

University of Science and Technology of Hanoi Address: Building 2H, 18 Hoang Quoc Viet, Cau Giay, Hanoi

Telephone/ Fax: +84-4 37 91 69 60

Email: <a href="mailto:officeusth@usth.edu.vn">officeusth@usth.edu.vn</a>
Website: <a href="mailto:http://www.usth.edu.vn">http://www.usth.edu.vn</a>

# **COURSE SYLLABUS**

Subject: Antennas and Microwave Engineering	Academic field: Information and Communications Technology and Space				
Lecturer: Nguyen Ngoc Truong Minh, PhD	Affiliation: School of Electrical Engineering, International University, VNU-HCM				
Phone: 0903 760 100	E-mail: nntminh@hcmiu.edu.vn				
Academic year: 2015-2016					

# **COURSE DESCRIPTION**

Credit points	03				
Level	Undergraduate				
Teaching time Location	In 8 weekdays University of Science and Technology of Hanoi (USTH)				
	Lecture	34 hrs			
Time Commitment	Exercises	6 hrs			
Time Commitment	Practical	0 hrs			
	Total	40 hrs			
Prerequisites	Electromagnetic Theory				
Recommended background knowledge	Differential Equations, Electromagnetic Theory				
Subject description	This course is intended for advanced senior undergraduate students in Electrical and Telecommunications Engineering programs. Broad range of topics in the field of RF/Microwave engineering will be covered. In particular, a detailed discussion on transmission lines, waveguides, impedance matching, microwave resonators, RF filters, RF amplifiers, and passive RF and microwave devices (couplers, mixers, duplexers, etc.) will be presented. Furthermore, an introduction to antenna design as well as RF/Microwave communications link design will be provided.				
Objectives & Out-come	Objectives Students are expected to be able to:  1. Understand basic antenna parameters, including radiation resistance, input impedance, gain and directivity  2. Expose to different types of antennas and measurements  3. Analyze transmission lines and waveguides  4. Use Smith Chart to perform impedance matching and other advanced microwave/RF system design  5. Design and analyze microwave/RF oscillators and/or mixers				



University of Science and Technology of Hanoi Address: Building 2H, 18 Hoang Quoc Viet, Cau Giay, Hanoi

Telephone/ Fax: +84-4 37 91 69 60

Email: <a href="mailto:officeusth@usth.edu.vn">officeusth@usth.edu.vn</a>
Website: <a href="mailto:http://www.usth.edu.vn">http://www.usth.edu.vn</a>

	Design and analyze microwave/RF filters						
	7. Design and analyze end-to-end microwave/RF communication links						
	8. Read English textbook and to solve related problems						
	9. Ability to work as a team to solve a given problem (team project)						
	10%						
	Exercise(s)	15%					
Assessment/ Evaluation	Practical	%					
	Mid-term test	25%					
	Final exam	50%					
	[1] Constantine A. Balanis, "Antenna Theory – Analysis and Design", 3 <sup>rd</sup> edition, John Wiley, 2005						
Prescribed Textbook(s)	[2] David M. Pozar, "Microwave Engineering", 4th edition, John Wiley, 2012						
	[3] David K. Barton, Sergey A. Leonov, "Radar Technology Encyclopedia", Artech House, 1998						

# **COURSE CONTENTS & SCHEDULE**

# **During class time**

- 1. Attend lectures given by lecturer or some of your classmates.
- 2. Use the required software (with your laptop and/or classmate's laptop) to simulate a specific circuit to practice what you have learnt in class.
- 3. Prepare and present in-group a complex circuit chosen from the list given by the lecturer.

#### At home

- 1. Do homework
- 2. Review the material given in previous classes and prepare for the next class

<b>50</b>	Contents	Hours				
Class		Lect.	Exr.	Prc.	Ref./Resources	Assignment(s)
1	Chapter 1 – Introduction  1.1 Brief History of Microwaves and Antenna Systems  1.2 Frequency Spectrums  1.3 Wireless Applications  1.4 A Simple System Example	4				
2	Chapter 2 – Antenna and Propagation for Wireless Systems  2.1 Antenna Analysis and Parameters  2.1.1 Introduction  2.1.2 Isotropic Radiator and Plane-Waves  2.1.3 Far-Field Region  2.1.4 Antenna Analysis  2.1.5 Antenna Characteristics and Parameters	8	2	0		



University of Science and Technology of Hanoi Address: Building 2H, 18 Hoang Quoc Viet, Cau Giay, Hanoi

Telephone/ Fax: +84-4 37 91 69 60

Email: <a href="mailto:officeusth@usth.edu.vn">officeusth@usth.edu.vn</a>
Website: <a href="mailto:http://www.usth.edu.vn">http://www.usth.edu.vn</a>

2.2.1 Monopole and Dipole Antennas 2.2.2 Horn Antennas 2.2.3 Historian Patch Antennas 2.2.4 Microstrip Patch Antennas 2.2.5 Historian Patch Antennas 2.2.5 Friis Equations 2.3.1 Friis Equation 2.3.2 Effective Isotropic Radiated Power 2.3.3 Impedance mismatch 2.3.3 Equivalent circuits for transmit and receive antenna 2.4 Wave Propagation Problems  Chapter 3 – Microwave Components 3.1 Introduction and History 3.2 Couplers, Hybrids, and Power Dividers/Combiners 3.3 Resonators, Filters, and Multiplexers 3.4 Isolators and Circulators 3.5 Detectors and Mixers 3.6 Switches, Phase Shifters, and Attenuators 3.7 Oscillators and Amplifiers 3.8 Frequency Multipliers and Dividers Problems  Chapter 4 – Microwave Transceiver Architectures and System Parameters 4.1 Receiver 4.1.1 Typical Receiver Architectures 4.1.2 System Considerations 4.1.3 Natural Sources of Receiver Noise 4.1.4 Receiver Noise Figure 4.1.5 Compression Points, Minimum Detectable Signal, and Dynamic Range 4.2 Transmitter architecture 4.2.2 Transmitter architecture 4.2.2 Transmitter architecture 4.2.2 Transmitter Parameters 4.2.3 Transmitter Parameters 5.1 Introduction 5.2 Frequency Stability and Spurious Signals 5.2 Frequency Stability and Spurious Signals 5.3 Frequency Tuning, Output Power, and Efficiency Problems  Chapter 5 – Microwave Wireless Communication Systems 5.1 Introduction 5.2 Friis Transmission Equation 5.3 Space Loss	2.2 Duratical Autorica	1	l		
2.2.2 Horn Antennas 2.2.3 Parabolic Antennas 2.2.3 Microstrip Patch Antennas 2.2.5 Antenna Arvays and Phased Arrays 2.3.1 Friis Equation 2.3.1 Priis Equation 2.3.2 Effective Isotropic Radiated Power 2.3.3 Impedance mismatch 2.3.4 Polarization mismatch 2.3.5 Pateivalent circuits for transmit and receive antenna 2.4 Wave Propagation Problems  Chapter 3 — Microwave Components 3.1 Introduction and History 3.2 Couplers, Hybrids, and Power Dividers/Combiners 3.3 Resonators, Filters, and Multiplexers 3.4 Isolators and Circulators 3.5 Detectors and Mixers 3.6 Switches, Phase Shifters, and Attenuators 3.7 Oscillators and Amplifiers 3.8 Frequency Multipliers and Dividers Problems  Chapter 4 — Microwave Transceiver Architectures and System Parameters 4.1.1 Receiver 4.1.1 Pytical Receiver Architectures 4.1.2 System Considerations 4.1.3 Matural Sources of Receiver Noise 4.1.4 Receiver Noise Figure 4.1.5 Compression Points, Minimum Detectable Signal, and Dynamic Range 4.2 Transmitter 4.2.1 Transmitter Parameters 4.2.2 Transmitter 4.2.2 Transmitter 4.2.3 Transmitter Parameters 4.2.3 Transmitter Parameters 4.2.3 Transmitter Parameters 4.2.3 Transmitter Parameters 4.2.3 Transmiter Parameters 4.2.4 Transmiter Parameters 4.2.5 Frequency Stability and Spurious Signals 4.2.5 Frequency Tuning, Output Power, and Efficiency Problems  Chapter 5 — Microwave Wireless Communication Systems 5.1 Introduction 5.2 Fiis Transmission Equation 5.3 Space Loss	2.2 Practical Antenna				
2.2.3 Parabolic Antennas 2.2.4 Microstrip Patch Antennas 2.2.4 Microstrip Patch Antennas 2.3.2 Friis Equations 2.3.1 Friis Equations 2.3.2 Effective Isotropic Radiated Power 2.3.3 Impedance mismatch 2.3.4 Educate mismatch 2.3.5 Equivalent circuits for transmit and receive antenna 2.4 Wave Propagation Problems  Chapter 3 – Microwave Components 3.1 Introduction and History 3.2 Couplers, Hybrids, and Power Dividers/Combiners 3.3 Resonators, Filters, and Multiplexers 3.4 Isolators and Circulators 3.5 Detectors and Mixers 3.6 Switches, Phase Shifters, and Attenuators 3.7 Oscillators and Amplifiers 3.8 Frequency Multipliers and Dividers Problems  Chapter 4 – Microwave Transceiver Architectures and System Parameters 4.1 Receiver 4.1.1 Pypical Receiver Architectures 4.1.2 System Considerations 4.1.3 Natural Sources of Receiver Noise 4.1.4 Receiver Noise Figure 4.1.5 Compression Points, Minimum Detectable Signal, and Dynamic Range 4.2 Transmitter 4.2.1 Transmitter architecture 4.2.2 Transmitter Parameters 4.2.3 Transmiter Parameters 4.2.3 Transmiter Parameters 4.2.3 Transmiter Parameters 4.2.4 Transmiter Parameters 4.2.5 Frequency Subility and Spurious Signals 4.2.5 Frequency Tuning, Output Power, and Efficiency Problems  Chapter 5 – Microwave Wireless Communication Systems 5.1 Introduction 5.2 Fiis Transmission Equation 5.3 Space Loss					
2.2.4 Microstrip Patch Antennas 2.2.5 Antenna Arrays and Phased Arrays 2.3. Friis Equation 2.3.1 Friis Equation 2.3.2 Effective Isotropic Radiated Power 2.3.3 Impedance mismatch 2.3.4 Polarization mismatch 2.3.5 Aphaentesian problems  Chapter 3 — Microwave Components 3.1 Introduction and History 3.2 Couplers, Hybrids, and Power Dividers/Combiners 3.3 Resonators, Filters, and Multiplexers 3.4 Isolators and Circulators 3.5 Detectors and Mixers 3.6 Switches, Phase Shifters, and Attenuators 3.7 Oscillators and Amplifiers 3.8 Frequency Multipliers and Dividers Problems  Chapter 4 — Microwave Transceiver Architectures and System Parameters 4.1.1 Receiver 4.1.1 Typical Receiver Architectures 4.1.2 System Considerations 4.1.3 Natural Sources of Receiver Noise 4.1.4 Receiver Noise Gigue 4.2 Transmitter 4.2.1 Transmitter architecture 4.2.1 Transmitter architecture 4.2.2 Transmitter Parameters 4.2.3 Transmitter Parameters 4.2.4 Transmitter Parameters 4.2.5 Frequency Taning, Output Power, and Efficiency Problems  Chapter 5 — Microwave Wireless Communication Systems 5.1 Introduction 5.2 Friis Transmission Equation 5.3 Space Loss					
2.3.1 Friis Equations 2.3.1 Friis Equation 2.3.2 Effective Isotropic Radiated Power 2.3.3 Inpedance mismatch 2.3.4 Polarization mismatch 2.3.5 Equivalent circuits for transmit and receive antenna 2.4 Wave Propagation Problems  Chapter 3 – Microwave Components 3.1 Introduction and History 3.2 Couplers, Hybrids, and Power Dividers/Combiners 3.3 Resonators, Filters, and Multiplexers 3.4 Isolators and Circulators 3.5 Detectors and Mixers 3.6 Switches, Phase Shifters, and Attenuators 3.7 Oscillators and Amplifiers 3.8 Frequency Multipliers and Dividers Problems  Chapter 4 – Microwave Transceiver Architectures and System Parameters 4.12 System Considerations 4.1.3 Natural Sources of Receiver Noise 4.1.4 Receiver Noise Figure 4.1.5 Compression Points, Minimum Detectable Signal, and Dynamic Range 4.2 Transmitter 4.2.1 Transmitter architecture 4.2.2 Transmitter Parameters 4.2.3 Transmitter Noise 4.2.4 Transmitter Noise 4.2.5 Frequency Multipli, and Spurious Signals 4.2.5 Prequency Tuning, Output Power, and Efficiency Problems  Chapter 5 – Microwave Wireless Communication Systems 5.1 Introduction 5.2 Friis Transmission Equation 5.3 Space Loss					
2.3. Friis Equations 2.3.1 Friis Equation 2.3.2 Effective Isotropic Radiated Power 2.3.3 Impedance mismatch 2.3.4 Polarization mismatch 2.3.4 Polarization mismatch 2.3.5 Equivalent circuits for transmit and receive antenna 2.4 Wave Propagation Problems  Chapter 3 – Microwave Components 3.1 Introduction and History 3.2 Couplers, Hybrids, and Power Dividers/Combiners 3.3 Resonators, Filters, and Multiplexers 3.4 Isolators and Circulators 3.5 Detectors and Mixers 3.6 Switches, Phase Shifters, and Attenuators 3.7 Oscillators and Amplifiers 3.8 Frequency Multipliers and Dividers Problems  Chapter 4 – Microwave Transceiver Architectures and System Parameters 4.1.1 Typical Receiver Architectures 4.1.2 System Considerations 4.1.3 Natural Sources of Receiver Noise 4.1.4 Receiver Noise Figure 4.1.5 Compression Points, Minimum Detectable Signal, and Dynamic Range 4.2 Transmitter 4.2.1 Transmitter architecture 4.2.2 Transmitter Points, Minimum Detectable Signal, and Dynamic Range 4.2 Transmitter Points, Minimum Detectable Signal, and Dynamic Range 4.2.2 Transmitter Points, Minimum Detectable Signal, and Dynamic Range 4.2 Transmitter Points, Minimum Detectable Signal, and Dynamic Range 4.2 Transmitter Points, Minimum Detectable Signal, and Dynamic Range 4.2 Transmitter Points, Minimum Detectable Signal, and Dynamic Range 4.2 Transmitter Points, Minimum Detectable Signal, Transmi					
2.3.1 Friis Equation 2.3.2 Effective Isotropic Radiated Power 2.3.3 Impedance mismatch 2.3.4 Polarization mismatch 2.3.5 Equivalent circuits for transmit and receive antenna 2.4 Wave Propagation Problems  Chapter 3 – Microwave Components 3.1 Introduction and History 3.2 Couplers, Hybrids, and Power Dividers/Combiners 3.3 Resonators, Filters, and Multiplexers 3.4 Isolators and Circulators 3.5 Detectors and Mixers 3.6 Switches, Phase Shifters, and Attenuators 3.7 Oscillators and Amplifiers 3.8 Frequency Multipliers and Dividers Problems  Chapter 4 – Microwave Transceiver Architectures and System Parameters 4.1.1 Typical Receiver Architectures 4.1.2 System Considerations 4.1.3 Natural Sources of Receiver Noise 4.1.4 Receiver Noise Figure 4.1.5 Compression Points, Minimum Detectable Signal, and Dynamic Range 4.2 Transmitter 4.2.1 Transmitter architecture 4.2.2 Transmitter Parameters 4.2.3 Transmitter Parameters 4.2.3 Transmitter Noise 4.2.4 Frequency Stability and Spurious Signals 4.2.5 Frequency Tuning, Output Power, and Efficiency Problems  Chapter 5 – Microwave Wireless Communication Systems 5.1 Introduction 5.2 Friis Transmission Equation 5.3 Space Loss	· · · · · · · · · · · · · · · · · · ·				
2.3.2 Effective Isotropic Radiated Power 2.3.3 Impedance mismatch 2.3.4 Polarization mismatch 2.3.5 Equivalent circuits for transmit and receive antenna 2.4 Wave Propagation Problems  Chapter 3 - Microwave Components 3.1 Introduction and History 3.2 Couplers, Hybrids, and Power Dividers/Combiners 3.3 Resonators, Filters, and Multiplexers 3.4 Isolators and Circulators 3.5 Detectors and Mixers 3.6 Switches, Phase Shifters, and Attenuators 3.7 Oscillators and Amplifiers 3.8 Frequency Multipliers and Dividers Problems  Chapter 4 - Microwave Transceiver Architectures and System Parameters 4.1.1 Receiver 4.1.1 Typical Receiver Architectures 4.1.2 System Considerations 4.1.3 Natural Sources of Receiver Noise 4.1.4 Receiver Noise Figure 4.2.1 Transmitter 4.2.1 Transmitter Parameters 4.2.2 Transmitter Points, Minimum Detectable Signal, and Dynamic Range 4.2 Transmitter architecture 4.2.2 Transmitter Parameters 4.2.3 Transmitter Parameters 4.2.4 Frequency Stability and Spurious Signals 4.2.5 Frequency Tuning, Output Power, and Efficiency Problems  Chapter 5 - Microwave Wireless Communication Systems 5.1 Introduction 5.2 Friis Transmission Equation 8 1 0					
2.3.3 Impedance mismatch 2.3.4 Polarization mismatch 2.3.5 Equivalent circuits for transmit and receive antenna 2.4 Wave Propagation Problems  Chapter 3 - Microwave Components 3.1 Introduction and History 3.2 Couplers, Hybrids, and Power Dividers/Combiners 3.3 Resonators, Filters, and Multiplexers 3.4 Isolators and Circulators 3.5 Detectors and Mixers 3.6 Switches, Phase Shifters, and Attenuators 3.7 Oscillators and Amplifiers 3.8 Frequency Multipliers and Dividers Problems  Chapter 4 - Microwave Transceiver Architectures and System Parameters 4.1 Receiver 4.1.1 Typical Receiver Architectures 4.1.2 System Considerations 4.1.3 Natural Sources of Receiver Noise 4.1.4 Receiver Noise Figure 4.1.5 Compression Points, Minimum Detectable Signal, and Dynamic Range 4.2 Transmitter 4.2.1 Transmitter Parameters 4.2.2 Transmitter Parameters 4.2.3 Transmitter Noise 4.2.4 Frequency Stability and Spurious Signals 4.2.5 Frequency Tuning, Output Power, and Efficiency Problems  Chapter 5 - Microwave Wireless Communication Systems 5.1 Introduction 5.2 Friis Transmission Equation 8 1 0					
2.3.4 Polarization mismatch 2.3.5 Equivalent circuits for transmit and receive antenna 2.4 Wave Propagation Problems  Chapter 3 - Microwave Components 3.1 Introduction and History 3.2 Couplers, Hybrids, and Power Dividers/Combiners 3.3 Resonators, Filters, and Multiplexers 3.4 Isolators and Circulators 3.5 Detectors and Mixers 3.6 Switches, Phase Shifters, and Attenuators 3.7 Oscillators and Amplifiers 3.8 Frequency Multipliers and Dividers Problems  Chapter 4 - Microwave Transceiver Architectures and System Parameters 4.1.1 Receiver 4.1.1 Typical Receiver Architectures 4.1.2 System Considerations 4.1.3 Natural Sources of Receiver Noise 4.1.4 Receiver Noise Figure 4.1.5 Compression Points, Minimum Detectable Signal, and Dynamic Range 4.2 Transmitter 4.2.1 Transmitter 4.2.2 Transmitter Noise 4.2.3 Frequency Stability and Spurious Signals 4.2.5 Frequency Tuning, Output Power, and Efficiency Problems  Chapter 5 - Microwave Wireless Communication Systems 5.1 Introduction 5.2 Friis Transmission Equation 8 1 0	2.3.2 Effective Isotropic Radiated Power				
2.3.5 Equivalent circuits for transmit and receive antenna 2.4 Wave Propagation Problems  Chapter 3 – Microwave Components 3.1 Introduction and History 3.2 Couplers, Hybrids, and Power Dividers/Combiners 3.3 Resonators, Filters, and Multiplexers 3.4 Isolators and Circulators 3.5 Detectors and Mixers 3.6 Switches, Phase Shifters, and Attenuators 3.7 Oscillators and Amplifiers 3.8 Frequency Multipliers and Dividers Problems  Chapter 4 – Microwave Transceiver Architectures and System Parameters 4.1 Receiver Noise 4.1.1 System Considerations 4.1.3 Natural Sources of Receiver Noise 4.1.4 Receiver Noise Figure 4.1.5 Compression Points, Minimum Detectable Signal, and Dynamic Range 4.2 Transmitter 4.2.1 Transmitter architecture 4.2.2 Transmitter Parameters 4.2.3 Transmiter Parameters 4.2.4 Frequency Stability and Spurious Signals 4.2.5 Frequency Stability and Spurious Signals 4.2.5 Frequency Tuning, Output Power, and Efficiency Problems  Chapter 5 – Microwave Wireless Communication Systems 5.1 Introduction 5.2 Priis Transmission Equation 5.3 Space Loss					
antenna 2.4 Wave Propagation Problems  Chapter 3 - Microwave Components 3.1 Introduction and History 3.2 Couplers, Hybrids, and Power Dividers/Combiners 3.3 Resonators, Filters, and Multiplexers 3.4 Isolators and Circulators 8 2 0 3.5 Detectors and Mixers 3.6 Switches, Phase Shifters, and Attenuators 3.7 Oscillators and Amplifiers 3.8 Frequency Multipliers and Dividers Problems  Chapter 4 - Microwave Transceiver Architectures and System Parameters 4.1 Receiver 4.1.1 Typical Receiver Architectures 4.1.2 System Considerations 4.1.3 Natural Sources of Receiver Noise 4.1.4 Receiver Noise Figure 4.1.5 Compression Points, Minimum Detectable Signal, and Dynamic Range 4.2 Transmitter 4.2.1 Transmitter architecture 4.2.2 Transmitter architecture 4.2.2 Transmitter architecture 4.2.3 Transmitter architecture 4.2.4 Frequency Stability and Spurious Signals 4.2.5 Frequency Tuning, Output Power, and Efficiency Problems  Chapter 5 - Microwave Wireless Communication Systems 5.1 Introduction 5.2 Friis Transmission Equation 5.3 Space Loss	2.3.4 Polarization mismatch				
2.4 Wave Propagation Problems  Chapter 3 - Microwave Components 3.1 Introduction and History 3.2 Couplers, Hybrids, and Power Dividers/Combiners 3.3 Resonators, Filters, and Multiplexers 3.4 Isolators and Circulators 3.5 Detectors and Mixers 3.6 Switches, Phase Shifters, and Attenuators 3.7 Oscillators and Amplifiers 3.8 Frequency Multipliers and Dividers Problems  Chapter 4 - Microwave Transceiver Architectures and System Parameters 4.1 Receiver 4.1.1 Typical Receiver Architectures 4.1.2 System Considerations 4.1.3 Natural Sources of Receiver Noise 4.1.4 Receiver Noise Figure 4.1.5 Compression Points, Minimum Detectable Signal, and Dynamic Range 4.2 Transmitter 4.2.1 Transmitter architecture 4.2.2 Transmitter Parameters 4.2.3 Transmitter Parameters 4.2.4 Frequency Stability and Spurious Signals 4.2.5 Frequency Tuning, Output Power, and Efficiency Problems  Chapter 5 - Microwave Wireless Communication Systems 5.1 Introduction 5.2 Friis Transmission Equation 5.3 Space Loss	2.3.5 Equivalent circuits for transmit and receive				
Problems  Chapter 3 - Microwave Components 3.1 Introduction and History 3.2 Couplers, Hybrids, and Power Dividers/Combiners 3.3 Resonators, Filters, and Multiplexers 3.4 Isolators and Circulators 3.5 Detectors and Mixers 3.6 Switches, Phase Shifters, and Attenuators 3.7 Oscillators and Amplifiers 3.8 Frequency Multipliers and Dividers Problems  Chapter 4 - Microwave Transceiver Architectures and System Parameters 4.1 Receiver 4.1.1 Typical Receiver Architectures 4.1.2 System Considerations 4.1.3 Natural Sources of Receiver Noise 4.1.4 Receiver Noise Figure 4.1.5 Compression Points, Minimum Detectable Signal, and Dynamic Range 4.2 Transmitter 4.2.1 Transmitter 4.2.1 Transmitter Parameters 4.2.2 Transmitter Parameters 4.2.3 Transmitter Parameters 4.2.4 Frequency Stability and Spurious Signals 4.2.5 Frequency Tuning, Output Power, and Efficiency Problems  Chapter 5 - Microwave Wireless Communication Systems 5.1 Introduction 5.2 Friis Transmission Equation 8 1 0	antenna				
Chapter 3 - Microwave Components 3.1 Introduction and History 3.2 Couplers, Hybrids, and Power Dividers/Combiners 3.3 Resonators, Filters, and Multiplexers 3.4 Isolators and Circulators 3.5 Detectors and Mixers 3.6 Switches, Phase Shifters, and Attenuators 3.7 Oscillators and Amplifiers 3.8 Frequency Multipliers and Dividers Problems  Chapter 4 - Microwave Transceiver Architectures and System Parameters 4.1 Receiver 4.1.1 Typical Receiver Architectures 4.1.2 System Considerations 4.1.3 Natural Sources of Receiver Noise 4.1.4 Receiver Noise Figure 4.1.5 Compression Points, Minimum Detectable Signal, and Dynamic Range 4.2 Transmitter 4.2.1 Transmitter 4.2.1 Transmitter architecture 4.2.2 Transmitter Parameters 4.2.3 Transmitter Parameters 4.2.4 Frequency Stability and Spurious Signals 4.2.5 Frequency Tuning, Output Power, and Efficiency Problems  Chapter 5 - Microwave Wireless Communication Systems 5.1 Introduction 5.2 Friis Transmission Equation 8 1 0	2.4 Wave Propagation				
3.1 Introduction and History 3.2 Couplers, Hybrids, and Power Dividers/Combiners 3.3 Resonators, Filters, and Multiplexers 3.4 Isolators and Circulators 3.5 Detectors and Mixers 3.6 Switches, Phase Shifters, and Attenuators 3.7 Oscillators and Amplifiers 3.8 Frequency Multipliers and Dividers Problems  Chapter 4 – Microwave Transceiver Architectures and System Parameters 4.1 Receiver 4.1.1 Typical Receiver Architectures 4.1.2 System Considerations 4.1.3 Natural Sources of Receiver Noise 4.1.4 Receiver Noise Figure 4.1.5 Compression Points, Minimum Detectable Signal, and Dynamic Range 4.2 Transmitter 4.2.1 Transmitter architecture 4.2.2 Transmitter Parameters 4.2.3 Transmitter Noise 4.2.4 Frequency Stability and Spurious Signals 4.2.5 Frequency Tuning, Output Power, and Efficiency Problems  Chapter 5 – Microwave Wireless Communication Systems 5.1 Introduction 5.2 Friis Transmission Equation 5.3 Space Loss	Problems				
3.1 Introduction and History 3.2 Couplers, Hybrids, and Power Dividers/Combiners 3.3 Resonators, Filters, and Multiplexers 3.4 Isolators and Circulators 3.5 Detectors and Mixers 3.6 Switches, Phase Shifters, and Attenuators 3.7 Oscillators and Amplifiers 3.8 Frequency Multipliers and Dividers Problems  Chapter 4 – Microwave Transceiver Architectures and System Parameters 4.1 Receiver 4.1.1 Typical Receiver Architectures 4.1.2 System Considerations 4.1.3 Natural Sources of Receiver Noise 4.1.4 Receiver Noise Figure 4.1.5 Compression Points, Minimum Detectable Signal, and Dynamic Range 4.2 Transmitter 4.2.1 Transmitter architecture 4.2.2 Transmitter Parameters 4.2.3 Transmitter Noise 4.2.4 Frequency Stability and Spurious Signals 4.2.5 Frequency Tuning, Output Power, and Efficiency Problems  Chapter 5 – Microwave Wireless Communication Systems 5.1 Introduction 5.2 Friis Transmission Equation 5.3 Space Loss	Chapter 3 – Microwave Components				
3.2 Couplers, Hybrids, and Power Dividers/Combiners 3.3 Resonators, Filters, and Multiplexers 3.4 Isolators and Circulators 3.5 Detectors and Mixers 3.6 Switches, Phase Shifters, and Attenuators 3.7 Oscillators and Amplifiers 3.8 Frequency Multipliers and Dividers Problems  Chapter 4 – Microwave Transceiver Architectures and System Parameters 4.1.1 Typical Receiver Architectures 4.1.2 System Considerations 4.1.3 Natural Sources of Receiver Noise 4.1.4 Receiver Noise Figure 4.1.5 Compression Points, Minimum Detectable Signal, and Dynamic Range 4.2.1 Transmitter 4.2.1 Transmitter 4.2.2 Transmitter Parameters 4.2.3 Transmitter Parameters 4.2.4 Frequency Stability and Spurious Signals 4.2.5 Frequency Inning, Output Power, and Efficiency Problems  Chapter 5 – Microwave Wireless Communication Systems 5.1 Introduction 5.2 Friis Transmission Equation 5.3 Space Loss	-				
Dividers/Combiners  3.3 Resonators, Filters, and Multiplexers  3.4 Isolators and Circulators  3.5 Detectors and Mixers  3.6 Switches, Phase Shifters, and Attenuators  3.7 Oscillators and Amplifiers  3.8 Frequency Multipliers and Dividers Problems  Chapter 4 – Microwave Transceiver  Architectures and System Parameters  4.1.1 Typical Receiver Architectures  4.1.2 System Considerations  4.1.3 Natural Sources of Receiver Noise  4.1.4 Receiver Noise Figure  4.1.5 Compression Points, Minimum Detectable  Signal, and Dynamic Range  4.2 Transmitter  4.2.1 Transmitter architecture  4.2.2 Transmitter Parameters  4.2.3 Transmitter Parameters  4.2.4 Frequency Stability and Spurious Signals  4.2.5 Frequency Tuning, Output Power, and Efficiency Problems  Chapter 5 – Microwave Wireless  Communication Systems  5.1 Introduction  5.2 Friis Transmission Equation  5.3 Space Loss	<del>-</del>				
3.3 Resonators, Filters, and Multiplexers 3.4 Isolators and Circulators 3.5 Detectors and Mixers 3.6 Switches, Phase Shifters, and Attenuators 3.7 Oscillators and Amplifiers 3.8 Frequency Multipliers and Dividers Problems  Chapter 4 – Microwave Transceiver Architectures and System Parameters 4.1 Receiver 4.1.1 Typical Receiver Architectures 4.1.2 System Considerations 4.1.3 Natural Sources of Receiver Noise 4.1.4 Receiver Noise Figure 4.1.5 Compression Points, Minimum Detectable Signal, and Dynamic Range 4.2 Transmitter 4.2.1 Transmitter architecture 4.2.2 Transmitter architecture 4.2.2 Transmitter Parameters 4.2.3 Transmitter Noise 4.2.4 Frequency Stability and Spurious Signals 4.2.5 Frequency Tuning, Output Power, and Efficiency Problems  Chapter 5 – Microwave Wireless Communication Systems 5.1 Introduction 5.2 Friis Transmission Equation 5.3 Space Loss					
3.4 Isolators and Circulators 3.5 Detectors and Mixers 3.6 Switches, Phase Shifters, and Attenuators 3.7 Oscillators and Amplifiers 3.8 Frequency Multipliers and Dividers Problems  Chapter 4 – Microwave Transceiver Architectures and System Parameters 4.1 Receiver 4.1.1 Typical Receiver Architectures 4.1.2 System Considerations 4.1.3 Natural Sources of Receiver Noise 4.1.4 Receiver Noise Figure 4.1.5 Compression Points, Minimum Detectable Signal, and Dynamic Range 4.2 Transmitter 4.2.1 Transmitter 4.2.1 Transmitter architecture 4.2.2 Transmitter Noise 4.2.4 Frequency Stability and Spurious Signals 4.2.5 Frequency Tuning, Output Power, and Efficiency Problems  Chapter 5 – Microwave Wireless Communication Systems 5.1 Introduction 5.2 Friis Transmission Equation 5.3 Space Loss					
3.5 Detectors and Mixers 3.6 Switches, Phase Shifters, and Attenuators 3.7 Oscillators and Amplifiers 3.8 Frequency Multipliers and Dividers Problems  Chapter 4 – Microwave Transceiver Architectures and System Parameters 4.1 Receiver 4.1.1 Typical Receiver Architectures 4.1.2 System Considerations 4.1.3 Natural Sources of Receiver Noise 4.1.4 Receiver Noise Figure 4.1.5 Compression Points, Minimum Detectable Signal, and Dynamic Range 4.2 Transmitter 4.2.1 Transmitter 4.2.1 Transmitter architecture 4.2.2 Transmitter Parameters 4.2.3 Transmitter Noise 4.2.4 Frequency Stability and Spurious Signals 4.2.5 Frequency Tuning, Output Power, and Efficiency Problems  Chapter 5 – Microwave Wireless Communication Systems 5.1 Introduction 5.2 Friis Transmission Equation 5.3 Space Loss		0	_	0	
3.6 Switches, Phase Shifters, and Attenuators 3.7 Oscillators and Amplifiers 3.8 Frequency Multipliers and Dividers Problems  Chapter 4 – Microwave Transceiver Architectures and System Parameters 4.1 Receiver 4.1.1 Typical Receiver Architectures 4.1.2 System Considerations 4.1.3 Natural Sources of Receiver Noise 4.1.4 Receiver Noise Figure 4.1.5 Compression Points, Minimum Detectable Signal, and Dynamic Range 4.2 Transmitter 4.2.1 Transmitter 4.2.1 Transmitter architecture 4.2.2 Transmitter Parameters 4.2.3 Transmitter Parameters 4.2.4 Frequency Stability and Spurious Signals 4.2.5 Frequency Tuning, Output Power, and Efficiency Problems  Chapter 5 – Microwave Wireless Communication Systems 5.1 Introduction 5.2 Friis Transmission Equation 5.3 Space Loss		8	2	Ü	
3.7 Oscillators and Amplifiers 3.8 Frequency Multipliers and Dividers Problems  Chapter 4 – Microwave Transceiver Architectures and System Parameters 4.1 Receiver 4.1.1 Typical Receiver Architectures 4.1.2 System Considerations 4.1.3 Natural Sources of Receiver Noise 4.1.4 Receiver Noise Figure 4.1.5 Compression Points, Minimum Detectable Signal, and Dynamic Range 4.2 Transmitter 4.2.1 Transmitter architecture 4.2.2 Transmitter Parameters 4.2.3 Transmitter Noise 4.2.4 Frequency Stability and Spurious Signals 4.2.5 Frequency Tuning, Output Power, and Efficiency Problems  Chapter 5 – Microwave Wireless Communication Systems 5.1 Introduction 5.2 Friis Transmission Equation 5.3 Space Loss	3.5 Detectors and Mixers				
3.8 Frequency Multipliers and Dividers Problems  Chapter 4 – Microwave Transceiver Architectures and System Parameters  4.1 Receiver 4.1.1 Typical Receiver Architectures 4.1.2 System Considerations 4.1.3 Natural Sources of Receiver Noise 4.1.4 Receiver Noise Figure 4.1.5 Compression Points, Minimum Detectable Signal, and Dynamic Range 4.2 Transmitter 4.2.1 Transmitter architecture 4.2.2 Transmitter Parameters 4.2.3 Transmitter Parameters 4.2.4 Frequency Stability and Spurious Signals 4.2.5 Frequency Tuning, Output Power, and Efficiency Problems  Chapter 5 – Microwave Wireless Communication Systems 5.1 Introduction 5.2 Friis Transmission Equation 5.3 Space Loss	3.6 Switches, Phase Shifters, and Attenuators				
3.8 Frequency Multipliers and Dividers Problems  Chapter 4 – Microwave Transceiver Architectures and System Parameters  4.1 Receiver 4.1.1 Typical Receiver Architectures 4.1.2 System Considerations 4.1.3 Natural Sources of Receiver Noise 4.1.4 Receiver Noise Figure 4.1.5 Compression Points, Minimum Detectable Signal, and Dynamic Range 4.2 Transmitter 4.2.1 Transmitter architecture 4.2.2 Transmitter Parameters 4.2.3 Transmitter Parameters 4.2.4 Frequency Stability and Spurious Signals 4.2.5 Frequency Tuning, Output Power, and Efficiency Problems  Chapter 5 – Microwave Wireless Communication Systems 5.1 Introduction 5.2 Friis Transmission Equation 5.3 Space Loss	3.7 Oscillators and Amplifiers				
Problems  Chapter 4 – Microwave Transceiver Architectures and System Parameters 4.1 Receiver 4.1.1 Typical Receiver Architectures 4.1.2 System Considerations 4.1.3 Natural Sources of Receiver Noise 4.1.4 Receiver Noise Figure 4.1.5 Compression Points, Minimum Detectable Signal, and Dynamic Range 4.2 Transmitter 4.2.1 Transmitter architecture 4.2.2 Transmitter Parameters 4.2.3 Transmitter Parameters 4.2.3 Transmitter Noise 4.2.4 Frequency Stability and Spurious Signals 4.2.5 Frequency Tuning, Output Power, and Efficiency Problems  Chapter 5 – Microwave Wireless Communication Systems 5.1 Introduction 5.2 Friis Transmission Equation 5.3 Space Loss	•				
Architectures and System Parameters  4.1 Receiver  4.1.1 Typical Receiver Architectures 4.1.2 System Considerations 4.1.3 Natural Sources of Receiver Noise 4.1.4 Receiver Noise Figure 4.1.5 Compression Points, Minimum Detectable Signal, and Dynamic Range 4.2 Transmitter 4.2.1 Transmitter architecture 4.2.2 Transmitter Parameters 4.2.3 Transmitter Parameters 4.2.4 Frequency Stability and Spurious Signals 4.2.5 Frequency Tuning, Output Power, and Efficiency Problems  Chapter 5 – Microwave Wireless Communication Systems 5.1 Introduction 5.2 Friis Transmission Equation 5.3 Space Loss					
Architectures and System Parameters 4.1 Receiver 4.1.1 Typical Receiver Architectures 4.1.2 System Considerations 4.1.3 Natural Sources of Receiver Noise 4.1.4 Receiver Noise Figure 4.1.5 Compression Points, Minimum Detectable Signal, and Dynamic Range 4.2 Transmitter 4.2.1 Transmitter architecture 4.2.2 Transmitter Parameters 4.2.3 Transmitter Parameters 4.2.4 Frequency Stability and Spurious Signals 4.2.5 Frequency Tuning, Output Power, and Efficiency Problems  Chapter 5 – Microwave Wireless Communication Systems 5.1 Introduction 5.2 Friis Transmission Equation 5.3 Space Loss	Chantar A Microwaya Transcaiyar				
4.1 Receiver 4.1.1 Typical Receiver Architectures 4.1.2 System Considerations 4.1.3 Natural Sources of Receiver Noise 4.1.4 Receiver Noise Figure 4.1.5 Compression Points, Minimum Detectable Signal, and Dynamic Range 4.2 Transmitter 4.2.1 Transmitter architecture 4.2.2 Transmitter Parameters 4.2.3 Transmitter Noise 4.2.4 Frequency Stability and Spurious Signals 4.2.5 Frequency Tuning, Output Power, and Efficiency Problems  Chapter 5 – Microwave Wireless Communication Systems 5.1 Introduction 5.2 Friis Transmission Equation 5.3 Space Loss	_				
4.1.1 Typical Receiver Architectures 4.1.2 System Considerations 4.1.3 Natural Sources of Receiver Noise 4.1.4 Receiver Noise Figure 4.1.5 Compression Points, Minimum Detectable Signal, and Dynamic Range 4.2 Transmitter 4.2.1 Transmitter architecture 4.2.2 Transmitter Parameters 4.2.3 Transmitter Parameters 4.2.4 Frequency Stability and Spurious Signals 4.2.5 Frequency Tuning, Output Power, and Efficiency Problems  Chapter 5 – Microwave Wireless Communication Systems 5.1 Introduction 5.2 Friis Transmission Equation 5.3 Space Loss					
4.1.2 System Considerations 4.1.3 Natural Sources of Receiver Noise 4.1.4 Receiver Noise Figure 4.1.5 Compression Points, Minimum Detectable Signal, and Dynamic Range 4.2 Transmitter 4.2.1 Transmitter architecture 4.2.2 Transmitter Parameters 4.2.3 Transmitter Noise 4.2.4 Frequency Stability and Spurious Signals 4.2.5 Frequency Tuning, Output Power, and Efficiency Problems  Chapter 5 – Microwave Wireless Communication Systems 5.1 Introduction 5.2 Friis Transmission Equation 5.3 Space Loss					
4.1.3 Natural Sources of Receiver Noise 4.1.4 Receiver Noise Figure 4.1.5 Compression Points, Minimum Detectable Signal, and Dynamic Range 4.2 Transmitter 4.2.1 Transmitter architecture 4.2.2 Transmitter Parameters 4.2.3 Transmitter Noise 4.2.4 Frequency Stability and Spurious Signals 4.2.5 Frequency Tuning, Output Power, and Efficiency Problems  Chapter 5 – Microwave Wireless Communication Systems 5.1 Introduction 5.2 Friis Transmission Equation 8 1 0 5.3 Space Loss	• =				
4.1.4 Receiver Noise Figure 4.1.5 Compression Points, Minimum Detectable Signal, and Dynamic Range 4.2 Transmitter 4.2.1 Transmitter architecture 4.2.2 Transmitter Parameters 4.2.3 Transmitter Noise 4.2.4 Frequency Stability and Spurious Signals 4.2.5 Frequency Tuning, Output Power, and Efficiency Problems  Chapter 5 – Microwave Wireless Communication Systems 5.1 Introduction 5.2 Friis Transmission Equation 5.3 Space Loss					
4.1.5 Compression Points, Minimum Detectable Signal, and Dynamic Range 4.2 Transmitter 4.2.1 Transmitter architecture 4.2.2 Transmitter Parameters 4.2.3 Transmitter Noise 4.2.4 Frequency Stability and Spurious Signals 4.2.5 Frequency Tuning, Output Power, and Efficiency Problems  Chapter 5 – Microwave Wireless Communication Systems 5.1 Introduction 5.2 Friis Transmission Equation 5.3 Space Loss					
Signal, and Dynamic Range 4.2 Transmitter 4.2.1 Transmitter architecture 4.2.2 Transmitter Parameters 4.2.3 Transmitter Noise 4.2.4 Frequency Stability and Spurious Signals 4.2.5 Frequency Tuning, Output Power, and Efficiency Problems  Chapter 5 – Microwave Wireless Communication Systems 5.1 Introduction 5.2 Friis Transmission Equation 5.3 Space Loss	<u> </u>				
4.2.1 Transmitter 4.2.1 Transmitter architecture 4.2.2 Transmitter Parameters 4.2.3 Transmitter Noise 4.2.4 Frequency Stability and Spurious Signals 4.2.5 Frequency Tuning, Output Power, and Efficiency Problems  Chapter 5 – Microwave Wireless Communication Systems 5.1 Introduction 5.2 Friis Transmission Equation 5.3 Space Loss	_	6	1	0	
4.2.1 Transmitter architecture 4.2.2 Transmitter Parameters 4.2.3 Transmitter Noise 4.2.4 Frequency Stability and Spurious Signals 4.2.5 Frequency Tuning, Output Power, and Efficiency Problems  Chapter 5 – Microwave Wireless Communication Systems 5.1 Introduction 5.2 Friis Transmission Equation 5.3 Space Loss	•				
4.2.2 Transmitter Parameters 4.2.3 Transmitter Noise 4.2.4 Frequency Stability and Spurious Signals 4.2.5 Frequency Tuning, Output Power, and Efficiency Problems  Chapter 5 – Microwave Wireless Communication Systems 5.1 Introduction 5.2 Friis Transmission Equation 5.3 Space Loss					
4.2.3 Transmitter Noise 4.2.4 Frequency Stability and Spurious Signals 4.2.5 Frequency Tuning, Output Power, and Efficiency Problems  Chapter 5 – Microwave Wireless Communication Systems 5.1 Introduction 5.2 Friis Transmission Equation 5.3 Space Loss					
4.2.4 Frequency Stability and Spurious Signals 4.2.5 Frequency Tuning, Output Power, and Efficiency Problems  Chapter 5 – Microwave Wireless Communication Systems 5.1 Introduction 5.2 Friis Transmission Equation 5.3 Space Loss					
4.2.5 Frequency Tuning, Output Power, and Efficiency Problems  Chapter 5 – Microwave Wireless Communication Systems 5.1 Introduction 5.2 Friis Transmission Equation 5.3 Space Loss					
Problems  Chapter 5 – Microwave Wireless Communication Systems 5.1 Introduction 5.2 Friis Transmission Equation 5.3 Space Loss  8 1 0					
Chapter 5 – Microwave Wireless Communication Systems 5.1 Introduction 5.2 Friis Transmission Equation 5.3 Space Loss  8 1 0					
Communication Systems 5.1 Introduction 5.2 Friis Transmission Equation 5.3 Space Loss	Problems				
5.1 Introduction 5.2 Friis Transmission Equation 5.3 Space Loss	Chapter 5 – Microwave Wireless				
5.1 Introduction 5.2 Friis Transmission Equation 5.3 Space Loss	<b>Communication Systems</b>				
5.2 Friis Transmission Equation 5.3 Space Loss					
5.3 Space Loss		8	1	0	
	-				
1 5 / Link Equation and Link Rudget	5.4 Link Equation and Link Budget				
5.5 Effective Isotropic Radiated Power and G/T	5.5 Effective Isotropic Natifactor Power and G/1				



University of Science and Technology of Hanoi Address: Building 2H, 18 Hoang Quoc Viet, Cau Giay, Hanoi

Telephone/ Fax: +84-4 37 91 69 60

Email: officeusth@usth.edu.vn
Website: http://www.usth.edu.vn

Parameters			
5.6 Radio/Microwave Links			
5.7 Satellite Communication Systems			
5.8 Mobile Communication Systems and Wireless			
Cellular Phones			
Problems			

#### Notes:

- Abbreviation: Lect. (Lecture), Exr. (Exercise), Prc. (Practice).
- Exercises may include assignment, reports, student's presentation, homework, class exercises... for each class sessions
- Practical mostly refer to Lab- work or outside practice such as field trip.

#### **References Literature**

[1] Constantine A. Balanis,	"Antenna Theory – Analys	sis and Design", 3 <sup>rd</sup>	edition, John Wiley, 2005
-----------------------------	--------------------------	----------------------------------	---------------------------

[2] David M. Pozar, "Microwave Engineering", 4th edition, John Wiley, 2012

[3] David K. Barton, Sergey A. Leonov, "Radar Technology Encyclopedia", Artech House, 1998