Candidate Statement:
Bertan Bakkaloglu, Department of Electrical Engineering

I joined ASU in 2004 after working for Texas Instruments Inc. for ten years. During the period I worked at the semiconductor industry, I was responsible for the development of several critical analog, radio frequency, and mixed signal integrated circuits for wireless and wireline communications applications. I lead several design teams responsible for the development of integrated system-on-chip (SOC) designs for communications, and also interacted with many successful university programs in the country. My industry background provided me the vision and mentorship experience to build a successful research program in the area of circuits and systems in a short span of three years.

Since joining ASU, I have focused my efforts towards forming an internationally recognized cross-disciplinary program that incorporates teaching and research in the area of analog integrated circuit (IC) design. My research program currently includes collaborations with faculty across the Fulton School of Engineering and the Biodesign Institute.

In the following sections I will provide details of my current and future research directions, teaching philosophy, and the synergies between these efforts. I will also summarize my contributions to both teaching and university service.

Current and Future Research:

My research focus at ASU has largely centered on generating innovative integrated circuit solutions to critical design bottlenecks in telecommunications, instrumentation, and biomedical applications with an emphasis on overall power reduction and efficiency improvement for all mobile applications from battery regulators to the antenna interface. The common theme among different areas of my research has been merging diverse areas of circuit design in order to achieve high efficiency, high spectral purity signal chains. As an example, I applied discrete-time signal processing to supply regulators and used data conversion techniques in frequency synthesizers and oscillators.

A successful program in integrated circuit design involves design, fabrication and characterization of integrated circuits, a labor intensive, high risk and costly task. In the last three years, my efforts attracted close to $1.1 million in external research funds. The funding sources included government agencies such as NSF, NIH, Air Force Research Labs and semiconductor companies and consortiums including Semiconductor Research Corporation, BAE Systems, Texas Instruments, Intel, Broadcom and Qualcomm.

In my goal to build high-impact applications of integrated circuits, I first focused on a portfolio of innovative solutions to fundamental problems in high efficiency, high linearity radio frequency transmitters, frequency synthesizers, and power regulation and distribution schemes.

As the second step towards a cross-disciplinary research program, my research team and I utilized our solutions and started several government funded collaborative efforts moving circuit design to novel nanodevices--heterogeneous integrated circuits that incorporate electrochemical and acoustic sensors. The outcome of these efforts will greatly enhance quality of life and improve environmental factors impacting human life.

These efforts resulted in 16 journal publications, 20 conference publications, five invited talks, a book chapter and a provisional patent application, all of which included student co-authors. To support these activities, I am currently mentoring more than eight PhD student researchers, four

MS students and two undergraduates in our labs. I also worked closely with a post-doc researcher and collaborated with a visiting Professor.

My research team and I made a conscious effort to build a program moving towards system-on-chip applications that address future needs of industry and government. Our main areas of research can be summarized as follows:

A. System-on-Chip Power and Battery Management

Low noise and high efficiency power supply regulation is a critical need to improve communication quality and extend battery life of telecommunication modules.

- In close cooperation with our industrial partners and government organizations we generated several innovative approaches to low noise supply regulation circuits for integrated RF transceivers and biomedical applications. We introduced the first use of several analog signal processing techniques to low noise, fast response supply regulators. First three architectures out of this research were published in two most prestigious and highly selective conferences in circuit design: *IEEE Solid State Circuits* (*ISSCC*) and *Custom Integrated Circuits* (*CICC*) *Conferences* and in *IEEE Transactions on Power Electronics.*
- We collaborated with low-power VLSI design groups at ASU led by Prof. Chakrabarti to develop the most comprehensive power consumption and optimization model for wireless communication modules, enabling power reduction at system and circuit level. This comprehensive power model was published in *IEEE Transactions on Very Large Scale Integration (VLSI) Systems.* We also collaborated with Prof. Aberle to build mixed signal circuits that minimize antenna radiation losses, thus extending battery life.

B. High Efficiency RF Transmitters & Frequency Synthesizers:

Generating spectrally clean clock signals and achieving a power efficient wireless transmission is a critical design problem in wireless systems.

- By applying mixed signal design techniques to radio frequency circuits, our research in the field of RF transmitters resulted in one of the first fully programmable digital-to-radio frequency data converters, which was published at *ISSCC* 2006.
- Our efforts resulted in several high efficiency circuits for polar modulated transmitter topologies, and the results are presented at *ISSCC* and published in *IEEE Transactions on Microwave Theory and Techniques* and *IEEE Transactions on Circuits and Systems*.
- Spectrally clean frequency synthesizers are fundamental building blocks in every communication and sensor module. We generated a nonlinear, time-varying simulation model for frequency synthesizers that predicts noise folding accurately and published the outcomes in *IEEE Transactions on Microwave Theory and Techniques*. We are currently working on applying discrete time analog design and noise cancellation techniques to synthesizers.
- We also generated the first low-cost self-calibrated built-in phase noise measurement module. This research resulted in an invited paper to *IEEE Journal Solid State Circuits* from *ISSCC*.

We strongly believe that we will continue to attract both industry and government organizations to support our research in this field.

C. Performance-Scalable Reconfigurable Analog and RF Design:

Developing custom integrated circuit design solutions for niche applications is becoming extremely expensive. Government organizations and the semiconductor industry are increasingly in need of reconfigurable analog systems that can change their performance and power consumption *in-situ* based on the system requirements, without the need for a complete re-design.

We started working on fundamental transceiver building blocks such as analog-to-digital converters, digital-to-analog converters and filters that can scale their power consumption based on their performance requirements, such as linearity and dynamic range. This research area contributes directly to the research applications detailed in sections A, B and D.

D. Analog, RF and Power Electronics for Bioengineering:

I see complex biological and biochemical sensor and actuators as a critical future application area for mixed-signal system-on-chip designs. I worked closely with faculty from University of California Riverside, ASU's Biodesign Institute and ASU's Electrical Engineering department, yielding excellent collaborations in the following areas:

- Approximately 28 million Americans suffer from a hearing impairment. Hearing loss affects approximately 17 in 1,000 children under age 18. As a lead PI, I collaborated with Dr. Kiaei and Dr. Chae at ASU on micro-electromechanical system based hearing aid components. This NSF funded research resulted in the first hearing aid chip that enables directional reception with integrated microphones and speakers. Our first micro-loudspeaker design has already gained nation-wide media coverage appearing on Medstar TV and 90 affiliated stations.
- We recently received a three year Grant Opportunities for Academic Liaison with Industry (GOALI) project funding from NSF, enabling us to engage our efforts with the hearing aid industry.
- Furthermore, I collaborated with Dr. Joseph Wang at ASU's Biodesign Institute and scientists from UC Riverside and received NIH funding for three years for using novel analog signal processing techniques for wearable electrochemical air pollution sensors. A second NIH proposal that I collaborated with Dr. Ranu Jung and Dr. James Abbas on neural signal interface circuits is under review.

E. Future Research on Analog and Mixed Signal Design using Novel Devices:

I am actively collaborating with Electrical Engineering faculty working in the areas of device physics, semiconductor processing and modeling in order to utilize these devices in critical application areas:

- I am collaborating with Dr. Trevor Thornton on the utilization of novel devices for nonlinear circuits and systems for image recognition supported by the Air Force Research Labs. Low power analog image recognition modules are the desired outcome of this work..
- I am working alongside Dr. Hongbin Yu on an NSF funded project using DNA-structure based inductors for high frequency analog and radio frequency design.
- I am also collaborating with Dr. Michael Kozicki on novel devices for continuously programmable capacitors and resistors for self-calibrating mixed signal circuit design.

Statement of Teaching:

One of the most rewarding and energizing parts of being a professor is to teach fundamentals of electrical engineering at graduate and undergraduate levels while working with students to utilize this background towards state of-the-art design innovations within their research interests. In order to increase prestige and visibility of Electrical Engineering and ASU in general, I strongly believe in engaging students with state-of-the-art problems currently faced by industry and government organizations. In order to achieve this, I constantly engage with external organizations to match students with mentors that are leading experts in their circuit design discipline.

Some of the highlights of my teaching at ASU are:

- Designed the syllabus and lab experiments for microelectronics classes EEE335 and EEE334 to bring them up to date with state-of-the-art issues and concerns. I am currently working with colleagues on the second revision of the microelectronics curriculum emphasizing CMOS circuit design.
- Developed a new graduate class on Oversampling Data Converters (EEE598J). In this class I covered several critical components of data converter design in detail, including system level knowledge such as spectral estimation techniques, discrete-time analog signal processing, decimation and interpolation filtering, as well as analog design for data converters.
- Re-designed an advanced analog integrated circuits class (EEE523). This class gave me an opportunity to emphasize the critical points associated with integrated amplifier and analog system design to the students. I also taught this class online, and a recorded version of this class is used by several industry training programs.

My undergraduate and graduate level class evaluations have been consistently higher than average with excellent reviews from students as well as area industry in terms of relevance and applicability of my syllabus.

Statement of Service:

Every organization requires active support and involvement of its fundamental components for its vitality and success. This support should be constructive, proactive and timely. At ASU I have served at the following department level committees:

- A member of Faculty Search Committees for the WINTech research center that resulted in hiring of four faculty in the areas of microelectronics, device modeling and MEMS. I am currently serving in a search committee for the bioelectronics faculty as well.
- A member of the Undergraduate Committee and represent the Microelectronics group. I am actively involved with laboratory manual preparation and curriculum development of undergraduate level microelectronics classes EEE334, EEE335 and EEE433.

I had an active technical and professional service outside ASU:

- An associate editor for *IEEE Transactions on Circuits and Systems-II* journal.
- Started the *IEEE Solid State Circuits Society* in the Phoenix region, and I am currently serving as the founding chair.
- Actively involved with the *IEEE Radio Frequency Integrated Circuits Conference* both as a steering committee member and technical program committee member.
- On the reviewer boards for *IEEE Journal of Solid State Circuits, IEEE Transactions on Circuits and Systems, IEEE Transactions on Microwave Theory and Techniques* and *IEEE Transactions on VLSI Systems*.

My last three years at the Electrical Engineering department have been energizing, exciting and productive. I strongly believe that my current and future efforts will increase prestige and visibility of the Electrical Engineering department, the Fulton School of Engineering and ASU in the coming years, and I look forward to continuing my career here.