Analog Haberleşme

Ders 10 – Tek yan bant (TYB-GM) ve FDM

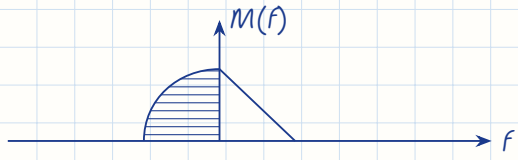
Orijinal not: Ders10.pdf

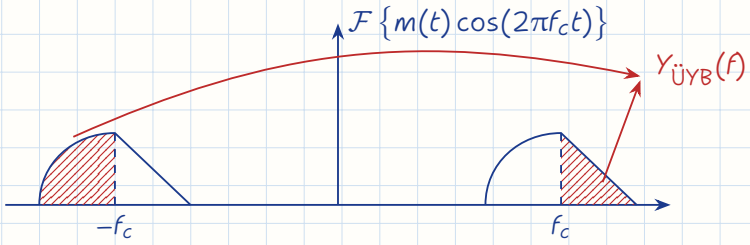
UYARI Bu belge, el yazısı ders notlarından Claude (Anthropic) yardımıyla dijitale aktarılmıştır. Yardımcı kaynak olarak hazırlanmıştır; hata veya eksik içerebilir. Lütfen orijinal notları ve ders kaynaklarını esas alın.

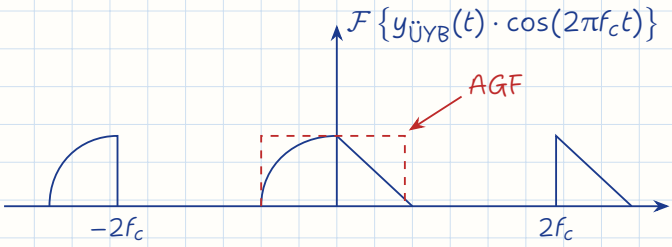
NOTICE *This document was transcribed from handwritten lecture notes with the help of Claude (Anthropic). It is meant as a supplementary resource and may contain errors or omissions. Always check against the original notes and official course material.*

orj. s. 1

TYB-GM (SSB-AM)







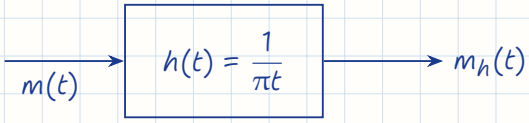
$$y_{TYB}(t) = A_c\left[m(t)\cos(2\pi f_c t) \overset{AYB}{\underset{ÜYB}{\pm}} m_h(t)\sin(2\pi f_c t)\right]$$

→ $m(t)$'nin Hilbert dönüşümü

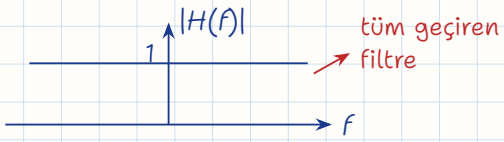
(? Prolcisite $\hat{m}(t)$)

$$m_h(t) = m(t) \circledast \underbrace{\frac{1}{\pi t}}_{h(t)}$$

$$m_h(t) = \frac{1}{\pi}\int_{-\infty}^{\infty} \frac{m(\tau)}{t-\tau}\,d\tau$$

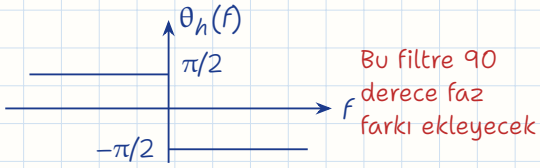


$$h(t) = \frac{1}{\pi t} \overset{F}{\longleftrightarrow} H(f) = -j\,\mathrm{sgn}(f) = \begin{cases} -j, & f > 0 \\ j, & f < 0 \end{cases} = \begin{cases} e^{-j\pi/2}, & f > 0 \\ e^{j\pi/2}, & f < 0 \end{cases}$$



$$|H(f)| = 1$$

$$\theta_h(f) = \begin{cases} -\pi/2, & f > 0 \\ \pi/2, & f < 0 \end{cases} \Longrightarrow$$



orj. s. 2

$$P_{y_{TYB}} = \frac{A_c^2}{2} P_m + \frac{A_c^2}{2} P_{m_h} \quad \nearrow \text{ o da } P_m\text{'e eşit genlik değişmediği için}$$
$$= A_c^2 P_m$$

$$y_{AYB}(t) + y_{ÜYB}(t) = 2A_c\, m(t) \cos(2\pi f_c t) = y(t)$$

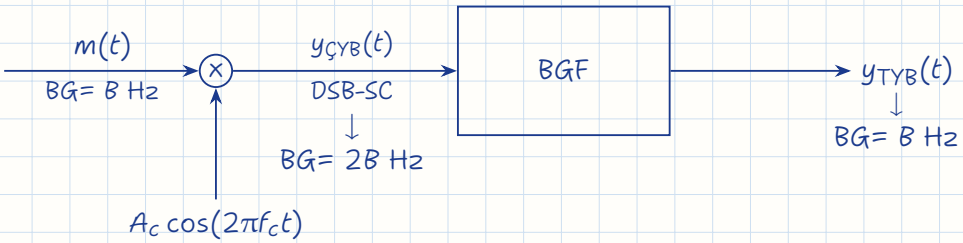
Örnek

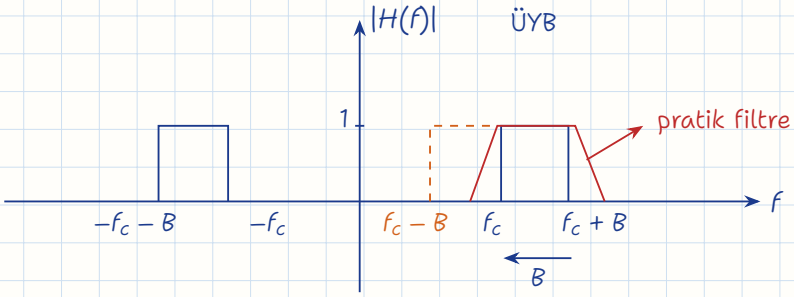
$$m(t) = \cos(2\pi f_m t)$$
$$m_h(t) = \cos(2\pi f_m t - \pi/2) = \sin(2\pi f_m t)$$
$$y_{TYB}(t) = A_c\left[\cos(2\pi f_m t) \cdot \cos(2\pi f_c t) \mp \sin(2\pi f_m t)\sin(2\pi f_c t)\right]$$
$$= A_c \cos\left[2\pi(f_c \mp f_m)t\right]$$

(başlığın üstünde küçük not: ? ek anlatılı)

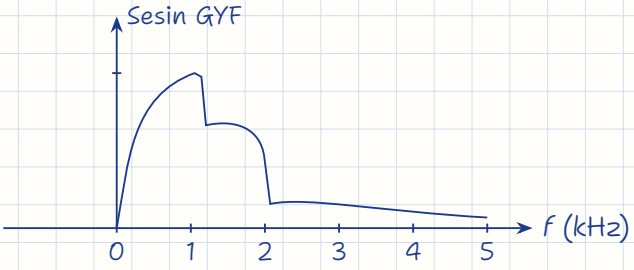
TYB-GM modülatörleri

1) Filtreleme tekniği (Filtering)

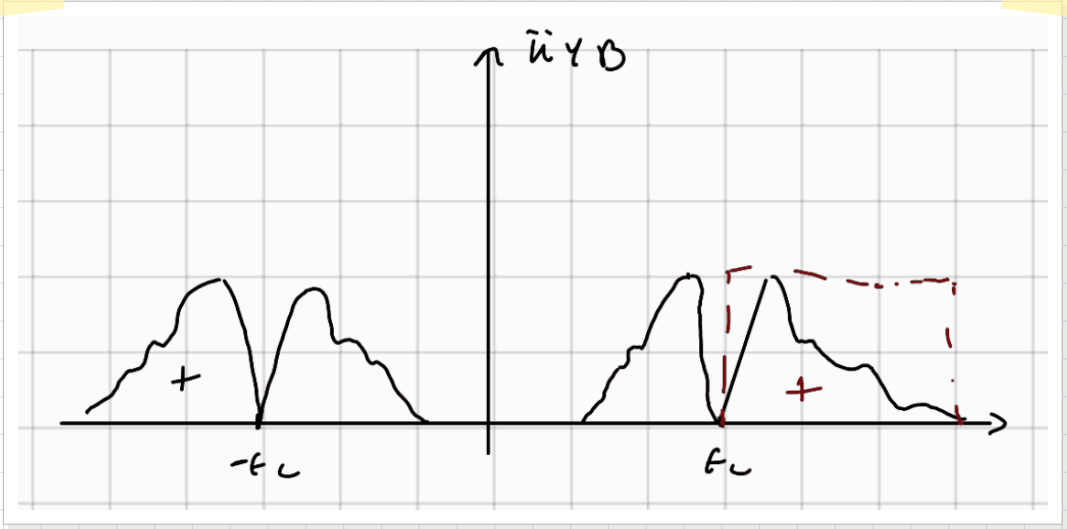




Mesaj işaretinin 0 Hz civarındaki frekanslarda bileşenleri 0'a yakın olmalıdır



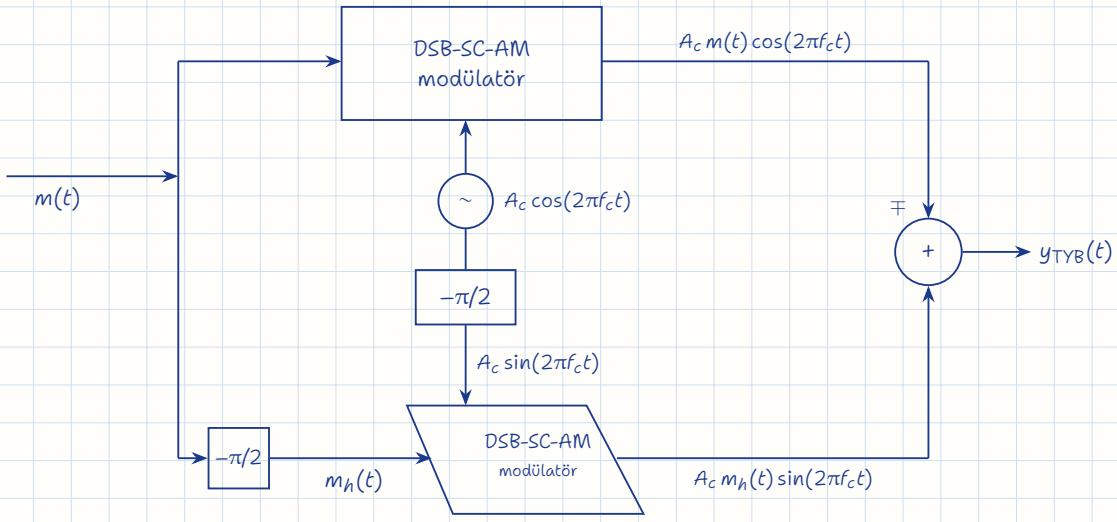
orj. s. 3



orijinal çizim, s. 3

Sesin anlamlı bileşenleri 300–3500 Hz

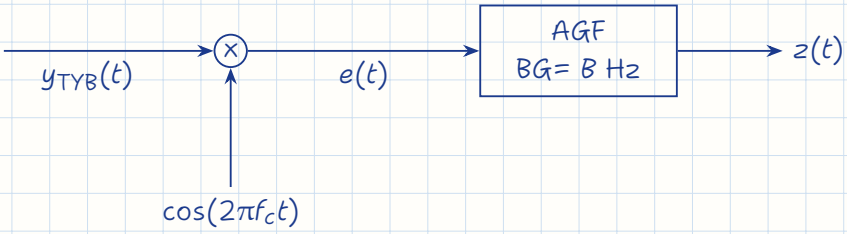
2) Faz öteleme tekniği



Hilbert filtresini tüm noktalara 90 derece ?ötelemek gerçekte zordur

TYB-GM – Demodülatörleri

1) Faz tahminli demodülasyon (Coherent demodulation)



orj. s. 4

$$y_{TYB}(t) = A_c\, m(t)\cos(2\pi f_c t) \mp A_c\, m_h(t)\sin(2\pi f_c t)$$

$$e(t) = y_{TYB}(t)\cdot\cos(2\pi f_c t)$$

$$= \frac{A_c}{2}m(t)\left[\overbrace{\cos(0)}^{1} + \cos(2\pi\, 2f_c t)\right] \mp \frac{A_c}{2}m(t)\left[\underbrace{\sin(0)}_{0} + \sin(2\pi\, 2f_c t)\right]$$

[1]

$$e(t) = \frac{A_c}{2}m(t) + \frac{A_c}{2}\underbrace{\left[m(t)\cos(2\pi\, 2f_c t) \mp m_h(t)\sin(2\pi\, 2f_c t)\right]}_{2f_c\text{'de TYB}}$$

↙ AGF'den geçmez

$$z(t) = \frac{A_c}{2}m(t)$$

⋆ Sınav sorusu alıcıyı tahmin ederken θ kadar faz farkı

$$e(t) = y_{TYB}(t)\cdot\cos(2\pi f_c t)$$

$$= \frac{A_c}{2}m(t)\left[\cos(\theta) + \cos(2\pi\, 2f_c t+\theta)\right] \mp \frac{A_c}{2}m(t)\left[\sin(\theta) + \sin(2\pi\, 2f_c t+\theta)\right]$$

$$e(t) = \frac{A_c}{2}m(t)\cos\theta \mp \frac{A_c}{2}m_h(t)\sin\theta + 2f_c\text{'de TYB}$$

↙ AGF'den geçmez

θ mesajı bozar, θ zamana bağlıdır

Faz tahminsiz demodülasyon (Non coherent demodulation)

Envelope detection of SSB-AM with LC = SSB + C

$$y_{SSB+C}(t) = \underbrace{A_c\cos(2\pi f_c t)}_{LC} + \underbrace{A\left[m(t)\cos(2\pi f_c t) + m_h(t)\sin(2\pi f_c t)\right]}_{SSB}$$

[1] Claude notu: ikinci terimde muhtemelen $m_h(t)$ olmalı (aşağıdaki benzer satırda da aynı durum var).

$$= [A_c + A\,m(t)]\cos(2\pi f_c t) + A\,m_h(t)\sin(2\pi f_c t)$$
$$= E(t)\cos(2\pi f_c t + \theta(t))$$

$$a\cos x + b\sin x = c\cos(x+\theta)$$
$$c = \sqrt{a^2+b^2}, \qquad \theta = -\arctan(b/a)$$

orj. s. 5

$$E(t) = \left[(A_c + A\,m(t))^2 + (A\,m_h(t))^2\right]^{1/2}$$
$$= \left[A_c^2 + A^2 m^2(t) + 2AA_c\,m(t) + A^2 m_h^2(t)\right]^{1/2}$$
$$= A_c\left[1 + \frac{A^2 m^2(t)}{A_c^2} + \frac{A^2 m_h^2(t)}{A_c^2} + \frac{2A\,m(t)}{A_c}\right]^{1/2}$$

$$\left.\begin{array}{l} A_c \gg A\,|m(t)| \\ \Rightarrow\ A_c \gg A\,|m_h(t)| \end{array}\right\} \Rightarrow E(t) \approx A_c\left[1 + \frac{2A\,m(t)}{A_c}\right]^{1/2}$$
$$\approx A_c\left[1 + \frac{A\,m(t)}{A_c}\right]$$
$$= A_c + A\,m(t)$$

$\star$ $|x| \ll 1 \ \Rightarrow\ (1+x)^n \approx 1 + nx$

ÇYB-GM

TYB-GM

$$\left.\begin{array}{l} A_c \geq |m(t)| \\ A_c \gg |m(t)| \end{array}\right\} V_{TYB} < V_{ÇYB}$$

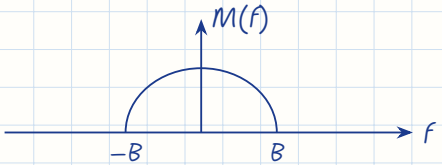
Artık Yan Band (AYB)-GM

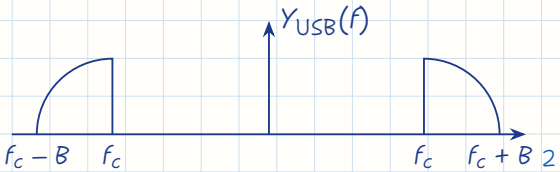
(Vestigial Side band (VSB)-AM)
asymmetric sideband

HF bandı

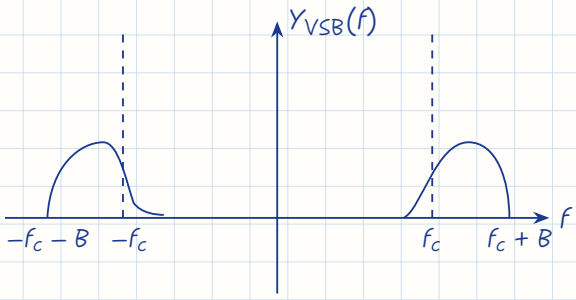
Siyah beyaz televizyon 6 MHz

$$BG\{AYB\} = 1{,}25\,BG\{TYB\}$$



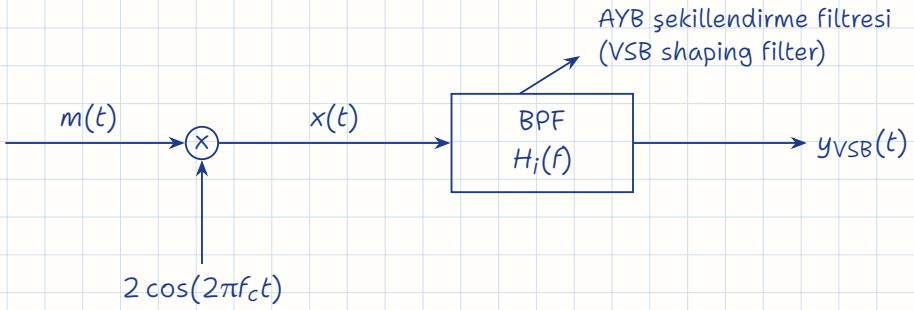


[2] Claude notu: ikinci şekilde sol taraftaki etiketler muhtemelen $-f_c - B$ ve $-f_c$ olmalı.

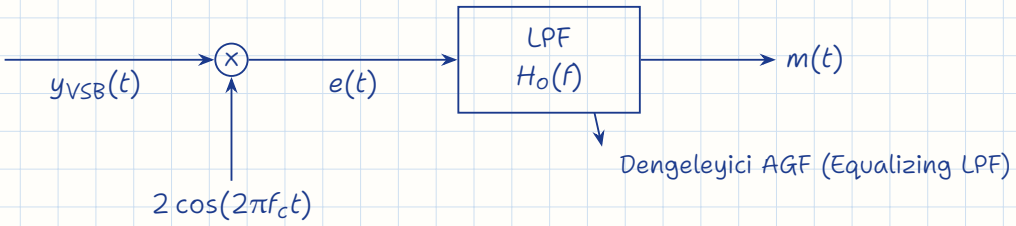


orj. s. 6

Modülatör



Demodülatör



Faz tahminli demodülasyon

$$e(t) = 2y_{VSB}(t)\cos(2\pi f_c t) \rightarrow E(f) = Y_{VSB}(f - f_c) + Y_{VSB}(f + f_c)$$
$$M(f) = E(f)\cdot H_o(f) = \left[Y_{VSB}(f - f_c) + Y_{VSB}(f + f_c)\right] H_o(f)$$
$$x(t) = 2m(t)\cos(2\pi f_c t) \rightarrow X(f) = \underline{M(f - f_c) + M(f + f_c)}$$
$$Y_{VSB}(f) = X(f)H_i(f)$$
$$= \underline{M(f - f_c)H_i(f) + M(f + f_c)H_i(f)}$$

$$M(f) = \Big[\cancel{M(f - 2f_c)H_i(f - f_c)} + M(f)H_i(f - f_c) + M(f)H_i(f + f_c)$$
$$+ \cancel{M(f + 2f_c)H_i(f + f_c)}\Big] H_o(f)$$

↙ AGF'den geçmezler

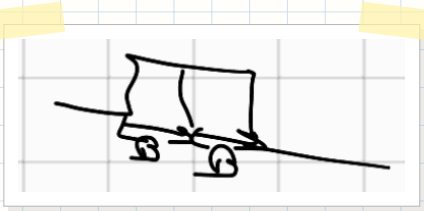
$$\cancel{M(f)} = \cancel{M(f)}\left[H_i(f - f_c) + H_i(f + f_c)\right] H_o(f)$$

$$H_o(f) = \frac{1}{H_i(f - f_c) + H_i(f + f_c)}, \qquad |f| \le B \text{ iken}$$

Eğer $H_i(f - f_c) + H_i(f + f_c) = 1$, $\underbrace{-B \le f \le B}_{|f| \le B}$

orj. s. 7

$H_o(f) = 1,\ |f| \le B = \Pi\left(\frac{f}{2B}\right)$ ideal AGF



orijinal çizim, s. 7

VSB+C

$$A_{c,DSB\text{-}LC} < A_{c,VSB} < A_{c,SSB+C}$$

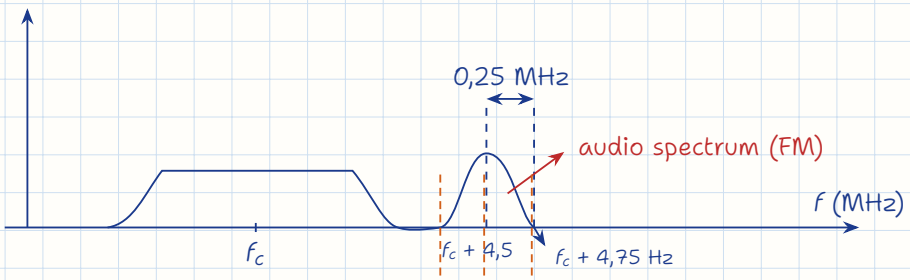
$$V_{DSB\text{-}LC} > V_{VSB+C} > V_{SSB+C}$$

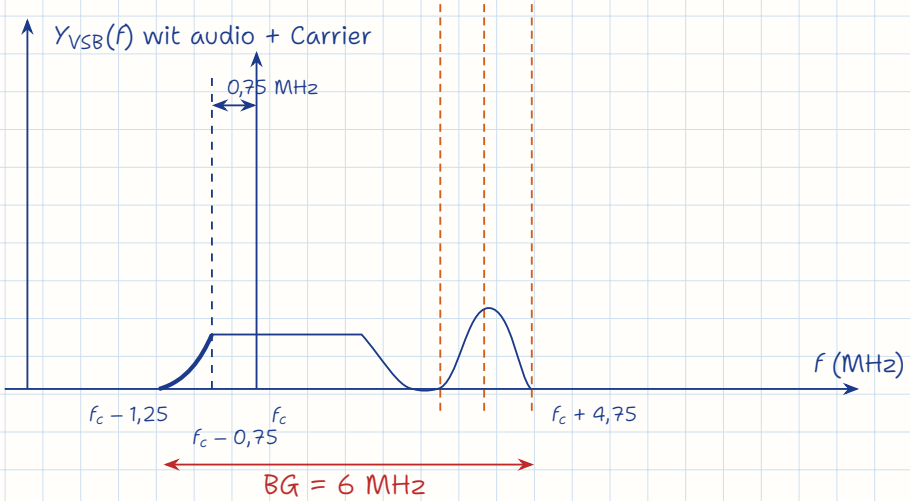
– Temel bant video işareti: (siyah beyaz) = 4,5 MHz

AYB → BG = 6 MHz

Television signal spectra

X(f) with audio spectrum





orj. s. 8

? Applications

Frequency Division Multiplexing (FDM)

(Frekans Bölmeli Çoklama – FBÇ)

