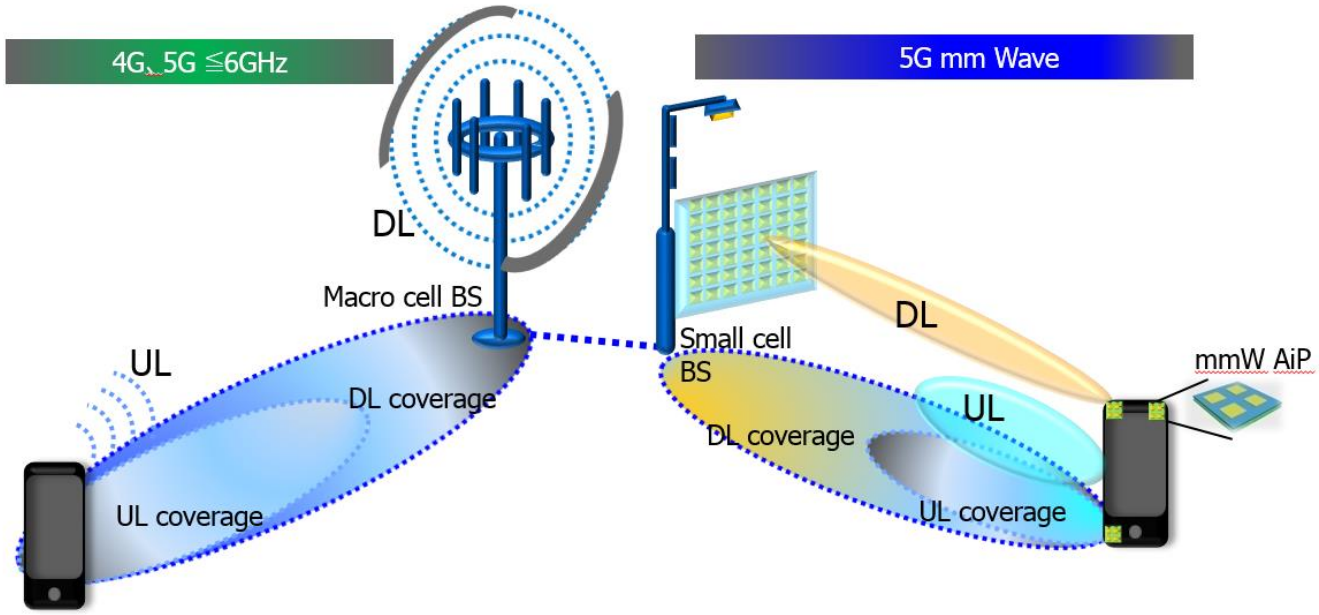
# 5G mm wave antenna system design and analysis, diagnosis including OTA and EMF for user device

***Abstract***

The next generation communication technology will bring new experiences and thus create new and exciting opportunities for society. This include higher bandwidth, data rate, capacity, security and lower latency to mention a few. Millimeter-wave (mmWave) frequency bands are promising spectrums for the 5G/6G mobile communication systems. Such bands require beam-forming antenna systems on both base station (BS) and the user equipment (UE) to compensate the higher path losses. The high-level technologies involved in such systems bring many new challenges to the antenna and RF engineers, such as antenna topology, spherical coverage, user blockage, device integration, beam-forming technology, RF front-end technology, Measurements technology in near-field or far-field, EMF and OTA aspects to mention a few.

This course presents recent progress and technology advancement in mobile industry and academic research on mmWave 5G/6G antenna systems. It focus mainly on mobile user device applications and covers topics such as: antenna design and integration, standardization and performance evaluation methods.

***Graphical abstract***



### *Recommended prerequisites*

- Antenna engineer and researcher from mobile industry;
- Stuff from Research institute,
- PhD students,
- People from antenna domain,
- People from EMF domain,
- People from OTA domain

### *Learning objectives*

From the course, the student will learn the 5G mm wave antenna and system requirement, progress in 3GPP standardisation, antenna design and integrations, mm wave propagation and channel characteristics, testing methods on OTA, EMF research and testing, evaluation and diagnosis of mm wave antennas, module, devices. After the course, the student will understand more on the 5G and beyond mm wave system, antenna design, performance characterizing, test method, simulation, 3GPP performance requirement, EMF regulation in mm wave, etc.

### *Course outline*

The course is divided into self-consistent sub-topics, each covered by power-point presentations by the two instructors. Each presentation is terminated with a summary and time for question and comments from the participants. All materials needed for the course will be provided to the participants.

The contents of the course include:

1) 5G mm wave system and requirements;
2) mm Wave Antenna design for UE and characterization fundamental;
3) mm Wave Propagation Characterization, Channel, MIMO, Beam forming;
4) Antenna array design, integrations issues in 5G devices;
5) 3GPP 5G NR UE requirement, OTA test Challenges;
6) EMF research, test challenge in 5G NR devices;
7) Mm wave antenna array, device testing; near-field and far-field;
8) Evaluation and diagnosis of mm wave antennas, module, device;

## *Instructor 1 – Biography*

Zhinong Ying is a principle engineer of antenna technology in the Access Technology Lab within the Research Centre, Sony Cooperation, Lund, Sweden, also as a distinguish engineer within the whole Sony group. He joined Ericsson AB in 1995 in Sweden. He became Senior Specialist in 1997 and Expert in 2003 in his engineer career at Ericsson. He served as TPC Co-Chairmen in International Symposium on Antenna Technology (iWAT), 2007, and served as session organizer of several international conferences including IEEE APS, and a reviewer for several academic journals. He also has been a guest professor in the Joint research centre of Royal institute of Technology, Sweden and Zhejiang University, China since 2001. He is a senior member of IEEE. He was a member of scientific board of ACE program (Antenna Centre of Excellent in European 6th frame) from 2004 to 2007.

His main research interests are small antennas, broad and multi-band antenna, multi-channel antenna (MIMO) system, antenna for body area network, antenna and propagation in 5th generation mobile network including massive MIMO and mm wave, near- field and human body effects and measurement techniques. He has authored and co-authored over **160 papers** in various of journal, conference and industry publications. He holds more than **160 patents** and pending in the antennas and new generation wireless network areas. He contributed several book chapters on mobile antenna, small antenna and MIMO antennas in "**Mobile Antenna Handbook 3rd edition**" edited H. Fujimoto and **"Handbook of Antenna Technologies"** edited by Z. N. Chen. He had contributed a lot of work in antenna designs and evaluation methods for the mobile industry. He has also involved in the evaluation of Bluetooth Technology which was invented by Ericsson. He received the Best Invention Award at Ericsson Mobile in 1996 and Key Performer Award at Sony Ericsson in 2002. He was nominated for President Award at Sony Ericsson in 2004 for his innovative contributions. He received Distinguish Engineer title at Sony Group globally in 2013.

## *Instructor 2 – Biography*

Lars Jacob Foged was born in Viborg, Denmark in 1966. He received his B.Sc from Aarhus Teknikum, Denmark in 1988 and M.Sc. in Electrical Engineering from California Institute of Technology, USA in 1990. He is currently the scientific director of Microwave Vision Group and associate director of Microwave Vision Italy.

He was a member of the EURAAP delegate assembly from 2009 to 2012 and responsible for the working group on antenna measurements. He was Vice-Chair of the Eucap 2011 conference in Rome, Industrial Chair of Eucap 2012 and 2014 conference in Prague and Den Haag and Technical Program Chair of Eucap 2016 in Davos.

Since 2006, he is a member of the board of the European School of Antennas (ESOA), and technical responsible and teacher in the biannual antenna measurement course. He is a senior member of IEEE and fellow of AMTA. Since 2004, he is secretary of the IEEE Antenna Standards Committee and has contributed to the development of different standards on antennas and measurements. He is board member of the European School of Antennas (ESOA), and technical responsible and teacher in Antenna Measurement courses in Europe and Asia since 2006. He is contributing to the IEC 62209 standard(s) on human exposure to electromagnetic fields since 2010. In 2016 he was appointed chairman of the Industry Initiatives Committee (IIC), a standing committee of IEEE APS. He has authored and co-authored more than 200 journal and conference papers on antenna design and measurement topics, contributed to 3 books and standards, and holds 4 patents.

### *Key bibliography*

1. “Small antennas for small devices”, edited by H. Fujimoto and K. Ito, Artech, Chapter 11, “Antennas for wireless broadband system”, 2018.
2. “Post-processing Techniques in Antenna Measurement”, edited by M. Sierra Castañer and Lars. J. Foged SciTech Publishing, The Institution of Engineering and Technology, London, United Kingdom ISBN 978-1-78561-537-5 (hardback), ISBN 978-1-78561-538-2 (PDF). (In press)
3. “Antennas from theory to practice”, Yi Huang, Kevin Boyle, WILEY 2008, ISBN 978-0-470-51028-5 (hardback), ISBN 979-11-5664-115-5 (In Korean), Chapter 7 “Antenna Manufacturing and Measurements”.
4. “Handbook on Small Antennas”, Lluis Jofre, Marta Martinez-Vazquez, Raquel Serrano, Gemma Roqueta, EurAAP 2012, ISBN 978-88-907018-0-1, Chapter 10 “Measurements of radiated performances for small antennas and terminals”
5. IEEE std 1720-2012, “Recommended Practices for Near-Field Antenna Measurements”.
6. IEEE std 149-2020, “Recommended Practice for Antenna Measurements”.