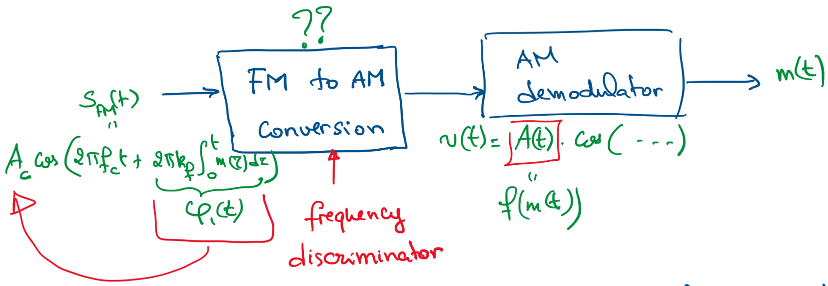
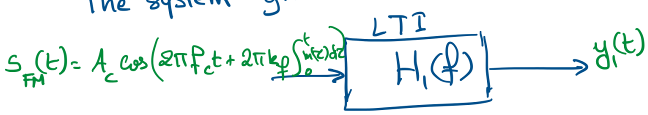
Online Tutorial #02 - FM Demodulation - Frequency Discriminator

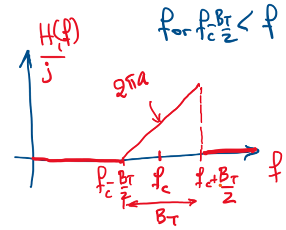
Friday, March 27, 2020
10:00 AM

Frequency discriminator: a system that allows to convert an FM modulation to an AM modulation.



The system given below has a transfer function $H_1(f) = j2\pi a\left(f - f_c + \frac{B_T}{2}\right)$ for $f_c - \frac{B_T}{2} < f < f_c + \frac{B_T}{2}$



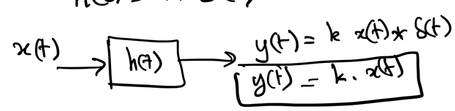


$$H_1(f) = j\,2\pi a\left(f - f_c + \frac{B_T}{2}\right)$$

$$H_1(f) = \underbrace{a \cdot j2\pi f}_{a \cdot \frac{d}{dt}} + \underbrace{j\,2\pi a\left(-f_c + \frac{B_T}{2}\right)}_{(\times)\text{ by a constant } + \text{ phase shift}}$$

$\rightarrow \pi/2$

$h(t) = k \cdot \delta(t)$



$$y_1(t) = a \cdot \underbrace{\frac{d\, S_{FM}(t)}{dt}}_{=} + 2\pi a\left(-f_c + \frac{B_T}{2}\right) \cdot A_c \cos\left(2\pi f_c t + 2\pi k_f \int_0^t m(\tau)d\tau + \pi/2\right)$$

$$y_1(t) = a \cdot A_c\left[2\pi f_c + 2\pi k_f\, m(t)\right] \cdot \cos\left(2\pi f_c t + 2\pi k_f \int_0^t m(\tau)d\tau + \pi/2\right)$$

$$+\ 2\pi a\, A_c\left(-f_c + \frac{B_T}{2}\right)\ \cos\left(2\pi f_c t + 2\pi k_f \int_0^t m(\tau)\,d\tau + \pi/2\right)$$

$$y_1(t) = 2\pi a A_c\left[k_f\, m(t) + \frac{B_T}{2}\right] \cos\left(2\pi f_c t + 2\pi k_f \int_0^t m(\tau)\,d\tau + \pi/2\right)$$

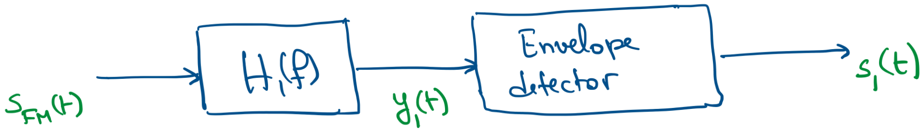
$$\boxed{y_1(t) = \pi a A_c \cdot B_T \underbrace{\left[1 + \frac{2k_f}{B_T}(t)\right]}_{} \cdot \cos\left(2\pi f_c t + 2\pi k_f \int_0^t m(\tau)d\tau + \pi/2\right)}$$

the modulation is now in the amplitude of the $\cos(\cdot)$

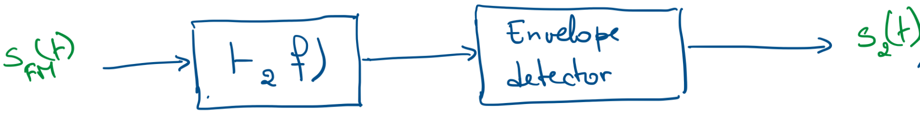
Conversion from FM $\longrightarrow$ AM $\rightarrow$ frequency discriminator

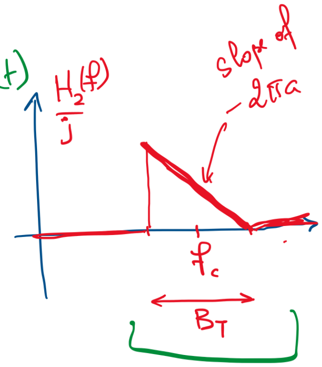
if $\left[1 + \frac{2k_f}{B_T} m(t)\right] > 0$ for all t.

then we can use an envelope detector to detect the message $m(t)$.

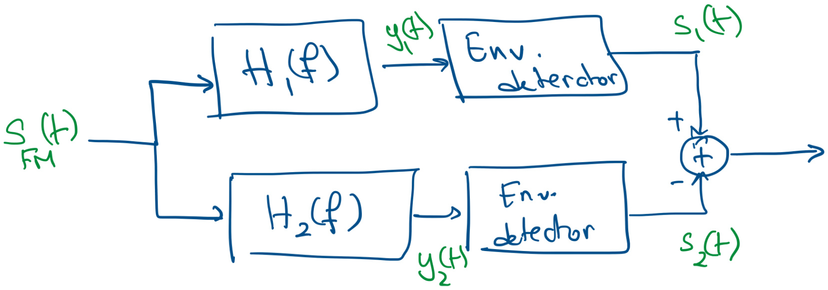


$$s_1(t) = \pi a A_c B_T \left[1 + \frac{2k_f}{B_T} m(t)\right]$$





$$\boxed{s_2(t) = \pi a A_c B_T \left[1 - \frac{2k_f}{B_T} m(t)\right]}$$



$$s_1(t) - s_2(t) = \underbrace{4\pi a A_c k_f}_{K} \cdot m(t)$$