AM Demodulation and the Superheterodyne Receiver

EELE445-14
Lecture 28-29

Figure 4–29 Superheterodyne receiver.
**Product Detection 4-13**

\[ s(t) \rightarrow \text{LPF} \rightarrow m(t) \]

\[ 2\cos(2\pi f_c t) \]

- Only method for DSB-SC, USB-SC, LSB-SC
- AM with carrier
  - Envelope Detection – Input SNR >~10 dB required
  - Synchronous Detection – (no threshold effect)
- Note the 2 on the LO normalizes the output amplitude

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**Figure 4-24** PLL used for coherent detection of AM.

\[ v_1 = A_0 \left[ 1 + m(t) \right] \sin(\omega_c t) \]

\[ v(t) \rightarrow v(t) \rightarrow -90^\circ \text{phase shift} \rightarrow \text{LPF} \]

\[ v_{\text{out}}(t) \]
Envelope Detector 4-13

Where $C$ is a constant

\[ C \cdot A_c \cdot (1 + a \cdot m(t)) \]

\[ C \cdot A_c \cdot a \cdot m(t) \]

\[ W \ll \frac{1}{R_1 C_1} \ll f_r \]

Envelope Detector Distortion

Hi Frequency $m(t)$
Slope overload

IF Frequency Present in Output signal

Figure 3.20 Effect of (a) large and (b) small $RC$ values on the performance of the envelope detector.
Superheterodyne Receiver

EELE445-14

MODEL AM/FM-108TK
14 TRANSISTORS, 5 DIODES
AM Antenna

FM Antenna

Super-Heterodyne AM Receiver
Super-Heterodyne AM Receiver

- Provides Image Rejection $f_{\text{image}} = f_{\text{LO}} + f_{\text{if}}$
- Reduces amplitude of interfering signals far from the carrier frequency
- Reduces the amount of LO signal that radiates from the Antenna

RF Filter
Figure 4–30 Spectra of signals and transfer function of an RF amplifier in a superheterodyne receiver.

Figure 4–29 Superheterodyne receiver.
Mixer and LO

• The mixer produces
  \[ f_{\text{SUM}} = f_{\text{LO}} + f_{\text{RF}} \]  and \[ f_{\text{DIF}} = f_{\text{LO}} - f_{\text{IF}} \]

• The conventional AM radio uses the difference frequency – spectrum analyzers often use the sum frequency

• The LO (Local Oscillator) tunes the radio so that the desired input frequency passes through the IF filters.

Antenna, Mixer, LO
Super-Heterodyne AM Receiver

IF Amplifiers and Filters

- The IF filters:
  - The bandwidth is set wide enough to pass the transmitted signal
  - Provides adjacent channel rejection.
    - If we are tuned to 1400 KHz, the Adjacent channels are at 1390 KHz and 1410 KHz
  - This bandwidth determines the noise bandwidth of the receiver
  - The filter is optimized for IF frequency so all input signals pass through the same filters. This simplifies filter and amplifier design
  - The IF amplifier gain is variable to adjust for changes in the input signal power level. The received signal level may vary from < 1mV to over 1V (>60dB)
  - Note that an FM radio uses a limiting IF amplifier not a variable gain amplifier. See FM notes
### TABLE 4-2 FILTER CONSTRUCTION TECHNIQUES

<table>
<thead>
<tr>
<th>Technique</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceramic disk</td>
<td>Electrodes, one section, fingers, piezoelectric substrate, finger overlap region.</td>
</tr>
<tr>
<td>Quartz crystal</td>
<td>Rod and disk transducers.</td>
</tr>
</tbody>
</table>

**IF Amplifier**

[Diagram of IF Amplifier]
AGC-Automatic Gain Control

- The envelope detector recovers the original $m(t)$ modulation and a DC voltage that is proportional to the received signal carrier amplitude $A_c$.
- The DC voltage is used to automatically adjust the gain of the IF amplifier in a control loop (AGC- automatic gain control). This maintains a constant recovered $m(t)$ amplitude as the receiver input signal level changes, otherwise the volume would change as much as 60dB!
IF and AGC

Detector, AGC, Audio
IF and agc

Heterodyne Converter (Frequency Translation) and RF filtering

- Image Rejection
- Frequency Translation
- RF amplification
- LO- tuning
Heterodyne Converter