ECE 447 Fall 2025

Lesson 09
Amplitude Modulation, Part 2

Schedule and Admin

- Schedule
- Admin
  - **HW1: due 2 Sep at 2359**
  - **Lab 2 Assignment**. The assignment associated with Lab 2 is due Lesson 10 - specifically 3 Sep by 2359 via Gradescope upload.

  - When are you going to get things graded??? Working on it...

Double-Sideband, Large-Carrier

- Add a signal at the carrier to the DSB-SC signal from last lesson
- Now we have the conventional AM used in broadcast signals (AM radio, Airband)
- Time domain:

$$\varphi_{AM}(t) = A\cos(\omega_c t) + m(t)\cos(\omega_c t) = [A + m(t)]\cos(2\pi f_c t)$$

- Frequency domain:

$$\varphi_{AM}(t) \Leftrightarrow \frac{1}{2}[M(f + f_c) + M(f - f_c)] + \frac{A}{2}[\delta(f + f_c) + \delta(f - f_c)]$$

AM: 215 vs. 447

ECE 215:

- Sinusoidal messages (tones) only:

  $A_c \cos(2\pi \cdot f_c \cdot t) \cdot [A_m \cos(2\pi \cdot f_m \cdot t) + B] =$
  $\frac{A_c A_m}{2} \cos[2\pi \cdot (f_c - f_m) \cdot t] + \frac{A_c A_m}{2} \cos[2\pi \cdot (f_c + f_m) \cdot t] + A_c B \cos(2\pi \cdot f_c \cdot t)$

- Modulation Index: $\alpha = \frac{A_m}{B} = \frac{2 \cdot Amp_{SB}}{Amp_{Carrier}}$

- Efficiency: $\eta = \frac{\alpha^2}{\alpha^2 + 2}$

ECE 447:

- Any arbitrary message:

  $\varphi_{AM}(t) = A\cos(2\pi f_c t) + m(t)\cos(2\pi f_c t)$

- Modulation Index: $\mu = \frac{m_p}{A}$, where m_p is the max value of $m(t)$

- Efficiency: $\eta = \frac{m(t)^2}{A^2 + m(t)^2}$ in general, and for tone modulation $\eta = \frac{\mu^2}{\mu^2 + 2}$

Example Problem

4.3-5 Consider an AM signal with $m(t)$ shown in Fig. P4.3-5 with $f_c = 10$ kHz and $\mu = 2$.

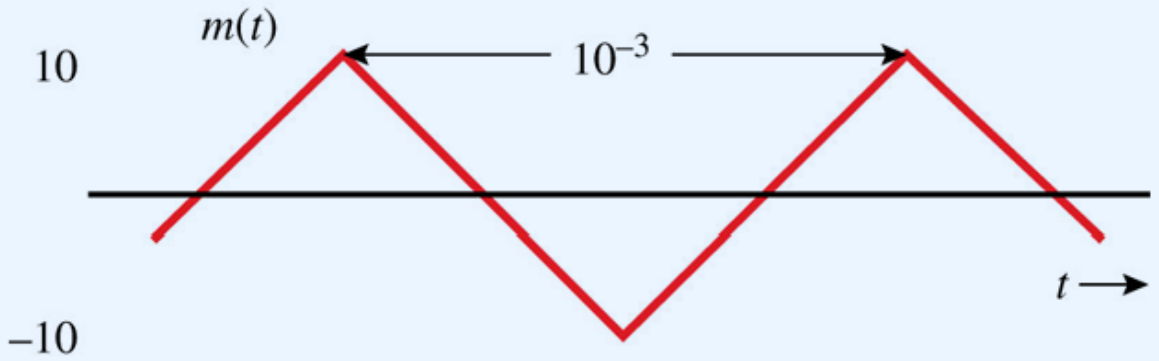
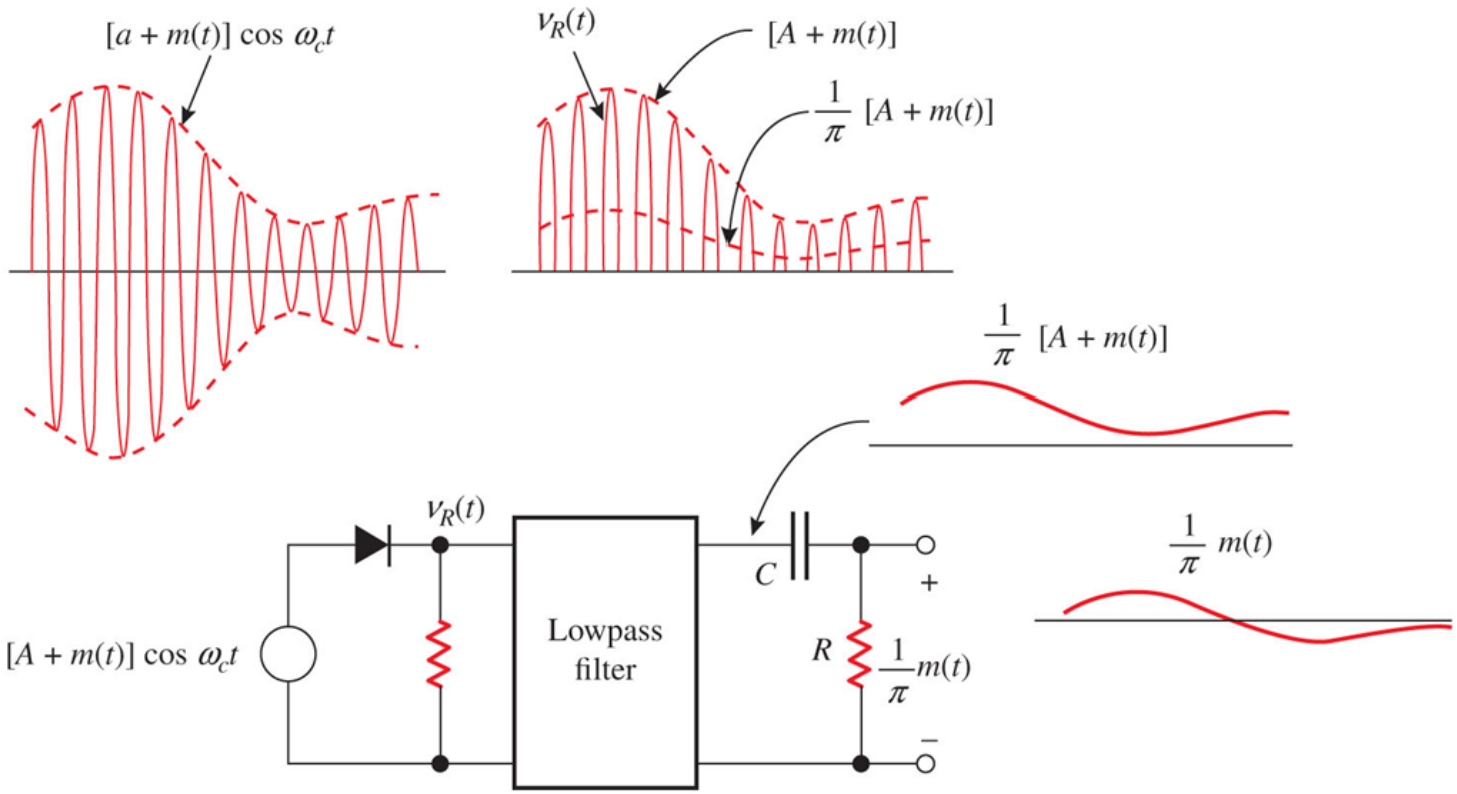


FIGURE P4.3-5 Enlarge image

a. Find the amplitude and power of the carrier.

b. Find the sideband power and the power efficiency η.

Envelope Detector Demodulation

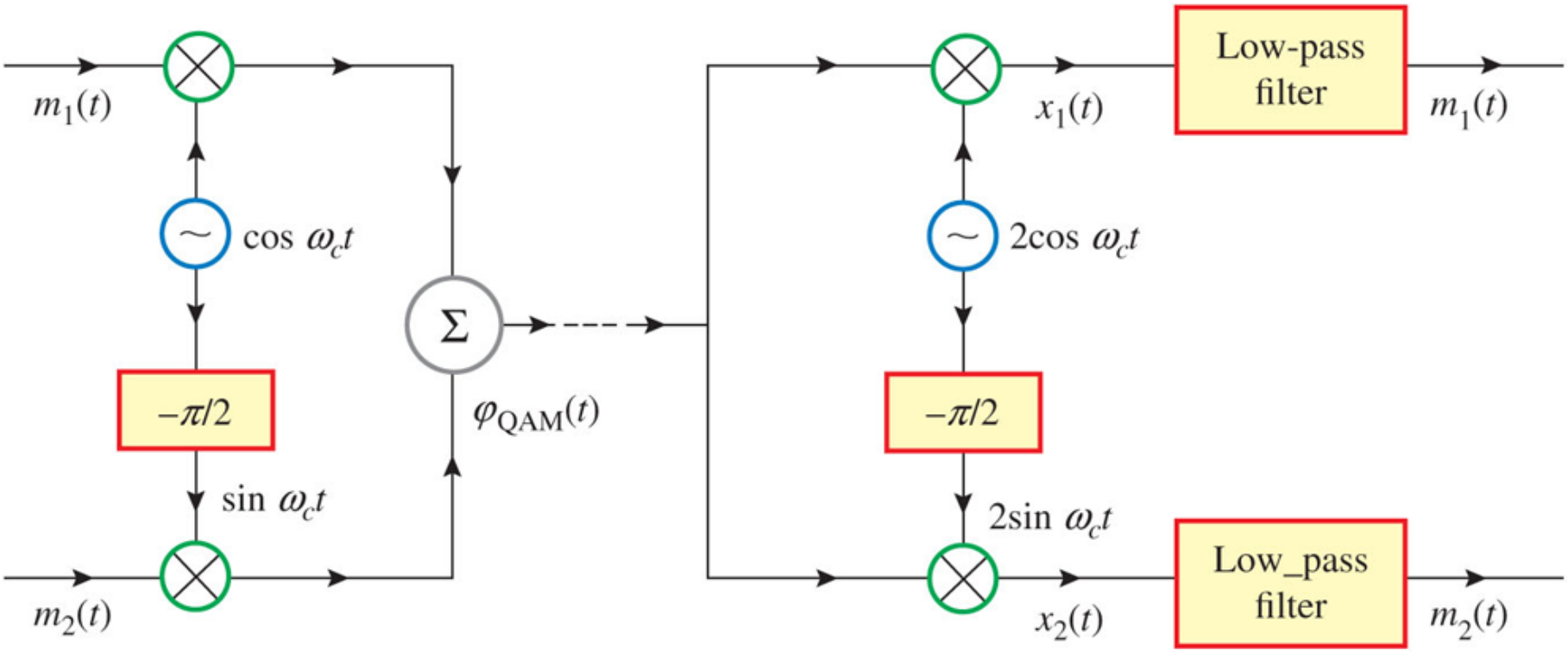


Let's Build One!

BW-Efficient Modulations

- DSB modulations use twice as much BW as necessary - the complete message info is contained in both the USB and LSB
- **One solution**: remove all or most of one of the sidebands!
  - **Single sideband, suppressed-carrier (SSB-SC)**: used in two-way radio (HF shortwave) and HAM radio
  - **Vestigial sideband, suppressed-carrier (VSB-SC)**: used in old analog TV video signals and modern ATSC Digital TV Standard to get slightly more BW than straight SSB
- **Quadrature Amplitude Modulation (QAM)**
  - Used in most modern wireless communication systems: Wi-Fi (all recent variants), 4G/5G cellular systems, satellite TV and radio, broadband internet
  - We will cover this one in much more detail in the future...

QAM



- $\varphi_{QAM}(t) = m_1(t)\cos(\omega_c t) + m_1(t)\sin(\omega_c t)$