CSIR Two-year Post-graduate Research Training Programme on High Power Microwave Devices and System Engineering at CEERI, Pilani

(2009-2010)

Introduction

High power microwave devices and systems have immense importance in modern day professional and strategic electronic systems. Travelling wave tube (TWTs) constitute the heart of satellite transponders that help run our TV, Internet and telephony networks. Klystron devices are used in all the industrial and medical accelerators that are used for scanning containers at ports and radiation treatment of cancers, respectively. Magnetrons powers the radars that keep vigil over our national boundaries and stratgeic installations.

Gyrotron devices generating megawatts of CW power in 40-170 Ghz range are used for heating the plasmas to fusion temperatures in fusion-based nuclear reactors (such as ITER) that are billed to be the unlimited sources of clean energy in the future. Great possibilities also await in the area of terahertz (THz) devices for imaging applications and vacuum microelectronic devices.

About the Programme

This PG research training programme provides in-depth understanding and exposure to the engineering concepts, scientific principles, research methodology and hands-on experience on advanced real-life R&D projects in different aspects of microwave devices and its system engineering. Students completing this two-year programme will be fully research-enabled and industry-ready.

The first semester of the programme focuses on core subjects and associated laboratories related to microwave communications and components.

The second and third semesters offer courses related to slow-wave and fast-wave devices, CAD techniques used for the design of microwave tubes, specialized tubes and their applications as well as fabrication technologies used for microwave tubes.

The third and fourth semesters give the opportunity to the candidates to effectively utilize the knowledge acquired through the courses towards advanced R&D project work and dissertation in their specialization areas.

CEERI's leading R&D expertise in this area, leveraged through the participation of the research scientists as faculty and mentors, provides a unparalleled opportunity for those aspiring to be leading microwave device and systems engineers.

Number of Seats in the Programme

The total number of seats available is 8.

Mode of Payment

The programme fees at CEERI can be deposited using the following modes :

1. NEFT Bank Transfer : Amount needs to be transferred to the saving account number 61033385318 of Director, CEERI at SBBJ, Pilani (IFSC code SBBJ0010398) with appropriate narration statement.

2. Demand Draft : Issued in favour of "Director, CEERI" payable at Pilani and post it by speed post or registered letter to "Director, CEERI, Pilani – 333 031" with your name and "PGRP-MDSE" written in pencil on the reverse side of the demand draft.

The hostel boarding and lodging charges will need to be made on periodic basis, as applicable.

Other Details (Admission Process, Eligibility, Fellowship, Important Dates, *etc*.)

Please visit the CSIR website <http://www.csir.res.in/>.

About CEERI

To know more about CEERI's current R&D activities, laboratory facilities and past achievements, please see <http://www.ceeri.res.in/>.

Semester-wise Scheme for High Power Microwave Devices and System Engineering

Semester-I

Subject Code	Subject	Credits
MDSE 101	Electromagnetic Theory, Transmission Lines, Circuit Equivalents and Measurement	4
MDSE 102	Numerical Techniques and Computer Aided Design of Microwave Tubes	4
MDSE 103	Microwave Communication	2
MDSE 111	Lab: Microwave Component Characterization	2
MDSE 112	Lab: Microwave Tube Processing Techniques	2
MDSE 151	Technical Communications	1

Semester-II

Subject Code	Subject	Credits
MDSE 201	Slow-wave Devices : Principles and Design	3
MDSE 202	Fast-wave Devices : Principles and Design	3
MDSE 203	Microwave and Millimeter-wave Tube Technologies	3
MDSE 211	Lab: CAD of Microwave Tubes	2
MDSE 212	Lab: Microwave Devices Characterization	2
MDSE 213	Lab: Microwave Tube Sub-assembly Fabrication	2
MDSE 251	Project Management Techniques	1

Semester-III

Subject Code	Subject	Credits
MDSE 301	High Power Microwave Devices, Systems and Applications	3
MDSE 30x	Elective-I	2
MDSE 311	Project Work and Seminar	12

Elective-I

Subject Code	Subject	Credits
MDSE 302	Electron Emitters and Surface Characterization	2
MDSE 303	Plasma-filled Microwave Sources	2
MDSE 304	Vacuum Microelectronic Devices	2

Semester-IV

Subject Code	Subject	Credits
MDSE 401	Dissertation Seminar and Viva-voce	4
MDSE 402	Dissertation Report	14

Course Description

MDSE 101 : Electromagnetic Theory, Transmission Lines, Circuit Equivalents and Measurement
(4-0-0) ***4 Credits***
Faculty : Dr. A. K. Sinha, Dr. V. V. P. Singh, Dr. R. S. Raju; Dr. S. N. Joshi

Maxwell's Equations; Wave equations and their solutions; Boundary Conditions and their applications. Electromagnetic energy and power flow; Poynting theorem. Transmission lines; Wave-guide and coaxial components. Scattering matrix representation. Propagation of electromagnetic waves through homogeneous, in-homogeneous, and anisotropic media. Surface resistance and RF resistance. Ferrite devices. Waveguides and resonators. Characteristic and interaction impedances. Quality factors (loss and diffractive). Impedance Matching. Measurement of "Q", power, noise figure, S-parameters, dielectric constant and Loss tangent, dispersion and impedance characteristics, and Loss parameters.

MDSE 102 : Numerical Techniques and Computer Aided Design of Microwave Tubes
(4-0-0) ***4 Credits***
Faculty : Dr. V. Srivastava; Dr. A. K. Sinha; Dr. L. M. Joshi

Numerical Solution of linear and non-linear differential equations of higher orders, Analytical and numerical techniques to the solution of electromagnetic field problems, Numerical techniques to the electrical, thermal, and structural design of slow-wave and fast-wave microwave tubes. Spent beam analysis for efficiency enhancement. Special focusing techniques for multi-beam electron guns, PIC simulation techniques, finite difference and finite element techniques, and method of moments applied to microwave devices.

MDSE 103 : Microwave Communication (2-0-0) ***2 Credits***
Faculty : Dr. V. V. P. Singh; Dr. R. K. Sharma; Sh. S. Raghunath

Ground/surface wave, space-wave, and sky-wave modes of communication. Tropo-sphereic Communication, Line of sight communication and system performance. Active and passive repeaters and their design. Analog and digital communication. Mobile communication. Satellite communication System. Earth station design criteria and direct reception system. Satellite transponders and their design criteria. Phase noise, Intra-pulse and inter-pulse noises and their significance.

MDSE 111 : Microwave Component Characterization Laboratory (0-0-3) ***2 Credits***
Faculty : Sh. O. S. Lamba

Scattering parameters, Measurement of impedance and Characterization of cavities, Dispersion and Impedance characterization of RF structures, RF loss measurements.

MDSE 112 : Microwave Tube Processing Techniques Laboratory (0-0-3) ***2 Credits***
Faculty : Sh. S. C. Nangru

UHV techniques, Heat treatment in protective atmosphere, Ceramic-to-metal sealing techniques, Chemical processing of components.

MDSE 151 : Technical Communication (1-1-0) ***1 Credit*** **(Same as ASE 151)**
Faculty : Sh. Raj Singh

Role and importance of communication; Effective oral and written communication; Technical report writing; Technical/R&D proposals; Research paper writing; Letter writing and official correspondence; Notices, agenda, minutes; Oral communication in meetings, seminars, group discussions; Use of modern aids.

MDSE 201 : Slow-wave Devices: Principles and Design (3-0-0) ***3 Credits***
Faculty : Dr. V. Srivastava; Dr. L. M. Joshi

Classification and high frequency limitations of conventional electron tubes. Formation and confinement of an electron beam. Slow-wave structures, couplers and RF windows. Beam-wave interaction mechanism. Spent beam collection. Efficiency enhancement by phase velocity tapering and multi-stage depressed collection. Different types of devices, their operation, and characteristics, High power and wide bandwidth issues. Future trends.

MDSE 202 : Fast-wave Devices: Principles and Design (3-0-0) ***3 Credits***
Faculty : Dr. A. K. Sinha

Merits of fast-wave devices over slow-wave devices. Operating principle of a gyrotron and design of its components: magnetron injection gun, beam tunnel, RF interaction cavity, magnetic field, non-linear taper, RF window, mode converter and collector. Beam-wave interaction and mode selection criteria. Other fast-wave devices: gyro-TWT, gyro-klystron, peniotron and FEL. Applications of gyro-devices and future trends. High Power Microwave (HPM) Devices.

MDSE 203 : Microwave and Millimeter-Wave Tube Technology (3-0-0) ***3 Credits***
Faculty : Dr. R. S. Raju; Sh. R. K. Gupta; Dr. A. K. Sharma

Fundamentals of vacuum technology. Vacuum generation and measurement, and leak detection. Ultra-high vacuum techniques. Surface physics and analysis in relation to electron Emitters. Electron-tube grade materials and their characteristics. Chemical processing. Heat treatment and special techniques: brazing, sintering, sputtering, TIG/electron beam/laser welding, glass-to-metal and ceramic-to-metal sealing, loss coating, and helix fitting. Vacuum processing of integrated devices. Design of tools, jigs, and fixtures. Engineering/mechanical design of components. Special machining techniques.

MDSE 211 : CAD of Microwave Tubes Laboratory (0-0-3) ***2 Credits***
Faculty : Dr. R. K. Sharma

Components design : electron guns, slow-wave structures, fast-wave structures, RF cavities, RF windows, collectors; Electron beam and RF wave interaction simulation; Thermal and structural design and simulation; CAD of complete tube; Computer aided engineering drawing.

MDSE 212 : Microwave Device Characterization Laboratory (0-0-3) ***2 Credits***
Faculty : Dr. L. M. Joshi; Dr. S. N. Joshi

Device characterization using spectrum analyzer, scalar/vector analyzer; Break-down tests; X-ray radiography; Cathode characterization using Auger and Thermal emission microscope; Hot RF characterization of devices.

MDSE 213 : Microwave Tube Sub-assembly Fabrication Laboratory (0-0-3) ***2 Credits***
Faculty : Sh. S. C. Nangru

Metal-to-metal brazing techniques; Leak detection; TIG/laser welding; Vacuum processing of devices; Cathode fabrication.

MDSE 251 : Project Management Techniques (1-1-0) ***1 Credit*** **(Same as ASE 251)**
Faculty : Sh. Raj Singh

Concepts and techniques of project formulation, evaluation and implementation; Project planning and scheduling; Resource allocation; Time management; Project monitoring and control; Project documentation.

MDSE 301 : High Power Microwave Systems and Applications (3-0-0) ***3 Credits***
Faculty : Dr. L. M. Joshi; Dr. R. K. Sharma; Dr. V. V. P. Singh

Special EW (Radar, ECM, ECCM) Systems and their requirements in respect of Microwave and Millimetre wave Devices. Various types of Jamming. Linear Accelerators, Microtrons, Synchrotrons, Plasma Heating Systems, Proton Accelerators, Thermonuclear Reactors and other Applications like Imaging, Spectroscopy, Biomedical and Industrial Heating, Electronic Power Conditioners, Modulators.

MDSE 302 : Electron Emitters and Surface Characterization (2-0-0) ***2 Credits***
Faculty : Dr. R. S. Raju

Physics of electron emission, Emission equation, Temperature limited and space-charge limited emission, Methods of determining work function. Oxide coated cathodes, Dispenser cathodes, Field emitters, Explosive emission cathodes, Secondary emitters. Fabrication and characterization of cathodes. Life testing and Surface analysis techniques. Nano-cathodes.

MDSE 303 : Plasma-Filled Microwave Sources (2-0-0) ***2 Credits***
Faculty : Dr. A. K. Sharma

Plasma and its physical parameters. Saha equation and its relevance. Motion of charged particles in static and slowly varying electric and magnetic fields. Motion of relativistic charged particles. Types of gaseous discharge. Hollow-cathode discharge and other kinds of low-pressure discharges. General features of electrons emission, control and extraction of electrons and ions from plasma in DC and pulsed mode conditions. Plasma sources for axially symmetric electron beams, Plasma cathode electron gun (PCE-gun). Advantages of plasma filling in high power microwave devices. Operating principles, characteristics, and applications of different types of plasma-filled devices including the pasotron.

MDSE 304 : Vacuum Microelectronic Devices (2-0-0) ***2 Credits***
Faculty : Dr. V. Srivastava

Basic semiconductor technologies like reactive ion etching, photo-lithography, oxidation, CVD, sputtering, LIGA and MEMS. Design considerations in vacuum microelectronic devices. Photonic band gap structures, folded wave guide and ladder structures. Terahertz devices including reflex klystrons. Micro-fabricated devices like TWT and klystrino. Combination of vacuum and semiconductor technologies in microwave devices, including microwave power module and their applications.

List of Faculty

S. No.	Name	Designation	Discipline
1.	Dr. S. N. Joshi	Ex-Scientist G	Microwave Engineering & Tube Technology
2.	Dr. V. Srivastava	Scientist G	Microwave Engineering & Tube Technology
3.	Dr. R. S. Raju	Scientist G	Microwave Engineering & Tube Technology
4.	Dr. L. M. Joshi	Scientist G	Microwave Engineering & Tube Technology
5.	Sh. R. K. Gupta	Scientist G	Microwave Engineering & Tube Technology
6.	Dr. V. V. P. Singh	Scientist F	Microwave Engineering & Tube Technology
7.	Dr. A. K. Sharma	Scientist F	Plasma Devices
8.	Dr. A. K. Sinha	Scientist E-II	Microwave Engineering & Tube Technology
9.	Sh. O. S. Lamba	Scientist E-II	Microwave Engineering & Tube Technology
10.	Dr. R. K. Sharma	Scientist E-I	Microwave Engineering & Tube Technology
11.	Sh. S. C. Nangru	Ex-TO E-II	Microwave Tube Technology
12.	Sh. S. Raghunath	Ex-Scientist G	Communications Engineering