AMPLITUDE MODULATED RADIO SIGNAL RECEIVER

HISTORY: Marconi 1895 - 1902
KEYED SPARK GAP SIGNAL

\[
\text{Signal Amplitude}
\]

\[
\begin{array}{c}
\text{Time}
\end{array}
\]

AMPLITUDE MODULATION

**Given Signal to Send**: \( \cos(\omega_C t) \) \( \omega_C > \omega_s 

**Carrier Signal**: \( \cos(\omega_s t) \)

**Modulated Signal**: \( f(t) = (1 + A\cos(\omega_C t))\cos(\omega_s t) \)

**A - Modulation Index**: \( 0 < A < 1 \)

\[ \begin{array}{c}
1 + A
\end{array} \]

\[
\text{Time}
\]

IN FREQUENCY DOMAIN:

\[
f(f) = \left(1 + \frac{A}{2}(e^{j\omega_C t} + e^{-j\omega_C t})\right)\left(e^{-\frac{f}{2}} - e^{\frac{f}{2}}\right)
\]

\[
= e^{j\omega_C t} + \frac{A}{4}e^{j(\omega_C + \omega_s)t} + \frac{A}{4}e^{j(\omega_C - \omega_s)t} - e^{-j\omega_C t} - \frac{A}{4}e^{-j(\omega_C + \omega_s)t} - \frac{A}{4}e^{-j(\omega_C - \omega_s)t}
\]

\[
\text{Time}
\]

\[
1 \quad 1
\]

\[
-\omega_C \quad \omega_C
\]
In general, we represent a spectrum of frequencies contained in the audible range $0 \leq \omega \leq 2\pi (5-10 \text{ kHz})$

Many stations broadcasting at assigned frequencies $\frac{\omega}{2\pi}$ in range $550 \text{ kHz}$ to $1600 \text{ kHz}$, usually

-separately by $10-20 \text{ kHz}$.

The goal is to process a signal from one station so it can be heard.

Antenna

The modulated carrier is fed to an antenna which emits electromagnetic waves at $\omega_c$. We use loop antenna to receive signal.

**Figures:**

- Diagram of an antenna with a model.
- Diagram of a network model with $V_a(x)$.
- Diagram of a bandpass filter with $Q = \frac{f_c}{2f_s} = \frac{1.0 \times 10 \text{ kHz}}{2(5 \times 10^3)} \lesssim 100$. 

$$V_a = \frac{1}{R + Ls + \frac{1}{Cs}} \quad \text{and} \quad V_0 = \frac{1}{R + Ls + \frac{1}{Cs}}$$

$$\log \left( \frac{V_0}{V_a} \right) = \log (Q)$$
**Amplifier**

Give the signal a boost to get it to a reasonable voltage level.

\[ V_b = \frac{V_a}{100k} \Rightarrow V_b = \frac{V_a}{10k} \]

Most use OP amp with high gain-bandwidth product to achieve high gain @ 1.0 MHz.

LT1191 A\*BW \approx 70\times10^6

**Demodulator**

To recover \( V_3 \) frequency, we first clip off the negative portion of the signal.

**Low Pass Filter**

- Remove remaining carrier from the signal
- Remove constant component to avoid saturating downstream amplifier

Choose \( \frac{1}{\omega C_1} \) \& \( \omega = 100 \)

\[ \frac{V_d}{V_c} = \frac{-R_2/L_2s}{R_2 + \tfrac{1}{C_2s}} = \frac{-R_2/L_1}{1 + R_2/L_2s} \]

Choose \( R_2/L_1 = 10 \)

\[ R_2 = 10k, \quad R_1 = 100k \]

Set breakpoint at \( \omega = 2\pi(3\times10^3) = \frac{1}{R_1C_2} \)

\( C_2 = 5\times10^{-10} \) set to 470 pf
Power Amplifier to Drive 8 Ohm Speaker

**Incremental Model**

\[
N_E = \begin{cases} 
+ \frac{R_{SPK}}{g_m} (V_d - V_T) & |V_d| > V_T \\
+ \frac{g_m R_{SPK}}{1 + g_m R_{SPK}} & |V_d| \leq V_T
\end{cases} 
\]

Use Negative Feedback to Eliminate Distortion and Get Gain.

(10k Potentiometer for Volume Control)
6.002 Radio Receiver