**King Saud University**
**College of Engineering**
**Electrical Engineering Department** **Semester: 412**

# Senior Design Project Proposal Form

**Project # C1**

**Project Title:** Design of 5G User Equipment Considering RF EMF Exposure Limits

**Professor(s) Name(s):** Dr. Ibrahim Elshafiey & Dr. Abdel Fattah Sheta

**Number of Students:** Two

**Students Qualifications:**
Basic knowledge of Communication Engineering

**Statement of Problem**

5G systems are emerging to meet the need for higher data rate and low latency communication. Different frequency bands are considered for 5G systems. The human exposure to electromagnetic fields should be restricted to standard limits at each of used bands. Below 6 GHz, specific absorption rate SAR limits are identified. Above 6 GHz, radio frequency (RF) electromagnetic field (EMF) exposure from the mobile communication user equipment (UE) should be assessed in terms of incident power density, rather than SAR. Such regulatory RF EMF restrictions will constrain the transmit power of the UE and its peak equivalent isotropic radiated power (EIRP).

**Brief Description of the Project**

The project aims at designing user equipment for 5G systems to maintain safe exposure limits to human users. The project depends on simulation as well as hardware implementation. Analysis is conducted of the peak EIRP levels of UE containing code-book-based beamforming arrays. Different types of antenna elements, incremental element spacing are considered.

**Objectives**

The objective of this project

(1) Investigate the requirements of exposure limit standards.
(2) Analyze interaction of RF fields with human tissues.
(3) Design a prototype of analysis of interaction of radiated signal with a phantom.
(4) Conduct experimental validation tests.

**Technical Approach and Expected Deliverables**

The steps to achieve these objectives:

- Phase I: Students will investigate various standards of exposure limits.
- Phase II: Students will conduct simulation of RF radiation close to human body.
- Phase III: Students will analyze the performance at various frequency bands.
- Phase IV: Students will conduct experimental validation experiments using state of art software defined radio and power amplifier modules.

**Expected Deliverables:**

- Model of RF exposure to EMF for 5G systems.
- Validation setup of developed system.

## Project # C2

**Project Title:** **Design of Cloud-Based Radio Access Network for Millimeter-Wave 5G Systems**

**Professor(s) Name(s):** **Dr. Ibrahim Elshafiey & Dr. Abdulhameed Al-Sanie**

**Number of Students:** **Two**

**Students Qualifications:**
Basic knowledge of Communication Engineering

**Statement of Problem**
Millimeter-wave MMW systems are needed to solve the deficit of microwave spectrum. The propagation nature of in MMW band requires the use of compact size cells, and thus necessitates the deployment of very large number of cells. To reduce the cost and complexity, the cells should be equipped with simple and low functionality radio heads. Complex and intelligent functionality are to be carried into a central office and the obtained signal is carried through an efficient backhaul network to remote cells. This approach is recognized as cloud-based radio access network (C-RAN).

**Brief Description of the Project**
The project aims at desinining C-RAN system that optimizes cost, energy efficincy and spectral efficiency. The backhaul network of this system is realized through RF-over-Fiber, in which MMW signal is carried over optical fiber to remote head units.

**Objectives**
The objective of this project

(5) Investigate the requirements of 5G communication systems
(6) Get acquainted with simulation tools of wireless and optical communication systems.
(7) Design MMW RF-over-Fiber system.
(8) Simulate performance for C-RAN systems
(9) Conduct experimental validation tests.

**Technical Approach and Expected Deliverables**

The steps to achieve these objectives:

- Phase I: Students will investigate 5G communication systems using simulation.
- Phase II: Students will conduct simulation of RF over fiber system.
- Phase III: Students will test the performance of C-RAN system.
- Phase IV: Students will conduct experimental validation experiments.

**Expected Deliverables:**

- Model of RF over fiber backhaul of C-RAN of 5G Communication System
- Validation setup of developed system.

## Project # C3

**Project Title:** Tunable Microwave Sensors Using Varactor diodes for Material Characterization

**Professor(s) Name(s):** 1. Ali Albishi 2. Mohamed Abou El-Ela

**Number of Students:** Two to three students

**Students Qualifications**

1- Highly motivated, adaptable, quick, and eager learner of new materials and subject matters.
2- Responsible and Serious, ready to give the time to learn something new
3- Microwave circuit design (reading Pozar's book can help to catch up)
4- Knowledge of simulation tools such as Matlab and Numerical simulation (HFSS, CST, etc.)
5- Having skills in report writing and presentation.
6- Hard working students and can collaborate and work in a team

**Statement of Problem**

In practical sensing applications, there are many sources of errors including air gaps between microwave sensors and materials under test and the background noise. Characterizing many physical parameters simultaneously can also introduce another challenge. Using a single point frequency or the shift in the resonance frequency is not sufficient in the material characterization process. In this project, we try to solve these challenges by introducing the concept of tunable microwave resonators.

**Brief Description of the Project**

Planar microwave near-field sensors can provide many advantages such as high penetration, resolution, and sensitivity. The latter can be achieved by adopting the concept of electrically-small resonators where their largest length is relatively small compared to the excitation wavelength. The excitation mechanism is based on the use of the microstrip line technology where the sensing mechanism is based on observing the shifts in the resonance frequency due to the interaction with the materials under test (MUTs). Thus, after developing sensitive sensors, the sensors will be used to characterize the MUTs. The sensors will be fabricated using relatively cheap technology (printed circuit board). All the measurements will be conducted using vector network analyzers (VNAs).

**Objectives and tasks**

1. Conducting a comprehensive literature review of microwave resonators based sensors for sensing and particularly for material characterization
2. Choosing a well-cited paper and duplicate the results to build confidence with the simulation tools.
3. Trying to come up with new ideas for material characterization
4. Implementing the new ideas using the numerical simulation (HFSS)
5. Finally, being able to describe in details the steps to how one can be able to implement the idea experimentally

**Technical Approach and Expected Deliverables**

1- Conducting a comprehensive literature review on the topic using the university electronic library and international engineering journals such as IEEE. 2- Modeling using simulations tools such as HFSS and analyzing the result using MatLab

**Expected Deliverables**

Showing the real confidence in understanding the problem where the student able to explain the main problem, show what others have done, and provide novel solution. The experiments will be in the second parts of the graduation project (EE497).

## Project # C4

**Project Title:** Adaptive Noise/Clutter Cancellation (ANC) Techniques for Passive Radar

**Professor(s) Name(s):**
1. Dr. Mubashir Alam
2. Dr. Irfan Ahmed

**Number of Students:** Two to three

**Students Qualifications:** Students should be from the radar, signal processing, communication area, strong willingness to learn, and then model and simulate the different ANC techniques for passive radar using adaptive filters.

### Statement of Problem

The project covers the learning and then implementation of different ANC algorithms for passive radar. Different algorithms will also be compared in terms of complexity, speed and the effective ness in removing the noise/clutter.

### Brief Description of the Project

In radar systems, the ambiguity function of the applied illuminator signal essentially determines the detection capabilities. Zero Doppler interference (ZDI) or close targets returns can mask weak target reflections from higher distances. This is particularly the case for passive radars where the illuminator signal is not under the control of the radar designer. In recent times, great efforts have been carried out to research and develop efficiently working filter algorithms. These adaptive algorithms aim to cancel the undesired interference components in order to enhance the useful dynamic range..

### Objectives

(1) Mathematical Date modeling for passive radar with signal processing algorithm chain
(2) Implementation and simulation of different temporal ANC algorithms (1) least mean square (LMS), (2) normalized least mean square (NLMS), (3) recursive least squares (RLS), (4) extensive cancellation algorithm (ECA) (5) sequential cancellation algorithm (SCA) in passive radar scenario
(3) Comparison of different ANC algorithms presented in (2)

### Technical Approach and Expected Deliverables

This project will cover Data modeling and implementation of different ANC algorithms for passive radar in Matlab/LabView environment. The deliverables will be efficient implementations of different ANC algorithms in terms of speed and acccuracy.

## Project # C5

**Project Title:** Full Scale Automotive Radar Simulation for Autonomous Guidance Applications

**Professors Names:** 1. Dr. Saif Alsaif
2. Dr. Ahmed Alzuhair

**Number of Students:** Two

**Students Qualifications**

- Knowledge in basic Radar Theory and Control Systems
- MATLAB coding experience
- Good writing and presentation skills

**Statement of Problem**

In real world, dangerous incidents can occur if the driver of an automotive vehicle loses the ability to control the vehicle, or lacks the attention towards potential hazardous situations. Also driving through terrible weather conditions like snow, heavy rain or fog can reduce the driver's abilities, which might lead to poor decisions and potential danger. Research suggests that automotive radar can help in reducing the number of deaths, injuries, and economic losses linked to driving world wide.

**Brief Description of the Project**

The project aims at designing and simulating a full-scale frequency modulated continuous wave (FMCW) radar that acts as a perception end of a moving vehicle. The vehicle must have the ability to detect an obstacle, and hence, autonomously brake to avoid collision.

**Objectives**

- Full understanding of Radar, and especially FMCW Radar.
- Simulating an FMCW Radar
- Simulating a moving Vehicle
- Understanding a perception-action cycle, with Radar as perception and controlling vehicle's speed as action

**Technical Approach and Expected Deliverables**

- Students will gain the knowledge of basic Radar theory
- Students will distinguish between pulsed and continuous wave Radars
- Students will simulate an FMCW Radar and test the simulation on a single target
- Students will simulate a moving vehicle equipped with the FMCW radar and brake before reaching a stationary target