - Direct modulation & coherent systems
    - Noise, power reduction, channel equalisation, clock recovery
- Frequency synthesis and clocking
    - All Digital PLLs
    - Spur reduction, on-chip mmWave frequency references
    - Integrated jitter improvements

- RF filters, passive devices, integrated antennas

1.4.2 POWER MANAGEMENT

- Highly integrated conversion
    - Increasing response to fast transients
    - Switched cap and high frequency inductor
    - Circuit techniques that improve electromagnetic interference, efficiency & reliability,
- Integrated voltage regulation
    - High frequency (100MHz+) low-dropout linear regulators (LDOs)
    - Switched-capacitor voltage regulators (SCVRs)
    - Inductor-based buck-voltage regulators (LCVRs) .
    - Synthesizable digital LDOs
- Hybrid Conversion
    - Resonant switched cap
    - Improve utilization of active semiconductors and passive components
- Technologies
    - GaN power devices, gate drivers, instrumentation, and interface circuitry on the same die
- Energy Harvesting
    - Improving efficiency and MPPT for variable sources, multi-source balancing and storage management

1.4.3 PRECISION CIRCUITS

- Targeted FOM and PPA improvements in key application areas
    - Continue to build on the expertise developed
- Data Converters
    - Correction & calibration algorithms
    - Increased precision & noise immunity / mitigation
    - Increased bandwidth & linearity
    - Energy / Power - 10's of nW range. 1fJ/conv step
    - Application specific ADCs
        - Bio sensing (PPG, ECG, etc)
        - Level crossing, slope/TDC/VCO based ADC.
    - BIST and test cost reduction
- Analog front ends
    - Temperature sensors
    - Precision frequency and voltage references
    - Amplifiers, class-D, TIAs
- SPADs and interfaces (VCSEL, TDC, TIAs)
- Cryogenic and quantum control and circuits

1.4.4 DIGITAL

- PPA improvements – across the board
    - Improve robustness & power efficiency across PVT
- Exploitation of technology features
    - Body biasing, passive device advancements
- H/W security
    - Crypto circuit implementation
    - True RNG
    - Private data security - integrated AI training features
- AI & ML
    - Dedicated neural network accelerators execute ML functions faster

    - Neural network processing units (NPUs) – more energy efficient, higher throughput
    - Key metrics are Energy/Inference & Inference/Sec
    - Advanced nodes sub 12nm
- Quantum Circuits
    - Deep cryogenic temperature circuits
    - Circuits to control and observe quantum devices