RRY070: Millimeter wave and THz technology HT2020

Important note: **because of COVID-19 and Chalmers University recommendations, the course will be** given in remote mode via Zoom**. Zoom meeting info will be communicated to students via e-mail and a link at the course web-page.**

Aim

This course aims to introduce students to the problems of guiding, detecting and generating electromagnetic radiation at millimeter wavelengths (MM-waves) and at Terahertz frequencies. Through the course, students will receive lectures on the subjects outlined above and will additionally perform laboratory work to acquire practical skills. A project work guided by teachers will focus students' studies on a deeper understanding of a selected problem within the course subject. The course goal is to provide students with a wide introduction to millimeter and sub-millimeter (Terahertz) technology for industrial applications, instrumentation in radio astronomy, environmental science and other applications.

Learning outcome (after completion of this course, the student should be able to)

- understand principals of building and methods of characterization of low-noise receivers for millimeter and Terahertz bands;
- understand limitations and advantages of MMIC, bolometric and heterodyne receivers and choose technology suitable for particular frequency band and application;
- understand basic principles of operation of superconducting detector and mixer components such as TES, HEB, SIS;
- understand basic principles of building cryogenic HEMT amplifiers and perform Y-factor measurements of amplifier noise temperature;
- understand principals of Gaussian beam technique and be able to simulate basic schemes of millimeter and Terahertz receiver coupling with antenna beam; understand basic principles, limitations and advantages of using Terahertz waveguides;
- understand principals of generation of MM-wave and Terahertz radiation;
- use knowledge on low-noise receiver technology for applications, e.g. radio astronomy, environmental science observations, or other applications;

Lecturers

Victor Belitsky	Examiner Course responsible Lecturer	victor.belitsky@chalmes.se	Tel: 1893
Vincent Desmaris	Lecturer	vincent.desmaris@chalmers.se	Tel: 1846
Denis Meledin	Lecturer	denis.meledin@chalmers.se	Tel: 1842
Alexey Pavolotsky	Lecturer	alexey.pavolotsky@chalmers.se	Tel: 1833
Cristian Lopez	HFSS support	cristian.lopez@chalmers.se	Tel: 6059
Mohammed Aniss Mebarki	Lab responsible	mohamedaniss.mebarki@chalmers.se	

Literature

There is no dedicated course book. The recommended literature covers a wide course material, including journal papers and books and will be provided via direct links to pdf files or links via Chalmers Library access.

All necessary material such as Lab-manuals, lectures notes will be available on the course homepage

Organisation

Content

The course largely relies on and uses the pre-required knowledge of microwave techniques, theory of transmission lines, and general understanding of physics. The course material covers the following topics:

- Noise and receiver properties at mm and submm frequencies, cryogenically operated receivers;
- Antenna - receiver coupling: Gaussian beam technique, Terahertz waveguides;
- Receiver types, e.g. direct detection (bolometric) and heterodyne, quasi-optical and waveguidebased; basics of operation for different type of receivers, schemes and applications
- Bolometric receivers: theory, practical designs, examples;
- Heterodyne SIS receivers: theory, design, examples. Superconducting tuning circuitries;
  HEB heterodyne receivers: theory, design, examples.
- Terahertz MMICs: theory, design, examples.
- Generation of mm and submm waves: sources for local oscillators.
- HEMT cryogenic amplifiers: theory, design, examples.
- Superconductivity and thin-film processing for cryogenic and superconducting components: review of methods and technology.

Preliminary Schedule

The course includes about 19 lectures, laboratory work, a course project (list of project topics will be offered to allow deeper studies on selected course material, e.g. All course events are compulsory and require student attendance.

Examination (Johanneberg Campus, January 11th, 2021 morning session)

to successfully pass the course, the student must:

1. Have attended at least 85% of the lectures.
2. Have successfully completed the laboratory exercises.
3. Have performed the project work.
4. Have gathered at least a total of 24 points (of maximum 60) from the quiz, project and final written examination

Course Schedule

The course includes about 19 lectures, laboratory work, a course project (list of project topics will be offered to allow deeper studies on selected course material, e.g. All course events are compulsory and require student attendance.

Lecture#	Date	Teacher	Activity	Subject
1	2020-11-03	Victor Belitsky	Lecture	Introduction. Noise at THz Frequencies
2	2020-11-03	Victor Belitsky	Lecture	THzOptics I
3	2020-11-05	Victor Belitsky	Lecture	THz optics II
4	2020-11-06	Alexey Pavolotsky	Lecture	Employing Superconductivity for MM and SubMM (THz) electronics
5	2020-11-10	Denis Meledin	Lecture	Direct detector receivers, characterisation and measurements I
6	2020-11-10	Denis Meledin	Lecture	Direct detector receivers, characterisation and measurements II
7	2020-11-12	Vincent Desmaris	Lecture	THz sources I
	2020-11-12	Cristian Lopez	Project/lab kick-off	Project assignments / HFSS tutorial
8	2020-11-17	Victor Belitsky	Lecture	SIS-superconducting tunnel junction mixers I
9	2020-11-17	Vincent Desmaris	Exercise	THz sources II
10	2020-11-19	Victor Belitsky	Lecture	SIS-superconducting tunnel junction mixers II
11	2020-11-20	Denis Meledin	Lecture	HEB - HOT electron bolometer mixer I
12	2020-11-24	Denis Meledin	Lecture / Exercise	HEB - HOT electron bolometer mixer II
13	2020-11-26	Vincent Desmaris	Lecture	Millimeter-wave and THz MMIC technology / cryogenic amplifiers
14	2020-11-27	Vincent Desmaris	Lecture	Advanced IF circuitry
15	2020-12-01	Alexey Pavolotsky	Lecture	Thin-film technology for superconducting electronics I
16	2020-12-01	Alexey Pavolotsky	Lecture	Thin-film technology for superconducting electronics II
17	2020-12-03	Dr. Hawal Rashid (Ansys)	Lecture	Simulaton -based design exploration of THz receiver systems
18	2020-12-08	Dr. Mark Whale (Ericsson)	Lecture	An Introduction to Antenna Systemisation for 5G - 1/2
19	2020-12-10	Dr. Mark Whale (Ericsson)	Lecture	An Introduction to Antenna Systemisation for 5G - 2/2
	2020-12-10		project work	
	2020-12-15		project work	
	2020-12-17		Project presentation	