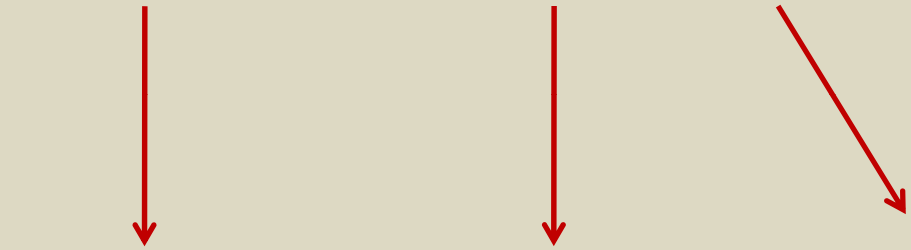
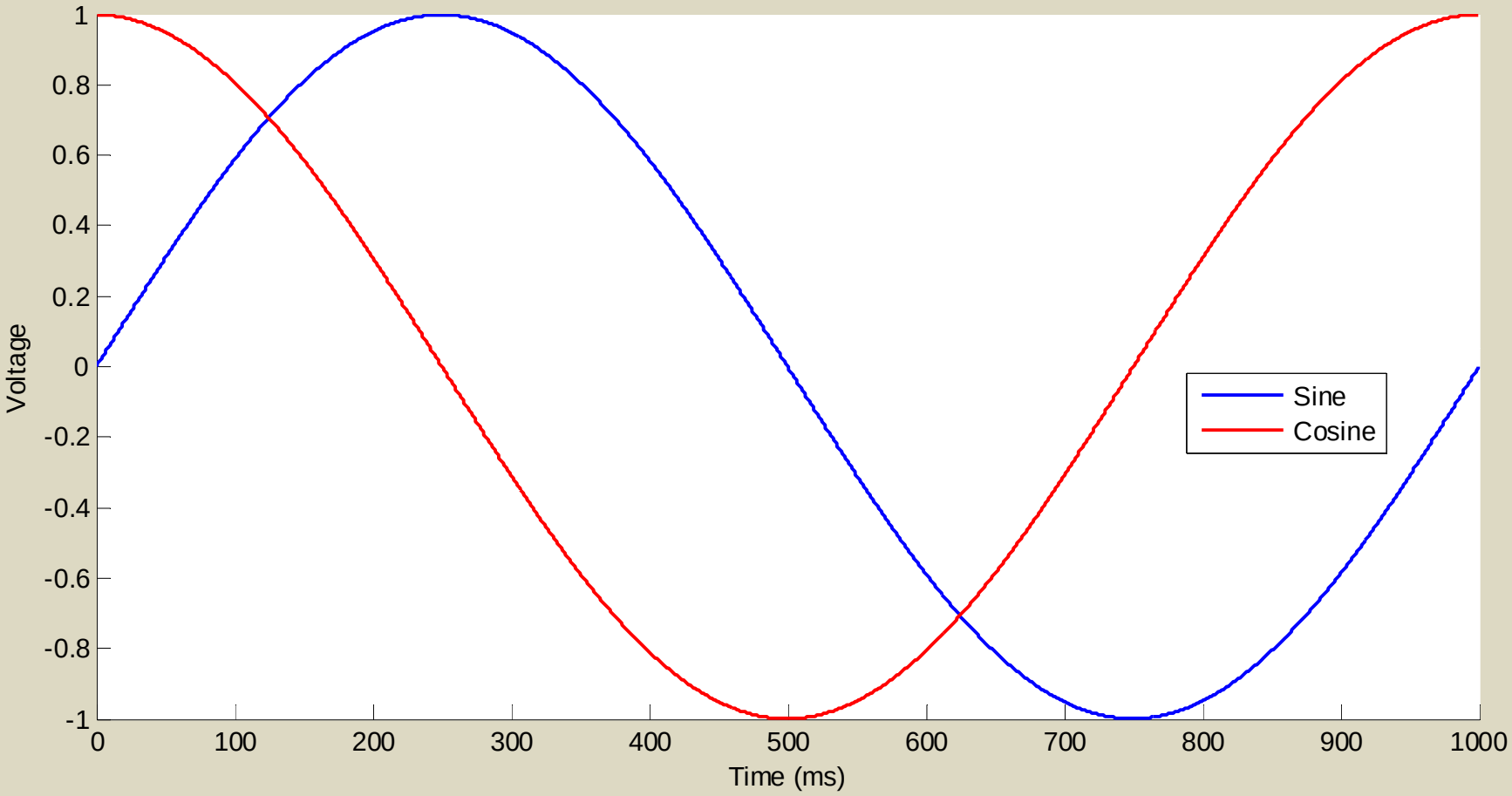
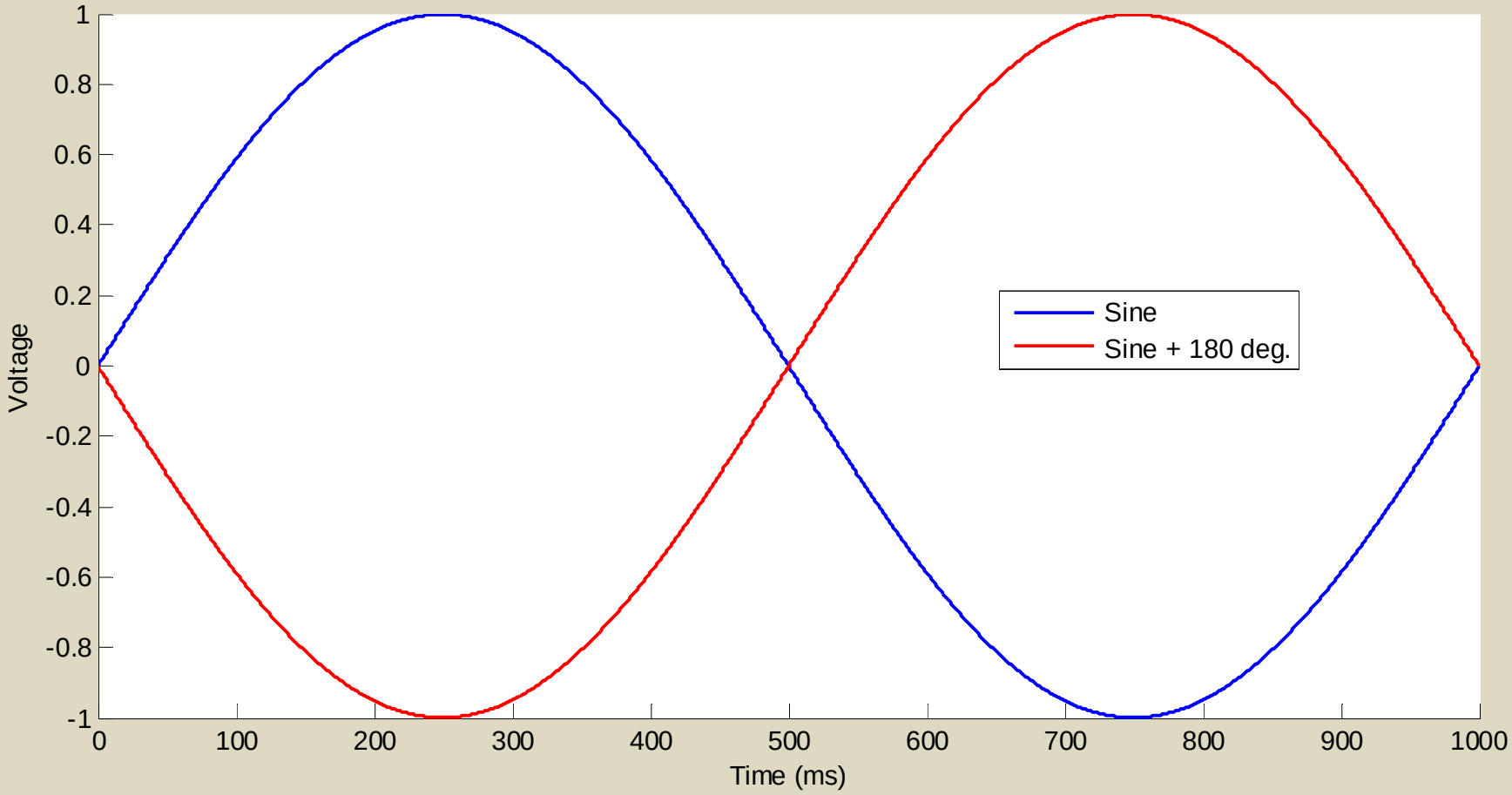
Sinusoid

$$y = A \sin(2\pi f t + \phi)$$



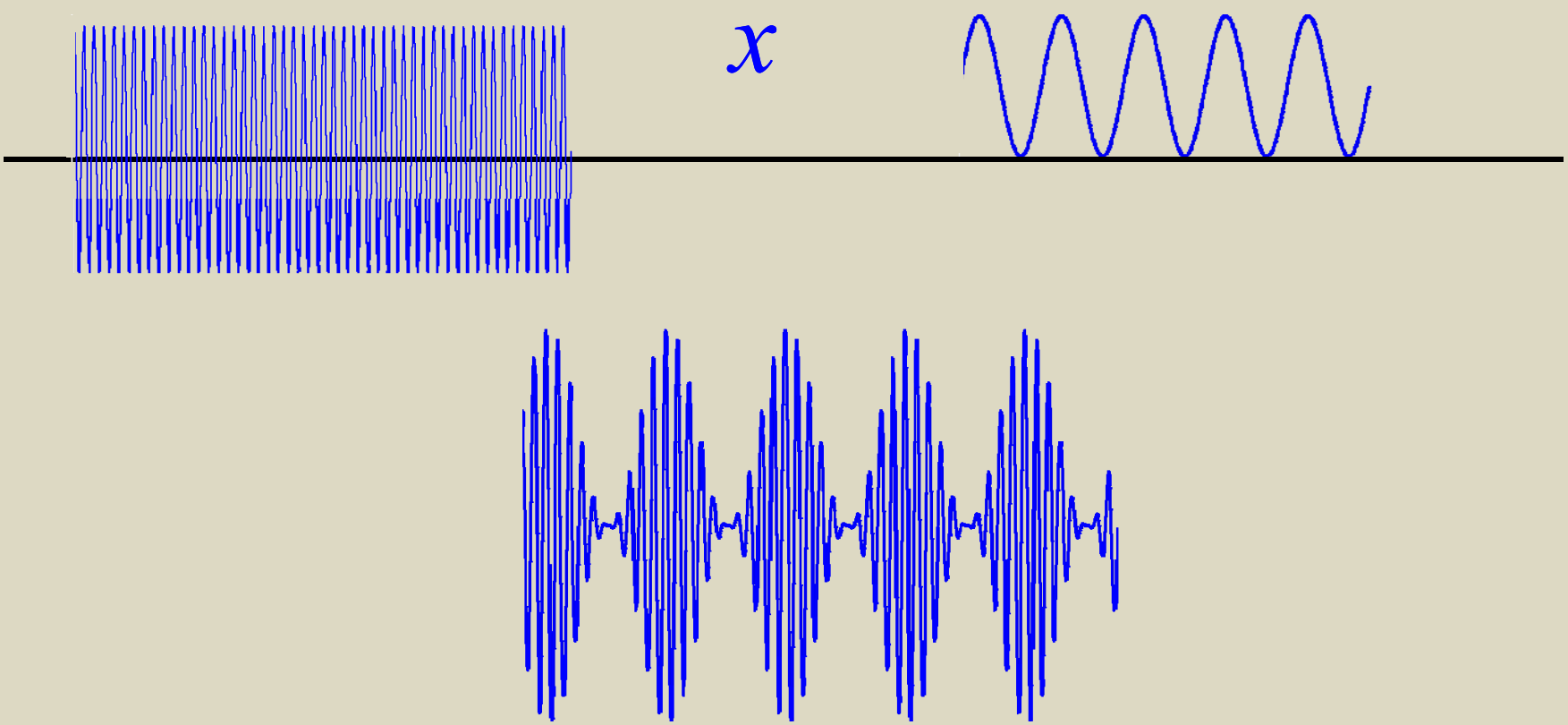
Amplitude Frequency Starting Phase


1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
Voltage
0
100
200
300
400
500
600
700
800
900
1000
Time (ms)
Sine
Cosine

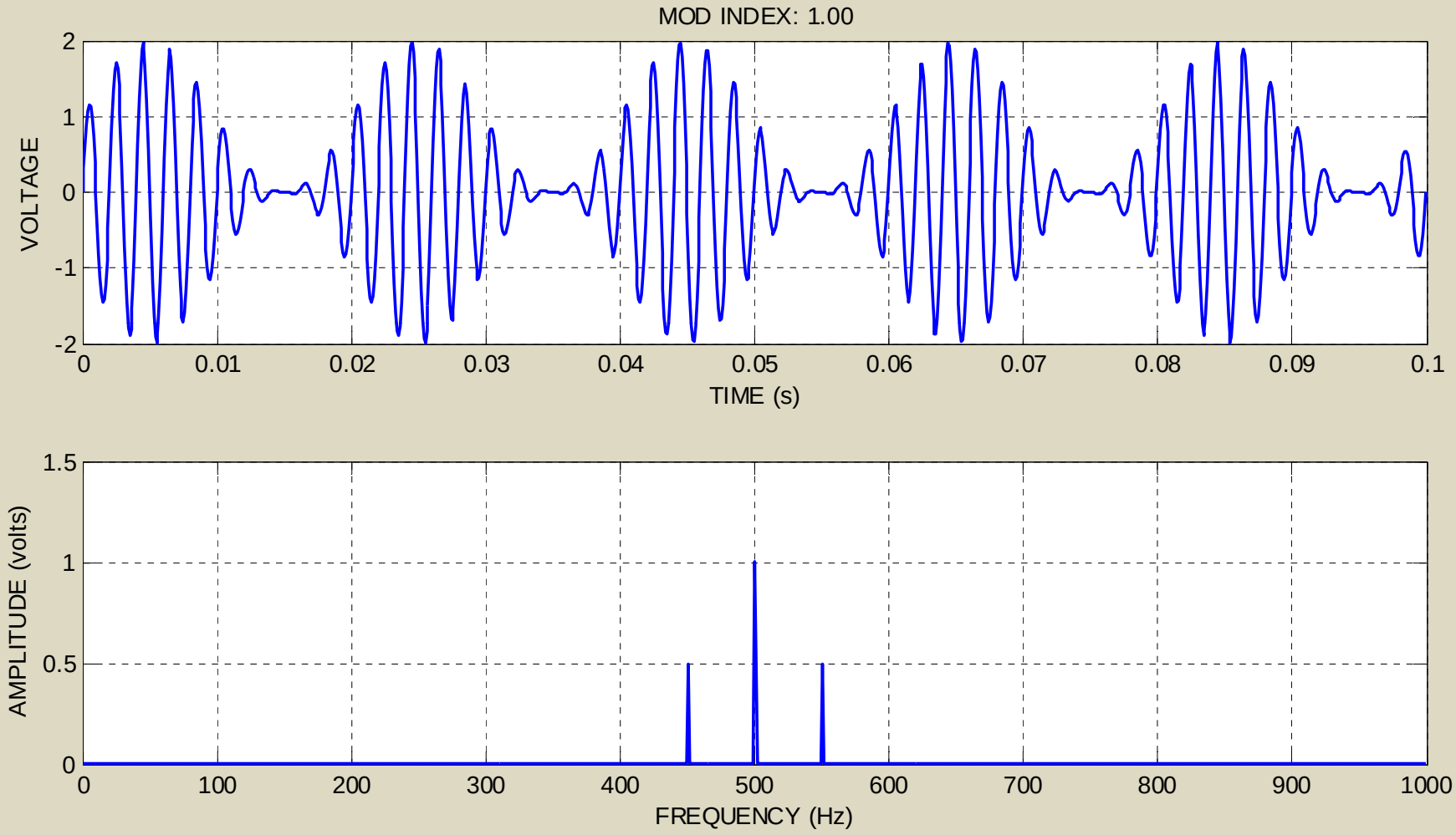

1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
Voltage
0
100
200
300
400
500
600
700
800
900
1000
Time (ms)
Sine
Sine + 180 deg.

Sinusoidal **A**mplitude **M**odulation

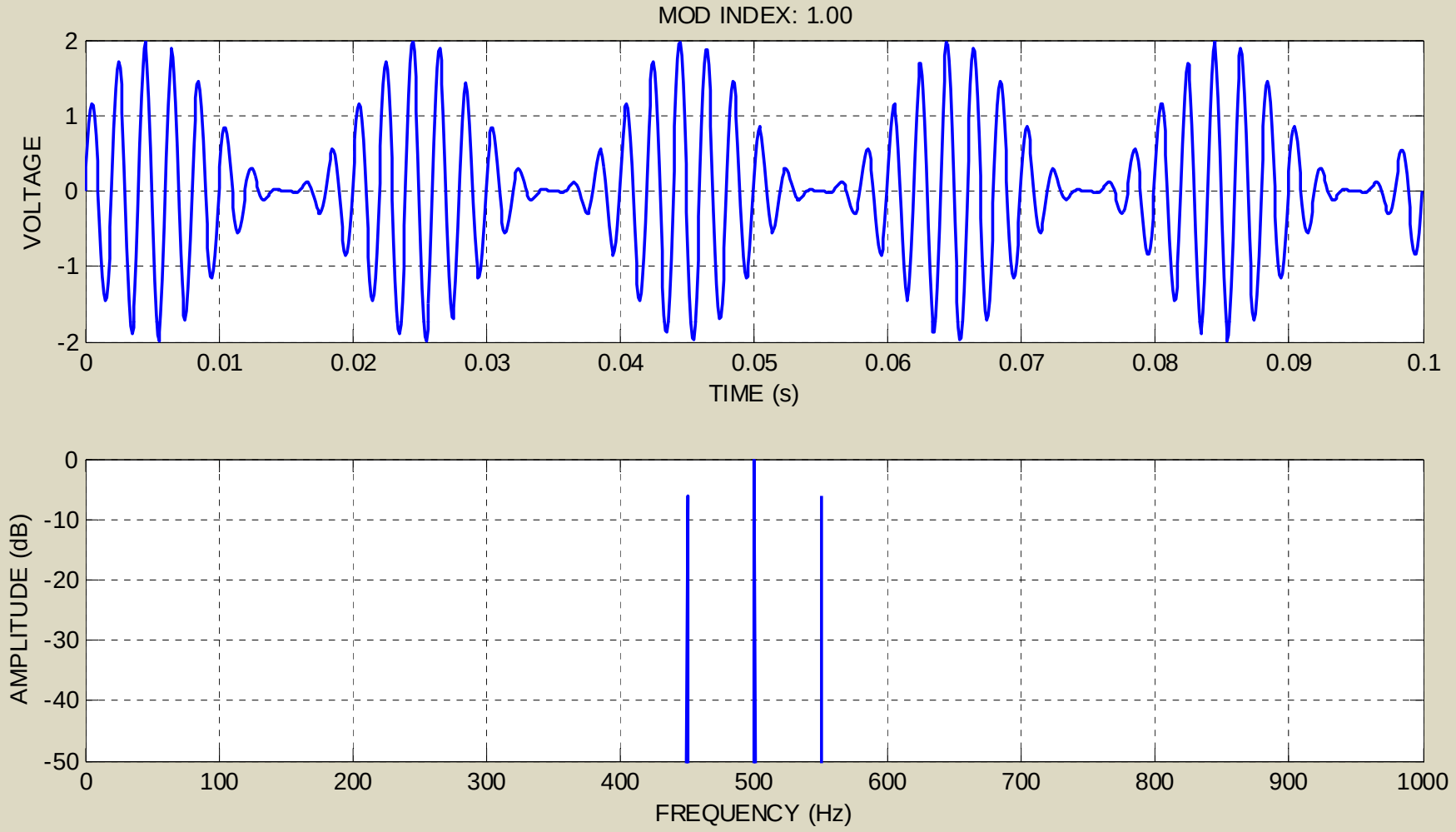
$$y = \sin(2\pi f_c t) \times [1 + m \sin(2\pi f_m t)]$$



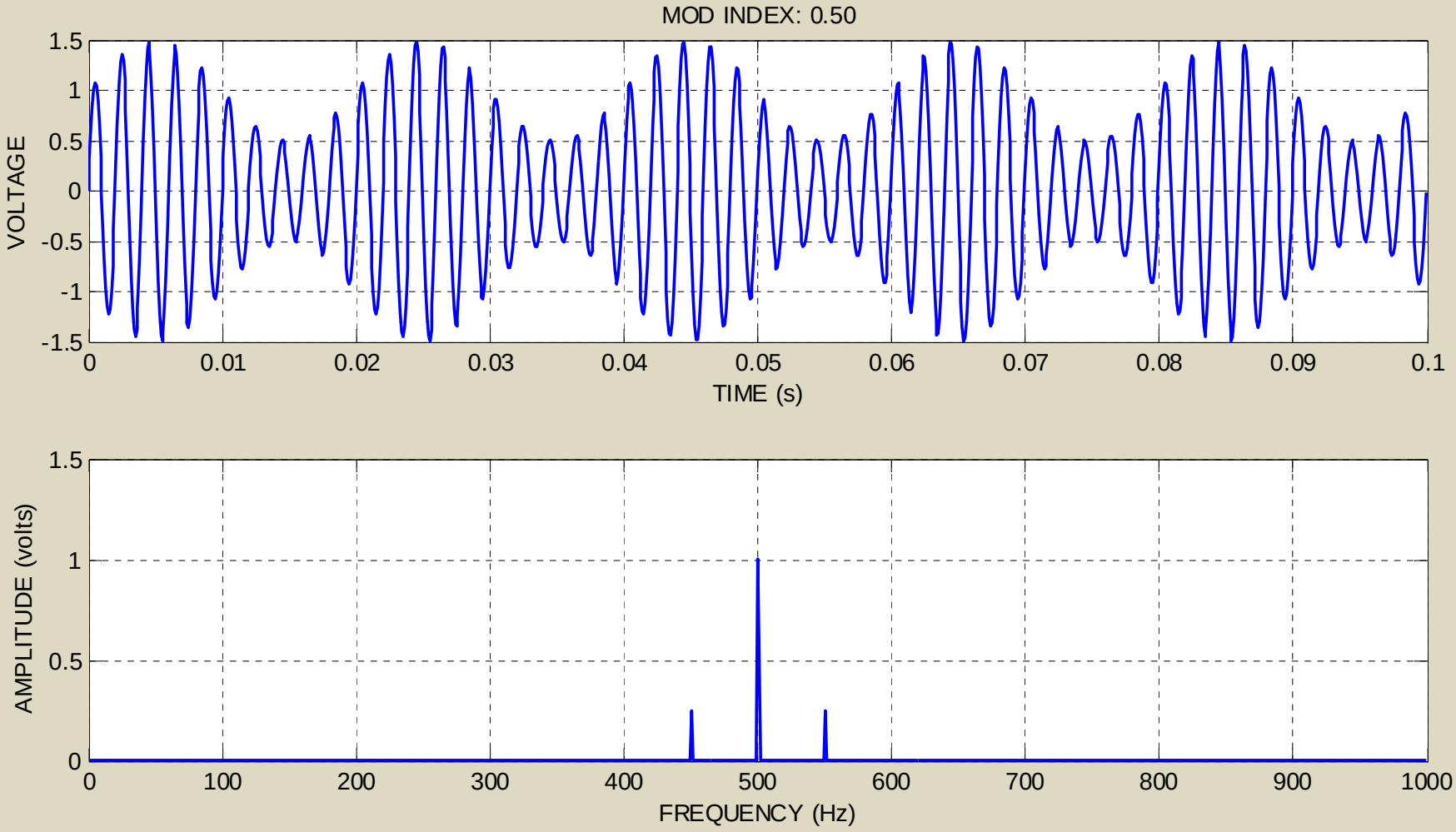
$$y = \sin(2\pi f_c t) \times [1 + m\sin(2\pi f_m t)]$$



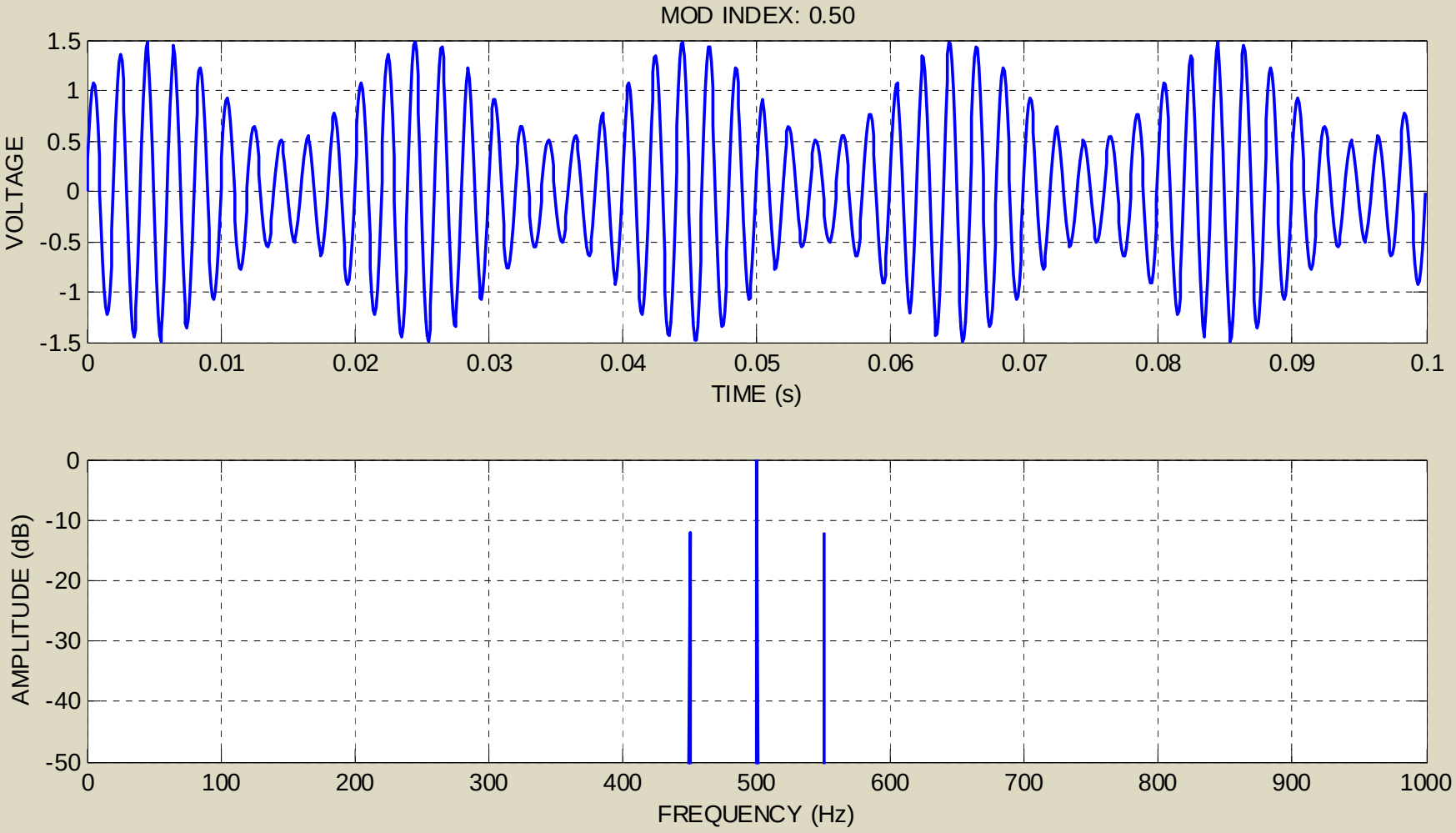
$$y = \sin(2\pi f_c t) \times [1 + m\sin(2\pi f_m t)]$$



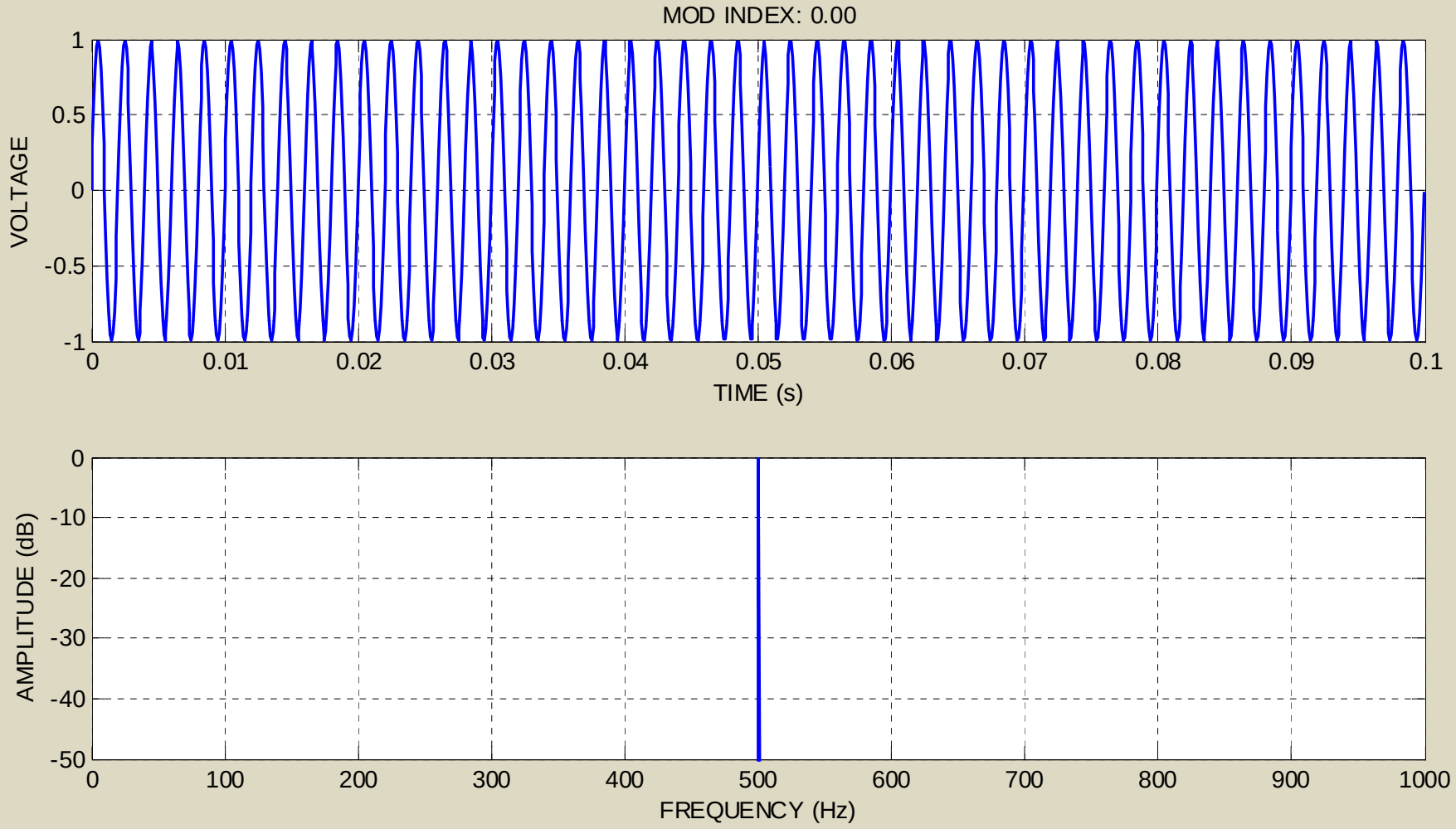
$$y = \sin(2\pi f_c t) \times [1 + m\sin(2\pi f_m t)]$$



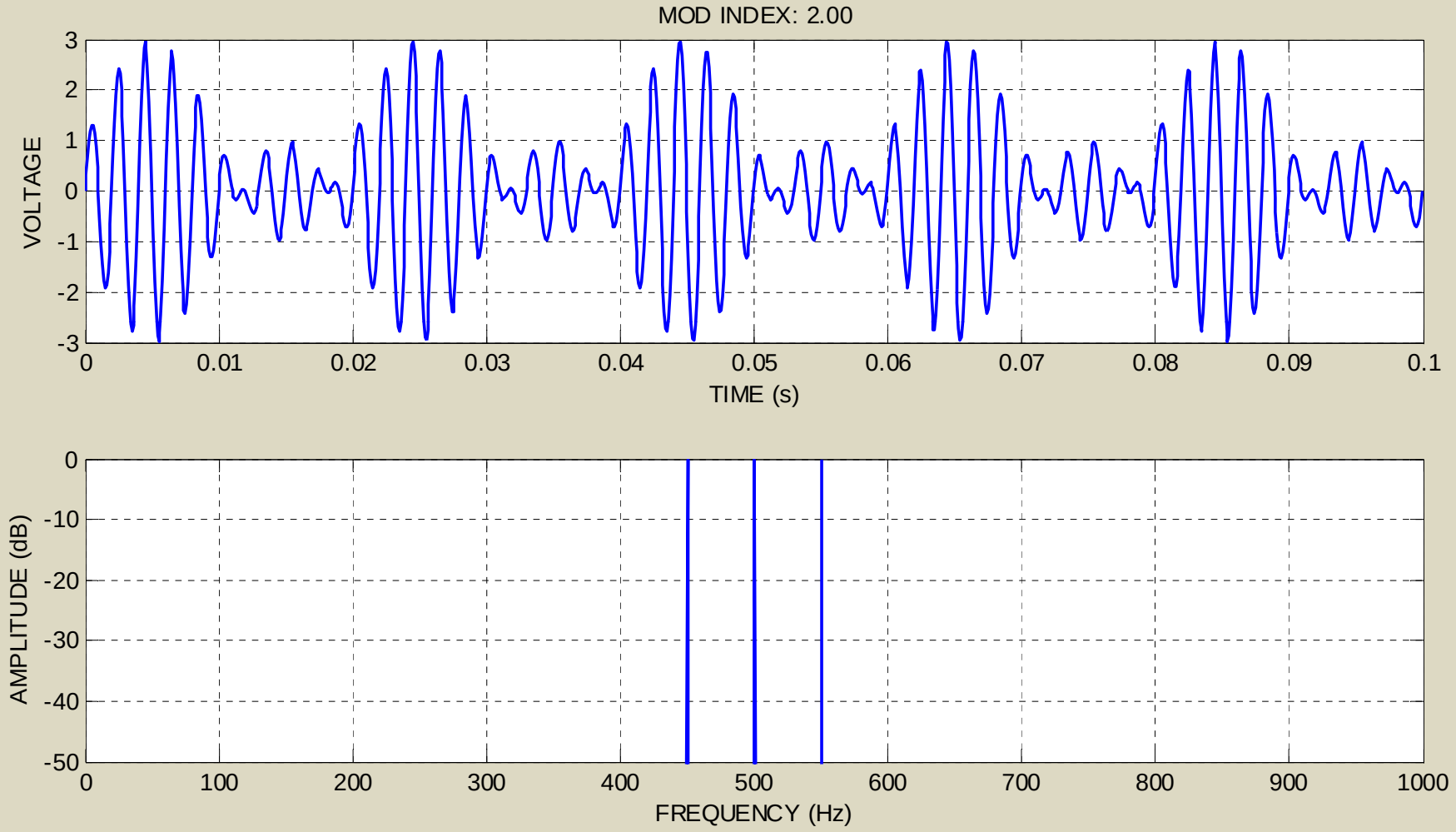
$$y = \sin(2\pi f_c t) \times [1 + m\sin(2\pi f_m t)]$$



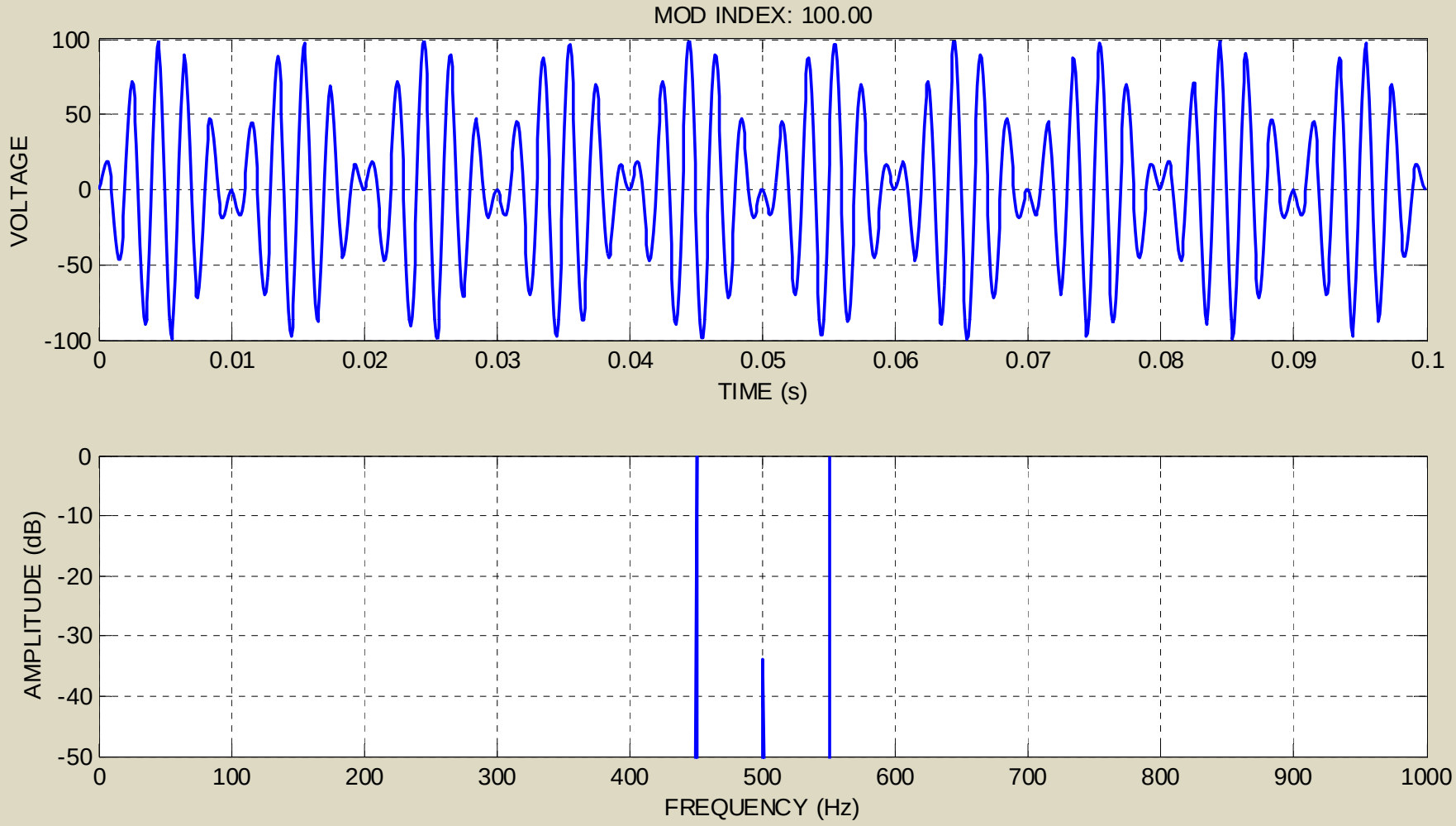
$$y = \sin(2\pi f_c t) \times [1 + m\sin(2\pi f_m t)]$$



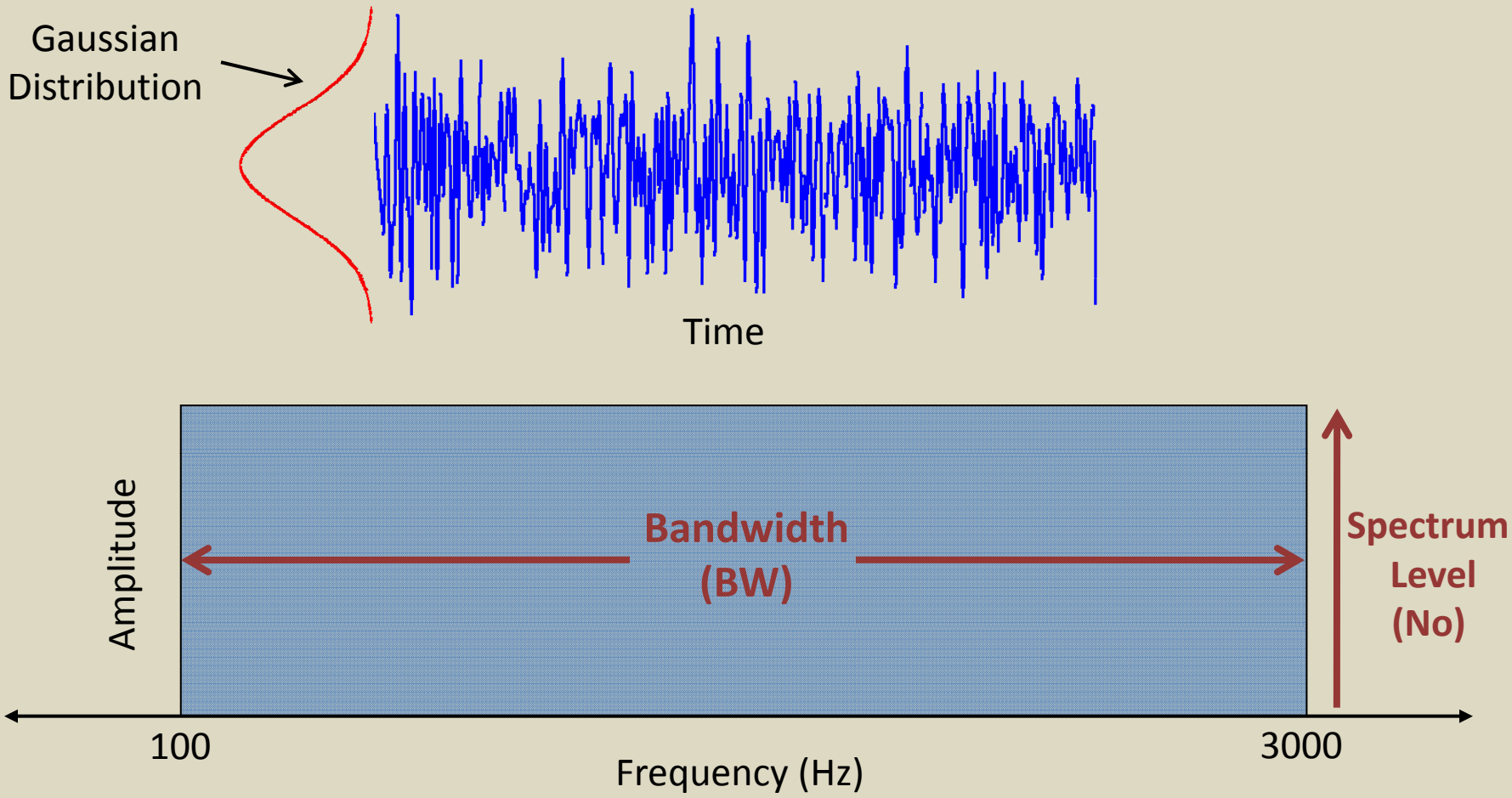
$$y = \sin(2\pi f_c t) \times [1 + m\sin(2\pi f_m t)]$$



$$y = \sin(2\pi f_c t) \times [1 + m\sin(2\pi f_m t)]$$

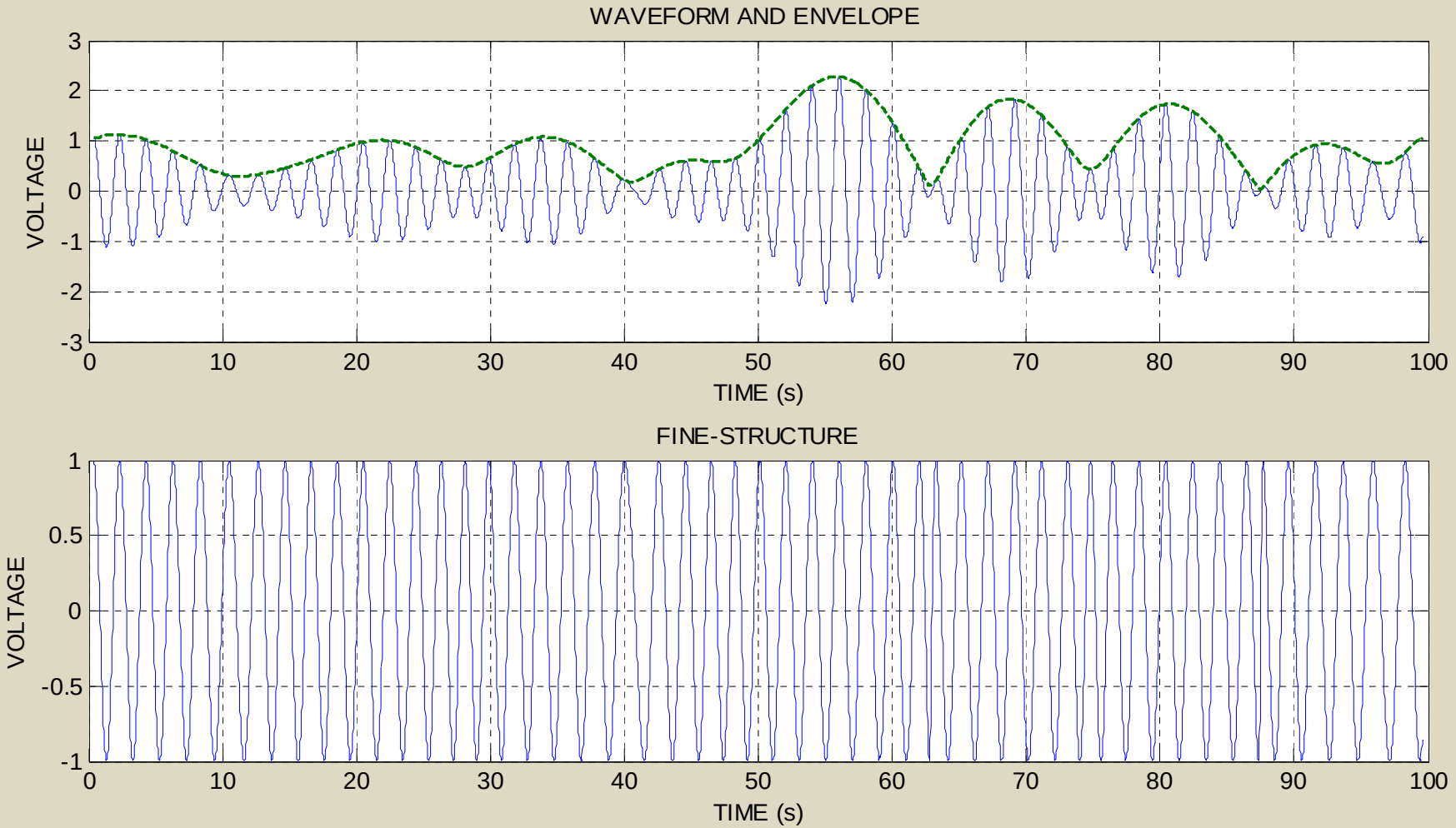


Noise

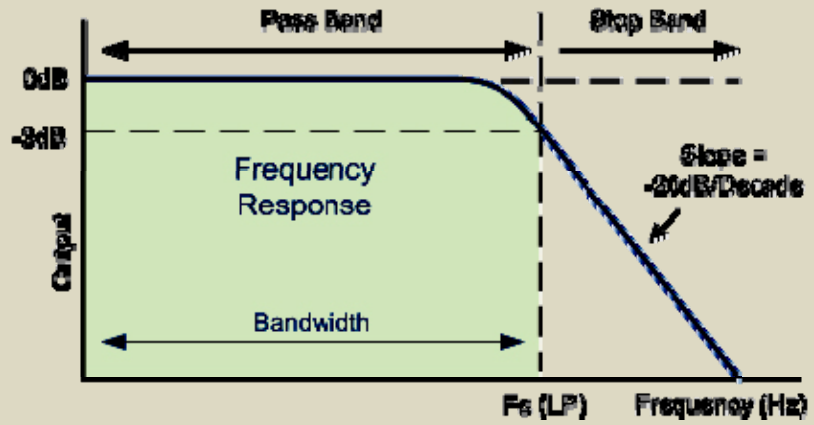


Overall Level = BW x No

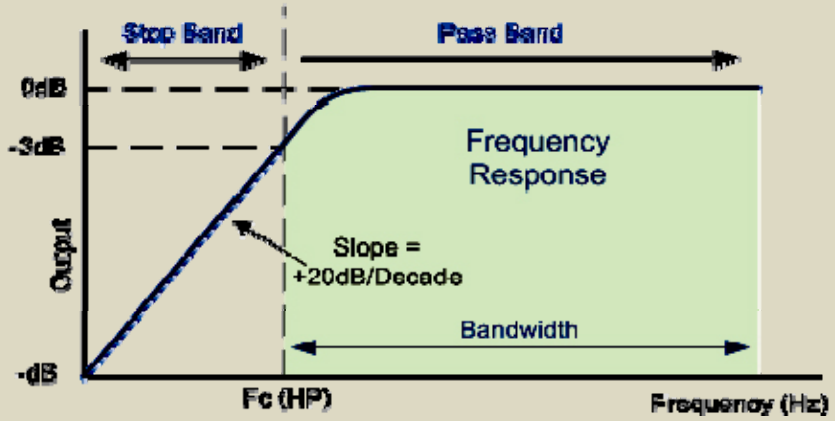
Overall Level (dB) = BW (dB) + No (dB)


WAVEFORM AND ENVELOPE
VOLTAGE
TIME (s)
FINE-STRUCTURE
VOLTAGE
TIME (s)

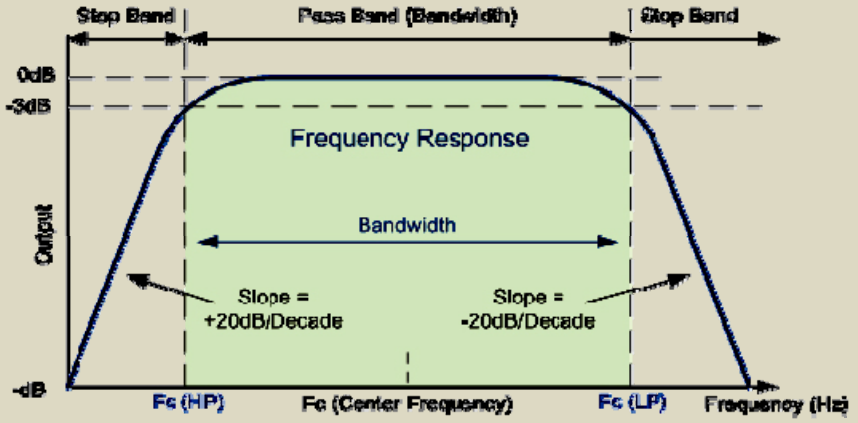
Lowpass Filter



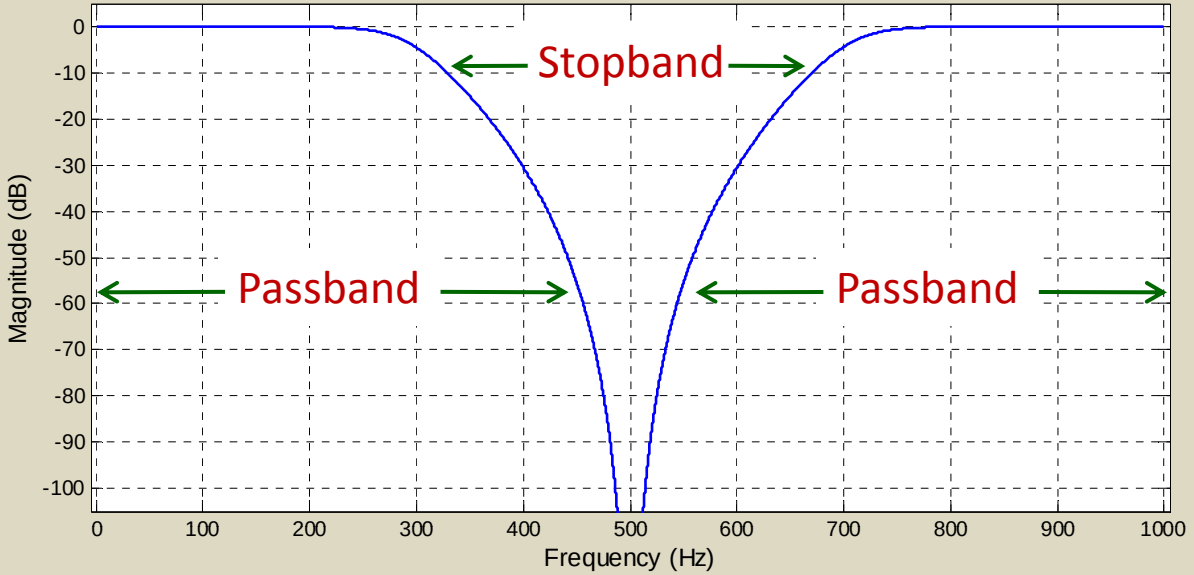
Highpass Filter



Bandpass Filter



Bandstop Filter



Decibels

Starting with two powers, P1 and P2:

"Reference"

dB = 10*log (P2/P1)

Decibels (dB) always refer to the **ratio** of two quantities.

If P2 is twice that of P1, then:

10*log (p2/p1) = 10*log(2) = 3.02 dB

A doubling of power corresponds to an increase of 3 dB.

If P2 is ten times that of P1, then:

10*log (p2/p1) = 10*log(10) = 10.00 dB

A ten-fold increase in power corresponds to an increase of 10 dB.

Decibels

Suppose one wants to compute the dB difference between two ***pressures***, p1 and p2:

Power (P) is proportional to pressure (p) squared, so:

$$dB = 10*\log(p2^2/p1^2)$$

$$= 10*\log(p2/p1)^2$$

$$= 10*2*\log(p2/p1)$$

$$= 20*\log(p2/p1)$$

Doubling pressure leads to a 6-dB increase.

Increasing pressure ten-fold leads to a 20 dB increase.

Power is a "10-log" quantity; pressure is a "20-log" quantity.

Decibels

Common decibel references:

Name	***Quantity***
SPL (Sound Pressure Level)	***0.0002 dynes/cm^2***
HL (Hearing Level)	***Clinically "normal" threshold***
SL (Sensation Level)	***A listeners own threshold***

Examples:

A sound presented at **70 dB SPL** means that it is 70 dB above the reference of 0.0002 dynes/cm^2.

A sound presented at **40 dB SL** means that it is 40 dB above the listener's own threshold.

A sound presented at **50 dB** means nothing!