NÁZOV: PREDMET:

ROČNÍK:

ČÍSLO: ČÍSLO ZLOŽKY 8 3

Amplitúdová modulácia

nosný signál $n(t) = A\cos(\omega_0 t + \varphi)$

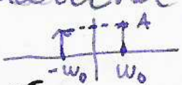
modulačný -||- $v(t) = V\cos\omega t$ $\qquad \omega_0 \gg \omega$

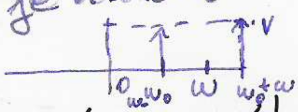
modulovaný -||- $s(t) = \dots$

amplitúda nosného sig. $A \Rightarrow A + v(t)$ okamžitá hodnota modulovaného sig.

$s(t) = (A + V\cos\omega t)\cos(\omega_0 t + \varphi)$

$\varphi \overset{!}{=} 0$ predpoklad, že počiatočná fáza je nulová





$s(t) = (A+V\cos\omega t)\cos(\omega_0 t) = A(\cos\omega_0 t + \frac{V}{A}\cos\omega t\cos\omega_0 t) =$

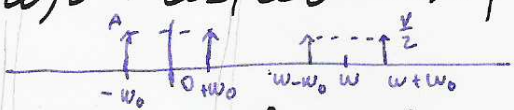
($\frac{V}{A}\cos\omega t\cos\omega_0 t$) reprezentuje modulačný teorém

$= A(\cos\omega_0 t + m\cos\omega t\cos\omega_0 t)$

Pri modulácii musíme vopred poznať vlastnosti spektra, ktoré chceme dostať, preto nás zaujíma frek. obl.

$s(t) = A\cos\omega_0 t + \frac{V}{2}\{\cos(\omega_0+\omega)t + \cos(\omega_0-\omega)t\}$

($A\cos\omega_0 t$) pôvodný nosný sig.



$m = \frac{V}{A}$ index (hĺbka) amplitúdovej modulácie

⇓ Spektrálna čiara v kmitočte ω_0 veľkosti A

⇓ ⇓ Spektrálna čiara v kmitočte $(\omega_0+\omega)$ a $(\omega_0-\omega)$ o veľkosti $\frac{V}{2}$

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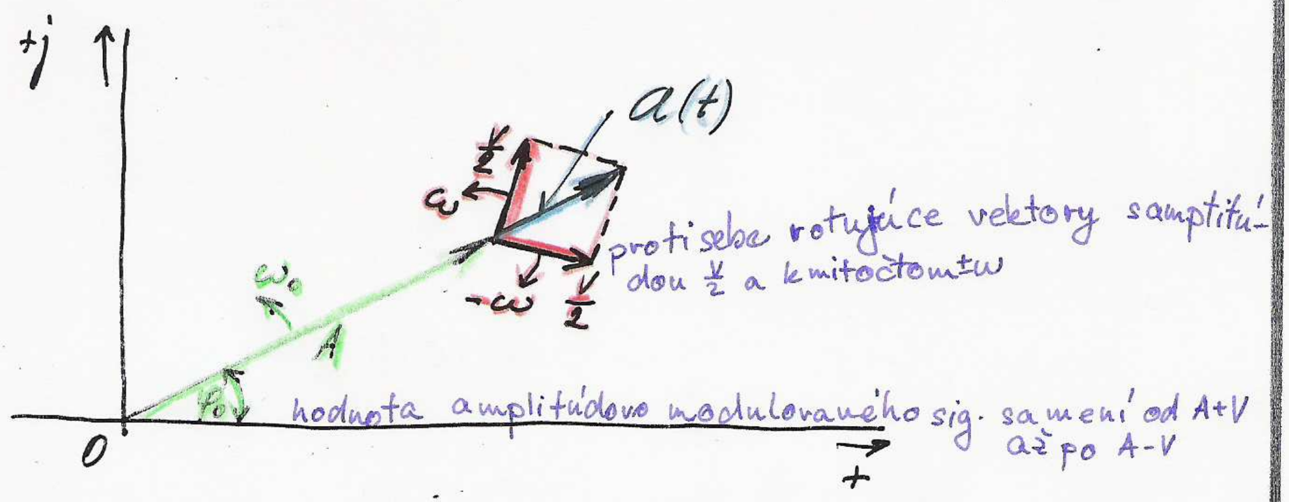
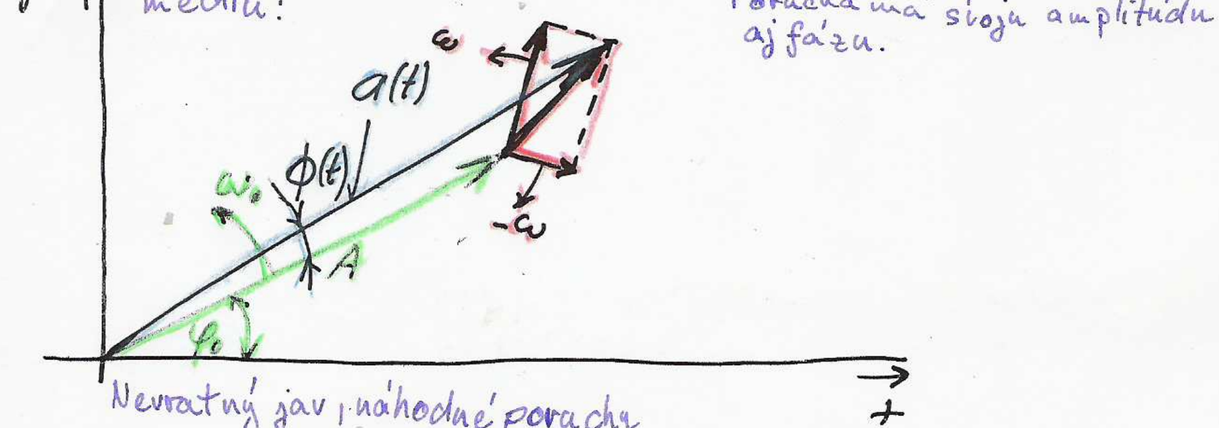


Poruchy pri amplitúdovej modulácii na prenosovom médiu:



$$a(t) = A + C(t) = A\left(1 + \frac{V}{A}\cos\omega t\right)$$

— • —

$c(t)$; $n(t)$

$$s(t) = [A + C(t)]\cos\omega_0 t = A\cos\omega_0 t + C(t)\cos\omega_0 t = s_1(t) + s_2(t)$$

$s_1(t)$ – harmonický signál

NÁZOV:

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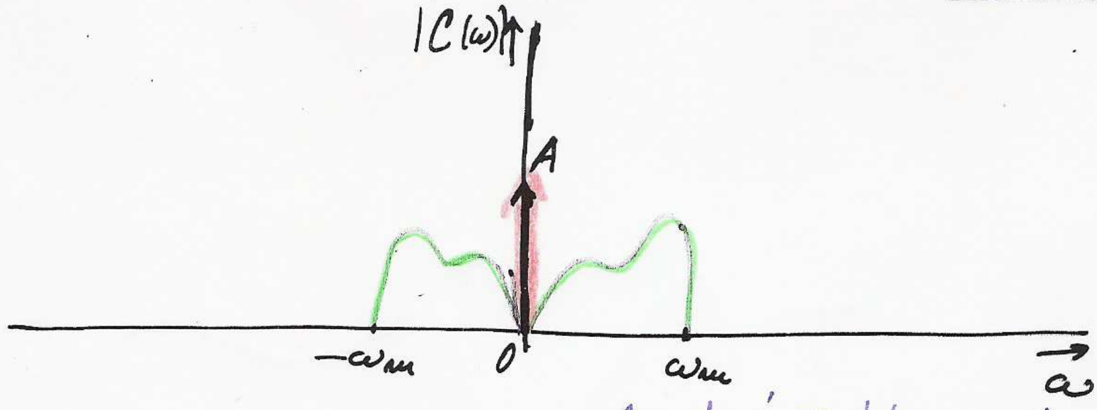
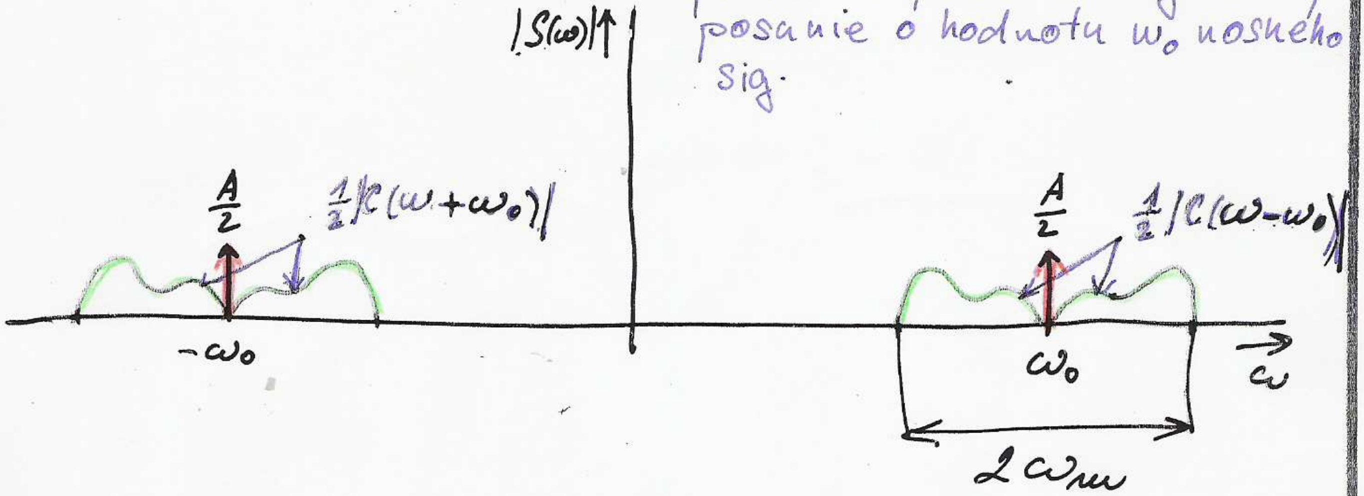
ČÍSLO ZLOŽKY 87



pôvodné spektrum sig. sa posunie o hodnotu w_0 nosného sig.



NÁZOV: PREDMET:

ROČNÍK:

ČÍSLO: ČÍSLO ZLOŽKY 88

$$s(t) = \{A + C(t)\}\cos\omega_0 t = A\cos\omega_0 t + c(t)\cos\omega_0 t$$

$$R = 1\,\Omega$$

$$P_s = \frac{1}{T_0}\int_0^{T_0} s^2(t)\,dt = \frac{1}{T_0}\int_0^{T_0}\{A^2\cos^2\omega_0 t + 2AC(t)\cos^2\omega_0 t + C^2(t)\cos^2\omega_0 t\}\,dt$$

Pre nosnú frekv.

$$P_n = \frac{1}{T_0}\int_0^{T_0} A^2\cos^2\omega_0 t\,dt = \frac{A^2}{T_0}\left[\frac{1}{2}t + \frac{1}{4\omega_0}\sin 2\omega_0 t\right]_0^{T_0} =$$

$$= \frac{A^2}{T_0}\left[\frac{T_0}{2} + \frac{1}{4\omega_0}\underbrace{\sin\frac{4\pi T_0}{T_0}}_{\emptyset}\right] = \frac{A^2}{2}$$

keďže

$$\frac{1}{T_0}\int_0^{T_0} A^2\cos^2\omega_0 t\,dt = \frac{1}{2}A^2 \Rightarrow \frac{1}{T_0}\int_0^{T_0}\cos^2\omega_0 t\,dt = \frac{1}{2}$$

NÁZOV:

PREDMET:

ROČNÍK:

ČÍSLO:

ČÍSLO ZLOŽKY

89

$$P_s = P_u + \frac{1}{T_0}\int_0^{T_0} C^2(t)\cos^2\omega_0 t\,dt + \frac{1}{T_0}\int_0^{T_0} 2AC(t)\cos^2\omega_0 t\,dt$$

$$\frac{1}{T_0}\int_0^{T_0} C^2(t)\cos^2\omega_0 t\,dt = \overline{C^2(t)\cdot\cos^2\omega_0 t} = \overline{C^2(t)}\cdot\overline{\cos^2\omega_0 t} = \frac{1}{T_0}\int_0^{T_0} C^2(t)\,dt \cdot \underbrace{\frac{1}{T_0}\int_0^{T_0}\cos^2\omega_0 t\,dt}_{=\frac{1}{2}}$$

$$P_s = P_u + \underbrace{\frac{1}{2T_0}\int_0^{T_0} C^2(t)\,dt}_{2P_p} + \frac{2A}{T_0}\cdot\frac{1}{2}\underbrace{\int_0^{T_0} C(t)\,dt}_{=\emptyset}$$

$$P_s = \frac{1}{2}A^2 + \frac{1}{2}\overline{C^2(t)} = P_u + 2P_p$$

$$m = \frac{V}{A}$$

$$2P_p = \frac{1}{2}\overline{C^2(t)} = \frac{1}{2}\frac{V^2}{A^2}\cdot A^2\overline{C_u^2(t)} = \frac{1}{2}m^2A^2\overline{C_u^2(t)}$$

NÁZOV:

PREDMET:

ROČNÍK:

ČÍSLO:

ČÍSLO ZLOŽKY 90

$$\alpha = \frac{V}{C_{ef}}$$ — max. hodnota ; — efekt. hodnota

α – vrcholový činiteľ

$$\alpha = \frac{V}{\sqrt{\overline{C^2(t)}}} = \frac{1}{\sqrt{\overline{C_n^2(t)}}} \rightarrow \sqrt{\overline{C_n^2(t)}} = \frac{1}{\alpha}$$

$$\overline{C_n^2(t)} = \frac{1}{\alpha^2}$$

$$P_s = \frac{1}{2} A^2 \left(1 + m^2 \overline{C_n^2(t)}\right) = \frac{1}{2} A^2 \left(1 + \frac{m^2}{\alpha^2}\right)$$

Nech

$$c(t) = V \cos \omega t \quad \rightarrow \alpha = \sqrt{2}$$

$$P_s = \frac{1}{2} A^2 \left(1 + \frac{m^2}{2}\right) = P_n \left(1 + \frac{m^2}{2}\right)$$

pre $m = 1$

$$P_s = P_n + \frac{1}{2} P_n = P_n + 2 P_p$$

$$P_n = \frac{2}{3} P_s$$

NÁZOV:

PREDMET:

ROČNÍK:

ČÍSLO:

ČÍSLO ZLOŽKY 9 1

T.f. signál $\alpha \doteq 8$

$$P_s = \left(1 + \frac{m^2}{\alpha^2}\right) P_m = \left(1 + \frac{m^2}{64}\right) P_m$$

$m = 1$

$$P_s = \frac{64+1}{64} P_m \Rightarrow \quad P_m = \frac{64}{65} P_s$$

$$2 P_p = \frac{1}{64} P_m$$

$$P_s = P_m + \frac{1}{64} P_m$$

$$P_{smax} = A^2 (1+m)^2 \quad \text{ak} \quad c_m(t) = 1$$

$$s(t) = A[1 + m\, c_n(t)] \cos \omega_0 t$$

$m = 1 \qquad P_{smax} = 4A^2$

Pr.

$m(t) = 5 \cos \omega_0 t$

$m = 80\%$; $\alpha = 8$

$P_s = ?$; $P_{smax} = ?$; $P_m = ?$; $P_p = ?$

$$m = \frac{V}{A} \Rightarrow V = mA = 0{,}8 \cdot 5 = 4V$$

$$\overline{c^2(t)} = \frac{V^2}{\alpha^2} = \frac{4^2}{8^2} = \frac{1}{4} W \; ; \; c_m(t) = \frac{c(t)}{V} \; ;$$

$$\overline{c_m^2(t)} = \frac{\overline{c^2(t)}}{V^2} = \frac{1}{4 \cdot 16} = \frac{1}{64}$$

$$P_p = \frac{1}{4} m^2 A^2 \overline{c_m^2(t)} = \frac{1}{4} \cdot 0{,}8^2 \cdot 5^2 \cdot \frac{1}{64} = \frac{1}{16} W$$

$$P_S = P_n + 2P_p = \frac{1}{2}A^2 + 2P_p = \frac{25}{2} + \frac{2}{16} = 12{,}625 W$$

$$P_n = 12{,}5 W$$

$$P_{smax} = A^2(1+m)^2 = 5^2(1+0{,}8)^2 = 81 W$$

NÁZOV:

PREDMET:

ROČNÍK:

ČÍSLO:

ČÍSLO ZLOŽKY 9 3

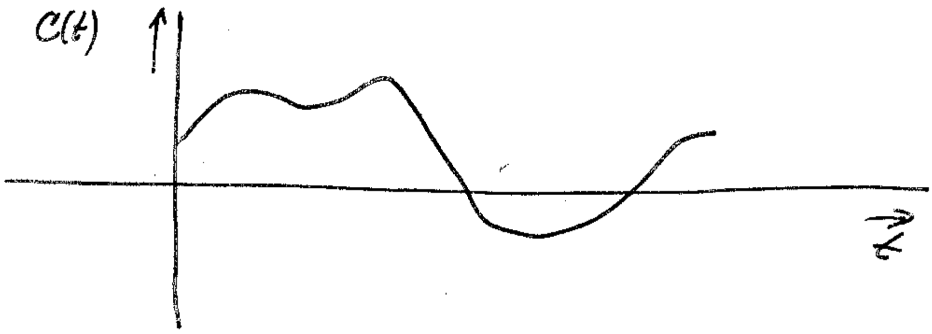
AM s potlačenou nosnou

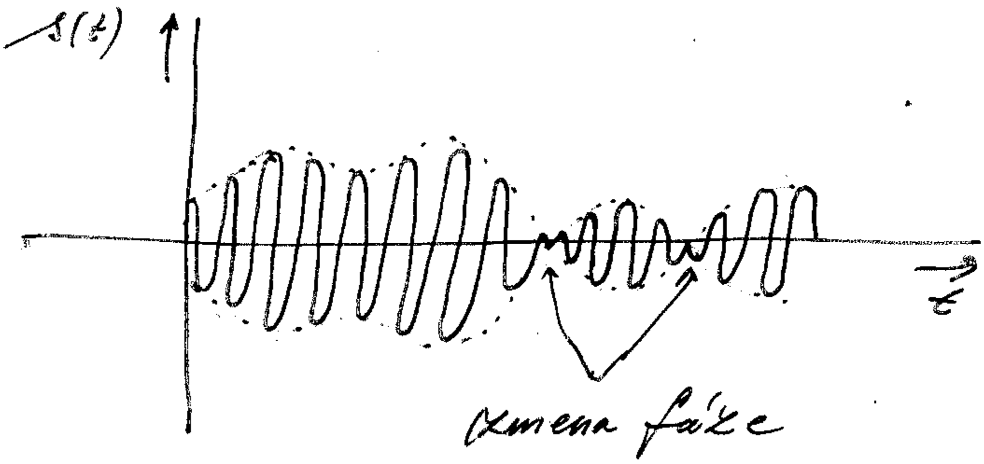
DSB (DSB − SC)

$$s(t) = A\cos\omega_0 t + C(t)\cos\omega_0 t = s_1(t) + s_2(t)$$

DSB

$$s(t) = C(t)\cos\omega_0 t$$





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PREDMET:

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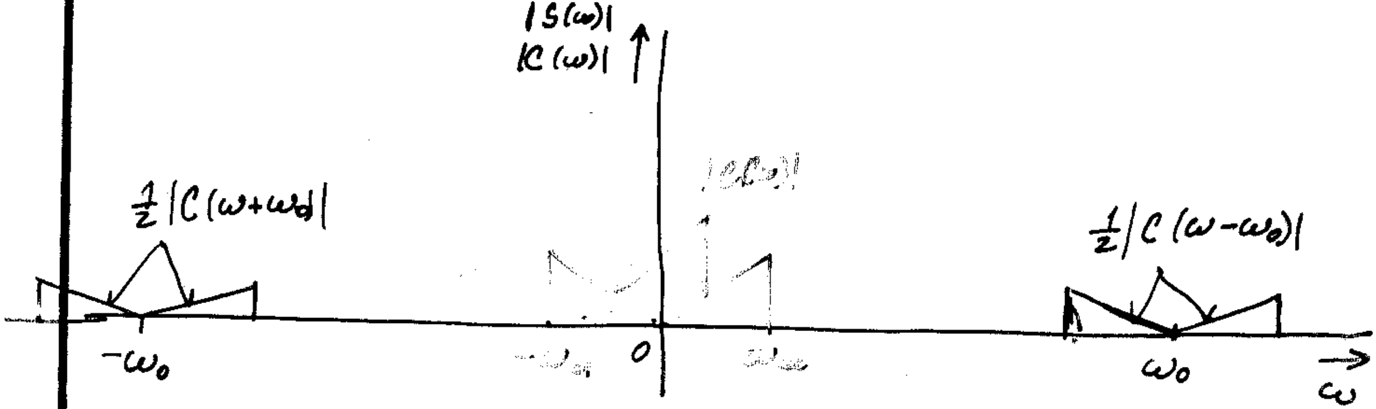
ČÍSLO ZLOŽKY

		9	4

$$S(\omega) = \frac{1}{2} C(\omega-\omega_0) + \frac{1}{2} C(\omega+\omega_0)$$



$$P_s(\omega) = \frac{1}{T_0}\int_0^{T_0} s^2(t)\,dt = \frac{1}{T_0}\int_0^{T_0} c^2(t)\cos^2\omega_0 t\,dt = \frac{1}{2}\overline{c^2(t)}$$

NÁZOV: PREDMET:

ROČNÍK:

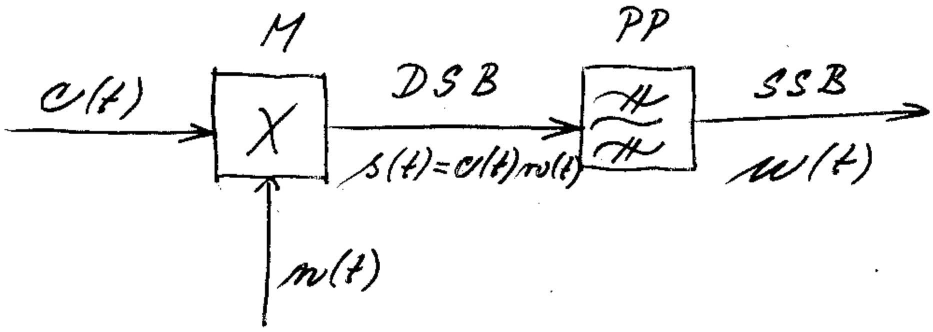
ČÍSLO: ČÍSLO ZLOŽKY 95

Telekomunikačné systémy s lineárnou moduláciou.

Dvojpásmový systém s nosnou frekvenciou
Dvojpásmový systém s potlačenou nosnou frekvenciou
Dvojpásmový systém s čiastočne potlačenou nosnou frekvenc.
Jednopásmový systém s nosnou frekvenciou
Jednopásmový systém s čiastočne potlačenou nosnou frekvenc.
Jednopásmový systém
Systém s nesymetricky potlačeným pásmom

Jednopásmová modulácia

1. Jednopásmová modulácia s použitím PP filtra



$$s(t) = v(t)\, A\cos\omega_0 t = VA\cos\omega t\cos\omega_0 t$$

$$v(t) = V\cos\omega t$$

NÁZOV: PREDMET:

ROČNÍK:

ČISLO: ČISLO ZLOŽKY 96

$$s(t) = VA\cos\omega t\cos\omega_0 t = \frac{1}{2}VA\{\cos(\omega_0-\omega)t + \cos(\omega_0+\omega)t\}$$

Horná postranná zložka

$$u_1(t) = \frac{1}{2}VA\cos(\omega_0+\omega)t$$

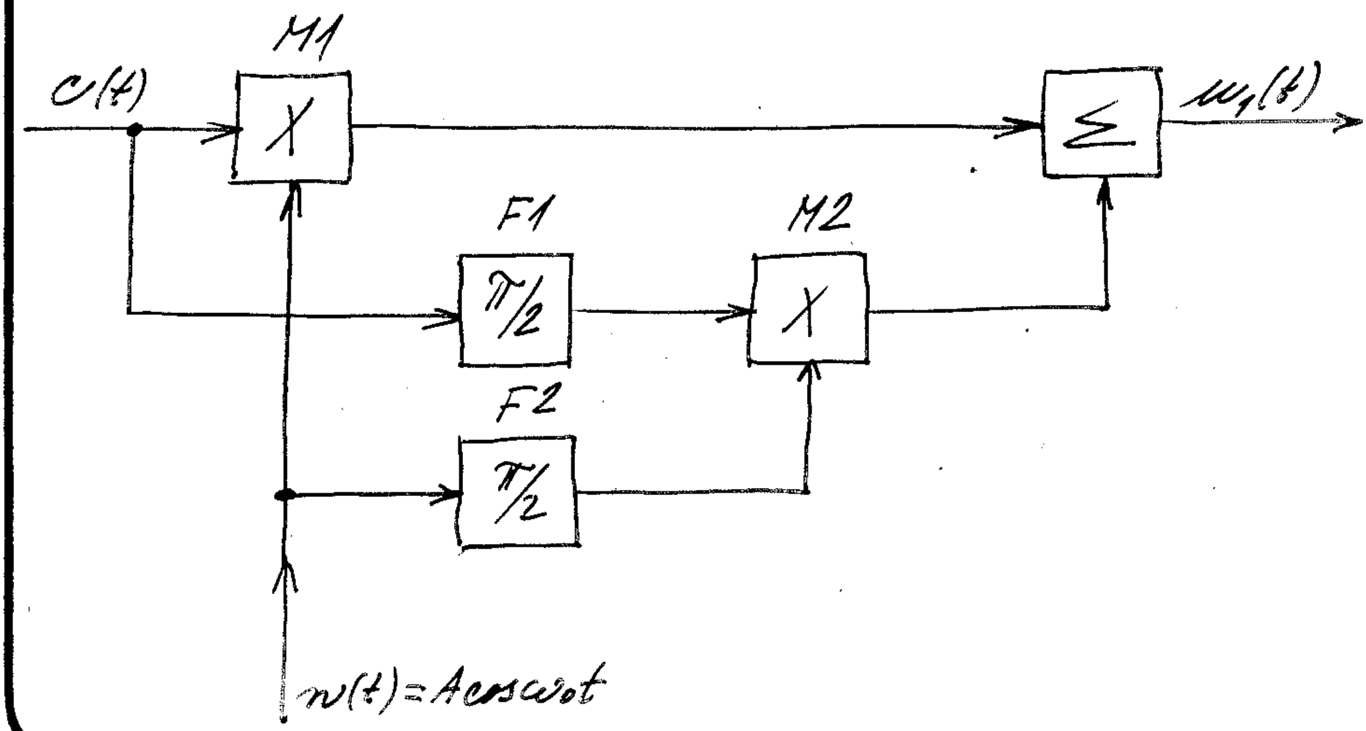
2. Jednopásmová modulácia s fázovou komp.

$$u_1(t) = \frac{1}{2}VA\{\cos\omega t\cos\omega_0 t - \sin\omega t\sin\omega_0 t\}$$

$$\sin x \longrightarrow \cos(x-\pi/2)$$

$$u_1(t) = \frac{1}{2}VA\cos\omega t\cos\omega_0 t - \frac{1}{2}VA\cos(\omega t-\frac{\pi}{2})\cos(\omega_0 t-\pi/2)$$

súfázová zložka   kvadratúrna zložka



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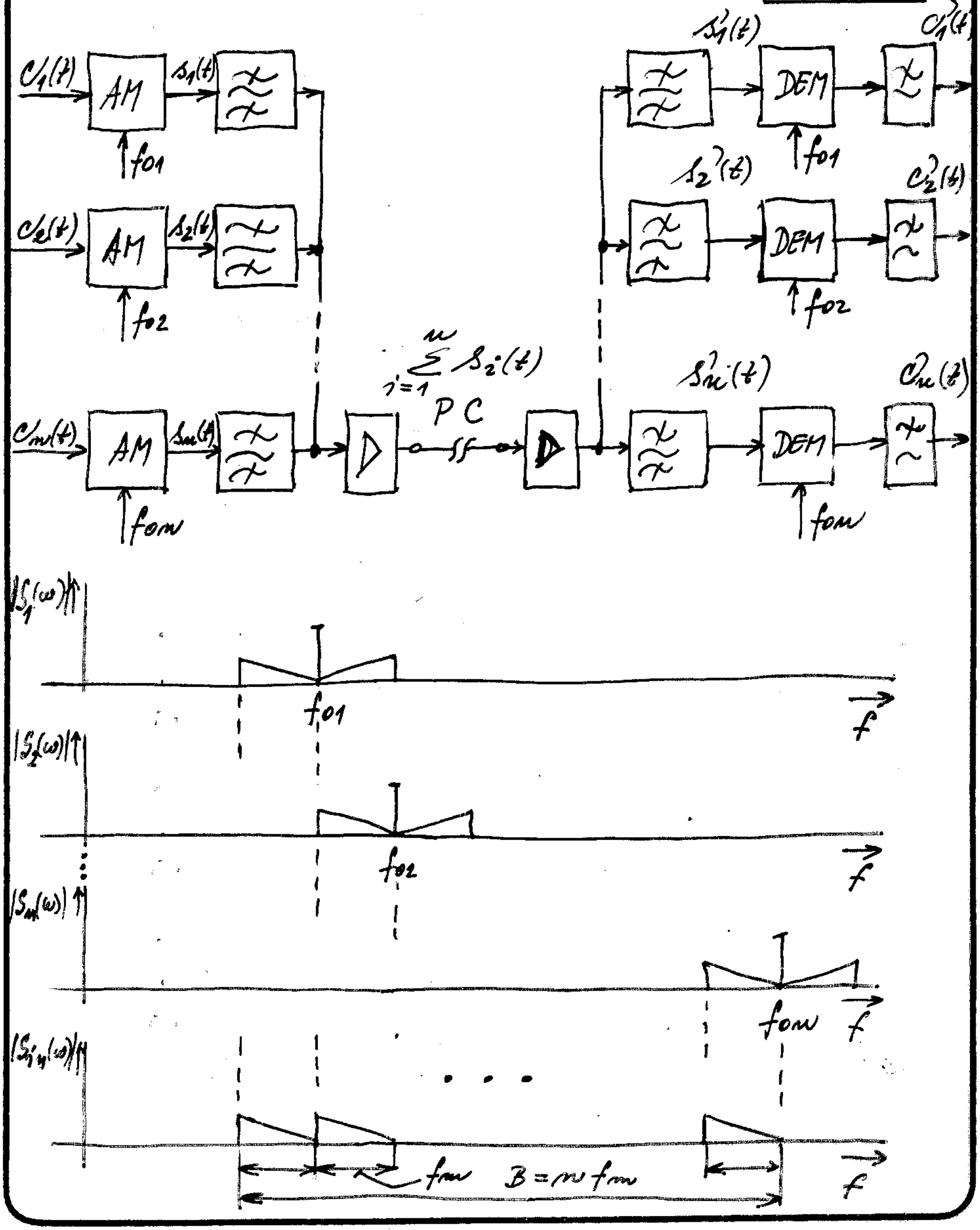
	1	0	1



NÁZOV: PREDMET:

ROČNÍK:

ČÍSLO: ČÍSLO ZLOŽKY 101

Uhlová modulácia

$$u(t) = A\cos(\omega_0 t + \varphi) = A\cos\phi(t)$$

$$\phi(t) = \omega_0 t + \varphi \quad [rad]$$

$$\omega_0(t) = \frac{d\phi(t)}{dt}$$

Keď $\omega_0(t) \neq konšt \Rightarrow$ fázová modulácia PM

$$\phi(t) = \int_0^t \omega_0(\tau)\,d\tau \rightarrow$$ FM frekvenčná (kmitočtová) modulácia

Pre nosný kmitočet

$$\omega_0(t) = \frac{d\phi(t)}{dt} = \frac{d(\omega_0 t + \varphi)}{dt} = \omega_0$$

$$\phi(t) = \omega_0 t + \Psi(t)$$

$$\omega_0(t) = \frac{d\phi(t)}{dt} = \omega_0 + \frac{d\Psi(t)}{dt} \quad [rad \cdot s^{-1}]$$

NÁZOV: PREDMET:

ROČNÍK:

ČÍSLO: ČÍSLO ZLOŽKY 102

$$s(t) = A\cos\phi(t) = A\cos[\omega_0 t + \Psi(t)]$$

$\Psi(t) = m_p\, c(t)$; m_p [rad.V^{-1}] koeficient úmernosti

$$\phi(t) = \omega_0 t + \Psi(t) = \omega_0 t + m_p\, c(t)$$

$$c(t) = V \sin \omega t$$

$$c_n(t) = \sin \omega t$$

$$\phi(t) = \omega_0 t + \Psi_m c_n(t) = \omega_0 t + \Psi_m \sin \omega t$$

$\Psi_m = m_p V$ – fázový zdvih
index fázovej modulácie

$$\omega_0(t) = \frac{d\phi(t)}{dt} = \omega_0 + \underbrace{m_p \frac{dc(t)}{dt}}_{\frac{d\Psi(t)}{dt}} =$$

$$= \omega_0 + \Psi_m \frac{dc_n(t)}{dt}$$

NÁZOV: PREDMET:

ROČNÍK:

ČÍSLO: ČÍSLO ZLOŽKY

	1	0	3

$$s(t) = A\cos\phi(t) = A\cos[\omega_0 t + m_p v(t)] = A\cos[\omega_0 t + \Psi_m v_m(t)]$$

$$v(t) = V \sin \omega t$$

$$s(t) = A\cos(\omega_0 t + \Psi(t)] = A\cos(\omega_0 t + \Psi_m \sin \omega t]$$

$$\omega_0(t) = \frac{d\phi(t)}{dt} = \omega_0 + \Psi_m \omega \cos \omega t$$

$\Delta\omega_0 = \omega \Psi_m$ frekvenčný (kmitočtový) zdvih

NÁZOV:

PREDMET:

ROČNÍK:

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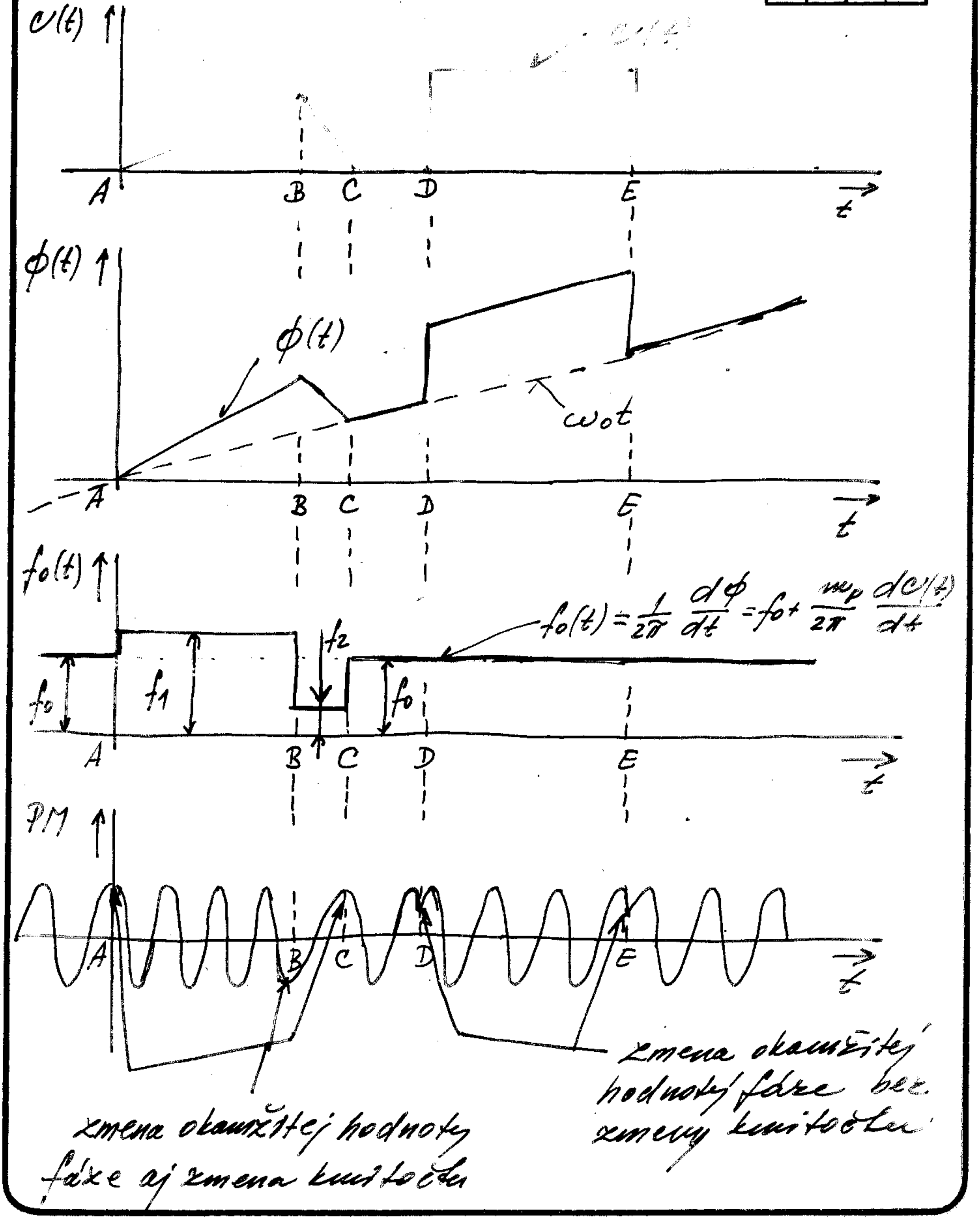
ČÍSLO ZLOŽKY

| | 1 | 0 | 4 |



NÁZOV: PREDMET:

ROČNÍK:

ČÍSLO: ČÍSLO ZLOŽKY 105

Frekvenčná modulácia:

$$\omega_0(t) = \omega_0 + 2\pi m_F u(t)$$

$$f_0(t) = f_0 + m_F u(t)$$

$m_F\ [Hz \cdot V^{-1}]$ – koeficient úmernosti

$$\omega_0(t) = \omega_0 + 2\pi m_F V u_m(t) = \omega_0 + \Delta\omega_0 u_m(t)$$

$\Delta\omega_0 = 2\pi m_F V = 2\pi \Delta f_0$ – frekvenčný zdvih

$$\phi(t) = \int_0^t \omega_0(\tau)\, d\tau = \omega_0 t + 2\pi m_F \int_0^t u(\tau)\, d\tau =$$

$$= \omega_0 t + \Delta\omega_0 \int_0^t u_m(\tau)\, d\tau$$

$$s(t) = A\cos\phi(t) = A\cos[\omega_0 t + \psi(t)] =$$

$$= A\cos\left[\omega_0 t + \Delta\omega_0 \int_0^t u_m(\tau)\, d\tau\right].$$

$$u(t) = V\cos\omega t$$

$$f_0(t) = f_0 + m_F V\cos\omega t = f_0 + \Delta f_0 \cos\omega t$$

$$\omega_0(t) = \omega_0 + 2\pi m_F V\cos\omega t = \omega_0 + \Delta\omega_0 \cos\omega t$$

NÁZOV:

ČÍSLO:

PREDMET:

ROČNÍK:

ČÍSLO ZLOŽKY 106

$$\phi(t) = \int_0^t \omega_0(\tau)\,d\tau = \omega_0 t + 2\pi m_F \int_0^t V \cos\omega\tau\,d\tau =$$

$$= \omega_0 t + \frac{2\pi m_F V}{\omega} \sin\omega t = \omega_0 t + m_F \frac{V}{f} \sin\omega t =$$

$$= \omega_0 t + \frac{\Delta f_0}{f} \sin\omega t = \omega_0 t + \beta \sin\omega t$$

$\beta = \frac{\Delta f_0}{f}$ — fázový zdvih, index frekvenčnej modulácie

$$s(t) = A\cos\phi(t) = A\cos\left(\omega_0 t + \frac{\Delta f_0}{f}\sin\omega t\right) =$$

$$= A\cos(\omega_0 t + \beta \sin\omega t)$$

NÁZOV:

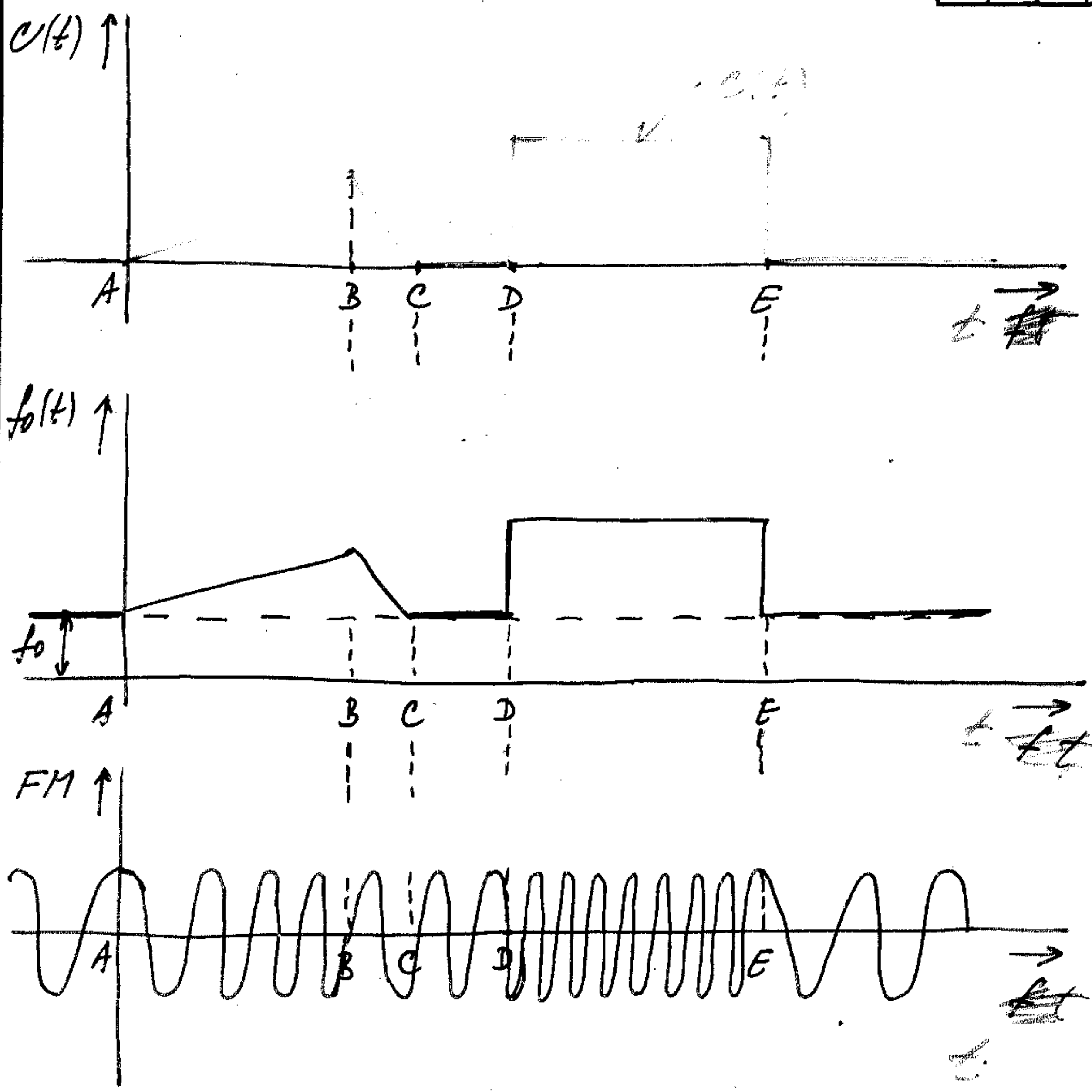
PREDMET:

ROČNÍK:

ČÍSLO:

ČÍSLO ZLOŽKY

	1	0	7



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PREDMET:

ROČNÍK:

ČÍSLO:

ČÍSLO ZLOŽKY 108

PM

$$s(t) = A\cos\{\omega_0 t + \varphi_m c_m(t)\}$$

$$c_m(t) \rightarrow \int_0^t c_m(\tau)\,d\tau$$

$$s(t) = A\cos\{\omega_0 t + \varphi_m \int_0^t c_m(\tau)\,d\tau\} \rightarrow \underline{FM}$$

FM

$$s(t) = A\cos\{\omega_0 t + \Delta\omega_0 \int_0^t c_m(\tau)\,d\tau\}$$

$$c_m(\tau) \rightarrow \frac{dc_m(\tau)}{d\tau}$$

$$s(t) = A\cos\{\omega_0 t + \Delta\omega_0 \int_0^t \frac{dc_m(\tau)}{d\tau}\,d\tau\} = A\cos\{\omega_0 t + \Delta\omega_0 c_m(t)\}$$

FM $s(t) = A\cos(\omega_0 t + \beta \sin \omega t)$

PM $s(t) = A\cos(\omega_0 t + \varphi_m \sin \omega t)$

$$\beta = \varphi_m \rightarrow s(t)_{FM} = s(t)_{PM}$$

NÁZOV: PREDMET:

ROČNÍK:

ČÍSLO: ČÍSLO ZLOŽKY 109

[illegible]

$$v(t) = V\cos\omega t$$

$$s(t) = A\cos\{\omega_0 t + \beta\sin\omega t\}$$

$$s(t) = A\cos\omega_0 t\cos(\beta\sin\omega t) - A\sin\omega_0 t\sin(\beta\sin\omega t)$$

$$\cos(\beta\sin\omega t) = J_0(\beta) + 2J_2(\beta)\cos 2\omega t + 2J_4(\beta)\cos 4\omega t + \\ + 2J_6(\beta)\cos 6\omega t + \dots$$

$$\sin(\beta\sin\omega t) = 2J_1(\beta)\sin\omega t + 2J_3(\beta)\sin 3\omega t + \\ + 2J_5(\beta)\sin 5\omega t + \dots$$

$$s(t) = AJ_0(\beta)\cos\omega_0 t + 2AJ_2(\beta)\cos\omega_0 t\cos 2\omega t + \\ + 2AJ_4(\beta)\cos\omega_0 t\cos 4\omega t + \dots - \\ - 2AJ_1(\beta)\sin\omega_0 t\sin\omega t - 2AJ_3(\beta)\sin\omega_0 t\sin 3\omega t - \\ - 2AJ_5(\beta)\sin\omega_0 t\sin 5\omega t - \dots$$

$$-2\sin\alpha\sin\beta = \cos(\alpha+\beta) - \cos(\alpha-\beta)$$

$$2\cos\alpha\cos\beta = \cos(\alpha+\beta) + \cos(\alpha-\beta)$$

$$J_{-(2k+1)}(\beta) = -J_{2k+1}(\beta) \qquad k = 0; 1; 2; \dots$$

$$J_{-2k}(\beta) = J_{2k}(\beta)$$

NÁZOV: PREDMET:

ROČNÍK:

ČÍSLO: ČÍSLO ZLOŽKY 110

$$s(t) = A\{J_0(\beta)\cos\omega_0 t + J_1(\beta)[\cos(\omega_0+\omega)t - \cos(\omega_0-\omega)t] +$$
$$+ J_2(\beta)[\cos(\omega_0+2\omega)t + \cos(\omega_0-2\omega)t] +$$
$$+ J_3(\beta)[\cos(\omega_0+3\omega)t - \cos(\omega_0-3\omega)t] +$$
$$+ J_4(\beta)[\cos(\omega_0+4\omega)t + \cos(\omega_0-4\omega)t] +$$
$$+ \dots \}$$

$$s(t) = A\sum_{n=-\infty}^{\infty} J_n(\beta)\cos(\omega_0 + n\omega)t$$

ak $n = -5$

$$A J_{-5}(\beta)\cos(\omega_0 - 5\omega)t = -A J_5(\beta)\cos(\omega_0 - 5\omega)t$$

$n = 5$

$$A J_5(\beta)\cos(\omega_0 + 5\omega)t$$

$$A J_5(\beta)[\cos(\omega_0+5\omega)t - \cos(\omega_0-5\omega)t]$$

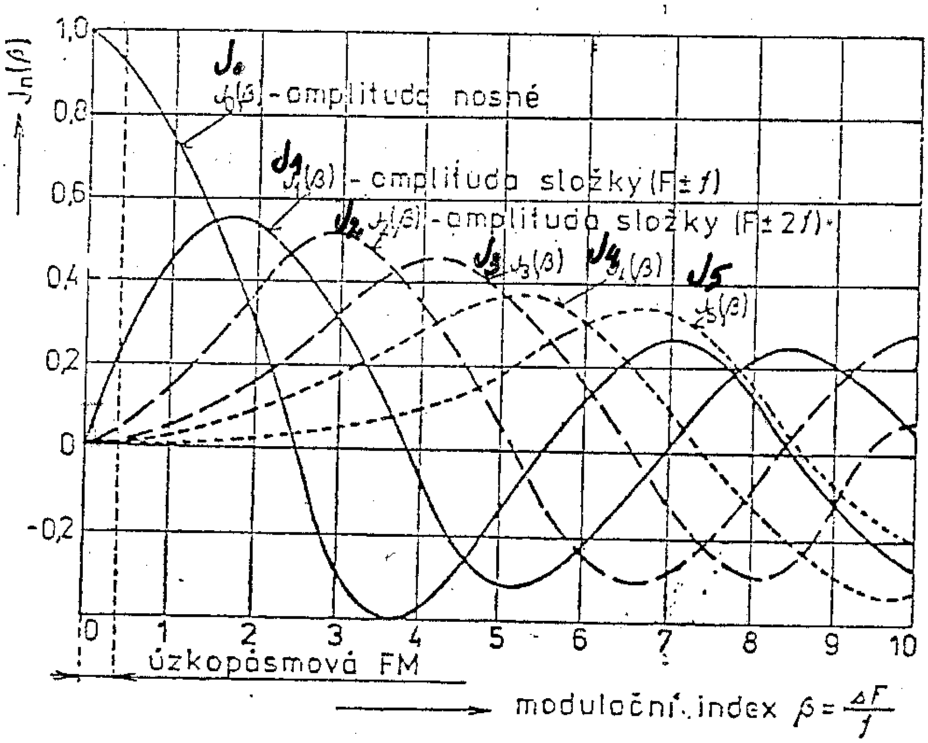
ak $n = -4$

$$A J_{-4}(\beta)\cos(\omega_0 - 4\omega)t = A J_4(\beta)\cos(\omega_0 - 4\omega)t$$

$n = 4$

$$A J_4(\beta)\cos(\omega_0 + 4\omega)t$$

$$A J_4(\beta)[\cos(\omega_0+4\omega)t + \cos(\omega_0-4\omega)t]$$



Obr. 110. Graf Besselových funkcí prvního druhu $J_n(\beta)$

NÁZOV:

PREDMET:

ROČNÍK:

ČÍSLO:

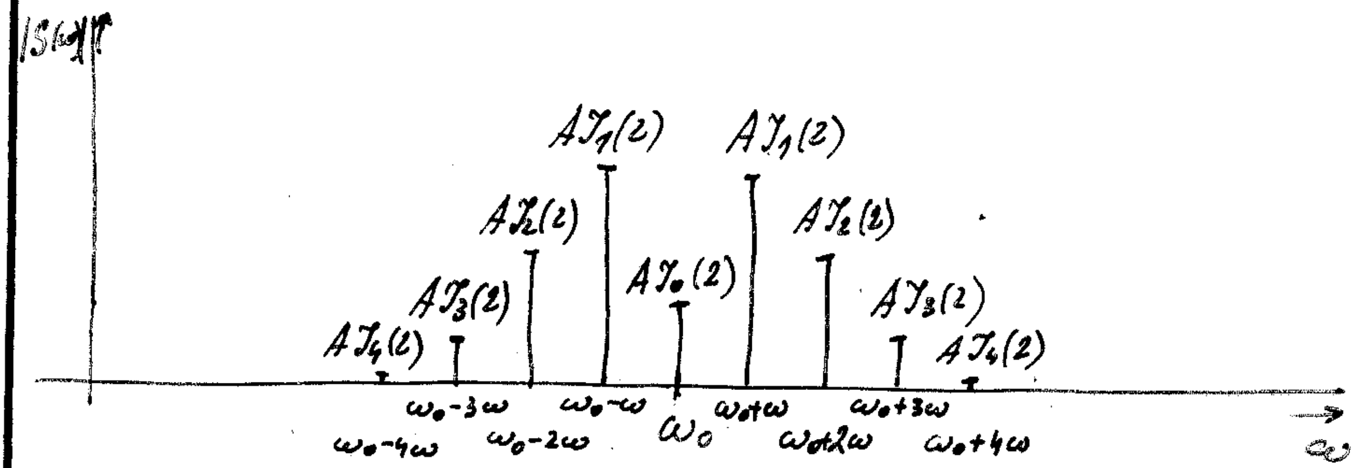
ČÍSLO ZLOŽKY

	1	1	1

$J_n(\beta)$

n	$J_n(0{,}2)$	$J_n(1)$	$J_n(2)$	$J_n(5)$
0	0,99	0,77	0,22	-0,18
1	0,1	0,44	0,58	-0,33
2		0,11	0,35	0,05
3		0,02	0,13	0,36
4			0,03	0,39
5				0,26

1. Spektrum FM $\Rightarrow$ $\omega_0 \pm n\omega$
$A J_n(\beta)$



2. $J_n(\beta)$ pre určité β – prechody cez 0

NÁZOV: PREDMET:

ROČNÍK:

ČÍSLO: ČÍSLO ZLOŽKY

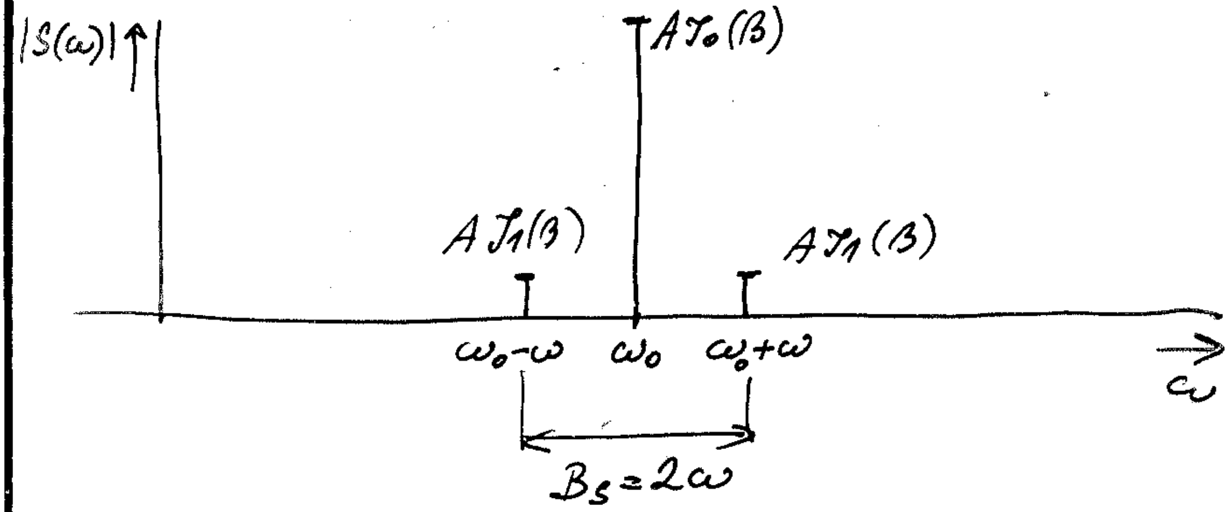
112

3. $\beta \ll 1$

$J_0(\beta) \doteq 1$

$J_1(\beta) \doteq \frac{\beta}{2}$

$J_n(\beta) \doteq 0$ pre $n > 1$



4. β narastá $\Rightarrow$ B_S narastá

5. Stredný výkon

$$P_s = \frac{1}{T_0}\int_0^{T_0} s^2(t)\,dt = \frac{1}{2}A^2\sum_{n=-\infty}^{\infty} J_n^2(\beta) = \frac{1}{2}A^2$$

$$\sum_{n=-\infty}^{\infty} J_n^2(\beta) = 1$$

NÁZOV:

PREDMET:

ROČNÍK:

ČÍSLO:

ČÍSLO ZLOŽKY

| | 1 | 1 | 3 |

$$c(t) = V_1 \cos\omega_1 t + V_2 \cos\omega_2 t$$

$$\phi(t) = \omega_0 t + \beta_1 \sin\omega_1 t + \beta_2 \sin\omega_2 t$$

$$s(t) = A\cos\phi(t) = A\cos(\omega_0 t + \beta_1 \sin\omega_1 t + \beta_2 \sin\omega_2 t)$$

$$s(t) = A \sum_{m=-\infty}^{\infty} \sum_{n=-\infty}^{\infty} J_m(\beta_1) J_n(\beta_2) \cos(\omega_0 + m\omega_1 + n\omega_2)t$$

a) $m = 0; n = 0 \Rightarrow A J_0(\beta_1) J_0(\beta_2)$

b) $n = 0; m = \pm 1; \pm 2; \pm 3; \dots$

$m = 0; n = \pm 1; \pm 2; \pm 3; \dots$

$\omega_0 \pm m\omega_1 \quad ; \quad \omega_0 \pm n\omega_2$

c) $m \neq 0; n \neq 0$

$\omega_0 \pm m\omega_1 \pm n\omega_2$

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ČÍSLO: ČÍSLO ZLOŽKY 114

$$s(t) = A\cos\phi(t) = A\cos[\omega_0 t + 2\pi m_F \int_0^t C(\tau)\,d\tau] =$$

$$= A\cos[\omega_0 t + \Delta\omega_0 \int_0^t C_n(\tau)\,d\tau]$$

$$\Delta\omega_0 = 2\pi m_F V$$

$$g(t) = \int_0^t C(\tau)\,d\tau$$

$$s(t) = A\cos\phi(t) = A\cos\omega_0 t \cos[2\pi m_F\, g(t)] -$$
$$- A\sin\omega_0 t \sin[2\pi m_F\, g(t)]$$

ak pre všetky hodnoty $C(t)$ platí

$$2\pi m_F\, g(t) \ll 1$$

$$\cos[2\pi m_F\, g(t)] \doteq 1$$

$$\sin[2\pi m_F\, g(t)] \doteq 2\pi m_F\, g(t)$$

$$s(t) = A\cos\omega_0 t - A\, 2\pi m_F\, g(t) \sin\omega_0 t$$

NÁZOV:

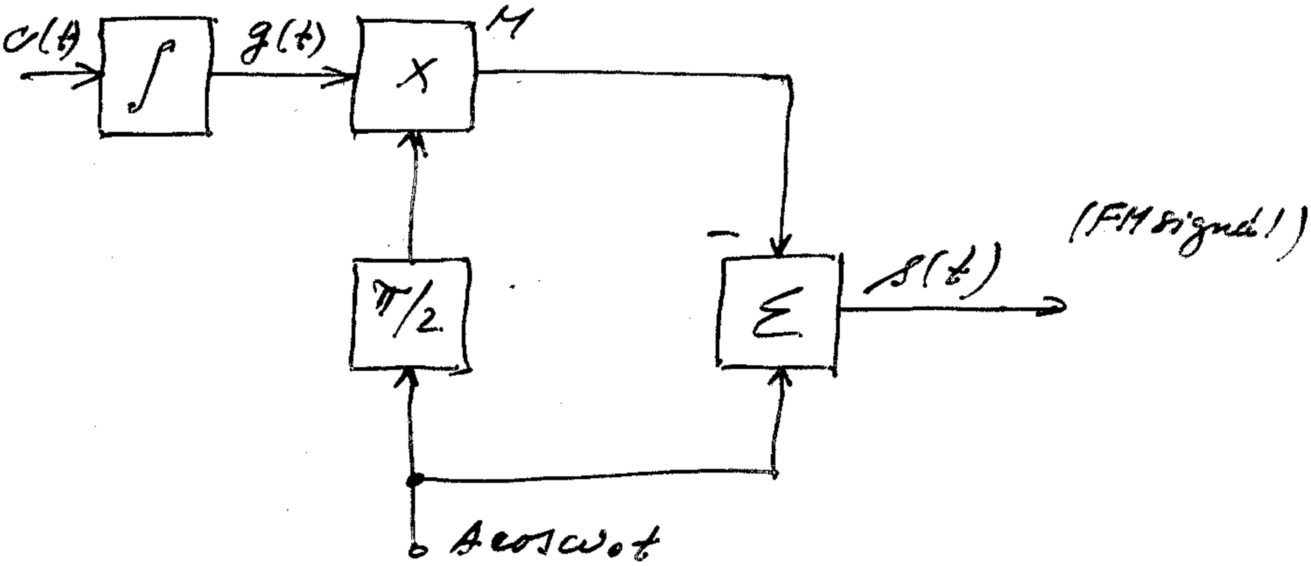
PREDMET:

ROČNÍK:

ČÍSLO:

ČÍSLO ZLOŽKY 115

$$G(f) = \frac{1}{j\omega} C(f)$$



$$c(t) = V \cos \omega t$$

$$s(t) = A \cos \omega_0 t - 2\pi A m_F\, g(t) \sin \omega_0 t$$

$$g(t) = \int_0^t c(\tau)\, d\tau = V \int_0^t \cos \omega \tau \, d\tau = \frac{V}{\omega} \sin \omega t$$

$$s(t) = A \cos \omega_0 t - A \frac{2\pi m_F V}{\omega} \sin \omega t \sin \omega_0 t =$$

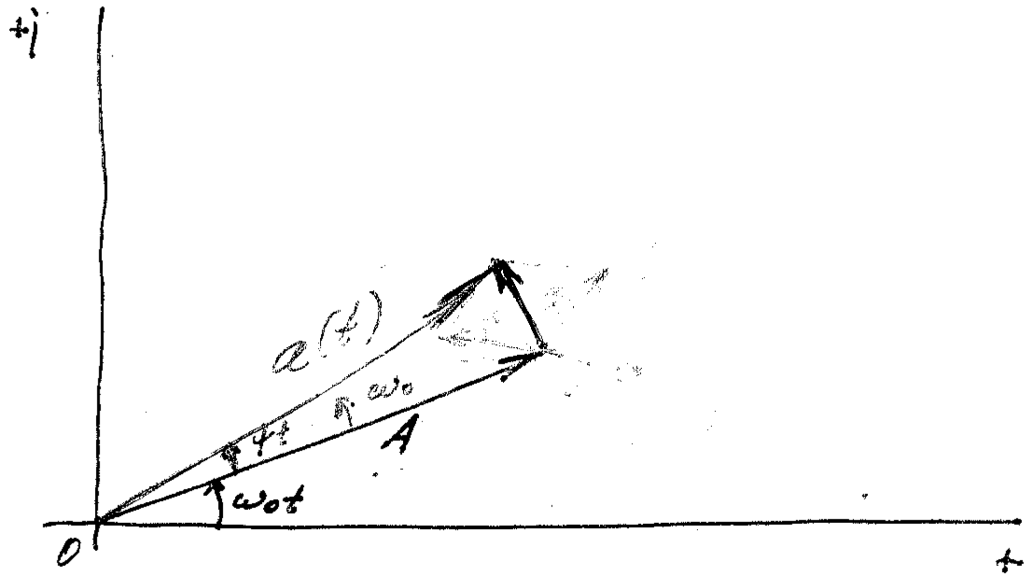
$$= A \cos \omega_0 t - \beta A \sin \omega t \sin \omega_0 t =$$

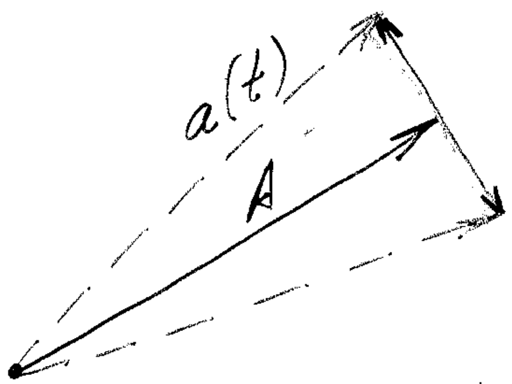
$$= A \cos \omega_0 t + \frac{1}{2} \beta A \cos(\omega_0 + \omega) t - \frac{1}{2} \beta A \cos(\omega_0 \ldots$$

NÁZOV: PREDMET:

ROČNÍK:

ČÍSLO: ČÍSLO ZLOŽKY 116





Šírka spektra FM signálu

1. C(t) — harmonický signál

$\beta \gg 1$

$(f_0 \pm m_c f)$

$m_c = \beta$

NÁZOV: PREDMET:

ROČNÍK:

ČÍSLO: ČÍSLO ZLOŽKY 117

$$B_s \doteq 2 m_c f \doteq 2 \beta f = 2 \Delta f$$

$\beta << 1$

$$B_s \doteq 2 m_c f = 2 f$$

2. $c(t)$ – ozuamovací signál

$$|J_m(\beta)| > \varepsilon$$

$\varepsilon \in (0{,}01; 0{,}1)$

$2 < \beta < 20$

$$m_c \doteq \beta + a$$

$a = 1$ pre $\varepsilon = 0{,}1$

$a = 3$ pre $\varepsilon = 0{,}01$

$$B_s \doteq 2 m_c f \doteq 2(\beta f + a f) = 2(\Delta f_0 + a f)$$

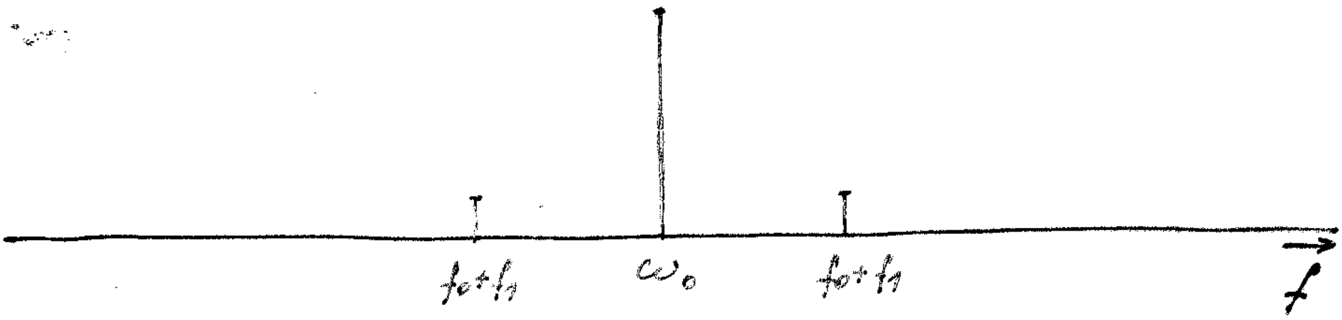
$f_{mod} = f_m$

$$B_s \doteq 2(\Delta f_0 + a f_m) \quad \text{pre FM}$$

$$B_s \doteq 2(\Upsilon_m + a) f_m \quad \text{pre PM}$$

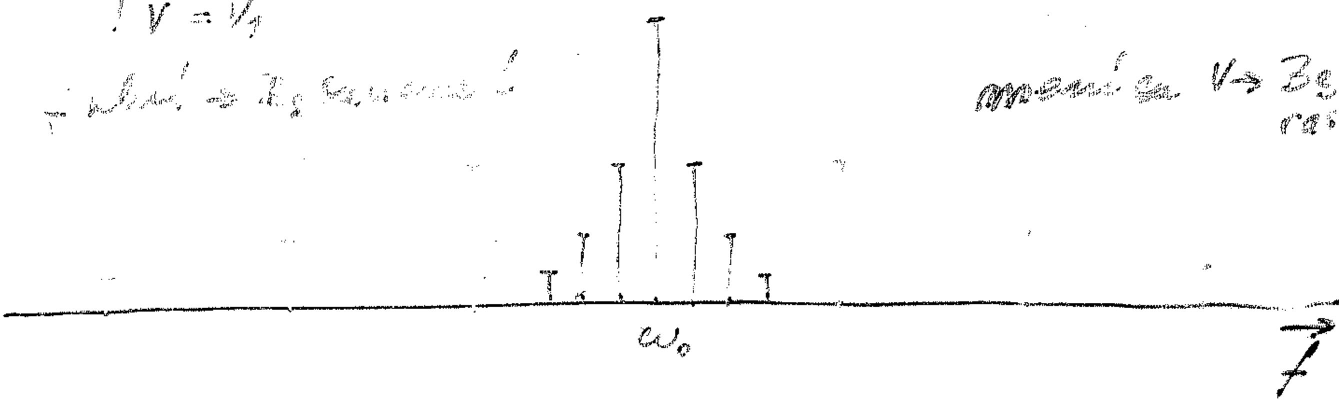
NÁZOV: | PREDMET:
ROČNÍK:
ČÍSLO: | ČÍSLO ZLOŽKY 118

$\beta = 0{,}2$ $\quad f_m = f_1$, $V = V_1$



$\left.\begin{matrix} f_m = \frac{f_1}{5} \\ V = V_1 \end{matrix}\right\}$ $\quad \beta = 1$

mení sa $V \to B_s$ rastie



$c(t) = V\, c_M(t)$ kde $f_m = f_{max}$ spektra

$$B_s \doteq 2(\Delta f_0 + a f_m) = 2(m_F V + a f_m) = 2(\beta f_m + a f)$$

$$m_F V = \beta \cdot f_m \Rightarrow \beta = \frac{m_F V}{f_m}$$

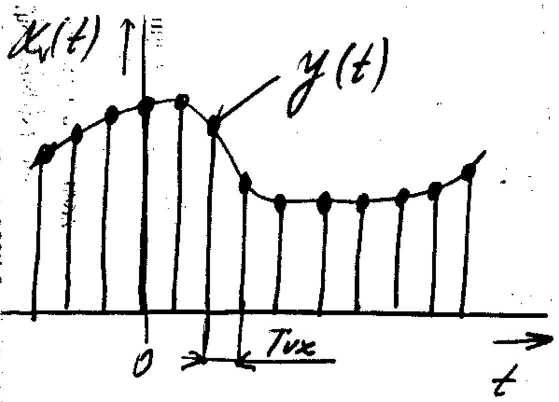
$\left.\begin{matrix} V = V_1 \\ f_m = f_1 \end{matrix}\right\}$ pre $\beta = 0{,}2$

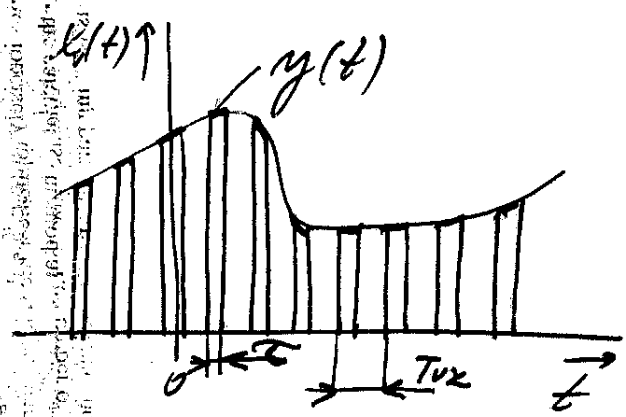
neč $\beta = 1$ $\quad$ a) $V = V_1 \to f_m = \frac{f_1}{5}$

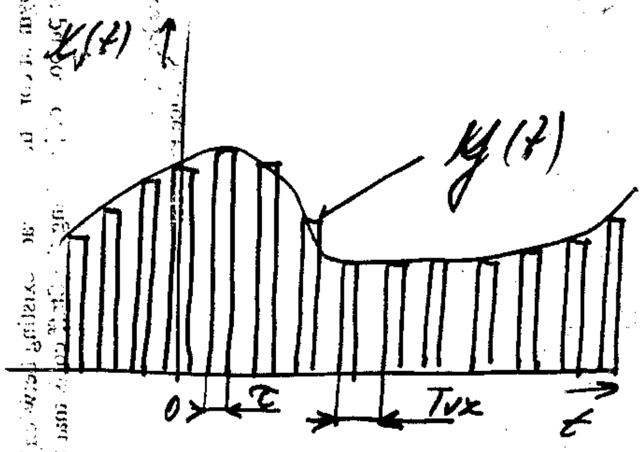
b) $f_m = f_1 \Rightarrow V = 5V_1$

64ac

Vzorkovanie signálu







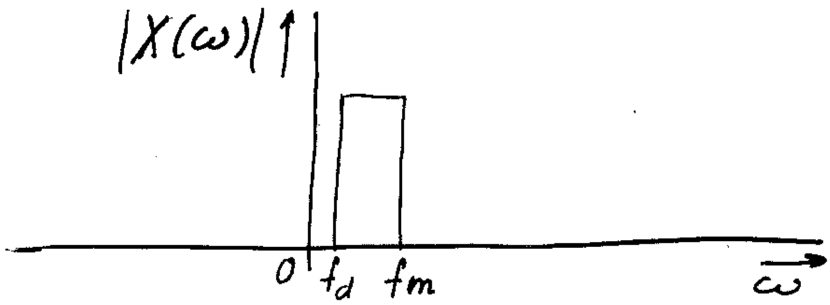
$x(t) \longrightarrow x(n T_{vz})$ $\quad n = 0; 1; 2; \ldots$

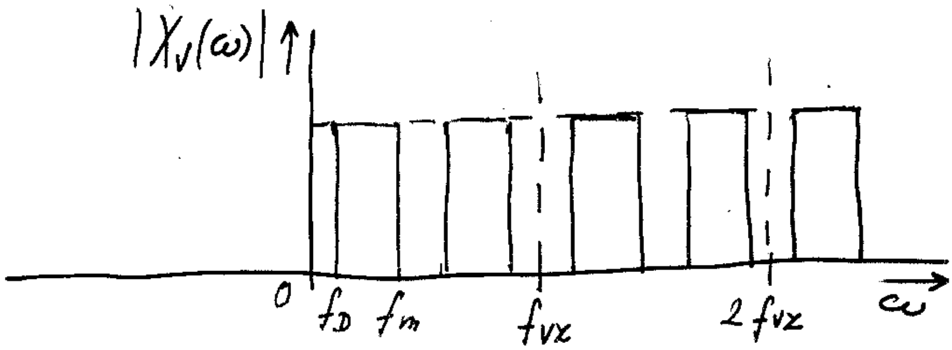
Ideálne vzorkovanie

$$x_v(t) = x(t) \sum_{n=-\infty}^{\infty} \delta(t - nT_{vz}) = x(t) \frac{1}{T_{vz}} \sum_{k=-\infty}^{\infty} e^{jk\omega_{vz}t}$$

$$X_v(\omega) = \frac{1}{T_{vz}} \sum_{k=-\infty}^{\infty} \mathcal{F}\{x(t) e^{jk\omega_{vz}t}\}$$

$$X_v(\omega) = \frac{1}{T_{vz}} \sum_{k=-\infty}^{\infty} X(\omega - k\omega_{vz})$$



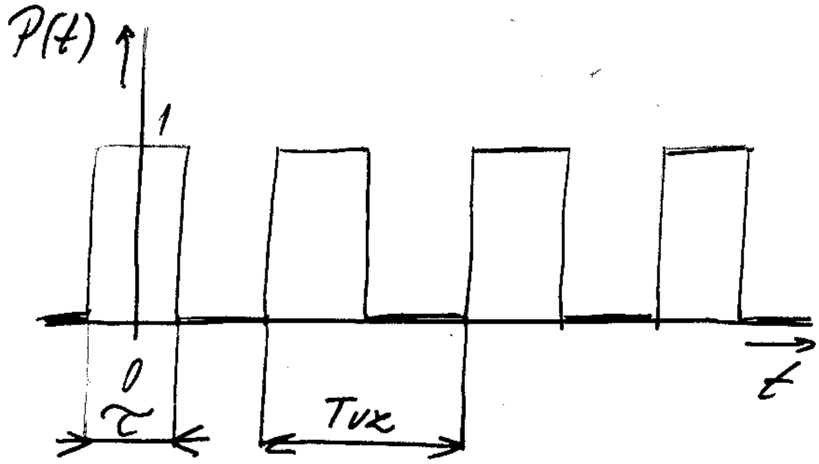


Shannon - Kotelnikova veta

$f_i \in \langle f_d; f_m \rangle$

$f_{vz} \geq 2 f_m \Rightarrow T_{vz} \leq \frac{1}{2 f_m}$

Vzorkovanie 1. druhu



$$P(t) = \sum_{k=-\infty}^{\infty} c_k e^{jk\omega_{vz} t}$$

$$c_k = \frac{1}{T_{vz}} \int_{-T_{vz}/2}^{T_{vz}/2} P(t) e^{-jk\omega_{vz} t} dt = \frac{\tau}{T_{vz}} \, \mathrm{Si} \, k \pi \tau f_{vz}$$

$k = 0; \pm 1; \pm 2; \ldots$

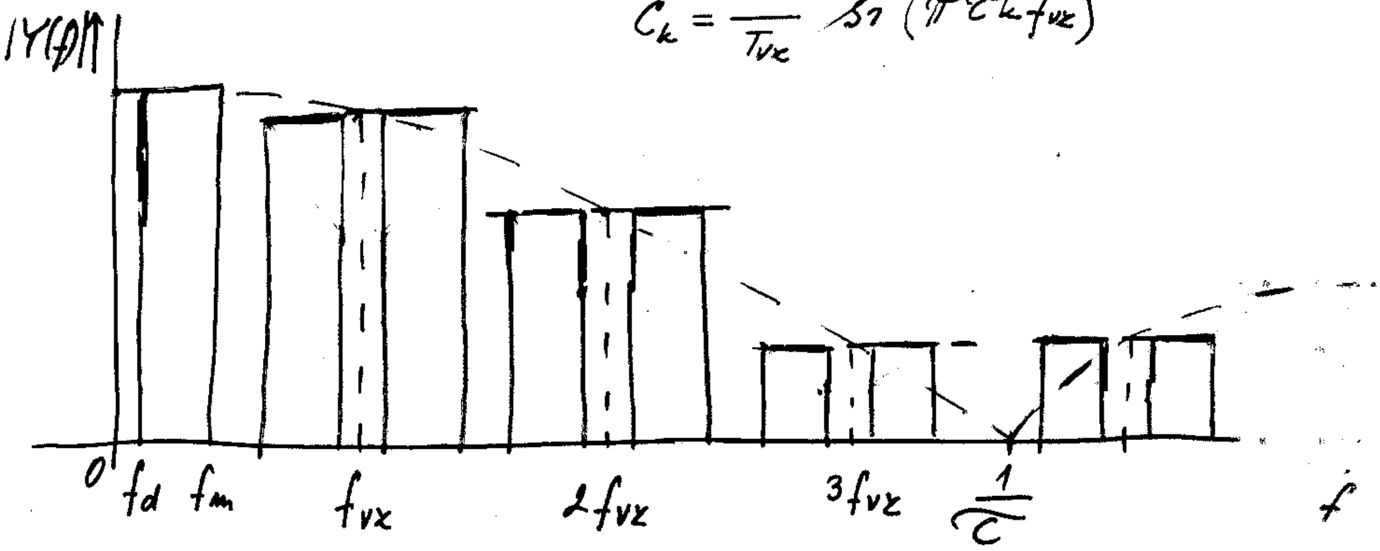
$$y(t) = x(t)\cdot P(t) = x(t)\sum_{k=-\infty}^{\infty} C_k e^{jk\omega_{vz}t}$$

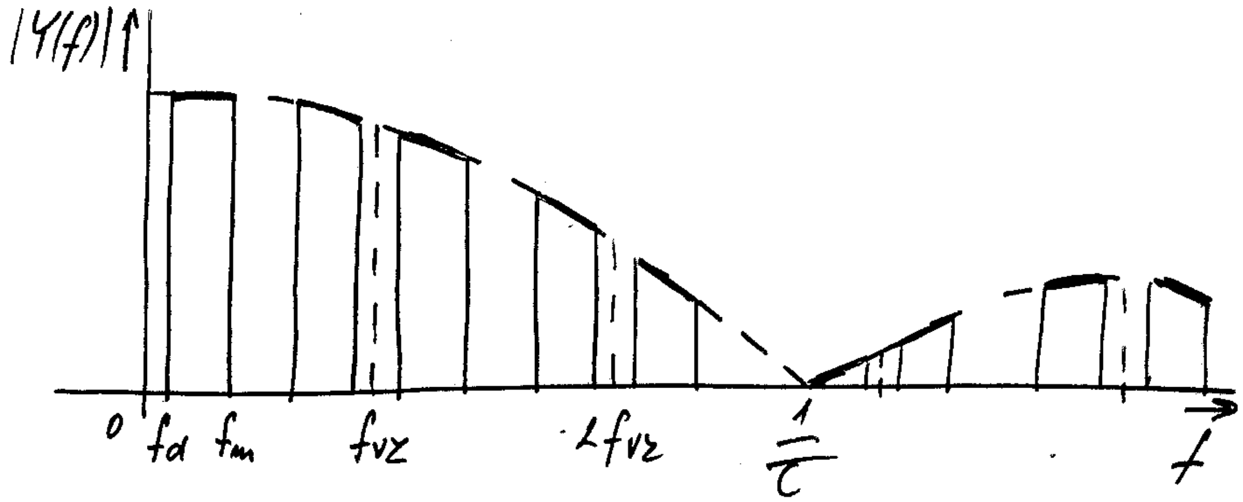
$$Y_k(f) = \int_{-\infty}^{\infty} x(t)\, C_k e^{jk\omega_{vz}t} \cdot e^{-j\omega t}\, dt =$$

$$= C_k \int_{-\infty}^{\infty} x(t)\, e^{-j(\omega - k\omega_{vz})t}\, dt = C_k X(f - k f_{vz})$$

$$Y(f) = \sum_{k=-\infty}^{\infty} C_k X(f - k f_{vz}) = C_0 X(f) + \sum_{k=1}^{\infty} C_k X(f \pm k f_{vz})$$

$$C_k = \frac{\tau}{T_{vz}}\, Si(\pi \tau k f_{vz})$$




|Y(f)|
0
fd
fm
fvz
2fvz
1/τ
f

Vzorkovanie 2. druhu

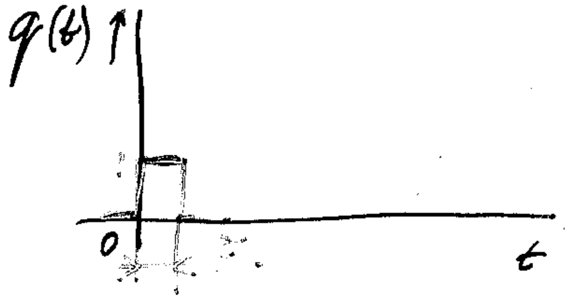
$$y(t) = \sum_{k=-\infty}^{\infty} x(kT_{vz})\, P(t - kT_{vz})$$

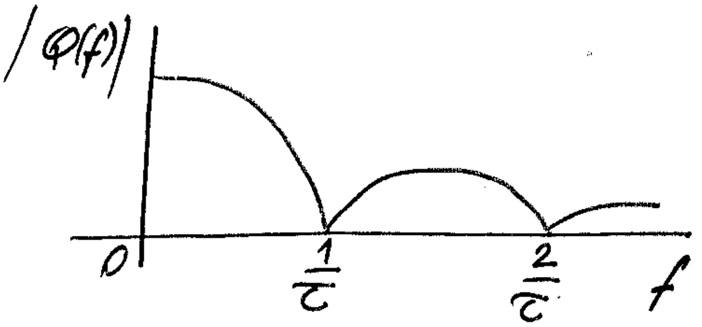
$$Y(f) = \int_{-\infty}^{\infty} y(t)\, e^{-j\omega t}\, dt$$

$$Y(f) = \int_{-\infty}^{\infty} \sum_{k=-\infty}^{\infty} x(kT_{vz})\, P(t-kT_{vz}) \cdot e^{-j\omega t}\, dt =$$

$$= \sum_{k=-\infty}^{\infty} \int_{kT_{vz}}^{kT_{vz}+\tau} y(kT_{vz})\, e^{-j\omega t}\, dt$$

$$Y(f) = \frac{\tau}{T_{vz}}\, Si(\pi \tau f) \left[X(f) + \sum_{k=1}^{\infty} X(f \pm k f_{vz}) \right]$$


q(t)
0
t


|Φ(f)|
0
1/τ
2/τ
f


|Y(f)|
f
2f
3f
f

$$x_\delta(t) * q(t) = \sum_{n=-\infty}^{\infty} x(nT_{vz}) \cdot q(t - nT_{vz}) = y(t)$$

Vo frekv. oblasti

$$Y(f) = X_\delta(f) \cdot Q(f)$$

$$x_\delta(t) = \sum_{n=-\infty}^{\infty} x(nT_{vz}) \cdot \delta(t - nT_{vz}) = x(t) \sum_{n=-\infty}^{\infty} \delta(t - nT_{vz}) =$$

$$= x(t) \cdot \frac{1}{T_{vz}} \sum_{n=-\infty}^{\infty} e^{jn\omega_{vz} t}$$

$$\downarrow$$

$$X_\delta(f) = \frac{1}{T_{vz}} \sum_{k=-\infty}^{\infty} X(f - kf_{vz})$$

$$Y(f) = \frac{1}{T_{vz}} \cdot Q(f) \cdot \sum_{k=-\infty}^{\infty} X(f - kf_{vz})$$

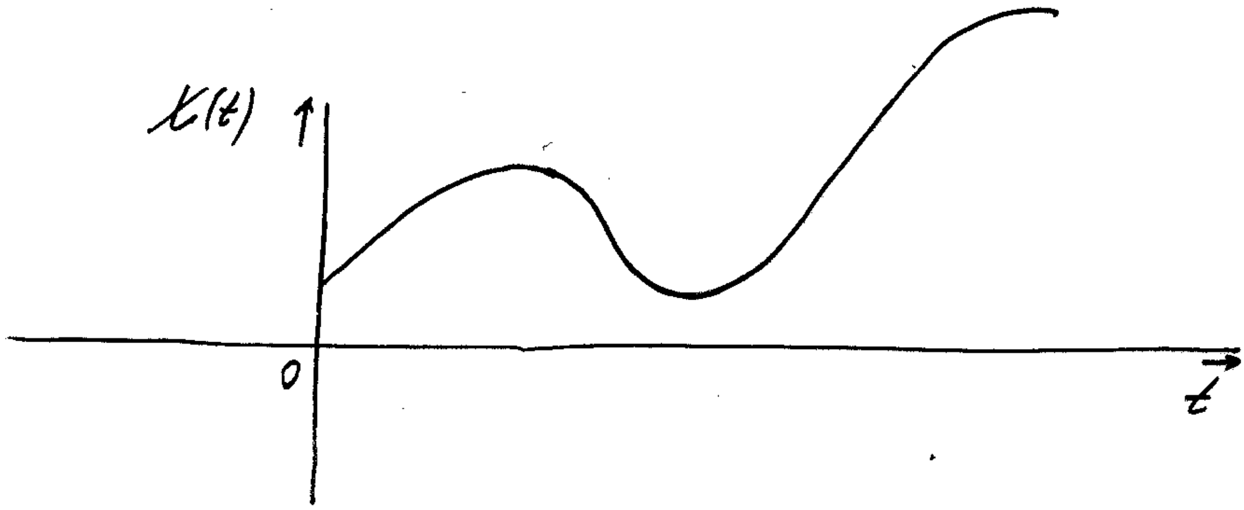
Vzorkovanie 2. druhu

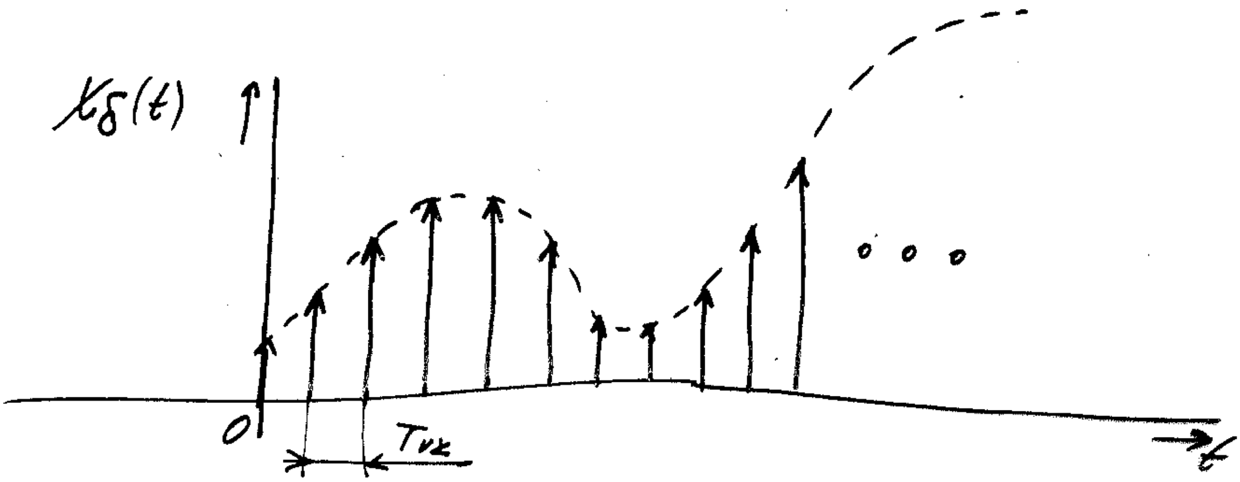
$x(t)$ - pôvodný spojitý signál

$q(t)$ - jednorázový pravouhlý impulz
T_{vz} - perióda vzorkovania
τ - šírka impulzu
$A=1$ - amplitúda

$y(t)$ - signál navzorkovaný vzorkovaním 2. druhu

$$y(t) = \sum_{n=-\infty}^{\infty} x(nT_{vz}) \cdot q(t - nT_{vz})$$





$$x_\delta(t) = \sum_{n=-\infty}^{\infty} x(nT_{vz}) \cdot \delta(t - nT_{vz})$$

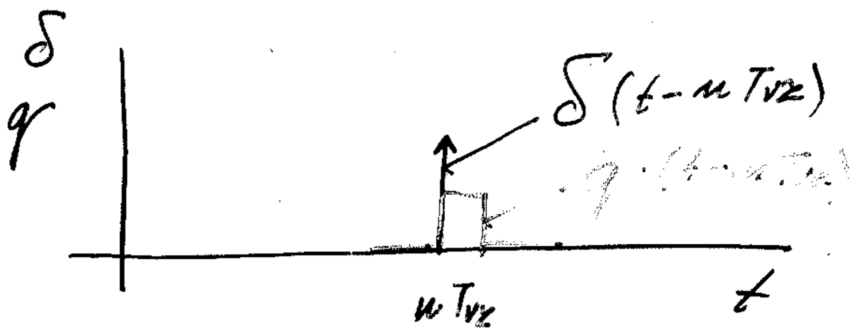
$$x_\delta(t) * q(t) = \int_{-\infty}^{\infty} x_\delta(\tau) \cdot q(t-\tau)\, d\tau =$$

$$= \int_{-\infty}^{\infty} \sum_{n=-\infty}^{\infty} x(nT_{vz}) \cdot \delta(\tau - nT_{vz}) \cdot q(t-\tau)\, d\tau =$$

$$= \sum_{n=-\infty}^{\infty} x(nT_{vz}) \int_{-\infty}^{\infty} \delta(\tau - nT_{vz}) \cdot q(t-\tau)\, d\tau$$

$$\int_{-\infty}^{\infty} \delta(t-t_0) \cdot x(t)\, dt = x(t_0)$$

$$\int_{-\infty}^{\infty} \delta(\tau - nT_{vz}) \cdot q(t-\tau)\, d\tau = q(t - nT_{vz})$$



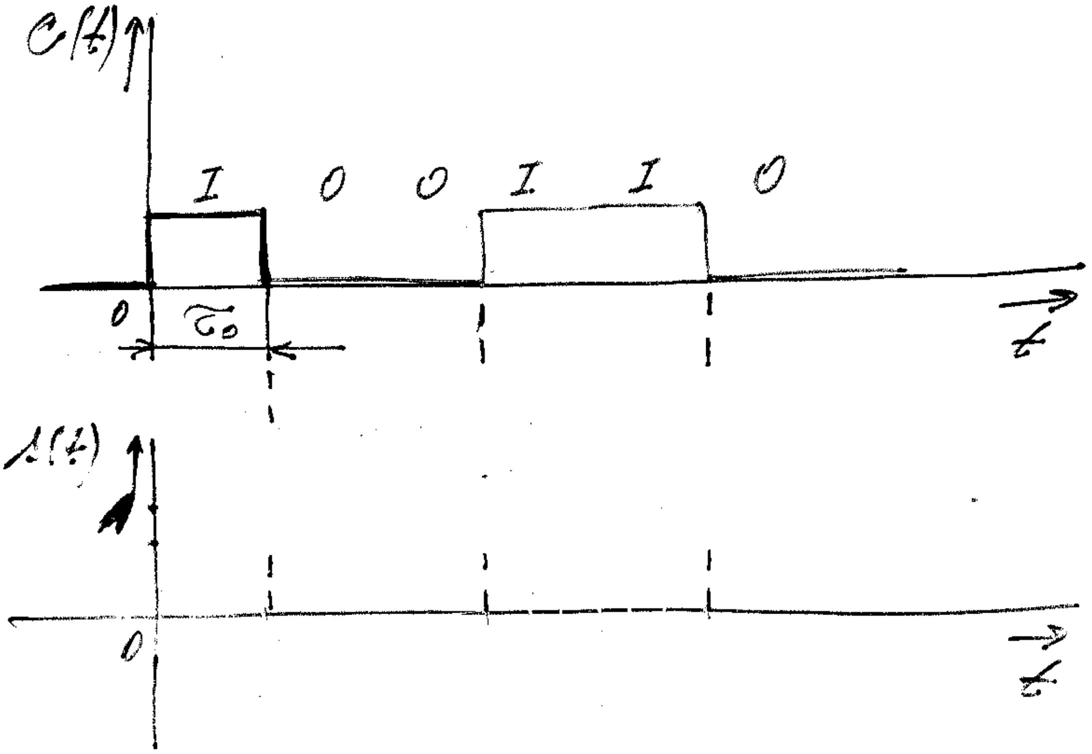
NÁZOV:

ČÍSLO:

PREDMET:

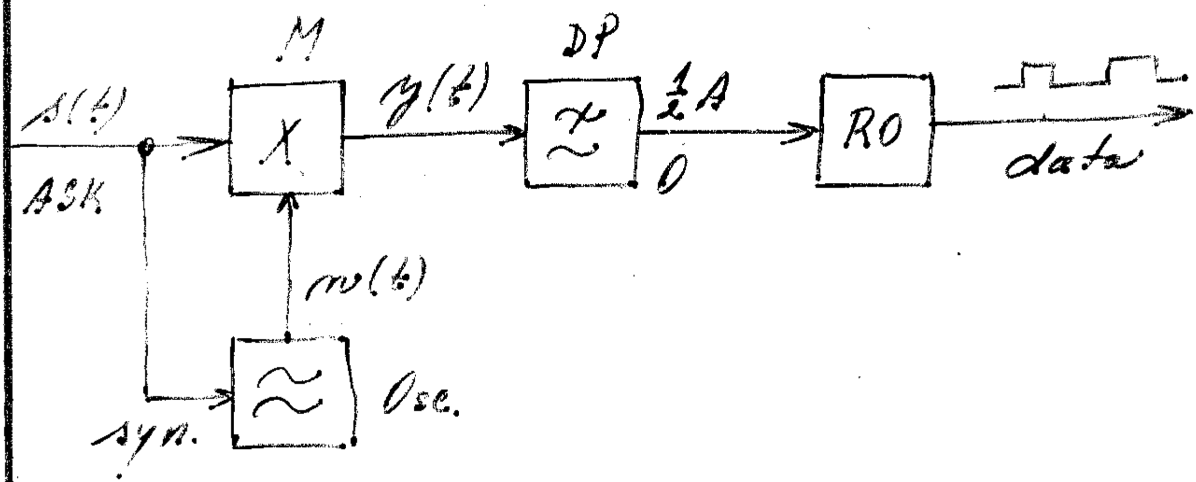
ROČNÍK:

ČÍSLO ZLOŽKY 128



Synchrónny (koherentný) demodulátor

$s(t) = A\cos\omega_0 t$



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ČÍSLO:

PREDMET:

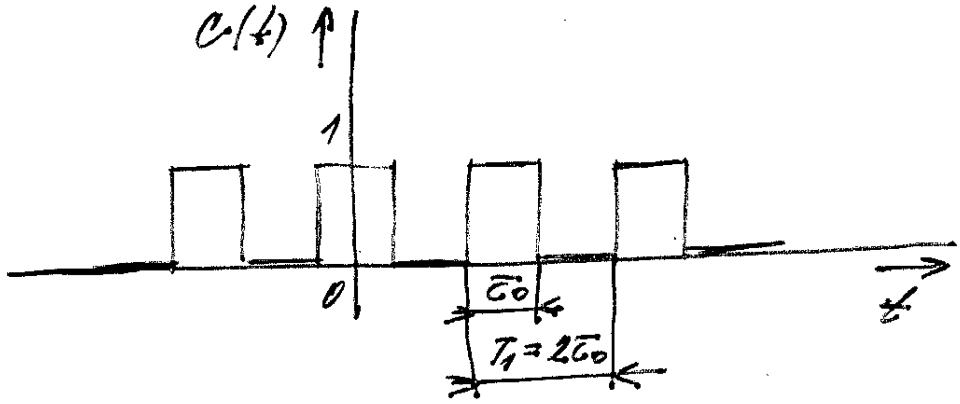
ROČNÍK:

ČÍSLO ZLOŽKY 129

$$y(t) = s(t)\cos\omega_0 t = A\cos^2\omega_0 t = \frac{1}{2}A + \frac{1}{2}A\cos 2\omega_0 t$$

$$v(t) = \begin{cases} \frac{1}{2}A\ ; & \text{ak } s(t) = A\cos\omega_0 t \\ 0\ ; & \text{ak } s(t) = 0 \end{cases}$$

Obálková (nekoherentná) demodulácia



$$c(t) = \frac{1}{2} + \sum_{n=1}^{\infty} \frac{\sin\frac{n\pi}{2}}{\frac{n\pi}{2}} \cos n\omega_1 t$$

$$\omega_1 = 2\pi\frac{1}{T_1} = \frac{\pi}{\tau_0}$$

NÁZOV:

PREDMET:

ROČNÍK:

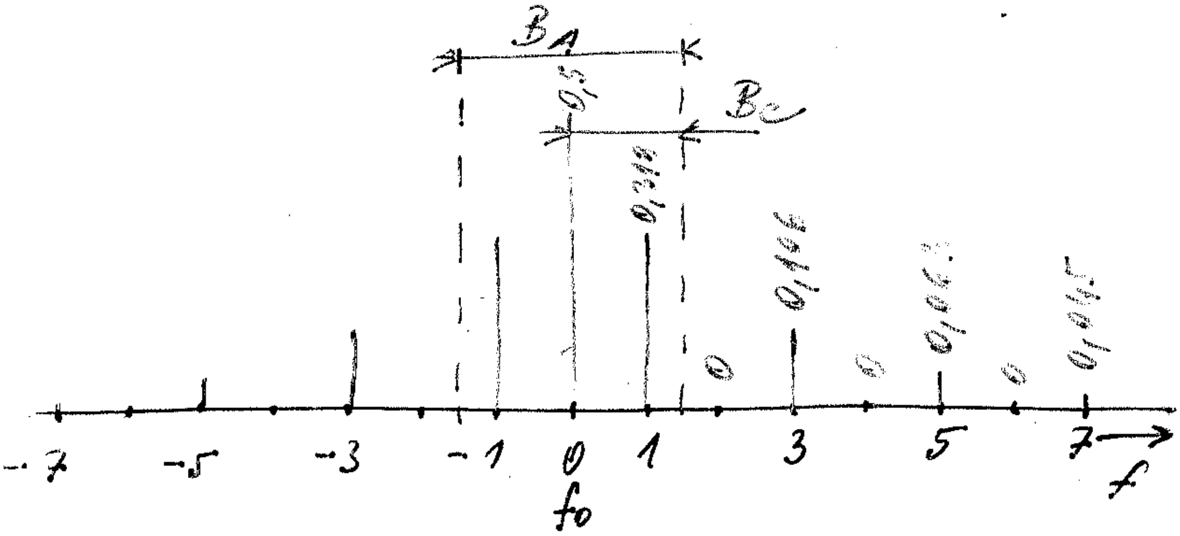
ČÍSLO:

ČÍSLO ZLOŽKY 130

$$u(t) = A\cos\omega_0 t$$

$$s(t) = A\,c(t)\cos\omega_0 t = \frac{A}{2}\cos\omega_0 t +$$

$$+A\sum_{n=1}^{\infty}\frac{\sin n\frac{\pi}{2}}{n\pi}\left\{\cos(\omega_0+n\omega_1)t+\cos(\omega_0-n\omega_1)t\right\}$$



NÁZOV:

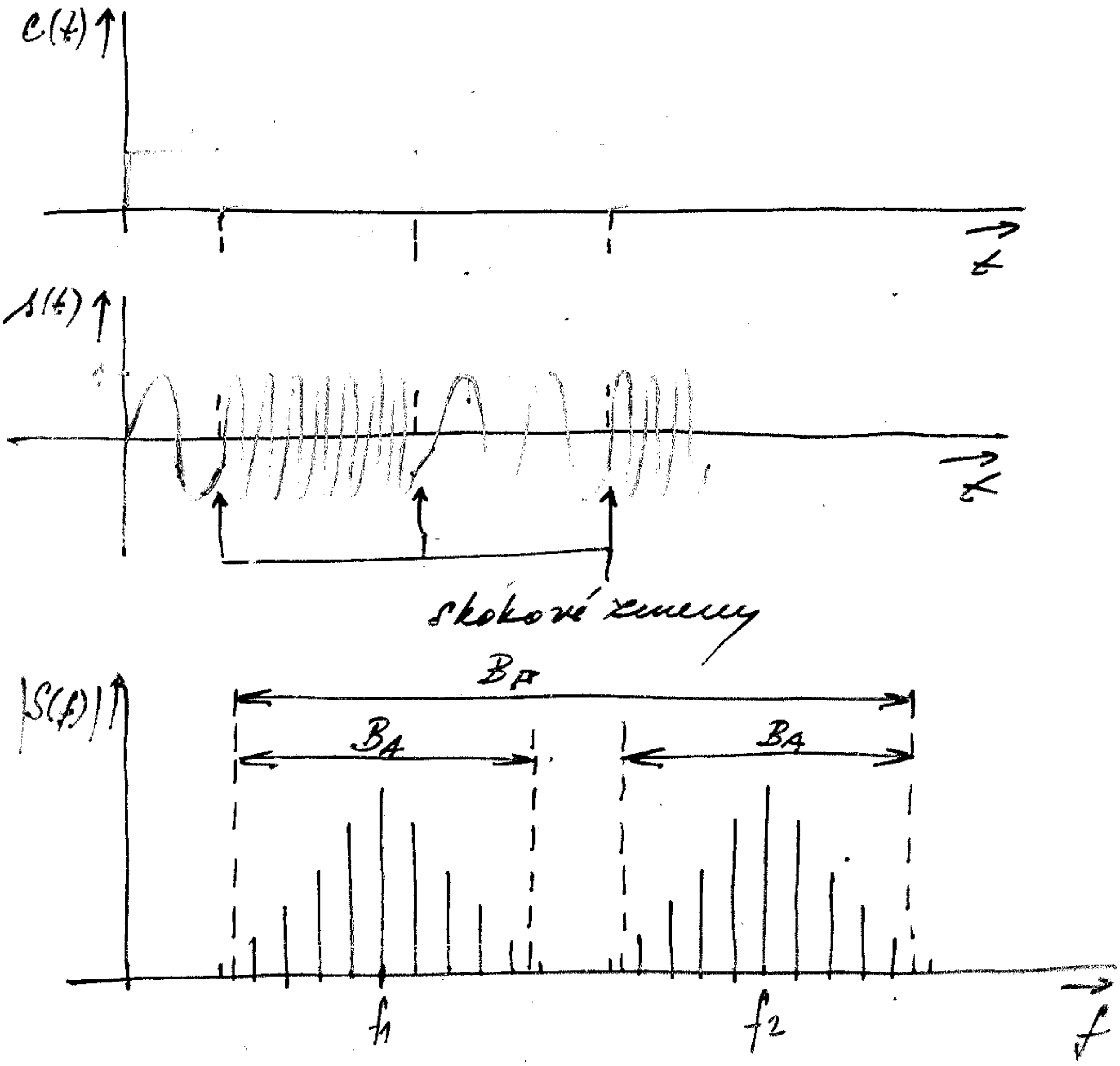
PREDMET:

ROČNÍK:

ČÍSLO:

ČÍSLO ZLOŽKY

	1	3	1



$$B_F = (f_2 - f_1) + B_A$$

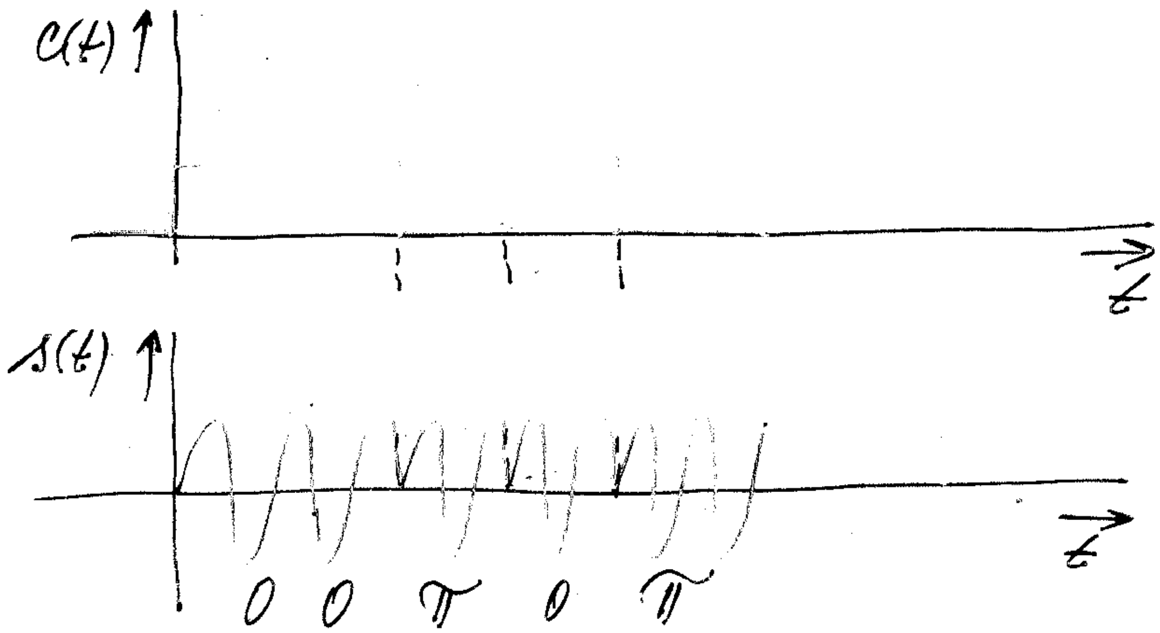
NÁZOV:

PREDMET:

ROČNÍK:

ČÍSLO:

ČÍSLO ZLOŽKY 137



$$s(t) = A\cos\{\omega_0 t + \varphi_m c_m(t)\} =$$

$$= A\cos\omega_0 t \cos\{\varphi_m c_m(t)\} - A\sin\omega_0 t \sin\{\varphi_m c_m(t)\}$$

$$s(t) = A\cos\varphi_m \cos\omega_0 t - A c_m(t)\sin\varphi_m \sin\omega_0 t$$

$$c_m(t) = \sum_{n=1}^{\infty} 4\,\frac{\sin n\frac{\pi}{2}}{n\pi}\sin n\omega_0 t$$

$$s(t) = A\cos\varphi_m\cos\omega_0 t - A\sin\varphi_m \sum_{n=1}^{\infty} 4\,\frac{\sin\frac{n\pi}{2}}{n\pi}\sin n\omega_0 t \sin\omega_0 t =$$

$$= A\cos\varphi_m\cos\omega_0 t + A\sin\varphi_m \sum_{n=1}^{\infty} 2\,\frac{\sin\frac{n\pi}{2}}{n\pi}\{\cos(\omega_0 + n\omega_0)t - \cos(\omega_0 - n\omega_0)t\}$$

NÁZOV:

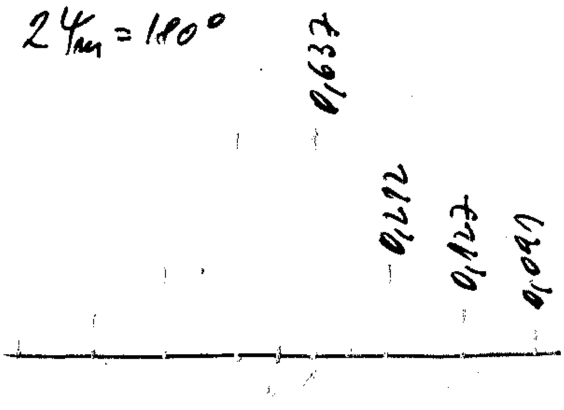
PREDMET:

ROČNÍK:

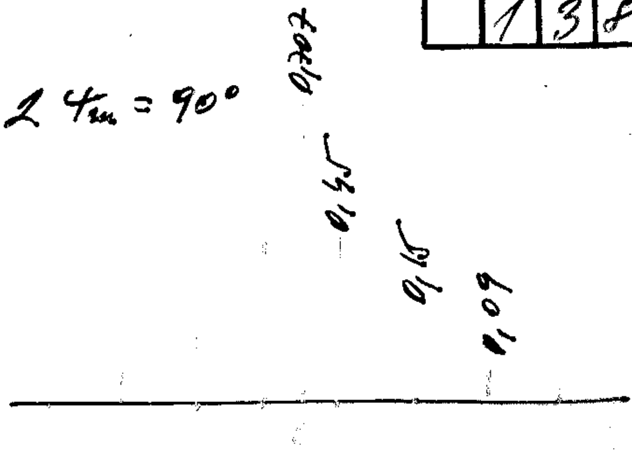
ČÍSLO:

ČÍSLO ZLOŽKY 138

$2\Psi_m = 180°$



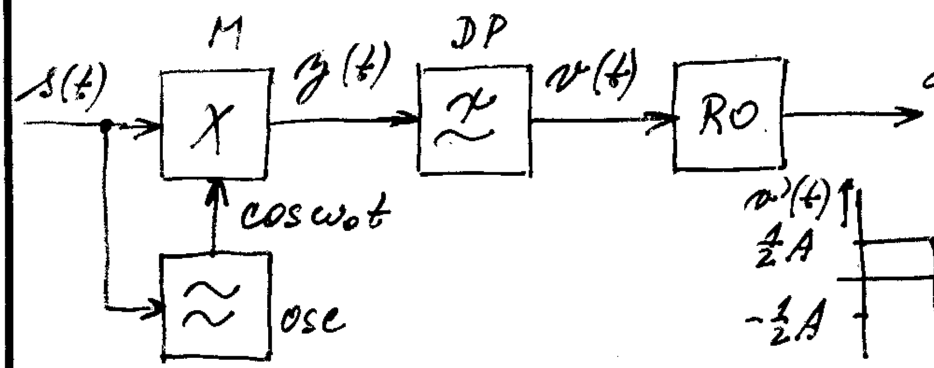
$2\Psi_m = 90°$

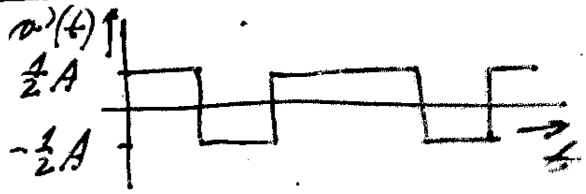


$$s(t) = A \cos(\omega_0 t + \varphi_i)$$

$\varphi_1 = 0$ [rad] pre I

$\varphi_2 = \pi$ [rad] pre 0





$$s_1(t) = a_1 \cos\omega_0 t = A \cos\omega_0 t \quad \text{pre I}$$

$$s_2(t) = a_2 \cos\omega_0 t = -A \cos\omega_0 t \quad \text{pre 0}$$

NÁZOV:

ČÍSLO:

PREDMET:

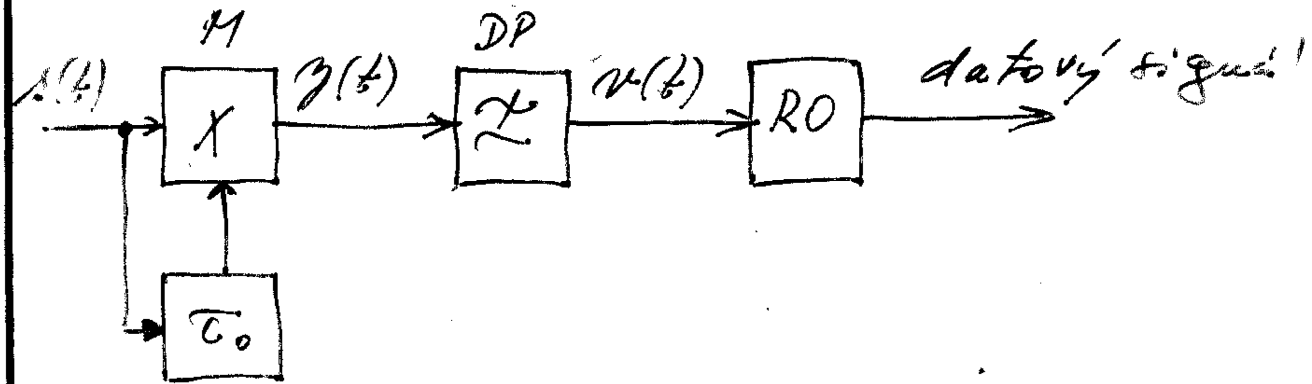
ROČNÍK:

ČÍSLO ZLOŽKY 139

$$y_1(t) = s_1(t)\cos\omega_0 t = A\cos\omega_0 t \cos\omega_0 t =$$
$$= A\cos^2\omega_0 t = \frac{1}{2}A + \frac{1}{2}A\cos 2\omega_0 t$$

$$y_2(t) = s_2(t)\cos\omega_0 t = -A\cos\omega_0 t \cdot \cos\omega_0 t =$$
$$= -A\cos^2\omega_0 t = -\frac{1}{2}A - \frac{1}{2}A\cos 2\omega_0 t$$

Rozdielová fázová modulácia



Pr.

datový signál ... I 0 0 I I 0 I 0 0 I ...
fáza nosnej vlny ... 0 0 π 0 0 0 π π 0 π π ...

NÁZOV:

PREDMET:

ROČNÍK:

ČÍSLO:

ČÍSLO ZLOŽKY 140

Pr.

vstup. demodulátora	... 0 0 π 0 0 0 π π 0 π π ...
oneskorený signál	... 0 0 π 0 0 0 π π 0 π π ...
výstup	... I 0 0 I I 0 I 0 0 I

n - stavová modulácia → s dvojk. zná.

$n = 2^s$

$V_p = s V_m$

↳ prenosová rýchlosť

Štvorstavová PM

$n = 4 \Rightarrow s = 2$

4 rôzne dibity

00; 0I; I0; II

NÁZOV:

PREDMET:

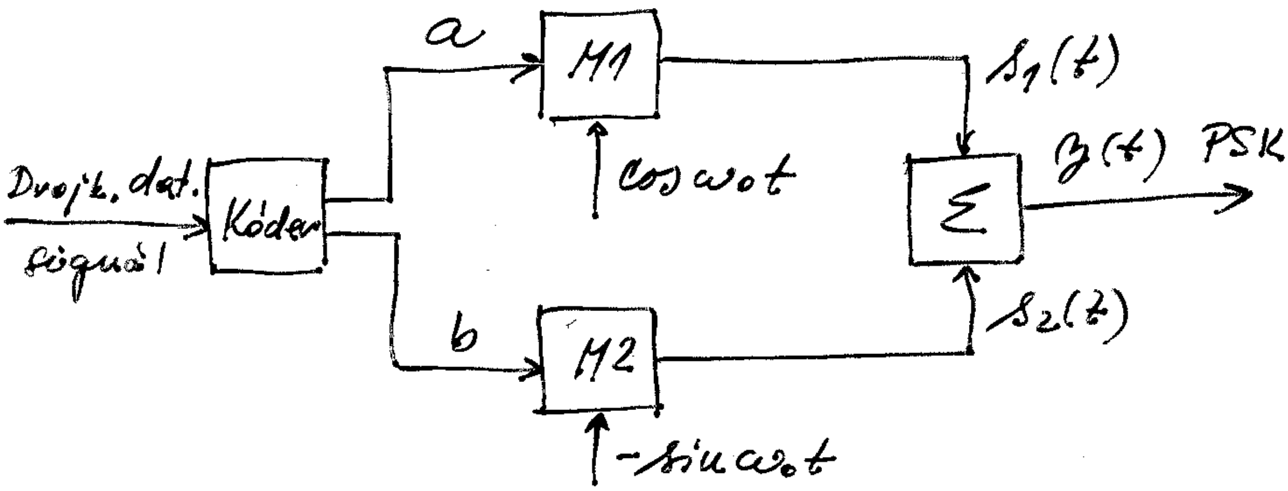
ROČNÍK:

ČÍSLO:

ČÍSLO ZLOŽKY

| | 1 | 4 | 1 |

dibit a b	fázový stav Φ_i
I I	45°
0 I	135°
0 0	225°
I 0	315°



$s_1(t) = a\cos\omega_0 t = \cos\omega_0 t$ pre $a = 1$

$s_1(t) = -\cos\omega_0 t$ pre $a = -1$

$s_2(t) = b\cos(\omega_0 t + \pi/2) = \cos(\omega_0 t + \pi/2)$ pre $b = 1$

$s_2(t) = \cos(\omega_0 t - \pi/2)$ pre $b = -1$

$$y(t) = s_1(t) + s_2(t) = a\cos\omega_0 t + b\cos(\omega_0 t + \pi/2) =$$

$$= a\cos\omega_0 t - b\sin\omega_0 t$$

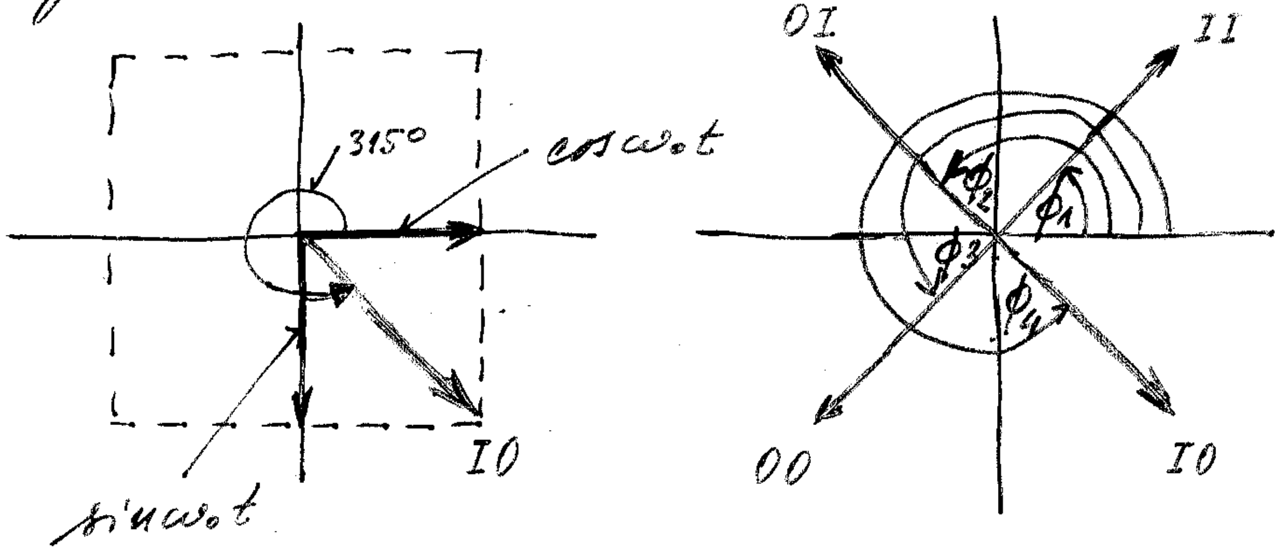
NÁZOV: **PREDMET:**

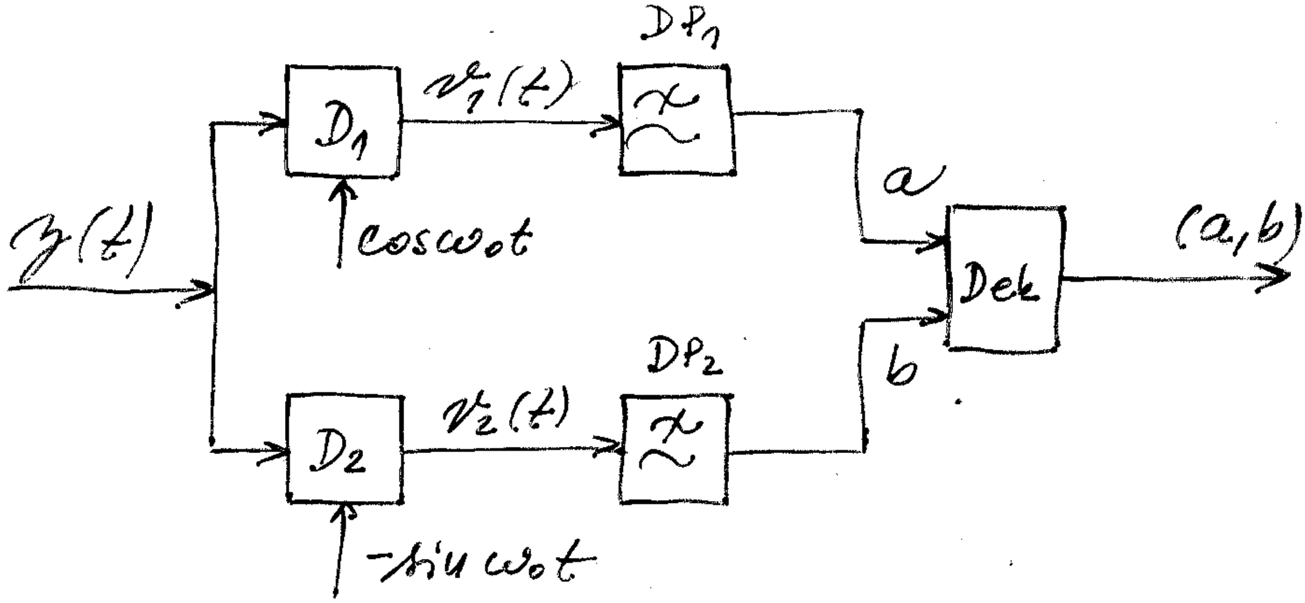
ROČNÍK:

ČÍSLO: **ČÍSLO ZLOŽKY** 1 4 2

Uvažujme dibit (10) → (a,b) → (1,-1)

$$y(t) = \cos\omega_0 t + \sin\omega_0 t = \sqrt{2}\cos\left(\omega_0 t - \frac{\pi}{4}\right)$$





$$v_1(t) = y(t)\cos\omega_0 t = a\cos^2\omega_0 t - b\sin\omega_0 t\cos\omega_0 t =$$

$$= \frac{1}{2}a + \frac{1}{2}a\cos 2\omega_0 t - \frac{1}{2}b\sin 2\omega_0 t$$