



How to Supervise Senior Design Projects

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Authors' contributions

This work was carried out in collaboration between both authors. Author MAA designed the framework and wrote some sections of the manuscript. Author OO performed literature search and wrote part of section 4. Both authors read and approved the final manuscript.

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ABSTRACT

Senior design projects for engineering students typically integrate various components of the curriculum to apply the basic sciences, mathematics and engineering sciences in realizing physical systems which solve real problems or make life more livable. The process of realizing senior design projects requires supervision from academics. Majority of young academics may not have sufficient experience to adequately understand the dynamics of this process, from conception to realization. The gap in experience as well as deficit of literary resources on practical steps for project supervision impacts negatively on the overall success of the student as well as the project. This paper presents, in practical steps, the general procedures for supervision of senior design projects in electrical and electronics engineering for optimal realization of projects. The paper discusses project supervision from conception to manuscript development, taking into consideration some of the potential challenges typically encountered. Finally, it presents typical inadequate and adequate titles as well as abstracts for a circuit.

Keywords: Senior design projects; supervision; circuit; engineering.

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1. INTRODUCTION

The senior design project course in electrical and electronics engineering typically integrates various concepts of the curriculum in a comprehensive engineering experience so as to ensure that the basic sciences, mathematics and engineering sciences which the student has learned in his freshman-to-senior years of study can be applied. It considers design of a complete project or system through a process which includes articulation of objectives and criteria, formulation of the problem statements, preparation of specifications, consideration of alternative solutions, feasibility and constraints

considerations, detailed engineering designs, project realization and manuscript (report) development [1]. At the undergraduate level essentially, electrical and electronics engineering project realization and supervision can be decomposed into initial engagement, project conception, project realization and manuscript development (Fig. 1) [2,3].

The design should take into consideration appropriate constraints such as economic factors, safety, reliability, ethics and environmental and social impact. Normally, initial project selection should be driven by student's interest while final selection of project should

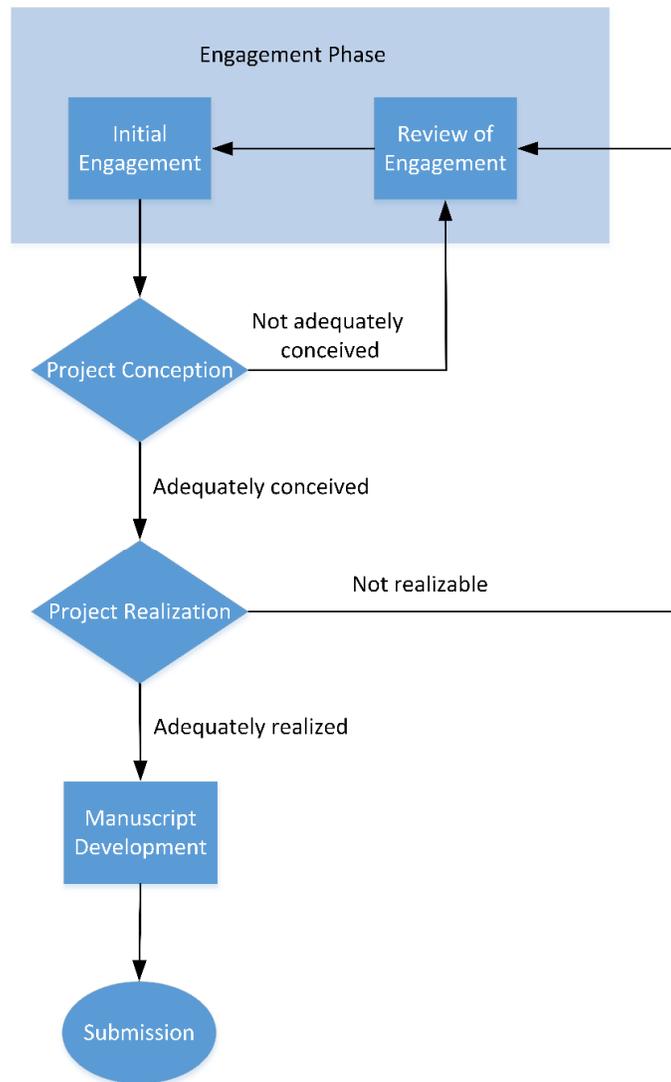


Fig. 1. A flowchart depicting the major phases of senior design project realization and supervision

require approval from the supervisor(s) and coordinator(s). In the course of the project, the student should be required to demonstrate ability to conduct research, perform relevant calculations, simulate and implement a practical engineering project, and present its report or findings concisely. In addition to submission of a practical system, the student is required to submit a structured report at the end of the project. Actualization of project's aim and objectives in both practical prototype and report come with risks, within the framework of the budget. Also, the student will be required to submit both prototype and report within a time frame in order to receive marks from supervisors and examiners. In order to de-risk project realization and to implement high-impact projects, team design projects are highly encouraged [4].

Project supervision entails transfer of skills from the supervisor to the student(s). To state that "you can only give what you have" is a popular adage. Since the motivation for senior design project is to avail the student opportunity to practically demonstrate the fundamental concepts he or she has learned, supervisors need to be skilled in terms of the fundamental concepts, how to apply the concepts in solving real problems and how to transfer the methods to the student(s). While the field of electrical and electronics engineering has large variance, undertaking a student project requires narrowing to a specific branch of the field. Generally, regardless of the branch in which the project belongs, senior design projects in electrical and electronics engineering can be carried out in the following major steps: Initial engagement with student, Project conception, Project realization and Manuscript development.

Initial Engagement with Student raises the question: Why do academics supervise senior design projects? Is it to satisfy supervisor's interest? Is it to satisfy students' interests? Is it to satisfy regulatory requirements?

Obviously, all the three reasons partly contribute to why academics supervise senior design projects. While the need to satisfy requirement is the main driver, the supervisor's interest is embedded in the student's interest. Thus, the student is the Lead Researcher and Project Manager, while supervisor provides guide on "the route" for the lead researcher. As a result, the initial engagement of supervisor with student is critical and should be student-centered. In rare cases, the student may not have clear project in

mind or clear project interest. In majority of initial engagements, the student will have clear project interest. However, the market relevance and adequacy or inadequacy of the student's project interest need to be reviewed by supervisor(s) or coordinator(s) [5,6].

The supervisor's first role in engaging with the student will typically be to ensure that the project is conceived to satisfy requisite regulation as well as curriculum and in a manner that allows for adjustment as realization of the project progresses. The 2017-2018 curriculum for senior design project at Nile University of Nigeria is presented (Fig. 2).

The course curriculum in Fig. 2 clearly outlines the activities that are considered projects in electrical and electronics engineering program of the university. The supervisor, during initial engagements, is expected to interact with the student with a view to assisting the student to define the project objectives to fulfill the requirements of the curriculum, in cases where the student has clearly defined project in mind. However, if the student's proposed project does not fit in, the supervisor is expected to help the student by first explaining to the student the reasons why his/her proposal is unacceptable before asking the student to consider other acceptable options. It is essential that the supervisor shares the course curriculum with the student at this stage. A timeline may be set for the student to come up with, say, three alternative proposed project titles [7,8].

By the end of the timeline and upon submission of the titles by the student, the supervisor evaluates the titles with a view to establishing if any or all of them fit in as projects. If there are viable titles, the supervisor helps the student make a choice of the most realizable option considering available constraints, including cost, component handling and sourcing. On the other hand, if the student's proposed titles do not fit in, the supervisor is expected to suggest, say, three titles to the student so that the student makes a choice. When the team finally arrives at a suitable tentative title, the supervisor is expected to set in mechanism for adequately conceiving and defining the project [9,10].

2. PROJECT CONCEPTION

Project conception is the second major phase in realization and supervision of senior design project, as depicted in Fig. 1. In this phase, and in all succeeding phases, the team undertakes

literature review to either identify gaps in projects reported in literature or to identify the fundamental concepts as well as circuits employed in published or unpublished literature [11].

Gaps in literature could be observed through identification of inadequacies in practical prototypes. Such inadequacies are typically reported by the authors as recommendations for future works in the reports. Literature review for identification of fundamental concepts typically helps the team to identify the circuits and concepts employed by previous researchers. The team could decide to realize the existing circuit first to gain deeper understanding of the operation of the circuit before optionally improving on the performance or efficiency of the circuit [12,13]. Alternatively, the team may decide to first perform circuit simulation to establish response of the circuit.

Upon identifying the circuit and working concepts, the supervisor may decide to task the student to critically articulate the usefulness of the project as well as identification of the components, strengths and weaknesses of the circuit, budget, risks, component handling and sourcing. In addition, the supervisor helps the student conceive the methods and instruments that would be required for testing the realized prototype on project board as well as when the prototype is packaged. At this stage, the supervisor may advise the student to prepare Gantt and PERT charts. An open source

software for preparing Gantt and PERT chart is found at www.ganttproject.biz. When the project is adequately conceived, defined and de-risked, the supervisor is expected to advise the student to commence the next phase – project realization [14].

3. PROJECT REALIZATION

In this phase, the supervisor transfers the skills of circuit design to the student. Usually, a preliminary quick design is undertaken to establish the values of components. In rare cases, where the supervisor identifies a brilliant and committed student, the design may be undertaken from concept block diagram (this approach shall not be discussed in this paper). Upon establishing component values through either use of pen-and-paper or appropriate design software, the team consults component *datasheet* for selection of standard commercial ratings of the components [15].

When standard commercial ratings are selected, the team validates the design through use of the standard commercial ratings. When the design is validated, the response of the circuit is simulated using requisite software. At this stage, the supervisor is expected to advise the student to commence *components sourcing*. For purpose of timely realization of the project, the supervisor may advise the student to utilize the time-lag of component sourcing in undertaking comprehensive design and record keeping.

	<p>EEE 595 Senior Design Project I This capstone design project course integrates various components of the curriculum in comprehensive engineering experience so that the basic sciences, mathematics, and engineering sciences which the student has learned in his freshman-to-senior years of study can be applied. It considers design of a complete project or system including establishment of objectives and criteria, formulation of the problem statements, preparation of specifications, consideration of alternative solutions, feasibility considerations, and detailed</p>	<p>3 Credits</p>
<p>Nile University of Nigeria Faculty of Engineering Page 43</p>		
<p>2017-18 STUDENT HANDBOOK ELECTRICAL AND ELECTRONICS ENGINEERING</p>		
<p>engineering designs. The design should take into consideration appropriate constraints such as economic factors, safety, reliability, ethics and environmental and social impact. Selected projects require approval from the coordinator(s). The student is required to demonstrate ability to conduct research, perform relevant calculations, simulate and implement a practical engineering project. Submission of a written report is an essential requirement for completion of the course. Team design projects, where appropriate, are highly encouraged.</p>		
<p>EEE 596 Senior Design Project II Continuation and completion of project started in EEE 597. Oral presentation, submission of final written report and demonstration of the design project are essential requirements for the completion of the course.</p>		<p>3 Credits</p>
<p>10 ELECTRICAL AND ELECTRONIC ENGINEERING LABORATORIES</p>		

Fig. 2. Typical curriculum for senior design project
 Source: Students Handbook, Nile University of Nigeria, Abuja, Nigeria [1]

Upon sourcing the components and troubleshooting (testing) each component to exonerate manufacturer's defects, *low-power* and *control* sub-circuits are realized on project board (see Fig. 3). Under auspices of the supervisor, the circuit is energized using appropriate power supply (the supply could be in the laboratory). In practice and on many occasions, the energized circuit will not respond adequately! However, if the circuit responds adequately, then, the team is lucky and could proceed to transfer the components from project board to Veroboard, replicating the circuit.

When the circuit fails to respond adequately as on many occasions, the team is expected to undertake fault diagnosis and troubleshooting. From experience, it is a good practice to partition large or complex circuit into its functional sub-circuits while undertaking fault diagnosis and troubleshooting. The supervisor is expected to guide the student to carry out fault diagnosis using basic instruments - voltmeter, ohmmeter and ammeter; first with voltmeter. The purpose of this task is to establish if poor or non-response of the circuit is attributable to open circuit or short circuit. If either of them is established, appropriate corrective measure is taken. However, if neither of them is established, then, the team is expected to perform component troubleshooting.

For the purpose of component troubleshooting, the team is expected to group all components within each functional sub-circuit into two: fragile

and rugged components. Fragile components are those with high failure rates and include transistors and integrated circuits. Rugged components are usually non-fragile and include inductors, non-polarized capacitors and resistors. The team is typically expected to focus troubleshooting on fragile components until the failed components are identified and replaced (it may be helpful to troubleshoot rugged components occasionally, especially after exhausting troubleshooting of fragile components). It is instructive for the team to identify the primary cause of failure, especially if the components were tested before insertion on the project board.

When the components are all functional and the circuit's response is unsatisfactory, it makes sense to consider adjustments and fine-tuning of component's value until satisfactory response is obtained. Thereafter, the supervisor is expected to advise the student to transfer the components from project board to Veroboard. On Veroboard, the components are carefully soldered using hot soldering iron and lead. If soldering is completed and the circuit's response is unsatisfactory or the circuit becomes non-responsive outrightly, the team is expected to undertake another round of fault diagnosis and troubleshooting until the cause of failure or poor response is identified and corrected. When the soldered circuit does respond adequately, the supervisor is expected to advise the student to commence packaging of the tested prototype and manuscript development simultaneously.

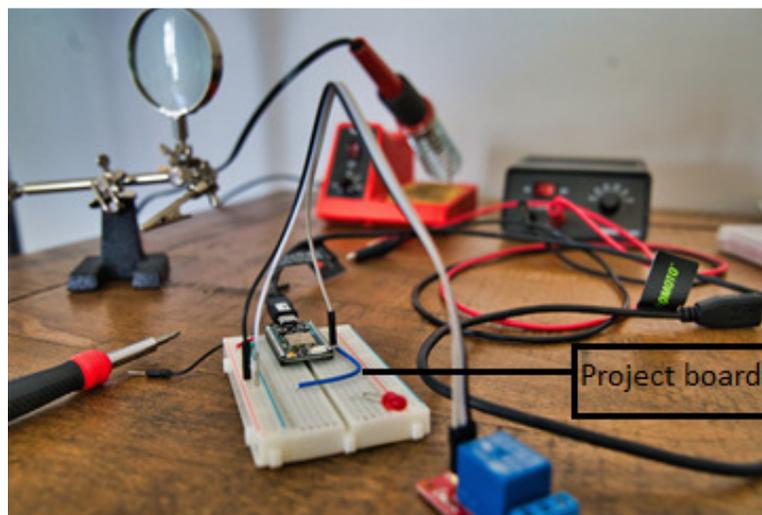


Fig. 3. A typical project board containing few electronic components and instruments

Source: Clint Patterson, Unsplash [16]

4. MANUSCRIPT DEVELOPMENT

The manuscript of a senior design project methodically reports on the work in terms of, among other things, fundamental design concepts, literary materials consulted, tests and results obtained, inference and recommendations for further work [17]. Without reading through the entire manuscript of a senior design project, its major elements include title, abstract and conclusion. Thus, this section provides simple guide on how to write title and abstract using a simple practical circuit.

4.1 A Simple Guide on How to Write Project Title

This sub-section focuses on writing typical titles for a senior design project, given the circuit diagram of the prototype. No doubt, writing of title commences in the initial engagement phase. However, early-stage titles are typically inadequate. Fig. 4 presents a simple practical circuit on FM transmitter. Assuming this is the circuit of a given project. There aren't water-tight

rules on writing title, however, a title for senior design project is expected to be apt, comprehensive and typically contains the phrase "design and construction of ...", or "design and implementation of ..." or "design and realization of ...".

Table 1. presents four typical titles for the project, given the circuit of Fig. 4. Two of the titles are considered inadequate for the project along with their deficiencies, while the remaining two are considered adequate for the project.

4.2 A Simple Guide on How to Write Abstract

The abstract of a project report is usually expected to briefly present the need for the project, what was done in the project, how the work was executed, results obtained and inference or conclusion made from the results. A good approach for writing abstract is to decompose the project circuit into blocks of functional sub-circuits and then write the abstract

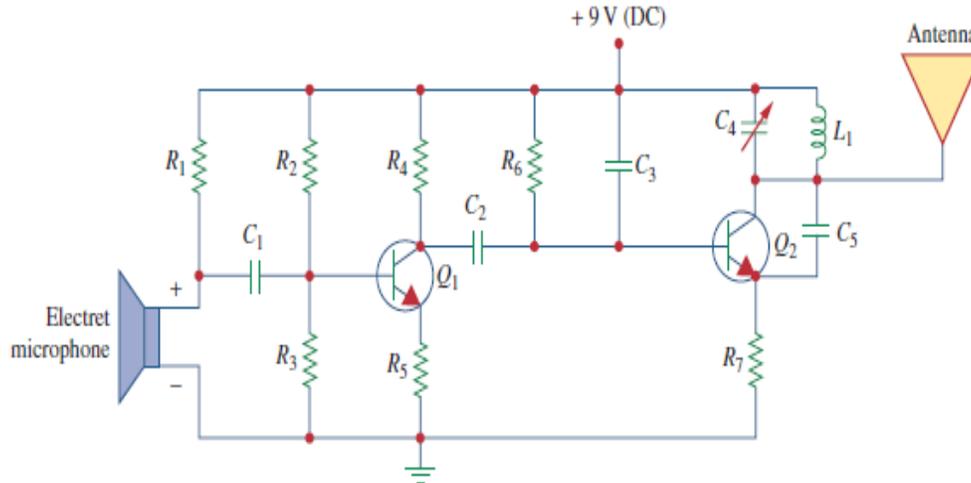


Fig. 4. A simple circuit of an FM transmitter
 Source: Alexander and Sadiku, *Fundamentals of Electric Circuits* [18]

Table 1. Sample inadequate and adequate titles for the project

S/No.	Inadequate Title	Deficiency	Adequate Title
1.	Design and implementation of FM transmitter	This title lacks the active power and frequency at which the transmitter radiates the signal	Design and implementation of 2.5 W FM transmitter
2.	Design and implementation of radiofrequency transmitter	In addition to lacking frequency and active power, this title lacks information on the specific type of radiofrequency	Design and implementation of 2.5 W 100 MHz FM transmitter

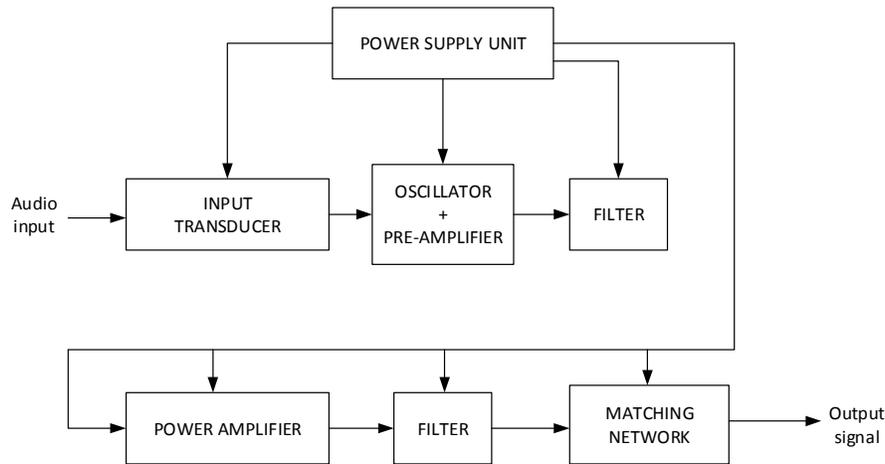


Fig. 5. A simple block representation of the circuit diagram presented in Fig. 4

Table 2. Sample inadequate and adequate abstracts for the project

Inadequate	Adequate
<p>Abstract</p> <p>At power on, the audio input is mixed with the carrier frequency and pre-amplified. Output of the pre-amplifier and high-frequency switching signals from the power supply are filtered and subsequently power-amplified. The amplified RF signal is further passed through a band-pass filter before it is radiated through an antenna. The antenna is coupled to the circuit by a capacitive matching system.</p>	<p>Abstract</p> <p>The FM transmitter is used by radio stations for dissemination of information, education and entertainment of the public. This report presents a 100MHz 2.5 Watts FM transmitter. When power is supplied, the audio input is mixed with the carrier frequency and pre-amplified. Output of the pre-amplifier and high-frequency switching signals from the power supply are filtered and subsequently power-amplified. The amplified RF signal is further passed through a band-pass filter before it is radiated through an antenna. The antenna placed at a height of 20m is coupled to the circuit by a capacitive matching system. At a height of 20m the transmitter has coverage range of 5.0 km radius.</p>
<p>Deficiency</p> <p>This abstract lacks information on need for the project, results obtained and conclusion or inference.</p>	

through descriptive connection of the blocks (the block diagram is usually required in the introductory or design chapter of the report). A typical (may not be universal) block representation of the project circuit is shown (Fig. 5).

5. CONCLUSION

This paper introduces the subject of how to supervise senior design projects by highlighting how effective supervision benefits the supervisee, the supervisor and the society at

large. It further describes the major steps in supervision of senior design projects for young lecturers in electrical and electronics engineering. These steps are initial engagement with student, project conception, project realization and manuscript development. Two major sections of manuscript development have also been explained in this paper using a simple project circuit. Finally, the paper provides typical inadequate and adequate titles as well as abstracts for the circuit. Thus, the paper provides step-by-step procedure for quality supervision of senior design project.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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