
ETHFE

High Frequency Electronics



Indholdsfortegnelse

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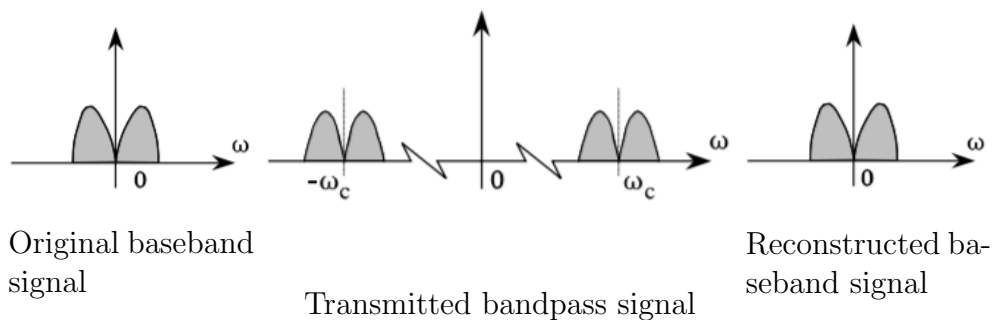
Amplitude modulation

1.1 Lektion 30-01-2018

1. Intro
2. AM Modulation/demodulation

- **Pensum:** JV, Ch 1 p 1-6
- **Opgaver:** P.I-1

1.1.1 Basic Modulation Types and Concepts



- **Modulation:** Hvordan signaler moduleres ind på bærebølger, der efterfølgende typisk sendes ud som elektromagnetiske signaler via et transmissionsmedie.
 - Bandpass signalet er det transmitterede signal til receiveren.
 - Flere baseband signals kan blive transmitteret samtidigt gennem den samme kanal ved forskellige carrier frequencies.

- **Demodulation:** Hvordan det sendte signal demoduleres så det originale signal gendannes.
 - Receiveren gendanner det low-frequency baseband signal.
 - Scopet af demodulationen afhænger af hvilken type data der bliver sendt.
 - * *In a radio telephony channel it may suffice at the receiver site to get an output with a power spectrum that contains the dominant part of the input power spectrum.*
 - * *In a television video channel it is important to reconstruct in time-domain the shape of the signal being send.*
 - * *In digital transmissions, the goal is to rebuild a logical bitstream representation equivalent to the input stream.*

1.1.2 Amplitude Modulations

Typer af moduleringer der er egnet for RF communication kaldes continuous wave modulations, **CW**.

- Baseband information er overlagt en sinusoidal carrier wave med amplitude A_{c0} og vinkelfrekvens ω_c .
 - *Carrier* 1.1
 - *Modulated carrier* 1.2

$$y(t) = A_{c0} \cos(\omega_c t) \quad (1.1)$$

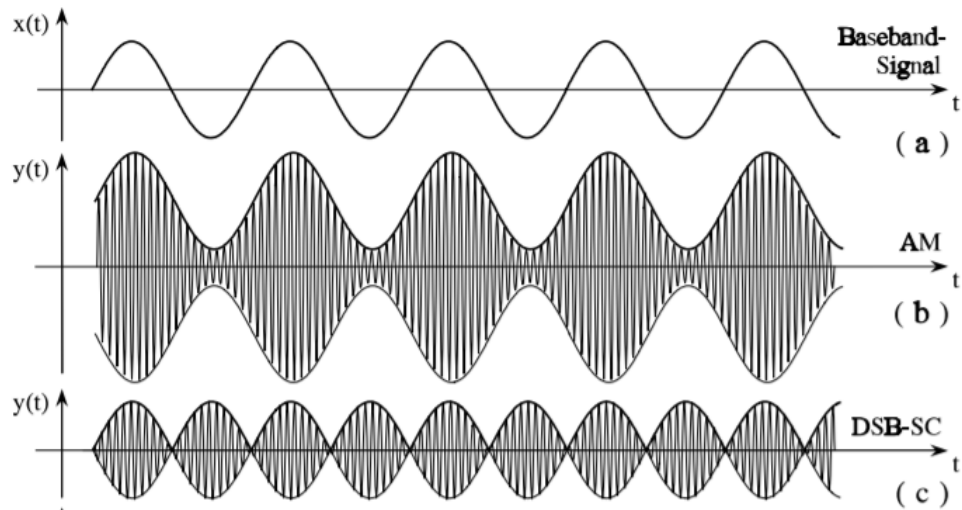
$$y(t) = A(t) \cos(\omega_c t + \phi(t) + \phi_0) \quad (1.2)$$

- *The time dependencies of $A(t)$ and $\phi(t)$ in 1.2 contain the baseband message and the angle ϕ_0 represents an offset phase for the carrier compared to the timing of the baseband message.*
- *If there is no synchronism between the two, the offset may be set to zero without loss of generality. Eq. 1.2 is called the envelope-phase representation of a modulated signal.*

Den største forskel mellem forskellige modulation typer er hvordan et baseband signal $x(t)$ indeholder det overlagte signal $y(t)$ som er moduleret. Amplitude modulations indebærer **AM** and **DSB-SC**.

AM

- Skalering af signalniveauerne beregnes ved modulation index m .
- Med et normaliseret baseband signal $|x(t)| \leq 1$, indebærer betingelsen $m \leq 1$ (eller 100%) et undistorted reproduction af baseband signalet.
 - m : modulation index
- Det er let at gendanne baseband signalet fra en AM modulated wave i en receiver med det simple envelope detector circuit.



Figur 1.1: Examples of modulation waveshapes (AM and DSB(-SC)) from a sinusoidal baseband signal $x(t)$.

- Amplitude modulation, $\phi(t) = 0$
 - *amplitude modulation, AM* 1.3
 - *double-sideband (supressed carrier), DSB/DSB-SC* 1.4

$$y(t) = A_{c0}(1 + mx(t)) \cos(\omega_c t) \quad (1.3)$$

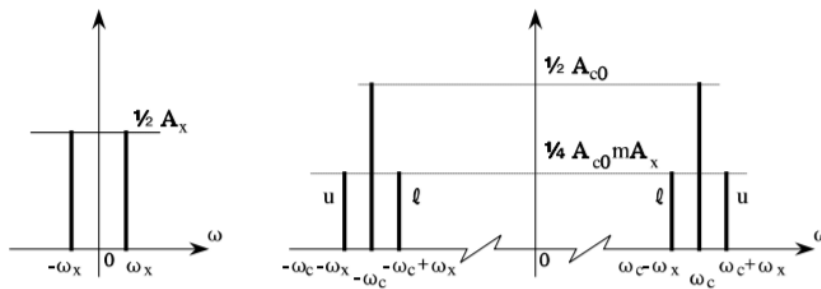
$$y(t) = A_{c0}x(t) \cos(\omega_c t) \quad (1.4)$$

- Envelope detectorens low-pass filter bandwidth skal være højere end envelope frekvensen.

- En AM modulated wave har spektrale komponenter fra baseband signalet over og under carrier signalet.

$$y(t)|_{AM} = A_{c0}(1 + mA_x \cos \omega_x t) \cos \omega_c t \Rightarrow \quad (1.5)$$

$$A_{c0} \cos \omega_c t + \frac{A_{c0}}{2} mA_x \cos(\omega_c - \omega_x)t + \frac{A_{c0}}{2} mA_x \cos(\omega_c + \omega_x)t \quad (1.6)$$



Figur 1.2: Spectral components in a double-sided amplitude spectrum of the sinusoidal baseband signal and the AM modulated waveform from Eq. 1.6. *u* and *l* are the upper and lower sideband components.

With maximum undistorted modulation, i.e. $m = 1$ and $A_x = 1$, the power of the AM modulated wave, say it is a voltage across a 1Ω resistor, becomes;

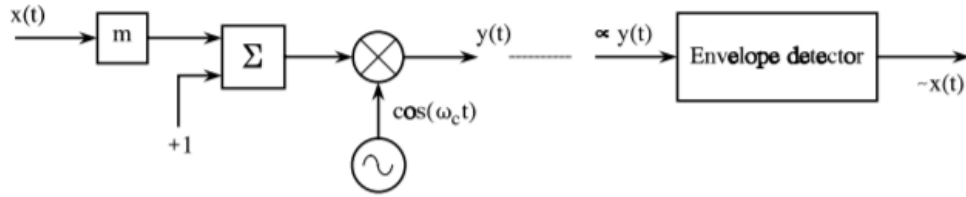
$$P_{AM} = 2 \frac{A_{c0}^2}{4} + 4 \frac{A_{c0}^2 m^2 A_x^2}{16} \quad (1.7)$$

carrier *envelope*

$$P_{AM} = \frac{1}{2} A_{c0}^2 + \frac{1}{4} A_{c0}^2 \quad (1.8)$$

so at most 33% of the transmitted power contains the message from the baseband signal.

- AM modulated signal i frekvens domænet:
 - Anvender eulers formel ($\cos 2\pi t \rightarrow e^{j2\pi\omega_c t} + e^{-j2\pi\omega_c t}$)
 - Fourier transform (gange i tidsdomænet · og folde i frekvensdomænet \otimes)



Figur 1.3: Block schemes for simple AM modulation (left) and demodulation (right).

DSB-SC

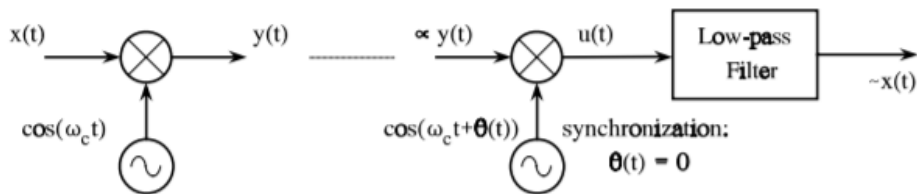
DSB moduleringen fra Eq. 1.4 har ingen carrier component deraf kommer betegnelsen *suppressed carrier* eller SC.

$$y(t)|_{DSB-SC} = A_{c0}A_x \cos \omega_x t) \cos \omega_c t \quad (1.9)$$

$$y(t)|_{DSB-SC} = \frac{A_{c0}A_x}{2} \cos(\omega_c - \omega_x)t + \frac{A_{c0}A_x}{2} \cos(\omega_c + \omega_x)t \quad (1.10)$$

- Carrier componenterne indeholder ingen information, derfor er det mere kompliceret at gendanne baseband signalet i receiveren.
- For at kunne detektere baseband signalet fra et DSB moduleret signal, skal dette signal igen multipliceres med en carrier.
 - Hvis fasen $\phi(t)$ er forskellig fra nul vil cosine enten reducerer eller forvrænge signalet.
 - For at få et predictable result skal oscillatoren i demodulatoren være synkroniseret med carrier af det modtagede signal.
 - *A simple method is to let a fragment of the full carrier - a pilot carrier - follow the signal.*

* Gøres ved at indsætte en konstant < 1 istedet for 1.



Figur 1.4: Block schemes for simple DSB-SC modulation (left) and demodulation (right).

Frequency modulation

Phase modulation
