UNIVERSITY OF CALCUTTA

Notification No. CSR/ 17 /14

It is notified for the information of all concerned that in terms of the provisions of Section 54 of the Calcutta University Act, 1979, (as amended), and, in exercise of his powers under 9(6) of the said Act, the Vice-Chancellor has, by an order dated 07.05.2014, approved the Revised Regulations, Course Structure and detailed Syllabi for M.Tech. Courses in (i) Radio Physics and Electronics and (ii) VLSI Design under this University as laid down in the accompanying pamphlet.

The above shall take effect from the academic year 2013-14 and onwards.

23.05.2014

(Prof. Basab Chaudhuri)

Registrar

SENATE HOUSE
KOLKATA-700073
The 23rd May, 2014

REGULATIONS

'Full Time' 2-Year (4-Semester) M. Tech. Degree Programmes offered by the Department of Radio Physics and Electronics [WITH OPTION FOR 'PART-TIME' 3 YEAR (6 SEMESTER)], University of Calcutta

1	The Department of Radio Physics and Electronics, University of Calcutta offers the following Full-Time 2-Year (4-Semester) Post Graduate Courses [with option for 3-year (6 semester) for practicing professionals] leading to an M.Tech. degree of the University of Calcutta: **Programme 1 – M. Tech in Radio Physics and Electronics**. **Specializations:** • **Space Science and Microwaves** • **Nanoelectronics and Photonics** **Programme 2 – M. Tech in VLSI Design** Full-time (FT) and Part-time (PT) Progammes will be referred to as 'FT' and 'PT' programmes respectively, whenever a distinction is to be made.
2(A)	The eligibility for admission to the 2- year M.Tech. Course will be as follows: (a) *'M. Tech Programme 1'*: (I) B.Tech. degree in Radio Physics & Electronics of the University of Calcutta. (II) B.Tech. degree in Information Technology of the University of Calcutta with Physics as a subject at the B. Sc. level. (III) M.Sc. degree in Electronics Science of the University of Calcutta with Physics and Mathematics as subjects at the B. Sc. level. (IV) A degree in Electronics and Communication Engineering from other University, or equivalent to (III) above. (V) M.Sc. degree in Physics (with Advanced papers in Electronics) of University of Calcutta. (b) *'M. Tech Programme 2'*: (I) B.Tech. degree in Radio Physics & Electronics of the University of Calcutta. (II) B.Tech. degree in Information Technology of the University of Calcutta with Physics as a subject at the B. Sc. level. (III) B. Tech degree in Computer Science and Engineering of the University of Calcutta with Physics as a subject at the B. Sc. level (IV) M.Sc. degree in Electronics Science of the University of Calcutta with Physics and Mathematics as subjects at the B. Sc. level. (V) A degree from other University, equivalent to (I), (II), (III) or (IV) above. (c) For admission to the Part Time (PT) programme, in addition to the above, a candidate must be a Full Time employee in a relevant industry or institution.
2(B)	The duration of the FT and PT Programmes will be divided into 4 Semesters and 6 Semesters, respectively, each of 6 months duration.
3(A)	Admission of the 'General' candidates to the 'Full Time' M.Tech. Course will be on the basis of marks obtained in the examinations of the degrees mentioned in 2(A) along with a suitable test, to be decided by the Board of PG Studies in Radio Physics and Electronics, conducted amongst the candidates possessing eligibility qualifications and short-listed for such test.
3(B)	For admission to the 'Part-Time (PT)' option, a candidate must produce a certificate from his/her employer that the company will release him/her during the part of the

	day that classes are scheduled in the University during the entire period of the course. The admission will be on the basis of an interview conducted amongst such candidates.
3(C)	Admission of the candidates under ‘Sponsored’ category will be on the basis of interview conducted amongst such candidates.
4	The academic programme to be pursued during the M.Tech. Course will have the following components: **(**i) Theory/Laboratory based papers comprising Lectures (L), Tutorials (T) & Practicals (P). (iii) Seminar (iv) Compulsory Project Work in Two parts: Foundation and Final. (v) General Viva Voce**.** Note: The number of papers to be offered and the Credit distribution thereof can be found from the detailed Course Structures.
5	Each paper will carry “**CREDITs**” according to the number of hours devoted per week as indicated in the following table. **Paper** **Hrs/week** **Credits assigned** **Lectures (L) 1 1** **Tutorials (T) 1 1** **Practical (P) 3 2**
6	The number of Lecture, Tutorial and Practical hours/week assigned to each paper as well as the Seminar and the Project Work of the Course, and the Credits thereof will be determined from the Structure of the Course in conjunction with the Table in clause 5.
7	The Total Credits of the M.Tech. Programmes will be 84. The Semester-wise distribution of credits (as per Course Structure) will be as follows. **<u>Semester</u>** **<u>Total Credits of the Semester</u>** **First 20** **Second 20** **Third 22** **Fourth 22** A ‘Full Time” student will be able to earn the total credits of the Programme in a minimum of Two Years. A ‘Part Time” student will be able to earn the total credits of the Programme in a minimum of Three Years.
8	The examinations for FT/PT M.Tech. Course shall be held in 4/6 parts. At the end of each Semester, an examination of the Papers/Seminar/Project Work covered in that Semester will be held. This examination will be referred to as the **M. Tech Examination of the corresponding Semester**. *The study break between the completion of regular classes and the commencement of the Semester Examination will generally be of 10 calendar days.* The schedule of a Semester examination and the credits to be earned will be in accordance with the Course structure. ***A student earns the credits assigned to a Paper or to Seminar or to Project/Thesis Work (Foundation/Final) or to General Viva Voce, when he/she satisfies the performance criteria stated below in clause 10.***

9	(a) Examination of a Theoretical component of a paper carrying 3 credits will be of 2 hour duration. (b) Paper Setters and Examiners for Theoretical component of a paper will be appointed from a Board of Examiners consisting of all the faculty members of the Department and the Honorary/Guest Lecturers, if any. (c) Evaluation of the Tutorial component of a paper will be based on sessional evaluation based on assignments and/or mid-semester examination, by the Faculty member(s) offering the course. (d) Evaluation of performance in the Practical (P) component of a Paper will be based on Sessional work in that paper, Lab Report and an end-semester viva voce. On completion of all the experiments in the Lab, a student will be given marks, out of notional full marks, according to the following allocations. (i) 50% for experiments performed in the lab – the Sessional work to be evaluated by the Teacher-in-Charge. (ii) 40% for Viva Voce on the experiments to be conducted by a Board consisting of the Teacher(s)-in-Charge and another Faculty member of the Department and an External Examiner. (iii) 10% for Lab Report to be evaluated by the Viva Voce Board.
10	(a) The performance of a student in a Paper, Seminar, Project work and General Viva Voce will be evaluated in terms of '**Grades**' and '**Grade Points**' earned by the student. The equivalence between 'Grade', 'Grade Point' and the Percent Marks (out of notional full marks) is tabulated below. **% of Marks** — **Grade** — **Grade-point(P)** **$\geq$ 90%** — **Ex** — **10** **$\geq$ 80% but < 90%** — **A** — **9** **$\geq$ 70% but < 80%** — **B** — **8** **$\geq$ 60% but < 70%** — **C** — **7** **$\geq$ 50% but < 60%** — **D** — **6** **< 50%** — **F** — **0** Grade 'F' implies failure to earn the corresponding credits. Grades higher than 'F' and GP $\geq$ 6 indicate successful clearing of a unit that will earn the student the corresponding Grade Point (P) and the Credits (C) assigned to that unit. (b) The '% of Marks' earned by a student in a paper consisting of 'L', 'T' and 'P' components will be evaluated from the following formula: $\% \; of \; Marks = \frac{C_L M_L + C_T M_T + C_P M_P}{C_L + C_T + C_P}$ where, C_L, C_T, C_P are respectively the Credits assigned to the Lecture, Tutorial and Practical components of the paper and M_L, M_T, M_P are respectively the percentage marks (calculated from the notional full marks) obtained by the student in the corresponding components of that paper. (c) The overall performance of a candidate in a particular (j th, j=1,2,3,4) Semester examination, who earns all the credits of that Semester in one chance, will be assessed by the **Semester Grade Point Average (SGPA) 'S'** to be computed from

$$\text{SGPA}\left[S^{(j)}\right] = \frac{\sum_i P_i^{(j)} C_i^{(j)}}{\sum_i C_i^{(j)}} \qquad \text{(I)}$$

where the summations are over the Grade Points and Credits earned in the examination of the j th Semester. C_i denotes the total credits (L/T/P components combined) associated with a Paper or Seminar or Project Work (Foundation or Final) or General Viva Voce and P_i would be the corresponding Grade Points earned. $\sum_i C_i^{(j)}$ is the total credit of the j th Semester and $\sum_i P_i^{(j)} C_i^{(j)}$ is the weighted sum of the Grade Points earned in the j th Semester.

(d) On completion of the M. Tech. Course (when 84 credits have been earned as per regulations), the final result of a candidate will be shown through the **Cumulative Grade Point Average (CGPA)**.

CGPA will be computed from

$$CGPA = \frac{\sum_{j=1}^{N} S^{(j)}.C^{(j)}}{\sum_{j=1}^{N} C^{(j)}} = \frac{\sum_{j=1}^{N} S^{(j)}.C^{(j)}}{84} \qquad \text{(II)}$$

where, *N* is the total number of semesters in the Programme (*N* = 4 for Full-Time and *N* = 6 for Part-Time Programmes) for a student who earns the total credits of the Course in single chance (consecutive semesters without back credits during the course of study); and from

$$CGPA = \frac{\sum_k P_k \; C_k}{84} \quad \text{(III)}$$

for a student who completes the M.Tech. Course in 4(FT)/6(PT) Semesters but with back credits during the course of study or in more than 4(FT)/6(PT) Semesters as per regulations, where P_k is the Grade Points earned in the k^{th} unit carrying C_k credits and the summation is over all the units: All the Papers, Seminar, Project Work and General Viva Voce of the M. Tech. Course.

(e) For the purpose of applying to institutions/organizations where ‘Percentage (%) Marks’ is required instead of ‘CGPA’, an equivalent percentage marks may be computed using the approximate formula:

Percentage (%) Marks = (CGPA – 0.5) X 10

For computing the Percentage (%) Marks of any individual semester the same formula may be used with ‘CGPA’ being replaced by the ‘SGPA’ of that particular semester.

11	(a) Each student will be allotted the topic of the Project Work at the beginning of the 3rd / 5th Semester for FT/PT programmes. He/she will have to carry out the Project Work under (i) the supervision of a Faculty member of the Department or (ii) the joint supervision of more than one Faculty members of the Department or (iii) the joint supervision of one or more Faculty members of the Department and an External Superviser, who is a Faculty member/Scientist/Technologist of another institution/organization. The programme under joint supervision will have to be approved by the BPGS in RPE. (b) At the end of the 3rd Semester or the Semester in which a student pursues the Project Work (Foundation), he/she will have to submit, through the respective Superviser(s), a Report on Project Work (Foundation) and defend the same in a viva-voce to be conducted by a Board of Examiners consisting of the Faculty members of the Department. (c) For Foundation Project Work, 60% of the notional full marks will be set aside for the Sessional Work and 40% for the Viva Voce. (d) At the end of the 4th Semester or the Semester in which the student pursues the Project Work (Final), he/she will have to submit, through the respective Superviser(s), a dissertation on the Project Work (Final) and defend the same in a viva-voce. The evaluation of the Dissertation and the viva-voce will be conducted by a Board of Examiners to be constituted by the BPGS in RPE from the Faculty members of the Department, External Superviser(s) and External Examiner(s). (e) The Project Work (Foundation) and/or the Project work (Final) or both can be undertaken in an organization/institution other than the Department of RPE as a programme under joint supervision (clause 11(a)).
12	(a) The classes of 2nd Semester onward will begin immediately after the completion of the previous Semester examinations. (b) A student who fails to earn the total credits of the 1st , 2nd and 3rd Semesters (for FT)/ 1st, 2nd, 3rd , 4th and 5th Semesters (for PT), at the first appearance in the Semester examinations, will be allowed to continue in the next Semester, provided he/she did not fail to earn the credits of more than 2 (for FT)/1 (for PT) papers in that semester examination. (c) If a student fails to earn the credits of more than 2 (for FT)/1 (for PT) papers in each of 1st 2nd and 3rd Semester (for FT)/1st, 2nd, 3rd, & 4th (for PT) 4th and 5th Semester examinations, he/she will be deemed to have failed in that Semester examination. (d) A student will have to earn the credits of the Project Work (Foundation) in the 3rd (for FT)/5th (for PT) Semester examination in order to be promoted to the next Semester to pursue the Project Work (Final). (e) In order to clear the Project Work (Final) of 4th (for FT)/6th (for PT) Semester, a student will have to earn the total of 22 credits of the Semester in a single chance. (f) A student who fails in a Semester examination (clauses: 12(c), (d)) or fails to appear in a Semester examination, will not be allowed to continue in the next Semester and will have to revert back to the same Semester in the next Academic Session. (g) The due-to-earn or 'back' credits of a Semester will have to be earned in the examination of the same Semester of the next academic session. The candidate will have two such additional chances (a total of 3 chances including the first) to earn the due credits.

	(h) After publication of the results of the 3rd Semester examination (for FT) / 5th Semester examination (for PT), if any student is found to have un-cleared 'back' credits, for which he/she has valid available chances to clear including any such 'back' credits in the 3rd Semester examination (for FT) / 5th Semester examination (for PT), a special supplementary examination will be arranged for those students to clear the un-cleared 'back' credits of the odd-semester examinations only. This supplementary examination will be counted as one of the two additional chances mentioned in clause 12(g) above. (i) In order to complete the M.Tech. course, a 'FT' student will have to utilize all the allowed chances within 4 years or 4 consecutive academic sessions or 8 consecutive Semesters, from the date of the first admission. For 'PT' students, the corresponding period will be 5 years or 5 consecutive academic sessions or 10 consecutive semesters. A student who fails to earn the total credits of the M.Tech. course within the allowed chances, will not be permitted to continue the course. (j) For a student who fails to earn the total credit of a Semester but gets promoted to the next Semester by virtue of clause 12(b), it would be necessary that the total un-cleared 'back' credits carried by the student at any stage does not exceed that of 3 (three) papers. If at the end of any Semester, the accumulated back credit of a student exceeds that of 3 papers, the student will not be permitted to pursue the course further. (k) A student who wishes to discontinue the M.Tech. programme, will have to inform, in writing, the Head of the Department. If such a student has an 'acceptable' performance (must have successfully completed all the course work excepting the Seminar and Project Work), he/she may be allowed to resume the programme at the appropriate Semester within five years from the date of first admission. However, the above clause of maximum 3 chances allowed for earning the credits of any unit will be applicable for such candidates.
13	(a) At the end of each Semester examination other than the final semester, the Syndicate will publish separate lists of following candidates. (i) One list will show the results of the candidates who earned all the Semester credit in one (first) chance and are allowed to continue in the next Semester. This list will also show the SGPA earned by the candidates as computed from formula (I) in clause 10(c). (ii) Another list will show the results of the candidates who did not earn all the credits of the Semester but earned the credits of the required number of papers in the first chance to be allowed to continue in the next Semester. The SGPA of such a candidate for the particular Semester examination will not be computed (hence not shown). (iii) A third list will show the results of the candidates who appeared in the Semester examination only for earning back credits. (b) At the end of the 4th(FT)/6th(PT) Semester examination, the Syndicate shall publish the following separate lists: (i) One list will show the results of the candidates who earned all the credits of the Semester in one (first) chance. This list will also show the SGPA earned by the candidates as computed from formula (I) in clause 10(c). (ii) One list will show the results of the candidates who could not earn all the credits of the Semester and hence 'failed' in the Semester examination according to clause 12(e). (iii) One list will show the results of the candidates who appeared in the Semester examination only to earn back credits. (iv) One list will show the candidates, who earned the total credits of the M.Tech. course in one chance (without any back credits in any Semester during the course of study), in order of merit, on the basis of the combined results of all the Semester examinations. The list will also show the CGPA (computed from Formula II of clause 10(c)) earned by the candidates.

	(v) A list of candidates who completed the M.Tech. course in consecutive Semesters but with back credits during the course of study. In such cases, CGPA will be computed from formula III of clause 10(c). (c) A candidate who completes the M.Tech. Course in the specified number of Semesters but with back credits or in more than the specified number of Semesters, will be deprived of his/her position in order of merit but will be awarded the CGPA he/she earns, computed from formula (III) of clause 10(c). (d) A Consolidated Grade Sheet, showing the combined results of all the Semester examinations of the M.Tech. Course will be issued to a candidate after he/she earns the total credits of the Course. The two categories of candidates, defined in clauses 13(b)(iv)-(v), will be issued the Consolidated Grade Sheet together with the Final Semester Grade Sheet. Those who complete the Course in more than the specified number of Semesters within the allowed chances will have to apply for the Consolidated Grade Sheet by submitting copies of all his/her Semester Grade Sheets. (e) A candidate may apply for review of the theoretical component of papers of a semester examination by depositing the fees prescribed by the University. The application must be made within one month from the date of publication of the results of that semester. The maximum number of papers for review in a semester examination for a student will be restricted to two.
14	In order to be able to appear in a Semester examination, a candidate shall have to pursue a regular course of studies in the Semester and attend at least 65% of the total Theoretical (including Tutorials) and total Practical classes separately in the Semester. For the Project work, both Foundation and Final, a certificate of satisfactory attendance would have to be obtained from the Supervisor(s) prior to registration for the Semester examination. A candidate who fails to earn the total credits of a Semester in the first appearance in the Semester examination (Semesters I & II), but gets promoted to the next Semester by virtue of satisfying the clause 12(b), will not be required to attend classes in the 'back' paper(s).

Course Structure of M.Tech in Radio Physics and Electronics

Semester- I

Sl. No.		L	T	P	Credit
1.	RP 4.1.1 - Advanced Engineering Mathematics	3	1	0	4
2.	RP 4.1.2 – Computational Methods using Matlab	0	0	6	4
3.	RP 4.1.3 - Applied Electromagnetics	3	1	0	4
4.	RP 4.1.4 - Advanced Communications	3	1	0	4
5.	RP 4.1.5 -Advanced Semiconductor Physics and Devices	3	1	0	4

Semester- II

(There are total 5 papers)
(At least 4 papers to be taken either from Group A or from Group B)

Group A: (Specialization: Space Science and Microwaves)

Sl. No.		L	T	P	Credit
1.	RP 4.2.1 - Radar Principles & Applications	3	1	0	4
2.	RP 4.2.2 - Microwave & Wireless Antennas	3	1	0	4
3.	RP 4.2.3 - Microwave Devices, Circuits & Materials	3	1	0	4
4.	RP 4.2.4 - Microwave Propagation	3	1	0	4
5.	RP 4.2.5 - Electromagnetic Interference and Compatibility	3	1	0	4
6.	RP 4.2.6 - Space-borne & Terrestrial Remote Sensing	3	1	0	4
7.	RP 4.2.7 - Digital Receiver	3	1	0	4
8.	RP 4.2.8 - Radio Astronomy Techniques	3	1	0	4
9.	RP 4.2.9 - GNSS (Global Navigation Satellite System) Aids and Applications	3	1	0	4
10.	RP 4.2.10 - Space Climatology and Weather	3	1	0	4

Group B: (Specialization: Nanoelectronics and Photonics)

Sl. No.		L	T	P	Credit
1.	RP 4.2.11 – Microelectronics Technology	3	1	0	4
2.	RP 4.2.12 - Quantum Theory of Solids	3	1	0	4
3.	RP 4.2.13 - Nanoelectronic Devices	3	1	0	4
4.	RP 4.2.14 - Nanostructures and Nano-materials	3	1	0	4
5.	RP 4.2.15 - Photonic Devices	3	1	0	4
6.	RP 4.2.16 - Guided Wave Photonics	3	1	0	4
7.	RP 4.2.17 - Optical Displays, Storage Devices and Sensors	3	1	0	4
8.	RP 4.2.18 - Optical Communication and Networking	3	1	0	4
9.	RP 4.2.19 – Nanophotonics (*With RP 4.2.19, RP 4.2.15 is to be taken*)	3	1	0	4

Semester- III

Sl. No.		L	T	P	Credit
1.	RP 5.1.1 Compulsory Thesis Work (Foundation)	0	0	12	8
2.	RP 5.1.2 Seminar	0	0	6	4
3.	RP 5.1.3 General Viva Voce	-	-	-	4
4.	Practical Paper 1	0	1	3	3
5.	Practical Paper 2	0	1	3	3

Practical papers to be selected from the following list.

Sl. No.		L	T	P	Credit
1.	RP 5.1.4 –Measurements on Microwave Circuits, Links, and Radiating system	0	1	3	3
2.	RP 5.1.5 - Measurements on Remote sensing Communication and GPS based Instrumentation	0	1	3	3
3.	RP 5.1.6 - Measurements and simulations of Photonic Devices and Systems	0	1	3	3
4.	RP 5.1.7 - Optical characterization of photonic devices	0	1	3	3
5.	RP 5.1.8 – Microelectronics Processing	0	1	3	3
6.	RP 5.1.9 – Micro Electro Mechanical Systems	0	1	3	3

Semester- IV

Sl. No.		L	T	P	Credit
1.	RP 5.2.1 Compulsory Thesis Work (Final)				
	Sessional	0	0	15	10
	Dissertation	0	0	9	6
	Viva Voce	-	-	-	6

Course Structure of M.Tech in VLSI Design

Semester- I

Sl. No.	L	T	P	Credit
1. RP 4.1.5 - Advanced Semiconductor Physics and Devices	3	1	0	4
2. RP 4.1.6 - Graph Theory and Combinatorics	3	1	0	4
3. RP 4.1.7 - Algorithms for VLSI Design	3	1	0	4
4. RP 4.1.8 - VLSI Circuits and Systems	3	1	0	4
5. Elective-I	3	1	0	4

Elective to be selected from :
RP 4.1.9 - Processor Organization and Architecture
RP 4.1.10 - Digital Signal Processing
RP 4.1.11 - Embedded Systems
RP 4.1.12 - Object Oriented Programming and Language Translation

Semester- II

Sl. No.	L	T	P	Credit
1. RP 4.2.11 - Microelectronics Technology	3	1	0	4
2. RP 4.2.20 - Analog and Mixed-Signal Circuits	3	0	0	3
3. RP 4.2.21 - Testing and Verification of VLSI Circuits	3	0	0	3
4. RP 4.2.22 - CAD Techniques (TCAD and IC Design)	0	1	3	3
5. RP 4.2.23 - Design Entry and Simulation Laboratory	0	1	3	3
6. Elective-II	3	1	0	4

Elective to be selected from :
RP 4.2.24 - Low Power Design
RP 4.2.25 - Design of VLSI CAD Tools
RP 4.2.26 - ASIC/Memory Design
RP 4.2.27 - RF and Microwave Integrated Circuit Design

Semester- III

Sl. No.	L	T	P	Credit
1. RP 5.1.1 Compulsory Thesis Work (Foundation)	0	0	12	8
2. RP 5.1.2 Seminar	0	0	6	4
3. RP 5.1.3. General Viva Voce	-	-	-	4
4. RP 5.1.10 - FPGA Lab	0	1	3	3
5. Laboratory course	0	1	3	3

Laboratory course to be selected from :
RP 5.1.8 - Microelectronics Processing
RP 5.1.9 Micro-Electro-mechanical Systems

Semester- IV

Sl. No.	L	T	P	Credit
1. RP 5.2.1 Compulsory Thesis Work (Final)				
Sessional Work	0	0	15	10
Dissertation	0	0	9	6
Project Viva Voce	-	-	-	6

List of Papers offered in M.Tech. courses by the Department of Radio Physics and Electronics

Paper	Description	L	T	P	Credit
RP 4.1.1	Advanced Engineering Mathematics	3	1	0	4
RP 4.1.2	Computational Methods using Matlab	0	0	6	4
RP 4.1.3	Applied Electromagnetics	3	1	0	4
RP 4.1.4	Advanced Communications	3	1	0	4
RP 4.1.5	Advanced Semiconductor Physics and Devices	3	1	0	4
RP 4.1.6	Graph Theory and Combinatorics	3	1	0	4
RP 4.1.7	Algorithms for VLSI Design	3	1	0	4
RP 4.1.8	VLSI Circuits and Systems	3	1	0	4
RP 4.1.9	Processor Organization and Architecture	3	1	0	4
RP 4.1.10	Digital Signal Processing	3	1	0	4
RP 4.1.11	Embedded Systems	3	1	0	4
RP 4.1.12	Object Oriented Programming and Language Translation	3	1	0	4
RP 4.2.1	Radar Principles & Applications	3	1	0	4
RP 4.2.2	Microwave & Wireless Antennas	3	1	0	4
RP 4.2.3	Microwave Devices, Circuits & Materials	3	1	0	4
RP 4.2.4	Microwave Propagation	3	1	0	4
RP 4.2.5	Electromagnetic Interference and Compatibility	3	1	0	4
RP 4.2.6	Space-borne & Terrestrial Remote Sensing	3	1	0	4
RP 4.2.7	Digital Receiver	3	1	0	4
RP 4.2.8	Radio Astronomy Techniques	3	1	0	4
RP 4.2.9	GNSS (Global Navigation Satellite System) Aids and Applications	3	1	0	4
RP 4.2.10	Space Climatology and Weather	3	1	0	4
RP 4.2.11	Microelectronics Technology	3	1	0	4
RP 4.2.12	Quantum Theory of Solids	3	1	0	4
RP 4.2.13	Nanoelectronic Devices	3	1	0	4
RP 4.2.14	Nanostructures and Nano-materials	3	1	0	4
RP 4.2.15	Photonic Devices	3	1	0	4
RP 4.2.16	Guided Wave Photonics	3	1	0	4
RP 4.2.17	Optical Displays, Storage Devices and Sensors	3	1	0	4
RP 4.2.18	Optical Communication and Networking	3	1	0	4
RP 4.2.19	Nanophotonics	3	1	0	4
RP 4.2.20	Analog and Mixed-Signal Circuits	3	0	0	3
RP 4.2.21	Testing and Verification of VLSI Circuits	3	0	0	3

RP 4.2.22	CAD Techniques (TCAD and IC Design)	0	1	3	3
RP 4.2.23	Design Entry and Simulation Laboratory	0	1	3	3
RP 4.2.24	Low Power Design	3	1	0	4
RP 4.2.25	Design of VLSI CAD Tools	3	1	0	4
RP 4.2.26	ASIC/Memory Design	3	1	0	4
RP 4.2.27	RF and Microwave Integrated Circuit Design	3	1	0	4
RP 5.1.1	Compulsory Thesis Work	0	0	12	8
RP 5.1.2	Seminar	0	0	6	4
RP 5.1.3	General Viva Voce	-	-	-	4
RP 5.1.4	Measurements on Microwave Circuits, Links, and Radiating system	0	1	3	3
RP 5.1.5	Measurements on Remote sensing Communication and GPS based Instrumentation	0	1	3	3
RP 5.1.6	Measurements and simulations of Photonic Devices and Systems	0	1	3	3
RP 5.1.7	Optical characterization of photonic devices	0	1	3	3
RP 5.1.8	Microelectronics Processing	0	1	3	3
RP 5.1.9	Micro Electro Mechanical Systems	0	1	3	3
RP 5.1.10	FPGA Lab	0	1	3	3
RP 5.2.1	Compulsory Thesis Work (Final)				
	Sessional Work	0	0	15	10
	Dissertation	0	0	9	6
	Project Viva Voce	-	-	-	6

Detailed Syllabus

SEMESTER I

Advanced Engineering Mathematics (RP 4.1.1)

Non-linear Differential Equations: Iterative, Variational and Perturbation Methods.
Integral Equations : Boundary value problems ; Boltzmann transport equation in EM. Field; Hilbert-Schmidt theory.

Green's Functions: Application to physical problems; Green's function by eigenfunction method; Solution of initial and boundary value problems in electromagnetic.

Probability Theory: Different probability spaces; Distribution functions and their decomposition; Expectation and its properties; Algebraic theory of Markov chains;

Random numbers: Fibonacci sequence of various techniques for the generation of random numbers. Random walk problem; Renewal theory; Two-stage Markov process; Queuing theory; Fokker-planck equation in continuous stochastic processes.

Group Theory: Group, Systematic group, Cuclic group, Sub group, Cosets, and Quotient group, Laggranges theorem.

Difference equation: Difference operators, Recurrence relations, Linear and Non-linear difference equations: Methods of solution. Galois foelds, prime fields and application to coding and information theory.

Optimization methods: Introduction to optimization – methods definition and classification;
Classical optimization techniques – single variable optimization; Multivariable optimization with equality constraints with inequality constraints; Convex programming problem;
Linear programming – simplex method; duality; transportation problem; quadratic programming;
Nonlinear programming – one-dimensional minimization methods; interpolation methods;
Geometric programming methods; Dynamic programming methods;Integer programming methods – Branch- and – Bound;Further topics in optimization;

Computational Methods using MATLAB (RP 4.1.2)

Numerical Methods: Solution of matrix equation by generalised inverse technique; Numerical evaluation of determinant; Computation of eigenvalues and eigenvectors; Matrix inversion by partitioning; Optimisation technique by conjugate gradient method and method of steepest descent.Monte Carlo tech, FEM, Fast-Fourier Transformation (FFT) algorithms; FFT of real functions; Convolution; Correlation and auto-correlation using FFT; Computation of Fourier integrals using FFT; Solution of boundary value problems by relaxation methods; Solution of integral equations by variational methods.

Applied Electromagnetics (RP 4.1.3)

Electrodynamics: Ohm's law, Electromotive force, Faraday's law, Lenz's law; Maxwell's equations; Boundary conditions; Scalar and vector potentials. Poynting vector. (3)

Electromagnetic Waves: Wave equations; Polarization; Boundary conditions: reflection and transmission; EM waves in non conducting media; Reflection and transmission; Snell's law; Brewster angle; EM waves in conductors: Reflection and transmission; Dispersion; Free electrons in conductors and plasmas; Plasma frequency. (5)

Guided Waves: Rectangular metallic waveguides; Coaxial lines; Modes; Dielectric Waveguides: planar and cylindrical. EM wave propagation and modes in step and graded index fibres. Dispersion: chromatic and polarization mode (7)

Wave propagation in Anisotropic Media: Birefringence; Optical activity; Index ellipsoid; Electro-optic effect; applications (4)

Wave propagation in periodic media: Bloch waves; Bragg reflectors; Periodic waveguides; Spectral Filters and Bragg gratings; 2D and 3D periodic media: concept of EM band gap materials and Photonic crystals. 5
Optical Properties of Materials; Refractive index; phase and group velocity, Complex refractive index and light absorption, Kramers-Kronig relation; Resonance absorption; Lattice absorption; Band-to-band absorption; Free carrier absorption; Light scattering : Rayleigh, Mie (5)

EM wave propagation in gain media: Absorption, spontaneous and stimulated emission; Einstein coefficients; Population inversion and gain; Amplification of EM waves (3)

Computational methods: Mode matching Technique, Galerkin's Method, Method of Moment, Finite Element Method, Finite Difference Method.

Advanced Communications (RP 4.1.4)

Wireless communication fundamentals, Various impairments in wireless channel, Radio signal propagation, Modulation Techniques for wireless communication, Equalization &Diversity techniques, Coding Techniques for mobile communication, MIMO system, Wireless Network, IEEE802.11, WLAN, WiMax, Blue tooth, GSM, GPRS, 3G & beyond, Cognitive radio.

Advanced Semiconductor Physics and Devices (RP 4.1.5)

Semiconductor fundamentals: Band theory, E-k diagram, effective mass, density of states, statistics, carrier density, degeneracy, compensation. (4)

Transport: Ohm's law, mobility, Boltzmann equation, Hall mobility, diffusion, scattering mechanisms, hot electrons (3)
Excess carriers: Recombination in direct gap, SRH theory, traps, continuity equation. (3)

P-N Junction theory: Band diagram of semiconductor P-N junction, depletion width, built-in potential, I-V characteristics, varactor diode (3)

MOS Capacitors and MOSFETs: Band diagram under depletion, inversion and accumulation, threshold voltage and its control; C-V curves; I-V characteristics, gradual channel approximation, charge sheet model, Pao-Sah current formulation, subthreshold; current conduction, channel length modulation; hot electrons. (8)

Advanced MOSFETs: CMOS scaling, short channel effects, threshold voltage roll-off, DIBL, GIDL, gate leakage current, hot carrier injection, punch through, silicon-on-insulators (SOI) MOSFETs, low power and high speed design issues. (7)

Heterostructures and Quantum Well Devices: Quantization and low dimensional electron gas, influence on MOSFET characteristics, band alignment in Si/SiGe heterostructures, high electron mobility transistors (HEMTs) , Quantum Well FETs. (3)

<u>Graph Theory and Combinatorics (RP 4.1.6)</u>

GRAPH THEORY:

Introduction to Graph Theory: Definitions and Examples, undirected and directed graphs, complete graph, bipartite graphs, trees. (2)
Connectivity: Trees and forest, biconnectivity, triconnectivity. (2)
Traversability: Eulerian and Hamiltonian, traveling salesman problem. (4)
Colouring: Cliques, independent sets, chromatic partition. (3)
Planarity: Definition, properties, colouring. (2)
Matching: Maxium and minimum matching (1)
Isomorphism (1)

COMBINATORICS:

Mathematical Induction (1)
Elementary combinatorics: Arrangements and selection, rule of sum and product, combinatorial identities. (4)
Generating functions: Modelling problems, arrangements, partition (3)
Stirling numbers: First and second kind. (2)
Recurrence relations: Homogeneous, inhomogeneous. (3)
Inclusions: exclusion principles. (1)
Derangements: Polya’s counting theorem. (1)

<u>Algorithms for VLSI Design (RP 4.1.7)</u>

VLSI Design Cycle: (2)

Design problem and design domains, levels of abstractions like algorithmic and system design, structural and logic design, transistor level design, layout design. Y diagram. Design flow for digital and analog VLSI design

Graph Algorithms and Computational Complexity: (6)
Basic definitions and data structures for representations of graphs, Examples of graph algorithms like depth-first search, breadth-first search, Dijkstra's algorithm, computational complexity, complexity classes, NP completeness and NP hardness,

VLSI design simulations: (3)
Basic concepts and purpose of simulations, Gate-level modeling and simulations, compiler-driven simulation and event-driven simulations, Transistor-level modeling and simulation

High-level Synthesis: (4)
Hardware models for high-level synthesis, data flow graph, simple, conditional and iterative data flow, data flow graph representations, ideas of allocation, assignment and scheduling

Logic level synthesis and verifications: (5)
Introduction to combinational logic synthesis, binary decision diagrams, ROBDD, two-level logic synthesis

Partitioning and Floor planning: (5)
Problem formulations, classification of partitioning algorithms, Kernighan-Lin Algorithm, basic ideas of floor planning problem

Placement and Routing: (5)
Basic concept, problem formulation and algorithms of placement, global routing, maze routing algorithms, line probe algorithm, detailed routing.

Electronic design automation: (4)
Basic ideas and purpose, examples of commercially available EDA tools, computer-aided analog designs

VLSI Circuits and Systems (RP 4.1.8)

Introduction: Overview of CMOS VLSI fabrication, Concept of Mask design, Mask layout, Stick diagram, Standard cell vs Custom design. (2)

Interconnects: Parameters – C, R, L. Electrical wire models – lumped vs. distribute R-C lines; Elmore delay model, Spice wire model, Buffers and their placement; Effect of L – the transmission line model. (5)

CMOS combinatorial logic design (review): Static vs dynamic CMOS, R-C calculation – delay analysis; Logical effort and electrical effort. Driving large fan-outs. Speed and power dissipation; Technology scaling (6)

Elements of sequential circuits: Timing metrics, Effect of clock skew and jitter; Staic and dynamic latches and registers, The Master-slave concept, Effect of clock overlap, Clocked-CMOS (C2MOS), True single-phase clocked register (TSPCR), Sense amplifier based registers; Non-bistable sequential elements – The Schmitt trigger, monostable and astable circuits. (7)

Timing issues in digital circuits: Timing classification – synchronous, mesochronous, plesiochronous and asynchronous interconnects (2)

Synchronous design: Sources of clock skew and jitter, clock generation and distribution techniques – PLL, DLL, Optical distribution. (5)
Asynchronous design: Self timed logic, completion signal generation, self timed signaling, practical examples (6)

Emerging concepts: synchronizers and arbeiters, network on a chip (2)

Processor Organization and Architecture (RP 4.1.9)

Introduction: Computing and Fundamentals of computer design (2)

The role of Performance: Measuring Performance; CPU performance equation; MIPS rate; Amdahl's Law (3)

Processor Organization: Machine and Assembler languages; Instruction Set Architecture (ISA) – principles and examples (4)

Computer Arithmatice: Data representations; Integer and Floating-point arithmatic; basic technique of constructing Arithmatic Logic Unit (ALU) (3)

Datapath Design and Control: Review of logic conventions and introduction to clocking; single and multi-cycle implementation; control and exception handling (7)

Pipelined processing: Basic and intermediate concepts, hazards and design considerations (5)

Memory Hierarchy Design: Memory technology – RAM, ROM; Memory systems; Cache memory design and performance; virtual memory basics (3)

Trends in Computer Architecture: RISC, CISC, Parallel processing – Instruction level parallelism, Parallel architecture (2)

Digital Signal Processing (RP 4.1.10)

Sampling, A/D & D/A converters: Sampling and reconstruction of LP, HP and Band pass signal, analog to digital conversion: analysis of quantization errors, oversampling A/D converters, Digital to analog conversions, first order hold, linear interpolation with delay oversampling D/A converters (3)

Implementation of discrete time systems: Structures of FIR and IIR systems: Direct Cascade, Parallel, Lattice structures State space system analysis and structures: state space description of systems, solution of state space equations, state space analysis in z domain Representation of numbers: fixed and floating point representations, error resulting from rounding and truncation, quantization of filter coefficient, analysis of sensitivity Round off effects in digital filters: limit cycle, scaling, statistical characterization of quantization effect in fixed point realization of digital filters. (7)

Multirate digital signal processing: Decimation, Interpolation, sampling rate conversion, polyphase decompositions, Nyquist filters, two channel QMF banks, perfect reconstruction, L channel QMF bank, Cosine modulated L channel filter banks. (6)

Linear prediction and optimum linear filters: Representation of stationary random process, AR process, MA process, ARMA process, relationship between filter parameters and auto correlation sequence, forward and backward linear prediction, Levinson Durbin algorithm, linear prediction filters, minimum and maximum phase, Wiener filters for filtering and prediction, equiripple linear phase FIR filters (7)

Power spectrum estimation: Computation of energy density spectrum, estimation of the auto-correlation and power spectrum of random signals- Periodogram, non-parametric method for power spectrum estimation: Burtlett method, Blackman and Tukey method, parametric methods for power estimation, relationship between the auto-correlation and model parameters, Yule –Wakler method MA an ARMA model for power estimation. (7)

<u>Embedded Systems (RP 4.1.11)</u>

Overview of Embedded Systems: (1)

Embedded System Architecture: Processor Examples - ARM, PIC, etc.; features of digital signal processor; (8)

SOC: Memory sub-system, bus structure (PC-104, I2C etc.), interfacing protocols (USB, IrDA etc), testing & debugging, power management; (4)

Embedded System Software: Program Optimization, Concurrent Programming, Real-time Scheduling and I/O management; (6)

Networked Embedded Systems: Special networking protocols (CAN, Bluetooth) (3)

Embedded System Design: Representation tools (UML, task graph, etc.), design space exploration, hardware-software co-design, testing and verification, dependability issues. (6)

Applications

<u>Object Oriented Programming and Language Translation (RP 4.1.12)</u>

Object Oriented Systems Design

1. Fundamental concepts of Object Oriented Programming: Introduction to the principles of object-oriented programming (classes, objects, messages, encapsulation, inheritance, polymorphism, exception handling, and object-oriented containers). (4)
2. Object design implementation in a programming language–C++ or Java (8)
3. Object oriented analysis, modeling and design using UML. (4)
   Use cases, Use case driven analysis.
   Structural Modeling: classes, relationships, interfaces, class diagrams, and object diagrams, in UML.

Behavioral / Functional modeling: use case diagrams, sequence diagrams, in UML.
Dynamic Modeling: statecharts
Architectural Modeling

4. Analysis patterns, Design patterns: (4)
    Creational
    Structural
    Behavioral
5. Aspect-Oriented Programming (AOP) – use AspectJ as example language. (2)
    Concepts of Cross Cutting Concerns, Point cut, Join, advice.
    Value of AOP in modelling

Language Translation

1. Introduction: Phases of compilation and overview. (1)
2. Lexical Analysis (scanner), Syntax Analysis (Parser) and Semantic Analysis. (5)
3. Use of generators – lex / flex and yacc / bison. (2)
4. Symbol Table: Its structure, symbol attributes and management. (2)

SEMESTER II

Radar Principles and Applications (RP 4.2.1)

Radar Introduction and Overview:
Introduction to radar; Types of radar; Information available from a radar ; Effects of operating frequency on radar; Applications of radar. (2)

Radar Transmitter:
Types of radar transmitters; Gyrotrons; Modulators; Choice of RF power source; Solid state transmitters. (2)

Radar Receivers:
Radar receiver configurations; Bandwidth considerations; Receiver front end; Digital receivers. (2)

Radar Detection and Tracking:
Automatic detection; Practical detectors; Optimal detectors; Automatic tracking; Range and velocity tracking; False alarm. (2)

Effects of Propagation Factors:
Atmospheric attenuation and refraction of radar waves; Attenuation, back scatter and Doppler effects in rain, clouds and snow; Propagation modeling. (2)

Radar Cross Section (RCS):
RCS of complex targets; Control of RCS; RCS reduction; Body shaping; Radar absorbing materials; Enhancement of RCS by multiple scatterers; RCS prediction techniques; RCS measurement techniques; Radar echo suppression. (3)

Radar Antennas:
Radar reflector antennas; Reflector feed design considerations; Phased Array antennas; Beam formers; Beam steering; Mutual coupling; Phase shifters (3)

Types of Radar:

MTI radar; Adaptive MTI radar; Air-borne MTI radar; Pulse Doppler radar; Synthetic Aperture radar; Space based remote Sensing radar; Meteorological radar; HF over the Horizon radar; Ground Penetrating radar; Through the wall radar; Noise radar; Civil marine radar; Bistatic radar

(8)

Clutter:

Clutter characteristics; Ground echo; Clutter suppression; Clutter at HF and mm-wave frequency; environmental clutter; clutter models. (2)

Radar Measurements:

Radar reflectivity measurement techniques; Monostatic and Bistatic measurements techniques; Radar measurement accuracy. (2)

Radar Signal Processing:

Special techniques for signal processing; Choice of waveforms in different environmental conditions; optimum waveform for detection in clutter; Receiver channel processing; Transmitter channel processing.

Microwave and Wireless Antennas (RP 4.2.2)

Large Reflector and feed: Analysis and radiation characteristics of symmetrical paraboloidal reflector antennas; Different types of dual reflector antennas and their characteristics; Offset-reflector antennas.; corrugated horns and their radiation characteristics, multi mode horns. (3)

Lens Antennas : Basic lens operation; Lens shape design; Waveguide lenses; Bootlace type lenses; Dome antennas. (2)

Printed Antennas : Microstrip Antennas: Basic configuration and advantages; Radiation mechanism; Analysis and CAD; Basic characteristics; Feeding techniques; Broadbanding techniques; Phased arrays; Printed antennas for mobile and portable wireless equipment; Reconfigurable antennas, wearable antenna, antennas for RFID systems. (5)

Dielectric Resonator Antennas (DRA) : Dielectric Resonators, modes, radiation mechanisms, feeding mechanisms, characteristics, design and applications; materials for DRA, integration with active devises, challenges in RFIC designs. (4)

Millimetre wave Antennas : Periodic dielectric antennas, uniform wave guide leaky wave antenna, tapered slot antennas and printed circuit antennas. (2)

Ultrawideband (UWB) Antennas: Monopole antennas, UWB Slot antennas, Loop antennas, Tapered slot antennas, Impulse Radiating antennas, Conical antennas, Frequency independent antennas, basic principles and characteristics, Radiation mechanisms. (5)

Antennas for special applications : Antennas for on-board systems, antennas for medical applications, antennas for radiometry and remote sensing. (4)

Antenna Measurements : Basic principles, antenna radiation measurements using anechoic chamber and compact range techniques, measurements of antenna patterns, gain, and efficiency, measurement circularly polarized antennas. (5)

Microwave Devices, Circuits and Materials (RP 4.2.3)

An overview of microwave devices, circuits and materials with applications. (2)

Device characterization models at microwave frequencies: Small-signal linear model using S-parameters, Large-signal non-linear models. (4)

High power microwave tube: Concept of Cyclotron Maser interaction for microwave signal generation in Gyrotron, Gyromonotron oscillator, Gyro-TWT amplifier. (3)

Modeling of microwave passive circuits: Equivalent circuits of discontinuities and obstacles in waveguides, Discontinuities in microstrip and fin-lines. (4)

Microwave filters: Filter design by insertion loss method, Filter transformation and implementation, coupled-line and coupled cavity filters. (4)

Microwave Oscillators, Amplifiers and Power combiners: Schemes for microwave oscillator, amplifier and power combiner using Gunn and IMPATT devices, design methodology and typical design. Dielectric resonator oscillator. (6)

Non-reciprocal Devices: Ferrite as microwave materials Electromagnetic wave propagation in magnetized ferrite medium, Resonance absorption Isolator, Y-circulator, Ferrite phase shifter. (3)

Metamaterial: Plasmonic and transmission line metamaterial, counter-intuitive properties of metamaterial with applications. (4)

Microwave Propagation (RP 4.2.4)

Maxwell's Equation: Maxwell's field equation in different field configurations and media, Field equation with sinusoidal time variation, Transverse nature of electromagnetic wave, Solution of wave equation in a)Rectangular co-ordinate system, b) Cylindrical co-ordinate system, c) Spherical co-ordinate system, Units in a)Electrostatic system, b)Electromagnetic system, c)Gaussian system, d)Heaviside-Lorentz System, e)Rationalized System
Classification of Radiowaves according to Propagation Mechanism: a)Direct wave b)Ground wave c)Tropospheric wave

Reflection and Interferrence of Radio Waves: plane wave at dielectric interface, Reflection coefficient for flat smooth Earth, Field strength due to reflection from flat Earth, Effect of curvature of the Earth, Mechanism of ground wave propagation,

Refraction and Path Delay: Radius of curvature of ray path, Refractivity is complex and Frequency dependent, Turbulence induced scintillation and Estimation of C_n^2, Propagation over in homogeneous surface, Tropospheric Ducting, Propagation delay and its estimation

Absorption of Microwaves: Absorption by atmospheric constituents, and its intensity calculation, Centrifugal distortion, Absorption Spectra, Water vapour and Microwave attenuation, Absorption calculation at peak and window frequencies, absorption due to rain, procedure for calculating rain attenuation depending on different prescribed models

Attenuation by Hydrometeors other than Rain: Snow, Hail, Fog, Aerosols, Clouds etc.

Microwave Link Design: Design Process flowchart, Fading and Fade margin, Link Multipath Outage Models, Quality and availability Calculations

Electromagnetic Interference and Compatibility (RP 4.2.5)

Introduction To EMI and EMC- Definitions, Different Sources of EMI(Electro-magnetic Interference), Victims of EMI, Inter Source and Intra Source s EMI, Electro-static discharge(ESD),Electro-magnetic pulse(EMP), Lightning, Mechanism of Electromagnetic Noise Coupling, Radiated Emission, Radiated Susceptibility, Conducted Emission, Conducted Susceptibility, Differential & Common Mode Noise Coupling. Concepts of EMC, EMC units.

EMC requirements for electronic systems:- World regulatory bodies- FCC, CISPR etc. Class-A devices, class-B devices, Regulations of the bodies on EMC issues.

EMC mitigation techniques:
Grounding: Fundamental grounding concepts, Floating ground, Single-point, Multi-point and hybrid ground, advantages & disadvantages of different grounding techniques.
Shielding: Basic concepts of shielding, Different types of shielding, Shielding effectiveness(S.E),S.E of a conducting barrier to a normal incident plane wave, multiple reflection within a shield, mechanism of attenuation provided by shield, shielding against magnetic field & Electric field (E & H Field shielding), S.E for Electronic metal & Magnetic metal, Skin-depth, S.E for far-field sources, shield seams, shielding materials.
Noise Coupling, Capacitive coupling between two conductors, inductive coupling, common impedance coupling, ground loop.
Filtering & decoupling.

Antennas - Characteristics of antennas, fields due to short electric dipole & small loop and large loop, near field & Far-field sources & their characteristics. Broadband antenna measurements, antenna factor (transmitting and receiving antenna factors), antenna gain calibration technique.

Detector: Quasi peak, peak and average detectors.
EMI-EMC Measurements - EMC measurement set, Power losses in cable, Measuring & Test systems, Test facilities, Open area test range and anechoic chamber and their relative advantage and disadvantages, Methodology for measurements of radiated emission and radiated susceptibility, Line Impedance Stabilization network (LISN), Methodology for measurements of conducted emission.

Non-ideal behavior of different electronic components – Examples: Personal Computers, Health Hazards-limits, EMC in healthcare environment.
Time-domain & Frequency-domain Analysis of Different Signals - Fourier series & Fourier transform of different signals, identifying the frequency, phase & power spectrum of different signals. Time-domain Reflectrometry (TDR) basics for determining the properties of a transmission line.
Characteristics of Surge, EFT/ Burst, ESD

Space-borne & Terrestrial Remote Sensing (RP 4.2.6)

Remote Sensing: Basics of remote sensing, EM spectrum, Atmospheric window, Type of remote sensing- Active and Passive, Ground based and Space based, Optical and Microwave, Applications, Indian Remote Sensing Satellite Systems.

Remote Sensing Principles: Spatial, spectral, Radiometric and temporal resolution, Satellite sensors, swath, FOV and Error sources, Image analysis- Raster image and Vector image, Elements of image interpretation.

Remote Sensing of Atmosphere and Earth Resources: Spectral response of water as a function of wavelength, Sea surface temperature/ wind speed/ color monitor, Precipitation, Clouds and aerosol, Water vapor, Convective system, Trace gases; Remote of earth resources.

Sensors and Systems : Active systems: SAR, SLAR, Altimeter, Scatterometer, Atmospheric radar, **Passive systems:** Radiometer, Charge coupled devices (CCD) ,**Terrestrial systems**: Weather radar, Clear air radar, Lidar, Radio Acoustic Sounding System, **Satellite systems:** TRMM, AURA-MLS, Megha Tropiques

GPS based remote sensing: Ground based and radio occultation techniques

Digital Receiver (RP 4.2.7)

Basic Concepts of Software defined Radio (SDR) and Cognitive Radio (CR), Advantages of software receiver over a conventional receiver – design and upgrade cycle (5)

Receiver architecture: codeless and semi-codeless, multipath monitoring, beam forming. (3)

Cognitive radio: Cognition cycle and levels of functionality, types of cognitive radio, Software Communication Architecture (SCA), Implementation of cognitive radio, Cognitive Radio Performance Evaluation (12)

Universal Software Radio Peripheral (USRP), USRP A/D and D/A converter, Anti-jamming, Direct Acquisition with Gold Code Jammer, Multi-Aspect Tomography, FLL and PLL Phase measurements, Noise Sensitivity (10)

Radio Astronomy Techniques (RP 4.2.8)

General Astronomy Fundamentals: Solar system, Milky Way Galaxy, Extra-galactic systems and the Universe, Coordinate Systems, Measurement of time, distance and motion, Visual, photographic and radio magnitudes (3)

Radio Astronomy Fundamentals: Introduction, Power, spectral power and brightness, Brightness distribution, Discrete sources, Radiance, Minimum detectable temperature and flux density (5)

Radio Telescope Receivers: General principles, Receiver types, System noise, Total Power Receiver and its Sensitivity related issues, Dicke Receiver, Interferometer Receiver, Correlation Receiver, Noise Temperature and Noise Figure of a linear two-port, Noise temperature of linear two-ports in series connection (7)

Major Radio Astronomy Facilities: GMRT – basic advantages offered by India, scientific objectives, system configuration, signal flow, LOFAR, SKA – key drivers, prime characteristics, configuration (5)

Wave polarization: Polarization Response of an antenna to a radio wave of arbitrary polarization, Ellipse and Poincare sphere, Stokes' parameters (5)

Propagation effects affecting radio astronomy observations: Angular refraction, Faraday Rotation, Scintillations (5)

GNSS (Global Navigation Satellite System) Aids and Applications (RP 4.2.9)

Existing non-space-based navigation aids – Non-directional Beacons, Very High Frequency Omnidirectional Radio, Distance Measuring Equipment, Long Range Radio Navigation (LORAN), OMEGA (4)

Early space-based navigation systems, Introduction and basic principles of operation of GPS, GLONASS and GALILEO, International GPS Service (IGS) (8)

Differential GPS (DGPS), Satellite based augmentation system (SBAS) – principle of operation, Minimum Operational Performance Standard (MOPS) of SBAS, PDOP, VDOP, HDOP, GDOP, GIVE, UIVE, Different operational SBAS – Wide Area Augmented System (WAAS), European Geostationary Navigation Overlay System (EGNOS), MTSAT based SBAS (MSAS), GPS and Geo-Augmented Navigation (GAGAN) (12)

International Civil Aviation Organization (ICAO) standards for application of GNSS, Aviation GPS Signal-In-Space Performance (6)

Space Climatology and Weather (RP 4.2.10)

Introduction: Definition of Space Weather, a historical perspective, advent of Space Weather programs (2)

Sun: The quiet Sun – general features, sunspots, ionizing radiations, solar radio emissions The active Sun – Flares, radio emissions, CME (2)

Interplanetary medium: Solar wind, observed properties of the solar wind, Interplanetary magnetic field and sector structure, coronal hole and fast solar streams, solar wind-planet interaction (2)

Magnetosphere: Formation of the cavity, geomagnetic field near the earth, magnetopause, magnetosheath and shock, polar cusps, magnetotail, charged particle motion in the geomagnetic field, plasmasphere, Van Allen particles, magnetospheric current systems: ring currents (4)

Ionosphere: Description of the ionospheric layers, anomalous features of the F-region, ionospheric irregularities, short-term and long-term behaviour of the ionospheric layers, sporadic-E, ionospheric models (3)

Techniques for observing geospace: Direct sensing of the gaseous medium using Langmuir probe, mass spectrometers, radiation sensors using optical and other electromagnetic receivers, magnetometers, indirect sensing of the neutral atmosphere for measurement of upper atmospheric winds, SOHO, STEREO, ACE, interplanetary spacecraft, observing techniques using spectroscopy (4)

Geomagnetic Storms: Geomagnetic variations, geomagnetic activity indices, geomagnetic storms and the ionosphere (2)

Space Weather Measurement Systems: Ionospheric Sounding Systems, Radar, Transionospheric Propagation Systems, GPS (3)

Space Weather Effects on Telecommunication Systems: outline of ionospheric effects, integrated propagation effects – refraction, phase and group path variation, Doppler shift, Faraday rotation, absorption, differential effects – scintillations, mitigation schemes (2)

Prediction Services and Systems: elements of the prediction process, forecasting services – organizational approaches and commercial forecasting, systems for forecasting – OPSEND, SCINDA (6)

Microelectronics Technology (RP 4.2.11)

Wafer Fabrication: Crystal structure, Defects in crystals, Silicon purification, Czochralski and Float Zone Crystal growth methods, dopant incorporation, wafer preparation

Metrology: Resistivity and Hall effect, Van der Pauw technique, microscopy and defect etches, optical characterization of thin films, ellipsometry, FTIR

Diffusion: Solid solubility, diffusion equation and its solutions, drive-in diffusion, measurement methods – C-V, ECV profilometry, SIMS

Ion Implantation: Equipment for implantation in silicon, Crystal structure and channeling, ion stopping mechanisms, damage production, annealing, different Ion implanter configurations, models and simulation.

Thermal Oxidation: Equipment for Oxidation, dry and wet oxidation, oxidation kinetics, linear parabolic model of thermal oxidation, the Si/SiO2 interface.

Thin film deposition for VLSI: PVD, metallization and sputtering, APCVD, LPCVD, deposition of epitaxial silicon, polysilicon, silicon dioxide and silicon nitride, PECVD, deposition of refractory metals, silicide formation

Photolithography: Light sources, wafer exposure systems, photoresists, alignment, mask design, limits to optical photolithography

Process integration: Clean room concepts, current trends in nanoscale fabrication.

Quantum Theory of Solids (RP 4.2.12)

Introduction: Wave-particle duality; Linear Operators – expectation value, operator algebra, Dirac notation (4)

Wave Mechanics; Basic postulates; Schrodinger equation; Time dependent and time independent; Applications: Infinite and finite rectangular potential wells; Barriers; Tunneling; Harmonic oscillators; Hydrogen atom. Harmonic oscillator: creation and annihilation operators. (5)

Perturbation Theory: Time dependent and time independent; Fermi's golden rule. (4)

Electrons in Periodic Lattice: Bloch theorem; Kronig-Penney model, crystal momentum and effective mass; Free electron and tight binding approximation. Density-of-states (4)

Lattice dynamics: Vibrational modes; Acoustic and optical modes; Quantization of lattice vibrations; Phonons; (4)

Simple Applications of Quantum Theory in Real Solids: de Broglie wavelength in semiconductors; Heterostructures; Quantum Nanostructures; Envelope functions and energy eigen values; Variational calculation of energy levels; Perturbation method for subband energy in electric field; k.p calculation of semiconductor band structures; Tunneling and resonant tunneling.
(5)

Electrical transport in semiconductors: Boltzmann transport equation and its application. Transport through heterostructures (3)

Scattering of Electrons in Semiconductors: Electron-phonon interaction; calculation of matrix elements and relaxation times; Impurity scattering. (4)

<u>Nanoelectronic Devices (RP 4.2.13)</u>

SOI MOSFETs: Source, drain and gate capacitances, fully and partially depleted devices, threshold voltage, body effect, short channel effects, current voltage characteristics, Lim and Fossum model, transconductance, transconductance-to-drain current ratio, channel mobility.
(10)

Other SOI MOSFETs: Multiple gate SOI MOSFETs, double gate SOI MOSFETs, surrounding gate SOI MOSFETs, FinFETs, current drive, short channel effects, threshold voltage, volume inversion, channel mobility. (9)

MOSFETs using high mobility channel materials: High performance MOSFETs using strained Si, Ge and III-V semiconductors, GeOI MOSFETs, high-k gate dielectrics, interface trap charge density, mobility model, device parameters related to analog and digital circuit applications.
(8)

Ballistic Nanotransistors: Introduction, physical insight to nanoscale MOSFETs, Natori' s theory of ballistic MOSFETs, nondegenerate, degenerate and general carrier statistics, I-V characteristics of ballistic MOSFETs, degenerate and nondegenerate Si nanowire FETs.
(7)

<u>Nanostructures and Nano Materials (RP 4.2.14)</u>

Nanostructured Materials: Concept of quantization; length scales; Review of structures and properties of Semiconductor Heterostructures, Quantum Wells, Supperlattices, Quantum Wires and Dots; Effect of strain on properties of semiconductor nanostructures; Review of growth techniques.

Different Materials: Nitride and Carbide semiconductors, Applications, Ceramic materials, Superconducting materials, HTS materials, Josephson junction, SQUIDs, Conducting polymers, Hybrid circuit materials, Fibre optic materials, Electro-optic materials, Microwave materials

Nanoelectronic Materials: High-k dielectrics and silicides for nano-scale CMOS; Group IV alloys for electronic and photonic devices. Nitride based materials and structures for blue-green lasers, solar blind photodetectors. Materials combinations for mid and long infrared and THz communication.
Nanocomposites: CNTs, magnetic materials, magnetic materials

Carbon Based Materials and structures for emerging electronics: Basic structure; chirality; Metallic and Semiconducting Nanotubes; Transport and mobility; CNT FETs; Other applications; Graphene: basic properties, application in electronics and other areas.
Materials for magnetoelectronics and spintronics: Basic concept of electron spin; Spin dependent transport in structures; Spin valves; Giant magnetoresistance; Application in computer storage and memory. Magnetic tunnel junctions and MRAMs; Semiconductor spintronics; Spin FET and other devices; applications; Magnetic semiconductors.

Metamaterials: Electromagnetic metamaterials; Negative refractive index; Classification: negative index, EM band gap, double +ve, chiral; Split-riing resonator; Applications; THZ-, Photonic Band Gap-, Tunable-, Frequency Selective Surface(FSS)-based metamaterials; Absorbers; Superlens; Cloaking devices; Metamaterial antenna.
Molecular Electronics: Materials and structures; transport; Mobility; Electronic and Photonic Device applications.

Smart Materials: Piezo-electric; Piezo-resistive;Piezo-restrictive; Magneto-strictive; Magneto-resistive properties; Shape Memory Alloys; Magnetically Activated Shape Memory Alloys; Active Fiber Composites; Electro and Magneto-Rheological Fluids; Smart Gels and Shape Memory Polymers; Sensors and Actuators; Applications in Electronics and Photonics.

<u>Photonic Devices (RP 4.2.15)</u>

Introduction: Absorption and Emission of light in semiconductors, Heterostructures, Quantum Structures, Materials for working at different wavelengths (2)

LEDs: Review of Principle, basic Structure and performance, Modulation characteristics, Driver circuits, Methods to improve performance, Advanced Structures, SLEDs, White LEDs, Noise, Applications: Display, Communication. (3)

LASERs: Review of Principle, basic Structure and performance of Semiconductor diode lasers, Threshold Current density, Linewidth and Mode Characteristics, Rate Equation, Modulation characteristics, Driver Circuits, Q-switching and mode-locking of laser pulses, Advanced structures and Methods to improve performance, Stripe geometry lasers, , DBR lasers, DFB lasers, VCSELs, Fibre lasers, Noise in lasers, Frequency chirping, Applications (Communications, Entertainments, display, etc.) (5)

Photodetectors: Review of Principle, basic Structure and performance of Photoconductors, p-n photodiodes, p-i-n, Schottky, M.S.M., Phototransistors and avalanche photodiode (APD); Responsivity, gain, Bandwidth, Noise performance: Noise current, Detectivity, NEP, Sensitivity; Advanced Structures and Methods to improve performance; Applications: Communication, Entertainment, Medical, Imaging, etc. (7)

Optical Modulators (External): Acousto-optic, Electro-optic, Magneto-optic modulators, Electro-absorption Modulators, QCSE modulators, Mach-Zehnder Modulator (3)
Optical Amplifiers: Erbium-doped Fiber Amplifier, Semiconductor Optical Amplifier, Raman Amplifiers (2)

Other Optical Devices: Optical isolators, Polarization control devices, Optical filters and diffraction gratings, Optical switches. (2)

Guided Wave Photonics (RP 4.2.16)

Optical Waveguides: Planar waveguides; Fibres; Rays and modes; Dispersion and birefringence in fibres; Guided wave excitation. (4)

Optical Fibers: Propagation characteristics in Optical fibers, Material Choice, Manufacturing Optical fibers, Multimode and Single-mode, Coupling into and out of a fiber, Attenuation, Group velocity, Dispersion, and Optical Non-linearities, Dispersion Shifted Fibers. (7)

Planar Optical Waveguides and Devices Dielectric Optical Waveguides: Modes of 3-layer slab waveguides,; Universal b-v relationship; Effective index; 3-D waveguides (6)

Passive Guided Wave Devices ; Directional couplers; switches; Power splitters; MZI-based couplers; AWG; Fabry-Perot resonators and filters; Tunable filters; Ring resonators; Bragg gratings. Integrated Optics. (7)

Photonic Crystals : Concept and origin of photonic bandgap; Quantitative description of 1-D structures via coupled mode theory. Derivation of Bragg wavelength and bandwidth, Defects in 1-D structures. Photonic band structure diagrams (Bloch modes), Lattice structure (square, triangular…). Applications and key practical issues, super prisms, compact waveguiding, emissive structures. Passive Guiding, routing, etc..; Active: emitters, density of modes; Emerging topics based on sub-wavelength diffractive structures. (6)

Optical Displays, Storage Devices and Sensors (RP 4.2.17)

Luminescence, Display Characteristics: Brightness, Colour hue and saturation, Contrast, Viewing angle, Efficiency, Response time, Memory, Resolution, Durability (5)

Display Devices: Cathode Ray Tube, LED, LCD: Structure, Operation, Colour displays; TFT, Plasma display (8)

Driving Schemes : Active, Passive. (2)

Storage Devices: CD, DVD –Read only, Recordable, Rewriteable (4)

Optical Sensors : Optical Fiber Sensors - Intensity modulation sensors, Acoustic sensors, Magnetic sensors, Gyroscope (5)

Optical Communication and Networking (RP 4.2.18)

Introduction: Concepts of digital communication including base band and broadband digital transmission, bit signal and bit-group methods, Fourier series; Fourier transforms; convolution theorem, Z-transform. (4)

Optical Communications Physics: Quantifying information; Shannon's formula for channel capacity; digital encoding of analogue signals; sampling theorem; Nyquist rate, quantization; multilevel signalling; information theory; redundancy; data compression; error detection and correction; System limitations: bandwidth, attenuation, noise, dispersion. (6)

Components: Optical Transmitter, Optical amplifier, Photoreceiver, Transmission media - free-space, twisted pair and coaxial cable, Optical Fiber (4)

Transmission System: Baseband and modulated transmission, bandwidth filtering, demodulation and signal recovery, multimode and single-mode; attenuation and dispersion; Optical MUX and DEMUX - Operating principle of mulitplexors and demultiplexors, optical telecoms. (5)

Communication networks: LAN, MAN, WAN; multiplexing (TDM, WDM, SDM); packet- and circuit-switched networks; network protocols, SONET/SDH, All optical networks; Access networks; (4)

Noise and Detection: Noise in optical transmitters, amplifiers and detectors, Crosstalk in WDM system: Component, Stimulated Raman Scattering, Four-Wave mixing, etc., Bit error rate, Power Penalty. (5)

Recent Developments: Solitons; Optical Time Division Multiplexing; All optical components; Photonic Band Gap Devices. (2)

<u>Nanophotonics (RP 4.2.19)</u>

Introduction: Semiconductor Nanostructures: Quantum well, Quantum Wire and Quantum dots, Superlattices, Subband Structures, Envelope Functions, Type II Structures (1)

Basic Optical Processes in Quantum Nanostructures: Density of States, Effect of Electric Field, Excitonic Effects, Franz-Keldysh Effect, Quantum Confined Stark Effect (5)

Nano-LEDs: Quantum Well LEDs, Quantum Dot LEDs, Structures, principle of operation and applications; (3)

Nano-Lasers: Quantum Well Lasers, Quantum Wire and Dot Lasers, Quantum Cascade Lasers: Structures, principle of operation and applications; (5)

Nano-photodetectors: Quantum Well, Quantum Wire and Quantum-Dot photodetectors – interband and intersubband: Structures, principle of operation and applications; Emitters and Detectors for Special Area applications (UV and IR photodetectors) (6)

Surface Plasmon on noble metal and semiconductor surfaces, Surface Plasmon waveguides and devices, applications (4)

Molecular Optoelectronics: Materials and structures, Organic LEDs, applications (3)

Analog and Mixed-Signal Circuits (RP 4.2.20)

Introduction to Analog Design: Why analog? Why CMOS? General Concepts of levels of abstraction in VLSI Design. Robust analog design. (1)

Basic MOS Device Physics: MOSFET Structure; Threshold voltage I-V Characteristics of MOS; NMOS, PMOS, CMOS parameters, Short channel effects; Sub threshold MOS Operation; MOS Device Capacitances; Small Signal and Large Signal equivalent circuit; MOS device modeling; MOS SPICE models; SPICE simulation of MOS circuits. (4)

MOS Components and Sub-circuits: MOS Switch; MOS Diode/Active resistors; MOS Capacitors; Switched Capacitor Resistor; Current Sinks and Sources; Current Mirrors; Current and Voltage reference; Bandgap reference; SPICE Simulation examples. (5)

CMOS Amplifiers: Inverters - Characteristics and properties as amplifiers; Differential amplifiers; Cascade Amplifiers; Output Amplifiers; Gilbert cell; Frequency response characteristics; SPICE simulation examples. (4)

Noise Analysis and Modeling: Statistical characteristics of Noise; Types of noise;
Noise analysis in amplifiers; SPICE Simulation. (2)

CMOS Operational Amplifiers: Basic concepts of Op-Amp; Performance Parameters; One state Op-amp; Two stage Op-amp; Stability and Phase compensation; Cascade Op-amp; Design of Two state and Cascade Op-amp; SPICE simulation of Amp; High performance CMOS Op-amps; Micropower Op-amp; Low noise Op-amp; Low voltage Op-amp; Design Examples. (4)

Comparators: Characterization, Two state open loop comparators; Discrete time comparators; high speed comparators circuits; CMOS Sample and hold circuits; Design examples; SPICE simulation. (3)

Switched capacitors circuit: General considerations; Switched capacitor integrators; First and second order switched capacitor filter circuits; Design examples; SPICE Simulation. (4)

Data Converter Fundamentals: Ideal D/A converters, Ideal A/D converter; Serial and Flash D/A converters and A/D converters; Medium and High Speed converters; Over-sampling converters, Performance limitations; Design consideration; SPICE Simulation. (5)

Special Circuits: CMOS Voltage Controlled oscillators; Ring oscillators; Phase locked loops PLLs with charge pump phase comparators, Design examples; SPICE simulation. (4)

Testing and Verification of VLSI Circuits (RP 4.2.21)

Introduction (3)

Purposes of testing, Difference between verification and Testing, Faults Errors and Failures, Test quality metrics, Testing Principle, Importance of Testing in new VLSI design flow

Fault Modeling (5)

Fault models, Fault models at different abstraction levels, stuck-at-fault models, stuck-on and stuck-open fault models, geometric fault models, delay fault models, fault collapsing, fault equivalence and dominance

Logic and fault simulation (4)
Simulation for design verification, true-value simulation, compiled-code simulation, event-driven simulation, fault simulation algorithms and its utility

Combinational ATPG (5)
ATPG principle, ATPG algebra, path sensitization method, D-frontiers and J-frontiers, D-algorithm, PODEM

Sequential Circuit Testing (5)
Basic concepts of sequential ATPG, differences with combinational ATPG, Time frame expansion, 9-valued ATPG algebra

Design for Testability (10)
Controllability and observability, Ad-hoc testing, scan-based testing, boundary scan, level sensitive scan design, BIST architecture and techniques

Verification (4)
Logic level and RTL level

<u>CAD Techniques (TCAD and IC Design) (RP 4.2.22)</u>

TCAD: Simulation of MOSFETs, transfer characteristics i. e., I_d vs. V_{gs} and extraction of threshold voltage, subthreshold slope and drain induced barrier lowering (DIBL), family of $I_d - V_{ds}$ curves for different gate voltages, effect of substrate doping on threshold voltage, body effect extraction, study of short channel effects for scaled MOS devices, determination of device parameters related to analog and digital circuit applications.

IC Design
1. Schematic capture of MOS circuits, Structure Editor
2. Front end design, analysis and performance evaluation using BSIM-SPICE
3. layout design of MOS circuits, Layout Editor
4. design rule check,
5. parasitic extraction,
6. post layout simulation,
7. layout vs. schematic check,
8. corner analysis
9. tape out of GDS II.

<u>Design Entry and Simulation Laboratory (RP 4.2.23)</u>

Writing SPICE circuit files, DC and AC simulation, Transient simulation

Monte Carlo analysis of circuits for variation of model parameters and noise analysis

Getting familiar with design entry tools: Xilinx ISE, Mentor Graphics FPGA Advantage

HDL Based Design: (a) Elements of combinatorial circuit design in VHDL/Verilog,
(b) Sequential circuit design in VHDL/Verilog

HDL Design simulation

Working with schematics
State Machine Design using State CAD

Low Power Design (RP 4.2.24)

Review of CMOS circuits: MOS Transistor structure and device model, The CMOS inverter and other gates. (1)

Sources of power dissipation: Static power – diode leakage, sub-threshold leakage; Dynamic power dissipation – short circuit power, switching power, glitching power; degrees of freedom (4)

Supply voltage scaling approaches: Technology level- feature size scaling, threshold voltage reduction; Logic level – Transistor sizing, Multiple Vt circuits, Logic styles for low power, synthesis of Low Power CMOS circuits; Architecture level – parallelism and pipelining; Algorithms level – Transformations to exploit concurrency (10)

Switched capacitance minimization approaches: System level – Power down, system partitioning; Algorithm level – concurrency, locality, regularity, data representation; Architecture level – concurrency, signal correlation; Logic level – Transistor sizing, logic optimization; Layout level – layout optimization; Technology level – advanced packaging, SOI (10)

Special Topics: Adiabatic switching, Battery driven synthesis (3)

Limits of Power: theoretical limits, practical limits (2)

Design of VLSI CAD Tools (RP 4.2.25)

Overview of digital design methodologies

Tour of VLSI design automation tool requirements - challenges

Computational complexity / Tractable and Intractable problems

Approaches to and Algorithms in

- Layout compaction
- Placement and partitioning
- Floor planning
- Routing
- Simulation of VLSI circuits
- Timing Analysis
- Logic synthesis
- Design Rule Checking
- Verification

ASIC Design Flow – case study from a design house

Walk through of some industry leading tools

Analytical Methods
- o LU decomposition/Iterative methods for solving NDEs
- o Power supply/ground plane analysis
- o Thermal analysis/ self-heating

Micro-Electro-Mechanical Systems

ASIC/Memory Design (RP 4.2.26)

A. **ASIC Design:**

VLSI Design Styles: Full Custom, Standard Cell, FPGA. (1)

ASIC Library Design: Transistors as resistors and parasitic capacitance, Logical Effort, Standard Cell and Datapath cell design, Pass transistor logic. (5)

Introduction to Hardware Description Language: Verilog, VHDL (4)

Physical Design Automation algorithms: Placement, routing, compaction, design rule check, power and delay estimation, clock and power routing (6)

B. **Memory Design:**

Semiconductor Memory Design: Memory organization, Types of memory – , Timing parameter, memory decoders (2)

Static RAM: Cell design – Read/Write operation, SRAM Cell layout, Column I/O circuitry, FPGA. (4)

Dynamic RAM: Three transistor cell, One transitor cell, External characteristics of dynamic RAM. (4)

Read Only Memories: MOS ROM Cell arrays, EPROM, EEPROM, Flash memory, FRAMs. (5)

Conditional Access Memory: CACHE, Memory Management (4)

RF and Microwave Integrated Circuit Design (RP 4.2.27)

RF Analog Circuits: Capacitance and Inductance in VLSI circuits, bandwidth estimation technology, design of high frequency amplifiers, design of low noise amplifiers, design of mixers and R.F. amplifiers, architecture of R.F. transmitters and receivers. (6)

Special Circuits: Voltage controlled oscillators, ring oscillators, phase locked loops. (3)

Monolithic Microwave Integrated Circuits: Introduction, advantages and tradeoffs, applications- satellite communications, wireless LANs, microwave links, cellular networks, choosing among device technologies: GaAs FET, GaAs HBT, etc. (6)

Network basics-different network parameters. (3)

Processing and layers. (3)

Passive MMIC elements and models, active MMIC elements and models. (8)

Biasing, microwave amplifiers, gain definitions - Gmax, MSG, Unilateral gain, conjugate matching. Stability analysis - odd mode, even mode analysis. (4)

Packaging and testing. (3)

SEMESTER III

Compulsory Thesis Work (RP 5.1.1)

Seminar (RP 5.1.2)

General Viva Voce (RP 5.1.3)

Measurements on Microwave Circuits, Links and Radiating Systems (RP 5.1.4)

Characterization of free running and phase locked Gunn/IMPATT oscillator; Characterization of satellite downlink signal at Ku-band; Measurements of radiation characteristics of linearly and circularly polarized printed antennas.

Measurements on Remote sensing, Communication and GPS based Instrumentation (RP 5.1.5)

Satellite Signal Calibration and Measurements; Doppler Radar Measurements Techniques; AWS Measurement Techniques; Radiometric Measurement Techniques;
Characterization of Wideband Communication Receiver using Satellite Signal; Measurements of position accuracy using GPS

Measurements and simulations of Photonic Devices and Systems (RP 5.1.6)

Experiments using Laser module and APDs in OTDR; Simulation of Photonics Devices and Systems using Commercial Softwares.

Optical Characterization of photonic devices (RP 5.1.7)

LEDs and Laser, emission spectra, beam profile, L-I characteristics, Optical Measurement Techniques: Photoluminescence, Optical transmission, reflectivity, polarization dependent measurements, Fabrication and characterization of Photodetectors.

Microelectronics Processing (RP 5.1.8)

Silicon oxidation and measurement of oxide thickness Dopant Diffusion and Resistivity / Hall effect measurement; Metallization by e-beam deposition and measurement of contact resistance; Mask design and photolithography: Fabrication of simple electronic/optoelectronic devices.

Micro Electro Mechanical Systems (RP 5.1.9)

MEMS Simulation: Design and simulation of MEMS devices using standard simulation software: Cantilevers, Micro-positioners, RF MEMS MEMS Fabrication: Photolithography (Mask design, topside and backside alignment), wet chemical crystallographic etching, dry etching, metallization, bonding MEMS testing.

FPGA Lab (RP 5.1.10)

Design implementation: Creating the User Constraint files; Programming PLD's: FPGA/CPLD – Simple combinational logic; Modifying designs at HDL level;
Studying report files; Using IP-cores: Embedded System Design; Probing inside the chip: Using the embedded logic analyzer – Chipscope Pro;Using DSP System Generator

SEMESTER IV

Compulsory Thesis Work(Final) (RP 5.2.1)