

My Experience and Challenges in Life of Power Electronics*

Contributed by Bimal K. Bose

1. Early Days in Life

I came from a remote village of Bangladesh (then a part of India) and a large poor family. My father used to work in Indian railways in Calcutta (now Kolkata), but took early retirement to settle down in our village home when during World War II Japanese planes started bombing on Calcutta ports. I still remember the planes hovering in the sky and sirens sounding loud in the evening, and people in the streets running to hide. My father settled in the village Khalis Khali with a small business. I was the eldest son in a family of eight children, and for anything, father used to impose responsibility on me as if I was the head of the house. I lost my mother when I was eight years old. From childhood days, I excelled in swimming and bicycling.



Fig.1. Village home (Jyotsna Kootir) in Bangladesh where I grew up

I was very shy and introvert with a spiritual bend of mind. My father had no confidence in me that I could look after the family when he dies. I started my education in the village primary school, and according to the headmaster of the school, I was very sincere and devoted to my studies, but did not top in the class.

The splendor of nature around us in my village with scenic river, lush vegetation, wide open horizon and star-studded night sky used to fill my heart with awe and inspiration all the time. When alone, I used to dream a



Fig.2. Village primary school (Kalke Nagar) where I began my study in 1940

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life far away from my home and seeing the wide open world with my own eyes. I was born with burning ambition.

Independence came to India from the British rule in 1947, and our village became a part of East Pakistan (which later became Bangladesh). Because of the communal fear, the school students started to emigrate enmasse to the neighboring India. With tremendous financial strain, I became an emigrant in India.

2. Days in Bhita High School as a Student

Because of my excellent school record, I was offered free lodging, board and tuition in the newly established village school Bhita M. P. Institution (<http://www.schoolius.com/school/543757502324227/Bhita+Mahendra+Public+Institution>) in India. I began to devote for my studies whole-heartedly in the school. The school Head Master Benoy Sen often used to ask me: "Bimal! Can you bring recognition to the school?" I began to dream how one day I can grow up to be an important man in the world. However, dire financial problem in the family kept me sad all the time. Later, this problem became a blessing in disguise in my life.



Fig.3. Bhita school students holding Bimal Bose scholarship checks in 2012)(donated by me)
(A teacher is sitting in the middle of front row



Fig.4. Bimal Bose seminar hall in Bhita school in 2007 (donated by me)



Fig.5. Bimal Bose open-stage in Bhita school in 2012 (donated by me)

I graduated from Bhita school in 1950 with a university scholarship securing Honors (more than 75%) in Mathematics, Additional Mathematics, Geography and Sanskrit. The Head Master was very happy with these results. I could not forget Bhita School in the later part of my life. Since graduation, I visited the school many times and tried to make many philanthropic donations. Sometimes, I carried sweets to the school and distributed to the students with my own hands.

After graduation from Bhita School, I returned to my village home in East Pakistan. My father wanted me to join his small business, but I had a different goal in life. How to find an opportunity to live in Calcutta and study in a college? This became my obsession.

3. Days in Calcutta Asutosh College as a Student

I got an offer from Asutosh College in Calcutta (https://en.wikipedia.org/wiki/Asutosh_College) with free tuition, board and lodging in the college hostel of Kalighat Road. I enrolled in I.Sc. (Intermediate of Science) with Physics, Chemistry, Mathematics and Biology. My results in I.Sc. were not very good because of a devastating illness. My father brought me to village home for herbal medicine treatment that worked very well for me. After my I.Sc. degree, one of my wealthy relatives offered me a job, but I did not accept it.

4. Undergraduate Engineering Education in Shibpur B. E. College

After independence of India in 1947, engineering became a very important profession, and I wanted to study Electrical Engineering in Bengal Engineering College (BEC) (now Indian Institute of Engineering Science and Technology (IIST)) in Shibpur. (https://en.wikipedia.org/wiki/Indian_Institute_of_Engineering_Science_and_Technology,_Shibpur)

However, the residential college was very expensive and the admission was highly competitive. I had to sit for a competitive entrance examination. Fortunately, I stood second in order-of-merit, and as a result, I got free tuition and maintenance scholarship all along that helped me to survive barely the expenses in the college.

I was a student in the college during 1952 to 1956. The BEC was an old institution, established in 1856, and renowned for undergraduate education.



Fig. 6. Bengal Engineering College (now IEST), Shibpur in 2013 (showing the clock tower)

The BEC had a large electrical machines laboratory where in our senior year, we were assigned machine experiments on Ward-Leonard speed control, Hopkinson's test (dc motor-regeneration with a coupled dc machine), synchronization of an alternator on a three-phase bus with the three-lamp method, and Schrage motor speed control. Prof. Ralph Benedict from the University of Wisconsin, Madison, visited us for one year and taught a course on mercury-arc rectifiers. We had two lab experiments on glass-bulb mercury-arc rectifiers. One was a single-phase, full-wave diode rectifier with center-tapped transformer. The other was a six-phase, half-wave, grid-controlled rectifier.

The college days were very hard for me because of dire financial problem. Often, I had to skip breakfast in the hostel and supplement it with cheap food. Saturday and Sunday were particularly painful for me because I had to stay alone in the hostel, whereas all the other students went home. The Summer vacation was extremely difficult for me when the hostel remained closed over a month.

Gradually, four years of college passed by and I became an electrical engineer in May 1956 with a First Class degree. It was a very exciting joy for me. Suddenly, my prestige went up in the society, and all my relatives who shunned me so far began to like me. Engineering and Medicine were the most prestigious professions in India in those days.

5. Six Months in Nepal Sikarbas Power House

After my engineering degree, I needed to have practical training in industry in order to be eligible for a regular job. I was assigned Government of India training in Tata Hydro Power Co., Bombay (now Mumbai) for two years. Towards the end of my training, it became difficult for me to get a job in spite of my first class degree from a highly reputed engineering college. At last, I accepted an offer without interview which happened to be in Nepal, near the border of India.

After a long overnight train journey, I came to Jogbani, an India-Nepal border town, and discovered that my place of employment was in Nepal Tarai Jungle – not in India. What a great blunder I made in selecting my first job! The darkest period of my life began, and I did not tell it to anybody. I was the superintendent (with the title of Assistant Engineer) of Morang Hydro Electric Power Co. which had a mini hydro power station at Sikarbas. The nearest city was Biratnagar, which was around 100 miles away. In deep jungle with practically no road and communications, I was totally isolated from the civilized world. However, the splendor of nature with majestic mountains, streams of river, waterfalls and serenity of nature was so superb that I have not seen in my whole life. I remember catching fish with hands from the river stream. Inspiration and spirituality filled my mind. I often feared that possibly this was the end of my life's dream. After isolation of six months from the human civilization, I was desperate to leave Nepal and return to India. I heard from local people that Sikarbas gets flooded in rainy season and many people die in Malaria because no medical treatment was available. I wanted to resign from my job, but was asked to stay until my replacement could be found. The rainy season was approaching fast. One fine morning, I decided to leave Sikarbas without telling anybody. I was lucky that this unhappy chapter of my life came to an end smoothly.



Fig.7. Inspiring view of Nepal Sikarbas with waterfall

6. M.S. degree at University of Wisconsin

I came back to Calcutta and started applying for jobs. One day, I saw a newspaper announcement that Government of India was accepting applications for TCM (Technical Cooperation Mission), which later became United States Agency for International Development (USAID) that provides scholarships from U.S. Government for post-graduate study in American universities. I applied for the scholarship and was selected after an interview in New Delhi. What a dramatic turn in my life! The ambition of higher goal of life was suddenly alive again. I was assigned in the University of Wisconsin, Madison with my colleagues Gopal Gangadharan and Dikshitulu Kalluri.



Fig.8. Bimal Bose (at left) as graduate student in University of Wisconsin in 1959
(with colleagues Gangadharan and Kalluri)

I pursued my master's degree at the University of Wisconsin, Madison, from 1958 to 1960. Besides my university education, the TCM organized an excellent program for our all-round experience with the American Educational System. Under the terms of this program, I was required to teach in an Indian university for a minimum period of three years.

In those days, spectacular revolution was going on in the field of electronics. In 1948, Bardeen, Brattain, and Schockley of Bell Laboratories invented the transistor that started the solid-state electronics revolution. In 1958, General Electric (GE) commercially introduced the silicon-controlled rectifier (SCR) or thyristor (solid-state thyatron) based on PNPN triggering transistor invented by Bell Labs in 1956. This was the beginning of the second electronics revolution or age of solid-state power electronics. Silicon power diodes started appearing in 1950s, replacing the old selenium, copper oxide, and gas-tube diodes, and they created a lot of excitement.

The University of Wisconsin was famous for its power engineering program. Prof. Ralph Benedict was my thesis adviser, and he also taught me industrial electronics course. There was an industrial electronics laboratory, where we conducted experiments on a thyatron (gas triode) dc motor drive and ignitron welding control, etc. I pursued my M.S. research on the study of three-phase diode-bridge rectifier harmonics and their effects on general utility systems using a distributed-parameter, LC-model transmission line. With the help of a harmonic wave analyzer, I could demonstrate the distribution of harmonics along the line and the resonance voltage boosting effect with a particular harmonic.

Coming from India to the USA, and Wisconsin in particular, was an exciting experience for me. It was a different world, where people looked so lively and prosperous. With an Indian friend, I rented an apartment where I used to cook Indian food, but during the day, I ate American food in the university cafeteria. Winter weather in Wisconsin was extreme, and sometimes temperature used to fall to -16°F . The streets and the two lakes, Mandota and Monona, in Madison were completely frozen. I found it difficult to walk on the sidewalks and roads with a heavy coat and my briefcase in hand. I could hardly believe that men were ice-fishing on the lakes.

7. Career in B. E. College, India 1960-1971

After completing my M.S. degree in Wisconsin, I was assigned a faculty position (Lecturer) in my Alma Mater B. E. College. I had to sign a warranty for three years in a teaching position as a condition of the TCM scholarship. My responsibility was to develop teaching and research program in industrial electronics. A new chapter started in my life. Initially, I started teaching Hydro Electric Plant at the request of my head of the department Prof. S. N. Ray. This was an optional course in Senior year. In addition, I taught Advanced Electrotechnology in Junior year. After a year, I was promoted to Associate Asstt. Professor. One day, I got a call from the Principal of our college who asked me to take NCC (National Cadet Corps) officer's training in Kamptee and Secunderabad for a period of five months. This was immediately after the China's attack to India in 1962. It had a devastating effect in my career, because this was not the desired path of my career. On completion of my training, I resigned from NCC, and started pursuing doctoral study in Calcutta University.

8. Start of My Research in India, 1960s

I selected magnetic amplifiers (MAs) as a topic of my research under Dr. Sankar Baral as my official adviser. Calcutta University (<http://www.caluniv.ac.in/>) was very famous for research activities in those days and produced a large number of brilliant scientists. Although thyristors were available at that time, Dr. Herbert Storm, a renowned authority in MAs at GE Corporate Research and Development (GE-CRD), Schenectady, NY advised me to work in this area and agreed to be my project adviser remotely. I grew close to Dr. Storm through professional correspondence. There was an era of magnetic amplifiers with saturable core reactors before the modern thyristor era, which were functionally similar to gas-tube or solid-state power electronics. Magnetic amplifiers were bulky but more rugged and reliable than gas-tube electronics, and they were promoted very heavily during World War II and postwar periods.

The analytical study of MAs was much more complex than that of thyristor converters. My research was somewhat hybridized with MAs (with silicon diodes), power transistors, and thyristors. My research projects included a magnetic servo amplifier for position control with a two-phase induction servomotor, and multi-channel telemetry encoding systems using MAs with transistors and thyristors. The NASA Langley Research Center in Hampton, Virginia, seriously considered them for satellite-to-earth data transmission. I completed my Ph.D. degree in 1966. From 1966 to 1971, before immigrating to the United States, I supervised many MA-

based research projects at BEC, including a four-quadrant analog multiplier, a dc-to-dc converter, a magnetic servo amplifier, and a digital voltmeter.



Fig. 9. B. E. College EE faculty in 1966 (I am standing at top left).

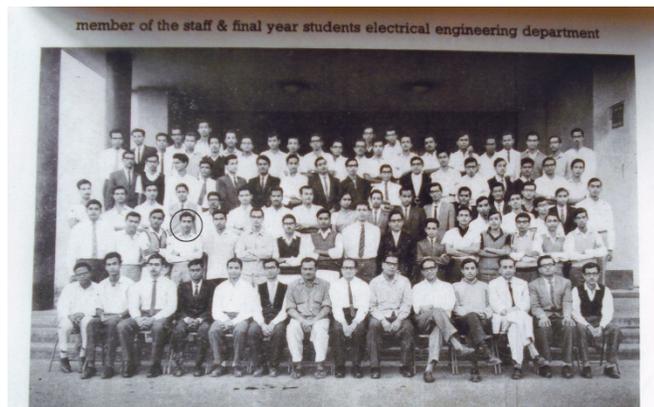


Fig.10. B. E. College EE faculty (sitting in front row) and final year students in 1968; (I am sitting in the middle of front row)

From the beginnings of 1970's, the political condition in India, particularly in West Bengal started deteriorating, and this created a devastating effect in our college. Soviet Communism (Marxist Communism or CPM) and Chinese Communism (Marxist-Leninist or CPI-ML) were fighting and played havoc in the educational system in our schools and colleges. In 1971, the deterioration in teaching and research in our college was extreme, giving me tremendous amount of frustration. I decided to quit my job and search for a new career abroad.

I applied in many U. S. universities with the help of my Wisconsin professor Ralph Benedict and got an offer in Rensselaer Polytechnic Institute (RPI) as a visiting professor. Because of my job offer in USA with M.S. degree from Wisconsin, getting emigration with Green Card became easy for me.

9. RPI and Research in Modern Power Electronics, 1970s

The year 1971 was very significant for me, as I emigrated from India to the USA and started my academic career at RPI as a visiting professor in modern power electronics. I might mention here that until now power

electronics was known as industrial electronics, particularly those that used gas tubes. The ambitious career opportunities in USA always fascinated me. Getting a job offer in USA while I was working in an Indian university was not easy. To test my knowledge, the RPI department chairman asked me to submit four doctoral research topics and formulate a full senior/graduate course in power electronics. This was quite a challenge for me because my strength was mainly in magnetic amplifiers. However, GE Corporate Research Center in Schenectady which worked closely with RPI's EE Department, examined my submission and approved it. Thus a new challenging chapter of my career began in RPI.



Fig.11. RPI Material Research Center (where my office was located) in 1971-1976.

RPI is a private university with a great reputation; the students were brilliant and constantly tested my knowledge in power electronics. To my knowledge, the only other university in the United States that had a power electronics program then was the University of Missouri, Columbia. RPI benefitted from its proximity to GE's research labs in Schenectady, which helped promote my power electronics program.

In the beginning, I started to teach a new senior course on Semiconductor Power Electronics with around 20 students. Gradually, I was asked to teach a general course of Electrical Engineering to Junior students with nearly 100 students. Since the teaching medium was English in India, I did not have any difficulty. However, the Assistant Dean of Engineering was somewhat suspicious about my pronunciation in British accent. He sat at the back of my class for a few days and certified my good teaching. Soon, I started teaching a graduate course in power electronics. Later, I introduced an undergraduate digital electronics course which became overwhelmingly popular. Power electronics was a new technology, and a large number of graduate students registered under me for their projects.

However, transitioning teaching and research from an Indian university to RPI was not easy for me. I completed a number of projects such as the development of a transistor ac switch and its application in matrix converter; triac speed control of induction motor; three-phase ac power control with transistors; and a thyristor-saturable core self-oscillating inverter. These were considered later as pioneering research activities.



Fig. 12. My RPI graduate student Bill Kenly won the IEEE international award for his research on triac speed control of induction motor under my guidance (Latham News Aug.6, 1974)



Fig. 13. My television interview for advising Bill Kenly project in 1974 (Bill Kenly on the right)

GE-CRD offered me a part-time (one day per week) consultancy on a project: a thyristor high-frequency resonant-link cycloconverter for power conversion. This again was a challenge, but the project turned out very well. I showed for the first time that a cycloconverter could be used at programmable leading or lagging line displacement power factor (DPF), and as a static VAR compensator (SVC) in extreme cases. As a reward, GE-CRD offered me a full-time job in 1976.

10. Changing Career Path from RPI to GE-CRD

I could not refuse GE-CRD's attractive offer. Having spent sixteen years in university career, I always felt that I had a large gap in my education and expertise. As a graduate student, I did not have much experience getting my hands dirty in fabricating large power converters with complex electronic circuits, or solving real world EMI (electromagnetic interference) problems of large converters. My doctoral studies were rich with analytical work using complex waveforms, equations, etc., but not with real world applications.

Naturally, I promoted similar analytical studies among my graduate students. As a professor, I had few opportunities to come across industrial research projects. I advised my students in lab experiments on what oscilloscope waveforms should look like, with lots of sketches on black boards, but I was hesitant to put my hands on breadboards on complex projects. Obviously, I was somewhat nervous with large projects that

involved higher levels of power. Power electronics is such an application-oriented practical subject, however, and it was time for me to fill these gaps if I wanted to have real impact as a university professor in the future.

GE-CRD was then considered as the ivory tower of power electronics worldwide, and power electronics specialists from all over the world used to visit its labs in Schenectady. All the conferences were then filled with the company's papers, and there were hardly any papers from universities. I thought it would be very unwise not to accept the GE offer. While in GE, I continued as Adjunct Professor of RPI and taught an advanced graduate course in power electronics in the evening and advised several graduate research projects from GE.

11. Working with Bill McMurray at GE-CRD

The transition to GE-CRD after a 16-year university career was another challenge to meet. My office was in the historic Building 37 in Schenectady, where [Ernst Alexanderson](#), [Gabriel Kron](#), [Philip Alger](#), and other famous scientists had offices. It was a thrilling experience to see so many world-renowned scientists in the hallways and offices. All researchers regardless of background had the title of Electrical Engineer. This was a bit humiliating for me because I had been a university professor for so many years.

I was given a desk and chair in the same room with [William "Bill" McMurray](#) (1926 – 2006). Bill is the founding father of power electronics, and the world bows to his memory with deep respect. All of his papers, particularly those on thyristor forced-commutation techniques, are considered classic contributions in power electronics. His research set the stage for the modern power electronics evolution. He worked at GE-CRD for 35 years with an M.S. degree, but his brain was extremely sharp. He deeply loved mathematics and filled pages after pages with complex equations, which were strewn all over his table and the floor. After a generalized analysis, he loved to draw normalized graphical plots.



Fig. 14. William McMurray (1926-2006), my guru of power electronics

I was surprised to see that such a world-famous scientist had barely a chair and desk with a telephone in his office. Bill was a chain smoker, and the room was always filled with smoke. In the later part of his life, he suffered from emphysema, which was the cause of his death. He rarely spoke with others. A young lady secretary with a noisy typewriter sat in the same room. She used to call him an "awful person" because of the heavy smoke in the room and his silence. Although I sat next to Bill, I could rarely speak with him informally. He insisted that I make an appointment for any talk. Once we rode together to Auburn, New York, where GE manufactured thyristors, and he did not talk to me during the entire six-hour journey. He seemed to be thinking the whole time.

Nonetheless, we had a very good working relationship, and Bill's highly creative contributions gave me inspiration. I learned from him that "research ideas do not necessarily come within the 8 a.m. to 5 p.m. work day in the office."

The thoughts linger most of the time beyond the office hours and often new ideas come when I am taking a bath, walking alone in the evening, or even in the midnight when I suddenly wake up with the flash of new idea. There is no difference between scientific research and transcendental meditation”.

12. Projects at GE-CRD, 1976-1987

There were three classes of research projects in GE-CRD. The most prestigious were assessed fund projects, which required invention, analysis, simulation (as needed), and laboratory experimentation. These projects were executed by premier scientists with the funds assessed from the company’s product divisions. My first project was an assessed fund project with Bill on ASCI (Auto-Sequential Current-fed Inverter) inverter analysis and simulation. It was an honor to have the opportunity to work with a world-famous scientist.

The other classes were government- and product department-funded projects, respectively. Some projects required bench-type development work, which were done mainly by B.S. and M.S.-level engineers. Of course, engineers like McMurray were exceptions. Externally funded projects, with deadlines for completion, were very demanding. If a project required study of background fundamentals, there was no company time allotted for it. It had to be done in the evening or weekends which we were supposed to spend with our family. Sometimes, meeting the project deadline required a lot of extra hours in office and home. We had to fill up time cards every week for our work. Allocation of company time for the projects was often a difficult task. If I or another researcher spent two hours in library, or three hours for a doctor’s visit, often we had to lie on the time card.

After joining the GE, my branch manager, [Robert H. “Bob” Guess](#) (1923-2010), gave me the freedom to choose an assessed fund project to work on. This was a big surprise. I noticed that most innovative projects terminated only in U.S. patents and IEEE publications. The company encouraged us to write as many patent disclosure letters as possible, some of which were only conceptual ideas. There was a handsome bonus for a disclosure letter if patent application was filed on it. Some of my colleagues working in power electronic circuits had more than 100 U.S. patents.

GE had received a large contract from the U.S. Department of Energy (DOE) to develop electric vehicles (EVs). This was the first major initiative by the U.S. government after the Arab oil embargo in 1973. Gasoline became very scarce and its price shot up. Suddenly, people realized that the U.S. was too dependent on foreign oil for automobile transportation. Electric vehicles could help solve that problem, at least for limited distance commuting. This was a stimulus to reviving research in power electronics, where thyristor technology and its application markets had become saturated. Thyristor converters had many limitations, of course, and it appeared that this was the end of the power electronics age. Some professionals in this area even started changing their fields.



Fig.15. GE-CRD project on hybrid computer simulation for microcomputer controlled ETV1 drive system in 1978. Myself and Paul Espalage (standing).

Our first EV project, [ETV1](#), with a power transistor chopper and dc motor drive (1979) with microprocessor control, was very successful. I became the principal engineer for the EV’s microcomputer control without knowing anything on microcomputers. GE thought that my university background and deep knowledge of power electronics would help

me overcome the challenge. Nonetheless, using digital signal processing to develop controls, monitors, and protection was a very difficult subject at that time for a middle-aged power electronics engineer, since the techniques and technologies involved were radically different from traditional power electronics. I had to study and understand thoroughly microcomputers and software, and then design and test the system so that the prototype EV operated satisfactorily before delivery to the DOE by the deadline.



Fig. 16. GE-CRD project on microcomputer control of ETV1 showing the converter and control modules under test in 1979; From left: Hunt Sutherland, Steve Peak, myself, and Paul Szczesny.

Of course, an experienced technician (Paul) always helped me. This was the most strenuous time in my career. I spent weekends and many nights at home for the study, and had hardly any time left for my family.

One night, our newly-designed EV drive was undergoing tests on Chrysler’s dynamometer in Detroit. My project manager woke me with a phone call at 1:00 AM one night in my home to say that the drive was having an instability problem while accelerating, and I should come to Detroit immediately in the morning to fix the problem. I lost sleep thinking how to do this. I flew out and solved the problem by canceling the software compensator with an inverse analog compensator, and then connecting an analog compensator in series. Although it was a brute-force method, everybody was happy when the problem disappeared.

Finally, when the project was completed successfully, it gave me tremendous satisfaction, especially when Queen Elizabeth II requested a demonstration in the U.K. for our new EV (ETV I). The last project I did at GE was the interior permanent magnet (IPM) synchronous motor drive using distributed TMS320 DSP-based control, for the ETX-II vehicle that GE designed with Ford Motor Company in 1987. In those days, people thought that it was crazy to use an IPM machine for EV drive, when everybody else used induction machines. Later, the IPM machine-based EV/HV drive became commercially accepted all over the world.

My other important projects included control development of a linear inductor machine for railroad propulsion;

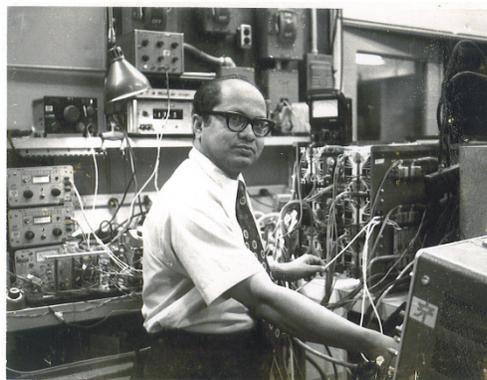


Fig.17. GE-CRD project on railway propulsion with linear inductor motor in 1977

a microcomputer-based hybrid (SPWM-SHE) pulse-width modulation (PWM) controller for an inverter; scalar decoupled control of an induction motor; control of a switched reluctance motor (SRM) drive; sliding mode control of



Fig. 18. Doing research at GE-CRD laboratory on DSP control of the EV (ETXII) project in 1986.

From left: Paul Szczesny, myself, and Hunt Sutherland.

induction motor; and maximum power-point tracking (MPPT) control of a residential photovoltaic system. Many of these projects were later considered as pioneering work in power electronics. Practical projects like these gave me a lot of experience, and confidence in designing, fabricating, and testing of large systems while gaining more specialized knowledge in power electronics. The experience accumulated from the interaction of projects in different product departments with different organizational partners. Large government-funded projects required contributions from many team members, including the lab technicians, whose help was essential for any project's success. Such collaboration can be painful for professors who are normally very individualistic. Often, I completed projects ahead of time. Surprisingly, all my GE-CRD projects were successful.

Occasionally, my program manager walked into my office, and I was happy to show him the excellent simulation result of the drive which I was developing. However, he strongly discouraged simulation studies, withholding his judgment until he saw the actual drive running in the laboratory. "I do not trust simulation results," was his comment. He only trusted waveforms on an oscilloscope or multi-channel recorder when the inverter was working and the motor was running.

Once a month, our senior laboratory manager Dr. Jim Lafferty invited each of us project heads in rotating order for lunch, where we had to briefly discuss our projects without any audio-visual aids. Suffice it to say that there was no pleasure in such lunches. GE had many product departments, but while the role of the CRD was to give them technology support, the labs' coupling with them was very poor. Hardly any of our inventions were translated into products. Of course, our large government-funded EV projects were for feasibility studies only.

13. Career Tracks at GE-CRD

In principle, the company had a policy of "parallel ladder" career paths, where researchers and managers competed on parallel paths for position and salary. However, it hardly existed in practice. Senior managers belonged to an elite class with power, status, and compensation. In comparison, most of the researchers were considered "second-class citizens." However, the scenario was entirely different when we went outside the company. GE scientists and engineers were highly respected throughout the world. It is mainly their contributions that helped to make power

electronics technology so rich today. The IEEE conferences in this area were dominated by the contributions of large corporations, and we were treated like superstars.

GE hired engineers with degrees from all over the world. A doctorate from MIT, for example, could negotiate a much higher salary in the beginning than that of a doctorate from India, like mine. There was a system of “totem pole” evaluations annually, however, where all the engineers were placed in serial rank according to performance, and the salary raise depended on the totem pole position. This means that it was possible for the engineer from India to get a higher salary than the one from MIT after a few years. I heard that the company maintained a secret database for every engineer, in which information related to his marriage, homeowner status, number and age of children, etc. were continually updated. The assumption was that if you were more settled, with less chance of switching jobs, your salary raise would decrease irrespective of your position on the totem pole. Every person had a price tag around his neck, and the question always asked was, “Are you disposable?” This theory of disposability made the scientist’s job more stable than that of the manager’s. During my eleven years in GE-CRD, I reported to about ten managers. This was the reason why some managers tended to be ruthless, in order to show their performance.

Whatever the case, with the totem pole position and the results from the database, the salary raises tended to dry up after a number of years. You received high raises early, small raises later, and then no raise at all for years in spite of great performance. This was the most painful stage in a career. The company always liked to get rid of older, fat-salaried engineers and then hire young, lean-salaried engineers while cleverly avoiding age discrimination lawsuits. If you thought that you were very valuable to the company, however, you could play a trick, and sometimes it worked. You arranged a job interview outside, which was easy for a GE engineer, and got an offer with a higher salary. Then it was time to bargain with your manager, which is, of course, very unpleasant and risky. There was only one exception. In CRD, we had a Nobel Laureate in Physics, [Ivar Giaever](#), who was the show-piece of the company to the outside world. Every year, the company vice-president would go and ask him how much of a raise he wanted.

There was one very good aspect to a job in a large corporation besides the technical projects. The company’s health and pension benefits were very liberal. If you retired from the company after lengthy service, it would bear most of your health costs, including hospitalization, for the remainder of your life. The pension benefits rose almost exponentially with length of service, and you could live a very comfortably after retirement. I found that hardly anybody quit the company.

However, this scenario changed rapidly after “Neutron” Jack Welch became chief executive in 1981. Such liberal benefits were no longer the standard. The managers in the company were under higher pressure to accelerate productivity. Finding the financial resources for a project was normally a manager’s responsibility, but now the researchers were also under tremendous pressure to find funded projects. It was suddenly chaotic everywhere. The company started transferring manufacturing units outside the U.S. to decrease labor costs. The slogan everywhere was “emigrate or evaporate.”

14. Comparing Research and Development in Japan to GE, 1980s

While the company work was very exciting because of the large projects, and highly prestigious to the outside world, the environment also started changing in the 1980s because of Japanese competition. During a visit to Japan, I found that Japanese engineers and managers were highly disciplined with total dedication to the company work, in a manner somewhat lacking in the USA. The Japanese management style was unique in that it promoted loyalty and friendliness among all in the work environment. While visiting Toshiba Fuchu Works research laboratory in Japan, I found that the top manager worked with the staff in ordinary work clothes. This amazed me. The R&D work in Japanese companies, unlike GE’s, was closely tied with the product development. The additional advantage is that the country is so small, the R&D centers and product departments are coupled and in close proximity.

The result was that Japan began dominating the world in manufacturing power electronic equipment with higher quality and lower prices, and it became a challenge to U.S. corporations like GE. Japanese engineers from Hitachi,

Toshiba, and Mitsubishi used to routinely visit the GE research laboratory. Suddenly, the door was slammed in their faces. Once I arranged the visit of Dr. [Akira Nabae](#), professor of Nagaoka University of Technology and formerly from Toshiba Corporation, the most eminent power electronics engineer in Japan. He came to Schenectady, but was denied a visit to the laboratory in spite of prior approval. What a humiliation!

15. Publishing at GE-CRD

Coming from university, IEEE publication of innovative work was very tempting for me. However, publications were discouraged, and often delayed until the related patent was approved. There was fear that competing companies might steal our ideas and use them in their products. Instead, writing patent applications were highly encouraged while paper writing was either forbidden or permitted only with a long delay after filing for the patent. Each publication required approval by the hierarchy of company managers, which caused more delays and much frustration. In university, we follow the “publish or perish” principle, where papers are often sent for publication even before completion of the project. In industry, the principle is the opposite: i.e., “publish or survive.” This means that you will survive in your job if you avoid publications. I estimated that I could have almost doubled my publication rate if there had been no company restrictions.

Once my manager called me in his office and indicated that I was wasting company time by writing too many IEEE papers. However, I knew that IEEE papers were extremely important for the long-term growth of my career. While working at GE-CRD, I edited my first book, *Adjustable Speed AC Drive Systems* (1981), and completed my first textbook, *Power Electronics and AC Drives* (1986).

This was not easy while working full time in a corporate environment. After I applied for the company approval for my textbook’s publication, my program manager gave me a hard time. His complaint was that I had taken a lot of company time to write it. I struggled to convince him that I wrote it in my home on weekends and holidays with the study door shut against family members, and this was the reason it had taken three years to write. Of course, it is true that I had to use company time occasionally to complete the book.



Fig.20. Publication of my first IEEE Press book in 1982;
From left: Walt Berninger (lab manager), myself, and Jim Wilson (unit manager).

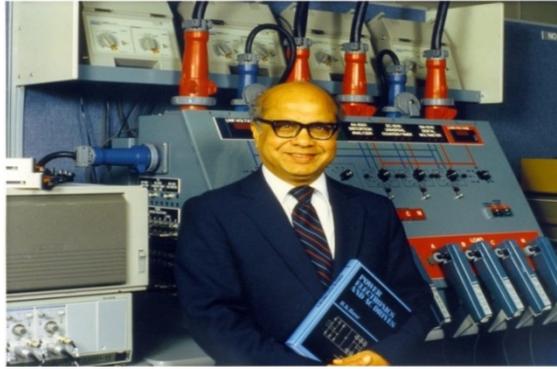


Fig. 21. Myself with my new text book in hand at the GE-CRD power electronics laboratory in 1986.



Fig. 22. GE-CRD silver patent medal recipients in 1986; (I am on right)

Corporate Research and Development
Schenectady, New York
No. 961, April 11, 1984



Bose Award Established by Indian Government

The Bose Award in Power Electronics, named after Dr. Bimal K. Bose, an electrical engineer at the Center, recently was established by the Electronics Commission of the Government of India.

The award will be presented annually to an engineer in India who has made outstanding contributions in research, development, design, education, or promotional activities in the area of power electronics. Bimal officially inaugurated the award at the recent annual convention of the Institute of Electronic and Telecommunication Engineers, New Delhi, India, where he also delivered the keynote address.

A native of Calcutta, Bimal received his bachelor's degree from Calcutta University in 1956, his M.S. degree from the University of Wisconsin at Madison in 1960, and his Ph.D. from Calcutta University in 1966, all in electrical engineering. He served as a member of the faculty at Calcutta University, where he was awarded the Premchand Roychand Scholarship and the Mount gold medal for his research contributions. In 1971, he joined the faculty of Rensselaer Polytechnic Institute.

Bimal joined the Center in 1976, and began research on power conversion systems and microcomputer-based performance optimization of power electronic systems. The author of 45 technical publications, he holds 10 patents. He also is an adjunct faculty member of RPI.

Active in professional organizations, Bimal was chairman of the Transactions Review of the Static Power Converter Committee for the Institute of Electrical and Electronics Engineers (IEEE) and editor of the IEEE Press Book titled "Adjustable Speed AC Drive Systems." He is a member of a number of IEEE committees and the Program Committee of the Tokyo International Power Electronics Conference.

Bimal and his family live on Michaelangelo Street in Latham.

Fig. 23. Bose IETE award established by Indian Government in 1983; (Published in GE-CRD newsletter)

16. Returning to Academia at the University of Tennessee as Power Electronics Chair, 1987-2003

I decided to return to a university career (<http://www.eecs.utk.edu/people/faculty/bbose>) in 1987 after spending eleven years in GE-CRD. Why did I leave? Although I climbed high up the GE totem pole, my salary raises practically stopped in the later years. I needed to reestablish my sense of self-esteem, which was shattered in the corporate environment. At the same time, I found that my expertise in power electronics had improved significantly due to the blending of practical experience with my theoretical knowledge. I also gained tremendous visibility in the world in the power electronics field because of my books and other publications. I thought it was the right time to migrate to the prestigious university job where I really belonged. One fine morning, I got a call from Prof. Jack Lawler of the University of Tennessee, Knoxville, with an invitation to visit the campus. There I was offered the endowed Condra Chair of Excellence in Power Electronics Applications. It was impossible to resist such a handsome salary, along with the initial tenured status that was becoming so rare in the academic community. In parallel, I was also offered the position of Chief Scientist of the newly established Power Electronic Applications Center (PEAC).



Bimal K. Bose says he saw "a tremendous opportunity" when he accepted his appointment to an engineering chair at the University of Tennessee.
 Kathy Forrester/News-Sentinel staff

New UT scientist has obsession for power

by LARRY LEE
News-Sentinel staff writer

A handmade sign behind Bimal K. Bose's desk reads, "WELCOME TO PEAC, DR. BOSE." He, probably hasn't even noticed.

Of course, he's busy. Yet, something else is riding high on Bose's mind — it has been for nearly 30 years. Even his family must sacrifice as he devotes hours to his overriding interest — passion — obsession for power.

It's his job. On July 1, the 54-year-old Bose filled the first of two University of Tennessee Condra Chairs of Excellence. Along with that appointment comes the title of chief scientist at the Power Electronics Applications Center off Pellissippi Parkway in West Knox County.

PEAC came to East Tennessee last year, the result of a nationwide search for a home by the Electric Power Research Institute of Palo Alto, Calif. PEAC's mission is to make electricity more productive.

Bose's charge, as he sees it, is to build a world-class program at UT in power electronics: the control and conversion of power by electronic means.

"We'd like to build up a program that will be the focus not only of the United States but of the world," Bose says. "It will merge tremendous resources by linking industry, government and university efforts. The concerted push will be "to build international competitiveness — that's our main goal," he says.

Bill Snyder, UT College of Engineering dean, describes Bose as "truly an international person" in his field.

Bose is especially prominent in his native India, where in 1984 the Institute of Electronics and Telecommunication Engineers created an annual award in his name.

He was trained as a power engineer at Calcutta University but watched in the late '50s as the research area of power engineering

diminished in importance. While he was in Wisconsin studying for a master's degree from 1958-60, his interest in electronics budged, sparked by the new transistor and semiconductor. He later returned to India to receive a doctorate and teach at Calcutta University.

In 1971, Bose came to the Rensselaer Polytechnic Institute at Troy, N.Y., as a visiting professor with the purpose of building the power electronics program. The next year he became a consultant at the General Electric Research and Development Center in Schenectady and eventually joined the GE staff full time.

There he conducted research on converter circuits and systems, direct current and alternating current drives, simulation, microcomputer control and the Ford electric automobile.

"One of the purposes of using power electronics is the conservation of energy," Bose says. "We cannot really wait until an energy crisis and then start developing the R&D. So let's work ahead of time."

When the call came a few months ago beckoning Bose to East Tennessee, "... I saw a tremendous opportunity," he says.

For now Bose is developing the laboratory at PEAC, which he says Gov. Ned McWherter will dedicate in October. The lab will be built in stages, and Bose expects the first phase to be finished within a year.

The research produced by Bose and his program will go toward finding ways to convert different types of power, such as from AC to DC or changing the frequency.

Coming to Knoxville with Bose were his wife, Arati, and their son, Amit, 12. His 21-year-old daughter, Papie, stayed behind in New York, where she is studying biology.

However, Bose says, "As soon as we crossed the border of Tennessee, we started loving it. The outstanding thing is the very hospitable people, always ready to help you."

Fig.24. Myself as UT scientist;
Published in Knoxville News Sentinel, July 16, 1987.



Fig.25. I am receiving IEEE Fellowship from the IAS President Mr. Fagan in 1989
“for Contributions in Power Electronics and Drives Technology”.

17. Chief Scientist of PEAC

My main responsibility as the Chief Scientist of PEAC was to promote power electronics education and research in USA, and transitioning technology to industry while working closely with EPRI. I had to travel a lot for this position, particularly to Palo Alto, California to support PEAC. The PEAC used to support many conferences and workshops in different parts of USA, and I had the main responsibility to organize the technical parts of them.

I had two offices: one in PEAC and the other in the university campus around 12 miles away. I had my main laboratory in PEAC, but classes were held in the campus. My graduate students were transported to the lab by university bus service. The campus did not have enough space for my lab. This was highly inconvenient for the students. Gradually, the Science and Engineering Building was constructed in the campus and my laboratory was shifted there.



Fig.26. PEAC staff members with the
visiting scientists in 1988; I am third from left.



Fig.27. PEAC director Dr.Owen Hilson (third from left);
From left: Dr. Dote (visiting professor from Japan), Dr. Lai (PEAC scientist), and myself at right in 1990.

After around three years, I found difficulty to satisfy requirements of both PEAC and the university. Gradually, I withdrew from PEAC and devoted wholeheartedly for developing the teaching and research program in the university. My title in PEAC was later changed to Distinguished Scientist.



Fig.28. I am opening the Industrial Exhibition in Tokyo in 1988 with Dr. Nishijawa

I taught the graduate courses in power electronics and motor drives. In addition to my regular graduate students, I managed to recruit a large number of visiting professors and research scholars from abroad to come and work in my laboratory, funded by their respective governments. All of them were very mature and brilliant scholars.

| | | |
|---|---|--|
| <p>Power Electronics In China</p> <p>Dr. Bimal K. Bose, holder of the Robert Condra Chair of Excellence in Power Electronics Applications at UT-Knoxville, visited mainland China for two weeks this summer. He was invited by the State Science and Technology Commission of China to be a United Nations consultant. His main mission was to promote modern power electronics technology in China. During his travels to Shanghai,</p> | <p>Beidaihe, Tianjin, and Beijing. Bose gave lectures in universities and professional associations, visited industries, held discussions with senior industry and government officials, and delivered the keynote address for the First Chinese Academic Conference on Variable Speed Drives (CAVD-89).</p> <p>Bose's first stop was Shanghai University of Technology, where he talked about some of the ongoing research in UT's power electronics program. In a visit to the power electronics laboratory in the Department of Automatic Control, he reviewed graduate research projects in areas such as microprocessor-based fault-tolerant control of dc drive; sliding mode control of induction motor and power-MOSFET inverter induction motor drive. Although impressed by the projects, Bose noticed that the laboratory was quite old and furnished with outdated equipment.</p> <p>Bose also delivered a lecture, "Power Electronics and Drives—Recent Trends," that was organized by the Shanghai Power Electronics and Drives Association. During the question and answer session afterward, he found the language barrier to be somewhat of a problem as he struggled to answer questions about power quality problems.</p> <p>Bose's topic for the keynote address for the First Chinese Academic Conference on Variable Speed Drives, held in the Pacific sea resort of Beidaihe, was "Power Electronics and Drives—Recent Research and Development Trends. Representatives from most universities and power electronics establishments were there, and Bose founded himself "flooded with technical questions" afterward. Through an interpreter, Bose was asked for his opinions on the possibility power electronics bringing a second electronics revolution; the quality of MOS-Controlled Thyristor; and Japanese vs. U.S. power electronics. Graduate students who met Bose after the conference were eager to come to the U.S., stating that an advanced degree from the U.S. is highly valued in China.</p> <p>In Tianjin, China's industrial city, Bose gave a presentation before the Tianjin Power Electronics and Drives Association. The meeting was organized by the leading power electronics institute in</p> | <p>China, the Tianjin Research Institute of Electric Drive (TRIED). He toured the institute's factory, where large thyristors are manufactured with foreign collaboration and large thyristor ac and dc drives are designed. Although the manufacturing environment seemed sluggish because of the heavy reliance on manual labor, Bose was impressed by the modern test laboratory. The test set-up for fully automated control and instrumentation of a remote operated hydro power station, which was supervised by a woman engineer, impressed him most.</p> <p>In Beijing, Bose discussed "Modern Trends in Power Electronics and Drives" and "Microprocessor-Control of Permanent Magnet High Performance Drive" before the Beijing Power Electronics Drives Association. The talk, hosted by the Beijing Rectifier Plant, drew many people from nearby universities and industries. The audience was very curious about U.S. power electronics technology. Bose said. After the question and answer session, he was given a short tour of the plant's thyristor manufacturing facility.</p> <p>Bose made several recommendations to the United Nations for improving Chinese technology. He observed that Chinese engineers were quite knowledgeable and capable of handling modern technology, and suggested that China follow Japan's two-phase approach to modernization. The first phase would involve importing all advanced technologies and sending Chinese engineers abroad as well as inviting experts to China. The second phase would involve taking a leadership role in technology advancement.</p> <p>Despite his full schedule of professional engagements, Bose found time for sight-seeing. Everywhere he went, he found the Chinese to be friendly and hospitable, and he was struck by the proliferation of bicycles, he said. He also found that the food was quite different from that served in Chinese restaurants here, noting the "complex and laborious preparations with fish, pork, chicken, and varieties of vegetables." However, Bose was most impressed by the television shows, which featured cultural and educational topics and were noticeably lacking in sex or violence.</p> |
|---|---|--|

Fig.29. My experience on power electronics status in China in 1989;
Published in UTK Context, Oct. 5, 1989.



Fig.30. I am with my three books in 1988;
(Includes Japanese translation of Power Electronics and AC Drives)

Dr. Bose (left) and his wife, Arati, (right) walked a portion of China's Great Wall with their host, Zheng-Yuan Wang, director of the Beijing Power Electronics Research and Development Center.

BOSE APPOINTED ADVISOR TO CHINESE RESEARCH CENTER

Dr. Bimal K. Bose's counterparts in mainland China hold him in such high regard that they recently asked him to serve as senior advisor to the Beijing Power Electronics Research and Development Center, an institution that's the mirror image of Knoxville's Power Electronics Applications Center.

Power electronics is a diverse field that encompasses such things as devices, circuits, machines, drives, and controls.

Here, Bose splits his time between the electrical and computer engineering department and the Power Electronics Applications Center. In the department, he teaches and works as a research scientist as the holder of the Condra Chair of Excellence in Power Electronics; at PEAC, he's an advisor on power electronics issues.

The Electric Power Research Institute, an organization supported by all electric utilities in the U.S., set up PEAC both to work in research and development and help transfer technology from university research labs to industry.

The U.N. sent Bose to China in 1989 at the request of the State Science and Technology Commission to promote modern power electronics technology that China can incorporate into its modernization program. He also gave the keynote address at the nation's first academic conference on variable speed drives.

That address added weight to Bose's reputation that was established when two of his books were translated into Chinese—*Power Electronics and AC Drives* and *Adjustable Speed AC Drive Systems*.

The concept of a Beijing research center developed while Bose was in China. Last year, the Chinese established the organization and sent a delegation here to collaborate with PEAC and the university. During this visit the delegation asked Bose to serve as an advisor to their center, a center that employs approximately 100 scientists.

Bose put his China experiences on paper in the form of a first-person report published in the March 1990 *IEEE Industrial Electronics Society Newsletter*.

Bose was back in China in July, again

under U.N. sponsorship, lecturing in Beijing, Xian, and Shanghai. The six-day Beijing seminar on power electronics and AC drives pulled together that nation's power electronics specialists.

While in China, the Shanghai University of Technology made Bose an honorary professor. Only six others have been so honored. Dr. Chen Boshi, head of SUT's Department of Automatic Control Engineering, said he nominated Bose because he is a world recognized expert in power electronics.

The Knoxville-China connection brings top Chinese scholars here. Dr. Chen Daoshen, a post doctoral researcher at Zhezang University, is currently doing research at UTK as is Shuqiao Zhou from the Metallurgy Institute of Hebei Province.

Bose taught at Rensselaer Polytechnic Institute in Troy, N.Y., and conducted research at General Electric's R&D center in Schenectady, N.Y., before coming to Knoxville.

"Historically, GE has been the leader in power electronics," Bose says.

"The Condra Chair of Excellence has a close collaboration with the Power Electronics Applications Center—a kind of dual function," he says.

"Being a person with a university background and a long industry background, I thought my expertise would be extremely useful in organizing the university's research and in teaching and in helping the PEAC." □

| CALENDAR | |
|---|-----------------|
| Spring Break | March 23-27 |
| Honors Program | April 30 |
| Spring Commencement | May 15 |
| Board of Advisors | September 25-26 |
| Homecoming | September 26 |
| Engineer's Day | October 15 |
| Americas of the International Polymer Society | October 19-21 |

Fig.31. I am appointed as senior advisor of Beijing Power Electronics Research Center in 1991;
UTK Engineering News, vol.3, no.1, Winter 1992.



Fig.31. Honorary Professorship is awarded to me by the President of Shanghai University in 1991. (Prof. Chen Boshi is on right)



Fig.32. Chinese power electronics specialists attended my lecture in Beijing in 1991; (I am standing in middle of front row).

Bose World's Top Power Electronics Man

That's the honor which was bestowed upon Dr. Bimal K. Bose, distinguished professor of Electrical Engineering, at the 1988 International Power Electronics and Intelligent Motion Conference and Exhibition in Tokyo, Japan.

Bose, who holds UT's Condra Chair of Excellence in Power Electronics, gave the keynote speech on "Power Electronics - Present and Future" at the Conference which was held at the Harumi Grand Hotel, December 8-10. In addition, Bose gave a speech on "Power Electronics Trends in the USA" for the Tokyo Electric Power Co.

Bose is also Chief Scientist at the national Power Electronics Application Center (PEAC) here in Knoxville. PEAC was established by the Electric Power Research Institute (EPRI) in October 1986 to provide a national focus for developing and promoting power electronics technologies to increase the efficient and productive use of electricity. PEAC is located in the Tennessee Center for Research and Development on Pellissippi Parkway.

Fig. 32. Publication in UTK Engineering Update, vol.6, no.1, Summer/Fall 1989

Most of them wanted to do research in the emerging AI (artificial intelligence) techniques, particularly in fuzzy logic and neural network applications. We did a lot of pioneering work in the application of AI techniques in power electronics. Unfortunately, the area did not pick up the desired momentum for innovation, possibly because of the general unfamiliarity of the power electronics community with the techniques, and consequently very few industrial applications. Some of our projects in the university were:



Fig.33. My keynote address in PEMC (Power Electronics and Motion Control) conference in Warsaw in 1994;
I am standing as speaker on far right.
Published in EPE Journal, vol.4, no.4, Dec. 1994.

- 1) Soft-switched converters for motor drives
- 2) High-frequency non-resonant link power conversion using MCTs (MOS-controlled thyristor)
- 3) Fuzzy control of dc and induction motor (IM) drives
- 4) Fuzzy-controlled wind generation system with efficiency optimization
- 5) Neural network –based drive feedback signal estimation and neural control of SVM multilevel converters
- 6) Converter fault investigation
- 7) Automated IM drive simulation and control by expert system
- 8) Sensorless vector control of IM
- 9) High temperature superconductivity (HTS)- synchronous motor (SM) ship propulsion with multilevel converter

Unfortunately, I was not very successful at gaining major funding from U. S. government agencies, possibly because I was working alone. In fact, I hardly tried for major funding. I love the university career for its freedom and prestige, but hated being a super-salesman in search of research grants. Instead, I travelled abroad extensively to give tutorials, invited seminars, and keynote addresses. During this period, I also completed one text book

18. Summary of Key Contributions

I invented the transistor ac power switch and demonstrated it for direct ac-ac power conversion in 1973. This has been recognized as a landmark contribution in matrix converter research. Matrix converters are now used extensively for ac motor drives and high-frequency-link power conversion systems. The IGBT-based ac switch is now universally used in matrix converters.

I invented the adaptive hysteresis-band (AHB) current control method and demonstrated in voltage-source inverter IPM synchronous motor drive (1989). The method is widely used in commercial DTC (direct torque and flux control) drives and other applications.

I introduced MPPT (maximum power point tracking) control for the first time in a photovoltaic control system (1984) which is now universally used.

I pioneered in the application of microprocessors in industrial control systems. After Intel introduced the 8080 microprocessor in 1974, I developed the first fully functional microcomputer-based electric vehicle (ETV1) control system (1978). The RTV1 was demonstrated before Queen Elizabeth II of England at her invitation.

I pioneered the application of artificial intelligence techniques (expert system, fuzzy logic, and neural networks) in the control and estimation of power electronics systems, including motor drives. I first promoted this emerging technology to the power electronics community through my books Modern Power Electronics and AC Drives (2001) and Power Electronics and Motor Drives – Advances and Trends (2006).

I first demonstrated high frequency, resonant link power conversion system for ac motor drive (1977) from concept to practice that could operate at programmable line power factor (leading-lagging).

I introduced high-frequency, non-resonant-link, soft-switched power conversion for ac motor drives (1998). The system used matrix converters with ac switches which I invented.

I proposed and demonstrated a high-frequency active filter in the dc link of a voltage-fed converter system (1991) to eliminate electrolytic capacitors.

I published the first text book (1986) on power electronics and motor drives in the English language. Along with its revised version (2001) , this has been translated in many languages and used extensively at universities around the world.

I promoted power electronics globally by extensive seminars, tutorials, books, IEEE Distinguished lectures, invited presentations, and keynote speeches. I was awarded the IEEE Meritorious Achievement Award in Continuous Education (1997) “for exemplary and sustained contribution to continuous education” for this activity. Power electronics has now grown as the most important technology for industrial automation, renewable energy systems, electric vehicles, smart grid applications, bulk energy storage systems, and improving energy efficiency of equipment.

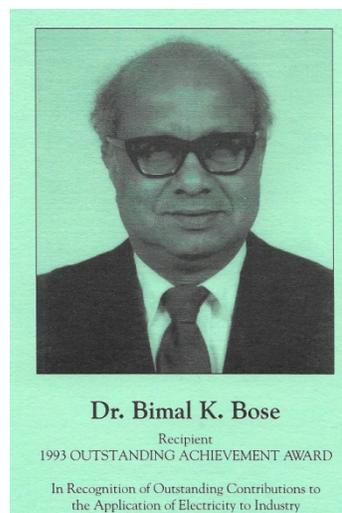


Fig. 34. IEEE -IAS Outstanding Achievement Award in 1993
“for Outstanding Contributions in the Applications of Electricity to Industry”.



Fig.35. IES President Alfred Weaver presents the Dr. Eugene Mittelmann Award to me in 1994

“in Recognition of Outstanding Contributions to Research and Development in the Field of Power Electronics and Life Time Achievement in the Area of Motor Drives”.

| | |
|-----------------------------|--|
| | <p><i>Bimal K. Bose, Ph. D. To Receive Outstanding Engineer Award</i></p> <p>Bimal Bose holds the Condra Chair of Excellence in Power Electronics at the University of Tennessee, Knoxville, following 15 years of teaching and 11 years performing research for General Electric. In a simultaneous position as Distinguished Scientist at EPRI's Power Electronics Applications Center, he has led the effort to promote university-industry collaboration.</p> <p>Dr. Bose has received international recognition for outstanding contributions as a technical leader, researcher, inventor, author, and educator in the field of power electronics and machine drives. He has made pioneering research contributions in power converters, pulse width modulation techniques, microprocessor control, control of AC drives, electric vehicle control, and expert system and fuzzy logic applications in power electronics.</p> <p>His publications span almost every aspect of power electronics systems. He has promoted the field of power electronics and drives throughout the world with lecture tours and state-of-the-art papers in IEEE and non-IEEE literature. The author of more than 100 technical articles and 170 technical presentations, Dr. Bose holds 18 U.S. patents. Several of his books have been translated into other languages</p> <p>A graduate of Calcutta University in India and the University of Wisconsin, Dr. Bose is the recipient of a General Electric Silver Patent Medal. The India Institute of Electronics and Telecommunications Engineers established the Bimal Bose Award in Power Electronics in his honor in 1983.</p> <p>Bimal Bose is being presented the Region 3 Outstanding Engineer Award for his outstanding achievements in power electronics and drive technology.</p> |
| <p><i>Bimal K. Bose</i></p> | |

Fig.36. IEEE Region 3 Outstanding Engineer Award is won by me in 1994
“for Outstanding Achievements in Power Electronics and Drives Technology”



Fig.37. I am receiving IEEE Lamme Medal from the IEEE President Wallace Read in 1996
“for Contributions to the Advancement of Power Electronics and Electrical Machine Drives”.



Fig.38. IEEE Medal recipients in Toronto in 1996; I am sitting fifth from left.



Fig. 39. Myself and my University of Tennessee doctoral students in 1993 with visiting professor Vedula Sastry of IIT, Madras. From left: myself, Gilberto Sousa, Karthikayn, Sunil Chyaya, Vedyula Sastry, Marcelo Simoes, Subhomoy Chatterjee and Debaprasad Kastha.



Fig. 40. My 8 books in Power Electronics

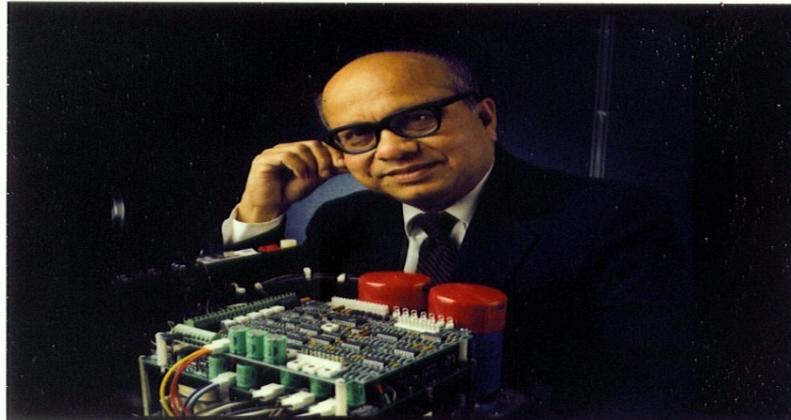


Fig.41. I am at the University of Tennessee Power Electronics laboratory in 1997, showing package of HF link converter.



Fig.42. IEEE President Charles Alexander presents the Meritorious Achievement Award in Continuing Education to me in 1997; (IAS Conference President Paolo Tenti is on left) *“for Exemplary and Sustained Contributions to Continuous Education”*



Fig.43. I am planting tree in Indian Institute of Technology, Delhi in 1999.

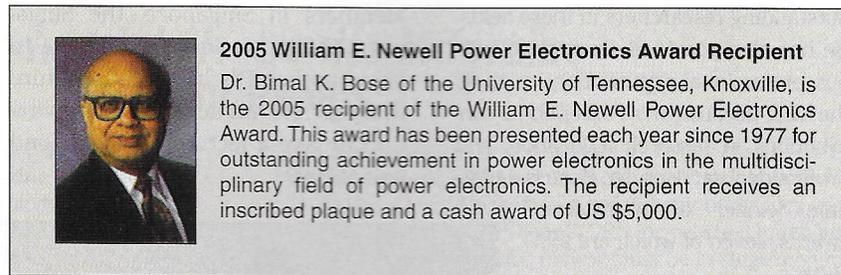


Fig.44. I received the William Newell Award from IEEE Power Electronics Society in 2005 in Brazil. *“for Outstanding Achievements in the Interdisciplinary Field of Power Electronics”*

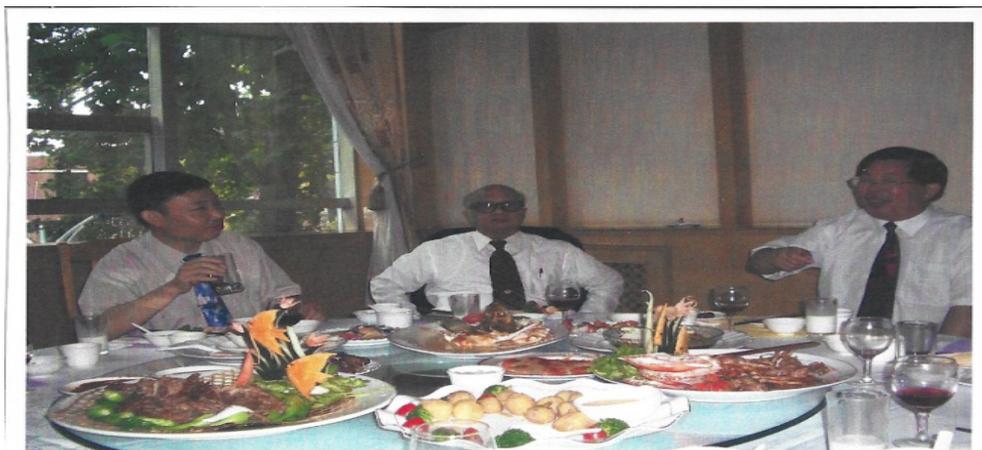


Fig. 45. CUMT (China University of Mining and Technology) President (right) invited me for lunch after the seminar in 2005 in Beijing; Dr. Wang, former UTK visiting scholar is on left.

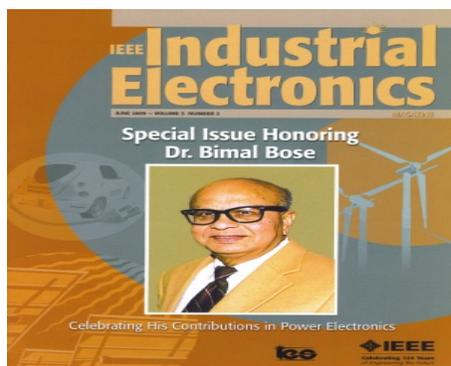


Fig. 46. IEEE Industrial Electronics Magazine honored me by publishing a special issue in June 2009 with his photo in front cover

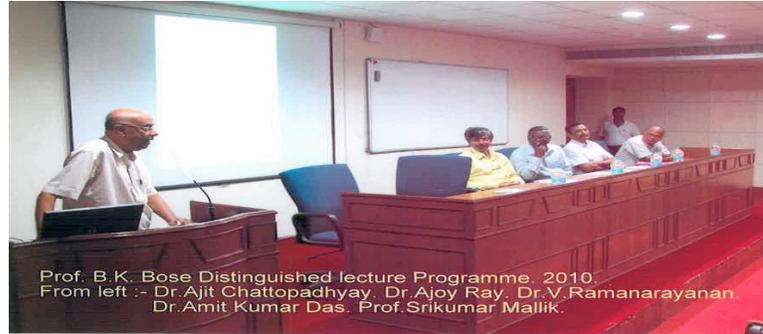


Fig.47. B. K. Bose Distinguished Lecture Award inauguration in IEST in 2010 by the Vice Chancellor Ajoy Ray (sitting on left)



Fig.48. I am being honored by the President of Sevilla University, Spain as visiting professor on May 16, 2012.

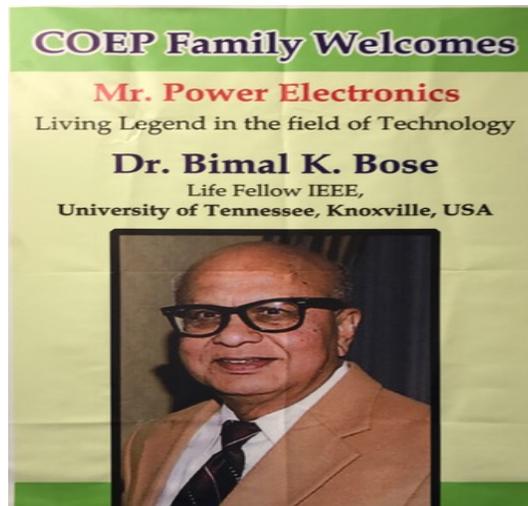


Fig. 49. I gave IEEE distinguished lecture in Pune Engineering College, India in 2012; (Poster announcement)



Fig.50. I received the Honorary D.Sc. degree from the President of India Mr. Pranab Banerjee at 15th annual convocation of BESU on January 13, 2013.
“in Recognition of Outstanding Contribution in Engineering and Service to the Nation”



Fig. 51. Power electronics group at the University of Tennessee, Knoxville, in 2013; I am in the middle of the back row.

19. Years as Emeritus Professor

The University of Tennessee kindly provided me an office with all the facilities to continue my research, publications, and the IEEE activities. I completed one book and wrote extensively to the IEEE literature during this time. Technical writing is my dearest hobby. I completed several consulting projects in the past few years. I got extensive invitations throughout the world for giving tutorials, IEEE distinguished lectures and conference keynote speeches, and travelled to see the whole world with my own eyes which was my dream from childhood days. I also did philanthropic activities generously. I think we have great responsibilities for the society that helps us to grow in life. I have particularly soft corner for the segment of the society which is poor and unprivileged. I am deeply grateful to my university that gave me favorable environment to grow professionally as well as a man. I was honored with U. S. National Academy of Engineering membership in 2017.

20. Concluding Comments – Summary of Lessons

I have briefly narrated my experience and challenges in life emphasizing my career in power electronics (https://en.wikipedia.org/wiki/Bimal_Kumar_Bose) with the objective that it will be useful to others, particularly to the young generation of engineers and scientists. In my experience, there is no short-cut for

success in life. Success in life is like a sustained meditation, where you need to sacrifice a lot of earthly pleasures. Achieving the goals of life requires persistent ambition, courage, hard work, and cooperation from the family. But, when you reach the top of Himalayan mountain, your mind remains filled with perennial pleasure which is so supreme in comparison with the earthly pleasures. Finally, before concluding, I would like to share the following lessons which I learnt in my life:

Summary of Lessons in my life

1. Need to have the basic ingredients:
Self-Discipline-Ambition-Diligence-Dedication-Honesty
2. Should have long-term as well as short term career goals – and climb one step at a time solving all The obstacles – never leave an obstacle until overcome
3. A simple and unsophisticated life style with some spiritual bend
4. Have a Guru in life whom you can emulate
5. Maintain a private diary – describing all your aspirations, problems and progresses in life
6. If you have a problem to solve, analyze it from all angles – never take impulsive decision
7. At the end of the day, analyze what you accomplished and then plan for tomorrow
8. In a new environment, talk a little but listen a lot to learn (my professor’s advice)
9. To solve a research problem – let it linger in your mind all the time – in walking – in bath – and even in the midst of sleep
10. Finally – **“KEEP THE FIRE BURNING”** always in your mind (as my professor advised)
