Enabling
High Frequency Electronics

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ARES and High Frequency Electronics

- **ARES Consortium** has its main facilities and competences in high-frequency electronics at the Department of Electronic Engineering (DIE) of the University of Roma Tor Vergata (the building where the meeting is held).

- The group at the DIE is composed by more than 20 people, including permanent staff (professors, researchers, technicians) and post-doc/PhDs.

- The heritage in microwaves and millimeter wave techniques dates back to the early ‘80s, thus summing up to more than 30 years experience.
ARES Activities - 1

Two main directions, namely

- **Device/subsystem characterization and modelling**: linear, non-linear and noise up to 110GHz (and above), scaleable, bias-dependent modelling with different approaches (equivalent-circuit, black-box, physical).

- **Circuit and subsystem design**: Amplifiers (PAs, LNAs, VGAs, DPAs ...), Mixers (resistive, passive, active ...), frequency multipliers, multifunction (Core chips, TR chips, Integrated Receivers ...) adopting state-of-the-art design methodologies. Long-track experience in **Hybrid** as well as **MMIC** design with many foundries (SLX, UMS, OMMIC, NGS, TRW, Triquint, Raytheon, ...).
ARES Characterization Facilities - 1

Tor Vergata

• 2 Vector Network Analysers (HP 8510C 0.05-50 GHz and Anritsu 37XXXD, 0.05-65 GHz, extended to 110 GHz)

• 2 Spectrum Analyser (HP 70000 DC-40 GHz, Agilent PSA E4448A 3Hz-50GHz)

• Noise Measurement System (HP8970B-HP8971C DC-26.5 GHz, with proprietary amplified SSB extension to 40 GHz)

• 2 Elettromechanical Tuners (Focus 0.08-18 GHz e 3-50 GHz)

• Digital Sampling Oscilloscope (TekTronix up to 50 GHz)

• I-V Pulsed Measurement System (GaAs Code)

• Power Amplifier (AR 0.8-4.2 GHz - 25 W)

• Synthesised Sources (2 Anritsu MG3692A 2-20 GHz e HP 83640A DC-40 GHz)

• Vector Signal Source (Agilent E4438C 250 kHz-6 GHz)

• Probe Stations (Cascade Microtech RF-1 and proprietary semi-automated one, equipped with anti-vibrating tables)

• Cryogenic Probe Station (down to 20 K, proprietary)

• Test-fixtures (Wiltron, Agilent, …)
ARES Characterization Facilities - 2

Closed Loop Cryo probe station (down to 20K)

Access to Active Harmonic Load-Pull

Access to Phase noise characterisation

S-Par &Noise integrated Test Bench
ARES activities are clearly used for internally-funded and coordinated basic research, and are very often adopted to support external companies for

- Technology assessment
- Technology optimization (*realise-characterise-model* loop)
- Technology development
- Realized subsystem characterization
- Active/passive device model extractions
- PDKs development and verification
- ad-hoc modelling
ARES Activities - 3

Examples:

- **KorriGan**: first large European-scale GaN project, in which MECSA acted (also) as device modelling center for Selex, III-V Lab and QinetiQ technologies, with evolving technologies.

- **GARANTE**: Italian MoD project for 0.25μm GaN technology assessment (Selex ES).

- **Quagas**: ASI project for Space qualification of 0.25μm GaAs technology (Selex ES).

- **TeraSCREEN**: FP7 project, within which a 0.04μm mHEMT technology is developed (OMMIC).

- In the past, several examples including **COSMIC, MANPOWER, ESPRIT IV** European projects.
ARES Activities - 4

... but also technological investigations:

- **Physical simulation and modelling** (Monte Carlo, Drift-diffusion ...), using both commercial and ad-hoc simulation tools.
- **Thermal simulation and modelling** (by using commercial and ad-hoc simulation tools)
- **Thermal characterization** (nonlinear thermal impedance measurements)
- **Basic technological exploration** (e.g. different semiconductor alloys and devices with non-conventional operating principles, such as Diamond)
ARES Activities - 5

• Regarding microwave circuit design, the research focus has been historically directed towards Design Methodologies for high-efficiency transmitting subsystems and high performance receivers.

• The heritage of ARES as circuit design center dates back to the early ’90s with the COSMIC FP2 project (monolithic transimpedance amplifier design) and continues since then with the participation to many projects, both national and international, public- or privately funded.

• All the major CAD tools are available (circuit, system and EM-oriented), also for commercial use.

• A representative list is attempted in the following, as an example of ARES capabilities and offer.
EDA project KorriGAN - 1


- To take advantage of high power densities and power handling of GaN, Switching SPDT (up to 18 GHz) for transmitters.
- Design with Selex – SI and Tiger GaN 0.25 μm microstrip technology
- Small- and Large-signal characterization of HEMT devices for switching applications
- Device modelling
- Broadband (2-18 GHz) and Narrowband (X Band) SPDT switch design
EDA project KorriGAN - 2


- To take advantage of high robustness and power handling of GaN devices for Low Noise applications.
- Design with Selex – SI GaN 0.25 μm microstrip technology
- Noise, Small- and Large-signal characterization of HEMT devices for switching applications
- Device modelling
- 2 Broadband (2-18 GHz) robust LNA designs as cascade of distributed amplifier cells
Design and implementation of the MMIC chip set for X-band T/R modules for SAR Payload of second generation (PROMIX), (2009-2010).

- Application: X-band T/R modules for SAR
- 2μm GaInP/GaAs HBT Technology HB20PX from UMS
- Characterization of HBT devices for model optimization
- Design and characterization of driver amplifiers and HPAs operating in pulsed condition (100 us / 30% duty)
- Optimization of HBT thermal behavior to avoid thermal runaway
- BUS bar solution for the final stage
- Optimization of large signal working point to avoid parametric oscillations
Design and implementation of the MMIC chip set for X-band T/R modules for SAR Payload of second generation (PROMIX), (2009-2010).

- Application: X-band T/R modules for SAR
- 0.2μm E/D PHEMT technology ED02AH from OMMIC
- Design and realization of a X-Band Core Chip featured by 6 bit phase control, 6 bit amplitude control and T/R switch, with integrated 3-stages LNA and MPA
- On-board S/P conversion
- T/R control of amplifiers’ biases
- Less than 15mm² total area
ESA project SCFE


- Application: future generation of C-band T/R modules for SAR
- 0.25\(\mu\)m AlGaN/GaN HEMT Technology GH25 from UMS and 0.5\(\mu\)m AlGaN/GaN HEMT Technology from Selex ES
- Foundries in the project team
- Characterization of passive and active GaN devices for model extraction/verification/optimization
- Design of SCFE in the two technologies integrating HPA, LNA and T/R output switch to obtain 40W output power (40% PAE), 36dB gain and 2.5dB NF in C Band
FP6 project RadioNET (Pharos)


- Application: build the future instruments for C-Band observation as focal-plane array receivers
- 0.2μm pHEMT Technology ED02AH from OMMIC
- Design of the entire electronic focal plane array components: LNAs, MPAs, PSs, ATTs (PAMs)
- Assembly and test of the entire focal plane array
- Cryogenic (20K) operation of the LNAs, 77K operation of the PAMs
Swiched Mode Power Amplifiers Realization of a Transmitter based on 

- **Application**: study and development of a Solid State Transmitter for Synthetic Aperture Radar (SAR) in P-band (435 MHz) for Earth observation, capable of achieving more than 80% efficiency at high power level (150 W) employing European technologies
- **Driver stages and modulator**: IHP CMOS process
- **Power stages**: UMS discrete devices (CHK040A)
- **Design of the power stages**
FP7 project SLOGAN

Space quaLification Of High-Power SSPA based on GaN technology (SLOGAN), (2013-2016).

- Application: to evaluate and apply the potentiality of mature UMS European GaN based technology (GH-50) for space applications, through the development of a GaN SSPA EQM for the next generation of Galileo satellites (E1 band, Pout 300W) ready to replace the current TWTAs
- Design and assistance in space qualification of the power stages

Preliminary Breadboarding of the PAs
Conclusions

• ARES is a public/private consortium joining together the experimental resources, the expertise and the critical mass of a dynamic university and the system capabilities of TECS.

• ARES heritage in high-frequency enabling electronics is based on more than 30 years experience.

• Only microwave/millimetre-wave electronic activities have been briefly presented: the activities in EM and propagation fields are also in the loop.

• ARES is open to collaborations, not only academic but also industrial and applied research in general, to promote and diffuse (as in its DNA) MTT, as demonstrated by the long-track experience briefly recalled.
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