Amplitude Modulation (and variants)

To send information, modulate the amplitude of a carrier.

As opposed to ...
"Angle" modulation –
To send information, modulate the angle (phase, frequency, etc.) of a carrier. → Chapter 5

Chapter 4 ...
4.1 introduction.
Variants of AM

4A 4.3 – Real AM, the simplest.
- Theory –
- Transmitters
- Envelope detectors

↓

4B 4.2 – Double sideband – suppressed carrier
- Theory
- Transmitters.
- Synchronous detectors.

4.4 – Quadrature AM – phase tricks.

↓

→ 4C – AM Lab?

4D 4.5 Single Sideband
- Theory
- Hilbert transform
- Filter method
- Phase shift method
- How to make a circuit with $G(\omega) = j$
  ($G(\omega) = j\omega$ is too easy!)

↓

5A 4.6 Vestigal sideband – TV bandwidth hack
- theory
- generation
- detection.

↓

AM Circuits, design tricks, etc.

5B 4.7 Carrier Acquisition
- Synchronous detection
- pilot signal
- Phase locked loops
  - voltage controlled oscillator
  - phase detection
  - "capture"

5C – PLL-Lab

↓

5D Suppressed carrier tricks.
- Signal Squared method
- phase locked loop.

single sideband, oops.

↓

6A 4.8 Superheterodyne receiver
- Mixers
- Filters
- Images.

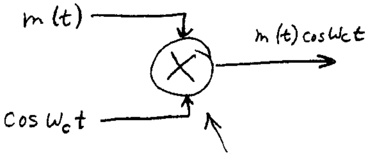
6B 4.9 Television
- Raster scan video
- Sync
- Color
- sound hack

6C – AM Test

Recall --

Frequency shifting.

To transmit:



Multiplier circuit
"balanced modulator"

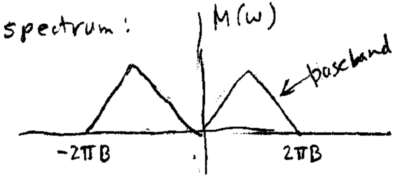
Has 2 inputs —
output is the product
of the inputs.

$$m(t)\cos W_c t \Leftrightarrow \frac{1}{2}\left[M(w+w_c)+M(w-w_c)\right]$$

↓
tells us....

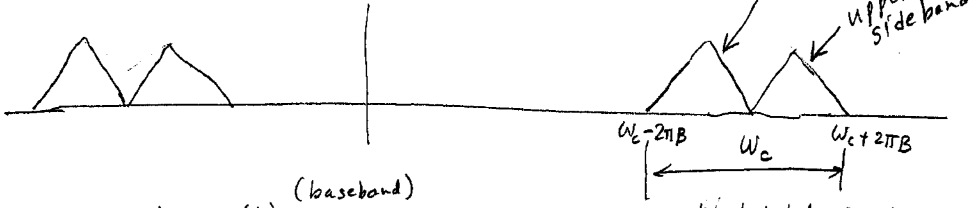
Frequency domain

input spectrum:



baseband
B = bandwidth in Hz

transmitted spectrum:

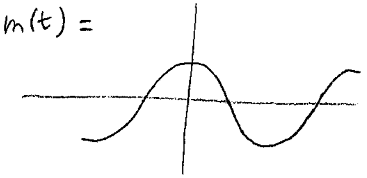


modulated signal bandwidth $= \underline{\underline{2B}}$ Hz
4πB rad/sec

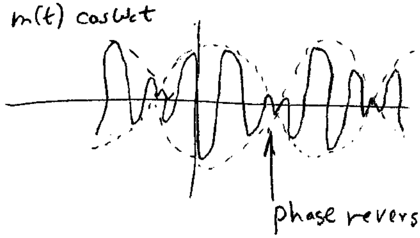
Note: m(t) (baseband) is not present
cos W_ct (carrier) is not present -
— only the sidebands are present.

Time domain:

m(t) =



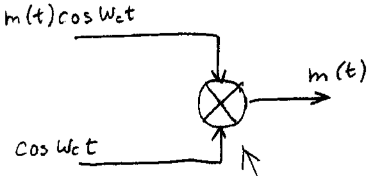
m(t) cos W_ct



← W_c contained in
envelope defined
by m(t)

To receive:

Need to frequency shift again,
back down to the baseband.



multiplier circuit
"product detector"

Problem: how to generate cos W_ct.

Note: sin W_ct won't work !!!

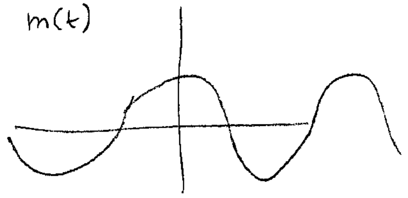
Output will be $\underline{\underline{0}}$.

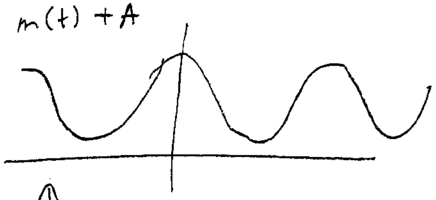
Brute-Force approach. —

How to generate $\cos W_c t$?

Transmit it!

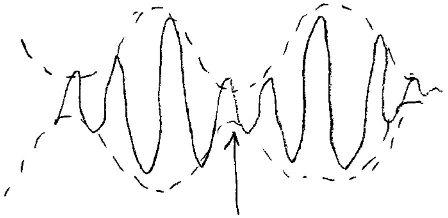
Idea: Level shift $m(t)$ (add a DC component) so it is always positive.





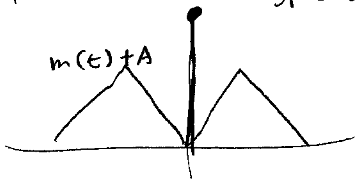
use this as the modulating signal.

$(m(t)+A)(\cos W_c t)$:

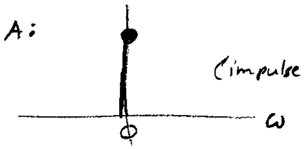


No phase reversals.

Frequency domain:



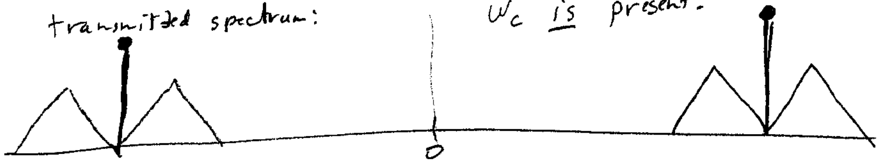
Spectrum of A:



(impulse at $\omega=0$)

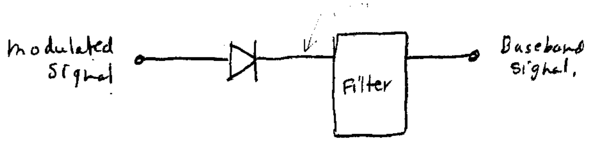
transmitted spectrum:

W_c is present.



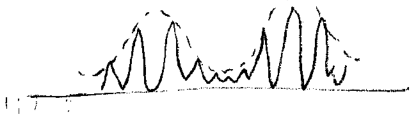
AM demodulation

It is simple now:



Rectifier detector:

After diode



After. Filter

takes average value, filtering out carrier.

Then use a coupling capacitor to center it, so $V_{DC}=0$

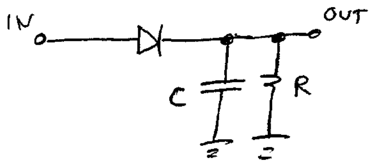
The filter is simple —

usually a simple RC will do —

because carrier frequency is much higher than baseband bandwidth!

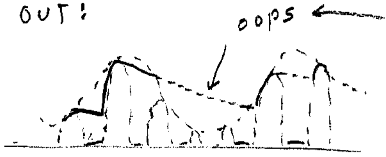
Envelope detector.

Same except to use a capacitor input filter — the cap charges to the peak value;



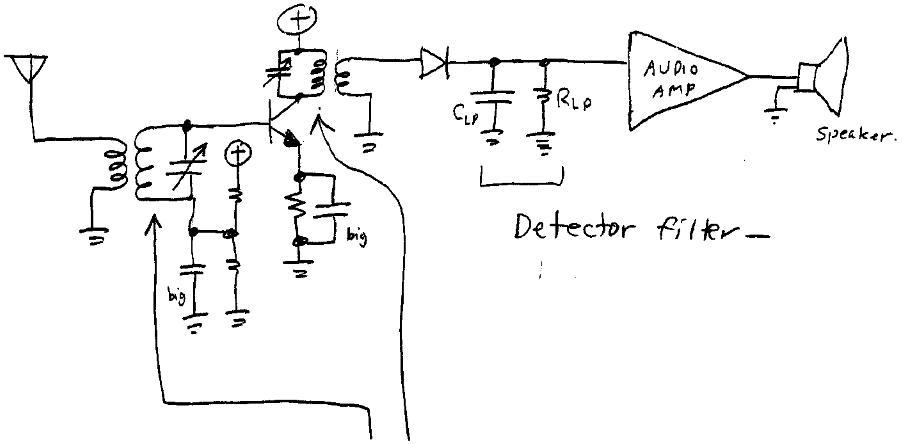
RC is chosen for proper filtering.

If time constant too long, it won't follow the envelope.



← shorter time constant.

A simple AM radio receiver:



Detector filter —

2 tuned circuits — RF filter to select frequency to receive.

Transmitting AM

→ They don't use balanced modulators!

Idea: Since the carrier is a single frequency, it is ok to use a "bad" amplifier then filter it.

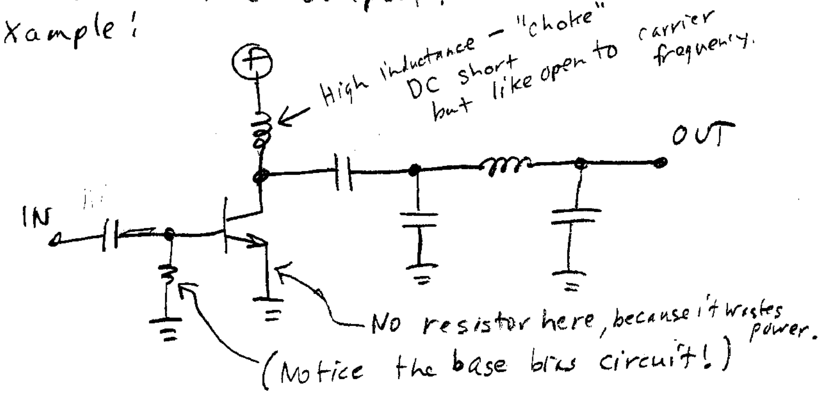
Class C amplifier:

Drive it to clipping.

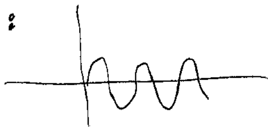
Bias it so it is off with no drive.

Filter the output.

Example!



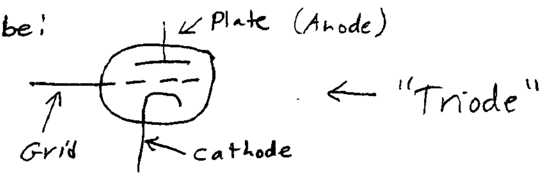
IN:



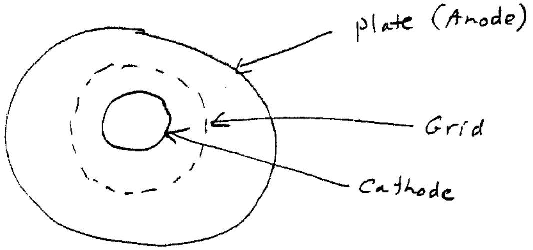
OUT (without filtering

Using historically correct devices:

Vaccuum tube:



Construction:



Cathode is heated, emits electrons.

Attracted to plate by positive charge

Grid controls flow of electrons.

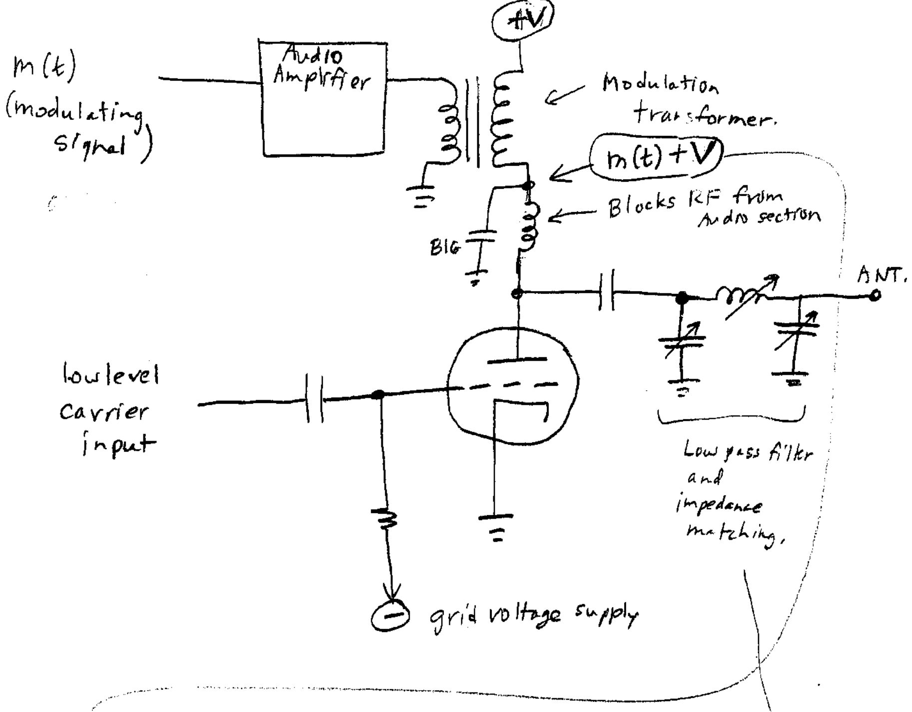
(like gate controls a FET).

Normally, current flows. Negative bias on grid reduces current.

Class C amplifier — is always clipping, so output depends on supply voltage

→ Apply modulation in series with power supply.

"Plate modulated" AM transmitter



Filters out Harmonics. Passes W_c rejects $2W_c$ and higher.

This m(t) +V is--

V is the power supply (≈ 1000 volts)

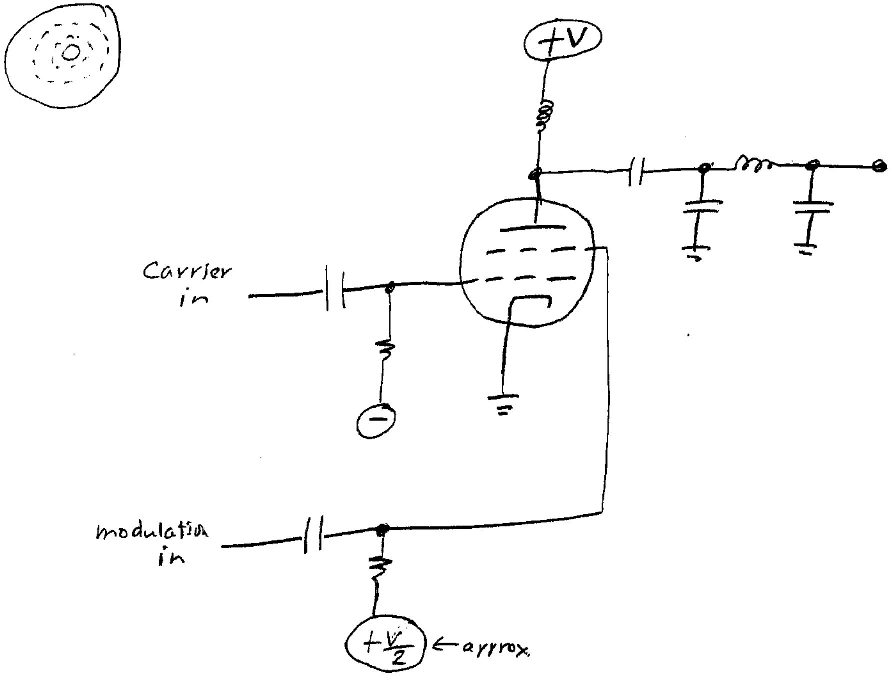
m(t) is a LARGE version of the modulating signal—

peak-to-peak voltage = $\underline{\underline{2V}}$ (2000 Volts)

Peak voltage at plate is 4X supply.

"Screen modulated" AM transmitter —

use a tube with 2 grids (tetrode)



"Screen" voltage adjusts the gain and current — so it modulates —