

Rinaldo Castello: Berkeley Roots

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When asked to write this article about Rinaldo Castello, I found myself reflecting on my own years at UC Berkeley, particularly when I first arrived in the early 1990s. As someone who grew up in Michigan, then attended the University of Michigan for my undergraduate degree, it was certainly a dream of mine to go to graduate school at a place like UC Berkeley. Initially, I was amazed by the faculty, all of them engineering luminaries. I have vivid memories of my first few days on campus, particularly the first time I walked down the corridor of faculty offices on the 5th floor of Cory Hall, awestruck by the names on each door I passed. Every few feet I would say to myself, ‘Yep, I used his textbook....yes, read his book....oh, I’ve seen several of his papers.’ However, after working a few months in Paul Gray’s research group (where, like Rinaldo, I was fortunate to find a place to hang my hat during my first year of graduate school), I soon realized that the uniqueness of Berkeley’s culture and excellence in IC research really lies as much, if not more, with the graduate students as it does with faculty. The leadership, the transfer of technical knowhow, and the breeding of a creative environment was really attributed



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to the students that surrounded us. With every successive generation of graduate students, there always seems to be one student who stands out and leaves a lasting impression. Although Rinaldo was long gone by the time I came to Berkeley, stories of his leadership and technical excellence still abounded; so much so, that before I met him for the first time, I almost had a larger than life image of this person who embodied the ethos of a collaborative research group and had gone on to do so many great things in the IC design community. I met Rinaldo early on during my graduate studies at Berkeley and not only did he live up to the image, but he also became a great friend, from whom I have received so much technical advice and career guidance through the years, as do many former and current EECS graduate students from UC Berkeley.

Rinaldo arrived at UC Berkeley as a graduate student in 1978. Right from the beginning, he made quite an impression on Paul Gray, who recounts, "I remember vividly my early conversations with Rinaldo when he was talking with faculty members in search of a research advisor in his first days at Berkeley. His tremendous enthusiasm and energy, and his fundamental instinct to seek a deep intuitive understanding in everything he does, came through very clearly. I had learned of Rinaldo through Paolo Antognetti, who was Rinaldo's thesis advisor at the University of Genoa, and who had been very active in involving Berkeley faculty in exchange activities in Italy. Paolo had strongly recommended Rinaldo, and fortunately he agreed to join my group of students." Similar remarks about Rinaldo's early Berkeley days were given by another faculty from UC Berkeley, Alberto Sangiovanni Vincentelli, "I just joined Berkeley's regular faculty in 1977 following six months as a visiting scholar and one year as visiting assistant professor when I met Rinaldo who arrived in Berkeley as a PhD student. I did know his advisor, Paolo Antognetti, well. He introduced me to his students

among whom Massimo Vanzi who went to Stanford and Rinaldo who was the wiser man since he chose Berkeley! We were close in age and I have always considered them friends. When I met Rinaldo, I was impressed by his intelligence and depth and drive to do good work rather than to achieve success at all cost."

From my own personal experience, there are many very sharp people at Berkeley with a passion for research. However, somewhat rarer, are the students who also have a personality that cultivates creativity and camaraderie amongst their fellow students. As described by many of the graduate students from the 1980s, Rinaldo truly stood out among his peers. Hae-Seung Lee, now a faculty member at MIT, paints an almost comical picture from that era, highlighting both his good-naturedness and the air of conviviality he brought to the group. "Integrated circuits research was much different back in the early 80's compared with today, one of the major difference being the lack of any foundry access. Not only a circuit designer must conceive a novel circuit idea, but also he or she must physically fabricate the chip in the university's laboratory. The proclamation "Fabricate it!" from the thesis adviser was typically met with a bittersweet reaction from the student. It meant finally the approval of the concept and the design, light at the end of the long tunnel of the arduous thesis research. But it also signaled a long, hard labor in the laboratory pushing wafers in and out of the furnaces, going through photolithography and etching steps, finding the circuit doesn't work, and doing it all over again, The Ground Hogs Day style, for months at a time. The "lab rats" who would spend day and night for many months included Rinaldo, Ping Li, Roger Howe, and myself plus a couple of the device folks. The lab rats had to deal with many common adversaries in the lab and we developed an enduring camaraderie. Of all, Rinaldo was the most disaster-prone, whether it was dropped wafers that

he already put two months of work on, contaminated chemicals, or dust particles ruining almost-completed chips. It was almost a daily occurrence with him, even though in most cases he was not at fault. Every time, he ranted in a rapid-fire Italian-style, but never lost his jovial attitude or gave up, and got through each debacle somehow making others feel fortunate and amused by his mischief. Although he himself found a great success, he also contributed to the success of other lab rats of the time in a psychological way. It was difficult times for us, but we have a fond memory and friendship as a result."

Comments from another Berkeley EECS graduate student, Giovanni De Micheli (EPFL in Lausanne, Switzerland), says as much about Rinaldo's character, as it does about where state-of-the-art research in IC design was in the early 1980s. "Rinaldo and I started our EECS doctoral program at similar times at UC Berkeley. We took classes together, and we spent endless week-ends while working together on assignments. I will never forget the layout (on paper) of cells for the 64k RAM (yes that is a "k") and the full SPICE model that had to satisfy tight specs! This was the time in which the first layout editors were just becoming available, but not to all graduate students (circa 1980)."

Virtually all the graduate students that I contacted from the 1980s describe Rinaldo as honest, forthright, a great lifelong friend. "Rinaldo is a sincere straight and 'seen-through' easily getting along with person. He helped me with all his effort as his own job, and expressed his happiness vocally and physically as a real 'Rinaldo'," were the comments from Chorn-Kuang Wang, now a Professor Emeritus from National Taiwan University (NTU). Giovanni De Micheli expresses similar feelings, "I was impressed by Rinaldo's rigor, dedication, and honesty. Each task for him was a mission, to be handled with full mind and heart. We shared opinions and expertise, as I was more on the CAD tool side and he on the circuit side."



FIGURE 1: From left: Bosco Leung, Sehat Sutardja, Rinaldo Castello, and Ting-Ping Liu. (Photo courtesy of Rinaldo Castello.)

Impact of Rinaldo's Berkeley Research

Although it is not difficult to find many kind words about Rinaldo's personality, what he is best recognized for internationally is his technical excellence and contributions to his field. As a graduate student at Berkeley, his technical prowess, along with his intensity and enthusiasm for both his research and that of his fellow graduate students, enabled him to make many significant technical innovations, as well as a lasting, positive impact on those in his research group. Again, comments by Paul Gray reflect on Rinaldo's research while at Berkeley "Rinaldo went on to make some very creative and important contributions as part of his PhD work at Berkeley, and those are well documented in his various publications. My most vivid recollections, however, are of his personal commitment to our group of students and to their larger collective success and impact. Graduate students at a place like Berkeley, at least in Engineering, absorb most of their new knowledge from the community of students they work with, not from the professors. At its best, a group of graduate students (and postdocs where they are involved) form a community of mutually supportive researchers who share knowledge and work collectively and collaboratively to have an impact on the field, often only loosely guided by the professor. The culture of mutual support and the search for truth above all other

values is essential for success, and during his years at Berkeley, Rinaldo was one of the best exemplars in my memory of someone who embodied and advanced this set of values. He was untiring in his concerns not just about his project but about the progress and direction of his fellow graduate students as well. As time went on and he became one of the most senior graduate students, and later a visiting faculty member for two years, this influence continued and increased. I and all of the students in our group through that period of time owe Rinaldo a great debt."

Similar comments about Rinaldo's tenacity, and attention to detail were given by a fellow graduate student from the 1980s, Bang-Sup Song, now a professor at the University of California San Diego. "When I was at Berkeley in early 1980s, all research assistants in the CMOS analog design area shared one huge office 401 in Cory Hall, and a day rarely passed by without heated discussions about analog circuits. In those days, most students were implementing sampled-data switched-capacitor techniques, and pursued numerous elusive goals hoping to be an analog guru someday. Rinaldo was already a real talent at that time, and his sophisticated design skill and knowledge were clearly distinguished.

What Rinaldo did at that time was to design a micro-power fast-settling amplifier for switched-capacitor filters. Most opamps at that time used to operate in the class-A mode, and the class-AB stages were used

mainly for the second stage only to drive the large load. Even after 30 some years, the image of Rinaldo's agonizing moments still lingers on my mind like in the memory as fresh as yesterday's. Rinaldo was extremely tenacious and methodical in deriving a class-AB structure for the opamp input stage, which still remains as a unique one-of-a-kind Rinaldo concept. Rinaldo seemed to believe that such a circuit existed, and only tried to find it. His audacious and intense effort reminded me of the famous Michelangelo's quote 'Every block of stone has a statue inside it, and it is the task of the sculptor to discover it.'

It is a rare opportunity to meet and get to know a creative and forward-looking analog designer of Rinaldo's caliber in our lifetime. His technical prowess in the analog and RF designs has led to an unusually broad range of contributions, which actually enabled numerous key technological advancements. Rinaldo's lifetime contributions and achievements can be rarely matched by others, and measured only up to the world's finest."

The comments on Rinaldo's PhD contributions in the area of low-power opamp design for switch-capacitor circuits was also noted by Hae-Seung, "Rinaldo and his adviser Paul Gray had the tremendous foresight of recognizing the importance of low power design well before the explosion of portable electronic applications. The class AB operational amplifier that they developed for the low-power switched-capacitor filter was a particularly ingenious circuit that paved the way to low power applications. By cross-coupling the NMOS and PMOS input transistors and reflecting their currents to the output via current mirrors at all 4 corners of the circuit, the transconductance was effectively doubled and the input referred noise reduced. This was in addition to the main purpose of the class AB amplifier of providing far greater slewing current than the stand-by current. This was a true classic."

Again, a recurrent theme of Rinaldo's personality, hard work, impact, and of course, his slightly accident prone nature were described by Alberto Sangiovanni, "I remember the long stories about his background, his family, his worries and his difficulties in Berkeley. I share the H-S. Lee's memories about the 'black' cloud surrounding Rinaldo! 'Bad' luck did not prevent him to show composure and to be serene. He would just shrug and carry on. I also remember very fondly our conversations about life and the future, about meeting his future wife Anna in Berkeley, about Berkeley professors (and I did not feel like one just yet) about doctors and dentists to trust... I was in the Systems Faculty and I did not know much about integrated circuits besides what I learned at school. Little I knew that my future would have taken me into this area at least as application domain for my research. Our late afternoon talks made me appreciate the complexity of analog circuit design and learn about the absolute excellence of the analog circuit group at Berkeley where faculty and students were inventing exciting new concepts that would have a strong influence in the evolution of the field. The group of students in the late 70s and early 80s included some of the people who changed the industry and founded successful companies."

Exporting a Little of Berkeley, Home to Italy

Rinaldo left a legacy of excellence at Berkeley with outstanding contributions in the area of switched-capacitor design, particularly for filters. However to this day, it's obvious that UC Berkeley, his advisor Paul Gray, and his fellow graduate students made an enormous impression on Rinaldo. Immediately after graduating with his PhD, Rinaldo had one goal in mind: taking what he learned technically and culturally back to his home in Italy. As Giovanni observes, "Rinaldo was considered as a role model by our fellow graduate students, and he has been a great asset

for Italy as he strongly wanted to go back "home" and transfer the knowledge that he acquired in California to a wide body of students." Further comments from Paul Gray also hint at how Rinaldo used Berkeley as a springboard to launch his career in Italy. "Rinaldo of course went on to an amazing career at ST, Pavia, and Marvell. He, his students, and colleagues have made many important technical contributions in utilizing scaled CMOS and BiCMOS for RF communications, Ethernet, and storage applications, among others. Perhaps more importantly, Rinaldo has played a leadership role in advancing the microelectronics industry in Italy, and particular advancing the type of close University-industry collaboration that is so important in order for Universities to be able to help advance the industry. The development of "Ticino Valley" owes a lot to the leadership of Rinaldo and his willingness to try what for Italian Universities were new modes of collaborating with industry."

Of course in the years since his time as a student at Berkeley, Rinaldo has made an enormous impact with respect to bringing the art of analog IC design to both Italian universities and industry. Alberto Sangiovanni notes, "Rinaldo's keen interest in research and ties to his home country

made him go back to the Italian University system. But to pursue his line of work he needed strong connections with industry to demonstrate the quality of his ideas on actual manufactured devices. The Berkeley school was about building circuits after conceiving them. The assumptions used to invent new structures had to be validated and students could not graduate without building their circuits. This belief was the origin of a long association with ST where Rinaldo consulted driving new products and leading some of the most exciting projects there. To witness the importance of Rinaldo's work for ST, the company established a center at University of Pavia where ST's designers were working side-by-side with Pavia's students, a wonderful idea that yielded not only new products for ST but also a new generation of designers. Other companies settle in the Pavia area to tap on the local IC design school. In particular, at the end of 2005, Marvell, led by Sehat Sutardja who was a fellow student of Rinaldo's at Berkeley, stepped in and founded an analog design center that now counts over 100 designers, a homage to Rinaldo's and his University colleagues' leadership in the field. Rinaldo after so many years is, as always, a lighthouse for analog circuit design world-wide."



FIGURE 2: Graduation 1984, Hearst Greek Amphitheater. (Photo courtesy of Rinaldo Castello.)

Maintaining the Berkeley Connection

From what I personally know of Rinaldo, I think his biggest impact on UC Berkeley probably came long after he left the campus in the way in which he has developed, maintained, and nurtured the many connections forged there, as well as facilitating many relationships beyond it. Every year since receiving his PhD, he returns to Berkeley for a few weeks around ISSCC, and spends quality time with members of the EECS department. He maintains a strong, collaborative interest in many Berkeley research projects, solid ties with the circuits faculty, and makes an effort to get to know many graduate students. He has also facilitated many relationships between industry and academia, including a link between myself and STMicroelectronics, a partnership that has continued to this day. Conversely, he has also helped Italian students, particularly those from Pavia, and Italian industry engineers, forge new relations with students and faculty at Berkeley. One of his former students, Francesco Brianti, worked for STMicroelectronics after graduating from Pavia. Rinaldo helped Francesco come to the Berkeley where he spent a year working with many of us. I, along with others in Paul's group, remain close friends with Francesco to this day. Francesco describes his experience and connection to Berkeley through Rinaldo,



FIGURE 3: Rinaldo and C.K. Wang at ISSCC 2014. (Photo courtesy of Rinaldo Castello.)

"I met Rinaldo while I was a student in electrical engineering in Pavia in the early 90s. I still remember him walking into class every day (he never missed any day) with his signature mustaches, and started talking about the true physics behind the Bipolar and CMOS transistor; a lot of talking indeed. It was this talking, rather than an "old school" teaching method that would keep me glued to the chair and come back every time wishing for more. All of this coupled with enthusiasm, passion and energy were making Rinaldo one of a kind professor, and still holding true today. Rinaldo and I kept in touch throughout my graduation, the early years of my professional career at STMicroelectronics where he helped me grow as an analog designer, and eventually supporting me getting into UC Berkeley EECS as Visiting Fellow. I indeed owe him a great part of my professional achievements."

Rinaldo remains a close and trusted friend to all of his fellow graduate students from the 1980s, and many such as myself who have passed through Berkeley years later. I think the current sentiments of all Rinaldo's UC Berkeley colleagues are best summarized by Paul Gray, "Rinaldo remains a great friend and colleague today, still in the midst of a very productive career and together with his colleagues producing technical innovations at a regular clip. Indeed, all of us fortunate enough to have been associated with him are lucky to have had that opportunity!"

About the Author

Jacques "Chris"tophe Rudell received degrees in electrical engineering from the University of Michigan (BS), and UC Berkeley (MS, PhD). After completing his degrees, he worked for several years as an RF IC designer at Berkana Wireless (now Qualcomm), and Intel Corporation. In January 2009, he joined the faculty at the University of Washington, Seattle, as an Assistant Professor of Electrical Engineering.

While a PhD student at UC Berkeley, Dr. Rudell received the Demetri Angelakos Memorial Achievement Award, a citation given to one student per year by the EECS department. He has twice been co-recipient of the best paper awards at the International Solid-State Circuits Conference, the first of which was the 1998 Jack Kilby Award, followed by the 2001 Lewis Winner Award. He received the 2008 ISSCC best evening session award, and was the co-recipient of the 2011 and 2014 RFIC Symposium best student paper awards. Dr. Rudell served on the ISSCC technical program committee (2003–2010), and on the MTT-IMS Radio Frequency Integrated Circuits (RFIC) Symposium steering committee (2002–2013), where he was the 2013 General Chair. He currently serves as an Associate Editor for the Journal of Solid-State Circuits (2009–present).

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FIGURE 4: From Left: Chris Rudell, Rinaldo Castello, and Thomas Cho at the 2014 ISSCC. (Photo courtesy of Rinaldo Castello.)