DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING(NITK)

PROJECT REPORT ON

Amplitude Modulation Using MATLAB *Simulink*

Submitted By

Dwaipayan Munshi

(181MN010)

Soumyabrota Sen

(181MEXXX)

Submitted To

Dr Mandeep Singh

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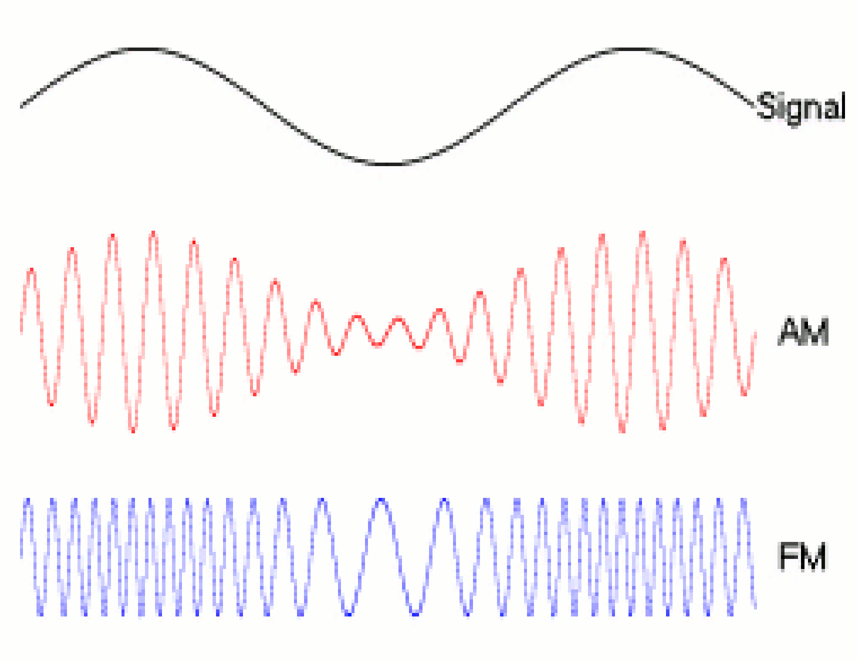
INTRODUCTION

What is Modulation ?

Modulation is the process by which a message or information-bearing signal is transformed into another signal to facilitate transmission over a communication channel (e.g., radio, satellite, twisted wire pair [TWP]). Modulation involves the use of an auxiliary waveform, usually sinusoidal, called a carrier. A modulated carrier is generated by varying some characteristic (e.g., amplitude, frequency, or phase) of the carrier in accordance with the message signal. Modulation is performed to accomplish one or more of these objectives: frequency translation, channelization, practical equipment design, or noise performance improvement. The illustration below, shows a few variations of of modulation



Amplitude Modulation

Amplitude modulation (AM) is a modulation technique used in electronic communication, most commonly for transmitting messages with a radio carrier wave. In amplitude modulation, the amplitude (signal strength) of the carrier wave is varied in proportion to that of the message signal, such as an audio signal. This technique contrasts with angle modulation, in which either the frequency of the carrier wave is varied as in frequency modulation, or its phase, as in phase modulation.

AM was the earliest modulation method used for transmitting audio in radio broadcasting. It was developed during the first quarter of the 20th century beginning with Roberto Landell de Moura and Reginald Fessenden's radiotelephone experiments in 1900. This original form of AM is sometimes called double-sideband amplitude modulation (DSBAM), because the standard method produces sidebands on either side of the carrier frequency. Single-sideband modulation uses bandpass filters to eliminate one of the sidebands and possibly the carrier signal, which improves the ratio of message power to total transmission power, reduces power handling requirements of line repeaters, and permits better bandwidth utilization of the transmission medium.

AM remains in use in many forms of communication in addition to AM broadcasting: shortwave radio, amateur radio, two-way radios, VHF aircraft radio, citizens band radio, and in computer modems in the form of QAM.

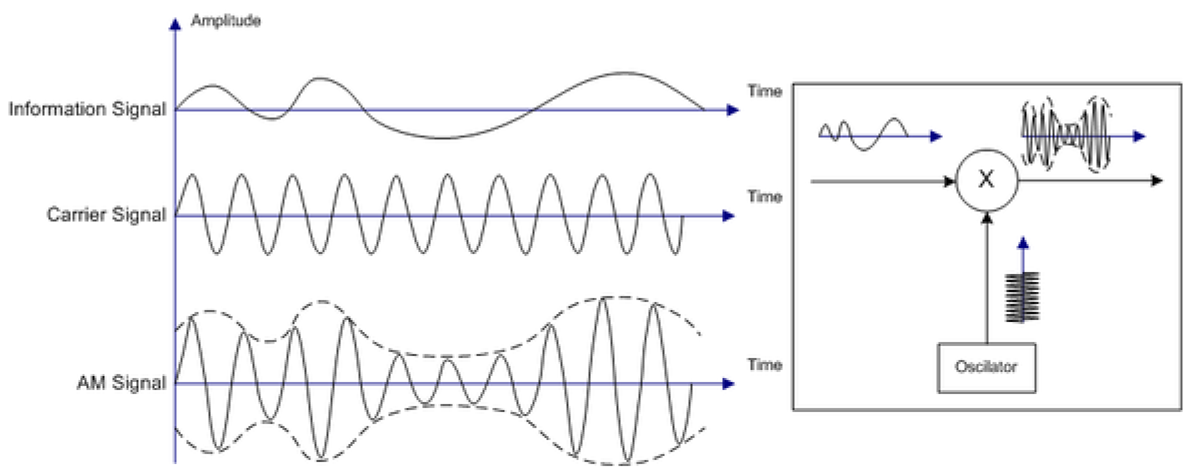


Fig 2 :- Illustration of Amplitude Modulation

Double Sideband Suppressed-Carrier AM

A double-sideband suppressed-carrier (DSB-SC) AM signal is obtained by multiplying the message signal s (t) with the carrier signal $c(t) = A_c s(t) \cos(2\pi f_c t)$ as shown in Figure 3 . Thus, we have the amplitude-modulated signal

$$x_{DSB}(t) = s(t)c(t) = A_c s(t)\cos(2\pi f_c t)$$

Figure 4 displays an assumed message signal and corresponding DSB-SC AM waveforms. Note that the modulated waveform retains the key characteristics of the message signal. Therefore, it can be used to recover the message signal at the receiver by appropriate signal processing.

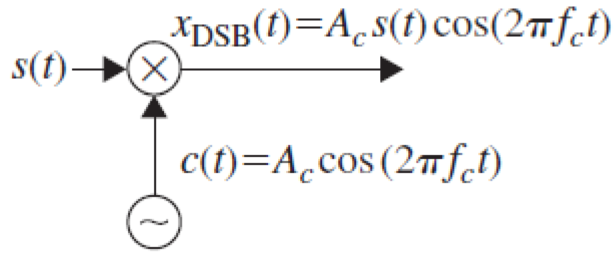


Fig 3 :- DSB-AC Amplitude Modulation

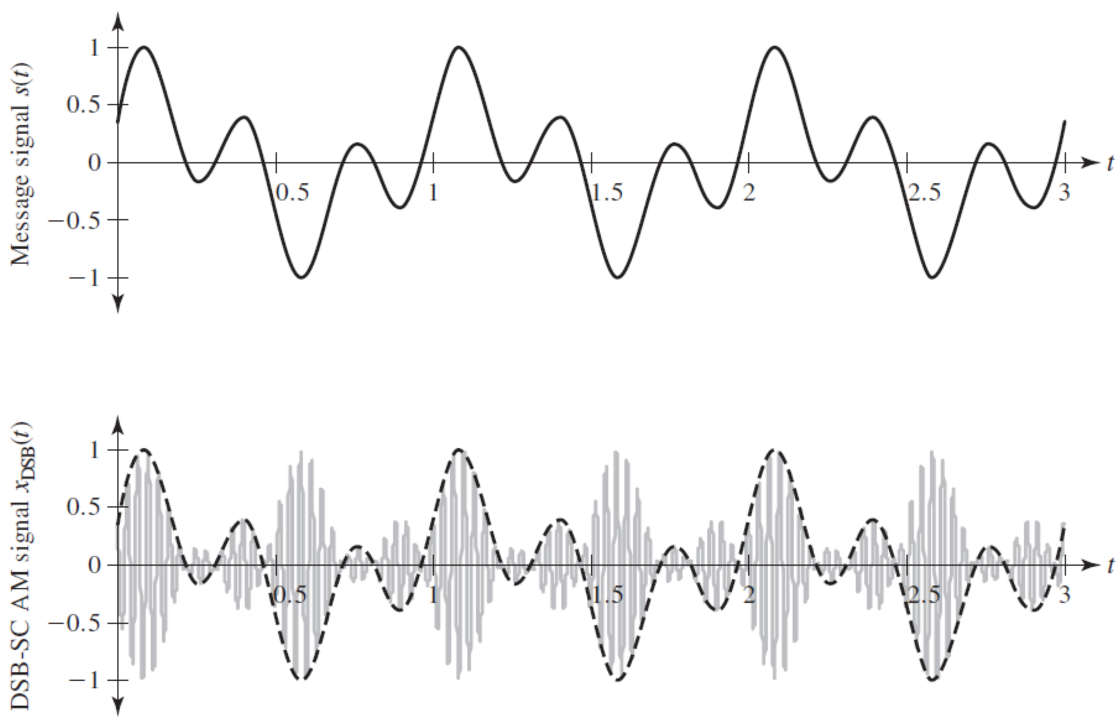


Fig 4 :- DSB-AC Amplitude Modulation Waveforms

Spectrum Of DSB-SC AM Signal

The spectrum of the modulated signal can be obtained by taking the Fourier transform (FT) of $x_{DSB}(t)$ and using convolution property. This yields

$$X_{DSB}(f) = S(f) \otimes C(f) = \frac{A_c}{2} S(f) \otimes \left[\delta(f - f_c) + \delta(f + f_c)\right]$$

$$= \frac{A_c}{2}\left[S(f - f_c) + S(f + f_c)\right]$$

Figure 5 displays the magnitude spectra for S(f) and $X_{DSB}(f)$. The message spectrum S(f) is chosen for the purpose of illustration only and it does not correspond to s(t) in Figure 4.4 . We observe that the modulation has translated the magnitude spectrum of the message signal s(t) by the frequency $\pm f_c$. Further, the amplitude-modulated signal occupies a bandwidth of 2 B, whereas the bandwidth of the message signal s(t) is B. Therefore, the bandwidth required to transmit the modulated signal $x_{DSB}(t)$ is given by

$$B_T = 2B$$

The spectrum of the modulated signal x DSB (t) in the frequency band | f | > f c is called the upper sideband of $X_{DSB}(f)$ and the spectrum in the frequency band | f | < f c is called the lower sideband of $X_{DSB}(f)$. Note that either one of the sidebands of $X_{DSB}(f)$ contains all of the information content that is in S(f). For example, the frequency content of the upper sideband for f > fc corresponds to the frequency components of S(f) for f > 0, and the frequency content for f < -fc corresponds to the frequency content of S(f) for f < 0 . Similarly, the lower sideband of $X_{DSB}(f)$ also contains all the spectral components of the message signal S (f) . Because $X_{DSB}(f)$ contains both the upper and the lower sidebands, it is called a double-sideband AM signal .

The other characteristic of the modulated signal $x_{DSB}(t)$ is that it does not contain energy at the carrier frequency fc . For this reason, $x_{DSB}(t)$ is called a suppressed-carrier signal. Because all the transmitted power resides in the sidebands, the resultant power efficiency makes the DSB-SC modulation scheme attractive. However for coherent demodulation, a locally generated carrier, that is frequency- and phase-locked with the carrier used for modulation at the transmitter, is required. The generation of such a coherent carrier, when the received signal has no spectral component at the carrier frequency, adds complexity to the receiver design.

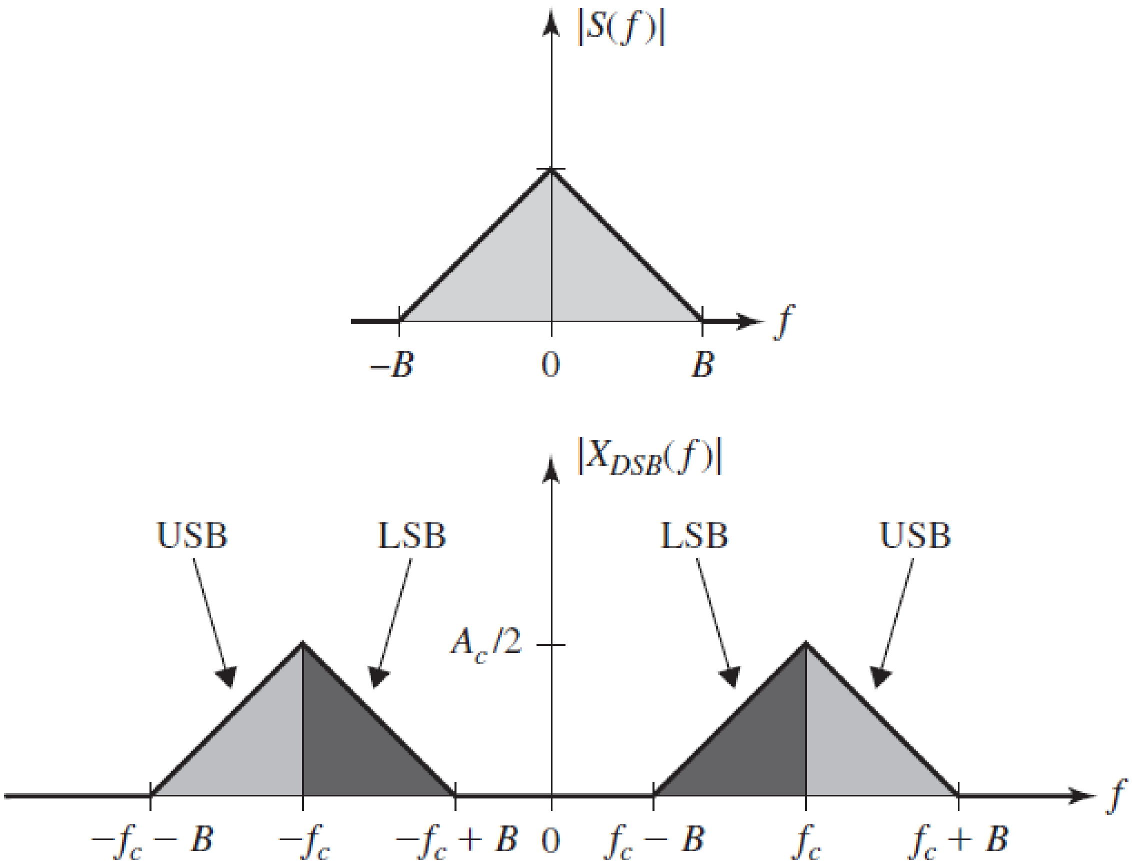


Fig 5 :- Spectra of the Message and DSB-SC AM Signal

Simulation Model of DSB-SC AM

MATLAB Simulink

Simulink is a software package for modeling, simulation, and analysis of dynamic systems. For modeling, Simulink provides a graphical user interface (GUI) for building models as block diagrams, using click-and-drag mouse operations. Simulink includes a comprehensive library of blocks for modeling sources, sinks, and various signal processing components. The custom blocks for a given application can be constructed by combining existing blocks or creating new blocks using MATLAB m-files or C code. Additional libraries of blocks (called “blocksets”) are available that specifically facilitate simulation and analysis of wired/wireless communication systems as well as various signal processing and control applications. The simulation models used in this text would require the capability of the Student Version of MATLAB and Simulink which includes MATLAB and Simulink as well as various toolboxes and Signal Processing Blockset.

Simulation of a dynamic system is a two-step process in Simulink. First, a block diagram of the system is created, using the Simulink model editor, that graphically depicts a time-dependent model of the dynamic system. The user then commands the Simulink software to simulate the system represented by the model from a specified start time to a specified stop time. In this chapter, we will focus on capabilities and features of the Simulink that students can quickly learn to simulate analog and digital communication systems. This, in turn, should enable them to study signal waveforms and spectra at different stages in the system. Also, it would be quite beneficial for them to make simulated measurements of key system performance metrics and compare them with theoretical results.

Model Development

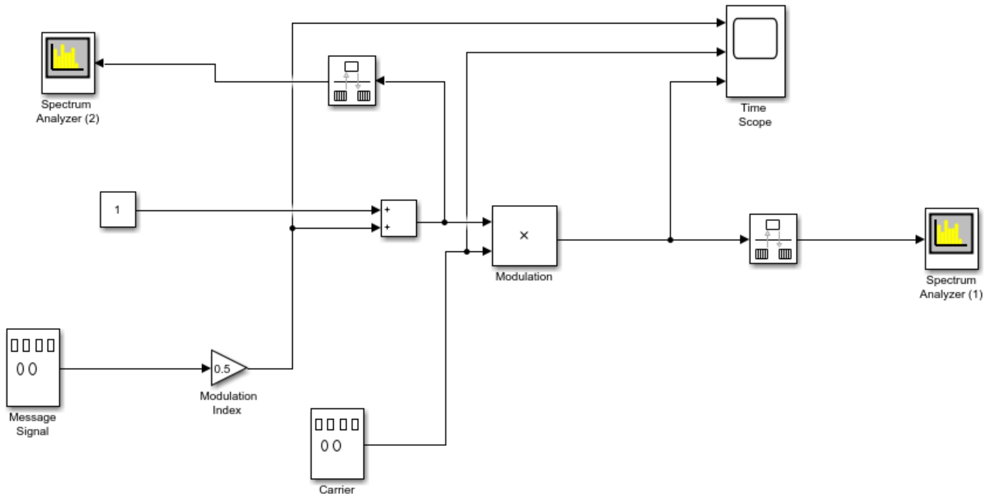


Fig 6 :- Model Built on MATLAB Simulink

Components Used In the Model

- **Spectrum Analyzer** :- The Spectrum Analyzer block, referred to here as the scope, displays the frequency spectra of signals.
- **Rate Transition :-** The Rate Transition block transfers data from the output of a block operating at one rate to the input of a block operating at a different rate. Use the block parameters to trade data integrity and deterministic transfer for faster response or lower memory requirements.
- **Time Scope :-** The Simulink® Scope block and DSP System Toolbox™ Time Scope block display time domain signals.
- **Constant :-** The Constant block generates a real or complex constant value signal. Use this block to provide a constant signal input. The block generates scalar, vector, or matrix output, depending on:
  - The dimensionality of the Constant value parameter
  - The setting of the Interpret vector parameters as 1-D parameter

  The output of the block has the same dimensions and elements as the Constant value parameter. If you specify for this parameter a vector that you want the block to interpret as a vector, select the **Interpret vector parameters as 1-D** check box. Otherwise, if you specify a vector for the **Constant value** parameter, the block treats that vector as a matrix.
- **Add, Subtract, Sum of Elements, Sum : -** The Sum block performs addition or subtraction on its inputs. The Add, Subtract, Sum of Elements, and Sum

blocks are identical blocks. This block can add or subtract scalar, vector, or matrix inputs. It can also collapse the elements of a signal and perform a summation. You specify the operations of the block with the List of signs parameter with plus (+), minus (-), and spacer (|).

  - The number of + and - characters equals the number of inputs. For example, +-+ requires three inputs. The block subtracts the second (middle) input from the first (top) input, and then adds the third (bottom) input.
  - A spacer character creates extra space between ports on the block icon.
  - If performing only addition, you can use a numerical value equal to the number of inputs.
  - If only there is only one input port, a single + or - adds or subtracts the elements over all dimensions or in the specified dimension.

The Sum block first converts the input data type to its accumulator data type, then performs the specified operations. The block converts the result to its output data type using the specified rounding and overflow modes.

- **Gain :-** The Gain block multiplies the input by a constant value (gain). The input and the gain can each be a scalar, vector, or matrix. You specify the value of gain in the Gain parameter. The Multiplication parameter lets you specify element-wise or matrix multiplication. For matrix multiplication, this parameter also lets you indicate the order of the multiplicands. Gain is converted from doubles to the data type specified in the block mask offline using round-to-nearest and saturation. The input and gain are then multiplied, and the result is converted to the output data type using the specified rounding and overflow modes.

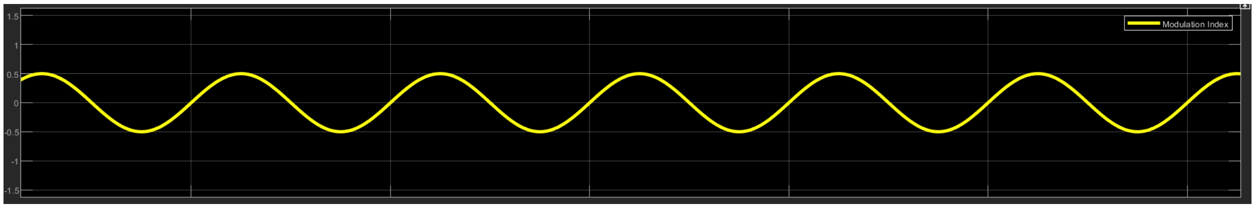
Parameters To Run Model

- Double click on the signal generator, and then set the frequency as 1 kHz with a waveform of sine
- Adjust the carrier sine wave's frequency as 20 kHz
- Set the simulation time such as 0.01 to observe the signals clearly
- Run the simulation

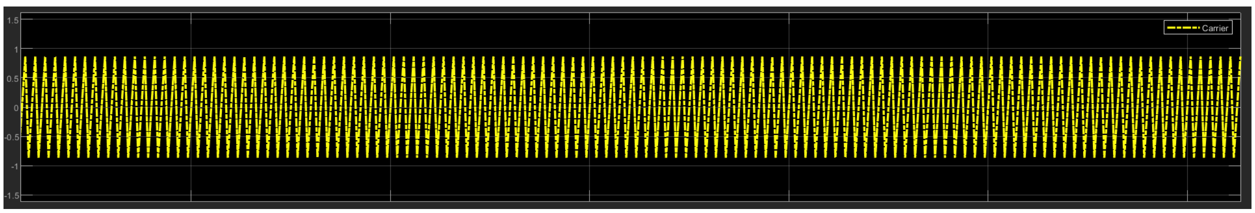
As it is clearly seen that the AM model is exactly based upon the mathematical foundation provided in the theoretical section. The message signal is multiplied by the modulation index, then it is added a DC carrier, finally is multiplied with a sinusoidal carrier signal in order to transmit the AM modulated signal.

Results & Discussion

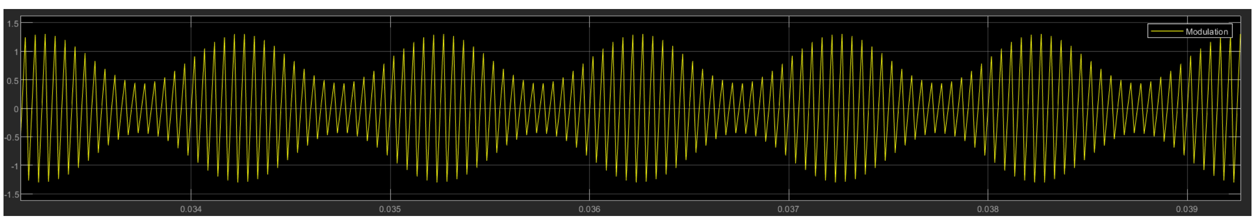
Message Signal Generated (1 kHz)



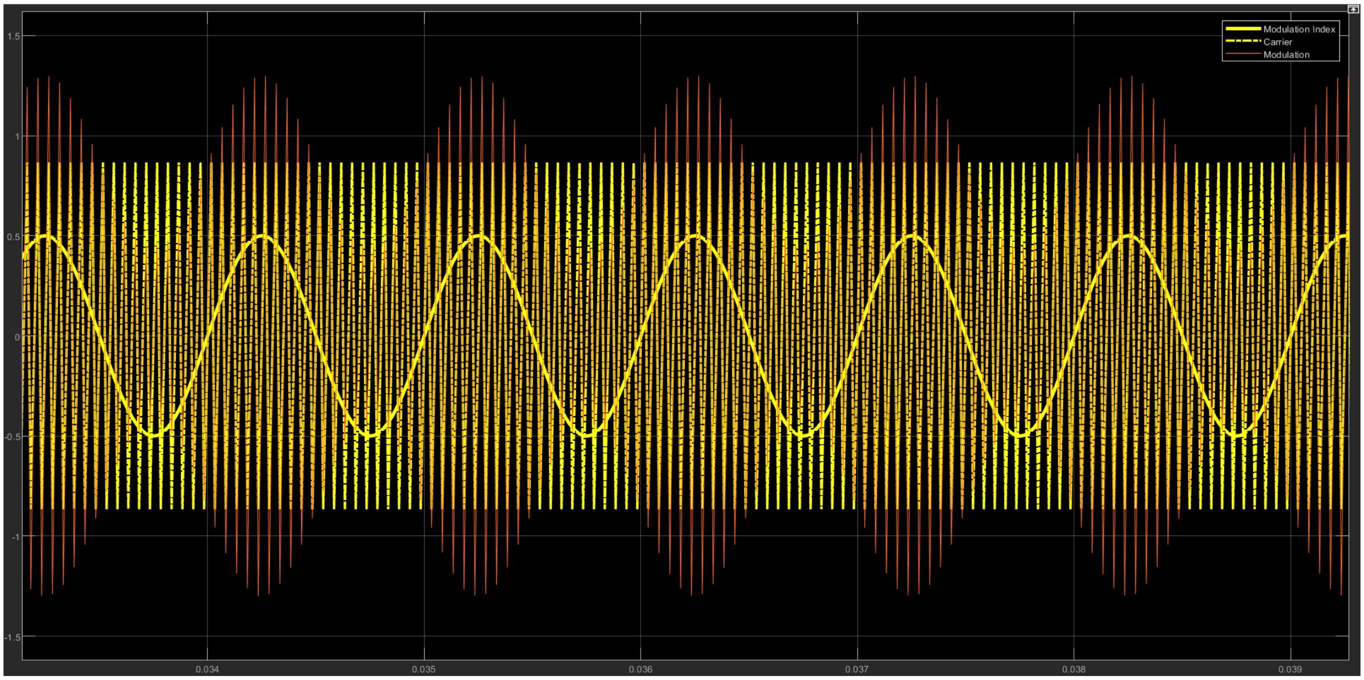
Carrier Signal Generated (20 kHz)



Modulated Signal Generated



Superimposed Illustration



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In.mathworks.com. 2021. SimulinkDocumentation- MathWorks India. [online] Available at: <https://in.mathworks.com/help/simulink/> [Accessed 25 Feb 2021].

GitHub Repository https://github.com/dwaipayan05/Amplitude-ModDemod-Simulink