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My passion for engineering began with some of my earliest childhood memories – watching space shuttles launch into orbit as my entire house shook behind me from the intense rumbling of the solid rocket boosters. This was a common occurrence when growing up only a few miles from the Kennedy Space Center (KSC) and it never failed to spark a sense of curiosity within me. I learned all about the space program throughout my childhood by attending summer space camps and spending countless days at the KSC Visitor's Center. I was captivated by the innovative technology that made space travel a reality and inspired by the scientists and engineers who designed these revolutionary systems that changed the world. During middle school, I was introduced to computer programming at a robotics camp, and I realized that I could change the world too. At that point, my career goals officially shifted from astronaut to engineer.

My inspiration kept me driven and focused through high school, where I taught myself multiple programming languages, excelled in math and science, and even secured a summer internship with NASA. My interest in technology grew as I notice societies' dependence on technologies like consumer electronics and biomedical applications. Intrigued by the electronics behind the devices, I chose to study electrical engineering at the University of Florida (UF). My curiosity spurred me to excel in my coursework as I gained a fundamental understanding of the specializations within my field. I discovered my passion within electrical engineering while taking a course on electronic circuits. My eyes were opened to mixed-signal and analog circuit design, a critical process in creating new electronic devices. The professor teaching the course, Dr. Nima Maghari, spoke of many challenges that plague top researchers in the field as the demand for smaller and more capable devices increases. Solutions to these challenges require many years of dedicated research, but they have the chance to improve technology in numerous aspects, such as speed or power-efficiency. Inspired by the accomplishments of engineers before me and passionate about making a difference, I dedicated myself to continue my journey towards a higher education.

Throughout my undergraduate career at UF, I pursued many opportunities that shaped my passions and allowed me to develop a skillset that is vital to success in research and graduate school. I completed four internships before beginning my graduate studies, spending three summers with the Central Intelligence Agency (CIA) and this past summer with Texas Instruments (TI). The nature of my work with the CIA was very fast-paced and demanding as it was not uncommon to receive a request from a customer to deliver a new product in only three weeks' time. I worked closely with a team of electrical, computer, and mechanical engineers to design these products. It was essential to develop exceptional organization, time management, and communication skills in order to work efficiently with a large team and meet demanding deadlines. I also provided innovative and reliable solutions to meet customers' specifications, reinforcing my critical problem-solving skills. Driven by the prospect that my work would aid the agency in upholding national security, I would often take on up to four different projects at a time. Through countless team projects and individual work, I established and refined these fundamental skills, which allowed me to excel as an undergraduate and prepare for future research.

Although I remained inspired to make a global impact, I also developed a passion for making a difference on a much smaller scale. During my second internship with the CIA, I acted as a mentor to new interns in my division. I provided suggestions for small projects that would teach them new concepts, instill confidence, and familiarize them with the tools and practices necessary for success in their internship. Upon returning to UF, I sought to continue teaching or mentoring and soon secured a teaching assistantship in Microprocessor Applications, a core undergraduate course reputable for being extremely difficult and time-consuming. I aspired to motivate students by exposing them to real world applications that utilized the concepts and theories they were learning in the course. My aspiration came to fruition each time a student confided in me about his or her progress thanks to my help. Many expressed excitement about solving my weekly quizzes, which introduced them to interesting engineering applications while also challenging their understanding of core concepts. I was filled with pride when I saw these students excel as they became motivated to truly understand and go beyond the course material. For the next three semesters, my enthusiasm for teaching grew and I refined my teaching style in an effort to make a lasting positive impact on my students. I focused on interactive teaching methods and guiding students through the problems they faced using the scientific method. This approach bolstered their analytical, problem solving, and communication skills, better preparing them for success in future courses and careers in engineering or academia.

My interest in commercial technologies flourished as I continued learning about analog circuit design at UF and, after three internships with the CIA, I decided to broaden my horizons by pursuing an internship in industry. I secured a position with TI as a mixed-signal design verification engineer working on an automotive product which would sense, convert, and relay multiple user inputs to a central microprocessor. My work was heavily analytical and hypothesis driven as I was required to (1) analyze circuit designs with customer specifications in mind, (2) predict cases in which the circuit might function improperly or fail to meet spec, (3) create accurate circuit models to simulate these cases, and (4) verify the functionality of the design based on simulation results. When I discovered design flaws, I collaborated with designers to determine viable solutions. The end product would be used in automobiles around the world to provide a more reliable user interface that requires fewer components and less power. It was truly inspirational to know that my contributions at TI would result in safer, more affordable, and more environmentally-friendly automobiles. This inspiration was evident in my work as I discovered critical design flaws that were overlooked by designers. If these defects had not been found they might have eventually led to recalls, not only costing TI millions of dollars, but also jeopardizing the safety of those in the automobiles. I learned to effectively and succinctly communicate my processes, results, and proposed solutions to others through multiple presentations to my entire department. The experience I gained from TI will be directly applicable to research as I will be able to analyze and evaluate previous research, produce meaningful results and solutions driven by the scientific method, and then effectively disseminate my work to make a positive impact.

In my last semester as an undergraduate I enrolled in a capstone design course, which required teams of two students to design and present a product that utilizes concepts learned in core undergraduate courses. My partner and I entered the course excited to create a novel product with a meaningful impact. We drew upon experiences with close family friends who once enjoyed playing instruments, but due to severe arthritis or multiple sclerosis, have lost control of fine motor skills and can no longer create music. Inspired to make a difference in the lives of disabled musicians, we tackled our project with unwavering tenacity. Our final product was a non-contact, dual synthesizer, which created music using electronic signals. One aspect of the project that made it unique was its user interface: an array of 12 infrared sensors used to detect hand movement in two dimensions and send the proper control signal to the two synthesizers. This interface allowed disabled musicians to once again enjoy creating music using gross motor movements, such as the wave of a hand. Many of our colleagues and professors were astounded by the complexity and scope of our project given that we only had four months to complete it. We were awarded the ECE Handley Scholarship for the top design project as voted by professors and selected industry members. I was also awarded the TI Analog Excellence Scholarship for designing a fully modular analog synthesizer and a power management system for our project. With high hopes, we entered our project in the TI Innovation Challenge: North America, a design contest open to all undergraduate and graduate students enrolled in universities in North America. Projects were judged on criteria such as originality, creativity, complexity, and quality of the design. Out of 300 teams from accredited universities across the continent, we were awarded first place and a prize of $10,000. As a result, we were invited to TI's headquarters in Dallas, Texas, to present the concepts and purpose behind our winning project to leading management within TI and Mouser Electronics.

As I began applying for graduate school, I remained in contact with Dr. Maghari, who originally sparked my interest in analog circuit design. Based on his NSF-awarded research in scalable and synthesizable analog-to-digital converters (ADCs) and his role as a reviewer for top journals in his field, I was confident that he would be an exceptional Ph.D. advisor. Because he had implemented a mentorship program within his research group to ensure the success of new graduate students, I was both reassured that I would have a mentor to offer guidance during my initial research and excited about the opportunity to become a mentor as my research progressed. During my senior year I continued to excel in my coursework and was awarded the Electric E Award, one of the most distinguished undergraduate awards granted by UF's Department of Electrical and Computer Engineering (ECE), for maintaining a 4.0/4.0 overall GPA. As a result of this achievement, along with my other undergraduate experiences, I was also awarded a Graduate School Fellowship (GSF), the most prestigious graduate student award provided by UF's Graduate School. This solidified my decision to pursue research at UF, and I chose to follow my enthusiasm for analog integrated circuit design, with Dr. Maghari as my Ph.D. advisor.

As I begin my first semester as a graduate student I continue to draw upon the inspiration that started my journey, as well as the many passions and skills I have developed along the way. I have already begun work on improving the performance (accuracy, linearity, and speed) of a digital-based time-to-digital converter, a structure that converts data from the voltage domain to the time domain with minimal power costs. I am working vigorously on this research in hopes of presenting my work at IEEE's International Symposium on Circuits and Systems (ISCAS) within my first year of graduate school. Through extensive review of the literature in my field I will analyze state of the art ideas and methodologies in high performance ADCs in order to propose solutions to existing design challenges. My work will focus on increasing performance while also reducing size and power requirements of the structure. As this research will have vast impacts on many different technologies from consumer electronics to biomedical applications, I understand the importance of widely disseminating my work. I intend to publish at least two papers in a prestigious journal in my field, such as IEEE's Journal of Solid State Circuits (JSSC), and also to present my work at distinguished conferences, such as the International Solid-State Circuits Conference (ISSCC). As my research progresses, I will take on the responsibility of mentoring new graduate students, offering guidance through the research process so they may be successful in completing and publicizing their research. After completing my Ph.D., I plan to pursue the advancement of technology in an industry research lab, such as Intel Labs or TI's Kilby Labs. These research groups offer the opportunity to make positive global impacts by researching innovative and revolutionary ideas to improve upon the technology that shapes our everyday lives. It is also common practice in groups like these to fund and collaborate with researchers in academia, which will allow me to continue mentoring and supporting graduate students throughout my career. My tenacity and focus brought on by my inspiration to make a difference has been exemplified by my past experiences with internships, teaching assistantships, and design projects. As a Graduate Research Fellow, I will resolutely uphold the reputation of the NSF in my venture to make a positive global impact through my graduate research.

Background/Motivation: As technology advances, countless electronic devices require more accurate data collection at a much faster rate while consuming less power. Virtually every electronic system, including the billions of devices connected to the Internet of Things, rely heavily on analog-to-digital converters (ADCs) in order to convert real world data into digital signals for more efficient data processing. ADCs are a type of analog/mixed-signal (AMS) integrated circuits (ICs), which contain both analog and digital circuitries. AMS ICs are affected in different ways by technology scaling, a term referring to the steady reduction of transistor sizes. Technology scaling degrades the performance of precision analog circuits by reducing intrinsic gains, increasing mismatch between transistors, and lowering supply voltages. However, digital circuits are optimized for scaling as they experience increased operating speeds and lower power consumption with minimal performance loss. Decreased transistor sizes further complicate analog circuit design by introducing enormous challenges in design verification, a process that can consume up to 70% of design time [1]. For this reason, analog circuit verification has proven to be a major bottleneck in the analog industry as it is an arduous and time-consuming task that is mostly done manually through analysis of simulation results. On the other hand, exceptionally sophisticated methods have been developed for digital circuit verification, making the process significantly more reliable and less time-consuming than analog verification. It is evident that modern AMS IC design is greatly limited by its analog sub-circuits, which are difficult to verify and experience a substantial tradeoff between performance, size, and power consumption due to technology scaling. This research will focus on replacing the traditional analog sub-circuits in AMS ICs with true-digital or semi-analog blocks to capitalize on the beneficial effects of technology scaling and the efficiency of digital circuit verification without sacrificing device performance.

Research Objectives: The objectives of this research are to (1) determine feasible digital circuit blocks to replace analog sub-circuits in various AMS ICs, including ADCs, (2) verify the traditional and proposed circuits using abstract models to assess the complexity and coverage of the verification process, (3) develop a physical prototype of the proposed design to obtain measured results, and (4) disseminate the results in prestigious journals in the field, such as IEEE's Journal of Solid-State Circuits (JSSC), and at distinguished conferences, such as the International Solid-State Circuits Conference (ISSCC).

Research Plan: This research will build upon a research effort that was previously funded by the NSF: "Scalable and Synthesizable Analog Circuits for Nanometer CMOS" under NSF grant ECCS-1128715. The funded research allowed Dr. Nima Maghari's group to develop novel scalable solutions for ADCs [2] and analog filters [3]. I will determine a feasible and novel digital implementation to replace analog sub-circuits in various AMS ICs (Objective 1) through extensive literature review, analysis of previously proposed solutions, and collaboration with my advisor, Dr. Maghari.

I will then design a circuit model and design flow of my proposed, digital-based AMS IC as well as the traditional AMS IC using an electronic design automation software (Spectre). By utilizing my experiences as an AMS design verification engineer at Texas Instruments, I will develop a verification plan and verify the functionality of each configuration through extensive simulations. Throughout the verification process, I will refine the proposed design in order to optimize its performance and efficiency. If the proposed design is unable to achieve improved performance, I will continue to modify the proposed design to resolve its limitations. Once verification is complete, I will directly compare the verification process of each configuration in terms of complexity, coverage (percentage of the circuit that was verified), and speedup to assess the expected improvements of the proposed design (Objective 2).

With a verified model and automated design flow, I will design a physical prototype of the AMS circuit, which will be tested in the lab to obtain measured results (Objective 3). If the measured results deviate greatly from the simulation results, debugging is possible using our lab's state of the art equipment. These measured results are necessary to characterize the final design, confirm the feasibility of the proposed flow, and disseminate my work (Objective 4).

Intellectual Merit: This work will be published in notable electrical engineering journals, such as JSSC, and presented at distinguished conferences, such as ISSCC. These sources provide the opportunity for my work to advance knowledge within electrical engineering by introducing a cutting-edge, scalable digital solution for high-performance, low-power AMS ICs. This proposed solution will utilize the advantages of imminent technology scaling and reduce design time by simplifying the verification process. The wide dissemination of my work will also allow future AMS research to build upon and refine my proposed methods, thus advancing knowledge within my field. As many AMS circuits, such as ADCs, are a cornerstone in sensors used to gather data, this work will have a staggering impact on advancing knowledge across countless other fields by enabling smaller sensors to gather more precise and accurate data with less power.

Broader Impacts: The increased demand for battery operated portable devices and implantable medical devices has placed an immense pressure on circuit designers to produce smaller precision AMS ICs that boast a higher performance and minimal power consumption. This research will not only allow modern AMS ICs to meet these stringent criteria, but the proposed design will also be scalable, thus its performance will only improve as technology is inevitably scaled down. By reducing the amount of analog circuitry in AMS ICs, the designers can forego complex and time-consuming analog verification processes, which will drastically shorten design time. Digital circuits are also inherently more reliable, cheaper to produce, and require much less design time as the design flow can be automated. For all of these reasons, virtually every electronic device will experience a faster time-to-market, reduced cost, higher performance, and lower power consumption. Therefore, this research will allow cutting-edge technologies to be produced at a much faster rate and more affordable for everyone. This will have an unparalleled effect on society as low-income schools will be able to equip classrooms with the latest educational technologies, homeowners across the globe can afford precision power monitoring systems to conserve energy worldwide, and farmers everywhere can upgrade to low-power 'smart farming' technologies to increase production and quality of agriculture. I intend to continue my role as a teaching assistant for analog circuit design courses, where I will include my research in the course work through circuit design and analysis labs. By exposing undergraduate students to real world applications that utilize the concepts they are learning, I aim to motivate them to excel in the course and in the rest of their academic careers. I hope to increase the diversity within electrical engineering by encouraging minorities and women to pursue undergraduate research and eventually graduate school. As my research progresses, I intend to mentor undergraduate and new graduate students in these underrepresented groups by involving them in projects and exposing them to the tools needed to conduct research in our field, laboratory techniques, and dissemination of research (co-authorships and conferences).

References:

[1] E. Barke, et al. "Formal approaches to analog circuit verification," in Proceedings of the Conference on Design, Automation and Test in Europe (DATE). European Design and Automation Association, 2009, pp. 724–729. [2] A. Fahmy, J. Liu, T. Kim, and N. Maghari, "An All-Digital Scalable and Reconfigurable Wide-Input Range Stochastic ADC Using Only Standard Cells" IEEE Trans. Circuits Syst. II, Exp Briefs, vol. 62, no. 8, pp. 731-735, Mar. 2015 [3] J. Liu, A. Fahmy, T. Kim and N. Maghari, "A Fully Synthesized 0.4V 77dB SFDR Reprogrammable SRMC Filter Using Digital Standard Cells", IEEE Custom Integrated Circuit Conference, Sep. 2015.