# PLA D'ESTUDIS DEL MÀSTER DE CIÈNCIES DE LA INFORMACIÓ I TECNOLOGIES DE LA COMUNICACIÓ (MASTER OF SCIENCE INFORMATION AND COMMUNICATION TECHNOLOGIES)

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# Master of Science in Information and Communication Technologies

**Escola Tècnica Superior d'Enginyeria de Telecomunicació de Barcelona**

Universitat Politècnica de Catalunya

Barcelona, 17 de juny del 2004

MÈMORIA JUSTIFICATIVA ACADÈMICA I ECONÒMICA

# 1 Denominació del títol propi

Dins del marc del pla estratègic de l'Escola Tècnica Superior d'Enginyeria de Telecomunicació de Barcelona (ETSETB) que pertany a la Universitat Politècnica de Catalunya (UPC), es vol posar en marxa una experiència pilot per impartir un Màster internacional pel proper curs 2004 / 2005. La denominació del Màster és la següent :

## *Master of Science in Information and Communication Technologies*

L'elecció d'aquest nom ha estat decidida en base als estudis que imparteix aquest centre, a la projecció internacional del títol i als noms que donen altres institucions estrangeres a aquest tipus d'estudis. Amb aquest nom s'ha presentat l'aplicació per a les "Actions 1 & 2" de la convocatòria Erasmus Mundus per al curs 2004-05, d'acord amb les universitats consorciades per aquest Master. No obstant, hi ha oberta una reflexió interna sobre la possibilitat d'incorporar algun element distintiu en la denominació del Màster.

# 2 Necessitats socials, científiques i professionals a les quals la nova titulació atén i els objectius que es pretenen assolir; perfils dels titulats com a resultat del procés de formació: coneixements, habilitats i destreces.

## 2.1 Objectius que es preten assolir

L'ETSETB vol ofertar un Màster Internacional en Enginyeria de Telecomunicació per formar professionals altament qualificats en el desenvolupament i aplicacions de les tecnologies de la informació i les comunicacions.

El programa d'estudis està dissenyat per aprofundir amb rigor en els coneixements i les habilitats que es requereixen per especialitzar-se en diversos camps de les Telecomunicacions. Les especialitats s'estableixen segons la demanda del mercat laboral. Així es tracta d'un model sòlid però dinàmic alhora.

Aquest Màster vol donar l'oportunitat a estudiants amb diferents objectius professionals a assolir un nivell avançat en les Telecomunicacions amb el valor afegit de fer-ho des d'una perspectiva internacional.

El quadre següent conté el conjunt de competències específiques i transversals que defineixen el perfil acadèmic i professional de la titulació:

## Perfil acadèmic i professional de la titulació proposada.

| | | |
|---|---|---|
| Continguts específics de la titulació | Coneixements | Base matemàtica de les TIC: matemàtica discreta, senyals deterministes i aleatoris, sistemes lineals.<br>Base física de les TIC: electromagnetisme, anàlisi de circuits, components i dispositius electrònics i fotònics.<br>Base tecnològica de les TIC: teoria de les comunicacions, computació i algorítmica, programació, tecnologies de hardware i de radiofreqüència. |
| | Professionals | Capacitat per identificar, formular i resoldre problemes en l'àmbit de les TIC.<br>Capacitat d'utilitzar les tècniques, les habilitats i les eines de l'enginyeria moderna per a una bona pràctica en l'àmbit de les TIC.<br>Capacitat per dissenyar un sistema, component o procès que compleixi unes especificacions des de diferents punts de vista com econòmic, social, polític, ètic, de salud, ambiental i de sostenibilitat.<br>Capacitat per realitzar i dirigir projectes.<br>Comprensió de l'enginyeria com una activitat econòmica i empresarial.<br>Competència en l'àmbit de la gestió i l'organització de les TIC. |
| | Acadèmics | Capacitat d'aplicar coneixements de matemàtiques, de ciències i d'enginyeria.<br>Capacitat de dissenyar i realitzar experiments, així com d'analitzar i interpretar els resultats.<br>Capacitat per investigar i desenvolupar nous productes i serveis en l'àmbit de les TIC. |
| Competències transversals | Intel·lectuals | Raonament crític: capacitat per analitzar i valorar diferents alternatives.<br>Solució de problemes: capacitat per trobar les solucions òptimes a problemes i projectes complexos.<br>Creativitat i innovació: capacitat per crear i innovar productes i serveis.<br>Habilitat d'adaptació a la ràpida evolució de les tecnologies i els mercats de les TIC. |
| | Comunicació | Escrita: habilitat en la redacció de projectes i documentació tècnica.<br>Oral: claredat i fluïdesa en la presentació de resultats, productes o serveis, tant en audiències especialitzades com no especialitzades.<br>Coneixement del software i les eines informàtiques d'ajuda per a la generació de la documentació i la seva presentació.<br>Idiomes. |
| | Interpersonals | Capacitat per treballar en equips multidisciplinars.<br>Capacitat de lideratge. |
| | Gestió personal | Aprenentatge al llarg de la vida: habilitat per seguir estudiant de forma autònoma i per a la formació continuada.<br>Capacitat per a la gestió de recursos i projectes. |
| | Valors | Ètica professional.<br>Capacitat d'anàlisi de la dimensió social de la seva activitat. |

## 2.2 Necessitats socials, científiques i professionals

És un fet indiscutible que la globalització és un fenomen que afecta a la nostra societat en tots els àmbits. Cada cop són més les empreses que requereixen no tan sols professionals que parlin una llengua estrangera, sinó que també volen persones capaces de treballar i adaptar-se a entorns multiétnics i multiculturals.

D'altra banda destaquem el desenvolupament científic i tecnològic que han assolit països com Estats Units. La clau d'aquest èxit ha estat en gran part degut a la gran capacitat d'atreure als millors estudiants d'arreu del món.

Aquests factors no han passat desapercebuts a Europa, i moltes Universitats han adaptat els seus estudis per atreure també als millors estudiants de tercers països. La Unió Europea també n'és conscient des de fa temps. El conegut procés de Bolonya ha fixat com objectius establir un Espai Europeu d'Educació Superior abans de l'any 2010. L'objectiu és arribar a desenvolupar un sistema de titulacions comparable pels estudis de grau i postgrau. Així, s'eliminaran barreres a l'hora d'interpretar i entendre la diversitat de titulacions i sistemes de crèdits existents en cadascun dels països europeus. Com a conseqüència, millorarà la mobilitat dintre d'Europa i augmentarà la capacitat d'atreure estudiants d'arreu del món. Més recentment s'ha creat el programa Erasmus Mundus centrat principalment en crear programes de Màsters entre Universitats Europees que inclou un sistema de beques molt atractiu per a estudiants de tercers països.

Dins d'aquest context, l'ETSETB va decidir impulsar la internacionalització dels estudis que oferta a través de la posta en marxa d'un programa de Màster en llengua anglesa.

Concretament les motivacions que han mogut a l'ETSETB a posar en marxar aquest pla pilot són les següents :

- Fer un primer pas a l'adaptació de Bolonya malgrat que el marc legal a Espanya encara no està vigent. Actualment hi ha més flexibilitat per dur a terme una experiència pilot de Màster que no pas de grau. L'escola està preparada i vol ser capdavantera en aquest procés.

- Oferir uns estudis de Màster en anglès que ja s'imparteixen amb èxit a d'altres Universitats de països europeus, per exemple a la TU Delft, Telecom Paris, Stuttgart University, TU Denmark, KTH d'Estocolm entre d'altres. En aquest aspecte l'ETSETB i la UPC serien capdavanteres a Espanya en l'oferta d'aquest tipus de Màster.

- Facilitar l'acollida d'estudiants d'altres nacionalitats (de llengües no llatines) ja que el Màster s'impartirà en llengua anglesa i atreurà així estudiants de molt bon nivell que sovint escullen països anglosaxons per fer estudis de Màster. Aquest aspecte no solament enriqueix el procés d'aprenentatge a les aules sinó que, en molts casos aquests estudiants, segueixen estudis de

doctorat, impulsant el nivell de recerca en el nostre país, o retornen als seus països d'origen havent establert vincles amb investigadors i professionals d'aquí, enriquint així el teixit industrial i tecnològic i els vincles culturals entre països.

- Donar continuïtat a les dobles titulacions i garantir la continuïtat de la mobilitat d'estudiants, que actualment a l'ETSETB supera el 30%. Molts països ja han adaptat els seus plans d'estudis a les directrius de Bolonya. El Màster internacional ens equipara a d'altres Universitats europees i permetrà que els intercanvis d'estudiants siguin recíprocs.

- Donar l'oportunitat als nostres estudiants de rebre una formació tècnica en anglès i obtenir un títol de Màster que els hi obri noves perspectives professionals no tan sols a Espanya, sinó també arreu del mon. Els estudiants que el cursin podrien obtenir la doble titulació d'Enginyeria de Telecomunicació i el Màster proposat amb un increment d'esforç aproximat d'un semestre.

- Participar en el programa Erasmus Mundus amb d'altres Universitats Europees per crear un programa de Màster conjunt i poder atreure els millors estudiants estrangers a través de les beques ofertes dins d'aquest programa. Els nostres estudiants també es beneficiaran de la xarxa i els vincles creats amb les Universitats associades podent obtenir dobles diplomes de Màster o títols conjunts si això és possible en un futur. El pla de mobilitat dels estudiants figura a **l'Annex 6** d'aquest document.

# 3 Destinataris del títol

Els perfils dels estudiants que s'han identificat com a potencials interessats són els següents :

- Estudiants estrangers amb estudis universitaris afins de 4 o més anys.

- Estudiants estrangers que venen a l'ETSETB a través d'un conveni bilateral de doble titulació i que han completat 4 anys d'estudis.

- Estudiants de l'ETSETB que tinguin tots els crèdits obligatoris aprovats, és a dir que han acabat el quart curs d'enginyeria de Telecomunicació i només els hi manca l'optativitat i el projecte fi de carrera.

- Estudiants espanyols amb una titulació universitària afí i amb una forta base matemàtica.

# 4 Model de direcció i de gestió dels estudis

## 4.1 Direcció dels estudis

Un/a sots-director/a de l'ETSETB nomenat per la direcció del Centre i prèvia autorització de la comissió permanent realitzarà les funcions de coordinació del Màster. Fins el nomenament del sots-director/a del Master, la sots-directora de Relacions Internacionals, Elisa Sayrol Clols, realitzarà les funcions de coordinadora del Màster.

La Coordinadora és responsable del seguiment més immediat del desenvolupament dels estudis. Les funcions de la Coordinadora seran totes aquelles que la comissió docent li delegui. Entre aquestes tasques s'inclou:

- Proposar totes aquelles mesures que estimi oportunes per garantir el correcte desenvolupament del pla d'estudis.

- Assignar tutor a cadascun dels estudiants i supervisar el bon funcionament de la tutoria.

- Fer difusió internacional del Màster. Establir contactes amb les institucions oportunes per establir mecanismes de difusió sòlids en el temps. Coordinar el manteniment de la pàgina web del Màster i del material de difusió.

- Establir contactes amb altres centres/universitats estrangeres associades juntament amb la sostdirecció de relacions internacionals de l'ETSETB.

- Establir contactes juntament amb la sostdirecció de relacions amb empreses col·laboradores per a l'obtenció de beques d'estudis, períodes de pràctiques pels estudiants, etc.

- Organitzar conferències amb renom en les àrees d'especialitat del Màster.

- Planificar els períodes de sol·licitud d'admissió al Màster.

- Organitzar el procés de selecció dels candidats

La coordinadora del Màster és responsable de totes les seves actuacions davant dels òrgans de govern de l'Escola.

## 4.2 Gestió dels estudis

Per dur a terme la gestió d'aquests estudis és necessària la incorporació del/de la responsable de relacions externes previst en l'estructuració dels serveis administratius del centre i que en aquests moments resta vacant. Un cop coberta aquesta plaça, l'equip d'administració del centre assumirà l'administració i gestió del Màster amb les funcions i tasques que li siguin assignades. El sistema d'informació i de gestió estarà integrat a PRISMA.

# 5 Càrrega lectiva i organització docent : durada en crèdits ECTS i calendari

La duració del Màster és de 120 crèdits ECTS, dels quals en una primera fase s'implementen 90 crèdits ECTS, ja que s'ha dissenyat un bloc de 30 crèdits ECTS (de cursos pont o bridge) d'adaptació per a iniciar els cursos d'assignatures nucli; en la primera fase d'implantació del programa només s'acceptaran estudiants que tinguin els coneixements del cursos Bridge. Aquesta mesura permet compatibilitat amb els actuals títols homologats d'Enginyeria de Telecomunicació. La proposta de Màster internacional de l'ETSETB que inclou el pla d'estudis i la definició de continguts elaborada pel professorat va ser aprovada per Junta d'Escola el 14 d'abril de 2004.

El calendari que s'ha establert és el següent:

El semestre de tardor del primer any consisteix en el semestre nucli, format per assignatures obligatòries del Màster.

El semestre de primavera del primer any consisteix en el semestre d'especialització, format per assignatures optatives que s'ofereixen també com a assignatures optatives de la titulació d'Enginyeria de Telecomunicació i d'Enginyeria en Electrònica.

El semestre de tardor del segon any consisteix en el semestre dedicat a la tesi de Màster, que haurà de finalitzar amb una presentació pública i l'avaluació per un tribunal seguint el mateix procediment que les avaluacions del projectes fi de carrera a l'ETSETB.

Als estudiants se'ls hi assignarà un tutor que els guiarà a l'hora d'escollir les assignatures de l'especialització i la temàtica de la tesi.

Totes les assignatures són semestrals i s'agrupen en dos períodes a l'any de 15 setmanes cadascun. El calendari acadèmic coincideix exactament amb el calendari de les titulacions que ofereix l'ETSETB.

## 5.1 Càrrega lectiva

La càrrega lectiva és de 30 crèdits ECTS per semestre.

## 5.2 Grups de classe

Les assignatures del semestre nucli s'estructuren en un sol mòdul de 30 estudiants per a la teoria i en grups de 15 estudiants per a les classes de laboratori.

Les assignatures del semestre d'especialització es comparteixen amb d'altres estudiants de l'ETSETB i els mòduls s'estructuren en grups de 60 estudiants per a la teoria i en grups de 15 estudiants per a les classes de laboratori.

## 5.3 Oferta d'assignatures

Les assignatures del semestre nucli s'oferiran amb una periodicitat anual. L'oferta d'assignatures optatives del semestre d'especialitat tindrà una periodicitat anual. Aquesta oferta serà determinada per l'ETSETB dintre de la seva planificació acadèmica anual, d'acord amb els departaments implicats i els recursos disponibles.

## 5.4 Avaluació dels estudiants

L'avaluació de l'activitat de l'estudiant realitzada a través de les assignatures a la UPC és contínua, ha de fomentar entre els estudiants la participació i l'aprenentatge continuat i ha de tenir en compte les qualificacions obtingudes en els diferents actes d'avaluació distribuïts al llarg del curs, que valoren les diferents activitats programades (conceptes adquirits a les classes teòriques, realització de pràctiques, presentació de treballs, participació, etc.). Els mètodes d'avaluació de les assignatures estan definits de manera que cap acte d'avaluació, per si sol, pugui determinar de manera exclusiva la qualificació final.

Els continguts, objectius i els mètodes d'avaluació de les matèries del nucli i d'especialització es descriu en les fitxes de **l'Annex 1**.

## 5.5 Normativa de permanència

L'entrada dels estudiants en aquest Màster serà molt selectiva de manera que s'espera que el rendiment dels estudiants sigui molt alt. No obstant, tenint en compte la periodicitat anual de les assignatures, es proposa un model d'un examen extraordinari pels estudiants que no superin una determinada assignatura del semestre nucli. Si després d'aquesta oportunitat extraordinària l'estudiant no supera l'assignatura es proposarà la suspensió de la matrícula en els estudis de Màster.

La duració màxima per finalitzar el Màster serà de dos anys.

# 6 Pla d'estudis, metodologia docent i d'aprenentatge

## 6.1 Pla d'estudis

L'estructura del pla d'estudis s'ha introduït en l'apartat anterior. En aquest apartat especificarem els dos semestres d'assignatures en detall.

### 6.1.1 Semestre nucli

En base a les característiques anteriors i tenint en compte les especialitzacions en l'àmbit de les telecomunicacions, el primer semestre es defineix segons la següent taula :

| ECTS | Programa | Dept | Professorat |
|---|---|---|---|
| | | | |
| | **Programa del Nucli - Primer Semestre** | | |
| 5 | Communication Theory | TSC | Gregori Vázquez/Javier Rodríguez Fonollosa |
| 5 | Propagation and Radiowaves | TSC | Angel Cardama/Lluís Jofre |
| 5 | Communications Systems, Networks and Services | ET | Luis de La Cruz/Emilio SanVicente |
| 5 | Advanced Programming and Distributed Applications | AC | Nacho Navarro/Leandro Navarro |
| 5 | Digital System Design | EE | Joan Pons/ Juan Chavez |
| 2.5 | Spanish Language and Culture/Lectures on Science, Technology and Society (for spanish students) | ANG | Montserrat Ginés |
| 2.5 | Management and Innovation in Telecommunications Companies | OE | Lluís Cuatracasas |

### 6.1.2 Semestre de cursos d'especialització

Les especialitats s'han elaborat seleccionant assignatures representatives de l'oferta actual d'assignatures optatives de segon cicle dins els plans d'estudis d'enginyeria de Telecomunicació i Enginyeria en Electrònica. També s'ha tingut en compte l'estudi de Màsters a Universitats estrangeres dut a terme per l'Escola (veure **Annex 7**), la coherència dins del programa, la disponibilitat dels professors per a impartir assignatures en anglès i l'atracció que poden tenir les assignatures per a estudiants externs. En el pla pilot s'introdueixen tres especialitats, cada una d'elles amb 5 o 6 assignatures optatives de 5 crèdits ECTS cadascuna:

- Communication Networks
- Communications and Signal Processing
- Electronic Systems

i sense descartar possibles assignatures d'altres àrees.

Cada estudiant tindrà un tutor que li farà les recomanacions oportunes.

Un estudiant haurà de cursar com a mínim 4 assignatures d'una especialitat i les altres 2 podran ser de la mateixa, d'una altra especialitat, de la resta d'oferta d'optatives de l'ETSETB i d'altres assignatures ofertades pels departaments, que el tutor consideri adequades i amb el vist-i-plau de l'ETSETB i el departament implicat. En particular les assignatures que es proposen en el pla pilot es resumeixen en la taula següent

| ECTS | Programa | Dept | Professorat |
|---|---|---|---|
| | | | |
| | **Programa Especialització - Segon Semestre** | | |
| | | | |
| | Communication Networks | | |
| 5 | Network Intelligence | ET | Josep Paradells/José Luis Muñoz |
| 5 | E-commerce | ET | Jordi Forné/Miquel Soriano |
| 5 | Cellular access networks | ET | Francisco Barceló/Juan Luís Gorricho |
| 5 | Broadband networks and services | ET | Xavier Hesselbach Serra/Mònica Aguilar |
| 5 | Protocols in telecommunications networks | ET | Anna Calveras/Jordi Casademont |
| | | | |
| | Communications and Signal Processing | | |
| 5 | RF and microwave circuits in Communications | TSC | Albert Aguasca/Lluís Pradell |
| 5 | Image and Video Communications | TSC | LluísTorres |
| 5 | Speech processing | TSC | Asunción Moreno/Antonio Bonafonte/José A. Rodríguez Fonollosa |
| 5 | Radionavigation systems | TSC | Jordi Mallorquí |
| 5 | Optical fibre telecommunications | TSC/AC | Gabriel Junyent/Josep Solé-Pareta |
| 5 | Multimedia Mobile Communications | TSC | FerranCasadevall |
| | Electronic Systems | | |
| 5 | Digital systems | EE | Francesc Masana /J. Manuel Moreno |
| 5 | VLSI digital design | EE | Jordi Madrenas/J. Manuel Moreno |
| 5 | Sensors and Signal Conditioning | EE | Ramon Bragós |
| 5 | Energy Management for Information and Communication Systems | EE | Eduard Alarcon |
| 5 | RF communication Systems-on-Chip | EE | José Luis Gonzalez/Xavier Aragonés |
| 5 | MEMS technology and devices | EE | Luís Castañer, /Angel Rodriguez-Martínez |

En **l'Annex 1** es detallen els continguts de cadascuna de les assignatures del semestre nucli i semestre d'especialitzacions.

## 6.2 Futur del Màster

Aquest pla pilot es portarà a terme durant dos anys i mig. La duració del Màster en règim permanent podria ampliar-se a 4 semestres, 3 de cursos i 1 de projecte de Màster. La implantació del Màster en règim permanent dependrà de la implantació del nou marc de Bolonya a les Universitats espanyoles i a hores

d'ara i pel curs 2004 / 2005 no es sap amb certesa com serà aquesta implantació.

El disseny del pla pilot s'ha enfocat des d'una perspectiva "Top-Down", és a dir, partint de les possibles especialitzacions s'han dissenyat els cursos del semestre nucli. Si en el futur el Màster constés de 4 semestres, s'hi afegiria un primer semestre addicional de cursos pont o d'adaptació (Bridge). Així, a partir del nucli es dissenyaria aquest semestre de cursos pont.

## 6.3 Indicadors de Resultats

Per quantificar de forma objectiva el grau d'assoliment dels objectius del Màster, es fa imprescindible definir uns indicadors de resultats. Aquests indicadors hauran de contemplar el següent:

- Avaluació de l'aprenentatge. S'obtindrà a partir dels resultats de l'avaluació dels estudiants, de la demanda dels titulats i les opinions que en tinguin les empreses i organitzacions on treballin.

- Avaluació de la docència i de l'organització. S'aplicaran les enquestes als estudiants que realitza periòdicament la UPC. Tenint en compte que hi ha quadrimestres que no es realitzen, atesa la condició d'experiència pilot i nivell d'excel·lència del Màster, caldrà garantir les enquestes per a cada semestre. A més, caldrà estudiar l'adaptació d'algunes de les preguntes de l'enquesta general, tal com ja s'està fent en el cas dels estudis semipresencials que imparteix actualment l'ETSETB. En particular és important demanar als estudiants la seva opinió respecte de l'organització de l'orientació tutoritzada, de la coordinació entre assignatures, etc.

- Inserció laboral i grau de satisfacció dels titulats. Cal destinar recursos per fer un seguiment dels estudiants que es graduïn per obtenir dades sobre la seva inserció al mercat laboral, la seva valoració social, els perfils professionals de la demanda, etc.

## 6.4 Metodologia docent i d'aprenentatge

El procés de Bolonya contempla un canvi de paradigma en l'educació i una sèrie de mesures per garantir la qualitat docent. Les més destacades són l'establiment de crèdits ECTS com a unitat acadèmica, l'acreditació de les titulacions i dels graduats per part d'agències nacionals o europees.

Tal com s'ha esmentat en aquest document, un objectiu fonamental del Màster és posar en marxa una experiència d'adaptació a l'Espai Europeu d'Educació Superior, l'anomenat procés de Bolonya. Aquest procés, a més d'impulsar una convergència administrativa tot facilitant la mobilitat dels estudiants, ofereix una oportunitat única de reformar les actuals metodologies docents i d'aprenentatge. És per això que en els darrers anys s'ha generat un ampli debat a les comunitats educatives europees i han aparegut moltes reflexions i propostes ambicioses en la direcció de millorar la qualitat de l'ensenyament. Només així Europa podrà competir per assolir el lideratge mundial en l'àrea de

l'educació, que cada vegada més pren una importància estratègica fonamental a la societat de coneixement.

El fet d'emprar crèdits ECTS, que quantifiquen la dedicació a l'aprenentatge de l'estudiant mitjà, i no al nombre d'hores de docència impartides pel professor, implica un *procés educatiu centrat en l'estudiant*. En aquest sentit el Màster permetrà desenvolupar aquest canvi de paradigma.

L'informe de juliol de 2002 del *Engineering Synergy Group* del Projecte Tuning reflexiona sobre la metodologia de l'ensenyament i especifica una sèrie d'habilitats i competències desitjables per als estudiants d'enginyeria. Més particular a l'àmbit de les tecnologies de la informació i les comunicacions, la iniciativa d'un grup d'empreses significatives en el sector, anomenat *Career Space*, també especifica aquests requeriments.

A més dels objectius científics i tècnics particulars de cada assignatura, es pretén de forma global que l'estudiant assoleixi una sèrie de capacitats i habilitats, complementàries als coneixements tècnics, però imprescindibles per a la seva carrera professional. Els objectius globals de l'aprenentatge estan definits al quadre de l'apartat 2 d'aquest document. La programació docent de les matèries està definida en aquest marc global de competències específiques i transversals que ha d'adquirir l'estudiant a través del programa Màster.

La pròpia definició d'aquest Màster potenciarà els aspectes de comunicació intercultural i la comunicació en anglès. La vocació històrica de l'ETSETB per oferir un grau elevat d'experimentalitat facilita el desenvolupament de les habilitats pràctiques. La proposta de treballs en equip, projectes, la realització de convenis de cooperació educativa amb empreses i de la tesi de Màster contribueixen a potenciar les capacitats i habilitats definides.

La metodologia docent de cadascuna de les assignatures està especificada en **l'Annex 2** d'aquest document.

La figura del professor tutor també juga un paper rellevant des del punt de vista d'orientació de l'estudiant per aconsellar-li l'itinerari més adient ateses les seves aptituds i interessos acadèmics i professionals.

### 6.5 Recursos materials de l'aprenentatge

El fet de disposar d'una aula del Màster, equipada amb recursos informàtics, multimèdia i connexió a xarxa és un valor afegit important que permetrà innovar en la docència. A més, els laboratoris docents de l'ETSETB, juntament amb els laboratoris de recerca (per a la realització de la Tesi de Màster) contribuiran a la formació experimental de l'estudiant i al seu desenvolupament i aprenentatge autònom.

## 7 Proposta inicial de nombre i característiques del professorat que participarà en la docència

La implantació del Màster suposa un increment d'encàrrec docent de 45 crèdits ECTS, corresponents a 30 crèdits ECTS per assignatures de nova creació dins el semestre nucli i a 15 crèdits ECTS de l'especialitat d'electrònica, que s'oferiran tant en anglès com en català, donat que s'han escollit 3 assignatures que són obligatòries dins el pla d'estudis de segon cicle d'Enginyeria en Electrònica. Les assignatures del semestre d'especialització són part de l'encàrrec i l'oferta d'optatives que ofereix l'ETSETB als estudiants de segon cicle.

Qualsevol professor assignat actualment a l'ETSETB pot participar en la docència del Màster de l'ETSETB. El professorat que participarà en la posta en marxa del pla pilot durant el curs 2004 / 2005 està inclòs en les taules anteriors.

Degut a la impossibilitat d'augmentar la plantilla de professorat, l'ETSETB ha optat per permetre l'organització de les assignatures del semestre nucli de 5 crèdits ECTS entre 2 professors, no permetent superar aquest nombre, per mantenir una homogeneïtat al llarg del curs.

D'altra banda les assignatures optatives s'organitzen de forma semblant a les assignatures optatives de les titulacions de segon cicle, en que en alguns casos és un professor i en d'altres són dos o més professors els qui imparteixen l'assignatura.

En la proposta inicial s'ha comptabilitzat un total de 39 professors en el semestre nucli i d'especialització. Les característiques del professorat són les següents .

| Department | CU | TU | PA |
|---|---|---|---|
| Teoria del senyal i Comunicacions | 9 | 4 | |
| Enginyeria Electrònica | 1 | 8 | 1 |
| Enginyeria Telemàtica | 2 | 7 | 1 |
| Arquitectura de Computadors | | 3 | |
| Organització d'Empreses | 1 | | 1 |
| Anglès | | 1 | |

En **l'Annex 5** s'inclouen els CVs dels professors que participaran en el Màster en el curs 2004 / 2005.

# 8 Condicions específiques d'accés, preus, beques, places mínimes i màximes ofertes i criteris de selecció

## 8.1 Condicions d'Accés.

Per al primer any d'implantació del Màster, i per als estudiants d'universitats nacionals, les condicions generals d'accés específiques i mínimes, es concreten en el següent:

- Estudiants de l'àrea de l'enginyeria de telecomunicacions que hagin superat totes les matèries obligatòries que figurin als plans d'estudi oficials de primer i segon cicle.

- Els estudiants han de demostrar un nivell d'anglès suficient per seguir sense problemes el procés formatiu.

A **l'Annex 3** d'aquest document s'adjunta la formulació completa de les condicions d'accés oberta a l'entorn europeu del qual forma part aquest programa.

## 8.2 Places Mínimes i Màximes Ofertes

S'ofertaran **30 places**. La distribució de places segons el tipus d'estudiant s'adequarà cada any a la demanda i als objectius estratègics de l'ETSETB. Com a mínim un terç dels estudiants seran estrangers provenint de països de parla no catalana/castellana.

Així la distribució inicial que es desitja és la següent:

- 10 d'estudiants de l'ETSETB
- 15 d'estudiants estrangers
- 5 provenint d'altres titulacions amb perfil adequat o titulats de països de parla castellana.

# 9 Requisits per a l'obtenció del títol: modalitat de formació i sistema de valoració del rendiment acadèmic

## 9.1 Requisits per a la obtenció del títol

Superar els 60 crèdits ECTS de cursos del semestre nucli i d'especialització i el projecte de Màster valorat en 30 crèdits ECTS.

Aquestes condicions són necessàries i suficients per a l'obtenció del títol propi de ***Master of Science in Information and Communication Technologies***. També és possible cursar un programa conjunt de Màster sota aquest mateix nom, amb d'altres Universitats Europees que formen part d'un consorci creat arran de la convocatòria Erasmus Mundus. Així, un estudiant realitzaria un primer curs en una Universitat de la xarxa i hauria de superar 60 crèdits ECTS i un segon curs en un altre Universitat, superant així mateix 60 crèdits ECTS. L'estudiant rebria el títol de Màster de les dos Universitats.

El disseny del programa, orientat a la compatibilitat amb el pla d'estudis oficial d'Enginyeria de Telecomunicació, facilita l'obtenció per als titulats del Màster que procedeixen de la UPC, del títol oficial d'Enginyer de Telecomunicació.

## 9.2 Modalitat de Formació

La formació es realitzarà en modalitat presencial i a temps complet.

### 9.3 Sistema de valoració del rendiment acadèmic

El sistema de valoració del rendiment acadèmic s'adequarà als sistemes nacionals de cada universitat participant en el programa. S'establiran taules de correspondència per traduir els resultats a una escala comú.

## 10 Proposta de convalidacions

Seguint la política d'intercanvis de l'ETSETB, les convalidacions només seran possibles quan es realitzin assignatures optatives o el projecte de Màster en Universitats associades a l'ETSETB. Es podran convalidar fins a un màxim de 30 ECTS.
Dins al consorci Erasmus Mundus i seguint el model de mobilitat contemplat (veure **Annex 6**) es podran convalidar alternativament els 30 ECTS corresponents al semestre core.

D'altra banda els estudiants de l'ETSETB matriculats en el programa de Màster podran convalidar fins a 5 assignatures optatives del semestre d'especialització per assignatures optatives de les titulacions d'Enginyeria de Telecomunicació i d'Enginyeria en Electrònica i el projecte de Màster pel projecte fi de carrera.

## 11 Centres que participen en la impartició dels estudis

A **l'Annex 4** hi ha la relació d'universitats que forman part del Consorci organitzador del Màster.

## 12 Preus proposats; despeses i ingresos previstos per a la posada en marxa i desenvolupament del Màster

Vegeu **l'Annex 8** per al sistema de preus proposats i el càlcul d'ingresos de matrícula previstos a partir d'aquests preus.

### 12.1 Previsió de costos per a la implantació del Màster

Els costos s'han desglossat en els següents conceptes:

- Assignació del complement de sots-director/a al coordinador del Màster Internacional.

- Costos derivats de viatges, tant per la coordinació del Màster Internacional amb els socis europeus en l'inici d'implantació de la titulació conjunta, com pels viatges de promoció de la nova titulació.

- Costos derivats del material de promoció que requereix l'oferta d'una nova titulació tant en l'àmbit nacional com en l'internacional amb l'objectiu d'atreure als millors estudiants.

- Costos de posta en marxa d'assignatures de nova creació. Aquests costos es destinaran al que els responsables de cada assignatura considerin oportú i justifiquin adequadament en el seu projecte docent. Es poden incloure conceptes d'autoria, producció, becaris de suport,etc.

- Costos de posta en marxa d'assignatures optatives que actualment s'imparteixen en català i que s'impartiran en anglès dins el programa de Màster. Aquests costos es destinaran al que els responsables de cada assignatura considerin oportú i justifiquin adequadament en el seu projecte docent. Es poden incloure conceptes de producció, becaris de suport, etc.

- Classes de reforç i expressió en anglès pel professorat.

L'estimació total de despeses és de l'ordre de 80.000 euros que es financiaran amb els ingresos específics previstos (apartat 12.2), les convocatòries d'innovació educativa, tant de la universitat com dels organismes públics, convocatòries d'ajuts relacionats amb els conceptes de despesa, i la part d'ingresos de matrícula que estableix la pràctica de la gestió universitària.

### 12.2 Ingresos previstos

- Ajut viabilitat IGSOC (any anterior): 10.000 €
- Pla Pilot Dursi
- ERASMUS MUNDUS: 15.000 € per repartir entre els socis europeus en tres anys.
- Accions específiques de la Planif. Estratègica: 8.500 € el primer any

### 12.3 Ingresos de matrícula

Vegeu **l'Annex 8** per al sistema de preus proposats i el càlcul d'ingresos de matrícula previstos a partir d'aquests preus.

## 13 Descripció de les instal·lacions i mitjans materials

L'ETSETB disposa de la infraestructura ubicada al Campus Nord i que habitualment s'utilitza per la docència de les titulacions de l'ETSETB.

Dintre de la posta en marxa d'aquest Màster internacional està prevista la utilització d'una aula amb un recolzament tecnològic que permeti la implementació d'una metodologia docent innovadora.

Aquesta aula ha de ser polivalent en les possibilitats que ofereixi i per tant en els usos que se'n faran. En primer lloc es pretén que l'aula disposi d'un canó de projecció i d'uns 10 PC's per a l'ús d'estudiants que no disposin d'un ordinador portàtil. En segon lloc que estigui dotada de tecnologia sense fils de connexió (wireless). L'aula s'utilitzarà per a la impartició d'assignatures del Màster internacional, per a activitats docents dels departaments implicats en el projecte

i com a aula de treball de lliure ús pels estudiants del Màster per la connexió tant amb tecnologia sense fils (amb targetes WIFI en règim de préstec), com per cable.

L'ETSETB va sol·licitar un ajut dins de la convocatòria de projectes específics en el marc de la planificació estratègica de les unitats estructurals per tal de finançar l'equipament d'aquesta aula.

## ANNEXOS

**Annex 1** Oferta d'assignatures: fitxes de les matèries del semestre nucli i del semestre d'especialització: continguts, objectius i mètode d'avaluació.

**Annex 2** Crèdits ECTS: distribució d'activitats i pla de treball de l'estudiant

**Annex 3** Condicions d'accés a la titulació

**Annex 4** Universitats del Consorci europeu del Màster

**Annex 5** CVs del professorat

**Annex 6** Pla de mobilitat dels estudiants

**Annex 7** Estudi de Màsters en Universitats europees

**Annex 8** Preus proposats

# Master of Science in Information and Communication Technologies

## ANNEX 1

**- Oferta d'assignatures del Nucli: continguts, objectius i mètode de valoració del treball dels estudiants.**

**- Oferta d'assignatures d'Especialització: continguts, objectius i mètode de valoració del treball dels estudiants.**

Barcelona, 17 de juny del 2004

**Master of Science in Information and Communication Technologies**

**ETSETB**

# ANNEX 1

# Oferta d'assignatures del Nucli: continguts, objectius i mètode de valoració del treball dels estudiants.

| **Communications Systems, Networks and Services** | CSNS | Type : Core |
|---|---|---|

| | | | |
|---|---|---|---|
| Lecturer Coordinator | Luis de la Cruz | Lecturers Team: | Luis de la Cruz and Emilio Sanvicente |
| Department | Telematics Engineering | 5 ECTS Credits | Period : Year 1 Semester 1 |
| Language of Instruction: English | | | |
| Contact hours : 4 hr/week | | Lab hours: 10 hours | |

**Knowledge Prerequisites**

Probability. Stochastic Processes. Basic course in networking.

**Aim**

Presentation and evaluation of some advanced and present-day topics in communications networks.

**Teaching Method**

Lectures, individual projects

**Assessment Method**

| | |
|---|---|
| Passed class | 40 % |
| Final written/oral examination | 60 % |

**Syllabus**

1. Data link techniques.
2. Channel coding in wireless networks.
3. Multiple Access (IEEE 802.11, IEEE 802.17).
4. Networking and Internetworking.
5. Switching techniques.
6. Switch performance evaluation.
7. Routing.
8. Multicast.
9. Tornado codes.
10. MPLS.
11. Congestion control.
12. Resources allocation.
13. Quality of Service.
14. Integrated Services and Differentiated Services.
15. Queuing disciplines (FCFS, Priority queuing, WFQ).
16. Network security.
17. Applications.

**Bibliography**

**Basic**


- Walrand, Varaiya "High Performance Communication Networks", 2nd edition, Morgan Kurfmann, 2000


**Additional**


- D. Bertsekas, R. Gallager "Data Networks", 2nd edition, Prentice Hall, 1992


**Observations:**

Individual work:

Simulation models of queueing disciplines for differentiated services.

| **Advanced Programming and Distributed Applications** | APDA | Type : Core |
|---|---|---|

| | | | |
|---|---|---|---|
| Lecturer Coordinator | Nacho Navarro | Lecturers Team: | Nacho Navarro and Leandro Navarro |
| Department | Computer Architecture | 5 ECTS Credits | Period: Year 1 Semester 1 |
| Language of Instruction: English | | http://www.etsetb.upc.es | |
| Contact hours: 4 hr/week | | Lab hours: 2 hr/week | |

**Knowledge Prerequisits**

Computer systems, processor architecture, "C" programming, operating systems

**Aim**

To acquire intermediate knowledge of network programming, interaction and communication between clients and servers, distributed services. Students should understand the main design issues in these environments and be able take decisions on how to apply them in future projects that combine hardware and software.

**Teaching Method**

Lectures, individual projects

**Assessment Method**

| | |
|---|---|
| Continous assessment | 30 % |
| Laboratory assignements | 30 % |
| Final examination | 40 % |

**Syllabus**

1- Introduction
2- Network programming
   a. Layered Protocols. Remote Procedure Call. Remote Object Invocation. Message-Oriented Communication.
   b. Threads. Clients. Servers. Code Migration. Software Agents.
3- Distributed Systems
   a. Time Synchronization
   b. Mutual Exclusion, Election, Atomic Transactions, Replication, Consistency
   c. Fault Tolerance
   d. Topologies, distributed file systems and distributed shared memory
4- Name servers and Localization
   a. Naming Entities. Locating Mobile Entities.
5- Message protocols and Document formats
   a. CORBA. Distributed COM
   b. Distributed Document-Based Systems
6- Current case examples

**Bibliography**

**Basic**

A. S. Tanenbaum "Distributed Systems: Principles and Paradigms", Prentice Hall, 2002
R.E. Bryant, D. O'Hallaron "Computer Systems: A Programmer's Perspective, Prentice Hall, 2003

**Additional**

**Observations:**

**Individual work:**

Based on some given examples of distributed programming, the students will experience, at the lab, real situatiions to solve specific client-server scenarios.

| **Communication Theory** | CT | Type : Core |
|---|---|---|

| | | | |
|---|---|---|---|
| Lecturer Coordinator | G. Vázquez | Lecturers Team: | G. Vázquez<br>J.R. Fonollosa |
| Department | Signal Theory and Communications | 5 ECTS Credits | Period : Year 1 Semester 1 |
| Language of Instruction: English | | | |
| Contact hours : 4 hr/week | | Lab hours: | |

**Knowledge Prerequisites**

Probability, random variables and stochastic processes.

**Aim**

Presentation of the fundamental principles of communication theory and data transmission.

**Teaching Method**

Lectures, optional individual projects

**Assessment Method**

| | |
|---|---|
| Midterm written exam | 30 % |
| Final written exam | 70 % |

**Syllabus**

- Modeling of information sources. The Source Coding Theorem. Introduction to lossless source coding. Rate distortion theory. Quantization.
- Digital Transmission through the AWGN channel. Geometric Representation of Signal Waveforms. Optimum receiver design. Probability of Error.
- Digital Transmission through bandlimited AWGN channels. Power Spectrum of digitally modulated signals. Signal design for the bandlimited channel. Probability of Error. Digitally modulated signals with memory. The Maximum-Likelihood Sequence Detector. Channel Equalization.
- Channel capacity and communication bounds. Linear block codes, cyclic codes and convolutional codes. Applications.
- Digital Transmission on fading multipath channels. Spread Spectrum Communication Systems. Multicarrier Modulation and OFDM. Continuous phase modulation

**Bibliography**

**Basic**

- **Principles of Digital Transmission: With Wireless Applications (Plenum Series in Telecommunications)**
  by Sergio Benedetto, Ezio Biglieri Plenum Pr; (June 1999)

**Additional**

- **Digital Communications**
  by John G. Proakis McGraw-Hill Science/Engineering/Math; 4th edition (August 15, 2000)
- **Principles of Communication Engineering**
  by John M. Wozencraft, Irwin Mark Jacobs Wiley, New York (1965) and Waveland Press, Reprint edition (June 1990)
- **Information Theory and Reliable Communication**
  by Robert G. Gallager Wiley Text Books; (1968)
- **Synchronization Techniques for Digital Receivers (Applications of Communications Theory)**
  by Umberto Mengali, Aldo N. D'Andrea Plenum Pub Corp; (November 1997)
- **Digital Communication Receivers, Vol. 2: Synchronization, Channel Estimation, and Signal Processing**
  by Heinrich Meyr, Marc Moeneclaey, Stefan A. Fechtel John Wiley & Sons; 2nd edition (October 20, 1997)
- **Error Control Coding : Fundamentals and Applications**
  by Shu Lin, Daniel J. Costello Prentice Hall; (October 1, 1982)

**Observations:**

| **Digital System Design** | DSD | Type : Core |
|---|---|---|

| | | | |
|---|---|---|---|
| Lecturer Coordinator | J. Pons | Lecturers Team: | J.A. Chávez<br>J. Pons |
| Department | Electronic Engineering | 5 ECTS Credits | Period : Year 1 Semester 1 |
| Language of Instruction: English | | | |
| Contact hours : 4 hr/week | | Lab hours: 2 hr/week | |

**Knowledge Prerequisites**

Basic digital electronics topics: number systems, binary codes, Boolean Algebra, gate and module based combinational logic analysis and design, sequential modules (registers, counters, etc), finite state machine analysis and design. CMOS technology. Basic topics on microprocessors based systems.

**Aim**

Presentation and use of modern digital design tools and methodologies with especial emphasis on hardware description languages, programmable logic devices and advanced design techniques for mid-complexity digital subsystems.

**Teaching Method**

Lectures, practical classes, laboratory work

**Assessment Method**

| | |
|---|---|
| Laboratory work | 50 % |
| Course theory work and Final written examination | 50 % |

**Syllabus**

- Digital design and VHDL: digital electronic systems, structural vs behavioural description, digital ICs and technological alternatives, CAD/CAE tools, design flow, VHDL description language: aims and history, basic components, libraries, concurrent and sequential structures, application examples.
- Algorithmic systems: algorithms and digital systems, register level description, data subsystem components, control subsystem design, microprogramation.
- Programmable logic devices: Technologies, performance, classical and mid-complexity architectures (PLDs, CPLDs, FPGAs), modern architectures (SoPC).
- Advanced design techniques and topics: power consumption, hazards, area vs delay, timing performance, metastability, synchron vs asynchron, clock signal managing, state machine concurrency.

**Bibliography**

**Basic**


- John Wakerly, DIGITAL DESIGN PRINCIPLES AND PRACTICE. Prentice-Hall, 2003.
- Daniel D. Gajski, PRINCIPLES OF DIGITAL DESIGN. Prentice-Hall, 1997.


**Additional**


- Ashok K. Sharma, PROGRAMMABLE LOGIC HANDBOOK. PLDs, CPLDs & FPGAs. McGraw-Hill, 1998.
- S. Waterman, DIGITAL LOGIC SIMULATION AND CPLD PROGRAMMING WITH VHDL, Prentice Hall 2003.


**Observations:**

| MANAGEMENT AND INNOVATION IN TELECOMUNICATIONS COMPANIES | MITC | Type : Core |
|---|---|---|

| | | | |
|---|---|---|---|
| Lecturer Coordinator | Lluís Cuatrecasas Arbós | Lecturers Team: | Lluís Cuatrecasas Arbós<br>Carolina Consolación Segura<br>Josep M. Calvet Madrigal<br>Joan Sardà Ferrer<br>Jaume Mussons Sellés<br>Olga Pons Peregort |
| Department | Business Administration | 5 ECTS Credits | Period : Year 1 Semester 1 |
| Language of Instruction: English | | | |
| Contact hours : 4 hr/week | | Lab hours: | |

**Knowledge Prerequisites**

**Aim**

To introduce the students to different areas of management to understand the functioning of telecom firms. They will be able to see important aspects that help them to enter the work market.

**Teaching Method**

Seminars given by the team of lecturers in the Business Administration department

**Assessment Method**

| | |
|---|---|
| Problem-solving of proposed exercises and practical cases Business-game | 75 % |
| Class participation | 25 % |

**Syllabus**

1. The importance of environment and strategy of the firms. Industrial competitiveness in the European Union, Japan, U.E. The four vectors/components of the market competition. Survey on the industry in the E.U. Competition, trends and policy.
2. Development of all types of engineering skills for creativity, communication, team work, motivation and leadership.
3. New tendencies and modern tools in marketing services.
4. Cost systems applied in telecommunications firms. Volume-based costing versus Activity-based costing
5. Innovation management in process and production. Design and introduction of flexible process, efficient and competitive.
6. Business game simulator.

**Bibliography**

**Basic**

**Additional**

**Observations:**

With the business game simulator we try to develop a competitive business simulation between teams which are formed as companies, where the participants assume the roles of Marketing, Production, Finance and General managers. Alternatively, teams can also be organized by adopting a structure composed by a number of Product Managers where each team is in charge of the commercial, logistic and production management of every product or group of products.

| **Propagation and Radiowaves** | PR | Type : Core |
|---|---|---|

| | | | |
|---|---|---|---|
| Lecturer Coordinator | A. Cardama and L. Jofre | Lecturers Team: | A. Cardama and L. Jofre |
| Department | Signal Theory and Communications | 5 ECTS Credits | Period : Year 1 Semester 1 |
| Language of Instruction: English | | http://www-tsc.upc.es/eef/default.htm | |
| Contact hours : 4 hr/week | | Lab hours: | |

**Knowledge Prerequisites**

Electromagnetic Fields and Waves, Signals and Systems.

**Aim**

Presentation of the basic concepts and applications of antennas and propagation to communication systems, covering terrestrial and satellite radio systems in both mobile and fixed contexts.

**Teaching Method**

Lectures, individual projects

**Assessment Method**

| | |
|---|---|
| Homeworks | 20-40 % |
| Final exams | 80-60 % |

**Syllabus**

Introduction to radio communication. Properties of electromagnetic waves. Propagation mechanisms. Antenna fundamentals. Basic propagation models. Terrestrial fixed and mobile links. Satellite fixed and mobile links. Polarization and diversity. Small antennas. Smart antennas. Advanced and future developments.

**Bibliography**

**Basic**


- S. Simon R. Saunders, "Antennas and Propagation for wireless communication systems", John Wiley & Sons 1999
- A. Cardama, L. Jofre, et alt, "Antenas", Edicions UPC, Barcelona, 2002


**Additional**

**Observations:**

Individual work:

Simulation models of fixed and mobile communication channel modelization. Design of a Small Multi-element antenna for Wireless applications.

| Lectures on Science, Technology, and Society | STS | Type: Core |
|---|---|---|

| | | | |
|---|---|---|---|
| Lecturer Coordinator: | Montserrat Ginés Gibert | Lecturers Team: | Montserrat Ginés Gibert |
| Department: | English | 5 ECTS Credits | Period: Year 1 Semester 2 |
| Language of Instruction: English | | | |
| Contact hours: 4 hr/week | | Lab hours: | |

**Knowledge Prerequisites**

**Aim**

The purpose of the course is to make the students aware that in this world, science and technology have broken through the walls of industry and of the laboratory to become an inextricable and determining element of the natural and human environment, culture, and history. The lectures are intended to explore how science and technology evolved as human activities, and what role they play in the larger civilization. The STS perspective is crucial to understanding major events of our time (war and conflict, the economy, health, the environment) and to addressing these and other major public issues (privacy, democracy, education).

**Teaching Method**

Lectures

**Assessment Method**

| | |
|---|---|
| Assignments | 100 % |

**Syllabus**

Students will be requested to read a number of selected texts during the course and participate in the discussion of the major lines of thought and rationale underlying them. Students will also be asked to present a case to the class and make use of the necessary language and rhetoric skills to raise points and encourage discussion.

**Bibliography**

**Basic**

- Text book
- STS bibliography (already available at the BGF in Campus Nord) and selected electronic material

**Observations:**

**Master of Science in Information and Communication Technologies**

**ETSETB**

# ANNEX 1

# Oferta d'assignatures d'Especialització: continguts, objectius i mètode de valoració del treball dels estudiants.

| 1 VLSI Digital Design | VDD | Type : Optional |
|---|---|---|

| | | | |
|---|---|---|---|
| Lecturer Coordinator | Jordi Madrenas | Lecturers Team: | Jordi Madrenas, J. Manuel Moreno |
| Department | Electronics Engineering | 5 ECTS Credits | Period : Year 1 Semester 2 |
| Language of Instruction: English | | https://www-eel.upc.es/aha/dmii/ | |
| Contact hours : 4 hr/week | | Lab hours: 2 hr/week | |

**Knowledge Prerequisites**

Digital circuits, MOS transistors models, Logic design, FSM design.

**Aim**

Introduction of the IC design process. Identification of constraints imposed by digital VLSI implementations. To enable students to use the VLSI design style properly and to design by means of high-level hardware description languages, simulation, synthesis and validation tools.

**Teaching Method**

Lectures, Course project, Laboratory Work. Contact hours are distributed in lectures and seminars.

**Assessment Method**

| | |
|---|---|
| Laboratory Work | 40% |
| Course project | 20% |
| 1.1.1 Mid-term written examination | 1.1.2 15 % |
| Final written examinations | 25% |

## 1.1.3 Syllabus

I. **Introduction**. Digital technology. Integration capability and future trends. Design techniques. State of the art. Review of synchronous techniques for semi-custom ASIC design. Flip-flops. Building synchronous systems.
II. **CMOS logic design.** Switching characteristics. Delays, logical effort and buffering. Logic structures. Clock strategies.
III. **Physical design considerations.** Low-power design. Clock and power supply distribution.
IV. Arithmetic and logic subsystem design. Algorithmic systems and structured design. Datapath operators: adders and multipliers. Other operators.
V. **Test techniques.** Introduction. Manufacturing test principles. Design strategies for test. Self-test techniques. System-level test.
VI. **High-level design techniques.** System-on-Chip (SoC). Modeling with VHDL-AMS. SystemC.

**Laboratory work**: Microprocessor system description, simulation and synthesis using VHDL.

**Bibliography**

**Basic**


- Rabaey J.M. et al., Digital Integrated Circuits: a design perspective. Second edition. Prentice-Hall, 2003.
- Ashenden, P.J., The Designer's Guide to VHDL. Second edition, Morgan Kaufmann publishers, 2002.


## 1.1.4 Additional

**Observations:**

| **Broadband Networks and Services** | 11570 XSBA | Type: Optional |
|---|---|---|

| | | | |
|---|---|---|---|
| Lecturer Coordinator: | Xavier Hesselbach | Lecturers Team: | Xavier Hesselbach<br>Mònica Aguilar |
| Department: | Telematics Engineering | 5 ECTS Credits | Period: Year 1 Semester 2 |
| Language of Instruction: English | | | |
| Contact hours: 4 hr/week | | Lab hours: | |

**Knowledge Prerequisites**

That acquired previously in Communication Networks, Systems and Services.

**Aim**

To model and assess broadband networks and services. To become acquainted with the most common standards. To get to know the architectures of broadband protocols. To introduce the most common broadband services.

**Teaching Method**

Lectures, Practical Classes, Laboratory Work.

**Assessment Method**

| | |
|---|---|
| Continuous assessment | 40 % |
| Final examination | 60 % |

**Syllabus**

**I. Introduction** ..... **(2 hours)**
Review of concepts. OSI Reference Model.

**II. Access technologies** ..... **(10 hours)**
Frame relay. High-speed local networks Ethernet technologies. HFC technologies. xDSL technologies, PLC.

**III. ISDN and B-SDN** ..... **(4 hours)**
Reference model. Protocol architecture. Access methods ATM. The ATM layer and the adaptation layer. Control plan. Signaling. Standardization. ITU-T. ATM Forum. Traffic characterization

**IV. B-ISDN resource management** ..... **(14 hours)**
Classes of service. ATM traffic management. Traffic descriptors. Control mechanisms. Policing function. GCRA. Congestion control. Management using ABR services. Fairness.

**V. Interworking** ..... **(10 hours)**
IP over ATM. LANE. Frame relay over ATM.

**VI. Quality of service and traffic engineering** ..... **(4 hours)**
Integration of QoS on the network. RSVP, RTP, RTCP;IPv6. DiffServ and IntServ. QoS requirements

**VII. MPLS networks** ..... **(8 hours)**
Label Switching Basics. Label Distribution. MPLS and ATM networks. Traffic Engineering. VPN.

**Bibliography**

**Basic**


- ASATANI, Koichi. Introduction to ATM Networks and B-ISDN. John Wiley & Sons, 1997
- PRYCKER, M. Asynchronous Transfer Mode. 3rd ed. Prentice Hall, 1995.
- SACKETT, G. ATM and multiprotocol networking. McGraw-Hill, 1997
- BLACK, U., MPLS and Label Switching Networks. Prentice Hall, 2002.


**Advanced**


- ARMITAGE, Grenville. Quality of Service in IP networks. Macmillan Technical Publishing, 2000
- HÄndel, r., Huber, M.N., SchrÖder, S. ATM networks: concepts, protocols, applications. 3rd ed. Addison-Wesley, 1998
- LEDUC, Jean Pierre. Digital Moving Pictures – Coding and Transmission on ATM networks. Elsevier, 1994


**Observations:**

| Cellular Access Networks | 11569 XAC | Type: Optional |
|---|---|---|

| | | | |
|---|---|---|---|
| Lecturer Coordinator: | Francesc Barceló | Lecturers Team: | Francesc Barceló<br>Juan Luis Gorricho |
| Department: | Telematics Engineering | 5 ECTS Credits | Period: Year 1 Semester 2 |
| Language of Instruction: Spanish | | | |
| Contact hours: 4 hr/week | | Lab hours: | |

**Knowledge Prerequisites**

It is recommended that students take Network Architecture beforehand.

**Aim**

To introduce students to voice and data mobile cellular systems and their planning. Basic contents are the following. Cellular coverage. Access methods. Fixed networks in mobile systems. Mobility functions. Resource planning. Dynamic allocation mechanisms. GSM and DECT systems.

**Teaching Method**

Lectures, Practical Classes, Laboratory Work.

**Assessment Method**

| | |
|---|---|
| Continuous assessment | 40 % |
| Final examination | 60 % |

**Syllabus**

**I.** **Cell coverage** ..... **(4 hours)**
Resource sharing techniques Frequency, time, code and space. System quality

**II.** **Static resource allocation methods** ..... **(4 hours)**
Heuristic methods. Bounds on resource quantity estimation

**III.** **Dynamic resource allocation methods** ..... **(4 hours)**
Fixed-network controlled. Terminal controlled

**IV.** **GSM system** ..... **(18 hours)**
Elements of the system. Logic channels. Matching the channel to the service. Procedures

**V.** **Dimensioning of the GSM system** ..... **(6 hours)**
Mobility models. Quality criteria. Definition of service areas. Dimensioning of control channel capacity

**VI.** **The Qualcomm CDMA system** ..... **(4 hours)**
Structure of the control channels. Functioning of the system

**VII.** **Cordless telephone systems** ..... **(4 hours)**
Evolution. DECT system

**VIII.** **Closed user group telephone systems** ..... **(6 hours)**
Analogue systems MPT 13XX. TETRA system. Dimensioning

**IX.** **Satellite based systems** ..... **(2 hours)**
Iridium system

**X.** **Wireless local area networks** ..... **(4 hours)**
Proprietary systems. Standardized systems (IEEE80211 and Hyperlan)

**Bibliography**

**Basic**


- GORRICHO, M.; GORRICHO, J.L. "Comunicaciones Móviles". Edicions UPC, 2002
- BARCELÓ, F.; JORDÁN, J. "Telefonía Móvil. Caracterización de las conexiones". Ra-Ma, 2002


**Advanced**


- MOULY, M. The GSM system for mobile communications. The Authors, 1992
- TUTTLEBEE, W.H. Cordless telecommunications worldwide. Springer, 1997


**Observations:**

| **Digital Systems** | 11620 SD | Type: Optional |
|---|---|---|

| | | | |
|---|---|---|---|
| Lecturer Coordinator: | Francesc Masana<br>J.Manuel Moreno | Lecturers Team: | Francesc Masana<br>J.Manuel Moreno |
| Department: | Electronics Engineering | 5 ECTS Credits | Period: Year 1 Semester 2 |
| Language of Instruction: English | | | |
| Contact hours: 4 hr/week | | Lab hours: | |

**Knowledge Prerequisites**

Combinational and sequential system design. Computer architecture. Microprocessors and microcontrollers. Programmable devices. High frequency circuits.
To acquire a good knowledge of the topic, it is necessary to previously take Digital Systems (I) and previously/simultaneously Microelectronic Design (II).

**Aim**

To introduce the student to advanced digital systems. To provide an introduction to and analysis of the main communication protocols from the point of view of their application environment and hardware implementation from existing subsystems, focusing on microcontrollers and FPGA devices. To analyze problems brought about by higher clock rates.

**Teaching Method**

Lectures, Practical Classes, Laboratory Work.

**Assessment Method**

| | |
|---|---|
| Laboratory work | 50 % |
| Course work and final exam | 50 % |

**Syllabus**

I. **General concepts.** Elements of a digital system. Subsystems and their interconnection. The CPU. Memory subsystems. Input/output subsystems.
II. **Digital design and VHDL:** Review of digital design. VHDL description of digital systems.
III. **Communications protocol.** Serial and parallel protocols. Industrial protocols. $I^2C$, CAN, Fieldbus, Firewire.
IV. **Open digital systems.** The concept of the open system. Standardization needs. Open buses. Topology. Open bus examples: VME, Futurebus. The concept of the functional module. Functional module design. Example: VME BUS.
V. **Signal Integrity in digital design.** Noise margin. Noise immunity. DC and AC noise. The frequency spectrum of digital signals. Implications. Transmission lines. The reflexion. Electrical simulation. Coupled transmission lines. Crosstalk. Electrical simulation. Simultaneous switching. Clock skew.

**Bibliography**

**Basic**

- Class notes on the subject. (Available at the course web site)

**Advanced**


- CLEMENTS A. Microprocessor Systems Design: 68000 hardware, software and interfacing, 3rd ed. PWS Publishing Co., 1997
- DEXTER, A.L. Microcomputer Bus structures and Bus interface design. Marcel Dekker, 1986
- DI GIACOMO, J. Digital Bus handbook. McGraw-Hill, 1990
- ALEXANDRIDIS, N. Design of microprocessor-based systems. Prentice Hall, 1993
- POON, R.K. Computer circuits electrical design. Prentice Hall, 1995
- DALLY, W.J., POULTON, J.W. Digital Systems Engineering. Cambridge U.P., 1998


**Observations:**

| Electronic Commerce | EC | Type : Optional |
|---|---|---|

| | | | |
|---|---|---|---|
| Lecturer Coordinator | Miguel Soriano | Lecturers Team: | Jordi Forné<br>Miguel Soriano |
| Department | Telematics Engineering | 5 ECTS Credits | Period : Year 1 Semester 2 |
| Language of Instruction: English | | | |
| Contact hours : 4 hr/week | | Lab hours: | |

**Knowledge Prerequisits**

Network Architecture, Data Transmission, Network Systems and Communication Services

**Aim**

Presentation and evaluation of the different models and architectures used in E-commerce. Evaluation of the security and performance in different payment models. Presentation of the copyright techniques protection.

**Teaching Method**

Lectures, individual projects

**Assessment Method**

| | |
|---|---|
| Passed class | 40 % |
| final written/oral examination | 60 % |

**Syllabus**

Internet security SSH, S/MIME, TLS, WTLS, IPSEC, RADIUS, CHAP. Business models. B2B, B2C, A2B, P2P. Secure electronic payments. Micropayments. Copyright protection. Fingerprinting.

**Bibliography**

**Basic**

Sherif. Protocols for Secure Electronic Commerce. CRC Press. 2000
B. Sawyer, D. Greely, J. Cataudella, Creating stores on the web. 2nd. ed. Peachpit Press, 2000
SHAW, M., BLANNING, R., STRADES, T., WHINSON, A. Handbook on electronic commerce. Springer, 2000

**Additional**

**Observations:**

| **Energy management for Information and Communications Systems** | EMICS | Type : Optional |
|---|---|---|

| | | | |
|---|---|---|---|
| Lecturer Coordinator | Eduard Alarcón | Lecturers Team: | Eduard Alarcón |
| Department | Electronic Engineering | 5 ECTS Credits | Period : Year 1 Semester 2 |
| Language of Instruction: English | | | |
| Contact hours : 4 hr/week | | Lab hours: 2 hr/week | |

**Knowledge Prerequisites**

Time-domain, frequency-domain response and stability in linear systems, basic knowledge of electromagnetism, electronic devices.

**Aim**

The course focuses on energy management and supply subsystems specifically targeting communication and computing applications. The aim of the course is to provide the required knowledge and skills to recognize, model, select and use those subsystems. The course first introduces and reviews the fundamentals of the subsystems in charge of implementing energy management in information and communications systems, from the source to load through the energy processor. These aspects are subsequently illustrated by means of applications of interest ranging from energy distribution architectures in artificial satellites down to highly efficient miniaturized low-power supplies for battery-operated mobile communication portable terminals, through dedicated supply integrated circuits for future generation microprocessors.

**Teaching Method**

Lectures, lab

**Assessment Method**

| | |
|---|---|
| Assesment of lab activities | 50 % |
| Final written examination | 50 % |

**Syllabus**

I. **Introduction to energy management**.....**(2 hours)**
- 1.1 Basic concepts. Energy processing vs signal processing
- 1.2 Energy processing architecture: source, processor and load
- 1.3 Current applications

II. **Efficient energy conversion subsystems**.....**(8 hours)**
- 2.1 Converter classification: linear converters, switched capacitor converters, switching power converters
- 2.2 Switching power converters: fundamentals of synthesis and design-oriented analysis
- 2.3 Switching power regulators
- 2.4 Power processing modular architectures

III. **Batteries and other energy sources**.....**(3 hours)**
- 3.1 Classification of batteries
- 3.2 Battery modelling
- 3.3 Other energy sources: Fuel cells, supercapacitors, photovoltaic cells

IV. **Low-power load design** .....**(2 hours)**
- 4.1 Techniques for reduced power consumption: technology-level, circuit-level and system-level

V. **Energy management in battery-operated mobile telephone portable terminals** ..**(4 hours)**
- 5.1 Energy management within the system-on-chip architecture
- 5.2 Power converter miniaturization guidelines
- 5.3 Improved efficiency techniques: adaptive power management for DSP and RF amplifiers
- 5.4 On-chip energy distribution networks

VI. **Powering microprocessors**. .....**(4 hours)**
- 6.1 Voltage regulator modules (VRM). Specifications
- 6.2 Decoupling issues
- 6.3 Modular powering architectures for multi-processor systems.
- 6.4 Other issues: UPS (Uninterruptible power supplies) and PFC (Power factor correction) circuits

VII. **Bus architectures for energy distribution in satellites**. .....**(4 hours)**
- 7.1 Energy management architectures for aerospace applications. Effect of satellite orbit

7.2 Energy bus classification: non-regulated, hybrid and regulated bus

VIII. **Other applications**. ..... **(3 hours)**

8.1 Techniques for efficient DC to RF power conversion
8.2 Efficient switching power audio amplifiers
8.3 Power issues in line drivers

**LAB CONTENTS**

I. Circuit-level simulation of a voltage regulator module (VRM) powering a microprocessor
II. System-level simulation of the energy distribution bus architecture in a satellite
III. Experimental characterization of the energy management system in a Li-Ion battery-operated mobile phone

**Bibliography**

**Basic**


- Henk Jan Bergveld, Wanda S. Kruijt, Peter H.L. Notten, Battery management systems design by modelling, Kluwer Academic Publishers, 2002
- Robert W. Erickson, D. Maksimovic, Fundamentals of Power Electronics, 2ª ed, Kluwer Academic Publishers, 2001
- Anantha Chandrakasan, Robert Brodersen, Low power CMOS design, IEEE press, 1998


**Additional**


- Luca Benini, Giovanni de Micheli, Dynamic power management: design techniques and CAD tools, Kluwer Academic Publishers, 2002
- Massoud Pedram, Jan M. Rabaey, Power Aware Design Methodologies, Kluwer Academic Publishers, 2002
- Andrey V. Mezhiba, Eby G. Friedman, Power Distribution Networks in High Speed Integrated Circuits, Kluwer Academic Publishers, 2003
- Keng Chih Wu,Transistor Circuits for Spacecraft Power System, Kluwer Academic Publishers, 2002


**Observations:**

| **Image and Video Communications** | | 11671 IVC | Type: Optional |
|---|---|---|---|
| Lecturer Coordinator: | Lluís Torres | Lecturers Team: | Lluís Torres |
| Department: | Signal Theory and Communications | 5 ECTS Credits | Period: Year 1 Semester 2 |
| Language of Instruction: English | | | |
| Contact hours: 4 hr/week | | Lab hours: | |

**Knowledge Prerequisites**

Signal Processing.

**Aim**

The main objective of the course is to provide students with a working knowledge of image and video communications. The main tools and concepts of image and video coding are presented with special emphasis on current standards. Strong emphasis is put on applications such as digital television, mobile communications, video through Internet and video streaming. The course has a strong practical component and the student experiences in the laboratory with the major image and video communication techniques. The student is required to develop a practical image or video communications scheme.

**Teaching Method**

Lectures, Practical Classes, Laboratory Work.

**Assessment Method**

| | |
|---|---|
| Programming project | 70 % |
| Assessment and written test | 30 % |

**Syllabus**

I. **Introduction to image and video coding** ..... **(6 hours)**
- 1.1 The need of coding and compression
- 1.2 The Human Visual System and its influence in the design of image compression algorithms
- 1.3 Introduction to Information Theory
- 1.4 Lossless and lossy schemes. Scalable compression systems

II. **Lossless compression systems** ..... **(4 hours)**
- 2.1 Huffman coding
- 2.2 Other lossless systems

III. **Image coding systems** ..... **(10 hours)**
- 3.1 Predictive systems
- 3.2 Transform systems
- 3.3 The JPEG standard
- 3.4 Wavelet systems
- 3.5 The JPEG 2000 standard
- 3.6 Other image coding systems

IV. **Video coding systems** ..... **(8 hours)**
- 4.1 Motion estimation and compensation
- 4.2 Hybrid coding systems
- 4.3 The H.263 and H.264 standards. Application to Internet communications
- 4.4 The MPEG 1 and MPEG 2 standards
- 4.5 Digital TV transmission. Satelite, cable and terrestrial transmission.

V. **Second generation systems** ..... **(8 hours)**
- 5.1 Segmentation-based image coding systems
- 5.2 Model-based coding systems
- 5.3 Other video coding systems
- 5.4 The MPEG 4 standard.

VI. **Digital TV.** Satellite, cable and terrestrial television communications systems..... **(6 hours)**

VII. **Image and video communications through mobile systems**..... ..... **(6 hours)**

VIII. **Video through Internet, video streaming** ..... **(4 hours)**

IX. **Project presentations** ..... **(4 hours)**

**Bibliography**

**Basic**

- SAYOOD, K. Introduction to Data Compression. Morgan Kaufmann Publishers. Second Edition. 2000.
- PEREIRA, F., EBRAHIMI, T. The MPEG-4 Book. IMSC Press Multimedia Series. 2002.
- REIMERS, U., 'Digital Video Broadcasting (DVB). The International Standard for Digital Television'. Springer, 2001.


**Additional**


- TORRES, L., KUNT, M.Video Coding: The Second Generation Approach, Kluwer Academic Publishers, 1996
- CLARKE, R. Digital compression of still images and video. Academic Press 1995.


| **MEMS technology and devices** | MEMS | Type : Optional |
|---|---|---|

| | | | |
|---|---|---|---|
| Lecturer Coordinator | Luis Castañer | Lecturers Team: | Luis Castañer<br>Angel Rodriguez |
| Department | Electronic Engineering | 5 ECTS Credits | Period : Year 1 Semester 2 |
| Language of Instruction: English | | | |
| Contact hours : 4 hr/week | | Lab hours: | |

| | |
|---|---|
| **Knowledge Prerequisites** | |
| Basic electronics and electromagnetism | |
| **Aim** | |
| Principles of microelectromechanical systems (MEMS) and description of the main MEMS components in electronics , sensing and communications | |
| **Teaching Method** | |
| Lectures, homework | |
| **Assessment Method** | |
| Passed class, and homework | 25% |
| final written/oral examination | 75% |
| **Syllabus** | |
| Introduction to MEMS devices and transducers. Scaling of forces Basic mechanics of beam and diaphragm structures. Stress and strain, vibration. Air damping. Piezorresistance, coordinate transformation and piezoresistive coefficients. Piezoresistive sensors of pressure and acceleration. Electrostatic driven devices: actuators and variable capacitors. Stability and pull-in voltage. Voltage and charge control methods. Capacitive transducers. Resonant sensors. Microfabrication: bulk and surface micromachining, silicon processing, bonding and packaging. Case studies. Nanotechnologies for sensor and transducers | |
| **Bibliography** | |
| **Basic** | |
| M.-H.Bao Micromechanical transducers, in Handbook of sensors and actuators Vol. 8 Elsevier, 2000 | |
| **Additional** S.D.Senturia, Microsystem design, Kluwer Academy press 2001 | |
| **Observations:** highly interdisciplinary subject, basics reviewed, from concept to final device. | |
| **Individual work:** | |
| Homework will ask for problem solving, and Pspice or Matlab simulations | |

| **Multimedia Mobile Communications** | 11554 CMM | Type: Optional |
|---|---|---|

| | | | |
|---|---|---|---|
| Lecturer Coordinator: | Ferran Casadevall | Lecturers Team: | Ferran Casadevall |
| Department: | Signal Theory and Communications | 5 ECTS Credits | Period: Year 1 Semester 2 |
| Language of Instruction: Spanish | | | |
| Contact hours: 4 hr/week | | Lab hours: | |

**Knowledge Prerequisites**

The fundamentals of mobile communications, as taught in Radiocommunications.

**Aim**

To present the main characteristics of the multimedia mobile communication systems which are being (or will be) developed in the next years. Basic contents deal with the study of the protocols and functionalities related the current digital cellular systems like GSM/GPRS and UMTS as well as WLAN and Bluetooth, as examples of local and personal mobile communication systems. Issues related to the multiple access techniques in real environments, Quality of Service strategies, impact of the wireless environment on the behavior of high layer protocols, such as TCP, are also evaluated. Finally the course also addresses to the future evolution of the mobile communication systems under the concept of Systems Beyond 3G.

**Teaching Method**

Lectures, Practical Classes.

**Assessment Method**

| | |
|---|---|
| Report or written project | 70 % |
| Assessment and written test | 30 % |

**Syllabus**

**I. Introduction** ..... **(4 hours)**
Evolution of data services in mobile communications. Mobile multimedia services. Technologies for supporting mobile multimedia services: GPRS, HSDSC, WAP UTRAN.

**II. GPRS (General Packet Radio System)** ..... **(12 hours)**
Definition and services. Network architecture: interfaces. Air interface: Logic channels, multiplexing, encoding, etc. Quality of service. Mobility management. Interaction with other GSM services

**III. UTRAN: UMTS Terrestrial Radio Access Network** ..... **(20 hours)**
Objectives. Services. Circuit switching versus packet transmission. Network architecture
Protocol architecture. FDD and TDD air interface modes: Logic channels, multiplexing, encoding, etc.

**IV. WLAN: IEEE802.11** ..... **(10 hours)**
Objectives. Services. Network architecture and operation modes. Protocol description. Technology issues, Quality of Service, etc.

**V. BLUETOOTH** ..... **(8 hours)**
Objectives. Applications. Network architecture and protocols. Air interface

**VI. SYSTEMS BEYONND 3G** ..... **(6 hours)**
Evolution of the 3GPP releases. All-IP networks, Software Defined Radio

**Bibliography**

**Basic**


- J. SCHILLER, Mobile Communications. Addisson Wesley,2003


**Advanced**


- HOLMA, H. (Editor) WCDMA for UMTS. John Wiley and Sons, 2000
- R.J. BATES; GPRS: General Packet Radio Service; Mc-Graw Hill TELECOMM, 2000
- J. GEIER; WIRELESS LANs; SAMs Publishing, 2002
- N.J. MULLER; Bluetooth Demystified; Mc-Graw Hill TELECOMM, 200


**Observations:**

| 2 Network Intelligence | 11561 IX | Type : Optional |
|---|---|---|

| | | | |
|---|---|---|---|
| Lecturer Coordinator | Josep Paradells Aspa | Lecturers Team: | Josep Paradells Aspa<br>Jose Luis Muñoz Tàpia |
| Department | Telematics Engineering | 5 ECTS Credits | Period : Year 1 Semester 2 |
| Language of Instruction: English | | | |
| Contact hours : 4 hr/week | | Lab hours: | |

**Knowledge Prerequisites**

Communication Networks, Systems and Services.

**Aim**

The aim of this subject is to introduce how new telecommunication network services are made available today. For networks to offer these kinds of services, a control information transport system is required. This system consists of a signaling network, which is the nervous system of intelligent networks. This subject presents the concepts of switching and signaling, which are indispensable for building an intelligent network. Systems such as those supported by the Internet and broad-band networks are also described. Basic matters are: telephones, telecommunication services, intelligent networks, INAP, signaling, SS7, VoIP, SIP, H.323.

**Teaching Method**

Lectures, Practical Classes.

**Assessment Method**

| | |
|---|---|
| Class work on specific topics | 40% |
| Continuous assessment | 10% |
| 2.1.1 Exam | 2.1.2 25 % |
| Final examination | 25% |

## 2.1.3 Syllabus

**I. Telephone Networks** ..... **(15 hours)**
Telephone services over circuit switching. RDSI. Telephone services over packet switching. Voice over IP. Services over ATM networks. Broad-band RDSI

**II. Switching elements** ..... **(10 hours)**
SPC exchanges. PABX. Routers. ATM switches

**III. Signaling systems** ..... **(10 hours)**
Subscriber. Analogue. DSS1. Dss2. H.323. SIP. Between exchanges. SS7. QSIG

**IV.** Services ..... **(5 hours)**

**V. Intelligent networks** ..... **(15 hours)**
Historical evolution. Structure. Elements. INAP

**VI. Evolution** ..... **(5 hours)**
TINA. TMN

**Bibliography**

**Basic**


- MAGEDANZ, T., POPESCU-ZELETIN, R. Intelligent networks: basic technology, standards and evolution. International Thomson Computer Press, 1996
- FAYNBERG, I., GABUZDA, L.R., KAPLAN, M.P., SHAN, N.J. The Intelligent Network Standards, Their Application to Services. McGraw-Hill, 1997
- BLACK, U. The Intelligent Network, Customizing Telecommunication Networks and Services. Prentice Hall, 1998
- THÖRNER, J., Intelligent Networks. Artech House, 1994
- HERSENT, O., GURLE, D., PETIT, J. IP Telephony, Packet-based multimedia communications systems. Addison-Wesley, 2000

| **Optical Fiber Telecommunications** | 11673 TELFIB | Type: Optional |
|---|---|---|

| | | | |
|---|---|---|---|
| Lecturer Coordinator: | Gabriel Junyent Giralt | Lecturers Team: | Gabriel Junyent Giralt<br>Josep Solé Pareta |
| Department: | Signal Theory and Communications/ Computer Architecture | 5 ECTS Credits | Period: Year 1 Semester 2 |
| Language of Instruction: English | | | |
| Contact hours: 4 hr/week | | Lab hours: | |

**Knowledge Prerequisites**

Optical Communications. Telecommunications Systems.

**Aim**

For students to acquire knowledge of optical fiber telecommunications systems.

**Teaching Method**

Lectures, Practical Classes.

**Assessment Method**

| | |
|---|---|
| Continuous assessment | 40 % |
| Assignments | 60 % |

**Syllabus**

- **Characteristics of optical fiber.**
- **Optical and electro-optical components.**
- **Optical amplification.**
- **Optical switching and wavelength routing devices.**
- **Modulation formats.**
- **Optical transmitters.**
- **Optical detection.**
- **Optical receivers.**
- **Digital transmission systems.**
- **WDM optical networks: architecture and technology.**
- **System impact of fiber nonlinearities.**
- **Optical monitoring.**
- **Broadband HFC.**
- **Fiber-to-the-home (FTTH).**
- **Multiple access optical networks.**
- **Optical networking evolution in switched optical networks.**
- **Optical architectures for transporting IP: ASON and GMPLS-based optical networks.**
- **Traffic management in IP over WDM networks.**
- **Optical switching networks: burst, label and packet.**
- **Network survivability.**
- **Wireless optical systems.**

**Bibliography**

**Basic**


- CPET notes.
- Gerd Keiser,"Optical Fiber Communications", Ed. McGraw-Hill, 2000.
- R.Ramaswami and K.N.Sivarajan, "Optical Networks", Ed. Morgan Kaufmann Publisheres, 2002.
- T. Stern and K. Bala, "Multiwavelegth Optical Networks", Ed. Addison Wesley, 1999.
- Uyless Black, "Optical Networks, Third Generation Transport Systems", Prentice Hall, 2002.


**Observations:**

| **Protocols in Telecommunications Networks** | 11658 PRTX | Type: Optional |
|---|---|---|

| | | | |
|---|---|---|---|
| Lecturer Coordinator: | Anna Calveras Augé | Lecturers Team: | Anna Calveras<br>Jordi Casademont |
| Department: | Telematics Engineering | 5 ECTS Credits | Period: Year 1 Semester 2 |
| Language of Instruction: English | | | |
| Contact hours: 4 hr/week | | Lab hours: | |

**Knowledge Prerequisites**

Students are required to have taken Networks, Systems and Services.

**Aim**

To introduce students to the communication protocols used in data networks. To demonstrate the indispensability of protocol architectures, and to give an overview of the most extensive communication protocols including OSI and Internet. Basic contents of the course are: Students will study the functions of network levels for network interconnection, transport, session, file transfers, virtual terminals, e-mail and search engines.

**Teaching Method**

Lectures, Practical Classes.

**Assessment Method**

| | |
|---|---|
| Practical Sessions and Final Work | 40 % |
| Final examination | 60 % |

**Syllabus**

**I. Network architecture**
Levels of protocols. Services. Protocol architectures: ISO-OSI, INTERNET, SNA, NOVELL.
**II. Network levels**
Protocols for the interconnection of networks. Internet Control Message Protocol (ICMP)
Resource Reservation Protocol (RSVP) in real time. Multicast IGMP.
**III. Transport levels**
Design aspects of transport levels. Unreliable Datagram Protocol (UDP):
Reliable Transmission Control Protocol (TCP):Reliable Transmission Control Protocol (TCP):
**IV. Session level**
Session level functions. Real-time Transport Protocol (RTP).
**V. Presentation level**
Presentation level functions. Information representation.
**VI. Application level**
Service access elements. Internet applications.
**VII. Access to the Internet via switching networks**
PPP Protocol. New generation TCP/IP.
**VIII. Optional practical sessions**

**Bibliography**

**Basic**


- ALONSO, José Miguel. Protocolos de Comunicaciones para sistemas abiertos. Addison-Wesley Iberoamericana, 1996


**Advanced**


- COMER, Douglas E. Internetworking with TCP/IP. Volume I: Principles, protocols and architecture. Prentice Hall, 1995
- COMER, Douglas E., STEVENS, David L.Internetworking with TCP/IP. Volume II: Design, implementation and internals. Prentice Hall, 1991-1996


**Observations:**

| Radionavigation Systems | 11672 SISRAD | Type: Optional |
|---|---|---|

| | | | |
|---|---|---|---|
| Lecturer Coordinator: | Jordi Mallorquí | Lecturers Team: | Jordi Mallorquí |
| Department: | Signal Theory and Communications | 5 ECTS Credits | Period: Year 1 Semester 2 |
| Language of Instruction: English | | | |
| Contact hours: 4 hr/week | | Lab hours: | |

**Knowledge Prerequisites**

It is recommended that students take the following subjects beforehand: Radiation and Guided Waves, Signal Processing, Radiocommunications, Antennas, Microwaves and Radar. Any gaps in students' knowledge of the topics will be filled in by consulting a basic reading list.

**Aim**

Radionavigation technologies, particularly satellite based ones such as GPS or the future Galileo system in Europe, are becoming widespread in the following sectors: telecommunications; transport by land, air and sea; public works, etc. This subject aims to provide future engineers with the plethora of technical knowledge needed to successfully develop positioning and navigation applications that cater for the needs of a user sector in full expansion.

**Teaching Method**

Lectures, Practical Classes.

**Assessment Method**

| | |
|---|---|
| Group assignments | 40 % |
| Practical assignments | 10 % |
| Final examination | 50 % |

**Syllabus**

**I. Basic principles**
Introduction. Types of navigation. Mathematical models for representing the Earth. Propagation effects.

**II. Terrestrial systems**
Hyperbolic systems Loran C, Decca, Omega. Determination of direction. Air traffic support systems: Secondary radar, ILS, MLS, VOR, DME, TACAN.

**III. Satellite systems**
Orbits and geometry. Principles of satellite navigation Observables. Systems based on the Doppler effect. Traffic Cospass-SAR, Argos. Broadened spectrum signals. Navstar GPS and Glonass. Position determination. Errors and precision. GPS receivers. GPS-complementary sensors. Tracking with the Kalman filter. Augmentation systems: Differential systems and pseudosatellites. Integration with other systems. Intelligent transport systems (ITS). GNSS-1 systems and future constellations.

**Bibliography**

**Basic**


- FORSSELL, B. Radionavigation systems. Prentice Hall, 1991
- KAPLAN, E.D. Understanding GPS: Principles and applications. Artech House, 1996


**Advanced**


- KAYTON, W. FRIED, W. Avionics Navigation Systems. 2nd ed. John Wiley and Sons, 1997
- JAIME PÉREZ, R. Radionavegació. Edicions UPC, 1997
- PARKINSON, B.W., SPILKER, J.J. Global Positioning System: Theory and Applications (2 Vols.) American Institute of Aeronautics and Astronautics, 1996


**Observations:**

| RF and Microwave Circuits in Communications | 11536 RF | Type: Optional |
|---|---|---|

| | | | |
|---|---|---|---|
| Lecturer Coordinator: | Albert Aguasca Solé | Lecturers Team: | Albert Aguasca Solé<br>Lluís Pradell |
| Department: | Signal Theory and Communications | 5 ECTS Credits | Period: Year 1 Semester 2 |
| Language of Instruction: English | | | |
| Contact hours: 4 hr/week | | Lab hours: | |

**Knowledge Prerequisites**

Students are required to have a basic knowledge of microwaves and/or high frequency circuits, in transmitters and receivers.

**Aim**

To expand upon student's knowledge of circuits present in all microwave/RF frequency communications equipment. Basic contents of the course are the following. Passive broadband networks, filters, combiners and diplexers. Small-signal transistor amplifiers, power amplifiers and broadband amplifiers. Introduction to CAD for microwaves. High-power vacum tube amplifiers. Microwave generators/oscillators based on transistors and magnetrons.

**Teaching Method**

Lectures, Practical Classes.

**Assessment Method**

| | |
|---|---|
| Continuous assessment | 70 % |
| Final examination | 30 % |

**Syllabus**

**I.** **Introduction**.....(2 hours)
Justification of the subject. Structure of the subject. Some examples: Mobile telephone, RADAR, domestic microwaves, wireless local loop (broadband access via radio), electronic and medical instrumentation, etc.

**II.** **Conceptual background**.....(10 hours)
Characterization parameters (S, ABCD, Y, Z). Basic concepts of dual ports (gains, mismatch factors, properties). Transmission lines and systems. Design and limitations. Introduction to microwave CAD.

**III.** **Passive networks**.....(12 hours)
Matching networks. Filters. Transformers and tapers. Periodic structures. Combination networks. Diplexers

**IV.** **Active networks**.....(26 hours)
Amplifiers. Generators

**V.** **Regulations and recommendations concerning electromagnetic radiation at microwave frequencies**.....(2 hours)

**Bibliography**

**Basic**


- POZAR, D.M. Microwave engineering. Wiley, 1998
- ELLIOTT, R.S. An introduction to guided waves and microwave circuits. Prentice Hall International Editions, 1993


**Additional**


- BAHL, I., BHARTIA, P. Microwave solid state circuit design. John Wiley & Sons, 1988
- SOARES, R. GaAs MESFET circuit design. Artech House, 1988


**Observations:**

| **RF Communication Systems-on-Chip** | RF-CSoC | Type : Optional |
|---|---|---|

| | | | |
|---|---|---|---|
| Lecturer Coordinator | José Luis González | Lecturers Team: | José Luis González<br>Xavier Aragonés |
| Department | Electronic Engineering | 5 ECTS Credits | Period : Year 1 Semester 2 |
| Language of Instruction: English | | | |
| Contact hours : 4 hr/week | | Lab hours: | |

**Knowledge Prerequisites**

Signal Theory. Communications Systems. Electronic Circuits and Systems.

**Aim**

Presentation of the possibilities of CMOS technology for Integrated RF Circuits and Systems. Design methodologies for the basic building blocks of an RF transceiver. Circuit and system level design and simulation of RF Communication Integrated Circuits.

**Teaching Method**

Lectures, individual projects

**Assessment Method**

| | |
|---|---|
| Passed class | 20 % |
| Project and final written/oral examination | 80 % |

**Syllabus**

1. **The MOS transistor at RF.**
2. **Integrated passives.**
3. **Device noise in RF circuits.**
4. **Low Noise Amplifiers design and simulation.**
5. **Voltage Controlled Oscillators and Phase Noise.**
6. **Mixers.**
7. **Frequency synthesizer architectures.**
8. **RF power amplifiers.**
9. **System level design and simulation of RF transceivers.**

**Bibliography**

**Basic**


- Behzad Razavi "RF Microelectronics", Prentice Hall, 1998.
  Thomas H. Lee "The Design of CMOS Radio Frequency Integrated Circuits", John Willey & Sons, 1998.


**Additional**


- Derek K- Sjaeffer, "The Design and Implementation of Low-Power CMOS Radio Receivers", Kluwer Ademic Publishers, 1999.
- Behzad Razavi, ed., "Monolithic Phase-Locked Loops and Clock Recovery Circuits: Theory and Design, Wiley Interscience, 1996.
- Domine Leenaerts, Johan van der Tang, and Cicero Vaucher, "Circuit Desing for RF Transceivers", Kluwer Ademic Publishers, 2001.


**Observations:**

**Individual work:**

Literature search about techniques or advanced proposal for RF building blocks or system architectures. Exercices and design project.

| **Sensors and Signal Conditioning** | SSC | Type: Optional |
|---|---|---|

| | | | |
|---|---|---|---|
| Lecturer Coordinator: | Ramon Bragós | Lecturers Team: | Ramon Bragós |
| Department: | Electronics Engineering | 5 ECTS Credits | Period: Year 1 Semester 2 |
| Language of Instruction: English | | | |
| Contact hours: 4 hr/week | | Lab hours: 2 hr/week | |

**Knowledge Prerequisites**

Physical properties of materials used in electronics. Electromagnetism and magnetic circuits. Electronic circuits analysis. Analogue integrated circuits, their possibilities and limitations, and interpretation of their specifications. Signal acquisition. Analysis of errors in electronic circuits. Use of basic measurement instruments.

**Aim**

Study of sensors: functioning, properties and limitations. Specific interface design. Applications. Basic contents of the course are: Sensors, sensor signal conditioning, analog and mixed-mode signal processing, acquisition, calibration techniques, smart sensors interface protocols.

**Teaching Method**

Lectures, Practical Classes, Laboratory Work.

**Assessment Method**

| | |
|---|---|
| Continuous assessment of practices | 40 % |
| Continuous assessment of exercises | 10 % |
| Final examination | 50 % |

**Syllabus**

I. **Introduction to sensor-based measuring systems**.....(2 hours)
II. **Variable resistance sensors and their conditioners**..... (8 hours)
III. **Variable reactance and electromagnetic sensors and their conditioners**..... (8 hours)
IV. **Generator sensors and their conditioners**..... (6 hours)
V. **Digital sensors. Smart sensors** ..... (6 hours)

**Laboratory and remote practices** ..... (30 hours)

**Bibliography**

**Basic**


- PALLAS ARENY, R., WEBSTER, J.G. Sensors and signal conditioning. 2nd ed. John Wiley and Sons, 2000
- Laboratory and remote practices manuals


**Advanced**


- WEBSTER, J.G. The measurement, instrumentation and sensors handbook. CRC, 1999
- GARDNER, J.W. Microsensors: principles and applications. Wiley, 1994


**Observations:**

| Speech Processing | 11667 PVEU | Type: Optional |
|---|---|---|

| | | | |
|---|---|---|---|
| Lecturer Coordinator: | Asunción Moreno Bilbao | Lecturers Team: | Antonio Bonafonte<br>Asunción Moreno Bilbao<br>J.A:Rodríguez Fonollosa |
| Department: | Signal Theory and Communications | 5 ECTS Credits | Period: Year 1 Semester 2 |
| Language of Instruction: English | | | |
| Contact hours: 4 hr/week | | Lab hours: 1 hr/week | |

**Knowledge Prerequisites**

Signal Processing.

**Aim**

For students to acquire knowledge and perform evaluations of the following basic systems:
Speech analysis, speech synthesis, speech coding and speech recognition.

**Teaching Method**

Lectures, Practical Classes, Laboratory Work.

**Assessment Method**

| | |
|---|---|
| Two tests and a piece of practical laboratory work | 100 % |

**Syllabus**

**I. Introduction to speech processing**
**II. Introduction to speech coding**
**III. Analysis of the speech signal**
**IV. Quantization of speech**
**V. Waveform coding**
**VI. Hybrid coders and standards**
**VII. Suband coding. MPEG**
**VIII. Introduction to speech recognition**
**IX. Hidden Markov models**
**X. Continuous speech recognition**
**XI. Language modeling**
**XII. Speech synthesis**
**XIII. Real time implementation**

**Bibliography**

**Basic**


- JAYANT, N.S., NOLL, P. Digital coding of waveforms. Prentice Hall, 1984
- RABINER, L., JUANG, B.H. Fundamentals of speech recognition. Prentice Hall Inc.


**Advanced**


- Applications of Voice Processing to Telecommunications. L. Rabiner. Proceedings of the IEEE, Vol. 82, No. 2. February 1994
- Raymond Steele: Mobile Radio Communications. Pentech Press, 1992
- Advances in Speech and Audio Compression. A. Gersho. Proceedings of the IEEE, Vol. 82, No. 6. June 1994
- MPEG digital audio coding. Peter Noll. IEEE signal processing journal. September 1997
- Signal Modeling Techniques in Speech Recognition. J.W. Picone Proceedings of the IEEE Vol 81 no9. September 1999
- "A Tutorial on Hidden Markov Models and Selected Applications in Speech Recognition", L. Rabiner, Proceeding of the IEEE, Vol. 77, Nº 2, February 1989
- A Review of Large Vocabulary Continuous-speech Recognition. S. Young IEEE Signal Processing Magazine. September 1996


**Observations:**

# Master of Science in Information and Communication Technologies

## ANNEX 2

**- Aplicació dels crèdits ECTS: activitats, objectius i pla de treball de l'estudiant.**

Barcelona, 17 de juny del 2004

Escola Tècnica Superior d'Enginyeria de Telecomunicació de Barcelona
UNIVERSITAT POLITÈCNICA DE CATALUNYA

**TITULACIÓ:** Master of Science in Information and Communication Technologies
**ASSIGNATURA:** Propagation and Radiowaves

| | Descripció Tècnica | Activitat amb el Professor | | | Activitat Estudiant | | | Avaluació | | Total Hores ECTS | Crèdits ECTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Objectius | Hores setmana | Hores totals | Treball estudiant | Hores estudi / treball setmana | Hores estudi / treball totals | Procediment | Temps (hores) | | |
| **Teoria** | Classe magistral | Explicar els principals conceptes | 2 | 30 | Conèixer, comprendre i sintetitzar coneixements | 3 | 45 | Prova escrita | 2,5 | 77,5 | 2,8 |
| **Problemes** | Classe participativa | Resolució de problemes | 1 | 15 | Aprendre a analitzar problemes | 1 | 15 | Lliurament de problemes | | 30 | 1,1 |
| | | | | | | | | | | | |
| **Activitats dirigides** | Seminaris i casos pràctics | Realitzar en grup i presentar els treballs de l'assignatura | 1 | 15 | Treball en col·laboració. Documentar els casos i presentació d'un informi | 1 | 15 | Lliurament dels casos | | 30 | 1,1 |
| | | | | | | | | | | | |
| **Totals** | | | 4 | 60 | | 5 | 75 | | 2,5 | 137,5 | 5 |

Escola Tècnica Superior d'Enginyeria de Telecomunicació de Barcelona
UNIVERSITAT POLITÈCNICA DE CATALUNYA

**TITULACIÓ:** **Master of Science in Information and Communication Technologies**
**ASSIGNATURA:** **Communication Theory**

| | Descripció Tècnica | Activitat amb el Professor | | | Activitat Estudiant | | | Avaluació | | Hores ECTS | Crèdits ECTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Objectius | Hores setmana | Hores totals | Treball estudiant | Hores estudi / treball setmana | Hores estudi / treball totals | Procediment | Temps (hores) | | |
| **Teoria** | Classe participativa | Explicar els principals conceptes | 3 | 45 | Conèixer, comprendre i sintetitzar coneixements | 3 | 45 | Prova escrita | 3 | 93 | 3,32 |
| **Problemes** | Exercici aplicat | Explicar resolució de problemes | 1 | 15 | Aprendre a resoldre problemes | 1 | 15 | Problemes | 2 | 32 | 1,14 |
| **Laboratori** | | | | | | | | | | 0 | 0 |
| **Activitats dirigides** | Simulacions amb ordinador | Reforçar l'aprenentatge | | | Realitzar les simulacions i avaluar els resultats | 0,5 | 7,5 | Lliurament de resultats | | 7,5 | 0,27 |
| **Altres activitats** | Treball pràctic | Realitzar un treball de l'assignatura en grup | | | Cerca de referències, treball en col·laboració, disseny d'un projecte | 0,5 | 7,5 | Lliurament treball | | 7,5 | 0,27 |
| **Totals** | | | | | | | | | | **140** | **5** |

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UNIVERSITAT POLITÈCNICA DE CATALUNYA

**TITULACIÓ:** **Master of Science in Information and Communication Technologies**
**ASSIGNATURA:** **Digital Logic Design**

| | Descripció Tècnica | Activitat amb el Professor | | | Activitat Estudiant | | | Avaluació | | Hores ECTS | Crèdits ECTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Objectius | Hores setmana | Hores totals | Treball estudiant | Hores estudi / treball setmana | Hores estudi / treball totals | Procediment | Temps (hores) | | |
| **Teoria** | Classe magistral | Explicar els principals conceptes | 1 | 15 | Conèixer, comprendre i sintetitzar coneixements | 1,25 | 18,75 | Prova escrita | 2 | 35,75 | 1,27 |
| **Problemes** | Classe participativa i activitat dirigida | Resoldre exemples rea-listes i reforçar aprenentatge | 1 | 15 | Aprendre a resoldre pro-blemes manual-ment i amb simulacions | 1,25 | 18,75 | Prova escrita, lliurament de simulacions o problemes resolts | 1,5 | 35,25 | 1,25 |
| **Laboratori** | Pràctica de laboratori | Utilització d'eines reals i resolució de casos pràctics de disseny | 2 | 30 | Compendre especificacions i documentació, realitzar dis-senys, verificar-los, presentar resultats. | 2 | 30 | Demostracions en viu, lliurament d'estudis previs i memòries, prova escrita o en viu | 2 | 62 | 2,2 |
| **Altres activitats** | Treball teòric | Reforçar conceptes i treball en grup | | | Cerca i processament d'informació, treball en grup, generació de documentació | 0,5 | 7,5 | Presentació pública del treball | 0,5 | 8 | 0,28 |
| **Totals** | | | | 60 | | | 75 | | 6 | 141 | 5 |

Escola Tècnica Superior d'Enginyeria de Telecomunicació de Barcelona
UNIVERSITAT POLITÈCNICA DE CATALUNYA

**TITULACIÓ:** Master of Science in Information and Communication Technologies
**ASSIGNATURA:** Communication Systems, Networks and Services

| | Descripció Tècnica | Activitat amb el Professor | | | Activitat Estudiant | | | Avaluació | | Hores ECTS | Crèdits ECTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Objectius | Hores setmana | Hores totals | Treball estudiant | Hores estudi / treball setmana | Hores estudi / treball totals | Procediment | Temps (hores) | | |
| **Teoria** | Classe magistral | Explicar els principals conceptes | 2 | 30 | Conèixer, comprendre i sintetitzar coneixements | 3 | 45 | Proves escrites | 2 | 77 | 2,8 |
| **Problemes** | Classe participativa | Explicar resolució de problemes | 1 | 15 | Aprendre a resoldre problemes | 1 | 15 | Proves escrites | 2 | 32 | 1,1 |
| **Laboratori** | Pràctica de Laboratori | Orientar en la resolució del problemes pràctics i aplicats | 1 | 15 | Comprendre fenòmens físics, mesurar i realitzar memòria | 1 | 15 | Lliurament de memòria. | | 30 | 1,1 |
| **Activitats dirigides** | | | | | | | | | | | |
| **Altres activitats** | | | | | | | | | | | |
| **Totals** | | | | 60 | | | 75 | | 4 | 139 | 5 |

Escola Tècnica Superior d'Enginyeria de Telecomunicació de Barcelona
UNIVERSITAT POLITÈCNICA DE CATALUNYA

**TITULACIÓ:** Master of Science in Information and Communication Technologies
**ASSIGNATURA:** MANAGEMENT AND INNOVATION IN TELECOMUNICATIONS COMPANIES

| | Descripció Tècnica | Activitat amb el Professor | | | Activitat Estudiant | | | Avaluació | | Hores ECTS | Crèdits ECTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Objectius | Hores setmana | Hores totals | Treball estudiant | Hores estudi / treball setmana | Hores estudi / treball totals | Procediment | Temps (hores) | | |
| **Teoria** | Clase magistral | Explicar los conceptos básicos | 2 | 30 | Estudio de los conceptos | 6 | | Presentación trabajos | 4 | | |
| **Problemes** | | | | | | | | Corrección y evaluación | 4 | | |
| **Laboratori** | Búsqueda información | Despertar el interés por la búsqueda de información | | | Búsqueda de información | 6 | | | | | |
| **Activitats dirigides** | Simulación por ordenador | Poner en práctica el aprendizaje. Desarrollar habilidades a través de la presentación de trabajos en clase y trabajo en grupo | | | Simulación por ordenador: Business Game | 20 | | | | | |
| **Altres activitats** | Trabajos prácticos. Lecturas y casos | | | | Preparar las presentaciones | 5 | | | | | |
| **Totals** | | | | 30 | | **37** | | | 8 | 75 | 2.5 |

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UNIVERSITAT POLITÈCNICA DE CATALUNYA

**TITULACIÓ:** **Master of Science in Information and Communication Technologies**
**ASSIGNATURA:** **Network Intelligence**

| | Descripció Tècnica | Activitat amb el Professor | | | Activitat Estudiant | | | Avaluació | | Hores ECTS | Crèdits ECTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Objectius | Hores setmana | Hores totals | Treball estudiant | Hores estudi / treball setmana | Hores estudi / treball totals | Procediment | Temps (hores) | | |
| **Teoria** | Classe magistral | Explicar els principals conceptes | 3 | 45 | Conèixer, comprendre i sintetitzar coneixements | 3 | 45 | Prova escrita | 1 | 90 | 3,3 |
| **Problemes** | Classe participativa | Explicar resolució de problemes | 1 | 15 | Aprendre a resoldre problemes | 2 | 30 | Prova escrita | 1 | 45 | 1,6 |
| **Laboratori** | | | | | | | | | | | |
| **Activitats dirigides** | | | | | | | | | | | |
| **Altres activitats** | Treball pràctic | Realitzar un treball de l'assignatura en grup o individual | 0 | 2 | Cerca de referències, treball en col·laboració, disseny d'un projecte, aplicar coneixements, relacionar | 2 | 30 | Memòries dels treballs, seguiment personal | 0 | 32 | 1,16 |
| **Totals** | | | | | | | | | | 167 | 6,1 |

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UNIVERSITAT POLITÈCNICA DE CATALUNYA

**TITULACIÓ:** **Master of Science in Information and Communication Technologies**
**ASSIGNATURA:** **E-commerce**

| | Descripció Tècnica | Activitat amb el Professor | | | Activitat Estudiant | | | Avaluació | | Hores ECTS | Crèdits ECTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Objectius | Hores setmana | Hores totals | Treball estudiant | Hores estudi / treball setmana | Hores estudi / treball totals | Procediment | Temps (hores) | | |
| **Teoria** | Classe magistral | Explicar els principals conceptes | 2,5 | 37,5 | Conèixer, comprendre i sintetitzar coneixements | 3 | 45 | Prova escrita | 2 | 84,5 | 3,1 |
| **Problemes** | Classe participativa | Explicar resolució de problemes | 0,25 | 3,75 | Aprendre a resoldre problemes | 0,5 | 7,5 | Prova escrita | 0,5 | 11,75 | 0,42 |
| **Laboratori** | Pràctica de Laboratori | Orientar en la resolució del problemes pràctics i aplicats | 0,25 | 3,75 | Comprendre fenòmens físics, mesurar i realitzar memòria | 1 | 15 | Lliurament de memòria. | | 18,75 | 0,68 |
| **Activitats dirigides** | Simulacions amb ordinador | Reforçar l'aprenentatge | | | Realitzar les simulacions i avaluar els resultats | | | | | | |
| **Altres activitats** | Treball pràctic | Realitzar un treball de l'assignatura en grup | 0,5 | 7,5 | Cerca de referències, treball en col·laboració, disseny d'un projecte | 1 | 15 | Lliurament de resultats | | 22,5 | 0,82 |
| **Totals** | | | 3,5 | 52,5 | | **5,5** | 82,5 | | 2,5 | 137,5 | 5 |

Escola Tècnica Superior d'Enginyeria de Telecomunicació de Barcelona
UNIVERSITAT POLITÈCNICA DE CATALUNYA

**TITULACIÓ:** **Master of Science in Information and Communication Technologies**
**ASSIGNATURA:** **Cellular Acces Networks**

| | Descripció Tècnica | Activitat amb el Professor | | | Activitat Estudiant | | | Avaluació | | Hores ECTS | Crèdits ECTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Objectius | Hores setmana | Hores totals | Treball estudiant | Hores estudi / treball setmana | Hores estudi / treball totals | Procediment | Temps (hores) | | |
| **Teoria** | Classe Magistral | Explicar els principals conceptes | 3 | 45 | Conèixer, comprendre i sintetitzar coneixements | 4 | 60 | Prova escrita | 1,5 | 106,5 | 3,87 |
| **Problemes** | Classe participativa | Explicar resolució de problemes | 1 | 15 | Aprendre a resoldre problemes | 1 | 15 | Prova escrita | 1 | 31 | 1,13 |
| **Laboratori** | | | | | | | | | | | |
| **Activitats dirigides** | | | | | | | | | | | |
| **Altres activitats** | | | | | | | | | | | |
| **Totals** | | | 4 | 60 | | **5** | 75 | | | 137,5 | 5 |

Escola Tècnica Superior d'Enginyeria de Telecomunicació de Barcelona
UNIVERSITAT POLITÈCNICA DE CATALUNYA

**TITULACIÓ:** **Master of Science in Information and Communication Technologies**
**ASSIGNATURA:** **Broadband Networks and Services**

| | Descripció Tècnica | Activitat amb el Professor | | | Activitat Estudiant | | | Avaluació | | Hores ECTS | Crèdits ECTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Objectius | Hores setmana | Hores totals | Treball estudiant | Hores estudi / treball setmana | Hores estudi / treball totals | Procediment | Temps (hores) | | |
| **Teoria** | Classe magistral | Explicar els principals conceptes | 3 | 45 | Conèixer, comprendre i sintetitzar coneixements | 4 | 60 | Prova escrita | 1,5 | 106,5 | 3,9 |
| **Problemes** | Classe participativa | Explicar resolució de problemes | 0,5 | 7,5 | Aprendre a resoldre problemes | 0,5 | 7,5 | Prova escrita | 1,5 | 16,5 | 0,6 |
| **Activitats dirigides** | Treball pràctic | Realitzar un treball de l'assignatura en grup | 0,1 | 1,5 | Cerca de referències, treball en col·laboració, disseny d'un projecte | 0,3 | 4,5 | Lliurament de memòria del treball | 0 | 6 | 0,2 |
| **Activitats dirigides** | Seminari | Presentació conclusions del treball efectuat | 0,2 | 3 | Preparació presentació | 0,3 | 4,5 | Presentació | 0,5 | 8 | 0,3 |
| **Altres activitats** | | | | | | | | | | | |
| **Totals** | | | 3,8 | 57 | | 5,1 | 76,5 | | 3,5 | 137 | 5 |

Escola Tècnica Superior d'Enginyeria de Telecomunicació de Barcelona
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**TITULACIÓ:** Master of Science in Information and Communication Technologies
**ASSIGNATURA:** Protocols in Telecommunications Networks

| | Descripció Tècnica | Activitat amb el Professor | | | Activitat Estudiant | | | Avaluació | | Hores ECTS | Crèdits ECTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Objectius | Hores setmana | Hores totals | Treball estudiant | Hores estudi / treball setmana | Hores estudi / treball totals | Procediment | Temps (hores) | | |
| **Teoria** | Classe magistral | Explicar els principals conceptes | 3.5 | 52.5 | Conèixer, comprendre i sintetitzar coneixements | 4 | 60 | Proves escrites | 3 | 115.5 | 4.125 |
| **Problemes** | Classe participativa | Explicar resolució de problemes | 0.5 | 7.5 | Aprendre a resoldre problemes | 1 | 15 | Proves escrites | 2 | 24.5 | 0.875 |
| **Laboratori** | | | | | | | | | | | |
| **Activitats dirigides** | | | | | | | | | | | |
| **Altres activitats** | | | | | | | | | | | |
| **Totals** | | | 4 | 60 | | | 75 | | 5 | 140 | 5 |

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**TITULACIÓ:** Master of Science in Information and Communication Technologies
**ASSIGNATURA:** RF and Microwave circuits in Communications

| | Descripció Tècnica | Activitat amb el Professor | | | Activitat Estudiant | | | Avaluació | | Hores ECTS | Crèdits ECTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Objectius | Hores setmana | Hores totals | Treball estudiant | Hores estudi / treball setmana | Hores estudi / treball totals | Procediment | Temps (hores) | | |
| **Teoria** | Classe magistral | Explicar els principals conceptes | 3 | 45 | Conèixer, comprendre i sintetitzar coneixements | 3,5 | 52,5 | Proves escrites | 3 | 100,5 | 3,35 |
| **Problemes** | Classe participativa | Explicar resolució de problemes | 0,5 | 7,5 | Aprendre a resoldre problemes | 0,5 | 7,5 | Lliurament de problemes | 4,5 | 19,5 | 0,65 |
| **Aplicacions** | Classe participativa | Explicar tècniques d'anàlisi amb simuladors | 0,5 | 7,5 | Aprendre a analitzar problemes amb simuladors | | | | | 7,5 | 0,25 |
| **Activitats dirigides** | Simulacions amb ordinador | Reforçar l'aprenentatge | | | Realitzar tutorials, simulacions i avaluar els resultats | 1 | 15 | Lliurament de resultats | | 15 | 0,5 |
| **Altres activitats** | Recerca bibliogràfica | Reforçar l'aprenentatge | | | Completar els coneixements amb resultats de l'estat de l'art | 0,3 | 4,5 | Elaboració d'un treball | 3 | 7,5 | 0,25 |
| **Totals** | | | 4 | 60 | | **5,3** | 79,5 | | 10,5 | 150 | 5 |

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**TITULACIÓ:** Master of Science in Information and Communication Technologies
**ASSIGNATURA:** Image and Video Communications

| | Descripció Tècnica | Activitat amb el Professor | | | Activitat Estudiant | | | Avaluació | | Hores ECTS | Crèdits ECTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Objectius | Hores setmana | Hores totals | Treball estudiant | Hores estudi / treball setmana | Hores estudi / treball totals | Procediment | Temps (hores) | | |
| **Teoria** | Classe magistral | Explicar els principals conceptes | 3 | 45 | Conèixer, comprendre i sintetitzar coneixements | 3 | 45 | Prova escrita | 2 | 92 | 3.5 |
| **Problemes** | - | - | | | - | | | - | - | | |
| **Laboratori** | Pràctica de Laboratori | Orientar en la resolució del problemes pràctics i aplicats | 1 | 15 | Comprendre fenòmens físics, mesurar i realitzar memòria | | | - | - | 15 | 0.6 |
| **Activitats dirigides** | - | - | - | - | - | - | - | - | - | | |
| **Altres activitats** | Treball pràctic | Realitzar un treball de l'assignatura en grup | | | Cerca de referències, treball en col·laboració, disseny d'un projecte | 1.5 | 22.5 | Presentació del treball a classe | 0.5 | 23 | 0.9 |
| **Totals** | | | | 60 | | | 67.5 | | 2.5 | 130 | 5 |

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UNIVERSITAT POLITÈCNICA DE CATALUNYA

**TITULACIÓ:** Master of Science in Information and Communication Technologies
**ASSIGNATURA:** Speech Processing

| | Descripció Tècnica | Activitat amb el Professor | | | Activitat Estudiant | | | Avaluació | | Hores ECTS | Crèdits ECTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Objectius | Hores setmana | Hores totals | Treball estudiant | Hores estudi / treball setmana | Hores estudi / treball totals | Procediment | Temps (hores) | | |
| **Teoria** | Classe magistral | Explicar els principals conceptes | 3 | 45 | Conèixer, comprendre i sintetitzar coneixements | 3 | 45 | Pruebas escritas | 6 | 96 | |
| **Problemes** | | | | | | | | | | | |
| **Laboratori** | Pràctica de Laboratori | Coordinación de proyecto | 1 | 15 | Desarrollo de un proyecto: búsqueda de bibliografía, desarrollo, coordinación, evaluación. | 2 | 30 | Memoria escrita y presentación oral | 12 | 57 | |
| **Activitats dirigides** | | | | | | | | | | | |
| **Totals** | | | | 60 | | | 75 | | 15 | 143 | |

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UNIVERSITAT POLITÈCNICA DE CATALUNYA

**TITULACIÓ:** Master of Science in Information and Communication Technologies
**ASSIGNATURA:** Radionavigation Systems

| | Descripció Tècnica | Activitat amb el Professor | | | Activitat Estudiant | | | Avaluació | | Hores ECTS | Crèdits ECTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Objectius | Hores setmana | Hores totals | Treball estudiant | Hores estudi / treball setmana | Hores estudi / treball totals | Procediment | Temps (hores) | | |
| **Teoria** | Classe magistral | Explicar els principals conceptes | 3,5 | 52,0 | Conèixer, comprendre i sintetitzar coneixements | 1,5 | 22,5 | | 1,3 | 75,8 | 2,7 |
| **Problemes** | | | 0,0 | 0,0 | | | 0,0 | | | 0,0 | 0,0 |
| **Laboratori** | | | 0,0 | 0,0 | | | 0,0 | | | 0,0 | 0,0 |
| **Activitats dirigides** | Pràctica de camp + lectura articles | Reforçar aprenentatge | 0,4 | 6,0 | Avaluar prestacions GPS en entorns urbans. Llegir artícles tècnics sobre GPS | 0,4 | 6,0 | | 0,5 | 12,5 | 0,5 |
| **Altres activitats** | Treball | | 0,1 | 2,0 | Cerca de referències, treball en col·laboració | 3,0 | 45,0 | | 3,0 | 50,0 | 1,8 |
| **Totals** | | | | 60,0 | | | 73,5 | | 4,8 | 138,3 | 5,0 |

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**TITULACIÓ:** Master of Science in Information and Communication Technologies
**ASSIGNATURA:** MULTIMEDIA MOBILE COMMUNICATIONS

| | Descripció Tècnica | Activitat amb el Professor | | | Activitat Estudiant | | | Avaluació | | Hores ECTS | Crèdits ECTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Objectius | Hores setmana | Hores totals | Treball estudiant | Hores estudi / treball setmana | Hores estudi / treball totals | Procediment | Temps (hores) | | |
| **Teoria** | Classe magistral | Explicar principis i conceptes | 3 | 45 | Conèixer, comprendre i sintetitzar coneixements | 3 | 45 | Proves escrites | 2 | 92 | 3,3 |
| **Problemes** | | | | | | | | | | | |
| **Laboratori** | | | | | | | | | | | |
| **Activitats dirigides** | Treballs Pràctics | Orientar el contingut del treball, aclarir dubtes | 1 | 15 | Aplicar els coneixements. Aprofundir alguns aspectes concrets dels temes estudiats | 2 | 30 | Lliurament de memòria i presentació oral | 3 | 48 | 1,7 |
| **Altres activitats** | | | | | | | | | | | |
| **Totals** | | | 4 | 60 | | 5 | 75 | | 5 | 140 | 5 |

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UNIVERSITAT POLITÈCNICA DE CATALUNYA

**TITULACIÓ:** **Master of Science in Information and Communication Technologies**
**ASSIGNATURA:** **Digital Systems**

| | Descripció Tècnica | Activitat amb el Professor | | | Activitat Estudiant | | | Avaluació | | Hores ECTS | Crèdits ECTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Objectius | Hores setmana | Hores totals | Treball estudiant | Hores estudi / treball setmana | Hores estudi / treball totals | Procediment | Temps (hores) | | |
| **Teoria** | Classe magistral | Explicar els conceptes fonamentals | 2 | 30 | Adquirir i sintetitzar els conceptes i la seva aplicació | 2 | 30 | Prova escrita | 4 | 64 | 2.2 |
| **Problemes** | Col·lecció de problemes | | | | Resoldre els problemes | 0.5 | 7.5 | | | 7.5 | 0.25 |
| **Laboratori** | Pràctiques de Laboratori | Realització pràctica de sistemes concrets | 2 | 30 | Dissenyar els sistèmes i preparar les memòries | 2 | 30 | Verificació de resultats al Laboratori i lliurament de memòries | 6 | 66 | 2.2 |
| **Activitats dirigides** | Simulacions amb ordinador | Abordar problemes de resolució complexa | | | Plantejar les simulacions i analitzar els resultats | 0.5 | 7.5 | Lliurament de resultats | 3 | 10.5 | 0.35 |
| **Altres activitats** | | | | | | | | | | | |
| **Totals** | | | | 60 | | | 75 | | 13 | 148 | 5 |

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**TITULACIÓ:** Master of Science in Information and Communication Technologies
**ASSIGNATURA:** VLSI Digital Design

| | Descripció Tècnica | Activitat amb el Professor | | | Activitat Estudiant | | | Avaluació | | Hores ECTS | Crèdits ECTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Objectius | Hores setmana | Hores totals | Treball estudiant | Hores estudi / treball setmana | Hores estudi / treball totals | Procediment | Temps (hores) | | |
| **Teoria** | Classe magistral<br>Sessions d'aplicació | Fonaments de disseny VLSI digital | 2 (x 5)<br>2 (x 3) | 10<br>6 | Estudi del material de teoria | 1 | 15 | Control de mig curs<br>Examen final | 1<br>2 | 34 | 1.24 |
| **Problemes** | Resolució guiada de problemes | Aplicar els coneixements. Desenvolupar el raonament i esperit crític | 1 (x 4) | 4 | Resolució de problemes | 1 | 15 | Lliurament de resolució de problemes | - | 19 | 0.69 |
| **Laboratori** | Pràctiques de laboratori | Disseny digital amb HDLs | 2 (x 13) | 26 | Preparació de les pràctiques | 2 (x 13) | 26 | Avaluació continuada<br>Control de pràctiques | -<br>1 | 53 | 1.93 |
| **Activitats dirigides** | Projecte de disseny (en grup) | Dissenyar un xip o un core IP | 1 (x 4) | 4 | Realització del projecte | 1.53 | 25.5 | Presentació del disseny | 2 | 31.5 | 1.15 |
| **Altres activitats** | | | | | | | | | | | |
| **Totals** | | | | 50 | | | 81.5 | | 6 | 137.5 | 5 |

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**TITULACIÓ:** **Master of Science in Information and Communication Technologies**
**ASSIGNATURA:** **Sensors and Signal Conditioning**

| | Descripció Tècnica | Activitat amb el Professor | | | Activitat Estudiant | | | Avaluació | | Hores ECTS | Crèdits ECTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Objectius | Hores setmana | Hores totals | Treball estudiant | Hores estudi / treball setmana | Hores estudi / treball totals | Procediment | Temps (hores) | | |
| **Teoria** | Classe magistral | Explicar els principals conceptes | 1,5 | 22,5 | Conèixer, comprendre i sintetitzar coneixements | 1 | 15 | Prova escrita | 3 | 40,5 | 1,5 |
| **Problemes** | Classe participativa | Explicar resolució de problemes i casos pràctics | 0,5 | 7,5 | Aprendre a resoldre problemes i a aplicar criteris de disseny | 1 | 15 | Lliurament gradual de problemes resolts | | 22,5 | 0,8 |
| **Laboratori** | Pràctiques de Laboratori | Orientar en la presa de decisions en casos pràctics | 2 | 30 | Comprendre fenòmens físics i limitacions dels circuits i sistemes de mesura | 2 | 30 | Lliurament gradual d'estudis previs i resultats | | 60 | 2,2 |
| **Activitats dirigides** | Laboratori remot | Complementar l'anàlisi de dades experimentals | | | Accedir al laboratori remot, obtenir dades, processar-les i avaluar el resultat | 0,4 | 6 | Lliurament interactiu de resultats | | 6 | 0,2 |
| **Altres activitats** | Treball cooperatiu | Realitzar un treball de l'assignatura en grup | | | Anàlisi d'una norma i aplicació a un cas real | 0,4 | 6 | Lliurament d'informe | | 6 | 0,2 |
| **Totals** | | | | 60 | | | 72 | | 3 | 135 | 5 |

Escola Tècnica Superior d'Enginyeria de Telecomunicació de Barcelona
UNIVERSITAT POLITÈCNICA DE CATALUNYA

**TITULACIÓ:** Master of Science in Information and Communication Technologies
**ASSIGNATURA:** Energy Management for Information and Communication Systems

| | Descripció Tècnica | Activitat amb el Professor | | | Activitat Estudiant | | | Avaluació | | Hores ECTS | Crèdits ECTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Objectius | Hores setmana | Hores totals | Treball estudiant | Hores estudi / treball setmana | Hores estudi / treball totals | Procediment | Temps (hores) | | |
| **Teoria** | Classe magistral | Explicar els principals conceptes | 1,5 | 22,5 | Conèixer, comprendre i sintetitzar coneixements | 2,5 | 37,5 | Prova escrita | 2 | 60 | 2,18 |
| **Problemes** | Classe participativa | Explicar resolució de problemes | 0,5 | 7,5 | Aprendre a resoldre problemes | 0,5 | 7,5 | Lliurament de col·lecció de problemes resolts | 1 | 16 | 0,58 |
| **Laboratori** | Pràctica de Laboratori | Orientar en la resolució del problemes pràctics i aplicats | 1 | 15 | Comprendre fenòmens físics, mesurar i realitzar memòria | 1 | 15 | Lliurament de memòria. Prova escrita sobre Laboratori | 1 | 31 | 1,13 |
| **Activitats dirigides** | Simulacions amb ordinador | Reforçar l'aprenentatge | 1 | 15 | Realitzar les simulacions i avaluar els resultats | 1 | 15 | Lliurament de resultats | 1 | 31 | 1,13 |
| **Altres activitats** | | | | | | | | | | | |
| **Totals** | | | | 60 | | | 75 | | 5 | 140 | 5 |

Escola Tècnica Superior d'Enginyeria de Telecomunicació de Barcelona
UNIVERSITAT POLITÈCNICA DE CATALUNYA

**TITULACIÓ:** Master of Science in Information and Communication Technologies
**ASSIGNATURA:** RF and Microwaves Circuits in Communications

| | Descripció Tècnica | Activitat amb el Professor | | | Activitat Estudiant | | | Avaluació | | Hores ECTS | Crèdits ECTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Objectius | Hores setmana | Hores totals | Treball estudiant | Hores estudi / treball setmana | Hores estudi / treball totals | Procediment | Temps (hores) | | |
| **Teoria** | Classe magistral | Explicar els principals conceptes | 2 | 11 | Conèixer, comprendre i sintetitzar coneixements | 3 | 45 | Prova escrita | 2 | 77 | 2.8 |
| **Problemes** | Classe participativa | Explicar resolució de problemes | 0.75 | 11.25 | Aprendre a resoldre problemes | 0.75 | 11.25 | | | 22.5 | 0.82 |
| **Laboratori** | | | | | | | | | | | |
| **Activitats dirigides** | Simulacions amb ordinador | Aprenentatge de Software d'Analisi i disseny de MICs | 0.75 | 11.25 | Simulació d'exemples treballats a classe | 0.25 | 3.75 | | | 15 | 0.54 |
| **Altres activitats** | Treball pràctic | Realitzar dos treballs de l'assignatura en grup | 0.5 | 7.5 | Disseny de MICs i comparació entre teoria i pràctica | 1.25 | 18.75 | Lliurament de Treballs | 3 | 29.25 | 1.06 |
| **Totals** | | | | 60 | | | 78.75 | | 5 | 143.75 | 5.22 |

Escola Tècnica Superior d'Enginyeria de Telecomunicació de Barcelona
UNIVERSITAT POLITÈCNICA DE CATALUNYA

**TITULACIÓ:** Master of Science in Information and Communication Technologies
**ASSIGNATURA:** **MEMS technology and devices**

| | Descripció Tècnica | Activitat amb el Professor | | | Activitat Estudiant | | | Avaluació | | Hores ECTS | Crèdits ECTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Objectius | Hores setmana | Hores totals | Treball estudiant | Hores estudi / treball setmana | Hores estudi / treball totals | Procediment | Temps (hores) | | |
| **Teoria** | Class | Motivation, concepts and models | 2 | 30 | Comprehension and concept appraisal | 3 | 45 | Exams (2) | 6 | 81 | 2.7 |
| **Problemes** | Problem solving | Quantify and evaluate solutions | 1 | 15 | Appraisal of magnitudes and quantitative results | 1 | 15 | Self-evaluation | 7.5 | 37.5 | 1.25 |
| **Laboratori** | | | | | | | | | | | |
| **Activitats dirigides** | Concept-to-device expertise | | | | Modelling-simulation-design | 1 | 15 | Technical report writing | 10 | 25 | 0.85 |
| **Altres activitats** | MEMS world awareness | | | | Critical Information search and data base creation | 0.2 | 3 | Summary writing, | 3 | 6 | 0.2 |
| **Totals** | | | | | | | | | | 149.5 | 5 |

# Master of Science in Information and Communication Technologies

## ANNEX 3

### - Condicions d'accés

Barcelona, 17 de juny del 2004

# ADMISSION REQUIREMENTS

As the academic level in the International MSc Program is highly advanced a thorough basic knowledge in electrical or telecommunications engineering fields, or in a strongly related study field, is required for admission.

Previous diplomas of applicants should be of substantial quality and proficiency in English is also required.

The applications are evaluated on the basis of the documents and information submitted by the applicant. The school will evaluate each applicant's capability to complete the MSc program successfully in one year and a half.

## Requirements for regular students

All students are required to prove a good level of English (TOEFL: minimum 573pts paper-based, 230pts computer-based; or similar). If undergraduate studies have been held in English, it is sufficient to provide a certification by the university.

The following documents have to be sent to the school :

- Application form.
- Certified copies of BSc or a MSc Diploma of a high scientific level.
- Official transcript of records from each institution attended at University level.
- TOEFL score report or equivalent language certification.
- Curriculum Vitae.
- 2 Letters of Reference.
- Statement of purpose/description of your professional and academic background described below.
- Other documents that might clarify the qualifications of the applicant, e.g. GRE test (recommended but not mandatory) and a short summary of the BSc or MSc thesis work of the applicant.

## Requirements for double degree students

Same academic requirements as for the double degree, established by the agreement with our partner universities.

All students are required to prove a good level of English (TOEFL: minimum 573pts paper-based, 230pts computer-based; or similar). If undergraduate

studies have been held in English, it is sufficient to provide a certification by the university.

The following documents have to be sent to the school :

- Application form with the approval of your home institution.
- Official transcript of records from each institution attended at University level.
- TOEFL score report or equivalent language certification.
- Curriculum Vitae .
- 2 Letters of Reference.

Requirements for ETSETB students

At least 110 UPC credits (88 ECTS) from the second cycle, including compulsory courses of 3B, 4A and 4B.

All students are required to prove a good level of English (TOEFL: minimum 573pts paper-based, 230pts computer-based; or Certificate in Advanced English, CAE).

The following documents have to be sent to the school :

- Application form
- TOEFL score report, or the Certificate in Advanced English.
- Curriculum Vitae

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## Academic background

The applicants must demonstrate skills in:

- Mathematics

  Linear algebra, analysis, and probability theory, e.g. corresponding to the following text: Leon-Garcia, A. Probability and random processes for electrical engineering. 2nd. ed. Addison Wiley, 1994 Papoulis, A. Probability, random variables and stochastic processes. 3rd. ed. McGraw Hill, 1991.

- Linear Systems

  Time continuous and time discrete signals and systems, e.g. corresponding to the following text: OPPENHEIM, A.V. and SHAFER, R.W. Discrete-time signal processing. 2nd ed. Prentice Hall, 1999.

- Electronic Design

  For analog circuits it is assumed a good knowledge of bipolar and MOS devices and basic circuits(a good reference is the Sedra & Smith´s "Microelectronic circuits" 4th ed., Oxford University Press) and operational amplifier based circuits(Sergio Franco, "Design with Operational Ampifiers and analog integrated circuits", Mc Graw Hill). Some Knowledge on digital design is required too, corresponding to: M.D. ERCEGOVAC, T. LANG and MORENO,J.H., "Introduction to digital systems", John Wiley, 1999, chapters 1-11

- Network Communications

  Larry L. Peterson, Bruce S. Davies, "Computer Networks: A System Aproach", 3rd edition, Morgan Kauffman, 2003.

- Software engineering including programming (C or equivalent)

  STALLINGS, W. Computer organization and architecture. Designing for performance. 5th. ed. Prentice Hall, 2000.

- Fundamental classical electromagnetics in simple media:

  LORRAIN, P., CORSON, D.R. & LORRAINE, F. Electromagnetic fields and waves. Freeman, 1988.

# Master of Science in Information and Communication Technologies

## ANNEX 4

### - Universitats del Consorci europeu del Màster

Barcelona, 17 de juny del 2004

**DEGREE AGREEMENT ON JOINT MASTER PROGRAMME IN INFORMATION AND COMMUNICATIONS TECHNOLOGY ( MINT)**

**BETWEEN :**

| | |
|---|---|
| Belgium | Katholieke Universiteit Leuven |
| Belgium | Université Catholique de Louvain |
| Denmark | Danmarks Tekniske Universitet (DTU) |
| France | Ecole Nationale Supérieure des Télécommunications de Paris |
| France | University of Pierre et Marie Curie Paris 6 |
| Germany | Universität Stuttgart |
| Italy | Università degli Studi di Genova |
| Poland | Akademia Górniczo-Hutnicza |
| Spain | Universitat Politècnica de Catalunya |
| Spain | Universidad Politécnica de Madrid |
| Spain | Universidad Politécnica de Valencia |
| Sweden | Kungliga Tekniska Högskolan |
| United Kingdom | University of Bristol |

**THE PARTIES ABOVE DECLARE**

Their willingness to establish the present agreement in order to strengthen their current cooperation on international postgraduate education. The expertise of the teaching and research staff of the Institutions involved can significantly contribute to improving the quality of this type of programme. This initiative is encouraged by the climate of change that currently concerns Higher Education in Europe.

# Master of Science in Information and Communication Technologies

## ANNEX 5

### - CVs del Professorat del Màster

Barcelona, 17 de juny del 2004

# Prof. Angel Cardama

Universitat Politècnica de Catalunya
Campus Nord. Mòdul D-3
Jordi Girona 1-3
08034 Barcelona, Spain

Tel : (34) 934016797
Fax: (34) 934017232
Email: cardama@tsc.upc.es

http://www-tsc.upc.es/eef

## Short Biography:

**Angel Cardama** received the Degree of Telecommunications Engineer from the School of Telecommunications Engineering in Madrid (1968), and the Sc.M. (1970) and Ph.D. (1973) in Electrical Engineering from Brown University. In 1972 he joined the faculty of the Telecommunication Engineering School at the Polytechnic University of Catalonia, where he holds the position of Professor. He is an elected Member of the Royal Academy of Doctors (2002).

His research interests range from the development of analytical and numerical techniques in electromagnetics to the design of microwave imaging systems and radar and communications antennas. He is the author of over sixty papers on the above fields, published in national and international journals and symposia. His group has pioneered research on fractal antennas and in 1998 the European Council of Applied Sciences and Engineering (Euro-CASE) recognized the originality of this technology awarding "The European Information Technology Prize.

He has been involved in science and technology management and planning at the National and European level. From 1987 to 1990 he coordinated the Area of Information and Communications Technologies at the National Agency of Evaluation and Prospective (ANEP) in Madrid. In 1993 he was a Member of the Advisory Board that prepared the 1st Research Plan for Catalonia. From 1997 to 2001 he served as Advisor for Engineering at the Board of Scientific and Technical Assessment (CONACIT) of the 2nd Research Plan for Catalonia. In 2001 he was appointed to the Board of Advice, Monitoring and Assessment (CASA) of the 3rd Research Plan for Catalonia. From 1992 to 1996 he became a Member of the Engineering Panel of the Human Capital and Mobility (HCM) and Training and Mobility of Researchers (TMR) Programs of the European Union and in the 5th Framework Program of the European Union he served as National Contact Point for the Key Action on "Future and Emerging Technologies" (1998-2002).

## Teaching Experience:

Courses taught:
- Applied Math, Networks, Fields and Waves, Antennas, Radiowave Propagation

Books:
- "Antenas" (co-author) Ed. UPC, 2nd ed. 2002. "Las telecomunicaciones en la Sociedad de la Información", CIMNE y RAD, 2003.

Publications in teaching:
- Class notes for the courses.

## 5 Most Relevant Research Publications:

- C. Puente, J. Romeu, A. Cardama, "Fractal-Shaped Antennas", Chapter 2 in "Frontiers in Electromagnetics" (D. H Werner and R. Mittra , Eds), pp. 48-93, IEEE Press, 2000. ISBN 0-7803-4701-3.
- S. Blanch, J. Romeu, A. Cardama, "Near field in the vicinity of wireless base-station antennas: an exposure compliance approach", IEEE. Trans. on Antennas and Propagation, vol. 50, n-5, May 2002, pp. 685-692.
- A. Camps, A. Cardama, D. Infantes, "Synthesis of large low-redundancy linear arrays", IEEE. Trans. on Antennas and Propagation, vol. 49, n-12, Dec 2001, pp. 1881-1883.
- A. Broquetas, J. Palau, L. Jofre, A. Cardama, "Spherical Wave Near-Field Imaging and Radar Cross-Section Measurement", IEEE Trans. on Antennas and Propagation, vol. 46, n 5, May 1998, pp. 730-735
- A. Cardama, E. T. Kornhauser, "Modal Analysis of Coupling Problems in Optical Fibers", IEEE Trans on MTT, vol. MTT-23, n 1, Jan. 1975, pp. 162-169.

## Participation in Relevant Research Projects:

He has participated in a large number of research projects. Some of the most recent ones are:
"Airborne remote sensing techniques for assessment, monitoring and surveillance of south Mediterranean maritime systems ("AMED")". (ESPRIT PROJECT-972561). 1998-2000.
"Fractal antennas for communication systems" (CICYT 2FD97/0135). 1998–2001.
"Advanced antennas and front-ends for UMTS base stations". (CICYT TIC 2001–2364-C03-03). 2001-2004.
"Improving fisheries monitoring through integrating passive and active satellite-based technologies ("IMPAST")", (Quality of Live Management of Living Resources Program QLRT-2000-02266). 2001-2004.
"Exploring the limits of fractal electrodynamics for the future telecommunications technologies ("FRACTALCOMS")", (IST 2001-33055). 2001 - 2003.

# Prof. Gregori Vázquez

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**Short Biography:**

**Gregori Vázquez** was born in Barcelona, Spain on April, 1961. He received the Telecommunication Engineering Degree by the Polytechnic University of Catalonia, the Ph.D. on Telecommunication Engineering by the Polytechnic University of Catalonia, 1988 and the Master on Business Administration (MBA) by the School of Business Management and Administration of Barcelona, ESADE, 1993.

Prof. Vázquez began his research and teaching activities at the Department of Signal Theory and Communications of the Polytechnic University of Catalonia in 1985 where he is now Full Professor.

Prof. Vázquez is a recipient of the 2003 Best Paper (Senior) Award of the IEEE Signal Processing Society.

Prof. Vázquez was elevated to Senior Member of the IEEE on February 1998 and he is serving as Associate Editor of the IEEE Transactions on Signal Processing in the Communications, Signal Detection and Estimation areas, since 1999. He is also member of the Editorial Board of the IEEE Signal Processing Magazine and member of the Signal Processing for Communications Technical Committee (SPCOM) of the IEEE Signal Processing Society and of the Conference Board of the IEEE Signal Processing Society, as well.

He is the chairman of the Communications Research Program of the Science and Technology Ministry of Spain. He has served as Associate Coordinator of the Spanish Evaluation Agency (ANEP) and panellist for the U.S. National Science Foundation (NSF) in the topics of Signal Theory and Communications.

Prof. Vázquez has been working in Signal Processing, Wireless, Satellite and Mobile Communications. Main areas of interest have been digital synchronization, adaptive techniques for digital equalization, MIMO optimal schemes and multi-user detection. He has been in charge of research and development projects for the European Space Agency (ESTEC/ESA), European Community (RACE, ACTS, HCM, IST), private and public companies and for the Spanish National Research Council (CICYT).

Prof. Vázquez has significant contributions in digital synchronization techniques, topic in which he has been specifically active. In this area, he has conducted research projects and Ph.D. students in the topic of single and multi-user synchronization. The main contributions on this area refers to cyclostationarity-based joint timing and carrier frequency synchronization, universal optimal quadratic timing and frequency synchronizers of linear modulations and binary continuous phase modulations and the evaluation of the performance upper bounds associated to these problems. Besides, he has also contributed to the study of near-far (MAI) resistant multi-user DS-CDMA synchronization techniques in AWGN and frequency selective channels. He has also work on the design of optimal MIMO transmission schemes based on coded-modulation communication systems. Additionally, Prof. Vázquez has been in charge of the definition and development of advanced satellite telecommunications systems. More precisely, he has been involved in pioneering projects related with satellite on-board multimedia processing payloads and satellite spread spectrum transponders, among others.

As mentioned above, the research tasks on digital synchronization have been complemented with research projects for the European Space Agency into the ESA's Advance Research and Development Programs on Digital Communications (ASTP and ARTES ESA's programs). Among other advanced projects on digital satellite communications, Prof. Vázquez was in charge at the UPC of the definition and development of on-board digital demodulators for the 'world first' Skyplex system for EUTELSAT Hot-Bird 4 satellite, that has been considered the first digital multi-media processor on board a satellite in the world by ESA. The Skyplex system was the first operative satellite payload capable of the on-board demultiplexing and digital demodulation of ETSI-DVB (Digital Video Broadcasting) signals from different geographical locations for the on-board multi-media composite signal multiplexing and coding in direct broadcast of DVB signals.

Prof. Vázquez has also been in charge at UPC of the definition and development of the digital communication and ranging systems for the ESA's ATV (Automatic Transfer Vehicle) of the International Space Station (ISS). Three Spread-Spectrum systems have been developed for the ATV project. The TDRSS Spread Spectrum transponder that it will ensure the communications between the ATV and the ground stations through the NASA's network Telemetry and Data-Relay Satellite System. The PLIST Spread Spectrum transponder that will be permanent equipment in the International Space Station and it will receive the images and the ranging information for the automated approach and docking to the Space Station of the ATV. Finally, the PLAST Spread Spectrum transponder that will ensure the correct telecommand of the ATV from the Space Station. An Ariane 5 rocket mid 2004 will launch the first ATV. Prof. Vázquez received a Special Mention of the 'Premi Ciutat de Barcelona' on Technology Innovation for this work.

Prof. Vázquez has been in charge at UPC of many others ESA's projects and technical studies in collaboration with industries, as the Multi-Carrier Demodulator 2 (MCD2), Multi-Purpose Modulator (MPM), the AMERHIS advanced OBP payload for Hispasat, among others.

Prof. Vázquez has been coordinator of a European Union network on Signal Processing Techniques in Digital Communications with the most well reputed European research institutions on Digital Communications with University of Aacken (G), Politecnico di Torino (I), University of Ghent (B), European Space Agency (NL), ENST Telecom Paris (F), Polytechnic University of Madrid (E), University of Pisa (I).

Prof. Vázquez has published more than 90 papers in international journals and conferences on Signal Processing and Digital Communications and he has been in charge and/or researcher in more than 45 Research and Development projects for public and private institutions on the same topics.

Prof. Vázquez was Workshop Co-Chairman of the ESA's Fifth International Workshop on Digital Signal Processing Techniques Applied to Space Communications DSP'96 held in Barcelona (Sitges), Spain, on September 1996. He was also member Technical Co-Chairman of the ESA DSP'98 and ESA DSP'03. He has been technical chairman, member of the technical committee and reviewer of more than 26 different international journals, conferences and events on Signal Processing and Digital Communications. Among others, he has served as reviewer of the following internationally reputed publications: IEEE Transactions on Signal Processing, IEEE Transactions on Communications, IEEE Signal Processing Letters, IEEE Communications Letters, IEEE Transactions on Selected Areas on Communications, IEEE International Conference on Communications, IEEE International Conference GLOBECOM and the IEEE Personal and Indoor and Mobile Communications Conference, IEEE International Workshop on Statistical Signal Processing.

**Teaching Experience:**

*Undergraduate:*

- Analog and Digital Communications (COM-I, COM-II, Lab. COM-I), E.T.S.E.T., Tech. University of Catalonia
- Signal Processing (SP), E.T.S.E.T., Tech. University of Catalonia
- Synchronization and Advanced Modem Design (SMAV), E.T.S.E.T., Tech. University of Catalonia
- Finance Analysis (PFC-I), E.T.S.E.T., Tech. University of Catalonia

*Graduate (Ph.D. Courses):*

- Advanced Statistical Signal Processing, Dept. of Signal Theory and Communications, Tech. University of Catalonia
- Introduction to Digital Communications, Universitat Oberta de Catalunya

**5 Most Relevant Research Publications:**

- Francesc Rey, Meritxell Lamarca, Gregori Vázquez

  "Robust Power-Allocation Algorithms for MIMO OFDM Systems with Imperfect CSI". Accepted and to appear in the IEEE Transactions on Signal Processing, 2004.

- Gregori Vázquez y Jaume Riba.

  "Non-Data-Aided Digital Synchronization". Signal Processing Advances in Communications. Prentice-Hall Inc, 2000. Volumen II: Single-User and Multi-User Communications. *Invited book chapter.*

- Jaume Riba, Josep Sala, Gregori Vázquez

  "Conditional Maximum Likelihood Timing Estimation". IEEE Transaction on Signal Processing. April 2001. ISSN 1053-587X. ***Best Paper Award 2003 of the IEEE Signal Processing Society.***

- Josep Sala and Gregori Vázquez

  "Statistical Reference Criteria for Adaptative Signal Processing in Digital Communications". IEEE Transactions on Signal Processing. *Special Issue on Signal Processing for Advanced Communications*, Jan. 1997. pp. 14-31, Vol.45, No.1. ISSN 1053-587X.

- Jaume Riba, Jason Goldberg and Gregori Vázquez

  "Robust Beamforming for Interference Rejection in Mobile Communications". IEEE Transactions on Signal Processing. *Special Issue on Signal Processing for Advanced Communications*, Jan. 1997. pp. 271-275, Vol.45, No.1. ISSN 1053-587X.

**Participation in Relevant Research Projects:**

"Soft Processing Techniques in Adaptive Coded Modulation for Broadband Wireless Communications". (TIC2003-05482). 2004-2007.

"Advanced Decoding Algorithms for Satellite Broadcasting". ESA. 2002.

"Integrated Broadcasting Interaction System (IBIS)". (IST-2000-25091). European Commission. 2001-2004.

"Fourth-generation Intelligent Transparent Networks Enhanced trough Space-Time Systems (FITNESS)". (IST-2000-30116). European Commission. 2001-2003.

"Analysis of the transmission section of a multimedia on-OBP payload". ALCATEL Espacio 1999.

"ATV DS_CDMA Digital Transponders", ESA. 2000-2001.

# Associate Professor Juan Antonio Chávez-Domínguez

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## Short Biography:

**Juan A. Chávez-Domínguez** was born in Andújar (Jaén), Spain on May 22, 1967. He received the M.Sc. (1991) and the Ph.D. degrees on Telecommunication Engineering from the Universitat Politècnica de Catalunya , Barcelona, Spain, in 1991. In 1992 he joined the Departament d'Enginyeria Electrònica of the Universitat Politècnica de Catalunya as an Assistant Professor. He became Associate Professor in 1998.

His research interests include thermoelectric cooling devices characterization, hazardous gases detection using infrared radiation, ultrasound non-destructive testing and low noise conditioning circuits. He is the author of 2 books, 13 journal and 38 conference papers in the areas of instrumentation and measurements, thermoelectric cooling and ultrasound non-destructive testing. He is an IEEE Member since 2000.

In 2001 the Director of Graduate School of Telecommunication Engineering (Escola Tècnica Superior de Telecomunicació de Barcelona) appointed Chavez deputy director of studies. He focused all efforts in development of a new syllabus based on European Space for a Higher Education.

## Teaching Experience:

He currently teaches advanced digital design topics and remote control systems in the post-graduate Electronic Engineering Master degree at the Escola Tècnica Superior de Telecomunicació de Barcelona (ETSETB). These subjects are offered in both classical (full classroom-presential sessions) and semi-distance formats. He also teaches basic and advanced analogue electronics in two undergraduate courses of the Telecommunication Engineering degree at the ETSETB.

Semi-distance teaching-learning methods and materials are topics of his interest. He is also working on the generation of interactive self-learning materials. Some of this work has been published in conference papers.

He has supervised more than 20 Master of Science Projects in the educational and research areas of interest, and in collaboration with privates companies.

Books and other relevant study materials:

- J. Pons, J.A. Chávez, "**Sistemes Digitals I**", Semi-distance material published in the web page of the Virtual Campus. Universitat Politècnica de Catalunya. 2002
- J.A. Chávez, S. Silvestre, "**Control Remoto de Sistemas**", Semi-distance material published in the web page of the Virtual Campus. Universitat Politècnica de Catalunya. 2003
- R. Bragós, J. A. Chávez, M. Fernández, J. Madrenas, V. Jiménez, E. Navarro, J. Salazar, L. Prat, "**Circuitos y Dispositivos Electrónicos. Fundamentos de Electrónica**." ISBN 970-15-0299-X. pp. 463. Alfaomega Grupo Editor, S. A. July 2001.

## 5 Most Relevant Research Publications:


- J. A. Chávez, J. A. Ortega, M. A. Pérez, M. J. García,"**Low-cost and minimal-conditioning interface for a PbSe photoconductor array",** IEEE Transactions on Instrumentation and measurement, Vol. 46, pp. 817-821, 1997-08-01.
- J. A. Chávez, J. A. Ortega, J. Salazar, A. Turó, M. J. García, "**Infrared simultaneous gas detector for an atmospheric environmental network",** Proceedings of the SPIE, ISSN 0277-786X, Vol. 3493, pp. 158-168, 1998.
- A. Turó, J. Salazar, J. A. Chávez, J. A. Ortega, M. J. García, "**Performance improvement of ultrasonic therapy equipment by modifying the classical transducer design",** IEE Proceedings - Science, Measurement and Technology, Vol. 146, pp. 107-112, 1999.
- J. Salazar, A. Turó, J. A. Chávez, J. A. Ortega, M.J. García, "**High-power high-resolution pulser for air-coupled ultrasonic NDE applications",** IEEE Trans. Instrum. Meas., Vol. 52, pp. 1792-1798, 2003.
- A. Turó, J. Salazar, J. A. Chávez, H. B. Kichou, T. E. Gómez, F. Montero de Espinosa, M.J. García,"**Ultra-low noise front-end electronics for air-coupled ultrasonic non-destructive evaluation",** NDE and T International, Vol. 36, pp. 93-100, 2003.

## Participation in Relevant Research Projects:

European Community Funding:

- **Development of a novel, low cost, easy to use instrument to estimate meat quality and composition in live animals based in measurements of backfat, loin eye muscle area and intramuscular fat** (ESCOLA). CRAF-1999-71276. Period: 2002-2004.
- **Application of a multisensor microsystem to prevent the overturn and improve the operational efficiency of small and medium sized mobile equipment** (SAFECONEQUIP). CRAFT-G3ST-CT-2001-50087. Period: 2001-2003
- **A low cost, piezoelectric powered pressure measurement technology, to help SME suppliers to differentiate themselves by adding value to eco-efficient product** (PIEZOTAG). CRAFT-1999-70093. Period: 2001-2003.
- **Development of an ultrasonic rheological sensor for non-invasive and non-destructive evaluation of dough.** (RHEODOUGH). CRAFT-QLK1-CT-2001-70377. Period: 2001-2003

National Funding:

- **Ultrasonic non-destructive testing system using lamb-waves in air**. CICYT DPI2001-2156-C02-01. Period: 2002-2004.
- **Non destructive testing and high resolution ecolocalization with air coupling. Generation, signal processing and signal conditioning.** TAP98-0911-C03-03. Period: 1998-2001

Private Funding:

- **Integrated Sensor for Environment Management** (SIGMA). Private funding: TRANSTOOL C-1666. Period: 1992-1993
- **Ultrasonic smart sensor system for the depth detection in a liquid medium.** Department of Hydraulic, Maritime and Environmental Engineering of the Technical University of Catalonia. 1996-1998
- **Infrared communication link for railway coach.** MYPE, S.L. 1999-2000
- **Design of a piezoelectric actuator for skin treatment using ultrasound.** SORISA. 1999-2000
- **Brushless motors testing system.** ATIPIC. 1999-2000
- **Water sensor for fuel filters.** ROBERT BOSCH ESPAÑA S.A. 2000-2001
- **Design of a piezoelectric transducer for an ultrasound therapy system.** SANISLINE, S.L. 2001-2002
- **Electrical characterization of ultrasound transducers and design of the output stage of a ultrasound therapy system.** ELECTROMEDICARIN, S.A. 2001-2002
- **Test and control automated system in an automobile panel assembly line.** Industrias JORDA. 1995-1996

## Other:

**Patents:**

- M. J. García Hernández, J. A. Chávez, J. A. Ortega, J. Salazar, A. Turó, "Body fat depth and elasticity measurement system", number 9801731, Spain, July 1998.
- M. J. García-Hernández, J. Salazar, J. A. Chávez, A. Turó, "Ultrasonic transducer for the evaluation of dough rheological properties", Number 200301604, Spain, July 2003.

# Associate Prof. Joan Pons Nin

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## Short Biography:

**Joan Pons**, born in Calafell, Spain, received the M.Sc. (1989) and the Ph.D. degree on Telecommunication Engineering (1995) from the Universitat Politècnica de Catalunya. In 1990 he joined the Departament d'Enginyeria Electrònica of the Universitat Politècnica de Catalunya, Barcelona, as an Assistant Professor. He became Associate Professor in 1997.

He has participated as a researcher in several projects funded by the Spanish and the European Union Governments. In May 1994 he was chairman of the VII Congreso Ibérico de Energía Solar, held in Vigo, Spain. In February 1997 he was a co-organiser of the 1st Conferencia de Dispositvos Electrónicos, held in Barcelona, Spain sponsored by the Electron Devices Society and the Spanish IEEE chapter. He is an IEEE and EDS Member since 1993. From 2000 he has been acting as a journal reviewer on MEMS control topics.

He is currently working on energy consumption and control optimization circuits for microelectromechanical devices based applications (MEMS). He has also worked on emitter characterization and optimization for advanced bipolar devices and on polysilicon contacted silicon solar cells. Semiconductor devices simulation and digital control circuitry are also research topics of his interest. He is the author of about 30 journal and conference papers in the area of electronic engineering.

## Teaching Experience:

Professor J. Pons currently teaches the basics of digital electronics in an undergraduate course of the Telecommunication Engineering degree at the Escola Tècnica Superior de Telecomunicació de Barcelona (ETSETB). He also teaches advanced digital design topics in the post-graduate Electronic Engineering degree (equivalent to a conventional Master's degree) at the ETSETB. This subject is offered in both classical (full classroom-presential sessions) and semi-distance (internet based learning) formats. He has also been teaching in discrete electronics and semiconductor devices subjects for several years.

Semi-distance teaching-learning methods and materials are topics of his interest. He is also working on the generation of interactive self-learning materials. Some of this work has been published in conference papers.

Books and other relevant study materials:

- R. Alcubilla, J. Pons, D. Bardés, '**Diseño Digital. Una perspectiva VLSI CMOS**.' pp. 311, Edicions UPC, Barcelona, Nov. 1995. 3rd Ed in Alfaomega Grupo Editorial, México, Feb. 1999.
- L. Prat, J. Pons, V. Jiménez, '**CyDEL: programa de autoaprendizaje de Circuitos y Dispositivos Electrónicos**.' ETSETB-UPC, 2001. ISBN: 84-699-6026-I. *Interactive software for basic electronicsself- learning that includes theory and tests generation and evaluation*.
- J. Pons, J.A. Chávez, "**Sistemes Digitals I**", Semi-distance material published in the web page of the Virtual Campus. Universitat Politècnica de Catalunya. 2002.

## 5 Relevant Research Publications:

- M. Domínguez, J. Pons, J. Ricart, A. Bermejo '**A Sigma-Delta Digital Oscillator for MEMS'** Proc. of the 2nd IEEE Int. Conf. on Sensors (Sensors 2003), pp. 834-838, ISBN: 07803-8134-3, Toronto (Canada), 22-24 October 2003.
- J. Pons, A. Rodríguez, L. Castañer. '**Voltage and pull-in time in current drive of electrostatic actuators**' IEEE Journal of Microelectromechanical systems (JMEMS), Vol.11, no.3, pp. 196-205, June 2002.
- L. Castañer, J. Pons, R. Nadal, A. Rodríguez. **'Analysis of the extended operation range of electrostatic actuators by current-pulse drive**.' Sensors and Actuators: Physical A, Vol 90/3, pp. 181-190, May 2001.
- L. Castañer, A. Rodríguez, J. Pons, S.D. Senturia '**Pull-in time-energy product of electrostatic actuators: comparison of experiments with simulation**.' Sensors and Actuators: Physical A, Vol 83/1-3, pp. 264-270, May 2000.
- J. Pons, R. Alcubilla, **"Superposition solutions for emitter quantum efficiency "**, Solid State Electronics, Volume 38, No 1, 1995, pp. 252-254.

## Participation in Relevant Research Projects:

'**Evaluation of possibilities of a polysilicon emitter technology for high efficiency silicon solar cells'** (ref.: JOULE No JOUR-0121-ES-HCLE), 1991-92.
'**Polysilicon emitter technology for silicon solar cells'** (Ref: JOULE II PL-920031, DGXII CE), 1992-95.
'**Aplicaciones de los dispositivos de heterounión a la tecnología y diseño de circuitos integrados'** (ref.: TIC 93-0517), 1993-96.
'**Energía en los microsistemas: aplicaciones a la generación de potencia y al control de actuadores'** (ref.: TIC98 0504), 1998-2001.
'**Sistema electrónico de control de calidad de Jamón Ibérico (JAMOTRON)**' (ref.: CICYT- FEDER-99), 1999-2001.
'**Sensor de alta precisión de ángulo de incidencia de luz'** (ref.: TIC00-0344-P4-04), 2001-03.
'**Desarrollo de filtros, osciladores y conmutadores en tecnologías de microsistemas para circuitos de radiocomunicación'** (ref.: TIC00-0144-P4-02), 2001-2004.
'**Excitación modo corriente de actuadores electrostáticos'** (ref.: TIC01 2163), 2001-2004.
'**Development of Control Circuits for RF MEMS Components'** (Ref: UPC-Nokia Research Center Contract), 2002-2003.

# Prof. Javier Rodríguez Fonollosa

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## Short Biography:

**Javier Rodríguez Fonollosa** was born in Barcelona, Spain on February 20, 1966. He received the telecommunication engineering degree from the Universitat Politècnica de Catalunya , Barcelona, Spain, in 1988, and the Ph.D. degree in electrical and computer engineering at Northeastern University, Boston, MA, in 1992. In 1989 he held a visiting appointment at the European Space Agency Centre in The Netherlands. From the Fall of 1989 until 1992 he was Research Assistant at Northeastern University, Boston, MA and the University of Southern California, Los Angeles, CA, where, upon completion of his Ph.D. degree, he became Research Associate. In 1993 he joined the department of Signal Theory and Communications of the Universitat Politècnica de Catalunya, Barcelona, Spain, where he became Associate Professor in 1996 and Professor in 2003.

He is the author of 15 journal and more than 70 conference papers in the area of signal processing and communications. In June 1995 he was co-chairman and organiser of the IEEE Signal Processing/ATHOS Workshop on Higher-Order Statistics held in Begur, Girona, Spain.

He was elected IEEE Senior Member and member of the Signal Processing for Communications (SPCOM) Technical Committee of the IEEE Signal Processing Society in February 1998 and January 1999 respectively. His research interests include many different aspects of statistical signal processing for communications. He participated as a panelist in the National Science Foundation (NSF) evaluation committee of Wireless Information Technology and Networking in 1999 and for the European Commission, Directorate-General XIII, in the evaluation of proposals and technical verification of research, technological development and demonstration projects submitted to the Fifth Framework Programme in 2001 and 2002. Since April 2003 he is evaluator for the European Commission, Directorate-General Information Society, Future and Emerging Technologies of the Sixth Framework Programme.

## Teaching Experience:

Courses taught:

- *Signal Processing in Communications, Signal Processing, Communications Laboratory II and Communications II*

## 5 Most Relevant Research Publications:

- Daniel P. Palomar and Javier R. Fonollosa, "**Practical Algorithms for a Family of Waterfilling Solutions**", accepted at IEEE Transactions on Signal Processing, (submitted Aug. 2003, revised Jan. 2004) 2004, ISSN 1053-587X.
- Xavier Mestre and Javier R. Fonollosa, **"Spatial Filtering for Pilot-Aided WCDMA Systems: a Semi-Blind Subspace Approach"**, IEEE Transactions on Signal Processing, Volume 51, No 10, October 2003, ISSN 1053-587X.
- Xavier Mestre, Javier R. Fonollosa and Alba Pagès, "**Capacity of MIMO Channels: Asymptotic Evaluation under Correlated Fading**", IEEE Journal on Selected Areas in Communications, Special Issue on MIMO Systems and Applications, Volume 21, No 5, June 2003, ISSN 0733-8716.
- Javier R Fonollosa, Markku Heikkilä, Jean Philippe Kermoal, Xavier Mestre, Alba Pagès, Adam Pollard, Laurent Schumacher, Juha Ylitalo, **"The IST METRA Project"**, IEEE Communications Magazine, Volume 40, No 7, July 2002, ISSN 0163-6804.X.
- Mestre and J. R. Fonollosa, **"ML Approaches to Channel Estimation for Pilot-aided Multi-rate DS/CDMA Systems"**, IEEE Transactions on Signal Processing, Volume 50, No 3, March 2002, pp. 696-709, ISSN 1053-587X.

## Participation in Relevant Research Projects:

In 1995 he lead UPC's participation in the European Commission funded ACTS Mobile projects TSUNAMI (II) and SUNBEAM that included the analysis of adaptive antennas in 2on and 3rd generation cellular mobile communication systems. Since January 2000 he was technical and project coordinator of the IST project METRA dedicated to the introduction of multi-antenna terminals in UMTS. This project belongs to Key Action 4 on Mobile, Satellite and Personal Communications and continued until 2003 under the name of I-METRA looking into more advanced systems and Systems beyond 3G.

# Prof. Lluis Jofre

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## Short Biography:

**Luis Jofre** was born in Barcelona, Spain in 1956. He received the M.Sc. (Ing) and Ph.D. (Doctor Ing.) degrees in Electrical Engineering (telecommunications eng.), from the Universitat Politècnica de Catalunya (UPC), Barcelona, Spain in 1978 and 1982, respectively.

From 1979 to 1980 he was Research Assistant in the Electrophysics Group at UPC, where he worked on the analysis and near field measurement of antenna and scatterers. From 1981 to 1982 he joined the Ecole Superieure d'Electricite, Paris, France, where he was involved in microwave antenna design and imaging techniques for medical and industrial applications. In 1982, he was appointed Associate Professor at the Communications Department of the Telecommunication Engineering School at the UPC, where he became Full Professor in 1989.

From 1986 to 1987, he was a Visiting Fulbright Scholar at the Georgia Institute of Technology, Atlanta, working on antennas, and electromagnetic imaging and visualization. From 1989 to 1994, he served as Director of the Telecommunication Engineering School (UPC), and from 1994-2000, as UPC Vice-rector for Academic Planning. From 2000 to 2001, he was a Visiting Professor at the Electrical and Computer Engineering Department, Henry Samueli School of Engineering, University of California, working on diversity systems, RF-MEMS and bio-communications. From 2002 to 2004 he has been serving as Director of the Catalan Research Foundation.

His research interests include antennas, electromagnetic scattering and imaging, and system miniaturization for wireless and sensing applications. He has published more than 100 scientific and technical papers, reports and chapters in specialized volumes.

## Teaching Experience:

Courses taught:
- Electromagnetics, Antennas, Communications Radar, Antennas for Wireless communications (UCI)

Books:
- Information Technology Policies, R&D Policies

Study material:
- Web and Multimedia Antenna &Electromagnetic courses materials

Publications in teaching:
- Antenas

## 5 Most Relevant Research Publications:

- Y.J.Kim**, L.Jofre**, F. De Flaviis, M.Q.Feng, **"Microwave Reflection Tomographic Array for Damage Detection of Civil structures"**, IEEE Transactions on Antennas and Propagation, Volume: 51, Issue: 11 , Nov. 2003, pp. 3022 – 3032.
- B.A. Cetiner, **L. Jofre**, J. Y. Qian, F. De Flaviis, **" Small-size Broadband multi-element Antenna for RF/Wireless Systems"**, IEEE Antennas and propagation Letters, Volume: 2, Issue: 22, 2003, pp: 326-329.
- **L. Jofre**, B.A.Cetiner, F. De Flaviis, **"Miniature Multielement Antenna for Wireless Communications"**, IEEE Transactions on Antennas and Propagation, May 2002, Vol. 50, No. 5, pp 658-669.
- H. Elsadek, H. Eldeeb, F. De Flaviis, **L. Jofre**, E. Abdallah, E. Hashish, **"Microwave Holographic 3D Rendering System Using Reduced Size Planar Array Antenna"**, Microwave and optical Technology Letters, vol. 29, no. 6, 1 May 2001, pp. 397-402.
- B.A. Cetiner, **L. Jofre**, F. De Flaviis, **"Reconfigurable Miniature Multielement Antenna for Wireless Networking**", Applied Microwave and Wireless, May 2002, pp. 658-669

## Participation in Relevant Research Projects:

He has participated in a large number of research projects. Some of the most representative ones are:
"Radar polarimetry. Theory and Applications", EU, FMRX-CT98-0211, 1998-2001
"Strategic Plan for the Information Society in Catalonia", Autonomous Catalan Government, 1998-2002
"Fractal antennas for communication systems" (CICYT 2FD97/0135). 1998–2001.
"Advanced antennas and front-ends for UMTS base stations". (CICYT TIC 2001–2364-C03-03). 2001-2004.
"Exploring the limits of fractal electrodynamics for the future telecommunications technologies ("FRACTALCOMS")", (IST 2001-33055). 2001 - 2003.
"Network Sensing Research Initiative", California Institute for Telecommunications & Information Technology (Cal-$(IT)^2$), 2001-20004
"3D Microwave imaging Technology for damage Assessment of Concrete Bridges", California Transportation Authority, 2002-2004

# Associate Prof. Leandro Navarro-Moldes

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http://people.ac.upc.es/leandro/

## Short Biography:

**Leandro Navarro-Moldes** was born in Barcelona, Spain on March 1964. He received the telecommunication engineering degree from the Universitat Politècnica de Catalunya, Barcelona, Spain, in 1988, and the Ph.D. degree in 1992.

He joined the Computer Architecture Department of UPC as an associate professor in 1988.

Leandro's research interests include the design of scalable and cooperative Internet services and applications. He is member of the ACM (Association for Computing Machinery) (SIGGroup, SIGComm), APC (Association for Progressive Communications) (Council member), IFIP TC6 WG6.4 (International Federation of Information Processing) (TC6-WG6.4 member), CCD (Centre de Cooperació per al Desenvolupament-UPC) (Council member), CPSR (Computer Professionals for Social Responsibility), IEEE (Institute for Electrical and Electronic Engineers), (Computer Society, Communications Society). He was a founding member of Pangea, a NGO providing Internet services to not-for-profit organisations and social movements, founding member of Espais Telemàtics S.L., and founding member of Rededia S.L. He is evaluator for the European Commission, Directorate-General Information Society, Future and Emerging Technologies of the Sixth Framework Programme.

## Teaching Experience:

AAD - Architecture of Distributed Applications: an introductory graduate course on the principles of distributed applications on the Internet.
CASO - Advanced Course on Operating Systems: a course on advanced topics of distributed operating systems.
DSD - The Design of Distributed Systems - an advanced course (graduate program) on Distributed Systems with emphasis on issues of scale in distributed systems and Internet scale systems.

Other courses I have taught:
XC - Computer Networks: an introductory undergraduate course on computer networks.
IO - Introduction to Computing: an introductory undergraduate course on computer architecture and programming (C language).

## 5 Most Relevant Research Publications:

- Generalization of The Fast Consistency Algorithm To a Grid With Multiple High Demand Zones, by Jesús Acosta-Elias, Joan Manuel Marquès, Leandro Navarro. Proceedings of the "International Conference on Computational Science 2003" (ICCS2003) LNCS - the copyright for this contribution is held by Springer-Verlag. February 2003.
- Decentralized vs. Centralized Economic Coordination of Resource Allocation in Grids, by T. Eymann, M. Reinicke, O. Ardaiz, P. Artigas, L. Díaz de Cerio, F. Freitag, R. Messeguer, L. Navarro, D. Royo, 1st European Across Grids Conference February, 13th-14th, 2003.
- Influence of the Document Validation/Replication Methods on Cooperative Web Caching Architectures", by Victor Sosa, Leandro Navarro. Communication Networks and Distributed Systems Modelling and Simulation Conference (CNDS'02), Western Multiconference (WMC'02). San Antonio, Texas. January 27-31, 200. Pags. 238-245. ISBN: 1-56555-244-X. January 2002.
- On service deployment on Peer-to-Peer networks, by Oscar Ardaiz, Leandro Navarro. IEEE Conference on Local Computer Networks (LCN 2001). November 2002.
- WWG: a Distributed Infrastructure to support groups, by Joan Manuel Marquès, Leandro Navarro. Proceedings of the ACM Conference: Group 2001 (Group'01). October 2001.

## Participation in Relevant Research Projects:

CRAC: Compartición de Recursos para Aprendizaje Cooperativo (also known as GPPMCLE: Grid and Peer-to-Peer Middleware for Cooperative Learning Environments). MCYT National project (UPC, UOC, UVA) (2002-2005).
Cosaco: Components for Cooperative Learning. CICYT National project (UVA, UPC) (2001-2003).
Other projects that I've been involved with in the past include:
Catnet: Catallactic mechanisms for the deployment of application networks on the Internet. (3/2002-3/2003)
MWeb: Distribution of Web Documents to Internet Digital Libraries
Comic: Computer-based Mechanisms of Interaction in Cooperative Work.
EPITELIO: a project for Social and Economic Integration of Citizens in Europe.
MOCCA: a research on environments for CSCW systems.
MSC: Muti-Site Computing. An experiment on High-Performance Computing and Networking for SME and Education.

# Associate Prof. José (Nacho) Navarro

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http://people.ac.upc.es/nacho/

## Short Biography:

**Nacho Navarro** has been teaching at the "Universitat Politecnica de Catalunya" since 1985. From 1983, he is working at the Computer Architecture Department (Departament d'Arquitectura de Computadors) and the European Center for Parallelism of Barcelona (CEPBA).

Nacho received the Ph.D. degree in Computer Science from the Technical University of Catalunya (UPC), Barcelona (Spain) in 1991. He is Associate Professor at the Computer Architecture Department (UPC), and actually Visiting Research Professor at University of Illinois at Urbana Champaign. He is vice-president of the Spanish UNIX User Group and he serves in the Board of Governors of the Spanish Computer Society (ATI). He was cofounder of the first Spanish Internet provider "Goya Servicios Telematicos", actually EUNET. He is member of the ACM and IEEE associations.

His research interests include operating systems, micro kernels, thread and processor scheduling policies, parallelizing compilers, embedded systems, performance analysis, and instrumentation and visualization tools.

At the European Center for Parallelism of Barcelona (CEPBA), in the framework of the European project NANOS, he worked in the interaction between the application, compiler and operating system towards improving the behaviour of parallel applications in shared-memory multiprogrammed multiprocessors.

From September 2001, he is working with the IMPACT group at the Coordinated Science Laboratory, UIUC. His current research is on automatic customization of complete operating environments by a combination of runtime analysis of application executions and deep static analysis done at compilation time. His focus is on Linux customization for embedded systems.

## Teaching Experience:

ISO – Introduction to Operating Systems: an introductory undergraduate course on operating systems.
SO – Intermediate course on operating systems concepts
DSO - Operating Systems Design: a course on advanced topics of microkernels and distributed operating systems.
SONAR – Operating systems for New Architectures- an advanced course (graduate program) on new research proposals on Systems and Computer Architecture.
Microcomputer Lab (UIUC) – Design and implementation of hardware devices using FPGA and the corresponding Linux device drivers.

## 5 Most Relevant Research Publications:


- Ronald D. Barnes, Erik M. Nystrom, John W. Sias, Sanjay J. Patel, Nacho Navarro, Wen-mei W. Hwu, "Beating In-Order Stalls with "Flea-Flicker" Two-Pass Pipelining", 36th Annual International Symposium on Microarchitecture, MICRO-36, December 2003
- Yolanda Becerra, Toni Cortés, Jordi Garcia and José I. Navarro. "Evaluating the Importance of Virtual Memory for Java". In 2003 IEEE International Symposium on Performance Analysis of Systems and Software (ISPASS-'2003), pp. 101-110, March 2003.
- Marc González, Albert Serra, Xavier Martorell, José Oliver, Eduard Ayguadé, Jesús Labarta and José I. Navarro. "Applying Interposition Techniques for Performance Analysis of OpenMP Parallel Applications". In 14th International Parallel and Distributed Processing Symposium (IPDPS'2000), pp. 235-240, May 2000.
- Xavier Martorell, Julita Corbalán, Dimitrios Nikolopoulos, José I. Navarro, Eleftherios Polychronopoulos, Theodore Papatheodorou and Jesús Labarta. "A Tool to Schedule Parallel Applications on Multiprocessors: the NANOS CPU Manager". In 6th Annual Workshop on Job Scheduling Strategies for Parallel Processing, pp. 55-69, May 2000.
- Albert Serra, José I. Navarro and Toni Cortés. "DITools: Application-level Support for Dynamic Extension and Flexible Composition". In USENIX Annual Technical Conference (USENIX'2000), pp. 225-238, June 2000.


## Participation in Relevant Research Projects:

- Nanos Project at CEPBA-IBM Research Institute: Effective Integration of Fine-grain Parallelism Exploitation and Multiprogramming
- C2S2: Long-range design solutions for next-generation circuits, systems built from circuits, and the software that runs on them.
- GSRC: the GSRC Soft Systems Theme at the MARCO Focus Center Research Program
- Gelato: Open source resources for running Linux on the Itanium (IA-64) platform

# Master of Science in Information and Communication Technologies

## ANNEX 6

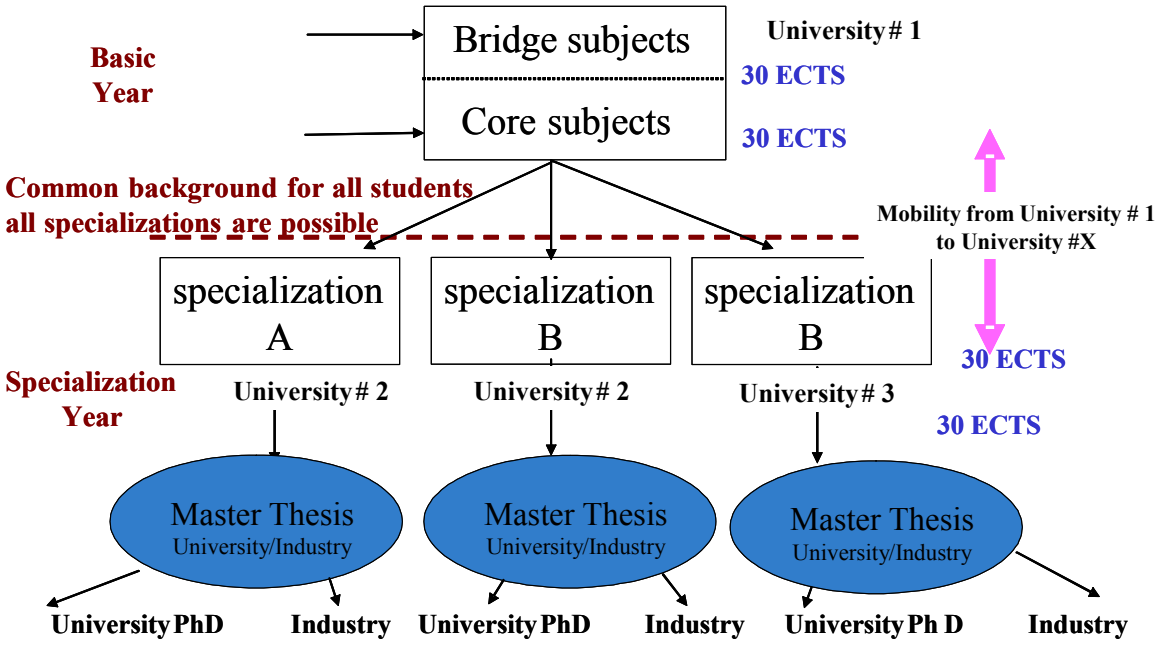
### - Pla de mobilitat dels estudiants

Barcelona, 17 de juny del 2004

## MODEL DE MOBILITAT CONTEMPLAT

Els estudiants admesos al Màster de l'ETSETB tindran l'opció de fer el programa íntegre a l'escola o bé fer part dels seus estudis a l'estranger. Amb aquest objectiu s'ha creat una xarxa gran d'Universitats de prestigi a Europa amb la intenció de proposar un programa de Màster conjunt. S'ha realitzat ja una proposta al programa de la comunitat europea Erasmus Mundus[1] pel curs 2004/2005.
Les Universitats europees que en principi s'han involucrat són :
Katholieke Universiteit Leuven; Université Catholique de Louvain; Danmarks Tekniske Universitet (DTU); Ecole Nationale Supérieure des Télécommunications de Paris; University of Pierre et Marie Curie Paris 6; Universität; Università degli Studi di Genova; Akademia Górniczo-Hutnicza de Cracovia; University of Bristol. A Espanya també s'han involucrat l'ETSIT de Madrid i València.
En principi la mobilitat pot ser variada. Un estudiant pot fer un semestre en una Universitat de la xarxa i els crèdits superats serien reconeguts a la Universitat d'origen. En particular a l'ETSETB es reconeixeran un màxim de 30 ECTS. També és possible fer un programa conjunt de Màster, de tal manera que un estudiant realitzaria un primer curs en una Universitat de la xarxa i hauria de superar 60 crèdits ECTS i un segon curs en un altre Universitat, superant així mateix 60 crèdits ECTS. L'estudiant rebria el títol de Màster de les dos Universitats. Per que això sigui possible, l'objectiu principal de la xarxa és anivellar coneixements després del cursos nucli de tal manera que qualsevol estudiant dins d'un programa de Màster pugui anar a fer una especialitat a qualsevol altre Universitat de la xarxa. Aquesta estructura està representada a la figura *Master Structure*. En el cas de l'ETSETB, com el pla pilot no contempla la realització de cursos pont, per obtenir el doble diploma l'estudiant faria els cursos nucli i d'especialització a l'ETSETB i una segona especialització i projecte de Màster en una altra Universitat.

[1] http://europa.eu.int/comm/education/programmes/mundus/index_en.html




***Master Structure***

# Master of Science in Information and Communication Technologies

## ANNEX 7

### - Estudi de Màsters a Europa

Barcelona, 17 de juny del 2004

## ESTUDI DE MÀSTERS A EUROPA

L'ETSETB ha realitzat un estudi dels Màsters en temàtiques properes a les Telecomunicacions que actualment (curs 2003/2004) s'imparteixen en algunes Universitats de prestigi i que s'adjunten amb aquest annex. Aquests documents han estat de força utilitat per definir l'estructura i els continguts del Master de l'ETSETB. En primer lloc es presenten quadres resums de les assignatures ofertades en els diferents Màsters, indicant, quan s'ha disposat de la informació, el nombre de crèdits ECTS, en quin període s'ofereixen les assignatures, si es tracta d'assignatures obligatòries o optatives, possibles especialitats i la duració de la Tesi de Master. A més a més, s'ha distingit en color vermell aquelles assignatures que ens han indicat representants de les Universitats sota estudi com a fonamentals dins el seu Màster i que nosaltres anomenem nucli. Els continguts d'aquestes assignatures s'especifiquen en el segon document. En un parell de casos també s'ha distingit en color blau, les assignatures que es consideren pont.

En quant a l'estructura dels Masters s'ha observat que en les Universitats europees el sistema semestralitzat és el més utilitzat, tret de l'ENST Paris que està organitzada per trimestres.

Pel que fa a la durada dels Masters és d'un any i mig o dos anys i no hi ha un predomini clar entre aquestes dues opcions. La taula 1 indica quines Universitats tenen Masters d'un any i mig i quines de dos anys.

| Masters d' un any i mig de durada | Masters de dos anys de durada |
|---|---|
| • U of Stuttgart (si no es fan cursos pont)<br>• KTH<br>• Chalmers<br>• ENST Paris<br>• AGHUST Krakow<br>• University of Bristol | • RWTH Aachen<br>• U of Stuttgart (amb cursos pont)<br>• TU Delft<br>• Denmark TU<br>• Helsinki UT |

Taula 1 Durada de Masters ofertats per diverses Universitats europees

El pes de la tesi de Màster és en general d'un semestre o 30 crèdits ECTS, excepte en el cas de la TU Delft que té un pes de 45 ECTS. La tesi es pot desenvolupar tan en una empresa com a la mateixa Universitat, tot i que predomina aquesta segona opció.

A nivell de continguts hi ha força afinitat amb el que l'ETSETB podria oferir com a assignatures nucli. En les assignatures més especialitzades hi ha més diversitat de continguts i d'estructuració.

# Masters offered by some European institutions in areas related to Electrical Engineering (Telecommunications)

## Universities under study :

### RWTH Aachen – Germany

http://www.rwth-aachen.de/zrs/v0001/english_ms_msegl_commegl.htm

**Master of Science in Communications Engineering**

### Stuttgart University - Germany

http://www.infotech.uni-stuttgart.de/prog/Prog_Curr_Courses.html

**Major in Communications Engineering and Media Technology**

### KTH Stockholm – Sweden

http://www.s3.kth.se/gradedu/MasterWireless/

**Master of Science with Specialization in Wireless Systems**

### Chalmers- Sweden

http://www.s2.chalmers.se/imp

**Master of Science in Digital Communication Systems and Technology**

### ENST Paris – France

http://www.enst.fr/3e-cycle-msc-masteres/master-science/

**Master of Science in Electrical Engineering**

### TU Delft – Holland

http://academics.its.tudelft.nl/nl/gidsen0304/MEE.pdf

**Master of Science in Electrical Engineering**

## Denmark Technical University - Denmark

http://www.com.dtu.dk/education/intmsc/

**Master of Science in Telecommunications**

## AGH University of Science and Technology – Krakow Poland

http://www.syllabus.agh.edu.pl/en/EL/main.html

**Master of Science in Electronics and Telecommunications Engineering**

## University of Bristol– UK

http://www.een.bris.ac.uk/admissions/postgraduate/msc/msc%20structure.html

**Master of Science in Communication Systems and Signal Processing**

## HUT - Finland

http://www.sahko.hut.fi/english/Telecommunications/

**Master program in Telecommunications**

# RWTH Aachen – Germany

**Master of Science in Communications Engineering**

| First Year | | Second Year | |
|---|---|---|---|
| First Semester | Second Semester | Third Semester | Fourth Semester |
| Compulsory Courses | Compulsory Courses | Elective Courses | |
| • Signals & Systems<br>• Estimation and Detection Theory<br>• Information Theory and Source Coding<br>• Communication Protocols<br>• Antenna Engineering | • Advanced Channel Coding and Modulation<br>• Algorithm Design of Digital Receivers<br>• VLSI Architecture<br>• Microwave Circuits<br>Elective Course<br>• Cryptography | • DSP-Design Methodologies and & Tools<br>• Multimedia Communications<br>• Advanced Topics in Communications<br>• Mobile Communication Systems | • Master Thesis (6 months) |
| • Laboratory<br>• Language Course | • Laboratory<br>• Industrial Internship (8 weeks) | • Seminar<br>• Management & Economics | |

# University of Stuttgart – Germany

**Master of Science in Information Technology**

Majors in : Communication Engineering and Media Technology; Embedded Systems Engineering; Micro and OptoElectronics

**Communication Engineering and Media Technology:**

| First Year | | Second Year | |
|---|---|---|---|
| Preparatory Semester | First Semester | Second Semester | Third Semester |
| • System Theory<br>• Operating Systems Principles<br>• Communications Transmission<br>• Computer Structure and Organization<br>• Electronic and Digital Circuits<br>• Concepts of Programming Languages<br>• Radio Frequency Technology<br>• Data Structures and Algorithms | • Communication Networks I<br>• Communications III<br>• Digital Signal Processing<br>• Image Understanding<br>• Introduction to Distributed Systems Networks and Processes<br>• Radio Frequency Technology III<br>• Real Time Programming | • Basics of Radio Frequency Technology<br>• Communication Networks I<br>• Communication Networks II<br>• Communications III<br>• Database and Information Systems<br>• Digital Signal Processing<br>• Digital Video Communications<br>• Error Detecting and Error Correcting Codes<br>• Image Understanding<br>• Introduction to Distributed Systems<br>• IP based Networks and Applications<br>• Graphical Interactive Systems<br>• Mobile Communications I<br>• Mobile Communications II<br>• Netbased Applications and e-Commerce<br>• Networks and Processes<br>• Optoelectronic Devices and Circuits II<br>• Optoelectronic Devices and Systems I<br>• Parallel Programming<br>• Radio Frequency Technology III<br>• Real Time Programming<br>• Software Engineering for Real-Time Systems<br>• Systems Programming<br>• Teletraffic Theory and Engineering<br>• Visualization | • Master Thesis |

# KTH Stockholm –Sweden

**Master of Science with Specialization in Wireless Systems**

Electives with three profiles : Wireless Communications, Information Transmission and Processing, Networks and Services

| First Year | | Second Year |
|---|---|---|
| First Semester (divided in 2 quarters) | Second Semester (divided in 2 quarters) | Third Semester |
| 30ECTS (Compulsory & Electives) | 30 ECTS (Compulsory & Electives) | 30 ECTS |
| **Quarter 1:**<br>• RadioCommunication (6 ECTS)<br>• Introduction to Signal Theory (4.5 ECTS)<br>**Quarters 1-2:**<br>• Communication Theory(9 ECTS)<br>**Quarter 2**:<br>• Queuing Theory and Teletraffic Systems (6ECTS)<br>• Digital Signal Processing (7.5 ECTS)<br>• Speech Signal Processing (6 ECTS) | **Quarter 3:**<br>• Information Theory and Source Coding (7.5 ECTS)<br>• Adaptive Signal Processing(6 ECTS)<br>• Advanced Communications Theory (6 ECTS)<br>• InternetWorking (6 ECTS)<br>• Antenna Systems Technology (7.5 ECTS)<br>**Quarters 3-4:**<br>• Communication System Design (15 ECTS)<br>• Wireless Seminars(3 ECTS)<br>**Quarter 4:**<br>• Information Theory and Channel Coding (7.5 ECTS)<br>• Radio Electronics(7.5 ECTS)<br>• Wireless Networks (12 ECTS)<br>• Agent Programming (6 ECTS)<br>• Intelligent Interfaces (6 ECTS)<br>• Project Course : Signal Processing/Digital Communications(9 ECTS) | • Master Thesis (at KTH or in the Industry) |

# Chalmers - Sweden

**Master of Science in Digital Communication Systems and Technology**

Three blocks : Fundamentals of Digital Communications, Wireless Applications & Network Applications

| First Year | | Second Year |
|---|---|---|
| First Semester (divided in 2 quarters) | Second Semester (divided in 2 quarters) | Third Semester |
| Compulsory Courses | Elective Courses | |
| **Quarter 1:**<br>• Computer Introduction (1.5 ECTS, optional)<br>• Applied Signal Processing (5.25 ECTS)<br>• Probability and Stochastic Processes (6 ECTS)<br>**Quarters 1-2:**<br>• Digital Communications (9 ECTS)<br>**Quarter 2**:<br>• Computer Communications (4.5 ECTS)<br>• Statistical Digital Signal Processing (5.25 ECTS) | **Quarter 3:**<br>• Internet Technology (6 ECTS, elective)<br>• Microwave Engineering in Communications (6 ECTS elective)<br>**Quarters 3-4:**<br>• Data Compression (9 ECTS)<br>• Wireless Communications (9 ECTS)<br>**Quarter 4:**<br>• Advanced Internet Technology (6 ECTS, elective)<br>• Satellites in Communications and Navigation (6 ECTS, elective) | • Master Thesis (at Chalmers or at the Industry) |

# ENST Paris –France

**Master of Science in Electrical Engineering**

| First Term (Sep_Dec) | Second Term(Jan-Mar) | Third Term(Ma-June) | Internship(July-Dec) |
|---|---|---|---|
| Compulsory Courses | 2 options (18.5 ECTS) | Elective Courses (13.5 ECTS) | |
| • Signal Processing for digital communications. 4.5 ECTS<br>• Electronic Architectures for Telecommunications Systems. 4.5 ECTS<br>• Fundamentals of Optical and Radiofrequency Systems. 4.5 ECTS | **Digital Communications**<br>• Optical communications and WDM<br>• Optical networks for IP and ATM<br>• Digital Communications<br>• Radiofrequencies & microwaves<br>• Mobile RadioCommunications Networks.<br>**Electronics for communication Systems**<br>• Electronic System Integration for Radiocommunications<br>• Radiofrequencies and Microwaves<br>• Microelectronics<br>• Architecture, Systems and Compilation<br>• Real Time and Multimedia Applications | **Digital Communications**<br>• High PayLoad Networks and IP New Technologies<br>• Communications, links and digital access<br>• CARTAPP<br>• Wide Band Local Loop<br>**Electronics for communication Systems**<br>• Electronic System Integration Project for Intelligent Transportation<br>• Communications project<br>• Signal Processing : study case and simulations<br>• Digital Integrated Systems Development<br>• Robotics and embedded systems | • Internship |
| • French & Humanities (4.5 ECTS) | • French | • French & Core Units in Economics and Management (4.5 ECTS) | |

# TU Delft – Holland

**Master of Science in Electrical Engineering**

Variants in : Telecommunications, MicroElectronics, Electrical Power Engineering

**Variant in Telecommunications :**

| First Year | | Second Year | |
|---|---|---|---|
| First Semester | Second Semester | Third Semester | Fourth Semester |
| Compulsory (20-26 ECTS) | Elective Courses (37 ECTS) | | |
| • Electromagnetic Radiation, Scaterring and Imaging (4 ECTS)<br>• Electromagnetic waveguides(2 ECTS)<br>• Antenna Systems(4 ECTS)<br>• Transmission Systems Engineering(4 ECTS)<br>• Mobile and Wireless Networking (4 ECTS)<br>• Observation Technology (4 ECTS)<br>• Advances in Networking (3 ECTS) | • Imaging and Inverse Scattering<br>• Electromagnetic Compatibility in Communications<br>• Propagation and radiowaves<br>• Radar<br>• RadioNavigation<br>• Traffic Guidance Systems<br>• Information Transmission Techniques<br>• Error Correcting Codes<br>• Performance Analysis<br>• Enterprise Networks<br>• Introduction to Avionics<br>• Signal Processing for Communications | • Wavefields Imaging<br>• Computational Electromagnetics<br>• Digital Signal Processing<br>• Radar Earth Observation<br>• Avionics Lab<br>• Intro to Ultra-Widedband Sys. And Anten.<br>• Electromag. Simul. For Wire. And Radar Eng.<br>• Advanced Topic in Digital Wireless Comm | • Master Thesis (45 ECTS)<br>• Free elective space (18 ECTS) |

# Denmark Technical University

**Master of Science in Telecommunications**

120 ECTS (15 mandatory list, 80 mandatory and specialization list, 10 free, 30 thesis)

| First Year | | Second Year | |
|---|---|---|---|
| Mandatory list | Specialization list | Specialization list (cont.) | Third Semester |
| • Optical Communications (10 ECTS)<br>• Telecommunication (10 ECTS)<br>• Internet Technologies and their applications. (10 ECTS)<br>• Nanoscale Materials Physics (10 ECTS)<br>• Solid-State Electronics and MicroTechnology (10 ECTS) | • Error Correcting Codes<br>• Cryptology<br>• Introductory Programming<br>• Introduction to E-business (Project Course)<br>• Digital Design and Computer Organization<br>• Design and Synthesis of Embedded Systems<br>• Design of Integrated Circuits<br>• Concurrent Systems<br>• Distributed Systems<br>• Real-Time Systems<br>• Software Engineering<br>• Object Oriented Analysis and Design<br>• Object Oriented Domain Modeling<br>• Programming in C, C++<br>• Digital Signal Processing<br>• Applied Digital Signal Processing<br>• Advanced Digital Signal Processing<br>• Non-Linear Signal Processing<br>• Teletraffic Engineering and Network Planning<br>• Advanced Data Communication<br>• Integrated Broadband Electronics<br>• Broadband Networks | • Digital Image Analysis, Vision, and Computer Graphics<br>• Applied Mathematics for Physicists<br>• Optics and Photonics<br>• Fourier Optics<br>• Lasers<br>• Non-Linear Optics<br>• Wireless Communication<br>• RF Communication Circuits<br>• Microwave Techniques<br>• Antennas<br>• Semiconductor Optoelectronics<br>• Integrated Optics<br>• Experimental and Computational Photonics<br>• Physics of Semiconductor Optical Devices<br>• Nano-Photonic Devices<br>• Practical Integrated Optics<br>• Nonlinear Guided Wave Phenomena<br>• Future Trends in Photonics<br>• Optical Communication Systems<br>• Optical Networks<br>• Data Compression<br>• Digital Video Technology<br>• Digital Communication | Master Thesis (30 ECTS) |

| | | | |
|---|---|---|---|
| | • Access and Home Networks<br>• Advanced Protocols<br>• Optical Networks<br>• Network Modelling and Simulation<br>• Routing in Data Networks<br>• Advanced Telecommunications<br>• Future Mobile Communication Systems and Services<br>• Interaction Design - Multimedia Systems<br>• Multimedia Programming<br>• Multimedia and Communication Services<br>• Computer-supported Cooperative Work | • Tele-Information: Strategy - Creativity<br>• Introduction to E-business (Project Course)<br>• Information and Communication Technology - Markets and Business Models<br>• Telecommunication Economics and Policy | |

# AGH University of Science and Technology – Krakow Poland

**Department of Telecommunications**
**Master of Science in Electronics and Telecommunications Engineering**
**Telecommunications :**

| First Year | | Second Year |
|---|---|---|
| First Semester (Semester 8) | Second Semester (Semester 9) | Third Semester (Semester 10) |
| **Compulsory:**<br>• Operation System Networking (3 ECTS)<br>• Signal and Management Systems for Telecommunication (7 ECTS)<br>• Modelling and Analysis of Telecommunication Networks (7 ECTS)<br>• Satellite Communications (7 ECTS)<br>**Elective (2):**<br>• Access Networks<br>• Web system – Programming and directions of Development<br>• Digital Video Libraries<br>• Next Generation IP Networks<br>• Specification and Simulation of Telecommunication Protocol | **Compulsory:**<br>• Economics and Regulations of Telecommunications<br>• Multimedia Systems<br>• Telecommunications network planning<br>**Elective:**<br>• Legal Protection of New Technologies in Telecommunications<br>• Mobile Data Networking<br>• E-commerce and electronics transactions<br>• Modelling and Design of Information Sytems<br>• Selected Issues in Switching Systems<br>• Radio-relay Systems | • Master Thesis (30 ECTS) |

# University of Bristol– UK

**Master of Science in Communication Systems and Signal Processing**

| First Year | | Second Year |
|---|---|---|
| First Semester | Second Semester | Third Semester |
| **Compulsory:**<br><br>• Principles of Communication Systems<br>• Antennas<br>• Electromagnetic Compatibility<br>• Coding Theory<br>• Radio Frequency Engineering<br>• Mobile Communication Systems<br>• Digital Filters and Spectral Analysis<br>• Communication Systems<br>• World of the Entrepreneur<br>• Digital Signal Processing<br>• Optoelectronic Devices and Sytems<br>• Networks and Protocols | **Elective courses (Communications/Digital Signal Processing/Optical Data Communications):**<br><br>• RF Subsytems<br>• Satellite Communications<br>• Advanced Networks<br>• Introduction to Cryptography<br>• Advanced Mobile Radio Techniques<br>• Image and Video Coding<br>• Optimum Signal Processing<br>• Neural Networks<br>• Speech Processing<br>• VLSI<br>• Advanced Optoelectronic Devices<br>• Optical Communication Sytems and Data Networks<br>• Integrated Circuits Engineering | Individual Research Project |

# Helsinki University of Technology

**Master program in Telecommunications**

4 Majors : Radiocommunications/Telecommunications Software/Digital Signal Processing/Networking Technology

**Major in RadioCommunications**

| First Year | | Second Year | |
|---|---|---|---|
| First Semester<br>Basic studies (24 ECTS) | Second Semester (24-30 ECTS) | Third Semester | Fourth Semester or earlier |
| • Transmission Methods in Telecommunication (6 ECTS)<br>• Telecommunication Systems (4.5 ECTS)<br>• Introduction to Software Engineering (4.5 ECTS)<br>• Mobile Communication Systems and Services (3 ECTS)<br>• Signal Processing Systems (3 ECTS)<br>• Finnish 1 (3 ECTS) | • Signal Processing in Telecommunications<br>• RadioPlanning Methods<br>• Communications Systems<br>• Product Devdelopment of Telecommunications Systems<br>• Finnish 2<br><br>**Electives**<br><br>• Capacity Enhancement Methods for Radio Interface<br>• Digital Communication Systems<br>• Communication Networks<br>• System engineering in wireless Communication | • Fixed Radio Networks<br>• Laboratory works in Radiocommunications<br>• Special Project<br><br>**Electives**<br><br>• Telecommunications Forum<br>• Foundations of Radio Engineering<br>• Introduction to Teletraffic Theory<br>• Spread Spectrum and Orthogonal Multiplexed<br>• Coding Methods<br>• Information Theory | Master Thesis (30 ECTS) |

# Helsinki University of Technology

**Master program in Telecommunications**

4 Majors : Radiocommunications/Telecommunications Software/Digital Signal Processing/Networking Technology

**Major in Telecommunications Software**

| First Year | | Second Year | |
|---|---|---|---|
| First Semester<br>Basic studies (24 ECTS) | Second Semester (24-30 ECTS) | Third Semester | Fourth Semester or earlier |
| • Database Management (4.5 ECTS)<br>• Telecommunication Systems (4.5 ECTS)<br>• Introduction to Software Engineering (4.5 ECTS)<br>• Mobile Communication Systems and Services (3 ECTS)<br>• Signal Processing Systems (3 ECTS)<br>• Finnish 1 (3 ECTS) | • Embedded Systems<br>• Computer Networkds<br>• Object-Oriented programming<br>• Multimedia Technology | • Laboratory Work of Telecommunications Software<br>• Information Security Technology<br>• Seminar on Network Security or in Internetworking<br>• Finnish 2<br><br>**Electives**<br><br>• Operating Systems<br>• Parallel and Distributed Systems<br>• Telecommunications Forum<br>• Computer Graphics | Master Thesis (30 ECTS) |

# Helsinki University of Technology

**Master program in Telecommunications**

4 Majors : Radiocommunications/Telecommunications Software/Digital Signal Processing/Networking Technology

**Major in Digital Signal Processing**

| First Year | | Second Year | |
|---|---|---|---|
| First Semester<br>Basic studies (24 ECTS) | Second Semester (24-30 ECTS) | Third Semester | Fourth Semester or earlier |
| • Transmission Methods in Telecommunication (6 ECTS)<br>• Telecommunication Systems (4.5 ECTS)<br>• Introduction to Software Engineering (4.5 ECTS)<br>• Mobile Communication Systems and Services (3 ECTS)<br>• Signal Processing Systems (3 ECTS)<br>• Finnish 1 (3 ECTS) | • Signal Processing in Telecommunications<br>• RadioPlanning Methods<br>• Digital Communications Systems<br>• Product Devdelopment of Telecommunications Systems<br>• Laboratory works in RadioCommunications<br>• Finnish 2 | • Statistical Signal Processing<br>• Signal Processing in Telecommunications<br>• Special Project<br><br>**Electives**<br><br>• Telecommunications Forum<br>• Foundations of Radio Engineering | Master Thesis (30 ECTS) |

# Helsinki University of Technology

**Master program in Telecommunications**

4 Majors : Radiocommunications/Telecommunications Software/Digital Signal Processing/Networking Technology

**Major in Networking Technology**

| First Year | | Second Year | |
|---|---|---|---|
| First Semester<br>Basic studies (24 ECTS) | Second Semester (30 ECTS) | Third Semester | Fourth Semester or earlier |
| • Telecommunication Forum (1.5-6 ECTS)<br>• Telecommunication Systems (4.5 ECTS)<br>• Introduction to Software Engineering (4.5 ECTS)<br>• Mobile Communication Systems and Services (3 ECTS)<br>• Service creation and Management (3 ECTS)<br>• Finnish 1 (3 ECTS) | • Introduction to Teletraffic theory<br>• Security of Communication Protocols<br>• Computer Networks<br>• Signaling Protocols<br>• Signal Processing Systems<br>• Finnish 2<br><br>Electives<br><br>• Basic course in C/C++ programming<br>• Basic Course in Programming 2<br>• | • Queueing Theory<br>• Network Technology, special assignment<br>• Laboratory Course on Networking Technology<br>• Routing in Communication Networks<br>• Protocol Design<br><br>**Electives**<br><br>• Networking business<br>• Teletraffic theory<br>• Service creation and Management | Master Thesis (30 ECTS) |

# Description of Core contents for Masters belonging to the following Universities :

## Stuttgart University - Germany

http://www.infotech.uni-stuttgart.de/prog/Prog_Curr_Courses.html

**Major in Communications Engineering and Media Technology**

## ENST Paris – France

http://www.enst.fr/3e-cycle-msc-masteres/master-science/

**Master of Science in Electrical Engineering**

## Denmark Technical University - Denmark

http://www.com.dtu.dk/education/intmsc/

**Master of Science in Telecommunications**

## University of Bristol– UK

http://www.een.bris.ac.uk/admissions/postgraduate/msc/msc%20structure.html

**Master of Science in Communication Systems and Signal Processing**

## 1.1 University of Stuttgart

| 1.1.1 Communication Networks I | 1.1.2 Digital Signal Processing | 1.1.3 Communications III |
|---|---|---|
| Fundamental Architectures, Functional Principles and Design Methodologies of Switched Communication Networks for Integrated Services<br>Network and Service Evolution: Evolution of Communication Networks, Communication Services and Applications<br>Network Architectures: Basic Network Concepts, System and Network Architectures, Formal Specification of Architectures<br>Switching Networks: Circuit Switching, Store-and-Forward-Switching (Packet Switching, Cell Switching), Integrated Switching Concepts<br>Control and Signaling: Switching Systems, Subscriber Signaling, Interoffice Signaling, Routing<br>Communication Network Technologies: Access Systems and Networks, Synchronous Digital Hierarchy (SDH), Integrated Services Digital Networks (ISDN), Digital Mobile Networks, Intelligent Network (IN)<br>Traffic Engineering and Network Management: Teletraffic and Basic System Models, Traffic Engineering, Network Management Functions, Models and Systems. | Properties of algorithms for digital signal processing such as DFT and FFT, FIR and IIR filters, convolution and correlation<br>Binary number representation and elementary operations like addition, multiplication and limitation of the word length by rounding or truncation<br>Booth's algorithm for multiplication<br>Conversion of the sampling rate in digital systems<br>Digital generation of functions using look-up tables, difference equations and digital circuits, e. g. digital sine-wave generator<br>Effects of limited word lengths and limit cycles as well as scaling to provide overflow protection<br>The structure of signal processors in Harvard-architecture, programming of signal processors<br>Algorithms for digital convolution and correlation | Digital transmission systems for multimedia signals (speech, audio, video, text and data), characteristics of electrical and optical, fixed and mobile channels, storage channels<br>Digital transmission: Mapping, impulse shaping, receiver design, intersymbol interference, eye diagram, noise, symbol error probability for multilevel transmission, Partial Response Technique. Summary on digital modulation and equivalent baseband channel<br>Discrete time mean squared error (MSE) and zero forcing equalizer, adaptive equalizer<br>System design with joint Nyquist and matched filter condition<br>Orthogonal signals, correlation receiver and equivalent matched filter receiver<br>Optimum detection: Bayes, Maximum Likelihood (ML) and Maximum Aposteriori Probability (MAP) detection, ML symbol by symbol and sequence detection, soft and hard decision, Viterbi algorithm, Viterbi-equalizer<br>Soft input decoding of convolutional codes<br>Principles of Code Division Multiplex and Access (CDMA), near-far problem, multi-user interference, synchronous orthogonal receiver<br>Time varying multipath channels for mobile communication, time and Doppler-variant transfer function, statistical channel description, scattering function, AWGN channel with Rayleigh-fading, error probability<br>Further Topics: Principles of Turbo Coding. and Selected examples of theoretical and real problems, also taken from applications like GSM, UMTS and cable modems |

| *1.2 ENST Paris* | | |
|---|---|---|
| **1.2.1 Signal Processing for Digital Communications** | **1.2.2 Electronic Architectures for Telecommunications Systems** | **1.2.3 Fundamentals of Optical and Radiofrequency Systems** |
| **Module 1 : Signal Processing for digital communications**<br>Fundamental Notions : Transmission model system. Review of basic signal processing. Sampling, quantification and reconstruction. Digital signal generation. Intersymbol Interference. Eye diagrams. Equalization. Nyquist Criterion, applications. Line codes and the spectrum of a digital signal. Optimal Receiver. Baseband and Carrier representation. Comparative analysis of digital modulations. Digital modulations. Introduction to multiple access.<br>**Module 2 Information Theory and Coding**<br>The notion of entropy : Mutual Information and Channel Capacity. Shannon Theorems. Notion of codes; detection and correction capacity of a code; bloc codes; Hamming distance. Linear block codes; code parameters. Notion of Parity check. Syndrome decoding. Linear block codes. Introduction to convolutional codes. Maximum likelihood decoding; the Viterbi algorithm, Linear codes performance. | The main objective is to introduce electronic architectures applied to telecommunication systems. The course is organized around two main topics :<br>- Case studies of specialized hardware for digital communications, radio communications and Generic signal or Image Processing<br>- Tools and methods for digital hardware and low level software design (algorithms implementations).<br>Topics :<br>Asics, DSP and processors architectures and tradeoff.<br>Hardware/Software tradeoff<br>Verilog anguage for simulation and synthesis<br>Low level sotware programming | Fundamentals of radiofrequency systems : transmission lines, impedance matching, network analysis, circuits and amplifiers. Antennas, idoor and outdoor propagation :<br>Line theory and microstrip lines. Impedance matching; Smith diagram. S parameters of a circuit. Gain and stability of an amplifier. Radiation and Propagation.<br>- Fundamentals of optoelectronics : lasers, modulation and optical amplification. Receivers |

| *1.3 TU Denmark* | | |
|---|---|---|
| **1.3.1 Optical Communications** | **1.3.2 Telecommunications** | **1.3.3 Internet Technologies and their applications** |
| Optical fibres: structure, conditions of propagation, attenuation and pulse dispersion. Optical amplifiers: Construction, amplification and noise. Light sources and transmitters: Construction, modulation bandwidth and spectral properties. Photodiodes and receivers: Construction, electrical bandwidth, noise and sensitivity. Optical communication systems with digital modulation formats: Construction and system budgets. Multichannel systems. Laboratory exercises with optical fibers, optical amplifiers and systems experiments. Computer simulations of optical transmission. | Optical fibres: structure, conditions of propagation, attenuation and pulse dispersion. Optical amplifiers: Construction, amplification and noise. Light sources and transmitters: Construction, modulation bandwidth and spectral properties. Photodiodes and receivers: Construction, electrical bandwidth, noise and sensitivity. Optical communication systems with digital modulation formats: Construction and system budgets. Multichannel systems. Laboratory exercises with optical fibers, optical amplifiers and systems experiments. Computer simulations of optical transmission. | This course will use collaboration tools and applications as an organizing theme for understanding the development of the Internet. It will begin with a historical perspective through analysis of the development on Internet (TCP/IP), email (SMTP) and WWW (HTTP and HTML) protocols. It will then cover current technologies and standards such as XML and RTSP as well as current applications for collaboration. The influence of standards and regulations on development will be included. Reading assignments will contain many of the original design documents and practical programming exercises will use the Python programming language. |

| *1.4 University of Bristol* | | |
|---|---|---|
| **1.4.1 Radiofrequency engineering** | **1.4.2 Digital Filters/Spectral Analysis** | **1.4.3 Networks and Protocols** |
| Components at RF, resonant circuits; Q factor, Fixed Q, High Q and low Q impedance matching; Semiconductors at RF and BJT models at RF; s-parameters.<br>Small-signal RF amplifier design: bias networks, stability and matching;<br>Smith chart matching network design;<br>Amplifier design using Smith charts: stability, gain control and matching network design;<br>Low noise design: choice of bias point and noise figure;<br>Principles of microwave systems; microwave amplifier design; Transmitter architectures;<br>Amplifier distortion: modelling, intercept point, harmonic and | *Spectral analysis*. Continuous time Fourier series (FS), continuous time Fourier transform (FT), sampling and aliasing, discrete time Fourier transform (DTFT), discrete Fourier transform (DFT), spectral smearing, windowing, time frequency trade-offs, implementation of DFT, fast Fourier transform (FFT), applications of FFT. *Digital Filter Design and Implementation***.** Finite impulse response (FIR) and infinite impulse response (IIR) digital filters. Design of FIR filters, linear phase response, zero-placement, design using windowing, design using frequency sampling, optimal design methods, variable transforms. Design of IIR filters, pole-zero placement, impulse invariance, bilinear transform. Implemenation of digital filters, direct form, cascade and parallel forms, lattice form, finite word- | Introduction and Definition of Terms: types of network - LANs, MANs, WANs, Wireless Networks. Software issues - protocols and their hierarchies, interfaces, connection-oriented vs connectionless services. OSI reference model, TCP/IP reference model, Examples of services. Data Link Layer (specifically Logical link Control Sub-layer): services provided. Framing, error control, flow control. Stop-and wait protocol. Go-back-N protocol. Examples of data-link protocols - HDLC, Internet, ATM. Medium-access Control Sub-layer: need for MAC and its place in the reference models. Multiple-access protocols - ALOHA, carrier sense protocols, collision-free protocols, wireless LAN protocols, digital cellular radio protocols. IEEE 802 family of protocols. Bridges - 802 family, transparent bridges, source routing bridges. High-speed LANs - FDDI, Fast Ethernet. Network Layer: services provided. Virtual circuits vs datagrams. Routing algorithms - shortest path, flooding, flow-based, distance vector, link state, hierarchical, broadcast, multicast. Congestion control. The Internet view of the Network Layer. The ATM view of the Network Layer. |

| | | |
|---|---|---|
| intermodulation distortion; Large-signal RF amplifier types and classes | length effects, limit-cycle oscillations in recursive filters, joint complexity/performance design. Introduction to multi-dimensional and multi-rate signal processing. | Transport Layer: services provided. Functions - addressing, establishing and releasing connections, flow control, multiplexing, recovery. The Internet view of the Transport Layer. Performance issues. |

# Master of Science in Information and Communication Technologies

## ANNEX 8

### - Preus proposats

Barcelona, 17 de juny del 2004

# CRITERIS PER A L'ESTABLIMENT DEL PREU PER CRÈDIT DELS MÀSTERS INTERNACIONALS UPC (Proves pilot)

Els màsters internacionals proposats per la UPC consten de 120 crèdits ECTS.
Atès que el Màster proposat per TSC té una clara orientació a la investigació, permetrà obtenir el DEA. En canvi, el Màster proposat per l'ETSETB té caràcter professional, permentent obtenir, a més del títol de Màster, el títol universitari oficial d'Enginyer de Telecomunicació.
Les alternatives per a la fixació d'un preu per aquests màsters són dos:

1. Equiparar el preu del crèdit al preu corresponent a un crèdit de primer i segon cicle actual, establint la correcció corresponent atenent al canvi d'unitat de mesura (1ECTS= 25-30 hores)
2. Equiparar el preu del crèdit al preu corresponent als crèdits de doctorat, en el cas del Màster de TSC, amb la correcció corresponent respecte de la unitat de mesura. En aquest cas, s'ha d'establir una diferenciació entre els crèdits de docència (equivalents als "core crèdits" del màster) i els crèdits de recerca ("concentration crèdits").

## OPCIÓ 1: EQUIPARACIÓ AL PREU PÚBLIC DELS CRÈDITS DE 1r i 2n CICLE

| | |
|---|---|
| El preu d'un crèdit dels estudis d'Enginyeria de Telecomunicació és de (preus 2003/2004, grau d'experimentalitat 4): | **12,27 €** |
| Número de crèdits que habitualment componen un segon cicle d'estudis homologats: | **150** |
| Cost dels crèdits en uns estudis homologats de segon cicle: | **1.840,50 €** |
| Número de crèdits ECTS de docència Màster ETSETB: | **90** |
| Preu per crèdit ECTS per equiparar-lo al preu dels estudis homologats: | **20,45 €** |
| Número de crèdits ECTS de la Tesis de Màster: | **30** |
| Preu crèdit ECTS de la tesis de Màster: | **20,45 €** |
| Cost dels crèdits del Màster ETSETB: | **2.454,00 €** |

## OPCIÓ 2: EQUIPARACIÓ AL PREU PÚBLIC DELS CRÈDITS DE DOCTORAT (TSC)

| | |
|---|---|
| Preu del crèdit de docència del programa de doctorat de TSC: | **53,69 €** |
| Número de crèdits de docència de programa de doctorat de TSC: | **20** |
| Preu del crèdit de recerca del programa de doctorat de TSC: | **68,19 €** |
| Número de crèdits de recerca del programa de doctorat de TSC: | **12** |
| Cost dels crèdits del programa de doctorat de TSC: | **1.892,08 €** |
| Número de crèdits ECTS equiparables a docència Master TSC (core credits): | **30** |
| Preu crèdit ECTS equiparable a docència (idem màster ETSETB): | **20,45 €** |
| Número de crèdits equiparables a recerca Màster TSC (concentration credits): | **60** |
| Preu crèdit ECTS equiparable a recerca (+12,70%): | **23,05 €** |
| Número de crèdits de la tesis de Màster: | **30** |
| Preu crèdit ECTS de la tesis de Màster: | **23,05 €** |
| Cost dels crèdits del Màster TSC: | **2.688,00 €** |

*Servei de Gestió Acadèmica, 8 de juny de 2004*

## TAXES APLICABLES ALS MÀSTERS INTERNACIONALS

Aquest preus s'haurien d'ampliar amb l'import de les taxes:

| | |
|---|---|
| Matricula (quadrimestral): | **32,94 €** |
| Documentació de matrícula (1 cop per cada matrícula): | **4,35 €** |
| Assegurança (anual. Preu aproximat): | **30,00 €** |
| Total taxes per quadrimestre: | **50,12 €** |

NOTA: sobre aquests preus no s'ha comptabilitzat cap tipus de recàrrec per repetició.

L'import dels crèdits de docència s'ha calculat com el preu total dels crèdits d'uns estudis homologats de 2n cicle entre els 90 crèdits de docència del màster ETSETB

*Servei de Gestió Acadèmica, 8 de juny de 2004*