# ITT Technical Institute

# ET275

# Electronic Communications Systems I

# Onsite Course

# SYLLABUS

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**Credit hours:** 4

**Contact/Instructional hours:** 50 (30 Theory Hours, 20 Lab Hours)

**Prerequisite(s) and/or Corequisite(s):**

Prerequisites: ET245 Electronic Devices II, ET255 Digital Electronics I, GE192 College Mathematics II or equivalent

**Course Description:**

In this course, several methods of signal transmission and reception are covered, including such techniques as mixing, modulating and amplifying.

# STUDENT SYLLABUS: ELECTRONIC COMMUNICATIONS SYSTEMS I

Instructor:            _____

Office hours:          _____

Class hours:           _____

## Major Instructional Areas

1. Introductory Topics
2. Amplitude Modulation: Transmission
3. Amplitude Modulation: Reception
4. Single-Sideband Communications
5. Frequency Modulation: Transmission
6. Frequency Modulation: Reception
7. Communications Techniques
8. Television
9. Review and Final

## Course Objectives

Upon successful completion of this course, the student should be able to:

1. Describe the components of a basic communication system.
2. Explain the relationship between information, bandwidth, and transmission time.
3. Explain the concept of noise, its sources, and its relation to bandwidth in a receiver.
4. Describe the operation of the basic circuits such as amplifiers, tuned amplifiers, frequency doublers and triplers, filters, and oscillators that make up communication systems.
5. Explain the concept of modulation and the need for it in a communication system.
6. Analyze the physical appearance of an AM wave, its makeup, and the concept of sidebands.
7. Analyze power, voltage, and current in AM systems.
8. Describe the operation and characteristics of standard AM transmission.
9. Identify the techniques of troubleshooting AM transmitters.
10. Define sensitivity and selectivity in AM receivers.
11. Name the methods of AM detection.
12. Describe the operation and characteristics of an AM receiver system.
13. Identify the techniques of troubleshooting AM receivers.
14. Analyze the operation of SSB transmission and reception.
15. Define angle modulation, frequency modulation, and phase modulation.
16. Analyze FM signals with respect to modulation index, sidebands, and power.
17. Describe the operation and characteristics of standard FM transmission.
18. Identify the techniques of troubleshooting FM transmitters.

19. Explain the operation of FM receivers and their similarities and differences from AM receivers.
20. Name the methods of FM detection.
21. Identify the techniques of troubleshooting FM receivers.
22. Describe the operation of AM and FM transceivers, the concepts of double conversion, delayed AGC, and auxiliary AGC.
23. Identify the different components of a standard television video signal.
24. Analyze the operation of color, as well as black and white TV receivers.
25. Identify the techniques of troubleshooting TV receivers.

## Teaching Strategies

Curriculum is designed to promote a variety of teaching strategies that support the outcomes described in the course objectives and that foster higher cognitive skills. Delivery makes use of various media and delivery tools in the classrooms.

## Student Textbook and Materials

**Text**: Miller, Gary M. and Beasley, Jeffrey S. *Modern Electronic Communications, Custom 8th Edition. Pearson Custom Publishing, 2006.*

**Lab Manual** : Beasley, Jeffrey S. and Fairbanks, Michael. *Laboratory Manual for Modern Electronic Communication, Custom 1st Edition. Prentice Hall, 2006.*

**CD**: Snyder, Gary A. *Multisim Circuit Files to accompany Modern Electronic Communications, Custom 1st Edition. Pearson Custom Publishing, 2011.*

**CD**: Snyder, Gary A. *Multisim Circuit Files for Supplemental Text to Accompany Modern Electronic Communications, Custom 1st Edition. Pearson Custom Publishing, 2011.*

# Course Outline

| Unit | Topic (Lecture Period) | Chapters | Lab and Other Coverage |
|---|---|---|---|
| 1 | Introductory Topics | 1 | Recommended Lab: Experiment 1<br>Additional Lab (optional): Experiment 3<br>Homework: Selected questions and problems from text or instructor-written |
| 2 | Amplitude Modulation: Transmission | 2 | Recommended Lab: Experiment 11<br>Additional Lab (optional): Experiment 10<br>Homework: Selected questions and problems from text or instructor-written |
| 3 | Amplitude Modulation: Reception | 3 | Recommended Lab: Experiment 12<br>Additional Lab (optional): Experiment 13<br>Homework: Selected questions and problems from text or instructor-written |
| 4 | Single-Sideband Communication | 4 | Recommended Lab: Experiment 14<br>Homework: Selected questions and problems from text or instructor-written |
| 5 | Frequency Modulation: Transmission | 5 | Recommended Lab: Experiment 16<br>Homework: Selected questions and problems from text or instructor-written |
| 6 | Frequency Modulation: Reception | 6 | Recommended Lab: System Project 8<br>Homework: Selected questions and problems from text or instructor-written |
| 7 | Communication Techniques | 7 | Lab: Continue System Project 8, if needed<br>Homework: Selected questions and problems from text or instructor-written |
| 8 | Television | 17 | Homework: Selected questions and problems from text or instructor-written |

| 9 | Review, Final Examination, and Final Lab | | The final examination will be based on the content covered in Chapters 1-7 and 17. |
|---|---|---|---|

# Evaluation Criteria and Grade Weights

| | |
|---|---|
| Quizzes | 10% |
| Homework | 15% |
| Exams | 15% |
| Lab Production | 25% |
| Final Exam | 20% |
| Lab Final | 15% |

Final grades will be calculated from the percentages earned in class as follows:

| | | |
|---|---|---|
| A | 90 - 100% | 4.0 |
| B+ | 85 - 89% | 3.5 |
| B | 80 - 84% | 3.0 |
| C+ | 75 - 79% | 2.5 |
| C | 70 - 74% | 2.0 |
| D+ | 65 - 69% | 1.5 |
| D | 60 - 64% | 1.0 |
| F | <60% | 0.0 |

# Student Note

Some of the projects require the use of radio frequency (for example System Project 8). Whenever signals of frequencies of 1 MHz or above are used in a project, in addition to the general rules, special measures should be considered in order to successfully implement the project:

- Identify the components that are sensitive to the high frequency effects and pay special attention to the layout, connectors, leads, and soldering of these components.

- Run short wires to interconnect the components.

- Lay out the circuitry in a linear manner, from the input towards the output, avoiding the crossover or overlapping of wires, leads, connectors etc.

- The leads of the high frequency components should be as short as possible in order to avoid parasitic inductors.

- When soldering terminals, use a minimum amount of solder in order to avoid parasitic capacitors.

- Provide filter capacitors, especially ceramic capacitors (or of other type with low impedance for high frequency) between the DC power line and the ground on the protoboard close to the high-frequency components.

- Place a conductor ground plane parallel and close to the board with the high-frequency circuit.

- Apply other special measures as indicated by your instructor.

# System Project 8

NAME _____

## SINGLE-CHIP FM TRANSMITTER

OBJECTIVES:

1. To experiment with the construction of a single-chip FM transmitter system using the MAXIM 2606 integrated circuit
2. To gain experience working with surface mount device (MAX 2606)
3. To gain experience assembling components on a project board

REFERENCES:

Modern Electronic Communication, 8th ed., Miller and Beasley, Chapter 5, section 5-7

TEST EQUIPMENT:

| | |
|---|---|
| Dual-trace Oscilloscope | DC Voltage Source |
| Function Generator | FM Receiver |

COMPONENTS:

Capacitors: 10µF, 0.47µF, 2200pF, 1000pF, 0.01µF, 1µF, 0.33µf, 0.1µF

Resistors: 22KΩ (2), 1KΩ (2), 270 Ω, 4.7 KΩ

100KΩ square potentiometer, 10KΩ square potentiometer

Inductor 390nH

Voltage regulator 5V

Surface-mount RCA phono jacks (2), power jack

Max2606 IC chip and proto-board adapter board

PROTO-Board, Universal PC Board

Stand-offs (4)

RCA jacks (2)

Power jack, leads, and clip for 9V battery

Battery, 9V

PROCEDURE:

Assemble an FM transmitter using the MAX2606 and required parts following the schematic provided in Fig. SP8-1. This is a low-power FM transmitter operating in the FM band (88-108 MHz). A schematic is provided in Figure SP8-1 that shows all the components required for assembling the project. The circuit runs off a single power supply (3-5 V). The left and right audio channels from your audio player (e.g., CD, MP3, iPod, etc.) connect via the RCA phono jacks to resistors R3 and R4. Resistors R3 and R4 are used to combine the left and right audio channels before inputting the signal input the MAX 2606. Potentiometer R2 is used for the volume control. The MAX 2606 is a voltage-controlled oscillator with an integrated varactor. The nominal frequency of oscillation is set by L1 (390 nH). This inductor value places the center frequency of the transmitter at 100 MHz. A 380 nH inductor can be used in place of the 390 nH inductor with minimal shifting of the transmit center frequency. Potentiometer R1 is used for tuning the transmitter to the desired channel. Potentiometer R1 connects to Tune input (pin 3) of the MAX 2606 IC. The tune input drives a voltage controlled oscillator with an integrated varactor. An FM antenna connects to pin 6 through a 1000 pF capacitor.
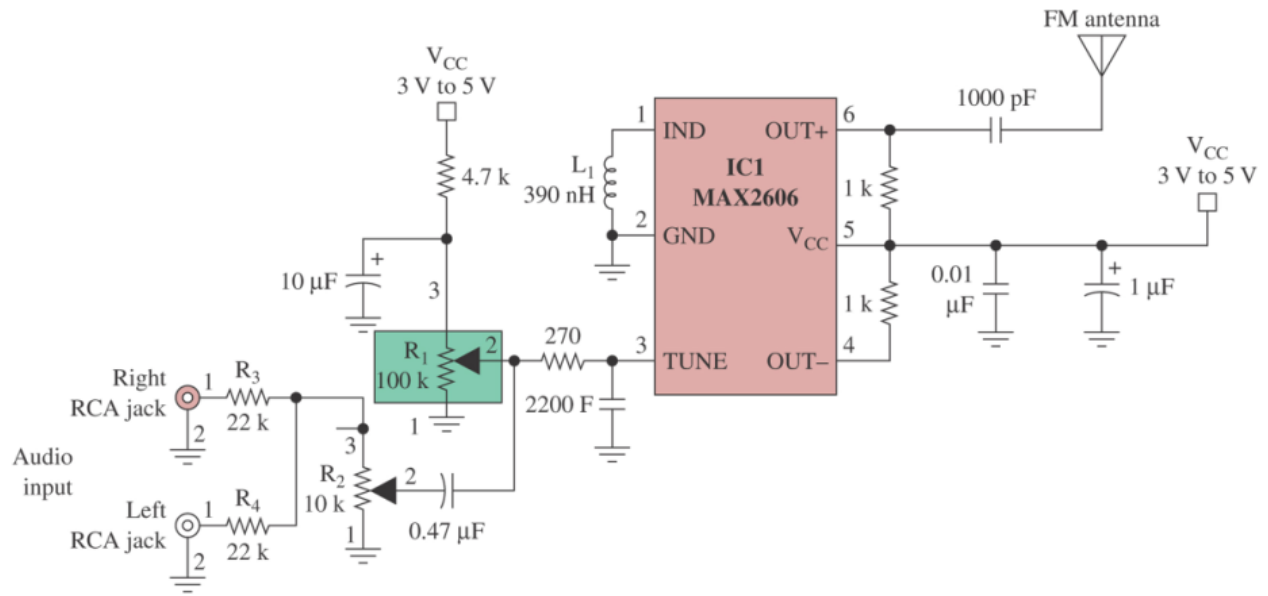
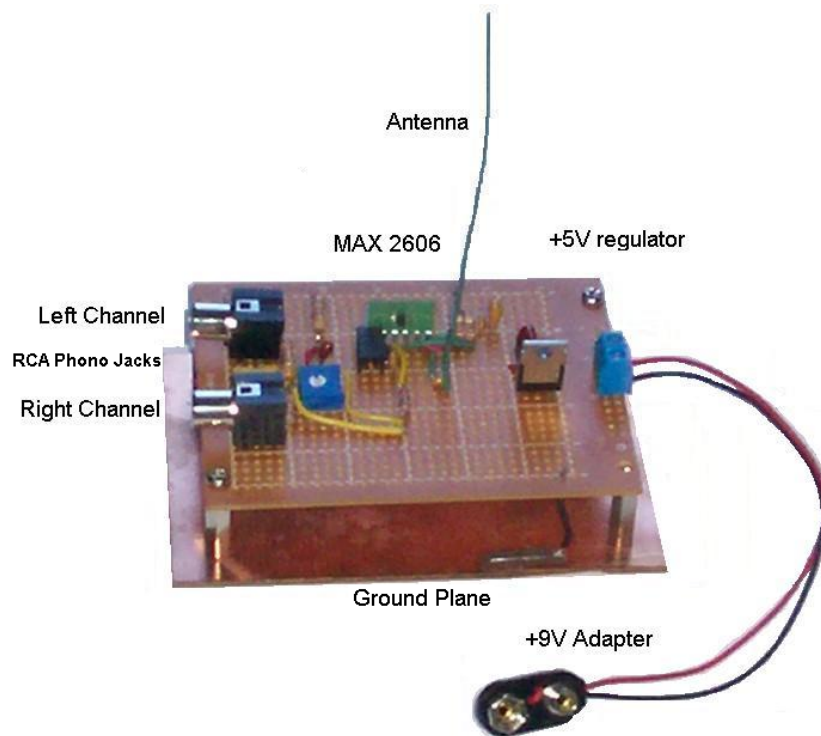**Figure SP8-1 The MAX 2606 single-chip FM transmitter**



**Figure SP8-2 An example of an assembled FM transmitter**
Note: The antenna is about 4 inches long.

## Circuit Construction, Operation, and Troubleshooting

1.  Assemble the circuit similar to the example provided in Figure SP8-2.

2.  Perform a continuity check of your assemble board before applying power.

3.  Verify that power is being properly provided to the circuit. The example provided in Figure SP8-2 uses a 9V battery with a +5V regulator on board to provide power to the circuit.

4.  Tune your FM radio to a frequency that does not have a signal. Turn on the transmitter and tune the FM transmitter (using R1) until the FM receiver goes quiet. FM receivers will go quiet in the presence of an FM carrier.

5.  Apply a signal to the audio inputs and experiment with the transmitter.

# EWB Experiment 1

## Simulation of Active Filter Networks

OBJECTIVES:
1.  To become acquainted with the use of Electronics Workbench Multisim for simulating Active Filter Networks.
2.  To understand frequency response measurements using the EWB Bode plotter.
3.  To measure the frequency response and phase of an active filter and compare the simulation results with the experimental results.

VIRTUAL TEST EQUIPMENT:
Dual-trace oscilloscope
AC voltage source
Bode plotter
Power supplies
Virtual resistors, capacitors
Simulation model of the 741 operational amplifier

THEORY:

The computer simulation of electronic circuits provides a way to verify the functionality and performance characteristics of your circuit prior to its fabrication and assembly. Many simulation models of both active (e.g., op-amps and transistors) and passive (resistors, capacitors, and inductors) devices are available and provide accurate simulation results. For example, in this experiment the 741 operational amplifier is specified for the operational amplifier. EWB Multisim includes a model of the 741 available for use in the simulation. Using this model, instead of an ideal operational amplifier, enables you to obtain computer simulation results that more closely resemble your experimental results.

PRELABORATORY:
Review your experimental results from Experiment 1–Active Filter Networks.

PROCEDURE:

In this exercise, you will be required to build an active filter circuit using Electronics Workbench Multisim. You will be asked to make both frequency and phase measurements on the circuit, and to compare your simulation results with those obtained in the experimental portion of Experiment 1.

*Note:* Do not forget to apply basic troubleshooting techniques when performing a computer simulation. Visual checks and power supply voltage verification are still a must.

Part I: Plotting the Output Magnitude for the Butterworth Second Order
      Low-Pass Active Filter

1.  The EWB Multisim implementation of a Butterworth Second Order Low-Pass Filter is provided in Fig.
    E1-1. Your first step is to construct this filter in EWB Multisim. After completing your design, start the
    simulation and use the oscilloscope to verify that the circuit is functioning properly. To do this,
    connect the oscilloscope to both the input and output of the filter and verify that the output sine wave
    is 180° out of phase with respect to the input sine wave. The output signal will also be attenuated with
    respect to the input (gain less than 1). The connections you need to make to the oscilloscope are
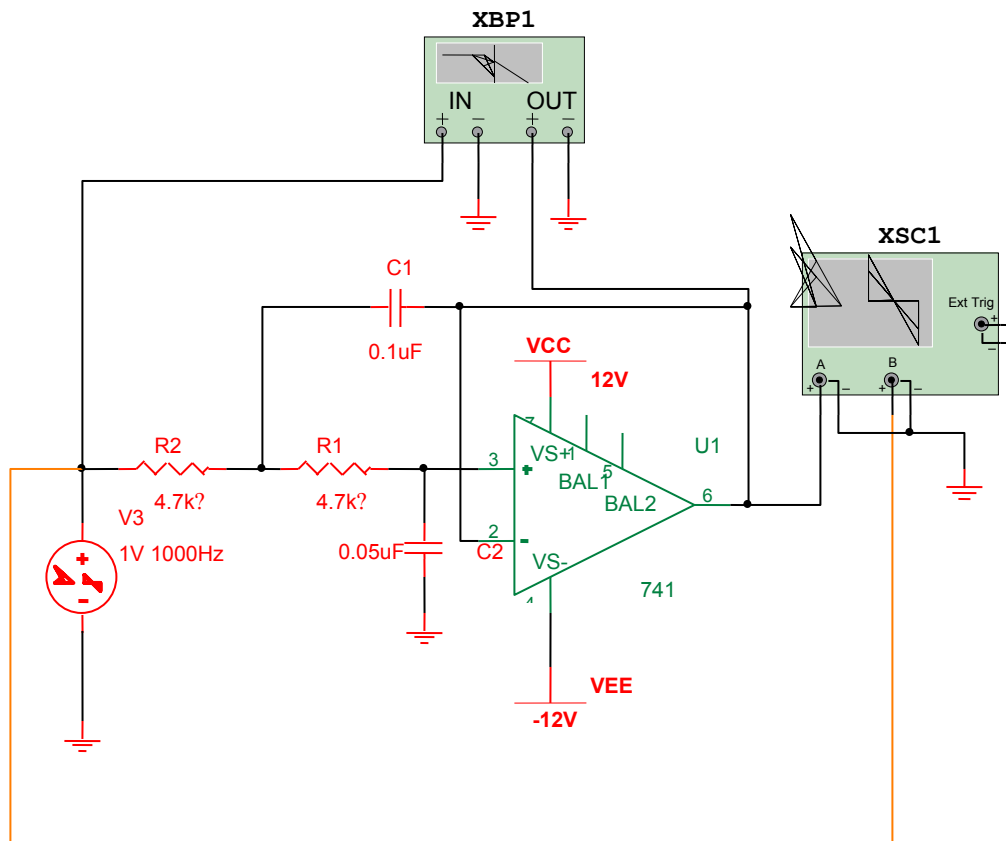    shown in Fig. E1-1.



**FIGURE E1-1**

2.  EWB Multisim provides a Bode plotter for making frequency and phase response measurements. A
    Bode plot graphs the output magnitude and phase as a function of the input signal frequency.

    Connect the Bode plotter as shown in Fig. E1-1. To use the Bode plotter, double-click on it and set
    the sweep frequency to an initial value **(I)** of 500 mHz and a final value **(F)** of 20 kHz. Both the
    Vertical and Horizontal settings should be set to Log. Adjust the initial and final level settings for the
    vertical axis as needed to display the data results. For this exercise click on the Magnitude button.
    The settings for the Bode plotter and the expected simulation results are shown in Fig. E1-2.
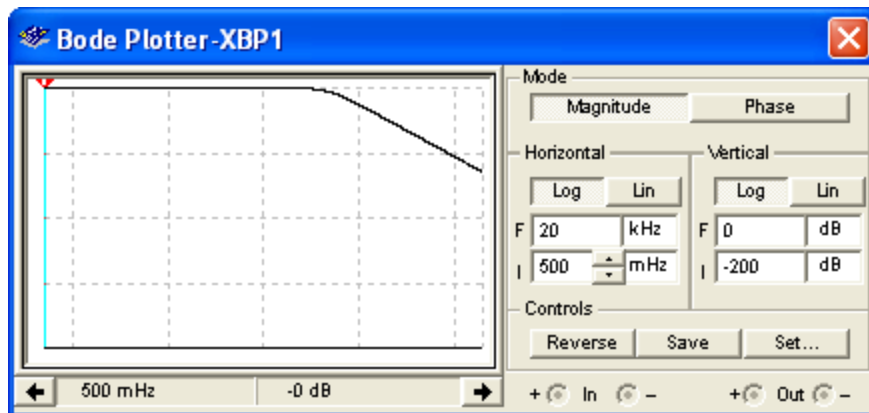
**FIGURE E1-2**

3.  Use the slider on the Bode plotter to measure the critical frequency. This will be the point where the plot drops from 0 dB to -3 dB. Record the value:_____
4.  Move the slider to 1 kHz and record the dB level: _____
5.  Move the cursor to 10 kHz and record the dB level: _____
6.  Calculate and record the dB level difference for 1 kHz and 10 kHz:_____

This is the amount in dB that the magnitude of the output voltage is being attenuated. Is this value correct? For assistance, refer back to Part I of Experiment 1 (the experimental lab) for a discussion on the Butterworth Second Order Filter.

Part II: Plotting the Output Phase for the Butterworth Second Order
       Low-Pass Active Filter

1.  In this exercise, you will make phase measurements on the Butterworth Second Order Low-Pass Filter provided in Fig. E1-1 using the EWB Bode plotter. Your first step is to double-click on the Bode plotter and select on the phase mode by clicking on the Phase button. Change the initial **(I)** phase setting to -180° and final **(F)** phase setting to 360°. The settings for the Bode plotter and the expected simulation results are shown in Fig. E1-3. You may need to rerun the simulation after making the changes.
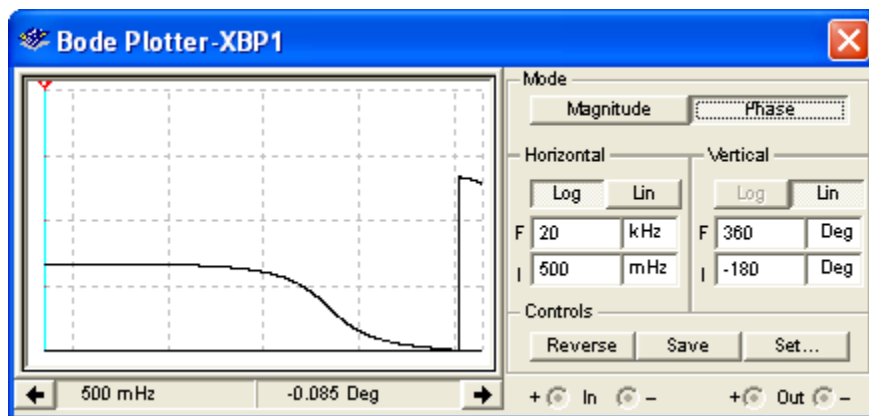


**FIGURE E1-3**

2.  Move the slider to the critical frequency you measured in step three of Part I. Record the amount of phase shift, in degrees: _____

At the critical (or 3-dB) frequency, the phase shift of a second order Butterworth filter should be about 90°. Verify that your measurement is close to this value.

**3.**  Move the cursor to 10 kHz and record the phase:_____

Your answer should be close to -180°. This is the amount of phase shift for an ideal second order Butterworth active filter. Double-click on the Bode plotter and change the final frequency to 500 kHz. Restart the simulation and you will see that the phase shift actually exceeds 180°. This is due to the additional contributions in phase shift provided from the LM741. The simulation for the LM741 models its behavior on real operating characteristics including the non-ideal characteristics such as the increased phase shift.

Part III: Additional EWB Exercise on CD-ROM

The active filter networks for EWB Experiment 1 are provided on the CD-ROM so that you can gain additional experience simulating electronic circuits with EWB and gain more insight into the characteristics of active filter networks. The file names and their corresponding figure numbers are listed.

<u>**FILE NAME**</u>
Lab1-low_pass_filter
Lab1-high_pass_filter
Lab1-bandpass_filter
Lab1-notch_filter