EES 351: In-Class Exercise # 15

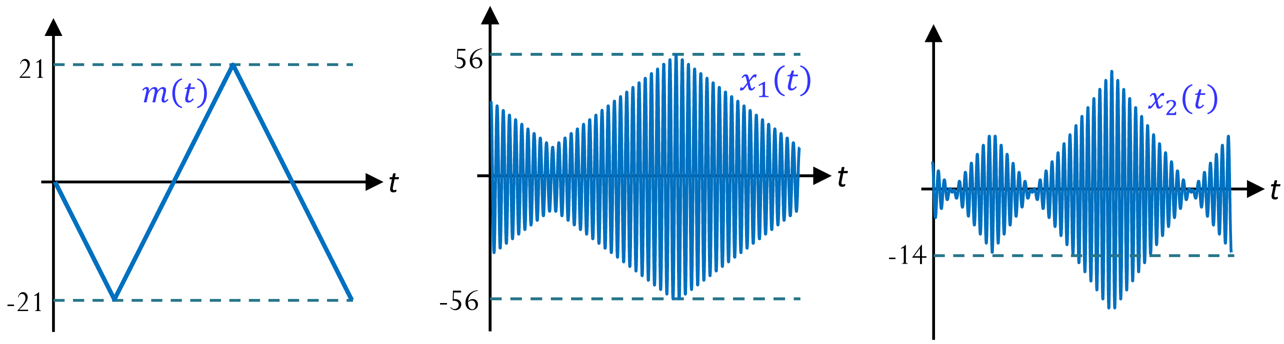
Date: 30 / 10 / 2020			
Name	ID (last 3 digits)		

Instructions

1. Work alone or in a group of no more than three students. **The group cannot be the same as any of your former groups after the midterm.**
2. Only one submission is needed for each group.
3. You have two choices for submission:
   (a) Online submission via Google Classroom
   - PDF only.
   - Only for those who can directly work on the posted files using devices with pen input.
   - Paper size should be the same as the posted file.
   - No scanned work, photos, or screen capture.
   - Your file name should start with the 10-digit student ID of one member. (You may add the IDs of other members, exercise #, or other information as well.)

   (b) Hardcopy submission
4. **Do not panic.**

1. Continue from the previous in-class exercise. We considered AM transmission of the message $m(t)$ shown on the left below.



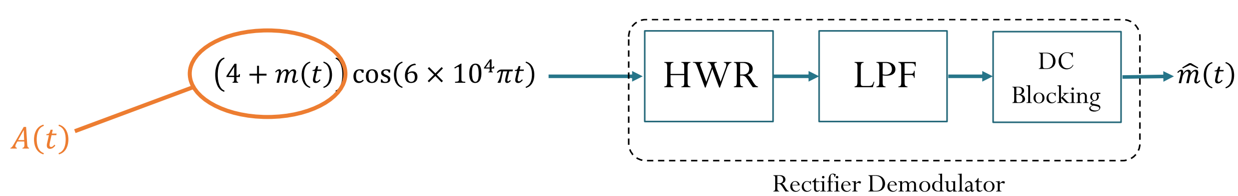
The middle and the rightmost plots show two AM signals $x_1(t)$ and $x_2(t)$ produced by using two different values of modulation index. During the previous in-class exercise, we have calculated the values of A and μ. They are summarized in the table below.

Suppose $m(t)$ is a periodic triangular wave with average power $\langle m^2(t) \rangle = 147$.

Calculate the corresponding value of the power efficiency for each case.

$x_{AM}(t)$	A	μ	Power Efficiency
$x_1(t)$	35	60%	$\text{Eff} = \frac{\frac{P_m}{2}}{\frac{A^2}{2}+\frac{P_m}{2}} = \frac{1}{\frac{A^2}{P_m}+1} = \frac{1}{\frac{35^2}{147}+1} = \frac{3}{28} \approx 0.1071 = 10.71\%$
$x_2(t)$	7	300%	$\text{Eff} = \frac{\frac{P_m}{2}}{\frac{A^2}{2}+\frac{P_m}{2}} = \frac{1}{\frac{A^2}{P_m}+1} = \frac{1}{\frac{7^2}{147}+1} = \frac{3}{4} \approx 0.75 = 75\%$

2. [ENRPr] Consider a rectifier demodulator shown below:



Assume that $m(t)$ has 0 average and that it is band-limited to 10 kHz.

The frequency response of the LPF is $H_{LPF}(f) = \begin{cases} 3, & |f| \le 14 \text{ kHz}, \\ 0, & \text{otherwise}. \end{cases}$

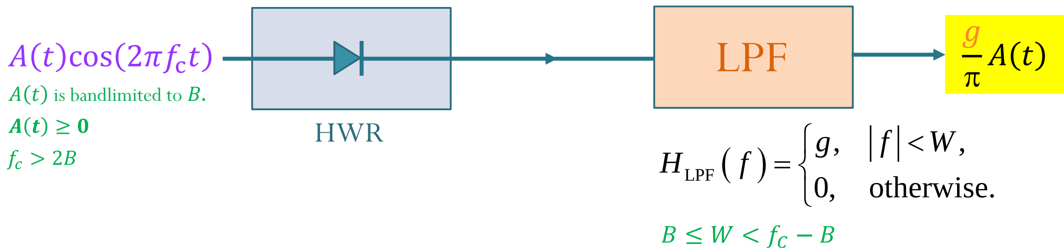
Assume that $m(t) \ge -4$ at all time.

Find $\hat{m}(t)$. (Your answer will contain $m(t)$.)

Here, $A(t) = 4 + m(t)$. Because $m(t)$ is ≥ -4 at all time, we know that $A(t)$ is always nonnegative.
Furthermore, from $A(t) = 4 + m(t)$, we know that if $m(t)$ is band-limited to B, then so is $A(t)$.
We are given that $m(t)$ is band-limited to 10 kHz. Therefore, we also know that $A(t)$ is band-limited to 10 kHz as well.
In class, we have shown that, if

1) $A(t)$ is band-limited to B,
2) $A(t)$ is always nonnegative,
3) $f_c > 2B$, and
4) $B < W < f_c - B$,

Then the output of the LPF is $\frac{g}{\pi}A(t)$.



We have already shown that conditions (1) and (2) are satisfied with $B = 10$ kHz.
From $f_c = 2 \times 10^4 = 30$ kHz. $B = 10$ kHz. $W = 14$ kHz, we can check that conditions (3) and (4) are satisfied as well.
Here, $g = 3$.
Therefore, the output of the LPF is $\frac{g}{\pi}A(t) = \frac{3}{\pi}\left(4 + m(t)\right) = \frac{12}{\pi} + \frac{3}{\pi}m(t)$.
Finally, the DC blocking box removes the DC component. Here, because we assume that $\langle m(t) \rangle = 0$, the DC component is

$$\langle \frac{12}{\pi} + \frac{3}{\pi}m(t) \rangle = \frac{12}{\pi} + \frac{3}{\pi}\langle m(t) \rangle = \frac{12}{\pi}.$$

So,

$$\hat{m}(t) = \frac{12}{\pi} + \frac{3}{\pi}m(t) - \frac{12}{\pi} = \frac{3}{\pi}m(t).$$