# ECE 662 Midterm Exam
# Fall 2019

( ***Individually done*** *- NOT a team assignment* )

Your Midterm-Exam will consist of demonstrating and documenting an FM broadcast band transmitter built from projects 1, and 2 circuits. Due dates are listed below.

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| Demonstration | On or before Tuesday, 11/5 |
| Documentation | Wednesday, Wednesday 11/6 |

## *Transmitter Construction*

An FM transmitter can be built by doing some fairly simple additions to your project 2 circuit and then combining it with your project 1 bandpass amplifier. ***You must add a microphone to your project 2 board as well as a data input, and design associated coupling/attenuator circuits. Then connect the boards together.*** See below for details on transmitter specifications so you design these needed circuits correctly. Once you have added your microphone and data input and connected the boards, check the operation using the spectrum analyzer and FM receiver. **Then signup for a demo time and writeup your report**.

## *Specifications and Demonstration*

Demonstrating your transmitter will consist of actual "on-the-air" tests showing that you can transmit analog audio signals (inclucing speech) and FSK data (from a provided Arduino-based packet generator) to a nearby portable FM radio. In the demonstration, you must show that you meet the following specifications:

- Output power of $\geq 4$ dBm into 50 Ohms at 98 MHz,
- Harmonic suppression of at least 40 dB when operating at 98 MHz,
- Tuning range of at least 77 MHz to 98 MHz ***(To to avoid violating FCC rules, do not transmit on-the-air below 88 MHz (or above 108 MHz), and if you do hook up an antenna, use a 50dB attenuator !)***
- Onboard microphone with good volume and fidelity when listened to on an FM radio receiver (not over-modulated) Leave the leads on the mic a little long so you can clip a signal-gen to them (see below).
- Deviation of +/- 75 kHz for audio input level of 100 mVpp from function generator connected across your microphone to over-ride it. [1]
- Audio frequency response of 20 Hz to 15 kHz (+0, -3 dB) as measured by checking the frequency deviation at these audio frequencies when driven from the audio function generator. [1]
- Deviation of +/- 75 kHz when connected to the Arduino board generated 1 kbps PRBS sequence (5V logic).
- Good data waveform as observed on the new Spectrum Analyzer's audio-out headphone jack.

***Test your transmitter early to see if it meets these requirements.***
***If needed, modify or fix it before the demo !***

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[1] Frequency deviation may be estimated from the spectrum width using ***Carson's rule***:
Bandwidth = $2(\Delta f_{pk} + f_{\text{mod}})$, where $\Delta f_{pk}$ is the peak frequency deviation and $f_{\text{mod}}$ is the frequency of the modulating sinusoid.

# *Documentation*

***Pay close attention to the instructions and assumed audience specified below !!***

Your documentation should consist of a type-written "Service Manual" (approximately 4 to 6 pages including diagrams and tables) describing the operation of your transmitter and the circuits from which it is built. Your figures can be neatly hand-drawn if you do not have access to an efficient drawing program. **Don't show sources and other things used to simulate**. Document ONLY your actual circuit elements/connections.

Organize your report in the following order :

- Cover page with your product name and your name (plus an optional "company name" :-)
- Table of Contents
- Section 1: Block diagram (moderately detailed) *and* associated description of transmitter. (1 page)
- Section 2: Specifications (see above, but give values your product would actually meet in production)
- Section 3: Schematic diagram (1 page) *and* brief circuit descriptions (1 to 2 pages - see below)

## Audience

You are writing a ***Service Manual,*** **NOT** a project report. It should be written assuming it will be read by a technician trying to understand and/or repair your circuit. ***You should NOT mention or assume the reader knows ANYTHING about "class projects", directly or indirectly.***

The documentation should be written at a level that a technician familiar with basic electronics (at an undergraduate Electronics-2 (ECE526) level), *but* ***unfamiliar*** *with RF circuits or FM transmitters* could use it to spin-up on and troubleshoot if it were to develop problems after manufacture and sale. To help the technician out, your ***block-diagram*** should show major functions/parts as blocks (core oscillator, FM modulation circuitry, regulator, amplifier, bandpass filter circuits, etc.), and the signal levels/frequencies present at each point. It should be followed by supporting text (e.g. ½ to 1 page) that describes the blocks, what each does.

Next, you should include a complete schematic (1 page) with component labels and part values shown, together with supporting text (1 - 2 pages). You may partition this into the individual "assemblies" (your boards), but a good schematic would be one that fits nicely and neatly on a single page. In addition to reference designators, values, and part numbers, show key DC bias voltages on the schematic to help out the service personnel with debugging. Your narrative should explain how the circuit works and what signal frequencies and signal levels are expected at various nodes. This should be written in enough detail that the technician could make measurements at the various points in the circuit and track down a problem if it is broken. ***Refer to components by their reference designator when describing circuits. For example: "the signal at the collector of Q2 is fed back to the emitter through voltage divider C6, C7 to create oscillation ...".*** If you are unfamiliar with this style, refer to the examples in the Comm lab.

***Use of equations should be minimal or non-existent!*** The goal in the circuit description is to explain the circuit's *operation*, not the design procedure. For example, explain in words how/why the oscillator produces a sinusoidal output and what determines its frequency - referring to circuit elements by reference designators as you talk the reader through this. How is the circuit biased (by what components) ? How is the frequency deviation produced and controlled to the correct amount? How does the amplifier increase the output power? Why is impedance matching used at the amplifier input/output (referencing the components involved)? What does the harmonic attenuation? What factors are important in the physical circuit construction and why? Etc...
*You must show that you understand the system and circuit operation in sufficient detail that you can impart this knowledge to another individual*.

## *Grading*

Your Midterm grade will be based on the correct operation of your circuit (10%) and on the quality of your Service Manual (10%).

**PLEASE NOTE:** Writing is hard, but incredibly important. We all need practice and I grade the writing in the midterm as if I am considering hiring a person for a job. I.e. It must be responsive to the assignment and read well, while being concise (in addition to being technically correct) to get a good grade.

***IMPORTANT:***

***Do your write-up with enough time left to review, proof-read, and revise it after stepping away from it for a day or so. This is the only way to create a good document.***