Ready for 5G and Beyond:

Aalto University has 3+ decades of research on mm-wave and THz antennas, circuits, and systems.

- Antennas (e.g. for Nokia E-band 5G demonstrators) and antenna measurement techniques
Aalto People

Kari Halonen  Jussi Ryynänen  Katsuyuki Haneda  Antti Räisänen

Zachary Taylor  Ville Viikari  Riku Jäntti  Olav Tirkkonen

• Interdisciplinary Group
  – Dept. of Electronics and Nanoengineering
  – Dept. of Communications and Networking

postdocs

Masters/PhD students

Aalto University
Software defined radio support for THz experimentation

- Department of Communications and Networking has a long track-record in developing full protocol stacks

- Base band processing implementation in C++
  - TD-LTE (Rel. 8) PHY + RLC
  - NB-IoT (Rel. 13) standalone mode
    - full base station implementation
  - NR (Rel. 15) PHY + RLC

- Cloud based Radio Access Networks (C-RAN):
  - Soft-real-time based band processing in standard Linux computing environments

- Ethernet front-haul

- Software defined radio units
Software defined radio support for THz experimentation

- Ultra-wideband experimentations
  - Transceiver algorithm implementations (C++, Matlab)
  - Waveform generation up to 6 GHz bandwidth with signal generator
  - IF generation with signal generator up to 70 GHz
  - Signal generator with 6 GHz bandwidth can be used as a receiver
Publications on full stack development and experimentation


Integrated circuits for Sub-THz bands

First full 60GHz CMOS receiver with on chip ADC already published in 2009

- 20 years of MMIC development for communications, space and radar

- Current focus
  - Develop digitally assisted array MMIC systems up to 200GHz
  - Push tech. boundaries towards THZ bands with individual building blocks
  - Develop antenna-IC codesign environment

- Utilization of nanometer CMOS and BiCMOS technologies
Recent examples of MMIC development

140-GHz Radiometer

0.325 THz CMOS amplifier

180-GHz CMOS Down-converter MMIC for Atmospheric Remote Sensing
Radio channel modelling / standardisation

- Successful contribution to the white paper ‘5G Channel Model for bands up to 100 GHz’ allowed us to kick-start 5G wireless standardisation activities in 3GPP (representatives of wireless equipment vendors and operators across the world).

- Successful leadership in a working group of radio channels in the European COST Action IRACON, led to an input document to the ITU SG3 about various radio propagation models at mm-wave frequencies.
Millimetre-wave Laboratory of Finland - MilliLab

- A Joint Laboratory, established 1995
  - VTT Technical Research Centre of Finland
  - Aalto University, School of Electrical Engineering

- An ESA External Laboratory on Millimetre-wave technology (since 1995)
  - Mission: assist European space *industry* in meeting the demands of future mm-wave missions

- Combines the benefits of the two mother organizations:
  - Aalto: Strong academic competence
  - VTT: Competence closer to industry, established processes, experts, facilities
MilliLab key Services and capabilities

• Millimeter wave test and measurement services
  – S-parameters, spectrum measurements, noise figure and noise parameters. On-wafer measurements up to 500 GHz and with waveguides up to 1.1 THz
  – Antenna measurements: near-field with a planar scanner up to 1 THz

• Laboratories and equipment for space qualification

• Reliability testing:
  – Temperature step stress tests, RF step stress tests, DC step stress tests, RF life tests, DC life tests, Temperature cycling, High humidity high temperature tests.

• Design and development services for millimeter wave components, circuits, modules, sub-systems
MilliLab dissertations in 2010-2018

Mikko Varonen: Design and characterization of monolithic millimeter-wave active and passive components, 2010
Patrik Pousi: Active and passive dielectric rod waveguide components for millimetre wavelengths, 2010
Dmitri Chicherin: Studies on microelectromechanically tuneable high-impedance surface for millimetre wave beam steering, 2011
Tero Kiuru: Characterization, modelling, and design for applications of waveguide impedance tuners and Schottky diodes at mm-wavelengths, 2011
Mikko Kyrö: Radio wave propagation and antennas for millimeter wave communications, 2013
Aki Karttunen: Millimetre and submillimetre wave antenna design using ray tracing, 2013
Aleksi Tamminen: Developments in imaging at millimeter and submillimeter wavelengths, 2013
Mikko Kärkkäinen: Design and characterization of monolithic millimeter-wave integrated circuits for receiver front-ends, 2014
Krista Dahlberg: Development of on-wafer calibration methods and planar Schottky diode characterisation at THz frequencies, 2014
Tomas Zvolensky: Periodic transmission lines for leaky-wave antenna applications at millimeter wavelengths, 2014
Zhou Du: Characterization of antennas and quasioptical components through simulations and measurements, 2015
Andrey Generalov: Dielectric rod waveguide components at sub-THz frequencies, 2015
Vasili Semkin: Reconfigurable antennas and radio wave propagation at millimeter-wave frequencies, 2016
Mikko Kantanen: Low-noise monolithic millimeter-wave integrated circuits and a radiometric imaging system, 2017
Irina Nefedova: Electrical and optical properties of carbon nanotube and silver nanowire layers for low-THz applications, 2017
Subash Khanal: Characterisation of Schottky diodes and dielectric materials for millimeter wave and THz applications, 2017
Ali Vahdati: Design and characterisation of monolithic millimetre-wave integrated circuits for phased-array transmitter front-end, 2017
Dristy Parveg: CMOS radio front-end circuit blocks for millimeter-wave communications and atmospheric remote sensing receivers, 2018
Industrial collaboration

- Nokia
- ESA
- Huawei
- HiSilicon
- SAAB
- Sasken
- Qualcomm
- DA-Design
- Pulse
- Nordic Semiconductor
- VTT
- Finnish Defence Force
- AAC Technologies
- Optenni
- Cojot
- Premix
- Keysight
- ETS-Lindgren
Visualizing spatiotemporal variation in burn edema

- Visualize the build up of tissue edema in response to burn injury
- Track water through space and time using THz imaging
- THz derived imaging features vary based on burn severity
- Early severity detection
Corneal water content char. with thin film metrology

Optical System Design

Human trials


