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Electronics and communications engineering in India: contributions of the Indian Institute of Science

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Abstract

The paper discusses the pioneering role of the Indian Institute of Science in electronics and communications engineering education, research, technology development and industry in India from its early days and highlights the major contributions.

Keywords: Electronics, communications, education, R&D, industry, India

1. Introduction

Engineering education and research, in particular electrical/electronics/communications, have received considerable attention at the Indian Institute of Science from its very inception. The establishment in 1911 of the Department of Electro Techniques (ET) (later renamed as Electrical Technology) by Prof. Alfred Hay (first head of the department) and opening of Wireless Laboratory (later redesignated as Electrical Communication Engineering (ECE) Section) in the ET Department in 1923 by his successor, Prof. J. K. Catterson–Smith stand out as the first steps in ECE education and research at the Institute. In fact, these were the first initiatives in India in electrical/electronics/communication engineering. This paved the way for rapid progress in teaching, instructional programmes and R&D in ECE in the country, as electronics and radio technologies were steadily expanding on the world scene in the post-World War-I years, and were attracting talented people. From this early period, systematic lectures on advanced topics, practical courses and research work in ECE have grown at the Institute based on the strong foundation laid by Profs Hay and Catterson–Smith. Table I summarizes the growth of academic programmes in ECE at the Institute.

In the following years, the ECE area at the Institute has continued to attract gifted faculty and merited students from all over the country (also from abroad) for its educational/training programmes and for conducting R&D work; and, its alumni have occupied key positions in education research, design, industry, and management in ECE in India and abroad for many decades. These factors coupled with the salubrious climate and the garden city environment of Bangalore and several facilities and encouragements/incentives offered by the successive central and state governments have made it possible to make it the ECE capital and the first high-tech city in India in recent years. Some aspects of these developments and the pivotal role played by the Indian Institute of Science are being highlighted in this paper.

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The paper is divided into five sections. Following this introduction, the growth of academic and research programmes in ECE and its influence on the Indian scene is covered in the next section. This is followed by a section on sponsored research and consultancy activities in ECE. The development of R&D and industry in electronics, communications engineering and related areas through many initiatives taken in ECE at the Institute is then described in Section 4. The concluding section reviews the major contributions and indicates future possibilities.

2. ECE Academic and research programmes

2.1. *Academic programmes*

It is well known that engineering is both a science and an art, through which the properties of matter and the sources of energy in nature are made useful to society; and, society needs people who take to engineering, as they can contribute to its material advancement. This has been the guiding spirit in the ECE academic programmes and curriculum planning at the Indian Institute of Science from the very beginning. Engineers generally fall into two categories:

- Planning, design, development and/or research engineers;
- Execution, operation, maintenance and/or testing engineers.

The training of ECEs belonging to the former category has been emphasized at the Institute from the early period. This is primarily on account of the research orientation at the Institute and the recognition that advanced-level instruction should be an important objective of the Institute in addition to original investigations.

a) *UG Course:* Therefore, the 3-year ECE certificate course was superposed on the strong base of Physics and Mathematics at the BSc level, when it was launched in the 1930s and it has continued in one form or the other (Cert. of Prof. (1932), DIISc (1947), BE (1961)) in the following decades. Over 1,000 ECE graduates have passed out of the portals of the Institute in about 55 years of conducting this course, which was eventually phased out during 1986. This is a major technical manpower contribution to the country at the first degree level in ECE. In the pre-World War-II years, subjects like electron tubes, electronics engineering, applied electronics, circuit theory, EM theory, radio wave propagation, antennas, radio engineering and line communication figured prominently in the ECE certificate programme. In all these cases, basic theory, analysis, experimental work and practical training were emphasized. The classes being small (limited to 8–10), the training and guidance were almost personal and the students received the best benefit/attention; and the ECE graduates found good employment in government establishments like All India Radio, Overseas Communications Service, Posts & Telegraphs and Defence, which were beginning to need ECE graduates. Not only did these establishments grow at a rapid rate in the succeeding years, but also the ECE graduates did continue to occupy key positions to direct them. The course was strengthened in the post-World War-II period in line with world-wide advances: new subjects like microwaves, acoustics and engineering mathematics were introduced in the curriculum and laboratory facilities upgraded, particularly radio, microwave, acoustics, vacuum tubes, line communication, taking advantage of the new status of ECE section as ECE Department (1946) and moving over to a new building (1951). Courses on transistor electronics, information theory, analog computers and instrumentation also found place in the DIISc curriculum in the 1950s. Looking at the changing employ-

Table I
ECE academic programmes at IISc: A chronology

Year	Programme
1911	Electrical Technology (ET) Dept set up; Systematic lectures and training in ET started; Post-BSc 3-year course launched; Certificate of Proficiency award to successful students.
1923-25	Planning and setting up Wireless Laboratory in ET Dept for training and research in electronics and radio; Courses in electronics and radio introduced for ET students in the final year; first time in India.
1928-29	Wireless Laboratory renamed as Electrical Communication Engineering (ECE) Section; Supplementary course (1-year) in ECE launched for ET/BE graduates.
1932	Post-BSc 3-year ECE course launched in ET Dept; first full-time ECE course in India.
1946	ECE Section upgraded to ECE Dept.
1947	Course work evaluation based on examinations and award of marks commenced at IISc; Diploma of IISc (DIISc) award in place of earlier Cert. of Proficiency.
1956	DIISc (PG) in Electronics Engg/Ultrashort & Microwave Engg/Line Communication Engineering of 12 months duration for DIISc (ECE)/BE (ECE) degree holders; Advanced-level courses, Project work, Industry/R&D Lab training emphasized; First ECE PG course in India. Deemed university status for IISc.
1958	Award of degrees in place of DIISc at IISc; BE (ECE) = DIISc; ME (ECE) = DIISc (PG).
1963	Restructuring ME(ECE) based on the Thacker Committee recommendations; Emphasis on mathematics, materials science & technology and instrumentation as core subjects; Vigorous theoretical/experimental analysis and research/design-oriented project work as part of curriculum; course duration : 2 years.
1970	Restructuring BE/ME programmes at IISc under the unit system; Credits fixed for theory/practicals/project work; average term load:16 credits; Flexible curriculum:Core, Electives, Project work; 5-point grading system in place of the marks system; first time in India.
1971	Centre for Information Processing (CIP) set up in ECE Dept, sponsored by the Ministry of Defence (CIP continued until 1979).
1974	A new 1-year DIISc (PG) course of 1-year duration launched for sponsored BE (ECE)/MSc (Phys.) degree holders; Specialization: Digital communication & data processing.
1975	Centre for Electronics Design & Technology (CEDT) set up in ECE Dept, supported by DOE, UGC, SDC (Indo-Swiss agreement), to train design engineers and technologists needed in electronics industry. First time in India; CEDT is a full-fledged centre since 1983. A new 1-year DIISc (PG) course launched for sponsored BE(ECE)/MSc (Phys.) degree holders.; Specialization:Electronics Design & Technology; this course upgraded to MTech (ED) since 1987.
1983	Restructuring ME(ECE) based on the Nayudamma Committee recommendations; 3 Semester (1 1/2 year) programme—emphasis on advanced-level courses and project work; Qualifying through GATE essential for admission; A new 4-year Post-BSc ME (Int) (ECE) course launched; First time in India; Post-BSc 3-year BE(ECE) continued for the time being.
1986	Post-BSc 3-year BE (ECE) course of long standing phased out.
1996	Divisional review of ME and ME(Int) courses in ES Division; Decision to phase out ME(Int) (ECE) course, strengthening of ME(ECE) course and launching of new ME courses in emerging areas jointly with other Depts/Centres.

ii) *Training in digital communication and data processing:* A specialized programme for defence scientists/service officers leading to DIISc (PG) of 1-year duration was organized in the 1970s to cover the emerging areas of digital communication and information processing—digital, optical, etc. It was a good success and over 20 trainees were provided hands-on training.

iii) *Electronics design and technology:* A separate DIISc (PG) course of 1-year duration was launched by ECE in 1975 to meet the immediate and growing needs of electronics industry in the country in the areas of electronics equipment design and technology. This included course work covering analog/digital design, thermal design, mechanical/product design, CAD, interconnection/mechanical technologies and related subjects and a comprehensive R&D and product-oriented project work. A full-fledged Centre for Electronics Design and Technology (CEDT) was set up for this purpose (Indo-Swiss project; supported by the Department of Electronics (DOE) and the University Grants Commission (UGC), which has become a highly successful programme of considerable interest to Indian industry. The DIISc (PG) course has now been upgraded to MTech (ED) course in the 1980s and the Centre has also become an autonomous unit. Nearly, 300 post-graduates have been trained through this course in about 20 years of existence of CEDT. Centres of similar type have now been set up in other parts of India by DOE and an Electronics Design Laboratory based on the concept of CEDT has been established at Chulalongkorn University, Bangkok, Thailand, under an Indo–Thai agreement. The Institute has played a dominant role in both these activities.

iv) *Continuing education:* Organizing continuing education programmes of short and long duration on emerging topics in ECE has been given considerable emphasis at the Institute from the early 1970s. One/two courses are generally organized every year and 50–60 engineers/scientists generally take advantage of these courses annually. These courses have proved to be very popular, and also make available specially prepared course notes, etc.

2.2. *Research programmes*

a) *Early years:* Research work has progressed hand in hand with academic programmes. While in the 1920s, research work on electronic/magnetic materials was taken up, topics like wave filters, telegraph repeaters, telephone transmission and ionosphere figured prominently in ECE research during the 1930s. In particular, the faculty and students conducted many interesting experiments by recording echoes received from the ionosphere using locally developed apparatus during 1934 which was declared as the International Polar Year and the results appeared in international journals. Research work in the 1940s covered such topics as nonsynchronous vibrators for radio sets, MW radio transmission, UHF studies, calibration of wavemeters and reverberation recorder development besides ionospheric investigations being continued. In addition, the faculty members assisted the P&T Department in 100 Hz standard signal transmission. Besides, testing of UHF transmitters/receivers was also given due attention during this period.

b) *The 1950s:* ECE research at the Institute got a major fillip in the 1950s as a result of the new laboratories (viz. Radio, Microwave, Acoustics, Vacuum Tubes and Line Com) estab-

ment scene, i.e. growing electronics/telecom industry in the country, electronic/radio design became an important subject in the BE course in the 1960s. Revision and updating of syllabi and strengthening of laboratory/experimental facilities were given much importance in the succeeding decades. As a result, ECE graduates from the Institute have always been in great demand in the country and abroad to fill academic positions in institutions/universities or to meet the needs in other sectors including industry.

b) *PG Course:* In the late 1950s, two factors were influencing the technological scene in the country: time scale of change in ECE was reducing year by year and the demand for ECE graduates was picking up. Besides, there was a growing need to familiarise many newly emerging and advanced subjects to the students so that they could be self-reliant in the rapidly advancing world of electronics. For meeting these compulsions, a 12-month-duration PG course, viz. DIISc (PG) was launched in ECE in 1956, the first such course in India, with specializations in electronics engineering, ultrashort and microwave engineering and line communication engineering. The 1960s saw rapid growth of this course (redesignated as ME (ECE): increased duration (2 years), addition of one semester-long project work, elective subjects, and regular revision/updating of course work/laboratory facilities. The 1970s and 80s have seen further progress and transformation of this course, major ones being the restructuring of the course to be of 18-month duration (Nayudamma Committee) and course work based on the unit system. These measures have made the course highly flexible and popular and also attractive to merited students (high percentile in Graduate Aptitude Test in Engineering). Besides, new laboratories set up in recent years like computer networks, microelectronics, optical communication and signal processing have played an important role in introducing new core/elective subjects and strengthening project work. This has made the ME (ECE) course as the first PG course of choice in India; and in about 40 years of existence (by 1996), nearly 600 ECE postgraduates have come out of the Institute. They have been playing a major role in R&D, technology development and indigenization efforts in electronics, telecom and related sectors in India and also have contributed a great deal in ECE education and research in India and abroad. The commencement of a 4-year integrated ME (ECE) course at the post-BSc level in the early 1980s has also helped greatly in ECE PG programmes at the Institute, enabling a gradual phase out of the BE (ECE) course in 1986. Over 130 postgraduates have come out of the Institute so far in this new programme, a majority of whom are already crucial personnel in R&D in government research laboratories and industries. Some of the modern subjects now covered in the 1990s in the ME (ECE)—both regular and integrated courses—include multimedia information systems, communication networks, microelectronics, designing with ASICs, VLSI design, sensor technology, optical electronics, integrated optics, fiber optic networks, microwave ICs, DSP, digital compression, ocean acoustics and speech processing. Some of these subjects are covered in PG courses for the first time in India, making the ECE ME courses highly attractive.

c) *Other initiatives:* Many other academic initiatives in ECE at the Institute also contributed a great deal in education/training in ECE in India. They are:

i) *Preparation of textbooks*: A number of textbooks on topical subjects have been prepared by the ECE faculty as learning material for students. They have been published through leading publishers in India and abroad. This has indeed served as a good contribution to ECE education.

mobile communication, wavelets and multirate signal processing, speech and audio processing, image/video compression, loss-less image coding, microelectronics and instrumentation, fuzzy logic systems, programmable instrumentation, logic synthesis and testing, etc. In all these areas, faculty members and students have been conducting studies and investigations, with an eye on present and future applications, as all these areas are of great national/international importance in ECE. Thus, the major research contributions of the Institute have aimed at training of scientific manpower and original investigations, both basic and applied, to strengthen national efforts in ECE.

3. Sponsored research and consultancy

Faculty members in ECE have been active in conducting sponsored research in new and emerging areas for many decades. This has greatly helped in upgrading the academic/research facilities, building up of infrastructure as well as in the setting up new laboratories in line with world-wide trends. Table II gives a summary of major sponsored research projects in ECE at the Institute in the 1990s. Research publications, patents, technical reports and manpower training have been major contributions of the Institute in this area.

Some of the recent industrial consultancy projects conducted at the Institute in ECE include:

- Performance analysis and optimization of the call processing subsystem of C-DOT digital switch (C-DOT);
- Development of a large model version of TCP/IP protocol software package (ITI);
- Traffic engineering in a GSM cellular mobile network with fullrate/halfrate mobiles (Phillips);
- Modelling, performance analysis and overload control of ITI digital switch (ITI).

It is very heartening that industrial consultancy is now picking up rapidly in the 1990s as electronics and communications products/services are becoming highly competitive in India on account of economic liberalization in the country. As a result, many multinational and overseas companies are also coming forward nowadays to avail of consultancy services in ECE at the Institute.

3.1. *Industrial Associate Programmes (IAP)*

Recognizing the growing interest of industries/companies to benefit from the knowledge and expertise pool in ECE at the Institute, a new programme has been recently launched (1996) to formalize the mechanisms, viz. IAP. Its major objective is to facilitate formal interaction between the industry/company and the Department of ECE for mutual benefit and with a view to stimulate R&D in the areas related to electronics, communications, signal processing, and computers. This programme provides a forum for the exchange of ideas and information on a regular basis. It also enables the participating industries, Industrial Associates and the Department to make use of each other's strengths and facilities towards developing a vibrant R&D culture.

lished in the newly constructed ECE building and the installation of India's first analog computer (Philbrik–Rideout electronic differential analyzer (PREDA)) by Prof. V. C. Rideout (1954). During this period, ECE research was generally in the following areas: electron tubes, microwaves, telegraphy and telephony, acoustics and communication engineering covering electronic circuits—transmitters, receivers and radar. Also, student training for research degrees commenced during this period and a few students obtained their AIISc (later designated as MSc (Engg)) degrees through research work. Thus, not only faculty research and research publications, but also student research towards research conferments became the major contribution of the Institute.

c) *Later years:* Research student training towards conferments received a major boost in the 1960s and many students joined for ECE research leading to PhD and MSc (Engg) degrees. Also, faculty research in new and emerging areas was stepped up. Studies on atmospheric radio noise and its inteference to communication received considerable attention during this period (Prof. S. V. C. Aiya) and many seminal contributions were made in the understanding of this problem. Also considerable work was carried out in predicting the radiation characteristics of different types of microwave antennas like horn, slot, dielectric, etc. and analysing/designing them for different uses. Investigations on the emerging information theory were also conducted, particularly on the relative efficiencies of Indian languages. Studies on Indian musical drums and their modes of operation as well as on stringed instruments like guitar and veena received much attention in acoustics research. Other major areas of research work during this period included electronic circuits and instrumentation—mostly micropower, analog, digital, etc. electron devices covering vacuum-based and gas-discharge systems, and analog/digital computers.

In the 1970s, a major thrust was given to research in information processing covering mostly digital and optical techniques, SAW devices, besides YIG devices at microwave frequencies. The setting up of the Centre for Information Processing under the Ministry of Defence made it possible to conduct advanced-level research in the above areas and also to train a large pool of scientific personnel in these emerging topics. Another major initiative of the Institute during this period was the setting up of the Centre for Electronics Design & Technology (Indo–Swiss project) with the support of DOE and UGC, which enabled R&D in electronic equipment using modern technologies. Digital electronics and microprocessor-based products for use in communications, instrumentation, industrial/power electronics systems were developed under this programme, satisfying to a great extent the needs of electronics industry in the country for trained design engineers and innovative product designs. This activity has grown in a commendable way in the 1980s and '90s.

The 1980s and '90s have seen further strengthening of research programmes in ECE in step with the growing demands in the country. Over 150 students have received their PhD and over 75 their MSc (Engg) conferments so far. Besides, the faculty and students have continued to publish their research results in learned journals and conferences in India and abroad from the beginning; over 900 scientific publications have emerged in the ECE area from the Institute from the 1920s until 1996. The areas of current research interest include communication networks, cellular networks, mobile cellular communications, microwaves, photonics and optical communications, optical networks, array signal processing, space–time signal processing for

Sl. no.	Project title/investigator	Funding source	Period
20.	Thick film version of the electronic circuits connected with fiber optic gyro Prof. A. Selvarajan	JATP	1996-98
21.	Revenue maximization, fairness, call admission control and pricing in cellular networks Dr Kumar N. Sivarajan	Bell Northern Research Laboratory (BNRL)	1996–96
22.	Photonic-switch based optical WDM networks Dr Kumar N. Sivarajan	EC	1995–96
23.	Fiber optic gyroscope phase I Prof. A. Selvarajan	JATP	1996–99
24.	Design and development of protocol stock and data compression package for wirless networks Prof. P. Venkataram	Samsung	1996–98

The benefits to the Industrial Associates include opportunity to:

- interact with the Departmental faculty to launch new activities, courses and programmes;
- attend technical presentations on the current activities of the Department twice a year;
- avail of technical publications and brochures;
- discuss technical problems and to solve them through consultancy projects at concessional fees;
- have access to laboratories in the Department through faculty approval and concessional fees, where applicable;
- have access to the Departmental library;
- be informed about the seminars, short courses, tutorials and conferences in the Department, and be eligible for concessional fees, if any;
- approach funding agencies jointly with the Department;
- add and update the expertise of their technical personnel;
- pursue Masters and Doctoral programmes by their personnel;
- benefit first from the ideas and products developed in the Department, and transfer of technology from the Department at concessional fees;
- strengthen R&D and improve products or processes at low cost.

Any industry or company in the areas related to electronics, communication, signal processing and computers can become an Industrial Associate by paying an admission fee and annual fees. This programme has been received well by industries/companies and many have enrolled in the very first year itself.

4. Extension service

Being the first ECE programme in the country and located in a place with salubrious climate and having enlightened government leadership, ECE at the Institute has been a major stimulant

Table II
Major research schemes and projects at the Department of Electrtical Communication Engineering in the 1990s

Sl. no.	Project title/investigator	Funding source	Period
1.	Design, fabrication and evaluation of an integrated optic gyroscope (IOG) suitable for strapdown inertial navigation systems Prof. A. Selvarajan	Joint Advanced Technology Programme (JATP)	1990–93
2.	System and VLSI design for digital TV receivers Drs T. V. Sreenivas and A. Makur	Department of Electronics (DOE)	1990–94
3.	Fibre optic sensors for underwater application Prof. A. Selvarajan	DOE	1990–93
4.	Performance analysis of superresolution algorithms for direction finding and their adaptive implementation Prof. V. U. Reddy	Defence Electronics Research Laboratories (DLRL)	1990–91
5.	Connected word recognition using dynamic time warping—Level building algorithm (DTW-LB). Dr T. V. Sreenivas	Tata Institute of Fundamental Research (TIFR)	1991–92
6.	Diffraction tomography for imaging of scatterers in ocean Prof. P. S. Naidu	Department of Ocean Development (DOD)	1992–94
7.	Studies on the ground based beacon system for estimation of position and velocity of a fast moving platform Prof. V. U. Reddy and Dr. K. V. S. Hari	Electronics Commission (EC)/JATP	1992–94
8.	Acoustic propagation model for active and passive sonars Prof. G. V. Anand	DOE	1992–95
9.	Signal processing and communication research programme Prof. V. U. Reddy	Defence Research Development Organization (DRDO)	1993–95
10.	Analysis of effects of multipath on the DF system and techniques to improve the performance Prof. G. V. Anand	DRDO	1993–96
11.	Low-temperature studies of microelectric devices Prof. M. Satyam	Department of Atomic Energy (DAE)	1993–96
12.	Fiber optic gyro Dr Vivek Srinivas and Prof. A. Selvarajan	JATP	1993–95
13.	Keyword spotting in continuous speech Dr T. V. Sreenivas	DRDO	1994–96
14.	Matched field processing for three-dimensional source localization Prof. G. V. Anand	DRDO	1994–97
15.	Hybrid integrated optic gyro phase II Dr Vivek Srinivas and Prof. A. Selvarajan	JATP	1994–95
16.	Development of tubal external cavity semiconductor diode laser Dr Vivek Srinivas and Prof. A. Selvarajan	Department of Science and Technology (DST)	1995–98
17.	Fibre optic gyro Prof. A. Selvarajan	JATP	1995–96
18.	All-optical wide area network performance evaluation, design and architecture Dr Kumar N. Sivarajan	DST	1996–99
19.	Design and development of wireless multimedia LAN Prof. P. Venkataram	DST	1996–98

(contd)

5. Conclusion

The Institute has come a long way in academic and research work, sponsored research and consultancy as well as in extension service of direct interest to a variety of organizations engaged in ECE. Not only Indian, but also overseas organizations are now benefiting from the knowledge and expertise pool at ECE. The Institute with its unique character of research and advanced-level teaching/instruction in the same work place continues to play an important role in meeting the growing demands from industries, R&D laboratories and academic institutions for technical advice, manpower training and a variety of other services to strengthen their ongoing and future programmes. Looking at these successes new initiatives taken by the Institute in engineering education, research training, scientific and industrial consultancy and industrial interaction in recent years are surely expected to flourish in the coming years in the service of the nation.

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to the growth of Bangalore city as the high-tech electronics capital of India from the very beginning. The setting up of the Indian Telephone Industries Ltd (ITI) at Bangalore in 1948, India's first public sector company, the establishment of defence research laboratories like Electronics & Radar Development Establishment (LRDE), Aeronautical Development Establishment (ADE) and Controllerate of Inspection Electronics (CIL) in the 1950s together with Bharat Electronics Ltd (BEL), a first major defence electronics company in India, during the same period were greatly facilitated by ECE activities. Not only did these new enterprises draw upon the knowledge and expertise pool at ECE and employ ECE students, but also were able to make use of the wide variety of test/calibration facilities and infrastructure built up at the Institute. These bonds grew further in the succeeding years, leading to specialized training programmes being set up at the Institute to update the knowledge base and capabilities of technical personnel in these organizations, rendering technical advice and also undertaking sponsored research and consultancy programmes. In the last nearly 25 years, this relationship has expanded further to cover external registration programme for research conferments and the flexible ME course at the Institute, which young scientists/engineers at these organizations are regularly making use of. These programmes have greatly helped in the training of qualified S&T personnel working in R&D laboratories and industries. These measures and various successes have ushered in a new era in Bangalore city, making it the most sought-after destination in India for high-tech activities in ECE. The setting up of various facilities under the Indian Space Research Organisation (ISRO), Department of Electronics (DOE), Department of Telecommunications (DOT), Council of Scientific and Industrial Research (CSIR), Defence R&D Organization (DRDO), state and central public sector enterprises and a large number of Indian private and multinational enterprises around Bangalore engaged in ECE in recent years is a clear testimony to this.

Some of the major programmes which have drawn support from ECE at the Institute are:

(i) Setting up of Centres for Electronics Design & Technology in different parts of India by DOE in the 1980s and '90s;

(ii) Establishment of Electronics Design Laboratory at Chulalongkorn University, Bangkok, Thailand, under Indo–Thai agreement (first programme of its kind undertaken by the Institute outside India) in the 1980s;

(iii) Technical advice on the setting up of Central Research Laboratories of Bharat Electronics Ltd in the 1980s and of Corporate R&D Centre for Electronics Corporation of India Ltd (at Hyderabad) in the 1990s;

(iv) Coordinating the Indian National Programmes on Advanced TV systems under DOE involving IISc, IITs (Indian Institutes of Technology) and other R&D laboratories;

(v) Planning of an R&D-focused technology park on the outskirts of Bangalore to bring together academic institutions (IISc, IITs, universities), R&D laboratories (CSIR, ISRO, DRDO, etc.) and industries for colocating their R&D activities in chosen high-tech ECE areas to facilitate technology transfer, commercialization and high-quality production.

These and related programmes and activities have certainly been a major contribution of ECE at the Institute for rapid progress in high-tech areas in the country.