Name: ______________________________ **Roll No.**____________________________

Signature of Teacher: _________________ **Date:** ______________________________

AMPLITUDE MODULATION

Objectives

- To examine the main parameters of an amplitude modulated Signal
- To check the operation of an amplitude modulator
- To carry out the characteristic measurements on an amplitude modulator.

Material

- Base unit:
  - Power supply mod.PS1-SU/EV
- Experiment module mod.MCM24/EV
- Dual-trace oscilloscope
- Function generator

THEORY

Consider a sine signal v_m (t) called *modulating signal* with frequency f (fig.2.1a):

$$v_m(t) = B . \sin(2\pi f \cdot t)$$

and another sine signal v_c(t) called *carrier signal* with higher frequency F:

$$v_c(t) = A \cdot \sin(2\pi F \cdot t).$$

Make the amplitude of the carrier v_c(t) change by adding the modulating signal v_m(t) to A.

An amplitude modulated signal $V_M(t)$ is obtained, that can be expressed with the relation:

$$V_M(t) = [A + k \cdot B \cdot \sin(2\pi f \cdot t)] \cdot \sin(2\pi F \cdot t) = A [l + m \cdot \sin(2\pi f \cdot t)] \cdot \sin(2\pi F \cdot t)$$

with k = constant of proportionality.

We define the following value as percentage *modulation index:*

$$m = [k \cdot B / A] \cdot 100$$

With reference to fig.2.1c, the modulation index m can be calculated with:

$$m = [(H-h) / (H+h)] \cdot 100\%$$

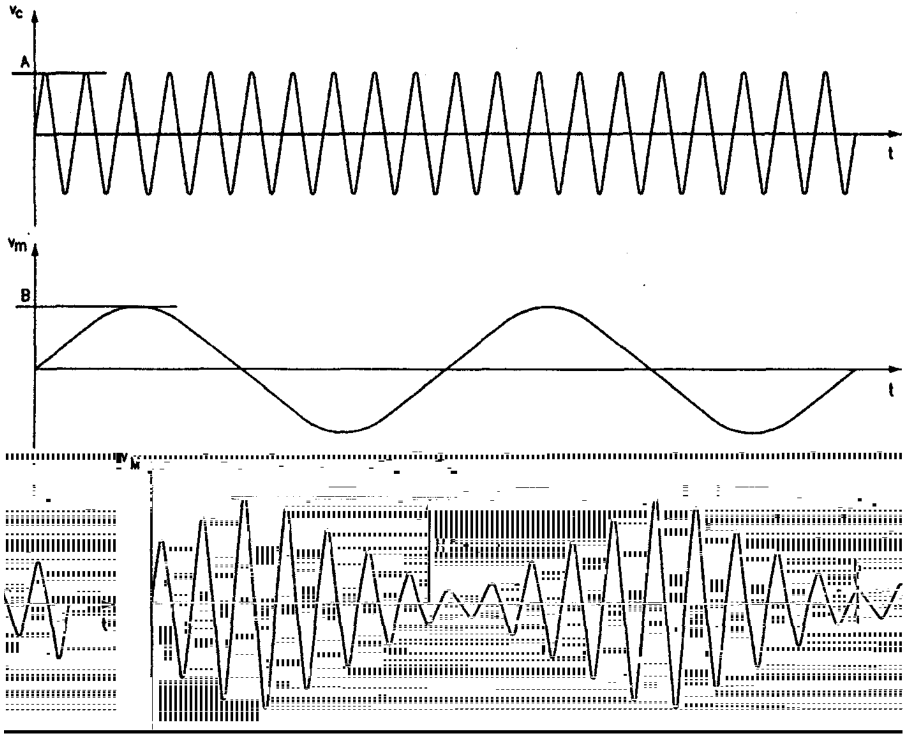
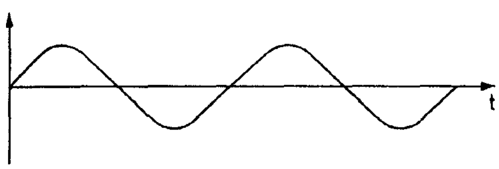


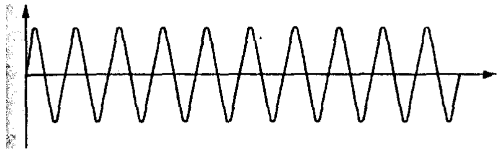
Fig. 2.1 (a) carrier signal
b) modulating signal
c) modulated signal

Particularly effective is the representation of the modulated signal into an Amplitude/ Frequency diagram (frequency domain). Figure 2.2 shows the different components of the AM signal, in the
Amplitude/Frequency as well as the Amplitude/Time diagram (time domain).

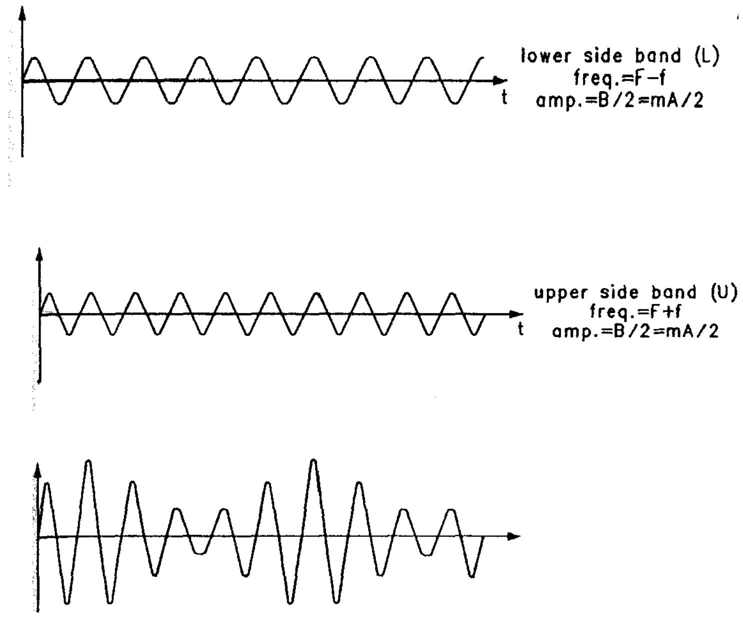
AMPLITUDE/TIME



Modulating Signal
Amplitude = B, Freq. = f
Carrier (C)



Amp.=A
Freq.=F



Modulated Signal = C + L + U

Figure 2.2

Power of the modulated signal

The total power of an AM signal is the sum of the contributes re the carrier and to the lower and upper side bands. Considering a sine modulating signal and a load resistor R, the components provide the following powers:

$Pc = A^2/2 \bullet R$ carrier power

$P_L = (m \bullet A)^2/8 \bullet R$ lower side band power

$Pu = (m \bullet A)^2/8 \bullet R$ upper side band power

It is important to note that:
• The power associated to the fixed carrier does not depend modulation the power associated to each side band depends on the mo index, and reaches at max the 25% of the carrier power (50° two side bands together).

Generation of the amplitude modulation

The circuits employed to generate an Amplitude Modulation must change the amplitude of a high frequency signal (carrier) as function of the amplitude of the low frequency signal (modulator).

Our module uses an active mixer carried out with a differential amplifier (section *MODULATOR/MIXER).*
When this component is balanced, a modulation is obtained with suppressed carried amplitude; otherwise there is an amplitude modulation with carrier.

The balun (impedance matcher transformer) converts the balanced signal at the output of the mixer into unbalanced signal to be sent to the next circuit.
The output signal consists in a constant that multiplies the product of the two signals present across the inputs *CARRIER IN* and *MOD IN.*

The switch *DSB/AM* enables to *balance* or *unbalance* the circuit: in the first case the output is exactly the product of the input signals and the circuit operates as balanced modulator; in the second case the output contains a fixed component of the carrier signal, too, and the circuit operates as amplitude modulator.

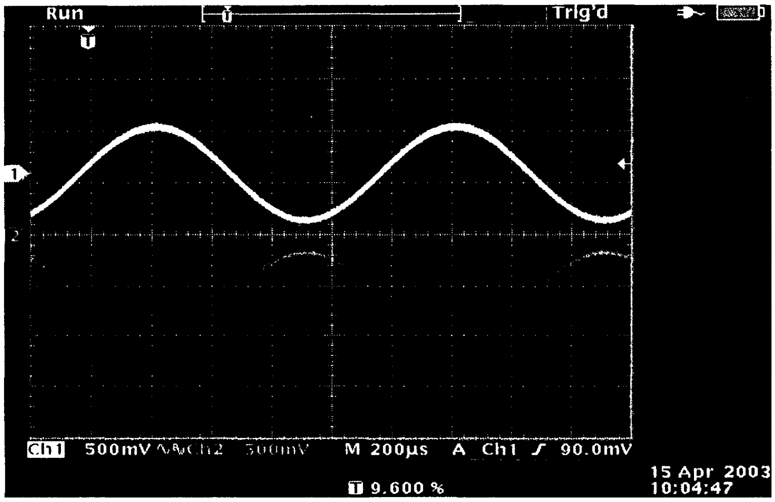
As the mixer produces all products of mixing between modulator and carrier, it is necessary to filter the output signal to take the single relevant components.
For this function the section *IF FILTER* is used, in particular the ceramic pass band filter, centered on the frequency of the intermediate frequency equal to 10.7 MHz.

Procedure:

•The following sections are used:
- *FREQUENCY MODULATOR / LOCAL OSCILLATOR 1* that provides the carrier signal
-*LOW FREQUENCY \h&* provides the modulating signal
-*MODULATOR /MIXER* to carry out the modulation

- Set switch *SW1* of the section *MODULATION SELECTORS* to AM/DSB/FM
- Turn the trimmer *LEVEL* completely clockwise to get the maximum amplitude of the signal *VCO1 OUT* provided by the local oscillator VCOl.
- Set switch *SW6* to PLLI to obtain the automatic control of the local oscillator frequency.
- Connect the output *OUT2* to the input *AM/DSB MOD IN.*
- Set switch *SW3* to AM to obtain the AM modulator carried out with the unbalanced mixer.
- Set switch *SW4* to MIX OUT to take the signal of the mixer and not the one of the VCO 1.
- Set switch *SW5* to CERAMIC to use the band pass filter of ceramic kind.
- Connect the probes of the oscilloscope as follows:
  - *Probe CHI* to the input of the modulating signal *AM/DSB MOD IN.*
  - *Probe CH2* to the output of the mixer where there is the modulated signal and all mixing products.
- Adjust the trimmer *LEVEL* of the modulating signal until the two wave-forms are overlaid: modulating signal and modulated signal (see fig.2.3).

Fig. 2.3



Observation:

- Change the amplitude of the modulating signal and check the following conditions:
  Percentage of modulation lower than 100% (under modulation)
  Equal to 100% (100% modulation)
  Higher than 100% (over modulation)

Observation Table:

S.No.	V m	V c	m = Vm / Vc x 100	$m = \frac{V_{max} - V_{min}}{V_{max} + V_{min}} \times 100$	Remarks
01					Undermodulation
02					100% Modulation
03					Overmodulation

Review Questions

Q#1. What is the Modulation Index?

Q # 2. How many Sidebands are generated in Amplitude modulation?

Q # 3. The frequency spectrum of an audio signal is limited via filters between 80 &5500 Hz. The same signal modulates the amplitude of a carrier with frequency of 700 KHz.

(i) What is the highest frequency in the spectrum of the modulated signal?

(ii) What is the lowest frequency?

(iii) What would be the Bandwidth occupied by the AM signal?