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Amplitude Modulation Fundamentals

User's Guide

Computer-Based Training Course

HP H5264A

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Purpose of this Course

This course is designed for those who have a basic knowledge of electronic theory and circuits and wish to learn about amplitude modulation. When you have completed this course, you will have a basic knowledge of the measurement techniques as well as the theory, technology and terminology of amplitude modulation.

Conventions

The following conventions are used throughout this manual:

- **Bold** is used to emphasize important information in the text or to highlight text to be entered from your computer's keyboard.
- *Italics* are used for titles that refer to the course and its modules, to indicate selections to be made, or for emphasis.
- **<Keystroke>** indicates a key or combination of keys to be pressed.

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Amplitude Modulation Fundamentals Computer-Based Training

- **Course Objectives**
- **The Amplitude Modulation Fundamentals Program**
- **Hardware/Software Requirements**

Course Objectives

When you have completed this course, you will be able to:

- Describe why modulation is needed to transmit signals.
- Describe the three basic modulation techniques.
- Identify amplitude modulated wave forms.
- Explain the waveform dynamics of amplitude modulation.
- Measure **m**, the AM modulation index.
- Explain alternative modulation and demodulation techniques.
- Understand alternative amplitude modulation techniques.

The Amplitude Modulation Fundamentals Program

The program needs to be downloaded from www.educatorscorner.com.

Hardware/Software Requirements

To use *Amplitude Modulation Fundamentals,* you will need a Vectra computer or an IBM PC/AT compatible computer equipped with the following:

- DOS 3.1 or higher
- Windows 3.0 or higher
- 2 MB of RAM
- A hard disk with 5.0 MB of available space
- One 1.44 MB diskette drive
- A Microsoft-compatible mouse
- VGA or higher resolution monitor. When using SVGA, the program will occupy only a portion of the screen.
- A processor running at 33 MHz is recommended for optimum performance. The program will run satifactorily on slower processors, but will take more time to complete.

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Getting Started

- **Setup and Installation**
- **Starting the Program**

Setup and Installation

Follow these steps to setup and install *Transmission-Line Fundamentals*.

1. Save the file TLF.exe to your computer.
2. Double-click on TLF.exe to unpack.
3. Choose the current file destination or change the folder name to another temporary directory. Note: these files will not be deleted during installation.
4. Click the unzip button.
5. Go to the destination folder you selected and open up the Set Up folder.
6. Then open up the Disk 1 folder.
7. Look for the setup.exe file and click on it to begin installation.
8. The set up and installation will start up.
9. Follow the step by step instructions for installation.

Starting the Program

Click on the Start button; go to Programs and look for TLF Fundamentals *and open your new program*.

You can go back and delete the setup files unpacked in the temporary folder.

Deinstalling the Program

1. Load the setup program using the steps on the previous pages.

2. At the Install/Deinstall prompt, click **Deinstall** and then click **OK**.

3. Type the path — drive specifier first, then subdirectory (Example: C:\AMF) — and click **OK**.

   The deinstall program defaults to the drive Windows is installed on and the subdirectory \AMF.

4. A screen will appear which reminds you that you are deleting the *Amplitude Modulation Fundamentals* files from their subdirectory and asks you if you want to continue. Click **OK**.

The deinstall program will quickly delete all files and remove the program group and icon from Windows.

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Troubleshooting

- **Installation**
- **Deinstallation**
- **During the Program**

Installation

Below are error messages which could appear while you install, deinstall, or use *Amplitude Modulation Fundamentals,* along with their causes and solutions.

The target location must be different from the source
Try another disk as the target.

The disk drive is an invalid disk
The disk can't hold the program.
Try a different disk drive.

There is not enough space
There is not enough room on the hard drive for the program. You will need to clear enough room for the program.

Unable to create specified path
You may have typed in the wrong path.
Retype the path.

Unable to copy, compress, or delete file
The file is missing or corrupted on the disk.
You may need a new copy if installing.
You may need to use Windows File Manager if deinstalling.

Cannot start ISlauncher
Your virus detection program is interfering with the installation. Scan the disks for viruses first, then turn off the detection program and install normally. Reactivate your virus detection program after installation.

Deinstallation

Unable to find *Amplitude Modulation Fundamentals* subdirectory?

You may have typed in the wrong path. Retype the path.

Unable to copy, decompress, or delete file?

You may not be deinstalling from the correct subdirectory or the file may already have been deleted.

During the Program

There is not enough memory...

You may not have enough RAM. Remember that you need 2 MB to be running extended memory drivers.

Text appears misaligned or overlapping?

Turn off the Adobe Type Manager and this problem should disappear.

To turn off Adobe Type Manager:

1. Exit *Amplitude Modulation Fundamentals*
2. Open the Windows Main Group
3. Open ATM Control Panel
4. Turn off ATM

Restart Windows when you exit from the ATM Control Panel, or the change will not be effective.

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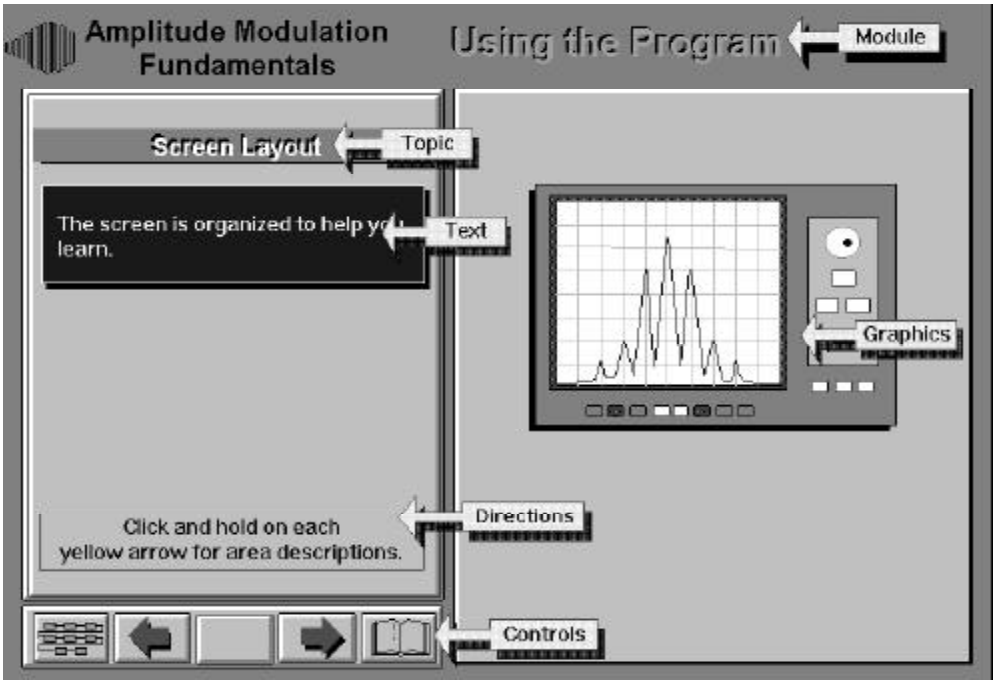
Using the Program

- **Screen Layout**
- **Navigating**
- **Math Reference Tool**
- **Glossary**
- **Hotwords**
- **Printing**
- **Exiting**

Screen Layout

A typical screen is organized like this:



Text
Provides instruction, description, or questions.

Topic
A short description of each page.

Module
Tells you which module you are currently working with.

Directions
Tells you where to click.

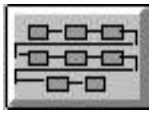
Controls
Provides navigation through the course.

Graphics
Illustrates the meaning of the text.

Navigating

These five controls are used to navigate through *Amplitude Modulation Fundamentals.* They are grouped together in a row on the lower left hand part of the screens.

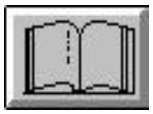
Control your course by pressing these buttons:


Returns you to the main menu.


Returns you to the previous screen.

Takes you to math reference tool.


Advances you to the next screen.


Takes you to the glossary.

There is also a page box in the lower left corner which you can use to go to any page of the course. To press the page box, click on it, type the page number you want and press **<Enter>**.

Returning
The glossary and math reference tool buttons will take you to those parts of the course for review or reference. You can return from these sections to the exact location you left at any time by pressing the **Return** button.

Math Reference Tool

The math reference tool provides additional information about the mathematical information and discriptions presented in the material. The math reference tool is not always active. When it is active, click on the math button to reference more material.

Glossary

The glossary alphabetically lists and defines all the technical amplitude modulation terms presented in the course. Each screen in the glossary covers listings under two letters of the alphabet (the first screen covers A-B, the second C-D, and so on) except the last, which covers W-Z.

A column of tabs which you can click to select any letter pair you want is provided on the right side of each glossary screen.

Scroll the glossary page up and down to run through all the listings for the letter pair selected.

To move to the listings for the next or previous letter pair, you can also click the page-ahead or page-back arrow at the bottom of the screen.

Clicking on the **Return** button will place you exactly where you were in the course before you entered the glossary.

Hotwords

Technical terms concerning amplitude modulation may be hotwords. Clicking on a hotword will display a short definition of the term. The cursor will change from an arrow to a window when positioned on a hotword. The hotword will also be underlined in the text. (The glossary will contain a more detailed definition.)

Printing

To print a screen, press **Ctrl-P** and select **Print**.

Exiting

You can exit the program from any screen by selecting the system menu box from the upper left corner and selecting **Close** from the menu.

You can also exit by using the **<ALT>** + **<F4>** combination.

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Course Contents

- **Module Descriptions**

Module Descriptions

The course provides basic understanding of the terminology and functions of amplitude modulation.

There are seven modules (not counting Using the Program, which describes how to use the course). We recommend that you take them all in order, but you may also choose to take only the specific modules you want to learn.

Module 1 **Why Modulation?**
explains why modulation is needed to transmit information signals.

Module 2 **Modulation Basics**
introduces the three basic modulation techniques used in communications.

Module 3 **Amplitude Modulation**
describes waveform dynamics of amplitude modulation.

Module 4 **Modulation Index**
explores methods of measuring **m**, the modulation index.

Module 5 **Modulation and Demodulation**
investigates amplitude modulation and demodulation systems.

Module 6 **DSBSC & SSB**
examines two alternative modulation techniques, double sideband suppressed carrier (DSBSC) and single sideband (SSB).

Module 7 **Review and Quiz**
asks questions to check your understanding of the material.

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Appendix

- **Glossary of Amplitude Modulation Terms**

Glossary of Amplitude Modulation Terms

AM Broadcast Band
The broadcast radio frequency band in the MF region from 550 kHz to 1650 kHz. The AM broadcast band is divided into 10 kHz channels which use full-carrier DSB modulation with a maximum allowed modulation frequency of 5 kHz.

Amplitude Modulation (AM)
A modulation process in which the instantaneous amplitude of a sinewave carrier is caused to vary from the carrier amplitude by an amount proportional to the instantaneous amplitude of the modulating wave.

Antenna
The part of a transmitting or recieving system designed to radiate electromagnetic waves. Antenna components must be comparable in size to the wavelengths to be radiated. Many communications appliations employ a dipole antenna design consisting of a thin metal conductor a half-wavelength or quarter-wavelength in length.

Balanced Modulator
A device that multiplies the modulating (information) signal with the carrier to yield the sum and difference frequencies without the carrier frequency.

Band-Pass Filter
An electronic device that transmits one group of frequencies while rejecting both lower and higher frequencies.

Bandwidth
The range of frequencies contained in or occupied by a signal; the range of frequencies that a device can process.

Glossary of Amplitude Modulation Terms

Baseband
The band of frequencies occupied by a signal before it modulates a carrier signal. The baseband signal usually ranges over distinctly lower frequencies than the carrier and may include direct current (zero frequency).

Carrier
An electrical signal that is modified in frequency, amplitude, and/or phase in order to transmit an information signal from one point to another.

Carrier Reinsertation
A process used in DSBSC and SSB receivers to recreate the untransmitted carrier for purposes of recovering the information signal.

Carrier Signal; Carrier Wave
See Carrier.

Channel
A connection between two points for the transmission of information, as in a communications channel.

Demodulation
The process of recovering (separating) an information signal from a modulated carrier signal.

Demodulator
A circuit that recovers the modulating (information) signal from a modulated carrier.

Depth of Modulation
See Modulation Index.

Glossary of Amplitude Modulation Terms

Detected Signal
The recovered information signal in the receiver after demodulation.

Distortion
Undesired alterations to the shape of a waveform. Can be caused by the addition of atmospheric or system noise (noise distortion) or the addition of undesirable frequencies (harmonic and/or intermodulation distortion) generated by non-linear system components.

Double Sideband or Double Sideband Full Carrier (DSB)
An amplitude modulation technique which transmits the carrier and both sidebands. Used for broadcast AM, mobile and marine short wave, and amateur radio applications in the MF and HF regions.

Double Sideband Suppressed Carrier (DSBSC)
An amplitude-modulation technique which removes (suppresses) the carrier before transmission. Viewed in the frequency domain, the signal has two sidebands and no carrier. Initially used in marine radio applications but subsequently replaced by SSB techniques.

DSB
See Double Sideband.

DSBSC
See Double Sideband Suppressed Carrier (DSBSC)

Electromagnetic Waves
Waves characterized by variations of electric and magnetic fields and classified as radio waves, heat rays, light rays, etc., depending on frequency. Radio waves range from 0 Hz to 1 THz. See Radio Spectrum.

Glossary of Amplitude Modulation Terms

Envelope Detection
Simplest method for the recovery of the information signal from an amplitude-modulated carrier. Uses a diode to rectify the modulated signal and a low-pass filter to reject the carrier component. The recovered information has the shape of the ‘‘envelope’’ of either the positive or negative portion of the amplitude-modulated carrier wave.

FM Broadcast Band
The broadcast radio frequency band in the VHF region from 88 MHz to 108 MHz. The FM broadcast band is divided into 200 kHz channels which use two-sideband, wide-band FM modulation with a maximum allowed modulation frequency of 15 kHz and a maximum allowed frequency deviation of 75 kHz.

Frequency Conversion
Process of combining an input signal with an injected frequency and putting them through a non-linear device which intermodulates them and generates sum and difference frequencies. If the sum frequencies are selected by filtering, the input signal can be converted or raised in frequency by the magnitude of the injected frequency. Also called frequency mixing or frequency multiplication.

Frequency Modulation (FM)
An angle modulation process in which the instantaneous frequency of a sinewave carrier is caused to depart from the carrier frequency by an amount proportional to the instantaneous amplitude of the modulating wave.

Frequency Multiplication
See Frequency Conversion.

Glossary of Amplitude Modulation Terms

Harmonics
Sinusoidal frequencies which are integral multiples of a signal frequency. Each signal frequency associated with a harmonic is called a fundamental frequency. Only a pure sine wave has no harmonics.

Heterodyning
The operation of multiplying a signal with an auxiliary sinusoidal signal; also called mixing. See Frequency Conversion.

Information Signal
The electrical signal containing the information to be transmitted; the modulating signal. In test situations, a single sinewave, or test tone, substitutes for the information signal.

Intermodulation
Frequency components that result from two tones modulating together. The frequencies present in the output satisfy the criteria $\omega n_m = | n\omega_1 \pm m\omega_2 |$ where ω_1 and ω_2 are the frequencies of the original tones.

Ionosphere
That part of the earth's outer atmosphere where ions and free electrons are normally present in quantities sufficent to affect propagation of radio waves.

Low Pass Filter
An electronic device that transmits one group of frequencies, including direct current (zero frequency) while rejecting higher frequencies.

Lower Sideband
A sideband having a frequency lower than the carrier signal frequency. See Sidebands.

Glossary of Amplitude Modulation Terms

m
See Modulation Index.

Mixer; Mixing
See Frequency Conversion.

Modulated Carrier Signal
A carrier to which the information signal has been added by the process of modulation.

Modulating Frequency; Modulating Signal; Modulating Waveform
See Information Signal.

Modulation
The process by which some characteristic (amplitude, frequency, and/or phase) of a carrier wave is varied in accordance with a modulating function or wave. See Amplitude Modulation, Frequency Modulation, and Phase Modulation.

Modulation Depth
See Modulation Index.

Modulation Distortion
Undesired alterations to the shape of the waveform, or undesired frequency components added by the process of modulation. See Distortion.

Modulation Index
A measure of the amount, degree or depth of modulation. In AM, the modulation index, **m**, ranges from 0 to 1 and relates to the amplitude of the sidebands with respect to that of the carrier, i.e. a modulation index of m means that each of the upper and lower sideband amplitudes are m/2 times the amplitude of the carrier. Multiplying the modulation index by 100 gives the percentage modulation.

Glossary of Amplitude Modulation Terms

Modulation Percentage
See Modulation Index.

Modulator
A circuit that adds the modulating (information) signal to an unmodulated carrier signal.

Multiplex
To interleave or simultaneously transmit two or more messages on a single channel.

Multipliers
See Frequency Conversion.

Over Modulation
A condition where the modulation index has exceeded its maximum. Results in distortion of the transmitted AM signal.

Percentage Modulation
See Modulation Index.

Phase Modulation (ϕ-M or PM)
An angle modulation process in which the phase angle, ϕ, of a sinewave carrier is caused to depart from a reference value by an amount proportional to the instantaneous amplitude of the modulating wave.

Glossary of Amplitude Modulation Terms

Radio Spectrum
The radio frequency portion of the electromagnetic spectrum subdivided as follows:

ULF (ultra low frequency) -- lower than 3 Hz
ELF (extremely low frequency) -- 3 Hz to 3 kHz
VLF (very low frequency) -- 3 kHz to 30 kHz
LF (low frequency) -- 30 kHz to 300 kHz
MF (medium frequency) -- 300 kHz to 3 MHz
HF (high frequency) -- 3 MHz to 30 MHz
VHF (very high frequency) -- 30 MHz to 300 MHz
UHF (ultra high frequency) -- 300 MHz to 3 GHz
SHF (super high frequency) -- 3 GHz to 30 GHz
EHF (extremely high frequency) -- 30 GHz to 300 GHz
Submillimeter -- 300 GHz to 1 THz

Regulatory Agencies
International and national governmental bodies responsible for the allocation and use of the airwaves.

RF
Also called Radio Frequency. See Radio Spectrum.

Second Harmonic Distortion
In amplitude modulation, unwanted signals separated from the carrier at twice the frequency of the information signal. Caused by non-linearity in the modulation process.

Selective Fading
Fading that affects unequally the different spectral components of a radio signal since the propagation characteristics of waves varies with frequency.

Glossary of Amplitude Modulation Terms

Short Wave
Radio signals having shorter wavelengths than those used by the AM broadcast band, i.e. less than 200 meters.

Sidebands
Frequency bands on both sides of the carrier containing the frequencies of the information signal produced by the process of modulation. See Upper Sideband and Lower Sideband.

Single Sideband, or Single Sideband Suppressed Carrier (SSB)
A amplitude modulation technique which removes (suppresses) the carrier and one sideband before transmission. Viewed in the frequency domain, the signal has a single sideband and no carrier. SSB applications transmit a single sideband in a 3 kHz channel. Used for mobile and marine short wave, and amateur radio applications in the MF and HF regions.

SSB
See Single Sideband.

Supressed Carrier
A carrier signal that has been removed from the modulated waveform before transmission. Typically implemented by a balanced modulator.

Unmodulated Carrier
A carrier signal to which no modulation has been added.

Upper Sideband
A sideband having a frequency higher than the carrier signal frequency. See Sidebands.

Notes

Notes