Name: ______________________________ **Roll No.**____________________________

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

AM SIGNAL DEMODULATION

Objectives:

- Operation of the envelope detector
- Operation of the AM synchronous detector.

Material:

- Base unit:
  - Power supply mod.PS I -PSU/EV,
  - Support for modules mod.MU/EV, -
  - Individual control unit mod.SISl/SIS2/SIS3
- Experiment module mod.MCM25/nV
- Experiment module mod.MCM24/EV
- Dual-trace oscilloscope
- Function generator

THEORY:

Envelope detector:

The extraction of the modulating signal from an AM signal can be carried out using an envelope detector (not included in the module being analyzed).
Consider in fact the AM signal shown in fig.3.1, and note that the modulating signal constitutes the envelope of the shown wave-form.

The most used envelope detector consists of a diode followed by an RC Filter Fig.3.2.Its *operation* is similar to the one of an half-wave rectifier, as the output Voltage follows always the maximum values of the carrier.
As the amplitude of the carrier is variable, the output of the detector can faithfully reproduce such variations by properly choosing R and C.

Distortions of the detected signal

The demodulated signal can show two kinds of distortions:

- If the time constant RC is too low in respect to the carrier period, the envelope is approximated to a broken wave-form as the lower is the value of RC (Fig.3.3).

- If the time constant R-C is too high in respect to the modulating period, the detected signal does not always follow the envelope behavior, but sometimes takes an exponential decreasing form of distortion for diagonal cut-off (Fig.3.4).

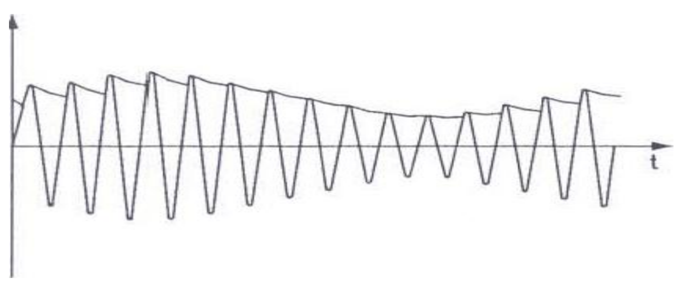

Fig. 3.3

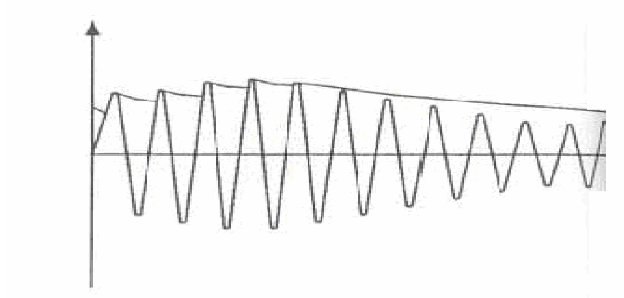

Fig. 3.4

Synchronous AM detector:

In the *AM synchronous detector,* known also as *AM coherent detector,* the amplitude modulated signal is mixed with a *coherent* carrier signal, and the result, then, crosses a low pass filter that provides the wished demodulated signal: it is practically the modulation inverse process. At last the synchronous detector translates in base band the contents of the side bands of the modulated signal.

Fig.3.5 shows the simplified block diagram of this demodulation system.

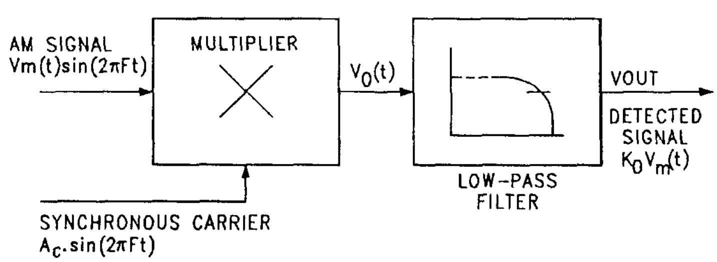

Fig. 3.5: Block Diagram of AM Synchronous Detector

The AM modulated signal (VM) can be expressed with the following relation:

$$V_M(t) = v_m(t).\ \sin(2\pi F.t)$$

where:

$$v_m(t) = A.\ [1+m.\sin(2\pi F.t)]$$

is the envelope amplitude of the AM signal, and F is the carrier frequency.

If the AM signal is *multiplied* with a *not modulated* signal that has the same frequency and phase, so the output of the multiplier is a composite signal $v_0(t)$ that can be expressed in this way:

$$v_0(t) = [Ac.\sin(2\pi F.t)] . [v_m(t).\sin(2\pi F.t)] = K_0.v_m. [I+\cos(27.2F.t)]$$

where K_O considers also the gain of the multiplier circuit.

Making the signal $v_0(t)$ cross a low pass filter, in order to remove the component with frequency 2.F, the resulting signal v_{out}, will be:

$$V_{out} = K_O.v_m(t)$$

Which corresponds to an AM detected signal.

Generally a PLL (Phase Locked Loop) system is used in the receiver to *regenerate* a signal exactly synchronous with the AM signal carrier. The block diagram of the complete detector is shown in fig.3.6.

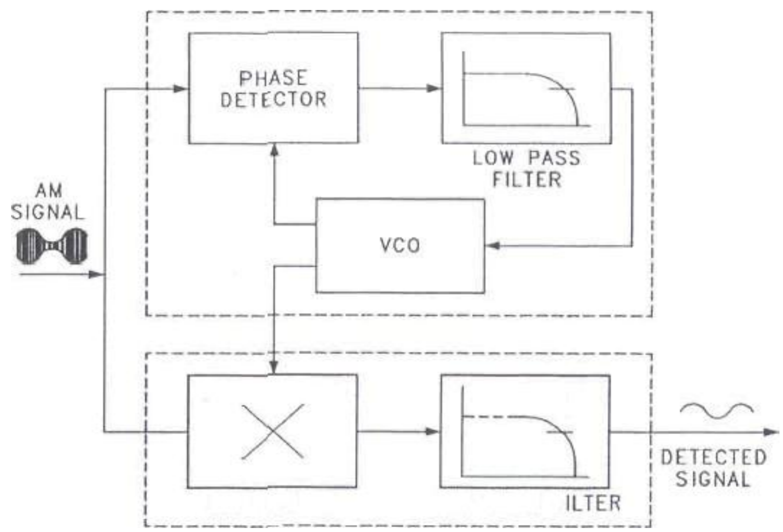

Fig. 3.6

In the applications where high quality is required, the use of the AM synchronous detector has some important advantages in respect to the envelope detector.

We can list some of them:

- low distortion
- Capacity to properly demodulate even AM signals with high modulation depth, or with quick variations of the modulating signal (as in pulse modulations).
- capacity to properly demodulate even DSB (Double Side Band) signals defined AM with suppressed carrier, too, because the receiver properly recovers the carrier that was not transmitted;
- Capacity to provide the detected signal amplitude with gain than more than with attenuation, as the one introduced by the diode detector.

Procedure:

The following sections are used:

- *ANTENNA /CABLE*, as signal input
- *RF FILTER*, as input band filters
- *VCA*, as RF amplifier with voltage controllable gain
- *RF MIXER 2*, as mixer from RF to IF
- *455 kHz IF FILTER*, as IF filter at 455 kHz
- *LOCAL OSCILLATOR 2*, as local oscillator used to provide LO2 to the mixer
- *IF AMPLIFIER / FM DEMODULATOR*, as amplitude detector of the converted IF signal
- *AGC/LEVEL METER*, as voltage control of the VCA gain
- *CARRIER REGENERATOR /AM DEMODULATOR as AM* synchronous demodulator
- *AUDIO FILTER & PREAMPLIFIER*, as output filter and preamplifier
- *POWER AMPLIFIER*, as power amplifier complete with loud speaker

  - Set switch *SW1* of the *ANTENNA / CABLE* section to CABLE.
  - In the *RF FILTER* section, set switch *SW2* to FILTER and SW3 to 1.5 MHz.
  - Set switch *SW5* of the *RF MIXER 2* section to RF
  - Set switch *SW7* of the *IF AMPLIFIER / FM DEMODULATOR* section to AM/DSB
  - In the *AGC / LEVEL METER* section:

    Set switch *SW6* OFF to disconnect the automatic control: In this mode the AGC control signal is adjusted continuously with the *DC SOURCE* trimmer of the same section.
    Turn the *DC SOURCE* trimmer completely counter-clockwise to obtain the minimum gain of the voltage controlled amplifier.

  - Set switch *SW14* of the *CARRIER REGENERATOR/AM DEMODULATOR* section to REG EXT.
  - Set switch *SWII* to AM/DSB and *SW13* to PLL
  - Connect an amplitude modulated signal to the input *CABLE IN* with the following characteristics in TP2 (it is possible to use an external generator or the module mod.MCM24):

Carrier frequency:	1 MHz
Modulating frequency:	1 kHz
Index of modulation m:	50%
Modulated signal amplitude:	l00mVpp

Operation of the carrier regenerator:

- Connect the oscilloscope to TPI0 *(IF2)* and TPI3.

- Set a sufficient gain to obtain an *IF2* of about I Vpp.
- Two signals will be detected like ones of fig.3.7 .
- See the signal in TP13 representing the IF signal *{IF2)* multiplied by itself (Mixer) and filtered across the band pass filter at 910 KHz. The signal is like the one of IF with double carrier frequency.

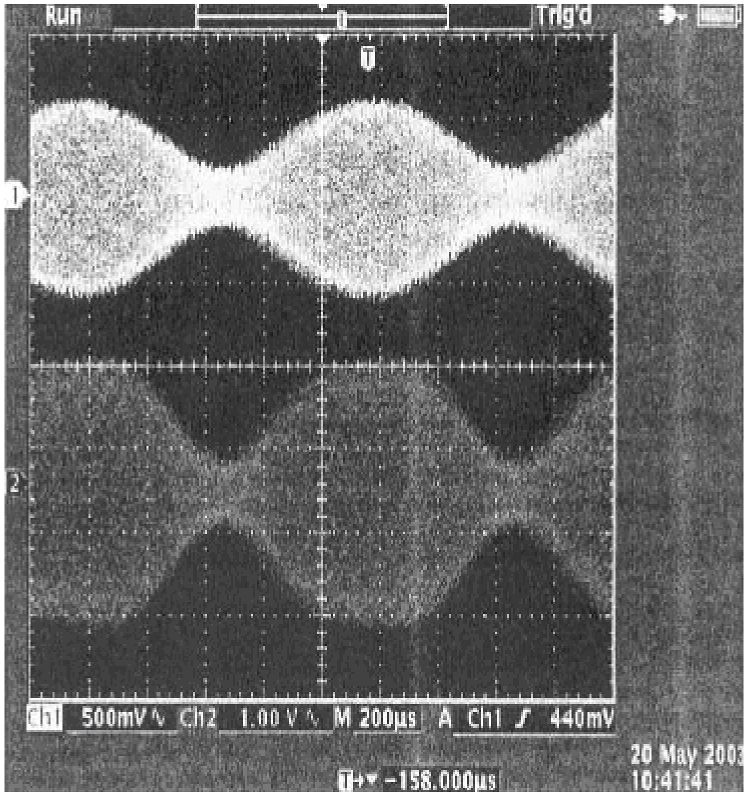

Fig. 3.7

- Move the probe of the oscilloscope from TPI 3 to IP 14 I
- See the signal in TPI4 representing the signal of TPI3 with the following processing:

  Extraction *of* the single component at 910 kHz with the PLL stage (SYNC VCO).

  Reduction of the frequency to half with the frequency divider stage (f/2).

  Extraction of the sine component with frequency 455 KHz with band pass filter (BPF 455 kHz). Note that it is necessary to use this stage because both the two last stages use digital signals.

- Connect the oscilloscope with a probe to TP2 and other to the AM AUDIO OUT output.
- Two signals will be detected like the ones of Figure 3.8.

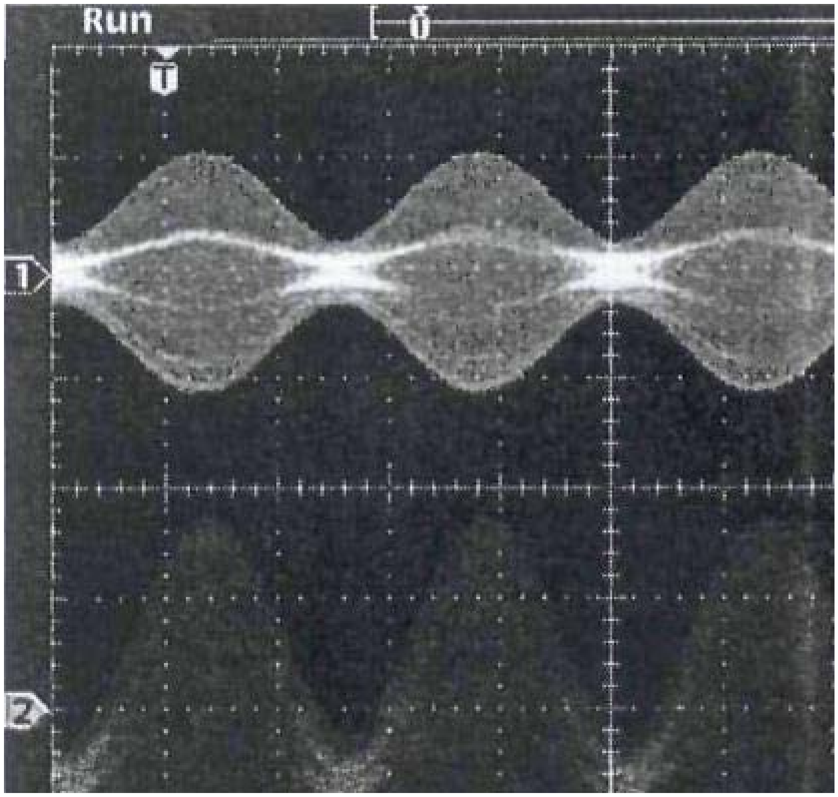

Figure 3.8

Filter and preamplifier operation:

- Connect the *AM AUDIO OUT* output to the *IN2* input
- Connect the *OUT5* output to the *IN4* input
- Connect the probes of the oscilloscope as follows:
  The one of the CH1 to the input of the *IN2* filter
  The one of the CH2 to the output of the *OUT5* preamplifier
- Adjust the preamplifier level to obtain I Vpp across the *OUT5* output.
- Adjust the volume of the power amplifier to obtain a proper acoustic sensation.
- See how the filter eliminates all components that are not necessary and extracts the single useful component (originally modulating signal).
- Change the amplitude of the modulating signal and see the corresponding variation of the demodulated one.
- See that when the amplitude of the modulating signal increases there is overmodulation in transmission (m>I00%) that causes distortion in the demodulated signal.

Review Questions

Q # 01 what is the function of an AGC / LEVEL METER in a receiver?

Q # 02 Is the signal across the AM AUDIO OUT output completely demodulated signal?

Q # 03 what can we state from the examination of detected signal?

Q # 04 what will be the effect on a demodulated signal when the amplitude of a modulating signal is increased i.e.overmodulation occurs?

Q # 05 what should be the position of SW1 (Switch 1) to transmit RF signal via ferrite antenna?