**King Saud University**
**College of Engineering**
**Electrical Engineering Department** **Semester: 422**

# Senior Design Project Proposal Form

## Project #C1

**Project Title:** Deep Learning Coordinated Beamforming for Highly-Mobile Communication 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**

Beamforming plays an essential role in modern wireless communication systems. By managing the beamforming, we can enhance spatial multiplexing and/or diversity performance of the system. Supporting beamforming particularly on high-mobility systems requires addressing many challenges. The fast hand-off between different base stations necessitates dealing with control and latency overhead. The estimation of beamforming vectors requires computational resources that rise considerably with the increase of the number of antennas increase as in massive MIMO systems.

**Brief Description of the Project**

This project seeks to integrate deep learning with optimization of beamforming to overcome the challenges and enhance the efficiency of high mobility communication systems.

**Objectives**
The objective of this project

(1) Investigate the requirements of high-mobility communication systems
(2) Get acquainted with simulation tools of wireless communication systems.
(3) Practice development of deep learning systems.
(4) Develop hybrid (Digital/Analog) beamforming systems.
(5) Integrate deep learning models with beamforming optimization.
(6) Conduct experimental validation tests using Software-Defined Radio SR Modules.

## Technical Approach and Expected Deliverables

The steps to achieve these objectives:

- Phase I: Students will investigate development of hybrid beamforming
- Phase II: Students will develop deep learning systems.
- Phase III: Students will integrate deep learning approach to coordinate beamforming .
- Phase IV: Students will conduct validation experiments.

**Expected Deliverables:**

- Model of deep learning based beamforming of communication system.
- Validation setup of developed system.

# Project # C2

**Project Title:** Signal Processing Algorithms for Spectrum Analysis of Surface Wave (SASW)

**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 signal processing/communication area, strong willingness to learn, and then simulate the data model and the advance spectrum analysis algorithms for surface wave using seismic sensors.

## Statement of Problem

Use of surface waves for soil characterization is an important tool in geo-technical area. The first step in this method is the determination and extraction of dispersion curves for different surface wave modes. These dispersion curves are estimated by using spectrum estimation techniques. The project will cover implementing the different spectrum estimation technique using single and multi-channel sensor data.

## Brief Description of the Project

SASW are very important and popular non-invasive methods for soil characterization which has importance in geo-physical signal processing. Surface waves travel in a medium along a free boundary and hence they are easily detected using transducers placed on the free surface of a body. Moreover they have some inherent properties that make them very useful for identification
problems. Their use in geotechnical characterization has recently spread out because modern equipment allows for a satisfactory analysis and an adequate inversion process, necessary to infer from the detected particle motion the properties of the medium in which the wave propagates.

## Objectives

(1) Mathematical modeling/Understanding the propagating model for surface waves
(2) Spectrum Analysis: Low Resolution Methods and High Resolution Methods
(3) Surface wave modes identification and extractions.
(4) Single/Multi-channel Processing

## Technical Approach and Expected Deliverables

This project will cover Data modeling and implementation of SASW algorithms in Matlab/LabView environment. The student are expected to generate the dispersion curves, mode extraction and its use in soil chaterization using inversion algorithms.

# Project # C3

**Project Title:** Design of High efficiency Multi-band Microwave Power Amplifier

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

**Number of Students:** Two

## Students Qualifications

Good Background in Transmission line theory at RF/Microwave Frequencies

## Statement of Problem

The recent progress in wireless communication applications forced the design of high efficiency RF components to cover wide range of applications such as: 5G base stations, sensor nodes, UAV and microsatellites for both airborne and earth stations. In such cases, the design of high efficiency single band and multi-band power amplifiers present one of the most important challenges for the current and future applications.

## Brief Description of the Project

Power amplifiers are usually used in the last stage of any wireless transmitter in order to amplify the RF signal enough to reach the receiver. Power amplifier consumes most of the power in any wireless transmitter. Therefore, high efficiency power amplifier is necessary to reduce the power consumption in some applications such as handset mobile devices, wireless sensors for IoT, UAV, and satellite communications. In this project, design techniques of high efficiency amplifier are explored at first. Selected configurations will be analyzed and designed.

## Objectives

(1) Explore and master suitable design tools and simulators
(2) Design High efficiency single band power amplifier at 2.4 GHz.
(3) Design High efficiency Multi-band power amplifier.

## Technical Approach and Expected Deliverables

Students will get help to practice work on ADS from Keysight which is the leading tool for microwave and Millimeter wave design.

The steps to achieve these objectives:

- Phase I: Students will investigate and study the power amplifier configurations and select the optimum one for multi-band operation.
- Phase II: Students will validate and optimize the design of a single-band amplifier using simulation.
- Phase III: Students will validate and optimize the design of a multi-band amplifier using simulation.
- Phase IV: Students will manufacture and experimentally characterize one prototype of the designed amplifiers.

# Project # C4

**Project Title:** Utilizing mobile internal storage to enhance the performance of mobile wireless network.

**Professor(s) Name(s):** 1. Dr. Yousef AlHassoun
2. Dr. Naif Almakhdhub

**Number of Students:** Two students

## Students Qualifications

Comfortable with MATLAB, EE320, EE422

## Statement of Problem

The growth of demand arising from mobile applications, especially video, is exceeding current mobile network capacity. One of the solutions to the problem is caching network. One side of this solution is to use the internal storage of the mobile device. The goal is to optimze the consumed storage and minimize the overall cost of the mobile network.

## Brief Description of the Project

The demand for the mobile network varies during the day. A peak time when service providers experience high costs to provide reliable communication of data content, and an off-peak time when available resources are left underutilized. The project aims to address this mismatch problem, we utilize the storage of the end-user mobile to balance the network throughout the day.

## Objectives

(1) Present a comprehensive literature review of optimization in mobile network.
(2) Develop a parameter to capture the mobile storage consumption.
(3) Validate the proposed solution using Simulation tool and a MATLAB code.

## Technical Approach and Expected Deliverables

Literature review, Modeling, formulate the problem, study the trad-off between storage and cost, simulations, find an optimal solution for various situations and special cases.

# Project # C5

**Project Title:** One-Port Scalar Network Analyzer for Microwave Return-Loss Measurement

**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 a lot to catch up)
4- Knowledge of simulation tools such as Matlab and Numerical simulation (HFSS, CST, etc, you will have at least two sessions of training lectures).
5- Having skills in report writing and presentation.
6- Hard working students and can collaborate and work in a team

**Statement of Problem**

Microwave planar sensors based on electrically-small resonators, where their largest length is relatively small compared to the excitation wavelength, can provide high penetration, resolution, and sensitivity. The microwave response of many microwave devices including planar sensors are characterized using vector network analyzers (VNAs). However, the main problem of the measurement apparatus (VNA) from a practical point of view is related to the relatively high price of such apparatus. Although, the sensors can be considered as quasi-static near-field sensor and most of the works are based on the scalar quantity of the scattering parameters, yet most of the published works are based on the use of the VNA to measure the response of the sensors, which is not practical at all. Imagine asking the user end to buy a device with a bulky-expensive VNA to monitor the glucose concentration in the blood. It would be preferable to use the traditional way rather than the expensive device. This is where this project comes in. In this project, we propose a system that can be used in the replacement of the expensive VNA, where a scalar quantity of the scattering parameters is needed to characterize a microwave near-field sensor. In particular, we will design a one-port scalar network analyzer for microwave return-loss measurement and test the analyzer with a designed one-port microwave sensor.

**Brief Description of the Project**

In this project, the students will be focusing more on the system aspect, where the students learn to design the system first, then proceed to connect its sub-system components together to achieve the overall response of the system. The general sub-system components will include, not inclusive, a frequency synthesizer, a directional coupler, a microwave power meter, and other important components. After that, the students will conduct an extensive literature review to understand and to know the main function of each sub-system and start slowly to investigate the way of connecting them together in the form of an integrated system. Note that, each sub-system can be characterized separately before the integration, which is an extremely important step in any system integration.

**Objectives**

1. Conducting a comprehensive literature review of microwave resonators as near-field sensors and stating the main challenges for them to be applied in real-world applications.
2. Conducting a comprehensive literature review of each sub-system components including a frequency synthesizer, a directional coupler, a microwave power meter, and other components important in the integration of the system.
3. Characterizing each sub-system components.

4. Proposing a way of integrating the components together to perform a one-port scalar network analyzer
5. Choosing a well-cited paper and duplicate the results to build confidence with the numerical simulation, HFSS
6. Designing a one-port microwave sensor using HFSS.
7. Finally, being able to describe in details the steps to how one can be able to implement the whole system together
8. Describing the next step in EE 497 to integrate the whole sub-system component into one system as an analyzer to be able to characterize a one-port sensor

## 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).