Course No.: NEMS516000

Frequency communication components and applications

(頻率控制元件與應用)

112 下學期

Instructor:

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Lecture Time:

W2W3W4

Course Description:

- Advanced frequency components are revolutionizing modern wireless communication systems, enabling them to achieve unprecedented levels of performance such as low latency and faster data rates. This course is designed to offer students a comprehensive understanding of frequency communication components and their applications. Throughout the course, students will learn about the properties of various components, including filters, resonators, and oscillators, and how they are utilized in advanced communication systems such as 5G, B5G, and LEO. By conducting hands-on experiments, students will develop practical skills in evaluating and testing these components.
- The course will explore key topics like piezoelectric theory, various material properties, and the design structure of filters, resonators, and oscillators. In addition, the course also reviews different types of oscillators, which are crucial for measuring and interpreting physical parameters like resonance frequency, motional resistance, capacitance, phase noise, jitter, and acceleration sensitivity, and a focus on specific parameters for different applications.
- In addition, this course is also designed to equip students with the knowledge of higher frequency components and introduce them to key techniques such as planar thin-film process technologies, photolithographic techniques, deposition and etching techniques, and the critical performance

considerations for high stability and accuracy applications. By exploring these topics in-depth, students will develop a deep understanding of the underlying principles and gain valuable hands-on experience in the advanced frequency components.

- This course includes hands-on lab practice in the Electronics Lab facility, where students will use specialized testing equipment to evaluate and measure various frequency communication components and their characteristics. They will learn how to use, such as network analyzers, spectrum analyzers, signal generators, and others to measure the performance of frequency components, thereby improving their experimental skills.

- Throughout the semester, students will develop a deep understanding of frequency communication components and their applications. They will acquire practical skills in evaluating, testing, and optimizing these components for specific applications, as well as the ability to troubleshoot and solve problems related to frequency communication systems. By the end of the course, students will be equipped with the skills necessary to pursue advanced studies in RF engineering and related fields.

Tentative Outline:

Week	Lecture
1	Introduction (modern wireless communication systems)
2	Applications in Wireless Communications I
3	Applications in Wireless Communications II
4	Piezoelectric Components and Examples
5	Frequency Control Components and Examples
6	Resonator Modeling and characteristics I
7	Resonator Modeling and characteristics I (Lab-1st)
8	Resonator Modeling and characteristics II
9	Resonator Modeling and characteristics II (Lab-2nd)
10	Midterm Exam or Midterm Project Presentation
11	Microfabrication Technologies
12	kHz/MHz Frequency Components and Structure Analysis
13	Frequency Oscillator Components and characteristics I
14	Frequency Oscillator Components and characteristics I (Lab-3rd)
15	Frequency Oscillator Components and characteristics II
16	Frequency Oscillator Components and characteristics II (Lab-4th)
17	Specialized Frequency Control Components
18	Final Project Presentation

Textbook:

(1) Class Notes.

References – Books:

(1) Handbook of Frequency Stability Analysis_NIST, W.J. Riley_2008

(2) Introduction to quartz frequency standards_CECOM_John R Vig_1997

(3) Bulk Acoustic Wave Theory and Devices, Joel F. Rosenbaum, ISBN-089006265X

References –Conference Proceedings and Journals:

(1) International Conference on Solid-State Sensors and Actuators

(2) IEEE International Electron Devices Meeting

(3) IEEE Ultrasonics Symposium (Ultrasonics'XX, every year)

(4) IEEE Frequency Control Symposium (IFCS'XX, every year)

(5) IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control (JUFFC)

(6) Sensors and Actuators

Prerequisite:

- **This course is intended for graduate students**, and although there are no specific prerequisites. It is important to note that the course is not entirely self-contained. Therefore, students without a background in the subject matter may need to engage in additional reading to fully comprehend the material. It is highly recommended that students have a basic understanding of Microelectronics and microfabrication techniques, including MEMS fabrication technologies such as thin film, metallization, etching, and lithography.
- Moreover, it is crucial for students to have a fundamental understanding of mechanical and electrical properties as well as basic physics and electronics concepts like frequency, resistance, capacitance, and inductance.
- **I would like to encourage that students with different academic backgrounds are welcome to take this course, even if they do not have a background in electrical engineering (non-EE)**. This course offers valuable interdisciplinary knowledge that can help students in their future careers.

Grading Policy: (subject to revision)

Homework 20%, Lab 20%, Midterm Exam or Project Presentation 25%, Final Project Presentation 25%, Class Participation 10%.