Third RaMSiS Summer School
WiMAX Radio Design: Circuit and System Design Challenges

July 16-18 2007, Renaissance Hotel, Gammarth, Tunisia

http://www.imit.kth.se/info/FOFU/ramsis/summerschool.html

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With contributions from RaMSiS members:
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Ana Rusu
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Saúl Rodríguez Dueñas

The **RaMSiS** Group (**Ra**dio And **M**ixed **Si**gnal **I**ntegrated **S**ystems) of the Swedish Royal Institute of Technology (KTH) and the Research and Development Group in **Elec**tronics and **Com**munications, **EleCom, LETI L**aboratory of **E**lectronics and **I**nformation **T**echnology of the National Engineering School of Sfax Tunisia, are pleased to announce the organisation of the Third RaMSiS Summer School. The School will be held July 16-18, 2007 In Gammarth, Tunisia and will include lectures from experts in the fields of wireless semiconductors and wireless communication systems, from both industry and academia. The Third RaMSiS school is co-sponsorised by IEEE.

Course Description

Wireless broadband is emerging as one of the most dynamic and important technologies worldwide. The rapid evolution of WiMAX from fixed point to multipoint to full mobility support has many wondering if this signals the beginnings of a 4th Generation (4G) network. Although it remains to be argued whether 4G will evolve around WiMAX, the complexity of WiMAX technology is far superior to all previous network generations. Combining multiple antennas (MIMO), scalable OFDMA modulation, advanced error correction schemes and all-IP royalty free based architecture, WiMAX stands to be a clear winner in the world of competitive data and voice networks.

The objective of this summer school is to provide the student with detailed knowledge on key WiMAX system and circuit design aspects. The course will focus on key trends in radio design and how WiMAX can benefit from them. Since an optimum radio design is better driven from the entire system, end to end, a detailed coverage of the WiMAX physical and MAC layers is included to enable a better understanding of the full systems aspects. Other critical topics such as regulatory and certification issues of WiMAX will also be analyzed as an integral part of today's development projects.

Target Participants

The school is intended for graduate students and researchers as well as design engineers, and product managers at industry. Participants will be awarded 3 credit points according to the Swedish system upon completion of the course.

Social Activities

Besides the technical program, a very entertaining social program is planned.

Gammarth

The School will be held in the Gammarth region; It offers proximity to the antique sites of Carthage and the picturesque villages of Marsa and Sidi Bou Said. Gammarth region is considered as one of the most beautiful sea side locations in Tunisia with its charming beaches.

Course Instructors

Jacques C. Rudell received a B.S. degree in electrical engineering from the University of Michigan, Ann Arbor. He later received a M.S.E.E. degree from the University of California, Berkeley, where he focused on high-speed, low-power digital-adaptive equalization techniques for magnetic disk-drive channels employing partial response signaling. He went on to receive his Ph.D. from UC Berkeley, completing his thesis and research on wireless transceiver architectures and systems suitable for high levels of integration in CMOS with multi-standard/modal operation capabilities.

From 1989 to 1991, he was an IC Designer and Project Manager with Delco Electronics (now Delphi), where his work focused mainly on bipolar analog circuits for automotive applications. From late 2000 to 2001, he was a postdoctoral Researcher at the University of California at Berkeley, in addition to holding consulting positions in several Silicon Valley firms. In early 2002, he joined Berkana Wireless, San Jose, CA as an Analog/RF IC Design Engineer and later became the Design Manager of Advanced IC Development exploring new transceivers systems in CMOS for a number of wireless applications. As of September 2005, Dr. Rudell joined Intel Corporation as the manager of the Advanced Radio Circuits and Architecture Research Group.

Dr. Rudell is a member of Tau Beta Pi and Eta Kappa Nu.. He was designated a James B. Angell scholar at the University of Michigan. He received the 1998 ISSCC Jack Kilby Best Student Paper Award and was the co-recipient of the 2001 ISSCC Lewis Best Paper Award. In 1999, he received the UC Berkeley EECS Demetri Angelakos Memorial Achievement Award. In addition, he is on the technical program committees for both the International Solid-State Circuits Conference (ISSCC) and the Radio Frequency Integrated Circuits (RFIC) Symposium.

Waleed Khalil received his BS and MS in Electrical Engineering from the University of Minnesota in 1992 and 1993, respectively. He is currently in the process of completing his Ph.D. at Arizona State University focusing on the area of "Wideband frequency synthesizers and on-chip phase noise measurement techniques".

He has been with Intel Corporation for 14-years, where he held various technical leadership positions in RF and analog groups. He is currently a Sr. Staff engineer leading the frequency synthesizer design team for Intel's advanced technology and wireless/radio group. Prior to that, he successfully led a group of engineers to develop Intel's first WCDMA analog front end IC. He is a member of the paper review committee for multiple IEEE transactions and other technical journals. He holds nine patents.

James Wilson received the B.S and M.S. degrees in electrical and computer engineering from The Ohio State University, Columbus, in 1999 and 2001, respectively, where he is currently working toward the Ph.D. degree in electrical and computer engineering. During 2000 and 2001, he was a Graduate Technical Intern with Intel Corporation in Chandler, AZ, working on low power data converters. More recently, he was a Senior RF IC Designer with Spirea AB, Stockholm, Sweden. He most recently co-founded Firstpass Technologies,Inc and is RF Engineering Manager.

Hicham Bouzekri was born in Méknes, Morocco in 1973. He received his Engineer diploma in electronics and communications from the Ecole Mohammadia d'Ingénieurs, Rabat Morocco in 1995. Between 1995 and 1997, he worked as a wire bonding process engineer for SGS-Thomson Microelectronics, Casablanca, Morocco. In 1997, he joined the M.S. program at the University of Florida, Gainesville USA, from which he graduated in 1998. He worked there as a research engineer in the Laboratory of Information Systems and Telecommunications on multimedia internet. In 1999, he joined the Ph.D. program of the Electrical Engineering dept. of Texas A&M University, College Station, TX USA. During three years, he worked as a research engineer in the Wireless Communications Laboratory and produced several publications in the area of MIMO wireless communications system design. He obtained his Ph.D. in 2002.
After joining STMicroelectronics design center in Rabat on 2002, he has held several management positions and is now IC design center manager for the Wireless Infrastructure Division. He concurrently holds an adjunct faculty in electrical engineering position with the School of Science and Engineering, Al Akhawayn University, Ifrane, Morocco since 2002.

Course Instructors

Mohammed Ismail has over 20 years experience of R&D in the fields of analog, RF and mixed signal integrated circuits. He has held several positions in both industry and academia and has served as a corporate consultant to nearly 30 companies in the US, Europe and the far east. He is The Founding Director of the Analog VLSI Lab at Ohio State and of the RaMSiS Group at KTH. His current interest lies in research involving digitally programmable/configurable fully integrated radios with focus on low voltage/low power first-pass solutions for 3G and 4G wireless handhelds.

He publishes intensively and has been awarded 11 patents. He has coedited and coauthored several books including a text on Analog VLSI Signal and Information Processing, (McGraw Hill). His last book (2007) is entitled Radio Design in Nanometer Technologies, Springer. He co-founded ANACAD-Egypt (now part of Mentor Graphics,Inc.) and Firstpass Inc., a developer of CMOS radio and mixed signal IPs for handheld wireless applications .

Dr. Ismail has been the recipient of several awards including the US National Science Foundation Presidential Young Investigator Award, the US Semiconductor Research Corp Inventor Recognition Awards in 1992 and 1993, and a Fulbright/Nokia fellowship Award in 1995. He is the founder of the International Journal of Analog Integrated Circuits and Signal Processing, Springer and serves as the Journal's Editor-In-Chief. He has served as Associate Editor for many IEEE Transactions, was on the Board of Governors of the IEEE Circuits and Systems Society and is the Founding Editor of "The Chip" a Column in The IEEE Circuits and Devices Magazine. He obtained his BS and MS degrees in Electronics and Communications from Cairo University, Egypt and the PhD degree in Electrical Engineering from the University of Manitoba, Canada. He is a Fellow of IEEE.

Ana Rusu received degrees of Diploma Engineer (M. S. degree) in Electronics and Telecommunications Engineering from Technical University of Iasi, Romania, in 1983, Ph.D. in electronics engineering from Technical University of Cluj-Napoca, Romania, in 1998 and Docent in Circuit Theory from Royal Institute of Technology Stockholm, Sweden in 2006. During 1983–1986 she was with Research Institute for Electronics and Telecommunications Bucharest, subsidiary Iasi, as a researcher. From 1986 to 1988 she was with Territorial Computer Centre, Piatra-Neamt, Romania, as a programmer in software engineering. Since 1988 she has been with the Technical University of Cluj-Napoca, Electronics and Telecommunications Faculty. In 1999 she was appointed as an associate professor. She has been in visiting researcher positions in University of Bradford, England in 1997; National Technical University of Athens, Greece in 1999; and TIMA Laboratory, Institute National Politechnique of Grenoble, France in 2001. Since September 2001, she has been with the Royal Institute of Technology (KTH), Stockholm, Sweden, where she is a senior researcher in radio and mixed-signal systems group. Her research interests include data conversion techniques and CAD tools for wireless communications; digitally-enhanced analog/RF front-ends; low-voltage low-power design; Software Defined Radio technology; wireless sensor networks. She has participated in several national and international research projects and has authored or coauthored more than 50 international scientific publications in journals, books, book chapters and conference proceedings.

Delia Rodríguez de Llera González received her Telecommunications Engineering degree from the Technical University of Madrid (UPM) in 2002, a M.Sc. in Complex Adaptive Systems from Chalmers University of Technology (CTH) in Göteborg, Sweden in 2002, and a M.Sc. in System-on-Chip Design from the Royal Institute of Technology (KTH) in Stockholm, Sweden, in 2003. She joined CERN (European Organization for Nuclear Research), Geneva, Switzerland, in 2002 and became a CERN fellow in 2003. She pursues her Ph.D. degree at the Royal Institute of Technology from 2004 working in the field of automatic design space exploration for multi-standard wireless receivers and programmable data converters. Her research interests include analog and mixed signal design, analog to digital conversion, low-voltage and low-power circuit design, and CAD tool development.

Jad G. Atallah B.E. in Computer and Communications Engineering (With Distinction) from The American University of Beirut, Lebanon, in 2001 and M.Sc. in Electrical Engineering with the specialization in System-on-Chip Design from The Royal Institute of Technology (KTH), Sweden, in 2003. Ph.D. student since 2004 at the Royal Institute of Technology (KTH), The RaMSiS Group, with research focus on frequency synthesizers for multi-standard wireless applications, and on hardware solutions for seamless handover in 4G wireless systems.

Saúl Rodríguez Dueñas received the B.S. degree from the Army Polytechnic School (ESPE), Quito, Ecuador in 2001 and the M.S. degree from the Royal Institute of Technology (KTH) in 2005. He joined the RamSiS group at KTH in 2005 where he is currently working towards the Ph.D. degree. His current research is wideband RF-front ends for multi-band, multi-standard receivers. His main interests are automatic circuit generation of direct conversion receivers and low power CMOS radio circuits.

Course Schedule

July 15	
Arrival to Gammarth (Tunisia) and registration	
21:00 -	Welcome dinner

July 16	
09:00 - 09:45	**WiMAX: A competing or complementary technology to 3G?** Mohammed Ismail
10:00 - 10:45	**WiMAX: the standard and its implications on radio architectures I** Jacques C. Rudell
10:45 - 11:15	Coffee Break
11:15 - 12:00 12:15 - 13:00	**Baseband processing in WiMAX systems I** Hicham Bouzekri
13:00 - 14:00	Lunch
14:00 - 14:45 15:00 - 15:45	**WiMAX Receiver Design: Challenges and Solutions** Delia Rodríguez de Llera González
15:45 - 16:15	Coffee Break
16:15 - 17:00 17:15 - 18:00	**Frequency Synthesis and Timing Effects in WiMAX Systems I** Waleed Khalil

July 17	
09:00 - 09:45	**WiMAX: the standard and its implications on radio architectures II** Jacques C. Rudell
10:00 - 10:45	**WiMAX: Design approaches to transmitter integration I** Jacques C. Rudell
10:45 - 11:15	Coffee Break
11:15 - 12:00 12:15 - 13:00	**Baseband processing in WiMAX systems II** Hicham Bouzekri
13:00 - 14:00	Lunch
14:00 - 14:45 15:00 - 15:45	**RF front-ends for WiMAX** Saúl Rodríguez Dueñas
15:45 - 16:15	Coffee Break
16:15 - 17:00 17:15 - 18:00	**Enabling ADC technologies for WiMAX radios** Ana Rusu
20:00 -	**Social Activity**

July 18	
09:00 - 09:45 10:00 - 10:45	**Frequency Synthesis and Timing Effects in WiMAX Systems II** Waleed Khalil
10:45 - 11:15	Coffee Break
11:15 - 12:00 12:15 - 13:00	**Frequency synthesizers for WiMAX radios: from System to Silicon** Jad G. Atallah
13:00 - 14:00	Lunch
14:00 - 14:45 15:00 - 15:45	**Design considerations for complex Multi-Mode CMOS Radios** James Wilson
15:45 - 16:15	Coffee Break
16:15 - 17:00	**WiMAX: Design approaches to transmitter integration II** Jacques C. Rudell
17:15 - 18:00	Summer School evaluation, wrap up and group picture

Lecture Abstracts

WiMAX: A competing or complementary technology to 3G?

Mohammed Ismail

This presentation will contrast WiMAX and 3G technologies and will discuss whether the two technologies are competing or complementary particularly for developing countries.The eventual convergence of the two in what is called "LTE or Long Term Evolution" or Super 3G (S3G) will also be discussed.To this end, the challenges that lie ahead in developing complex MIMO radios with multi-band front end modules will be discussed. An introduction of this year's summer school will then follow.

WiMAX: The Standard, Implications on Radio Architecture and approaches to Transmitter Integration

Jacques C. Rudell

WiMAX is evolving as a both a fixed point and mobile wireless standard for wide area, high-bandwidth data applications. The physical layer which is currently being refined in the standards committees is beginning to appear as one of the most challenging commercial applications from the perspective of implementing the front-end transceiver hardware. The existing WiMAX physical layer definition uses OFDM modulation with a high order 64-QAM constellation. Therefore, the hardware performance challenges are similar to WiFi standards with respect to linearity, noise figure, phase noise, and low frequency flicker noise. However, the required transmit output power for WiMAX is more analogous to cellular levels to obtain the vastly increased range as compared to WiFi. The combination of extreme linearity requirements, a very wide signal bandwidth and high output power has created one of the most challenging RF IC design problems since the dawn of CMOS RF in the early 1990s. Attempting to integrate the entire transmitter with integrated Power Amplifiers (PA) in CMOS, for WiMAX applications, will confound both academics and industrial engineers for the next decade. This presentation will begin by exploring the physical layer definition of WiMAX and the implications on the transmitter hardware with respect to common performance metrics such as linearity, gain variation, power output, Adjacent Channel Power Rejection (ACPR) Ratio, and Wideband Spurious Spectral performance. This will then be followed with a discussion of integrated transmitter architectures and circuits which might be good candidates for future implementation of WiMAX systems. While a fully integrated WiMAX transmitter solution in CMOS, lies well over the horizon, this talk will discuss some potential strategies and give thoughts about possible directions to pursue in the quest to deliver the new "holy grail" of CMOS RF… a fully-integrated long-range, wideband CMOS WiMAX transceiver.

Frequency Synthesis and Timing Effects in WiMAX Systems

Waleed Khalil

The effect of frequency impairments using single carrier modulation is generally well understood. However, the effect in OFDM systems is quite different. The role of frequency synthesizers are increasingly becoming a critical part in the design of the WiMAX systems for the following reasons:
1) it uses OFDM modulation with tightly spaced sub-carriers (i.e. 10 kHz)
2) It supports higher order modulation such as 64-QAM.
This imposes a tight requirement on the synthesizer close-in phase noise performance as well as the total integrated phase error specifications. In this presentation, different challenges in designing synthesizers to address the needs for WiMAX transceivers in deep submicron technology will be explored. Following this talk will address frequency impairments in both modulators and demodulators. It will discuss how these impairments affect OFDM systems and, where appropriate how this is different from the effect on single-carrier systems. Furthermore, several circuit techniques that are critical in designing synthesizers to meet the tight requirements for WiMAX will be examined.

Design considerations for complex Multi-Mode CMOS Radios

James Wilson

Muli-Input Multi-output (MIMO) WiMAX as well as future LTE (Long Term Evolution or Super 3G) handhelds require the design of a low power, complex multi band, and multi mode radio transceiver. WiMAX radios will cover three bands at 2.5GHz, 3.5GHz and 5GHz, while LTE or S3G radios will cover up to 6 RF bands. Both MIMO WiMAX and LTE are OFDM-based and their RF radios have to meet stringent phase noise, linearity and EVM requirements. This presentation will address the design of such complex radios in two aspects: top level integration issues and design-for-yield issues. In the first aspect, the talk will discuss floor planning , supply and ground strategies, power management as well as substrate noise isolation techniques for a complex multi-band radio integrated with digital parts in the same CMOS System-on-Chip(SoC).Then, the presentation will address a design methodology leading to first-time-right silicon for complex RF radios. In this regard, calibration techniques at both the radio system and RF block levels will be introduced to cope with random process variations as well as supply and temperature variations .This will help reduce NRE costs of integrated RF CMOS radios particularly as we move to manometer (below 100 manometer) CMOS technologies.

Baseband signal processing in WiMAX Systems

Hicham Bouzekri

This part of the course will cover physical Layer baseband processing issues in WiMAX systems from a system design perspective. To better apprehend these aspects of WiMAX systems, the course starts by positioning the standard as compared to other wireless access systems. The course continues with an overview of the concepts inherently needed to understand the challenges in baseband processing. A general presentation of the WiMax standard will then allow us to identify the choices made for baseband processing in this standard including for modulation and error coding. Generally, the focus will be on covering the fundamentals behind these choices including error rate performance, frequency and power efficiency as well as enhancements brought by usage of multiple antennas (MIMO) and OFDMA.

Enabling ADC technologies for WiMAX radios

Ana Rusu

The present-day mobile phones are really complex systems, incorporating text messaging, gaming, CD-quality audio playback, a digital camera and multi-band multi-mode radio transceivers, all with up to three weeks standby time. In addition to consumers needs, as FM radio, GPS and mobile TV, the personal connectivity necessitates the insertion of new standards as WiMAX UWB, and RFID, all of which operate in multiple bands. The demand for these features is driving the need of low-power, low-cost and higher-performance analog-digital interfaces. Clearly, the analog-to-digital conversion (ADC) technology continues to be an area of focus for reducing the radio complexity and it motivates the investigation and development of new ADC architectures and topologies. Among the variety of ADC architectures, the sigma-delta ADC has proven to be the most suitable solution for wireless mobile radios, and will dominate the evolution of the mobile devices.
This lecture will present and discuss the enabling ADC architectures and topologies for future WiMAX radios. It will discuss the key system-level issues, and circuit design challenges, imposed by the low-power specifications, small size and low cost in mobile devices. The focus will be mainly on sigma-delta ADCs, covering the features of discrete-time (DT) and continuous-time (CT) implementations in the perspective of a low-power CMOS design. The performance improvement due to innovative use of new architectures and topologies, such as pipelined and sigma-delta mixture will be addressed. In addition, the lecture will stress on the importance of use of adaptive digital-signal processing (DSP) for ADC compensation in the future wireless mobile radios. Finally, two sigma-delta ADC design examples for WiMAX radios will be presented.

WiMAX Receiver Design: Challenges and Solutions

Delia Rodríguez de Llera González

WiMAX, being a multi-band system using OFDM, Dynamic Bandwidth Allocation (DBA), and different modulation schemes, provides a whole world of possibilities together with a whole world of design problems. A good system level design is vital in ensuring the required performance levels as well as in shortening the time-to-market. The realization of an efficient frequency plan and receiver budget is one of the most compelling problems RF engineers face nowadays. Many tradeoffs have to be made when fixing the characteristics of each of the blocks. This lecture will walk us through the challenges posed by the realization of a WiMAX receiver at system level and suggest different techniques that help surmounting them. In this context, a tool called TACT, which helps explore design space at the architectural level, will be described and used to provide a case study.

Frequency synthesizers for WiMAX radios: from System to Silicon

Jad G. Atallah

The appeal of WiMAX stems from the fact that it resembles a collection of standards on the physical layer. This makes it a good research topic while maintaining a practical dimension and an industrial potential. The vast range of frequencies in which WiMAX operates makes it particularly challenging to design the frequency synthesizer. Towards this end, this session covers some important aspects of the frequency synthesizer design starting from the system level and going down to silicon. It particularly highlights the importance of system-level modeling and simulation in framing the specifications of the frequency synthesizer within the context of the overall RF front-end.

RF front-ends for WiMAX

Saúl Rodríguez Dueñas

One of the most prominent aspects of the WiMAX standard is that it provides a lot of flexibility. All this flexibility results in very complex design problems since the requirements for the circuits such as linearity, sensitivity, and phase noise are more demanding. The situation for the radio front-end part is even worsened by the fact that local regulation entities in different countries allocate bands in different parts of the spectrum. As a result, the WiMAX radio interface may require supporting bands that range from 2.3GHz up to 5.8 GHz.
This lecture addresses key design issues about the design of receiver front-end for WiMAX in CMOS. Three design cases are analyzed here: a narrowband receiver which is supposed to work on a fixed band, a multi-band receiver that reconfigures itself to work in a group of bands, and a broadband receiver that covers all the bands. Each solution has its own advantages and drawbacks. The last part of this lecture will introduce the ARCHER software which is a CAD tool capable of automatically compiling the schematic circuit of a direct conversion receiver based on system specifications including frequency of operation, gain, noise figure, and IIP3 linearity. A design example will be shown which consists of a WiMAX Rx front-end covering the 3.5GHz bands.

Course Material

The participants will be able to download the course material from a password protected website from few days prior to the course. Please note that no printed version will be provided.

Additional Information

Course venue:

The 3nd RaMSiS Summer School will be held at the Renaissance Hotel, in the Gammarth region; It offers proximity to the antique sites of Carthage and the picturesque villages of Marsa and Sidi Bou Said. Gammarth region is considered as one of the most beautiful sea side locations in Tunisia with its charming beaches.

For further information about the hotel, please visit:
http://marriott.com/hotels/travel/tunbr-renaissance-tunis-hotel/

Gammarth and Tunisia:

http:// www.tunisia.com/
http://www.tunisietourisme.com.tn/home-e.htm
http://www.nachoua.com/Tunisie/photos-sidibousaid.htm

How to get to Gammarth:

Gammarth is 20 km away from Tunis-Carthage International Airport. The Renaissance hotel can be reached by either by train, by taxi or by bus (Raoued station).

http://marriott.com/hotels/maps/travel/tunbr-renaissance-tunis-hotel/

Royal Institute of Technology (KTH):

Main page
http://www.kth.se
School of Information and Communication Technology
http://www.ict.kth.se/
RaMSiS project
http://www.imit.kth.se/info/FOFU/ramsis/

National Engineering School of Sfax Tunisia (ENIS):

http://www.enis.rnu.tn/

If you have a question that is not answered on this brochure or the course website, feel free to contact us:

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http://www.imit.kth.se/info/FOFU/ramsis/summerschool.html

Registration Form for Tunisian Attendees

First Name:		**Title:**
Last Name:		
Affiliation:		
Address:		
City:		**Postal Code:**
e-mail:	**Telephone :**	**Fax:**

Course registration:
☒ Check the box that corresponds to the appropriate registration fee.

Regular Registration fee	☐ 600 TND
Student Registration fee	☐ 400 TND
Industrial Registration fee	☐ 800 TND

The registration fee includes: Admittance to all lectures, course material, lunches and coffee breaks. Both Industrial and regular registrations include also participation to the social program.
Please contact the organization committee for further informations.

Registration has to be done before june 30th 2007

Payment Methods:
Beneficiary: **Association l'Université et l'Environnement .**

1- by order form, (Fiscal Immatriculation: 000NN791321/P)

2- by bank transfer (the operation must be free of charges for the beneficiary)**:**
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IBAN bank account number: **TN 59 03 701 045 0101 104387 04**
Bank name and address: **Banque Nationale Agricole, Rue Farhat Hached-Code Postal 3069 Sfax.**
SWIFT code: **BNT ETN TTASFX**
Please specify **"RaMSiS 07+participant's family name and first name"**

3- by bank check.

Please return to Mourad Loulou, National Engineering School of Sfax Tunisia
By email: ramsis-registration@tunet.tn - Fax: +216 74 247 498 – 74 676 703
A copy of the bank receipt or order form must be sent by email together with this form.

P.S.: An email will be sent to confirm the registration.