TSKS10 Signaler, information & Kommunikation

Föreläsning 2

Basbandsrepresentation, Samplade system

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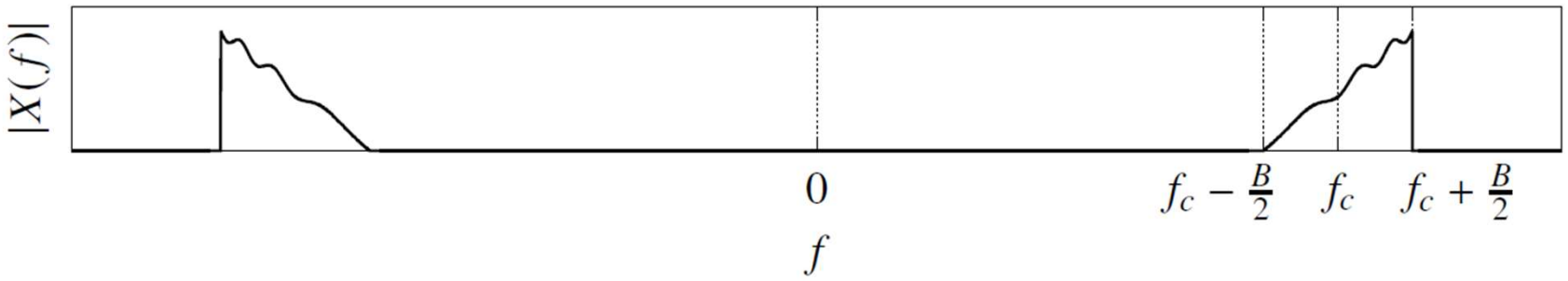
Spektrum $X(f)$ av smalbandig signal $x(t)$

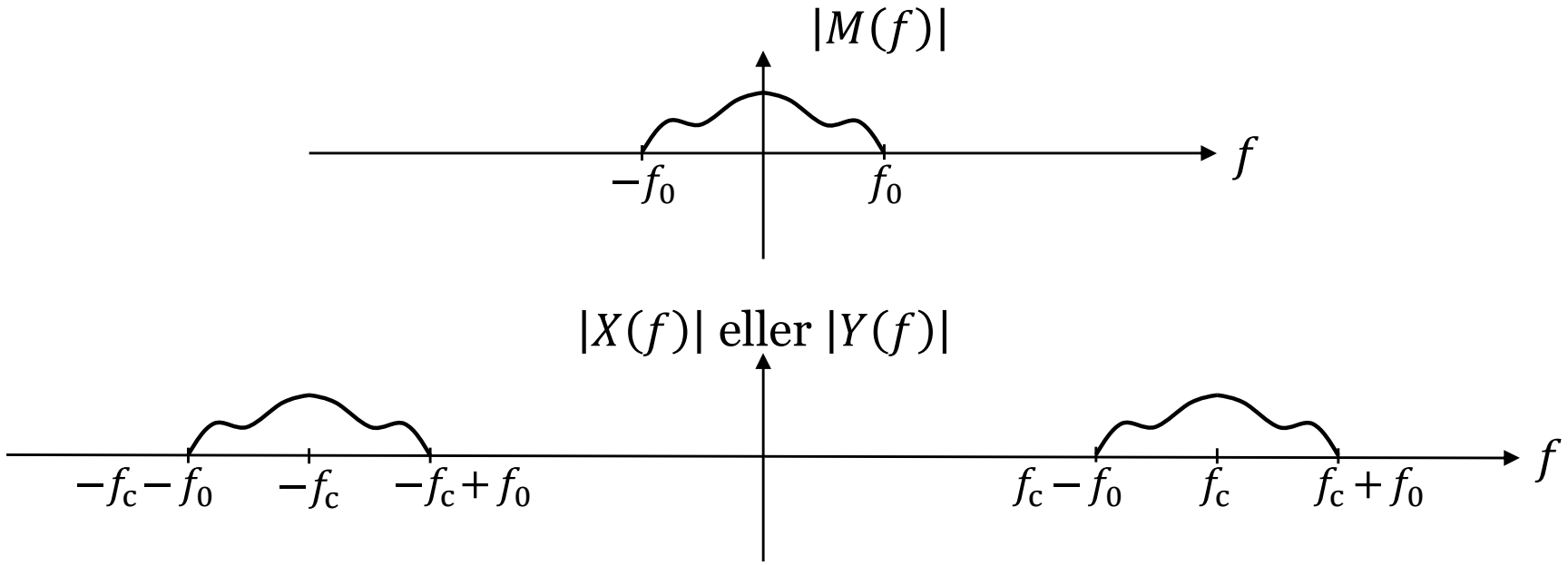


Figur 2.5 ur kursboken

Amplitudmodulation

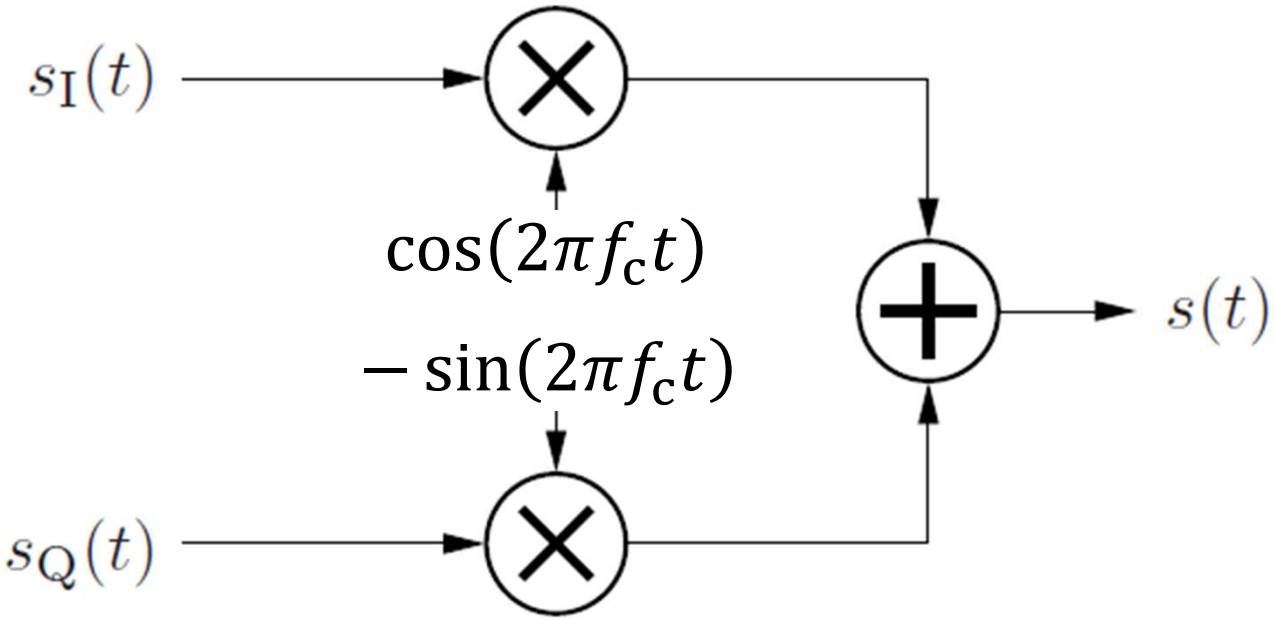
$$x(t) = m(t)\cos(2\pi f_c t) \qquad X(f) = \frac{1}{2}[M(f + f_c) + M(f - f_c)]$$

$$y(t) = m(t)\sin(2\pi f_c t) \qquad Y(f) = \frac{j}{2}[M(f + f_c) - M(f - f_c)]$$



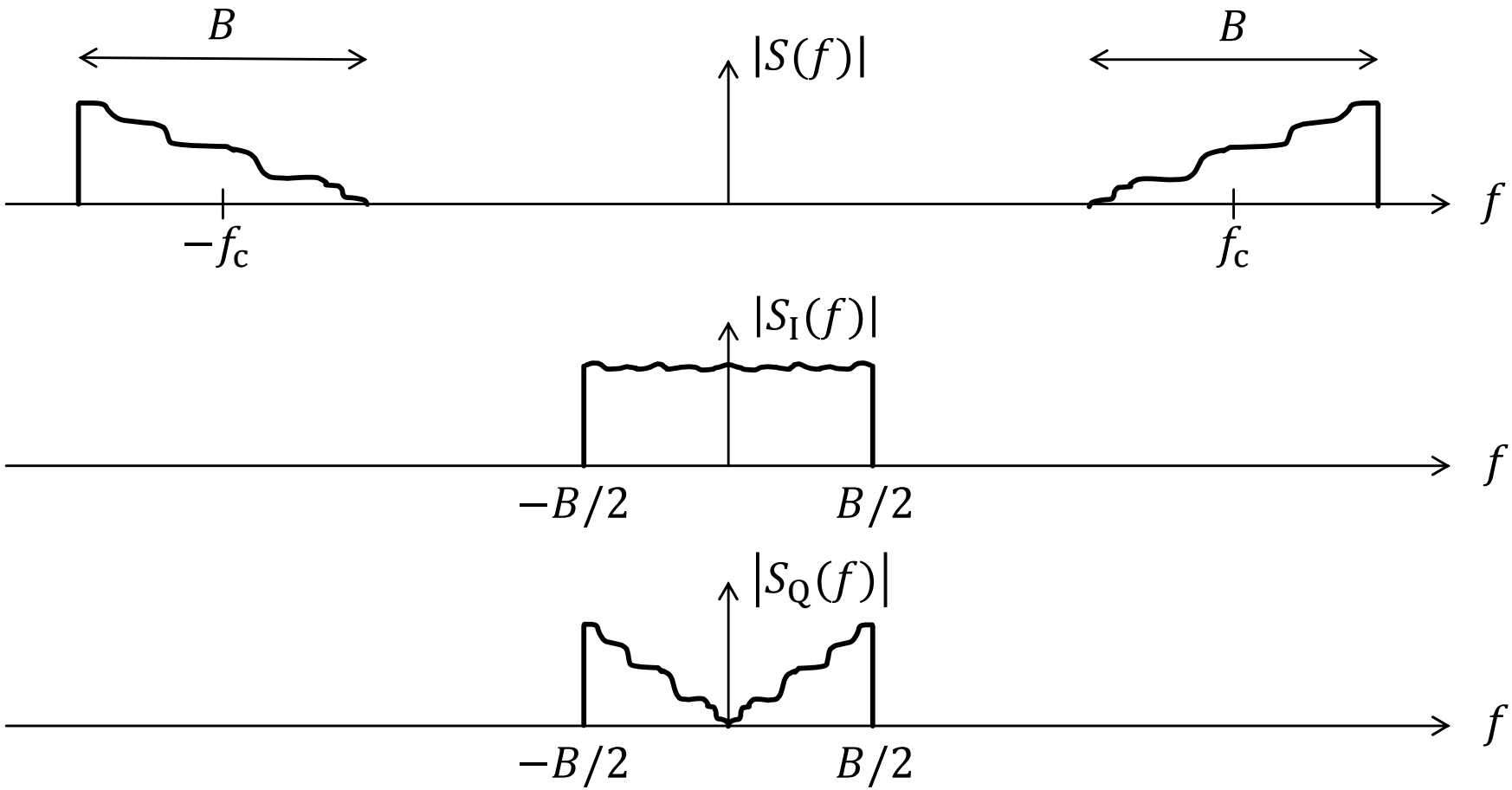
I/Q-modulation

BP signal: $s(t) = s_{\mathrm{I}}(t)\cos(2\pi f_{\mathrm{c}} t) - s_{\mathrm{Q}}(t)\sin(2\pi f_{\mathrm{c}} t)$



Complex envelope: $\tilde{s}(t) = s_{\mathrm{I}}(t) + j s_{\mathrm{Q}}(t)$

I/Q-representation passbandssignal



Figur 2.7 ur kursboken

I/Q-demodulation 1(2)

$$s(t) = s_{\mathrm{I}}(t)\cos(2\pi f_{\mathrm{c}}t) - s_{\mathrm{Q}}(t)\sin(2\pi f_{\mathrm{c}}t)$$

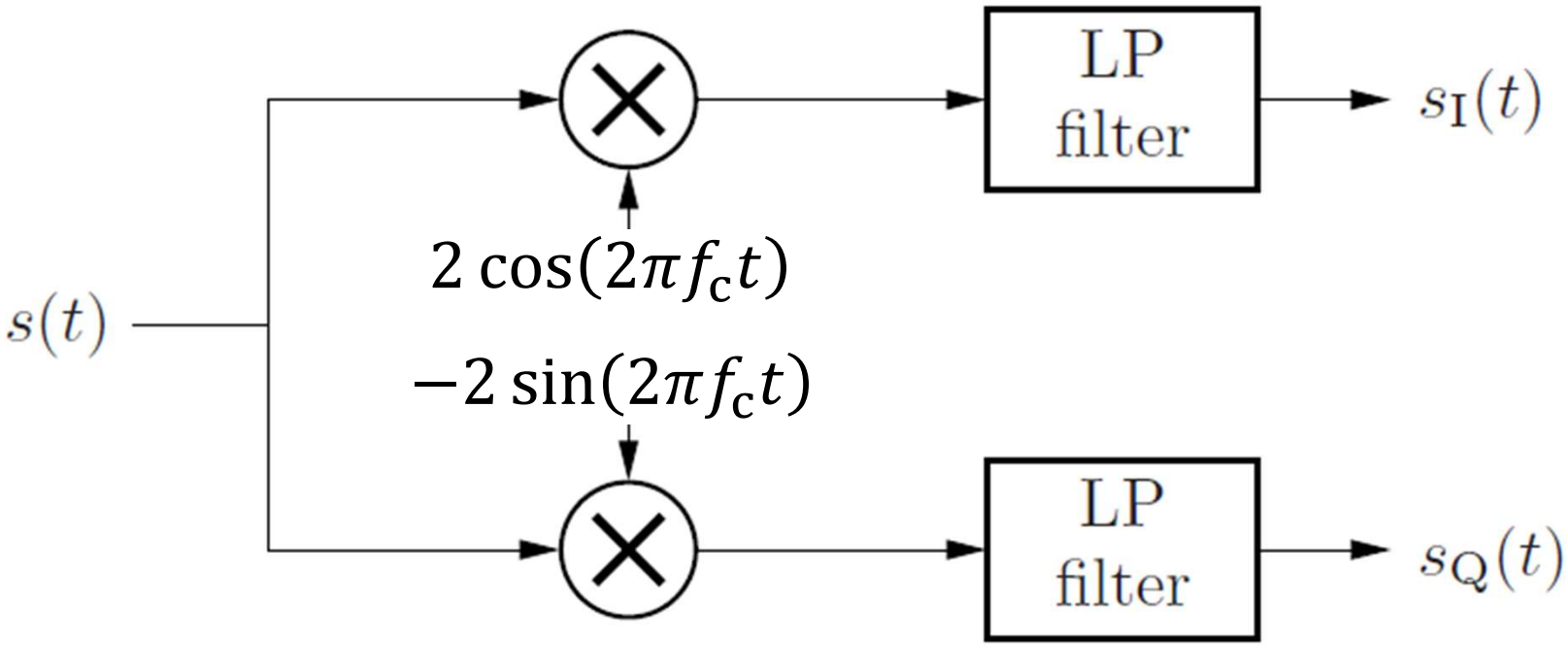
$$2s(t)\cos(2\pi f_{\mathrm{c}}t) = 2s_{\mathrm{I}}(t)\cos^2(2\pi f_{\mathrm{c}}t) - 2s_{\mathrm{Q}}(t)\sin(2\pi f_{\mathrm{c}}t)\cos(2\pi f_{\mathrm{c}}t)$$
$$= s_{\mathrm{I}}(t)[1 + \cos(4\pi f_{\mathrm{c}}t)] - s_{\mathrm{Q}}(t)\sin(4\pi f_{\mathrm{c}}t)$$

$$\mathcal{F}\{2s(t)\cos(2\pi f_{\mathrm{c}}t)\} =$$
$$= S_{\mathrm{I}}(f) + \frac{1}{2}\left[S_{\mathrm{I}}(f - 2f_{\mathrm{c}}) + S_{\mathrm{I}}(f + 2f_{\mathrm{c}}) + jS_{\mathrm{Q}}(f - 2f_{\mathrm{c}}) - jS_{\mathrm{Q}}(f + 2f_{\mathrm{c}})\right]$$

$$-2s(t)\sin(2\pi f_{\mathrm{c}}t) = -2s_{\mathrm{I}}(t)\cos(2\pi f_{\mathrm{c}}t)\sin(2\pi f_{\mathrm{c}}t) + 2s_{\mathrm{Q}}(t)\sin^2(2\pi f_{\mathrm{c}}t)$$
$$= -s_{\mathrm{I}}(t)\sin(4\pi f_{\mathrm{c}}t) + s_{\mathrm{Q}}(t)[1 - \cos(4\pi f_{\mathrm{c}}t)]$$

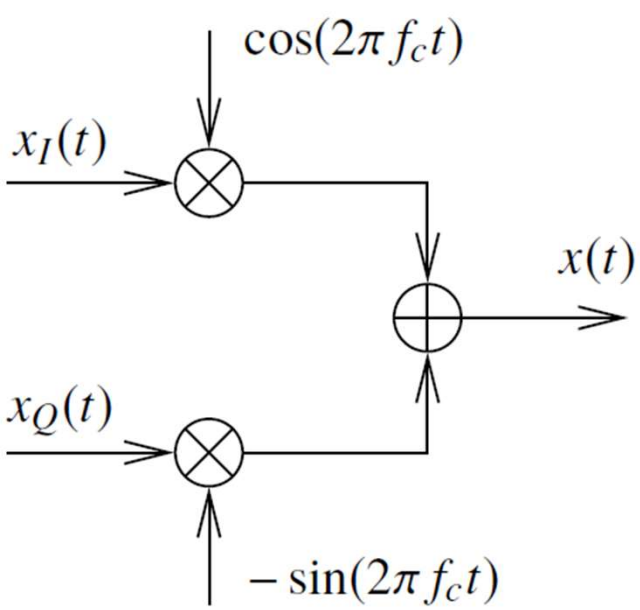
$$\mathcal{F}\{-2s(t)\sin(2\pi f_{\mathrm{c}}t)\} =$$
$$= S_{\mathrm{Q}}(f) + \frac{1}{2}\left[jS_{\mathrm{I}}(f - 2f_{\mathrm{c}}) - S_{\mathrm{I}}(f + 2f_{\mathrm{c}}) - S_{\mathrm{Q}}(f - 2f_{\mathrm{c}}) - S_{\mathrm{Q}}(f + 2f_{\mathrm{c}})\right]$$

I/Q-demodulation 2(2)

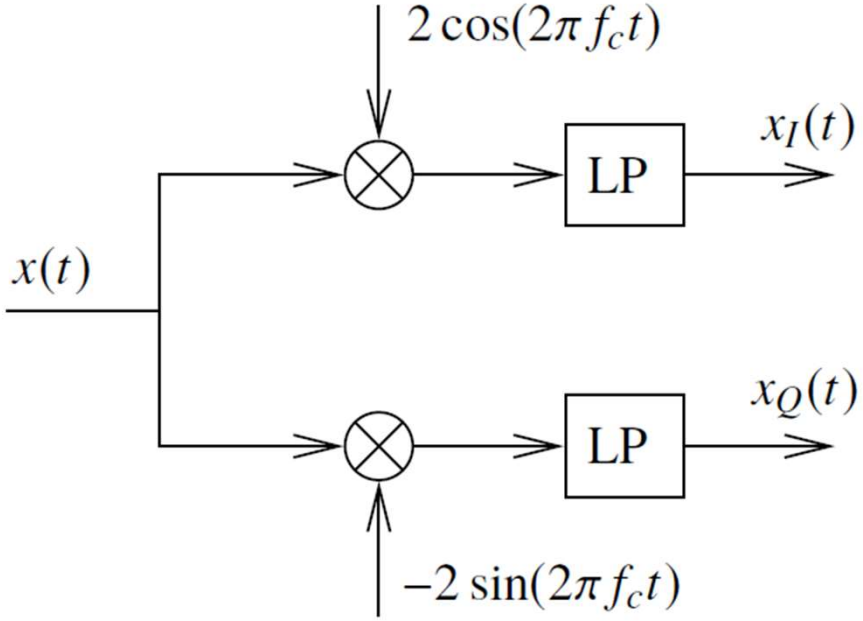


I/Q-modulator/demodulator – idealt fall

Sändare – Modulering

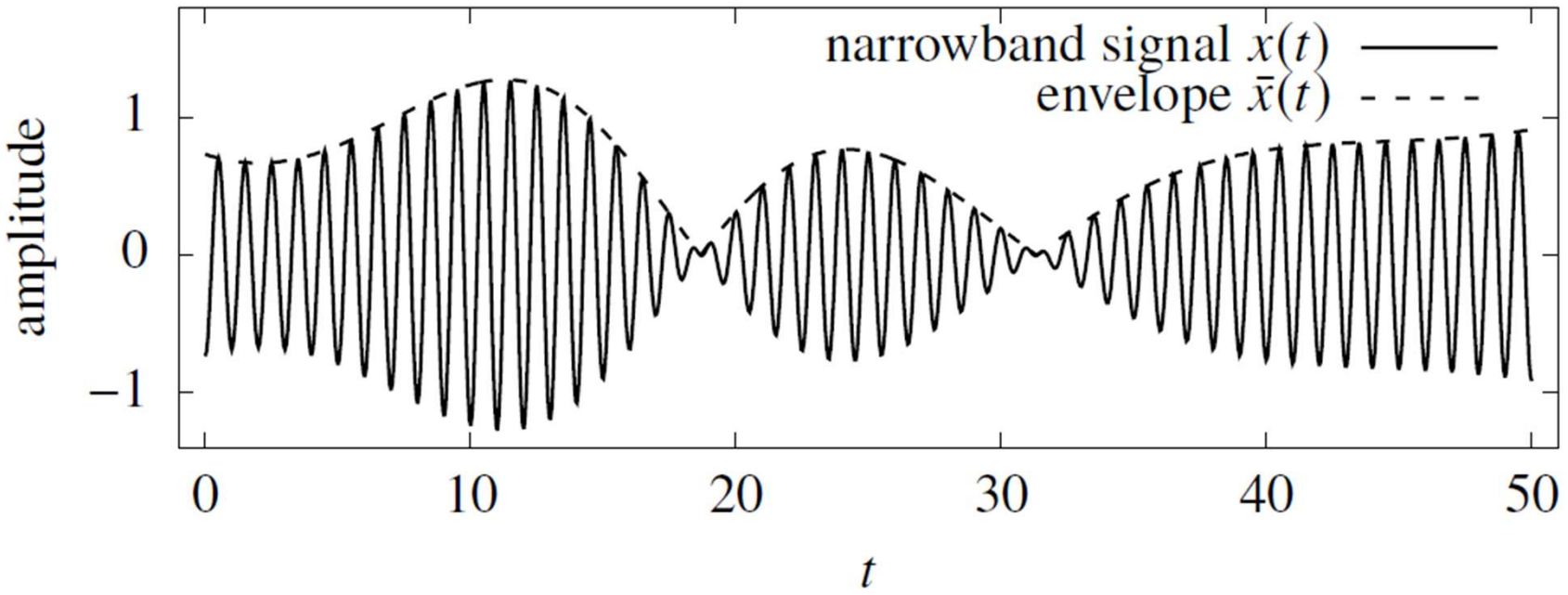


Mottagare – Demodulering



Figur 2.7 ur kursboken

Envelopp av smalbandig signal

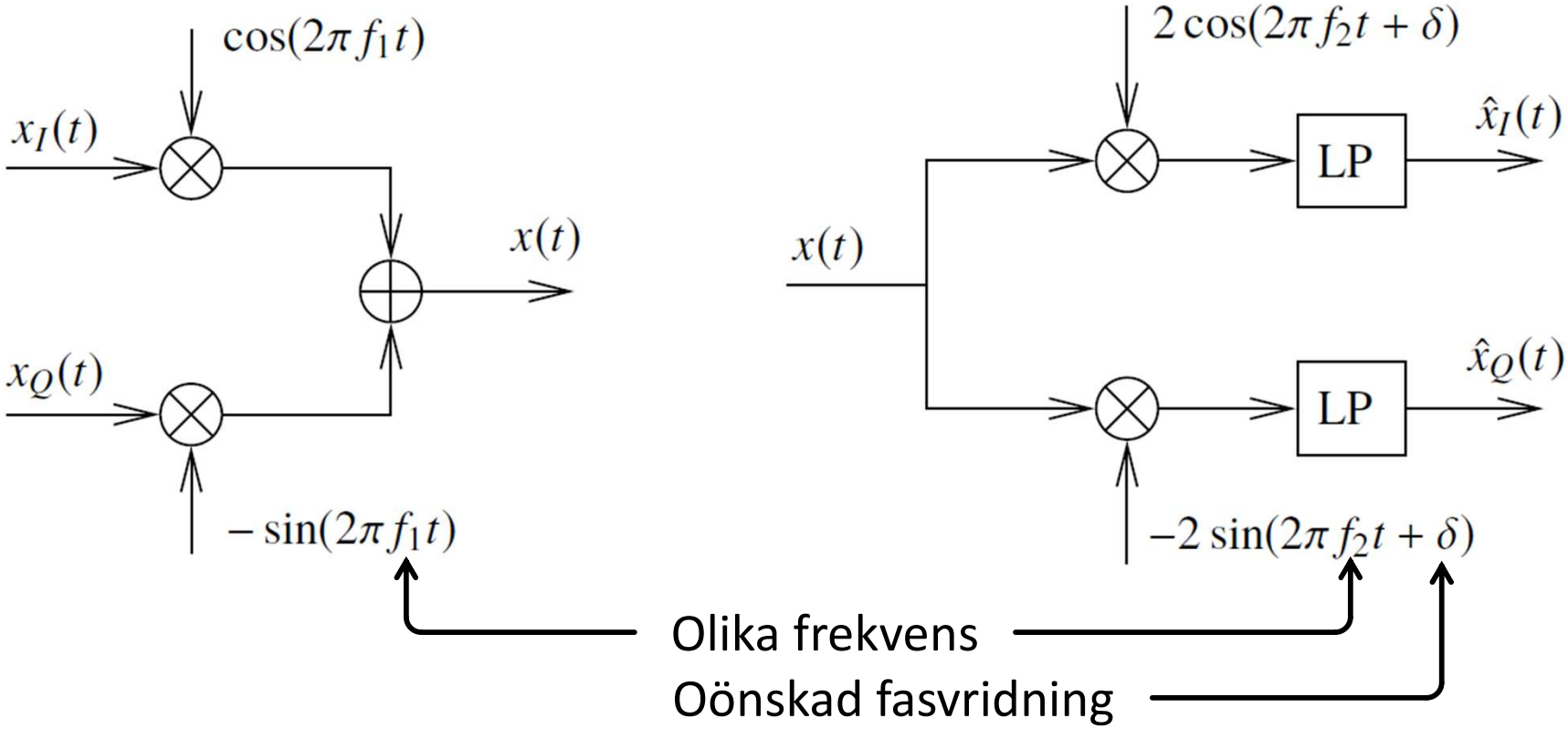


Figur 2.8 ur kursboken

I/Q-modulator/demodulator – verkligheten

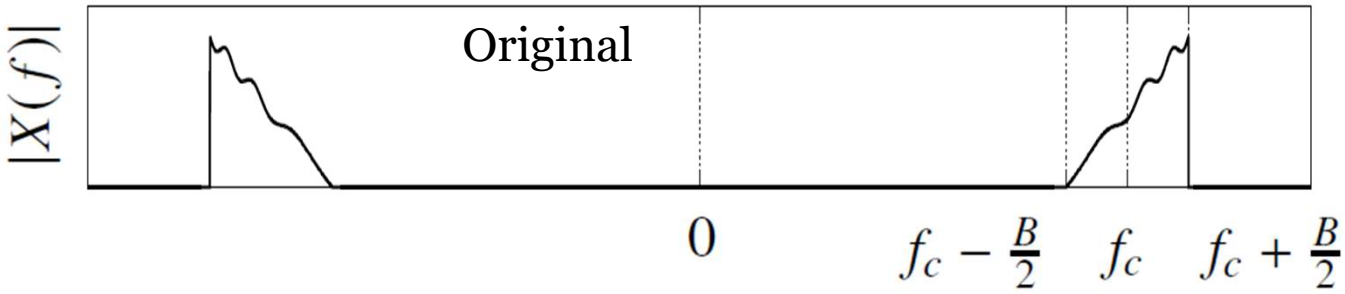
Modulering

Demodulering



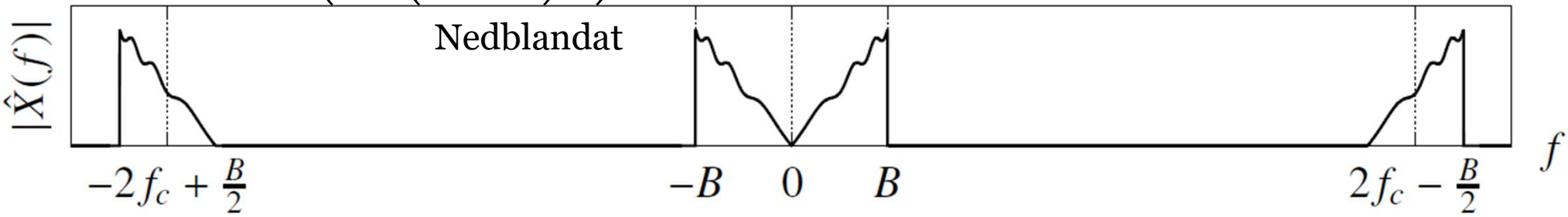
Kombination av figur 2.10 och 2.11 ur kursboken

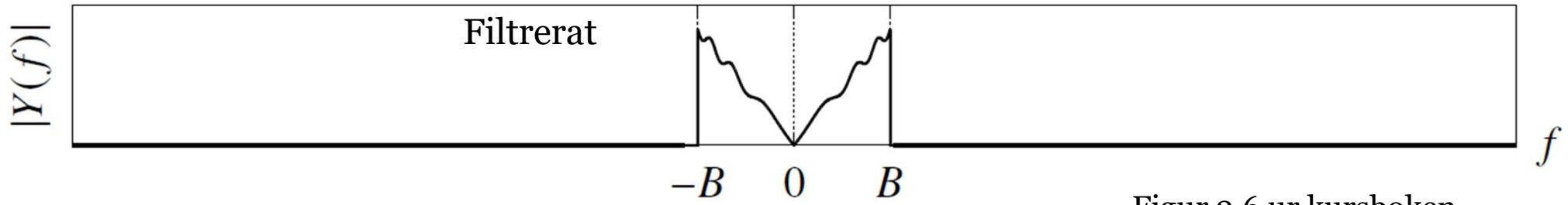
Direkt demodulation (nedblandning)



$$\hat{x}(t) = 2x(t)\cos\left(2\pi\left(f_c - \frac{B}{2}\right)t\right)$$

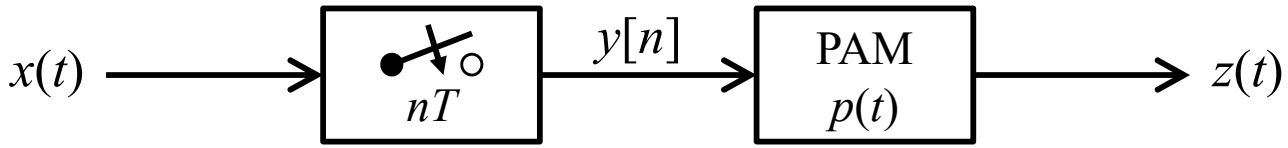
$$\hat{X}(f) = X\left(f + f_c - \frac{B}{2}\right) + X\left(f - f_c + \frac{B}{2}\right)$$





Figur 2.6 ur kursboken

Samplingsteoremet för deterministiska Signaler



Samplingsteoremet:

Betrakta en signal $x(t)$, med spektrum $X(f)$ och $X(f) = 0$ för $|f| \geq f_0$. Om $x(t)$ samplas med samplingsfrekvens f_s, då kan $x(t)$ rekonstrueras utan fel från den samplade signalen om $f_s \geq 2f_0$ gäller.

Detta betyder:

Det existerar en pulsform $p(t)$, sådan att $x(t)$ kan skrivas som

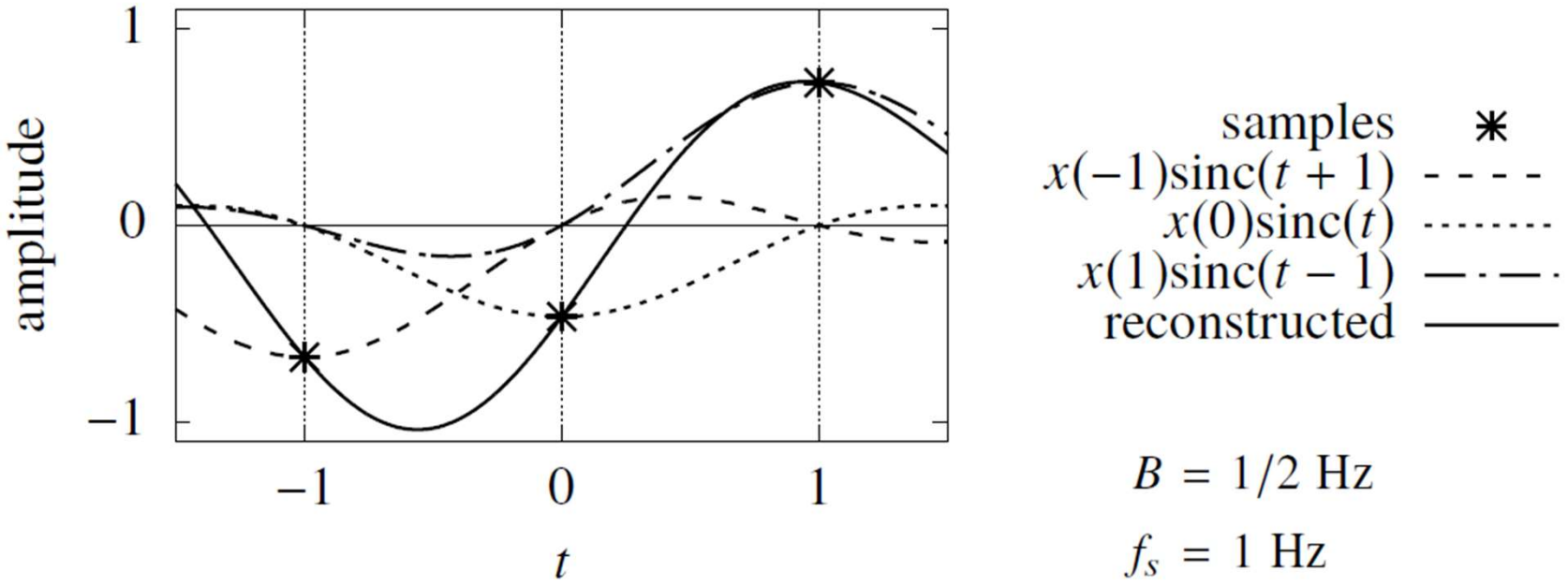
$$x(t) = \sum_n x(nT)\, p(t - nT)$$

om $f_s \geq 2f_0$ gäller, med $f_s = 1/T$.

Uppfyllt för:

Ideal rekonstruktion: $p(t) = \mathrm{sinc}(t/T)$

Sampling och interpolation



Figur 5.6 ur kursboken

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