

MTE 1001

Fundamentals of Sound Synthesis

Topic Area:

Modulation

Readings:

Previously: Chapt.4, pp. 146-148 (top)

New: [Roads: Chapter 6, pp. 215-224](#)

Modulation

Definition

One signal (carrier) varies according to the changes in another signal (modulator)

Amplitude modulation (AM)
Frequency modulation (FM)
Phase modulation (PM)

Amplitude Modulation

Type #1

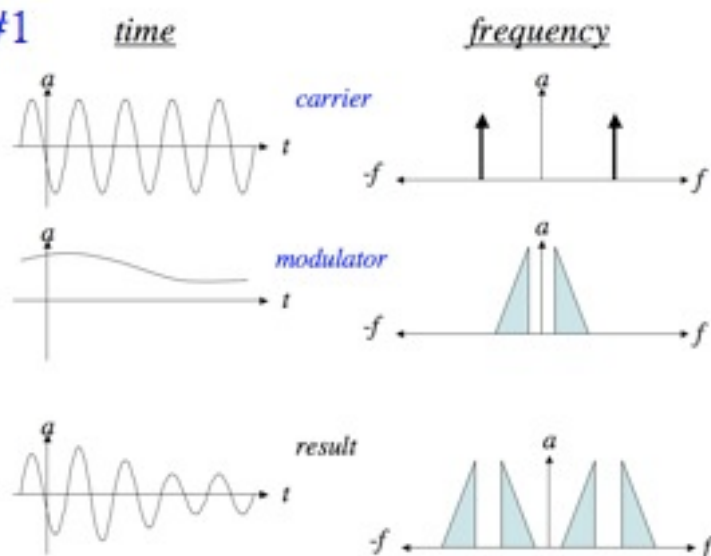
ring / balanced /
double-sideband suppressed carrier

amplitude modulation

$$f_1(t) * f_2(t)$$

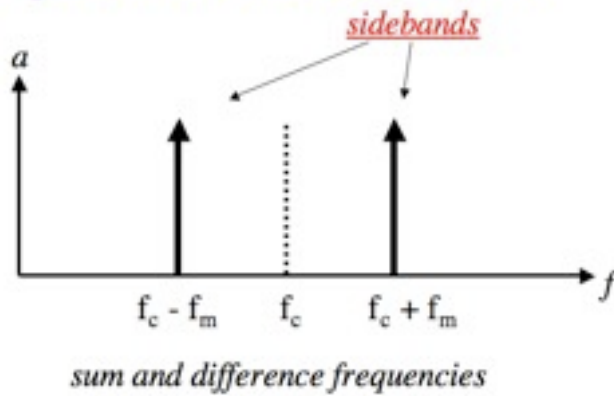
Amplitude Modulation

Type #1



Amplitude Modulation

Type #1



carrier $\sin(2\pi f_c t)$
 modulator $\sin(2\pi f_m t)$

Amplitude Modulation

Type #2

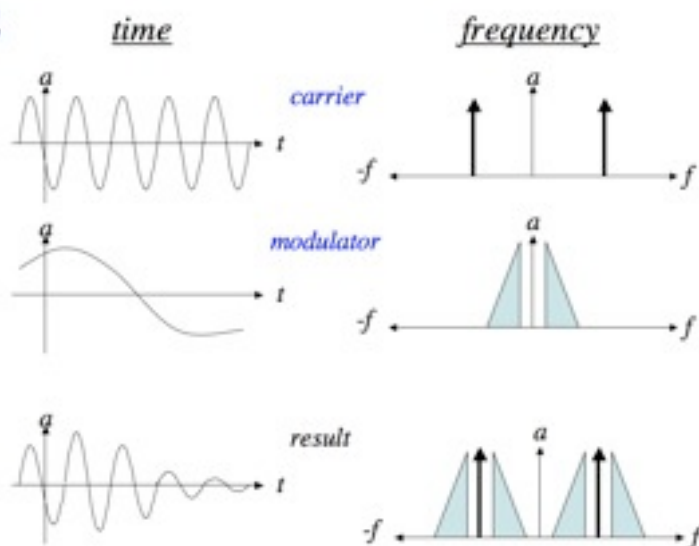
double-sideband
 amplitude modulation

$$0.5 * (1.0 + f_1(t)) * f_2(t)$$

f_1 is offset to range between 0.0 and 1.0 (unipolar)

Amplitude Modulation

Type #2



Amplitude Modulation

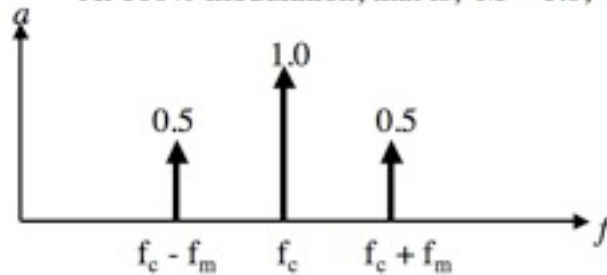
Type #2

Alternatively,

$$0.5 * (1.0 + M f_1(t)) * f_2(t)$$

where M is the modulation index

At 100% modulation, that is, $M = 1.0$,

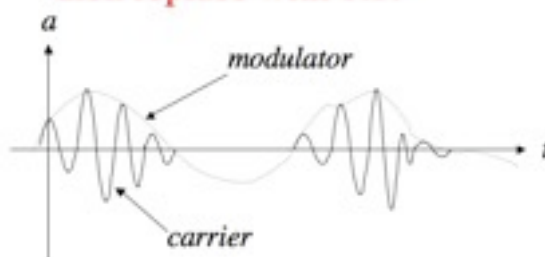


Amplitude Modulation

Type #2 Overmodulation occurs when $M > 1.0$

*the f_1 part ranges below zero
and greater than 1.0*

If $[0.5 * (1.0 + M f_1(t))] < 0.0$,
then replace with 0.0.



Amplitude Modulation

Type #3

single-sideband, suppressed carrier
amplitude modulation

*Not so easy to do digitally!
(Covered in later courses)*

Amplitude Modulation

20 Hz. Perceptual Threshold

- *In the range from below 10 Hz, the auditory system tracks moment-to-moment changes.*
- *Above 25 Hz, the auditory system integrates the changes into the moment.*
- *Between approx. 10 and 25Hz, there is a transition region generally centered around 20 Hz.*

Amplitude Modulation

For frequency and amplitude modulation, the consequence of the 20 Hz. perceptual threshold is that modulations that change faster than 20 Hz. are heard as part of the sound.

- Tremolo is amplitude modulation below 20 Hz.
- Vibrato is Frequency modulation below 20 Hz.

Amplitude Modulation

SuperCollider Demo

Amplitude Modulation

Examples of Amplitude Modulation

Ring modulation was its use by BBC Radiophonic Workshop to produce the voice of the Daleks in *Doctor Who*

Stockhausen used ring modulation extensively to process sounds both recorded and in live performance.

In electroacoustic works: *Kontakte* (1958) and *Telemusik* (1966)

Live performance works: *Mixture* (1964) and *Mikrofonie II* (1965) where the sounds of choral voices are modulated with a Hammond organ

Amplitude Modulation

Examples of Amplitude Modulation

Excerpt from Stockhausen's *Telemusik* (1966)

Amplitude Modulation

Examples of Amplitude Modulation

Excerpt from Stockhausen's *Telemusik* (1966)

**Next Topic:
Modulation
Frequency Modulation**