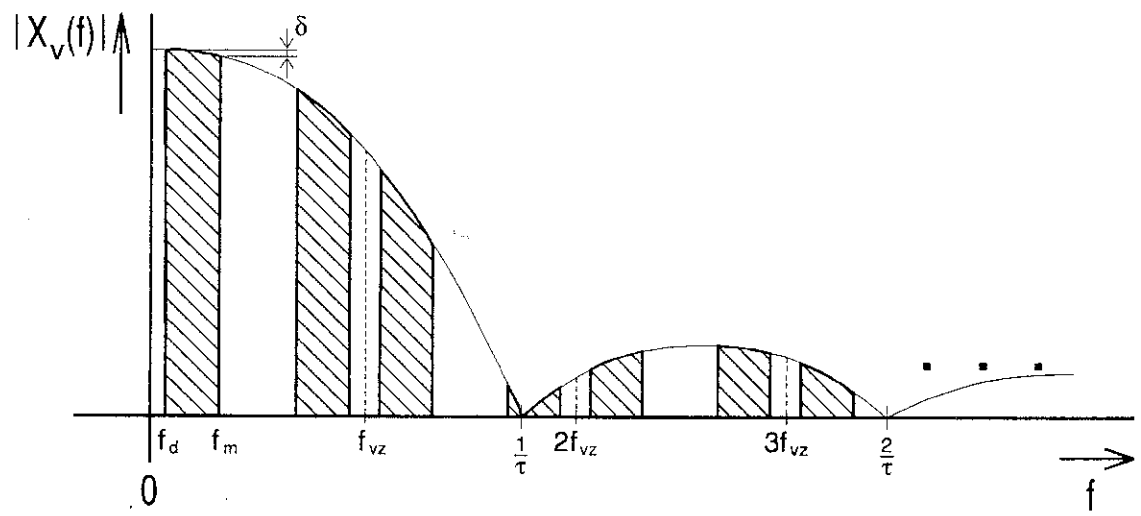
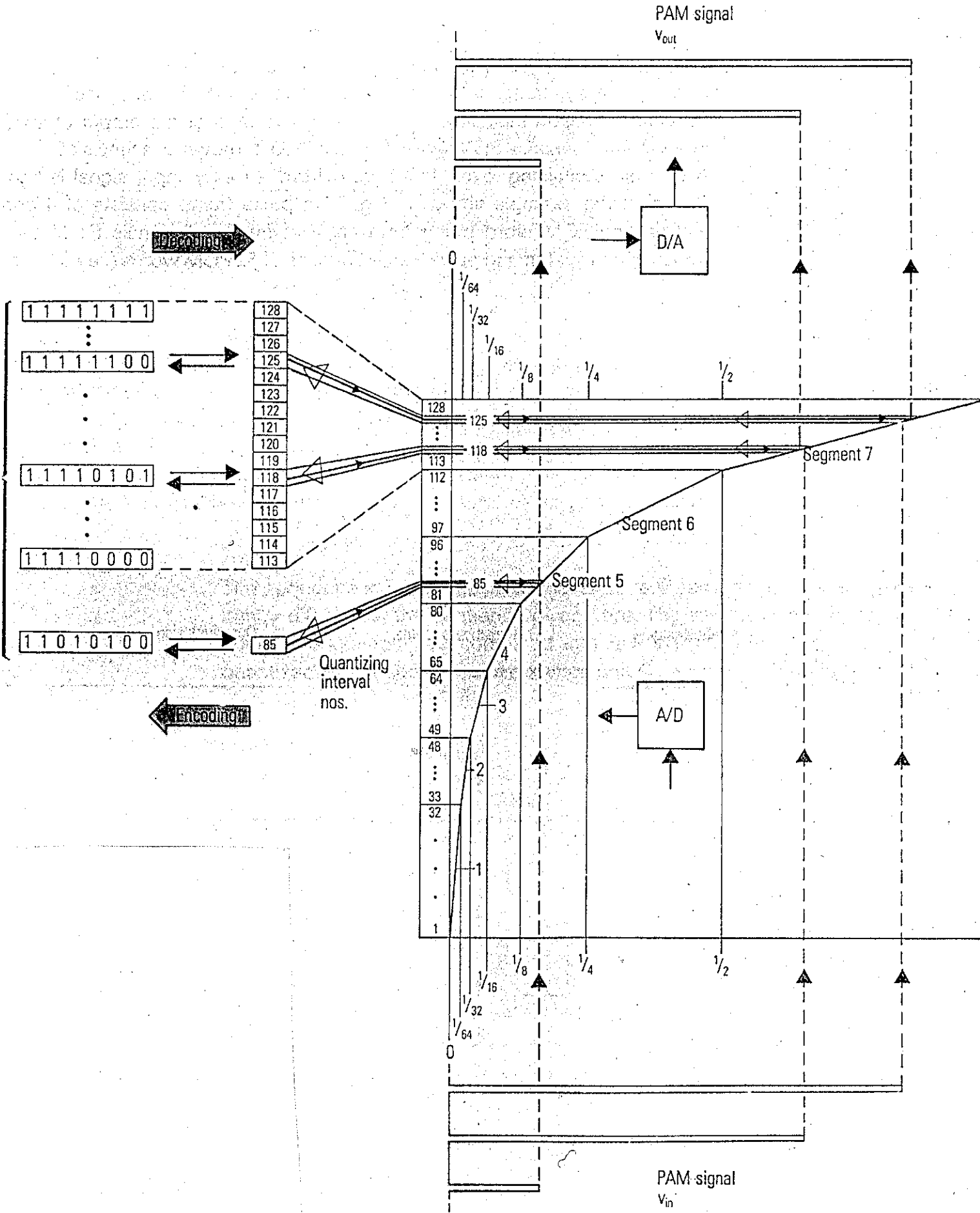


a)



b)

Obr.2.41



Impulzové modulačie

- * impulzové analógové
- * impulzové kódové

Impulzové analógové modulačie

nosný signál - impulzný signál
 modulačný signál - analógový signál

- * impulzová amplitúdová modulačia PAM
- * impulzová šírková modulačia PDM
- * impulzová polohová modulačia PPM

Impulzové kódové modulačie

modulačný signál $x(t)$ → vzorkovaný →
 → kvantovaný → kódovaný → vzniká čís-
 lícový signál

Impulzová amplitúdová modulačia PAM

odporúča vzorkovanie 2. dráhu

Impulzová šírková modulačia PDM

(Pulse Duration Modulation)

- * súmerná
- * nesúmerná

Spektrálna analýza

- periodický impulzový signál (T_{uz} , τ , A)

$$y(t) = \frac{A\tau}{T_{uz}} + \sum_{n=1}^{\infty} \frac{2A}{n\pi} \sin n\pi f_{uz} \tau \cos n\omega_{uz} t =$$

$$= A f_{uz} \tau + \sum_{n=1}^{\infty} \frac{A}{n\pi} \left\{ \sin n\pi f_{uz} (2t + \tau) - \sin n\pi f_{uz} (2t - \tau) \right\}$$

$\tau \left\{ x(t) \right\}$

$$\tau = \tau_0 + m x(t)$$

$$\tau_0 \rightarrow x(t) = 0$$

$m \rightarrow$ modulačný koeficient

$$\phi(t) = \pi f_{uz} \tau = \pi f_{uz} \left\{ \tau_0 + m x(t) \right\}$$

potom

$$y(t) = A f_{uz} \tau_0 + A f_{uz} m x(t) + \sum_{n=1}^{\infty} \frac{A}{n\pi} \left\{ \sin [n\omega_{uz} t + n\phi(t)] - \right.$$

$$\left. - \sin [n\omega_{uz} t - n\phi(t)] \right\}$$

1. člen - j.s. zložka
2. člen - základ. zl. \rightarrow modulačného signálu
3. člen - vyššie zl. - každý člen predstavuje fázovo modulovaný harmonický signál s frekv. $n f_{uz}$. Zmeny fáze odovzdajú, sú úmerné signálu $x(t)$.

NÁZOV:

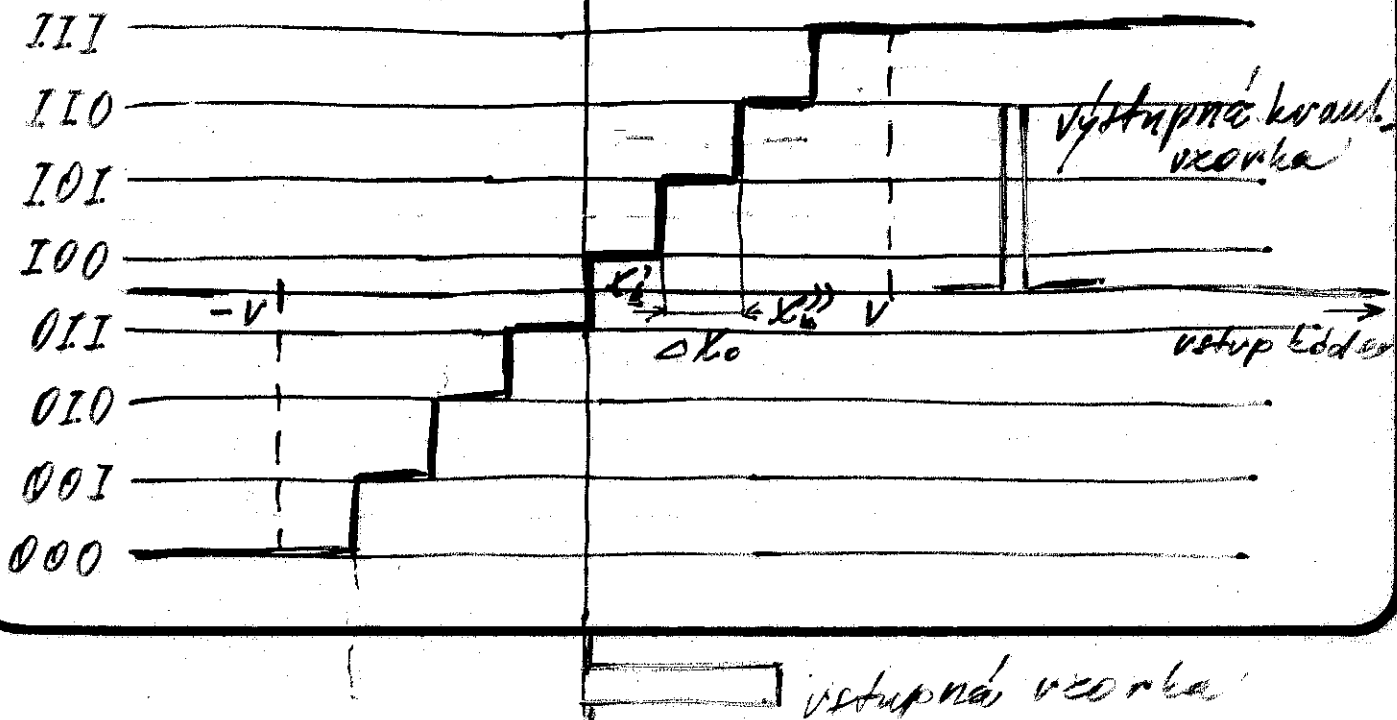
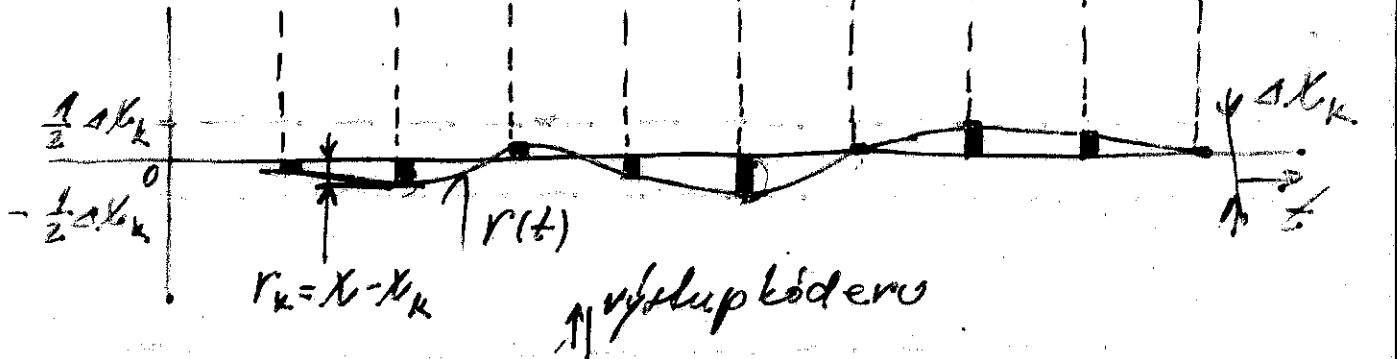
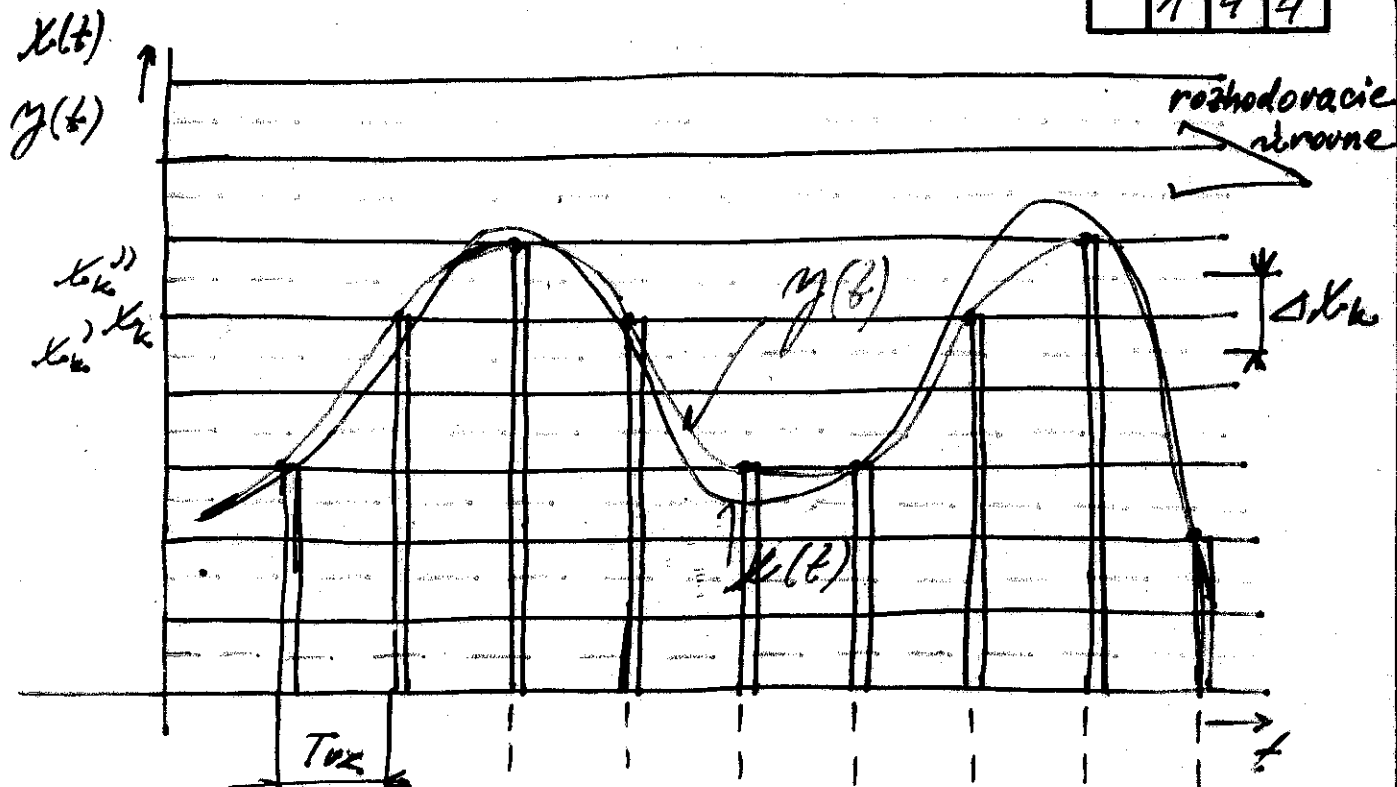
PŘEDMET:

ROČNÍK:

ČÍSLO:

ČÍSLO ZLOŽKY

1 4 4



NÁZOV:

PREDMET:

ROČNÍK:

ČÍSLO:

ČÍSLO ZLOŽKY

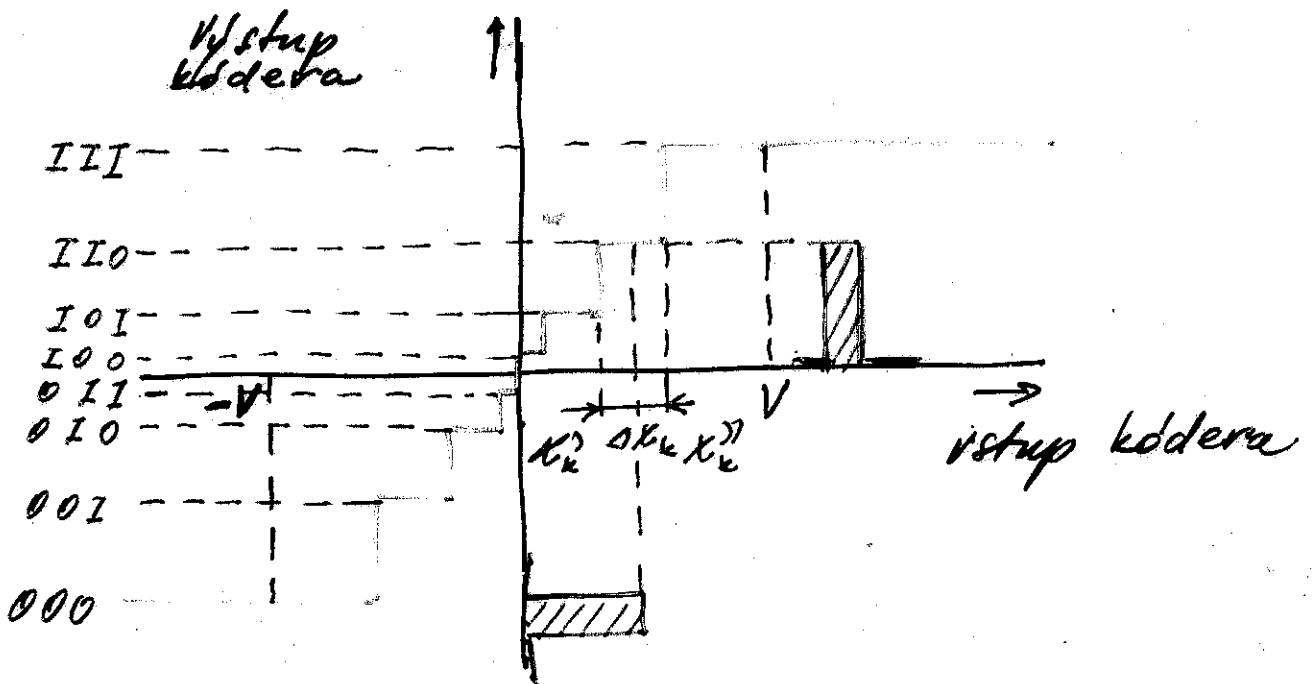
145

Prekročenie hodnoty $\pm V$
 Skreslenie obmedzeniu

$$r_k \in \left\langle -\frac{1}{2}\Delta_0; \frac{1}{2}\Delta_0 \right\rangle$$

$r(t)$ - kvantizačný signál

Nelineárne kvantovanie



NÁZOV:

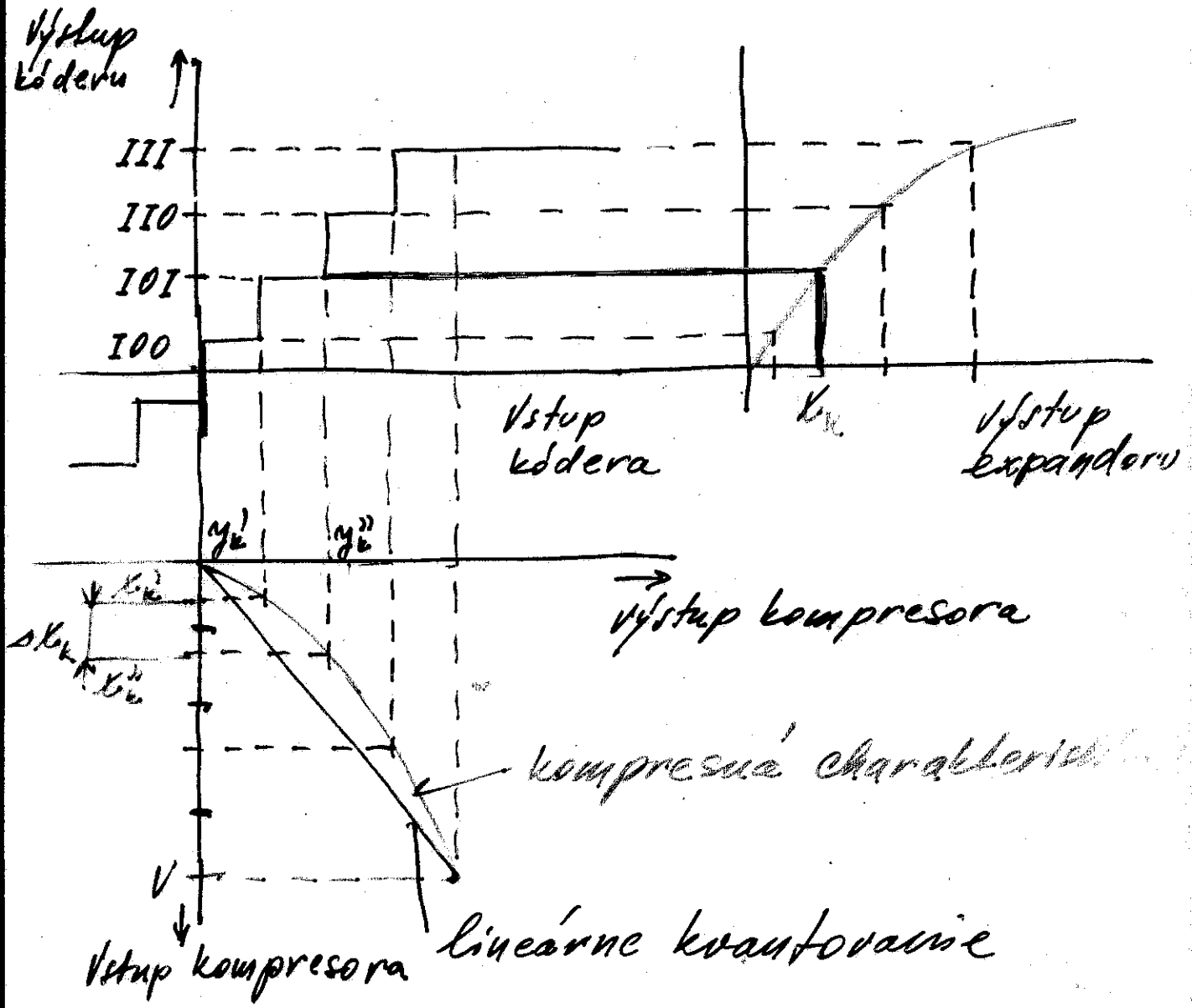
PREDMET:

ROČNÍK:

ČÍSLO:

ČÍSLO ZLOŽKY

146



NÁZOV:

PREDMET:

ROČNÍK:

ČÍSLO:

ČÍSLO ZLOŽKY

147

Impulzové modulačie

- impulzové analógové modulačie
- impulzové kódové modulačie

- impulzová amplitúdová modulačia PAM
- impulzová šírková modulačia PDM
- impulzová pozíčná modulačia PPM

Impulzová amplitúdová modulačia PAM

Modulačia PAM \rightarrow vkonkrovacie 2. druhu

Impulzová šírková modulačia PDM

Prímerná - šírka impulzu τ sa mení súmerne

Nesúmerná - posúva sa len 1 hrana impulzu.

NÁZOV:

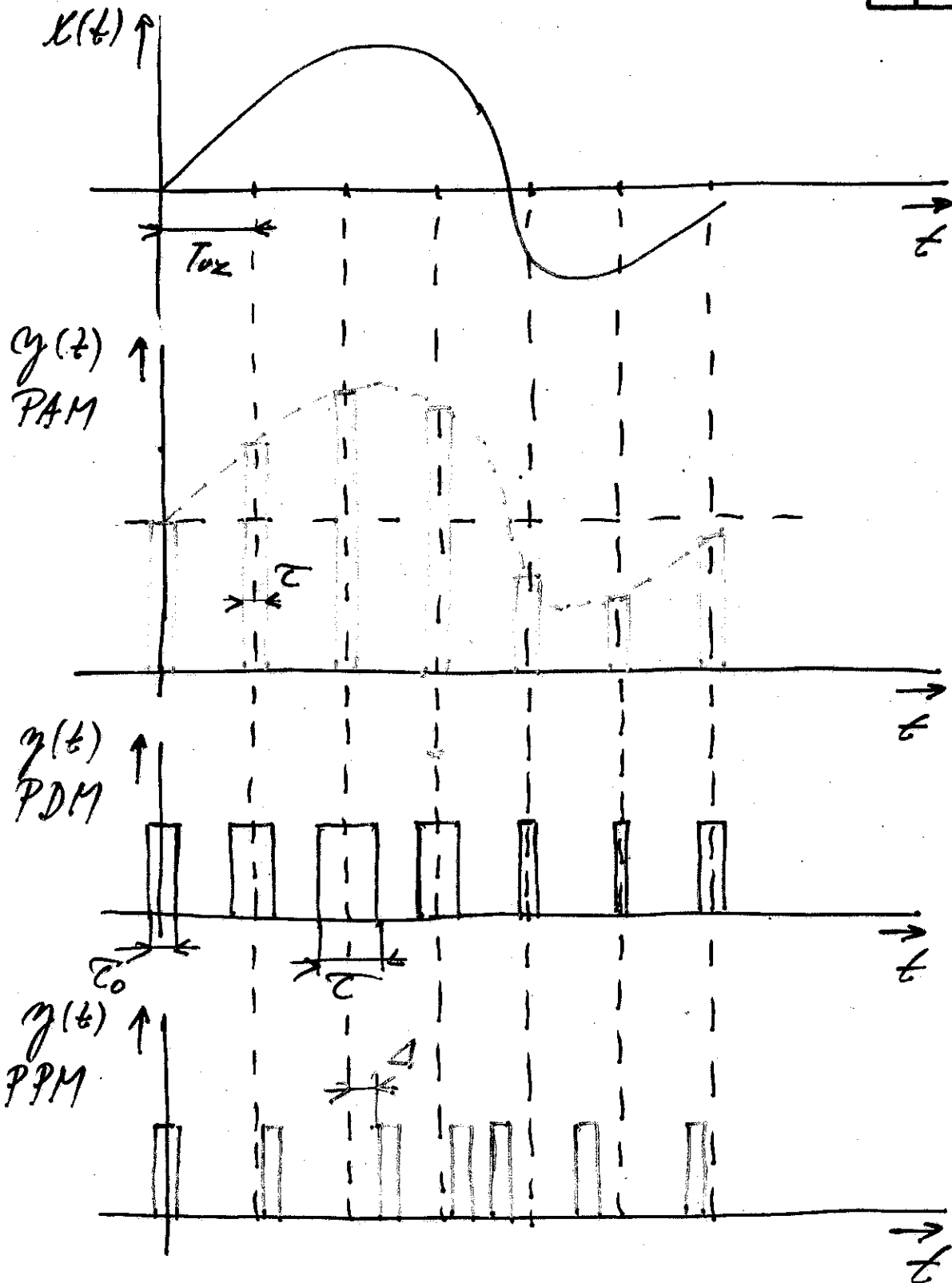
PREDMET:

ROČNÍK:

ČÍSLO:

ČÍSLO ZLOŽKY

1	4	8
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NÁZOV:

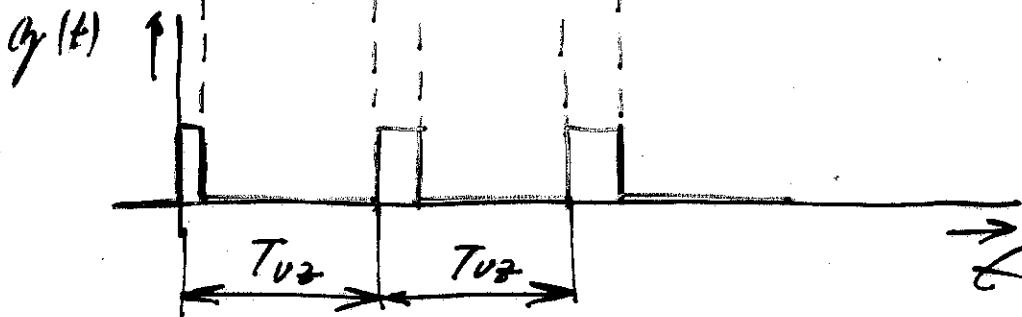
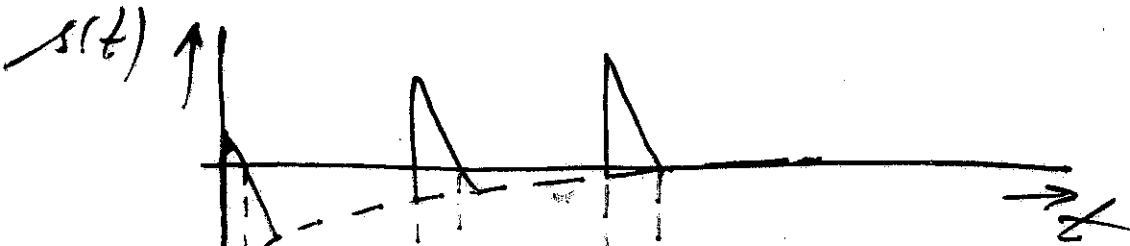
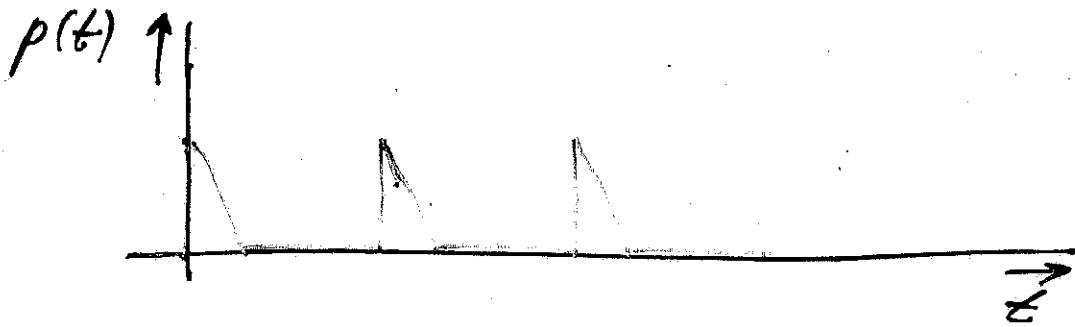
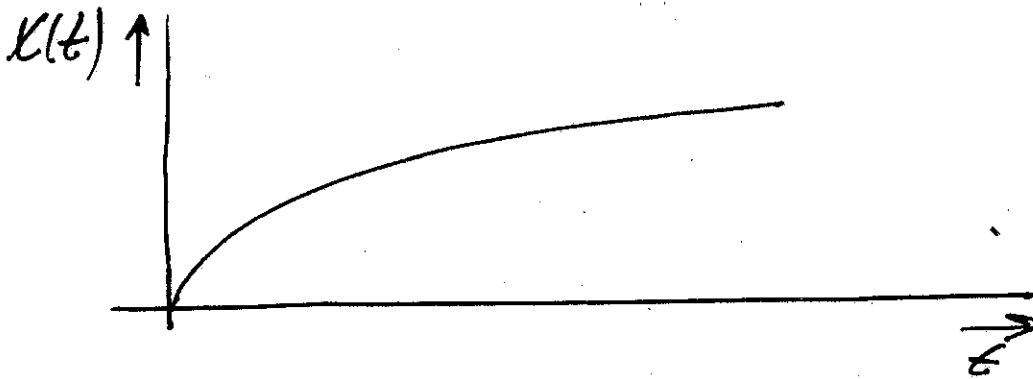
PREDMET:

ROČNÍK:

ČÍSLO:

ČÍSLO ZLOŽKY

1	4	9
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NÁZOV:

PŘEDMET:

ROČNÍK:

ČÍSLO:

ČÍSLO ZLOŽKY

150

Kmitočtová oblast

$$y(t) = \frac{A\bar{\tau}}{T_{vz}} + \sum_{m=1}^{\infty} \frac{LA}{m\pi} \sin m\pi f_{vz} \tau \cos m\omega_{vz} t =$$

$$= A f_{vz} \tau + \sum_{m=1}^{\infty} \frac{A}{m\pi} \left\{ \sin m\pi f_{vz} (2t + \tau) - \sin m\pi f_{vz} (2t - \tau) \right\}$$

$$\tau = \tau_0 + \mu \kappa(t)$$

$$\phi(t) = \pi f_{vz} \tau = \pi f_{vz} \left\{ \tau_0 + \mu \kappa(t) \right\}$$

$$y(t) = A f_{vz} \tau_0 + A f_{vz} \mu \kappa(t) + \sum_{m=1}^{\infty} \frac{A}{m\pi} \left\{ \sin [m\omega_{vz} t + \mu \phi(t)] - \sin [m\omega_{vz} t - \mu \phi(t)] \right\}$$

NÁZOV:

PREDMET:

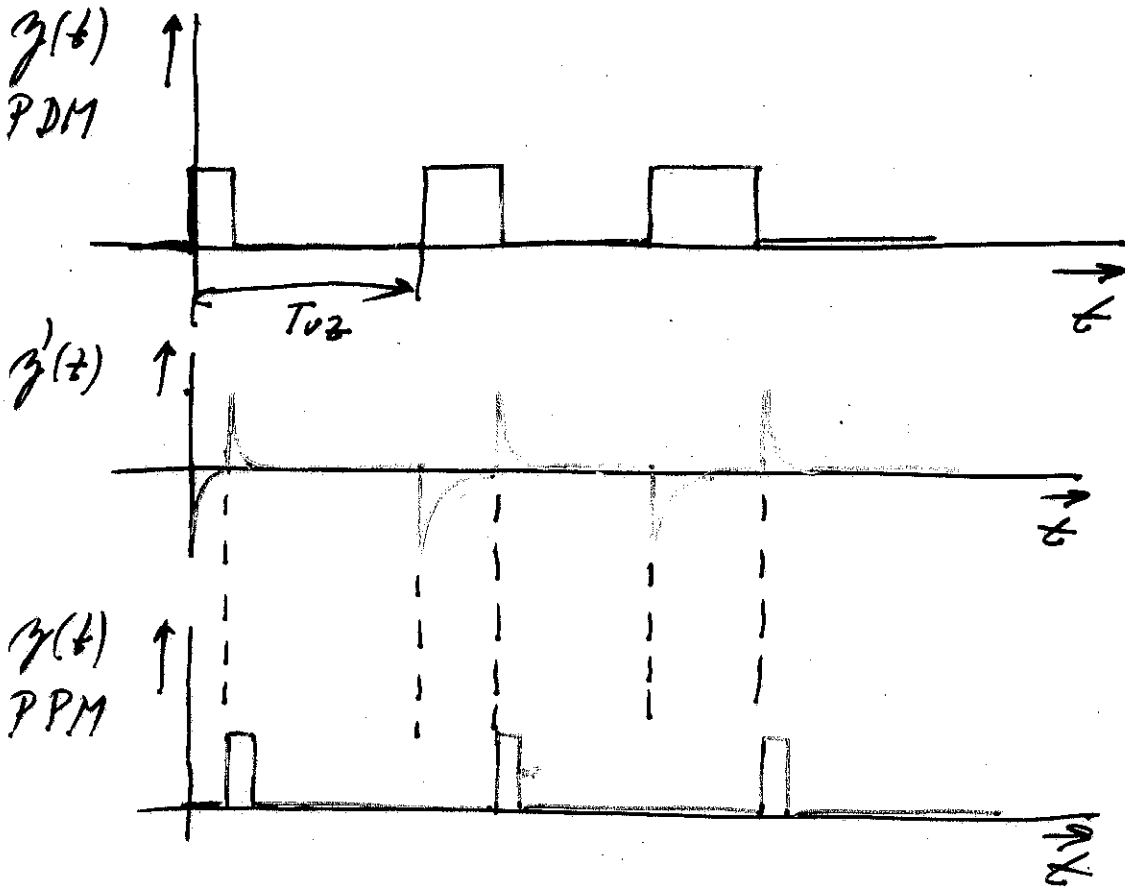
ROČNÍK:

ČÍSLO:

ČÍSLO ZLOŽKY

1	5	1
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Impulsová polohová modulace PPM



NÁZOV:

PREDMET:

ROČNÍK:

ČÍSLO:

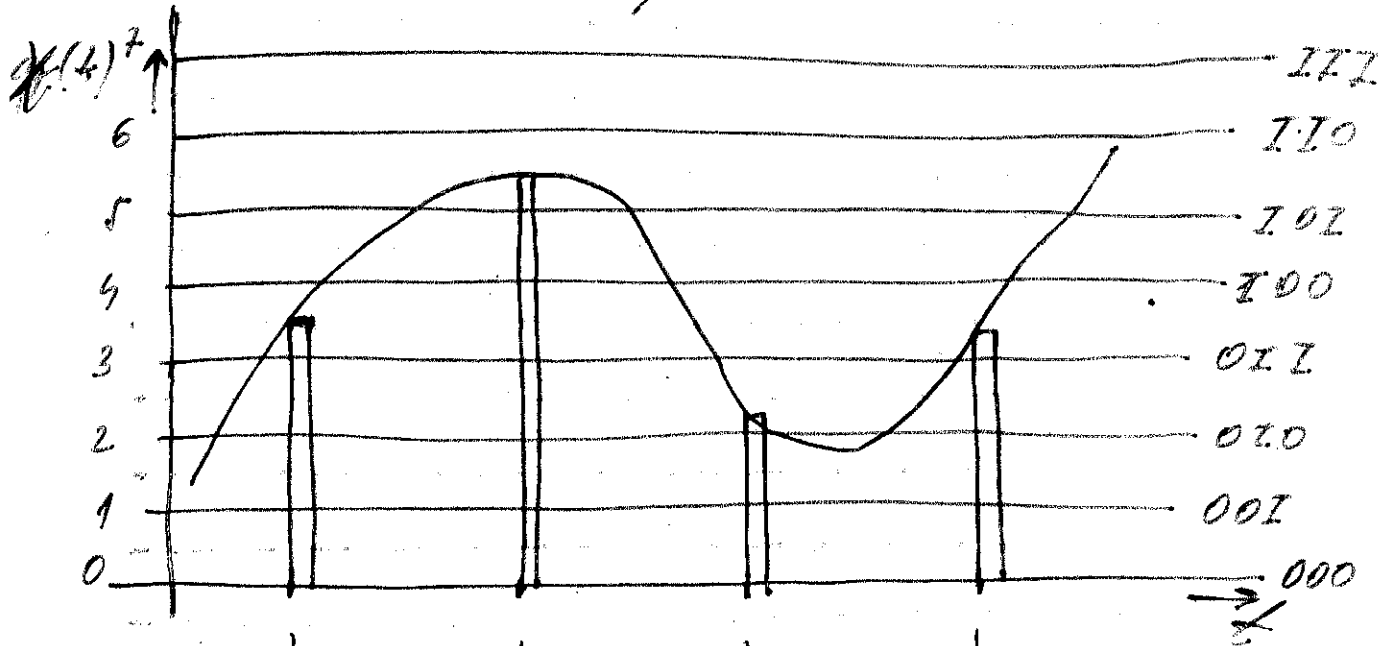
ČÍSLO ZLOŽKY

1 5 2

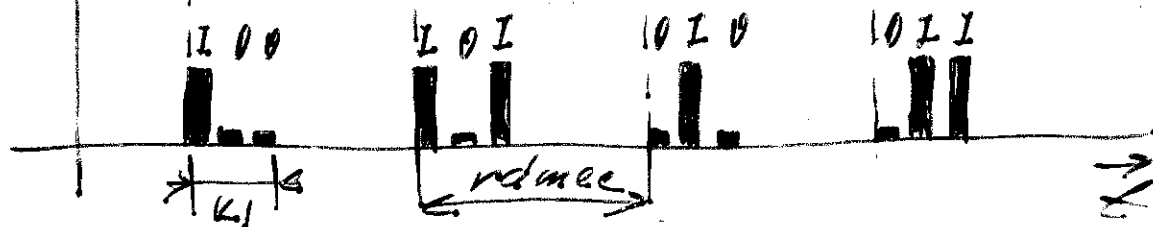
- impulzová kódová modulácia PCM
- delta modulácia DM
- diferenčná PCM modulácia DPCM

Impulzová kódová modulácia PCM

$x(t)$ - vzorkovaný



PCM ↑



NÁZOV:

PREDMET:

ROČNÍK:

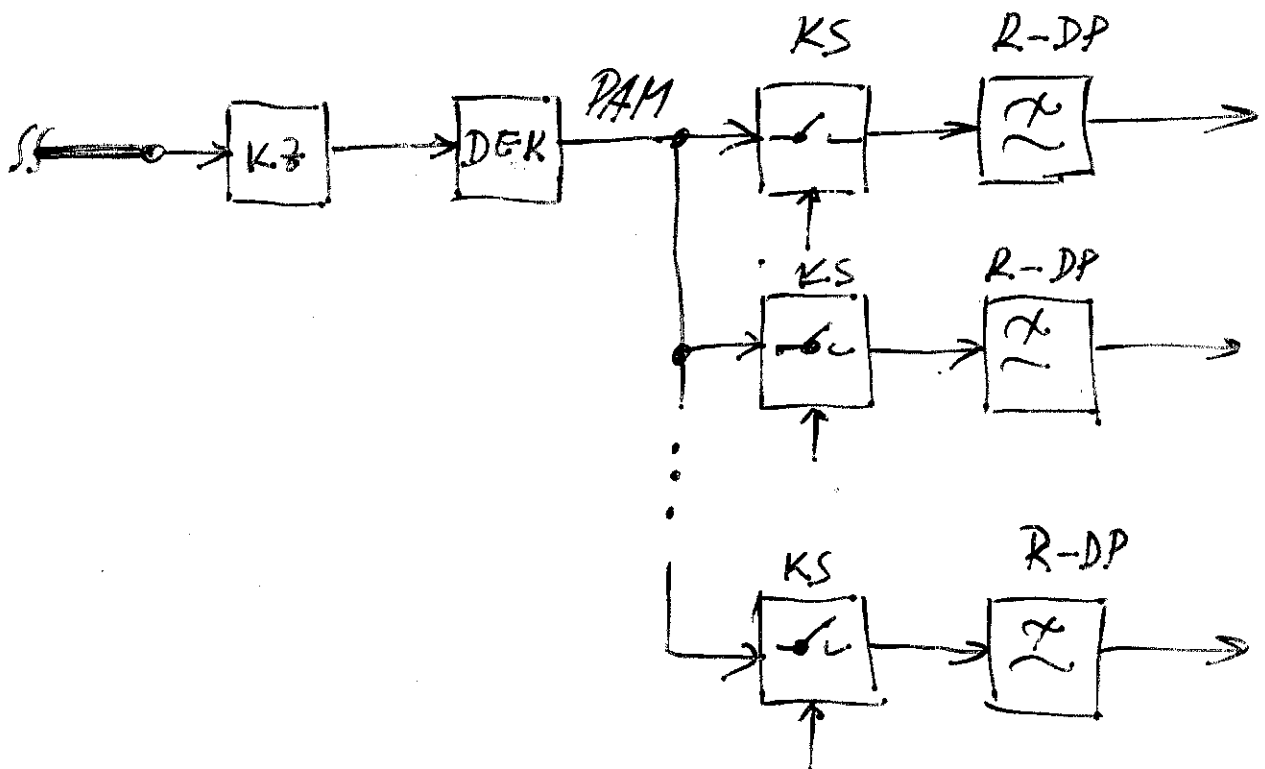
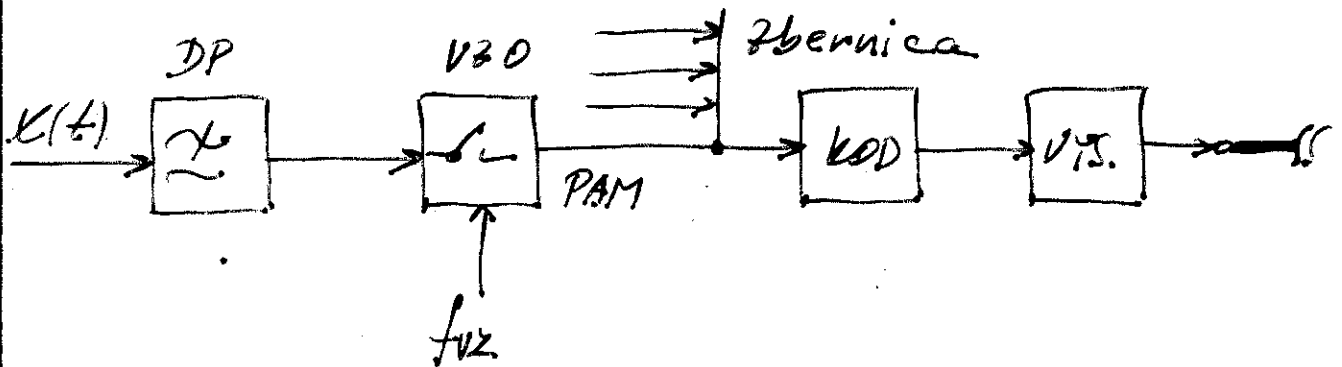
ČÍSLO:

ČÍSLO ZLOŽKY

1	5	3
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$$T_0' = \frac{1}{\mu f_{0z}}$$

$$T_0 = \frac{1}{\mu f_{0z} Q} \Rightarrow f_0 = \frac{1}{T_0} = \mu f_{0z} Q$$



NÁZOV:

PŘEDMET:

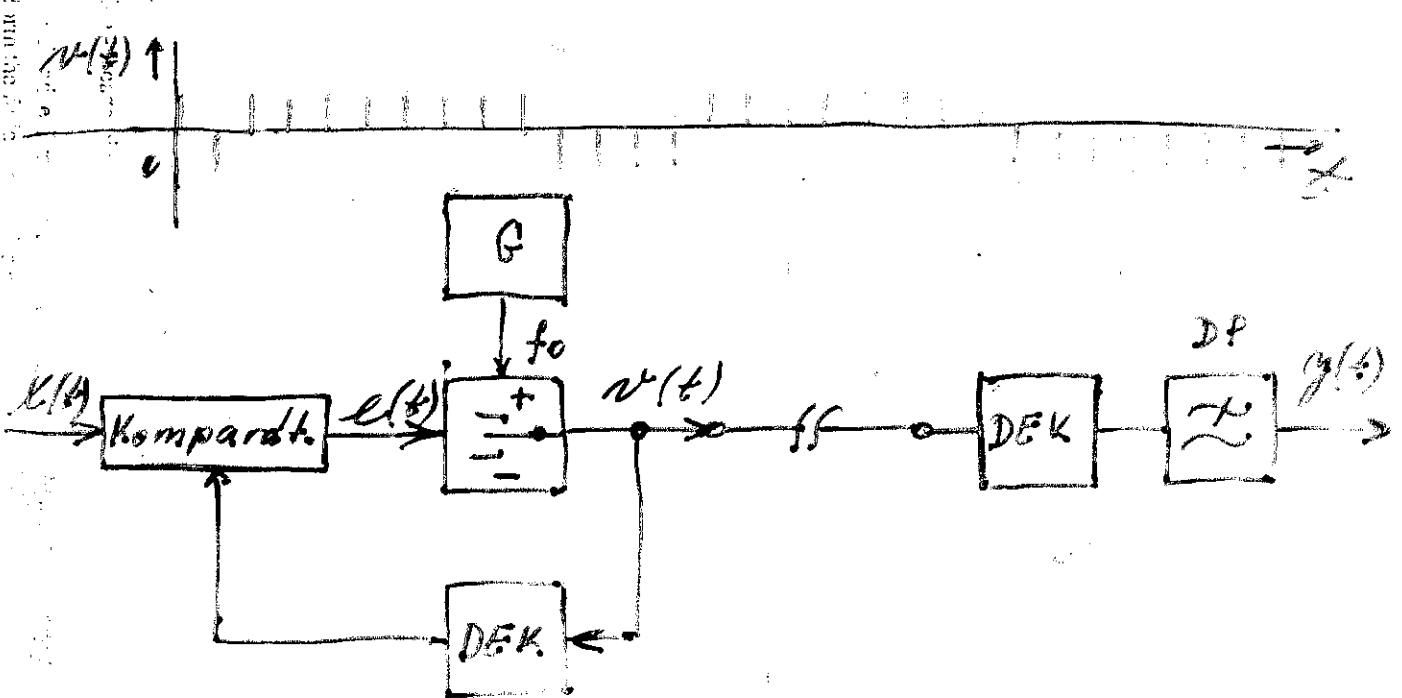
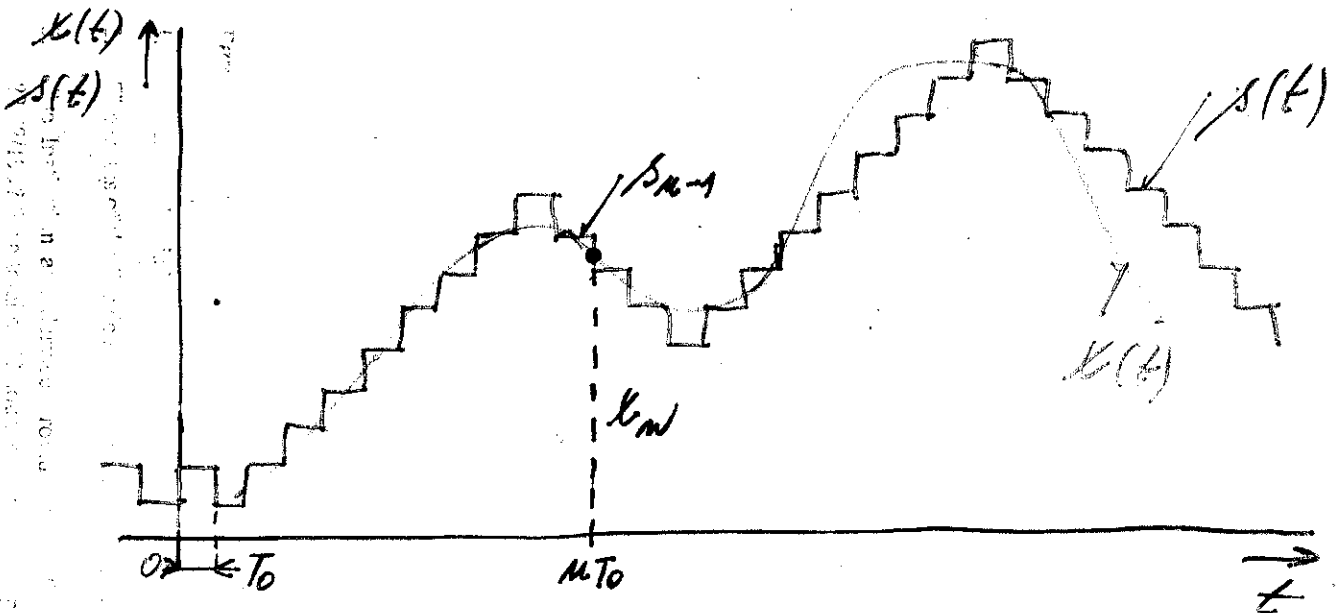
ROČNÍK:

ČÍSLO:

ČÍSLO ZLOŽKY

159

Delta modulace



NÁZOV:

PREDMET:

ROČNÍK:

ČÍSLO:

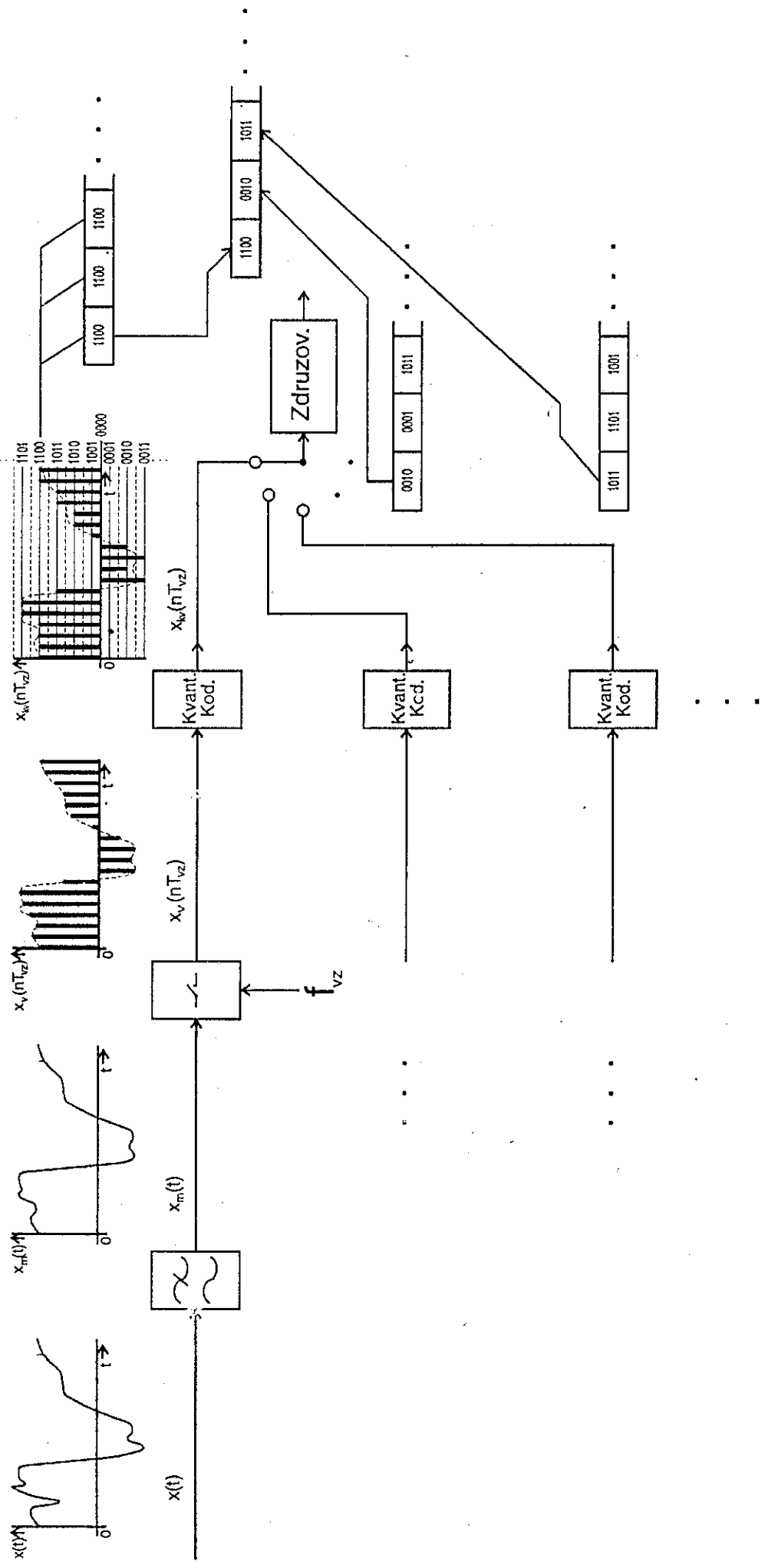
ČÍSLO ZLOŽKY

	1	5	5
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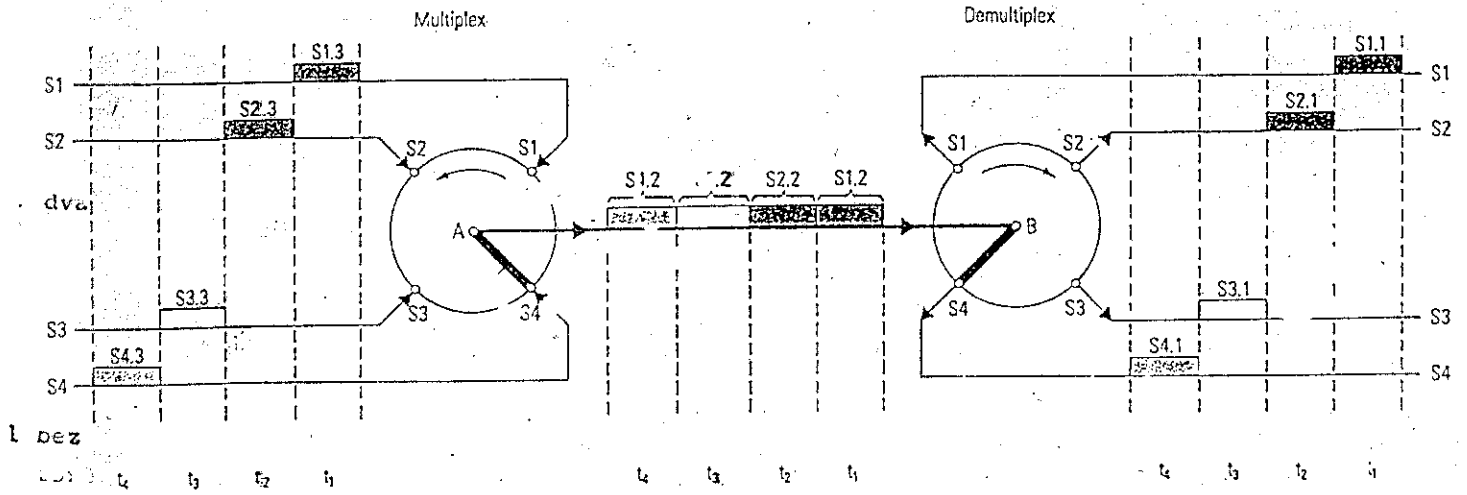
$$e(t) = x(t) - s(t)$$

a) $e_m = x_m - s_{n-1} > 0 \rightarrow$ kladný impuls

b) $e_m = x_m - s_{n-1} < 0 \rightarrow$ záporný impuls

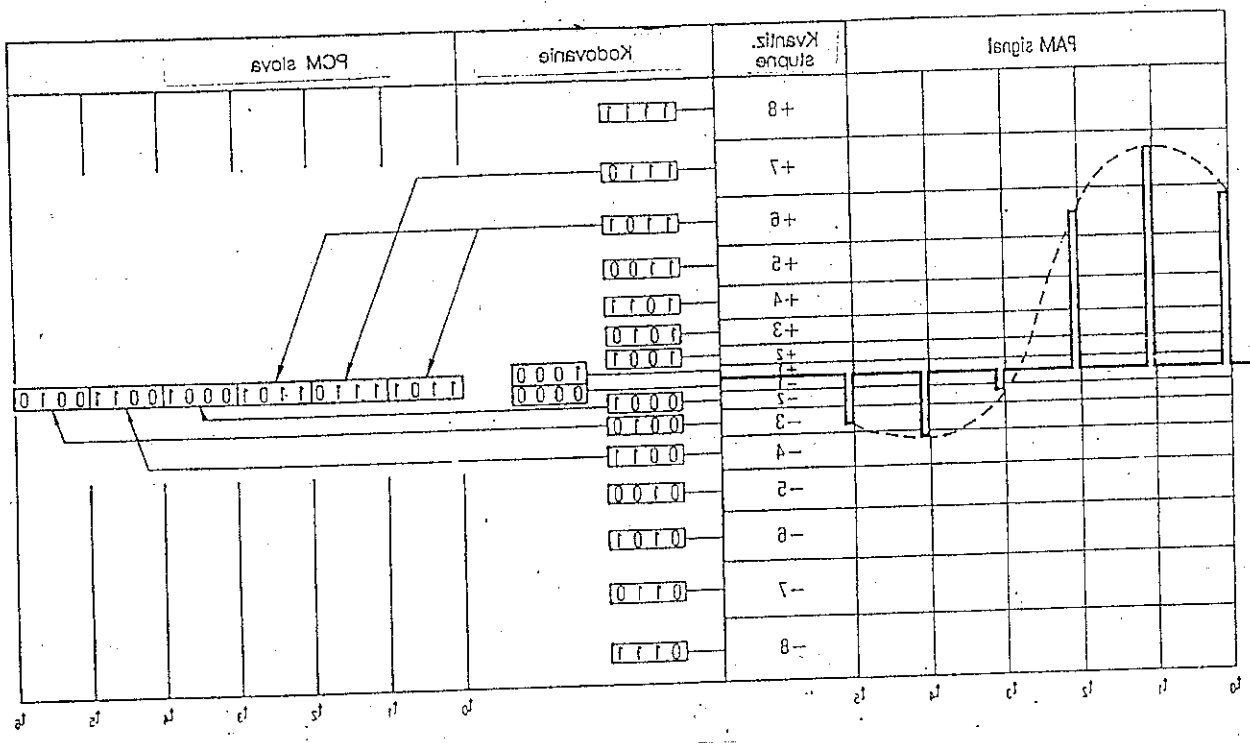
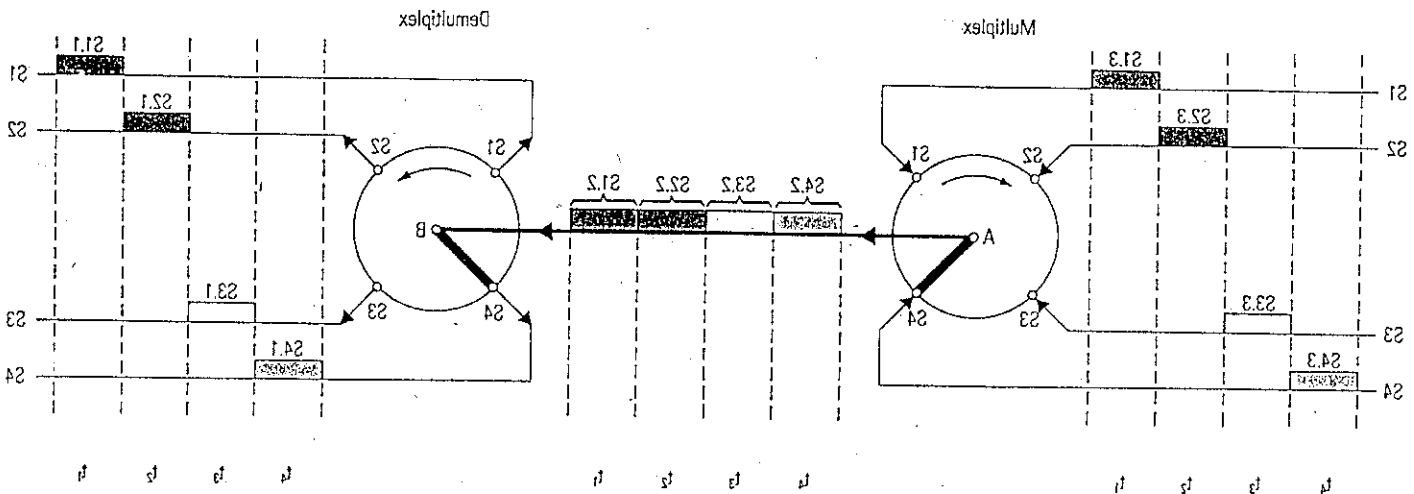


Obr.2.30



Obr.2.50

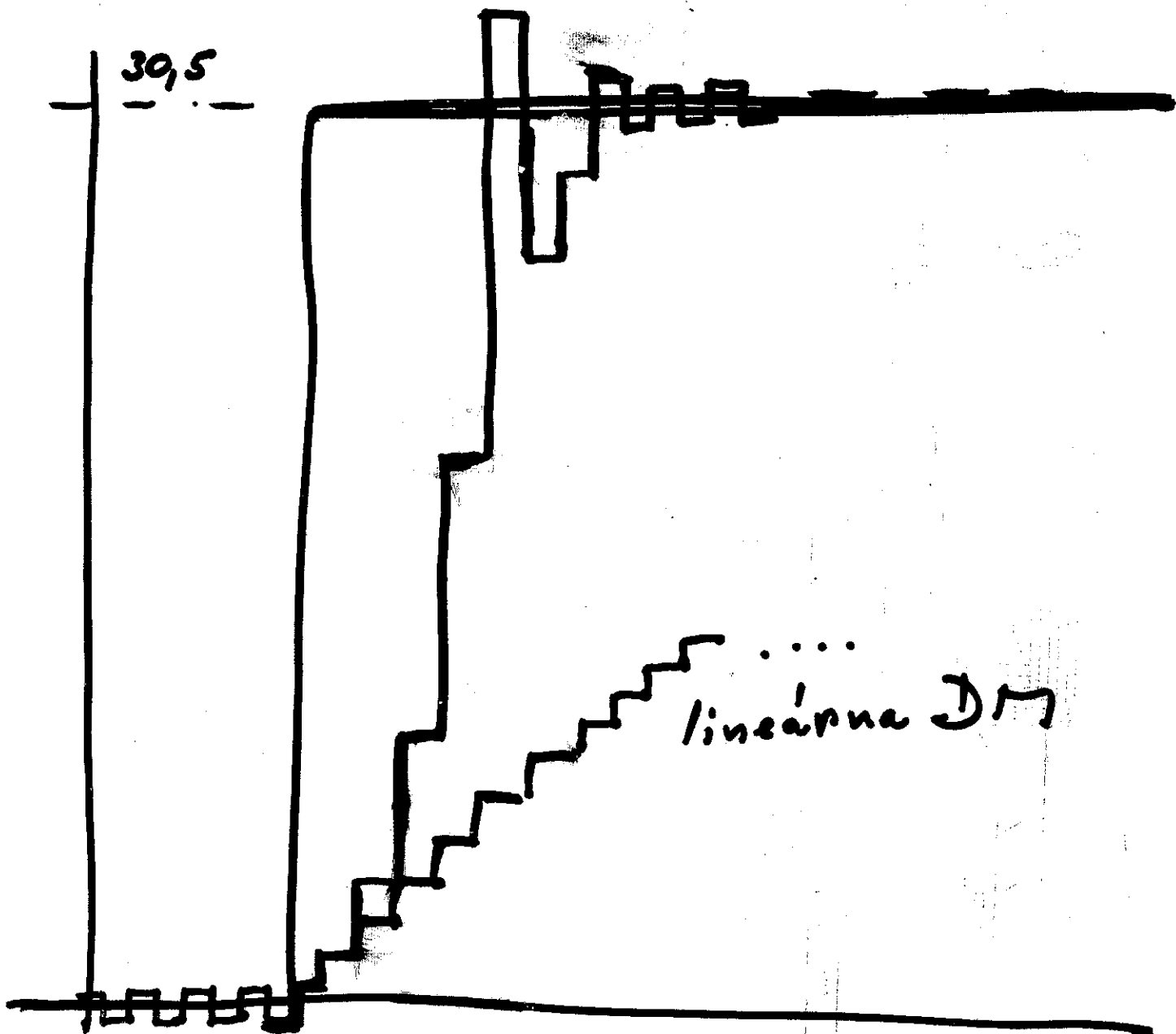
Op.5.50



Adaptívna Δ modulácia

$$\Delta = 2^m \Delta_0 \quad (1, 2, 4, 8, 16, \dots)$$

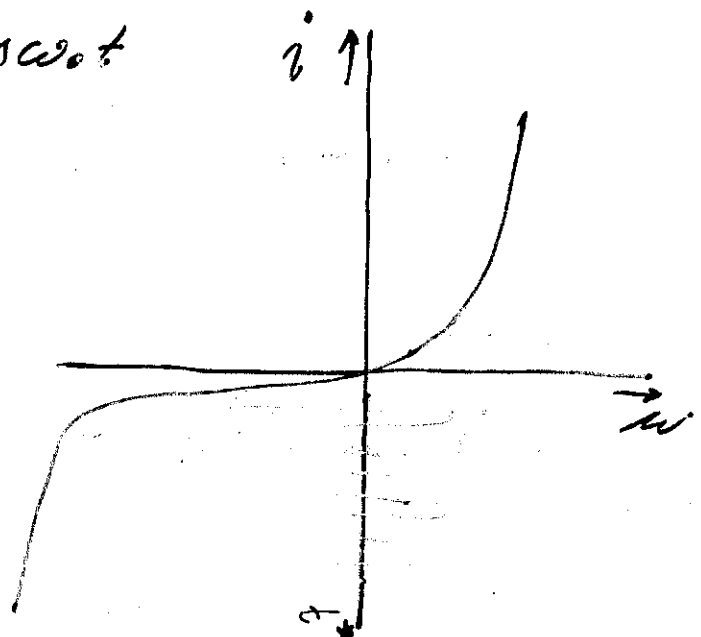
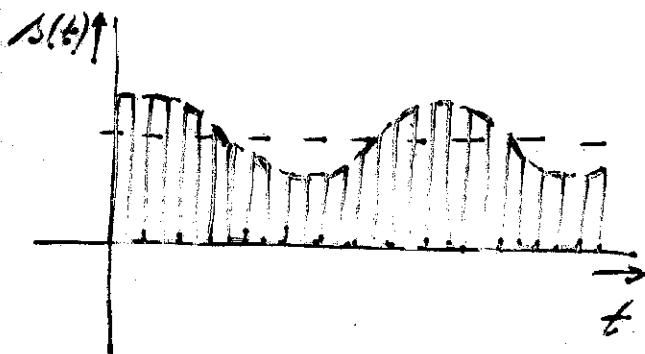
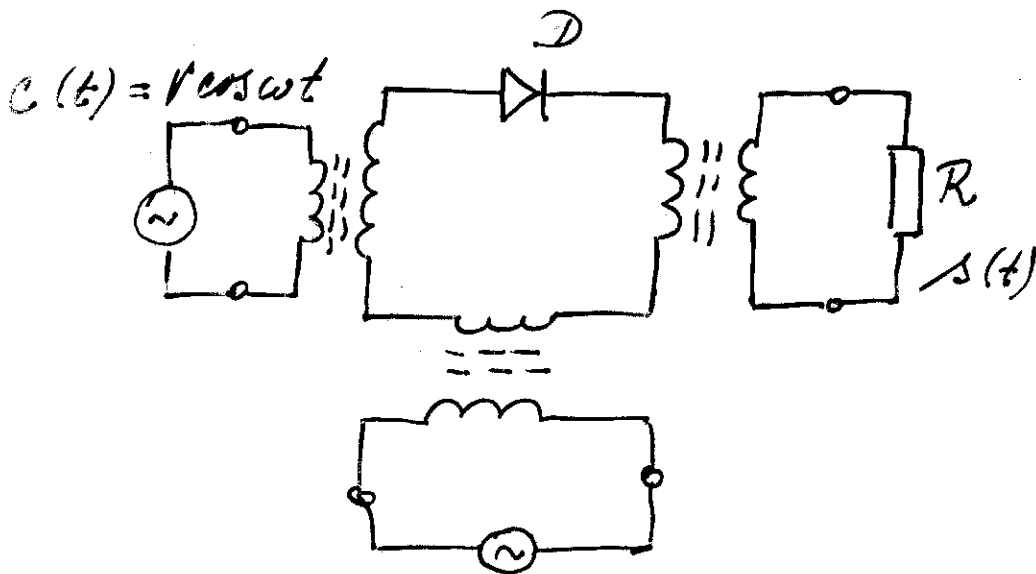
DM \rightarrow ADM
prenos napätového signálu $30,5 \Delta_0$



Modulátory

Amplitúdové modulátory

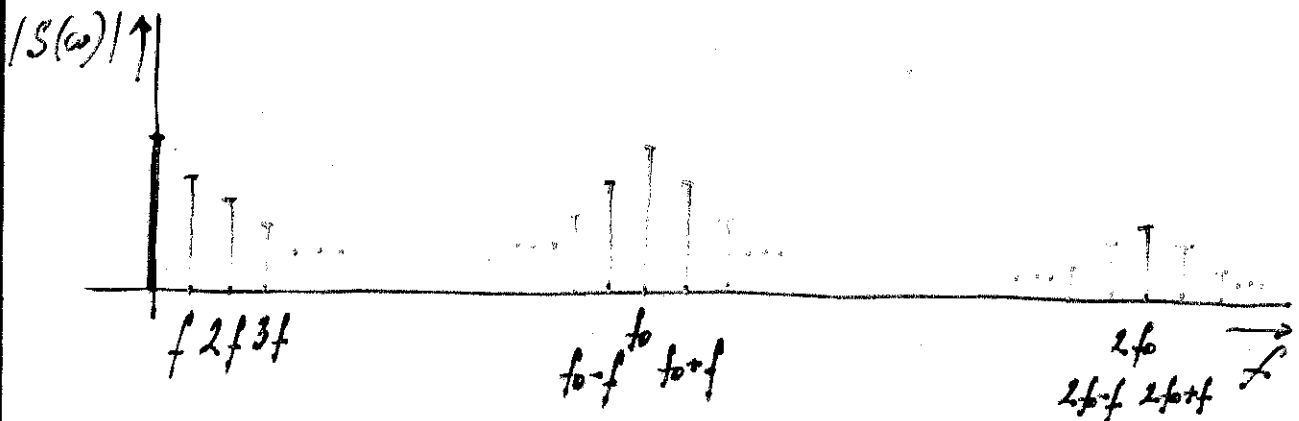
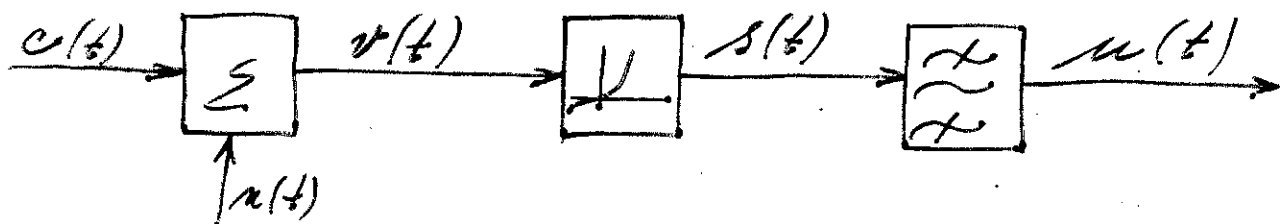
$$c(t) = V \cos \omega t$$
$$m(t) = A \cos \omega_0 t$$



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

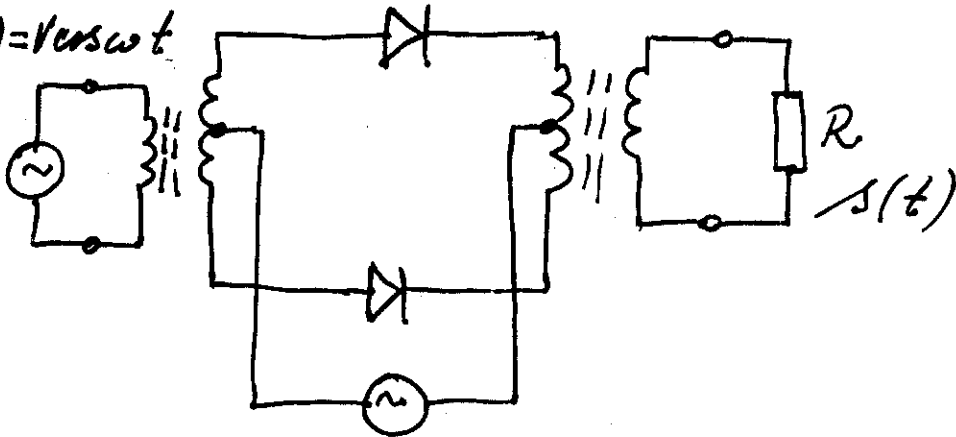
$$s(t) = a_1 v(t) + a_2 v^2(t) + a_3 v^3(t) + \dots$$

$$\begin{aligned} s(t) &= a_1 v(t) + a_2 v^2(t) = a_1 (V \cos \omega t + A \cos \omega_0 t) + \\ &\quad + a_2 (V \cos \omega t + A \cos \omega_0 t)^2 = \\ &= a_1 V \cos \omega t + a_1 A \cos \omega_0 t + a_2 V^2 \cos^2 \omega t + 2 a_2 V A \cos \omega t \cos \omega_0 t + \\ &\quad + a_2 A^2 \cos^2 \omega_0 t = \underline{a_1 V \cos \omega t} + \underline{a_1 A \cos \omega_0 t} + \frac{1}{2} a_2 V^2 + \\ &\quad + \frac{1}{2} a_2 V^2 \cos 2\omega t + \underline{a_2 V A \cos(\omega_0 - \omega)t} + \underline{a_2 V A \cos(\omega_0 + \omega)t} + \\ &\quad + \frac{1}{2} a_2 A^2 + \frac{1}{2} a_2 A^2 \cos 2\omega_0 t \end{aligned}$$

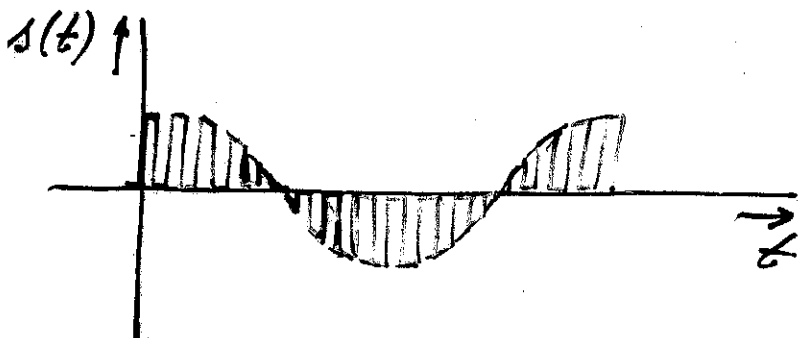


Vyvážený modulator

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

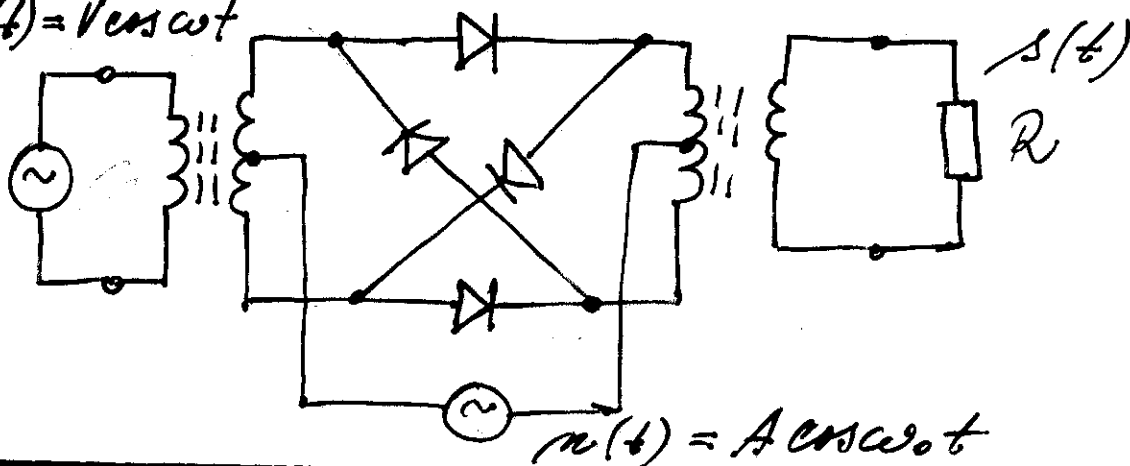


$$n(t) = A \cos \omega_0 t$$

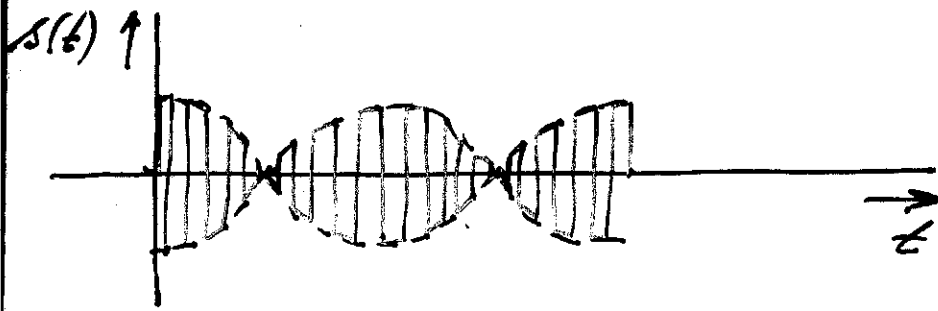


Dvojitý vyvážený modulator

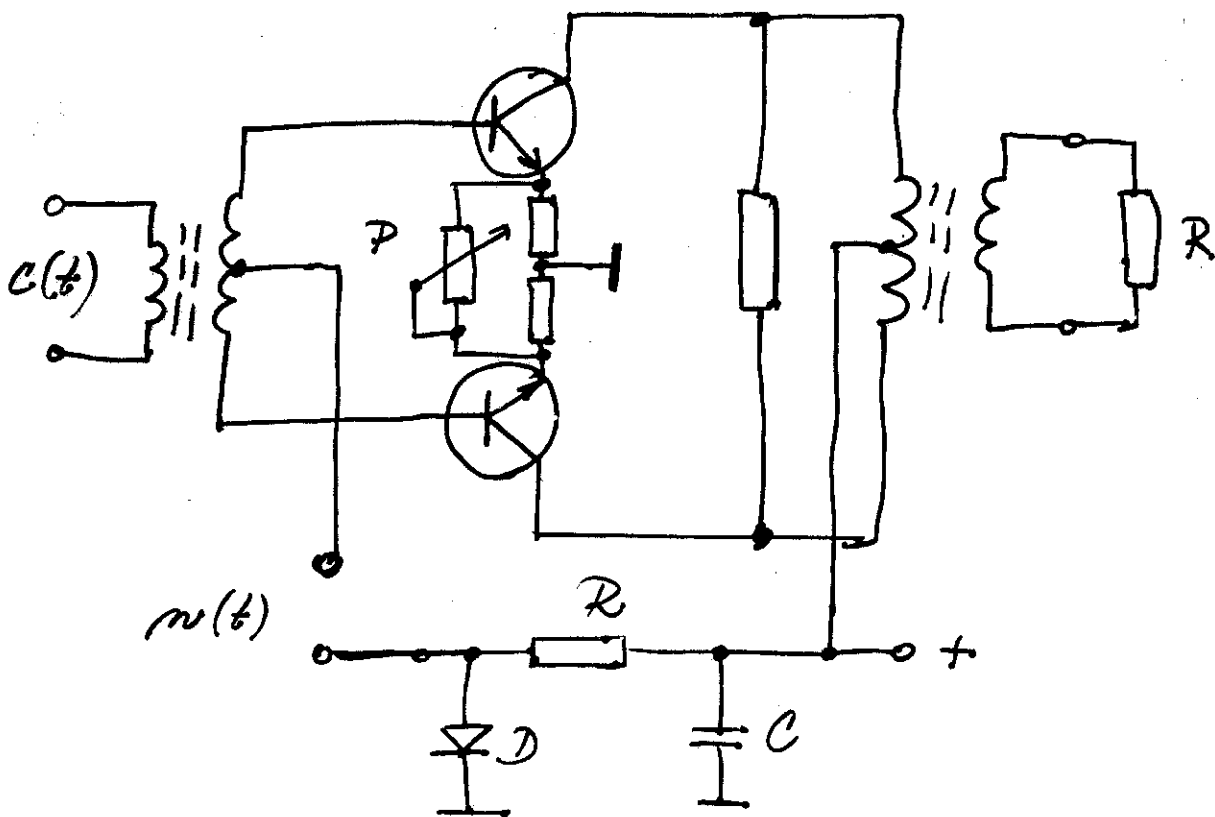
$$c(t) = V \cos \omega t$$

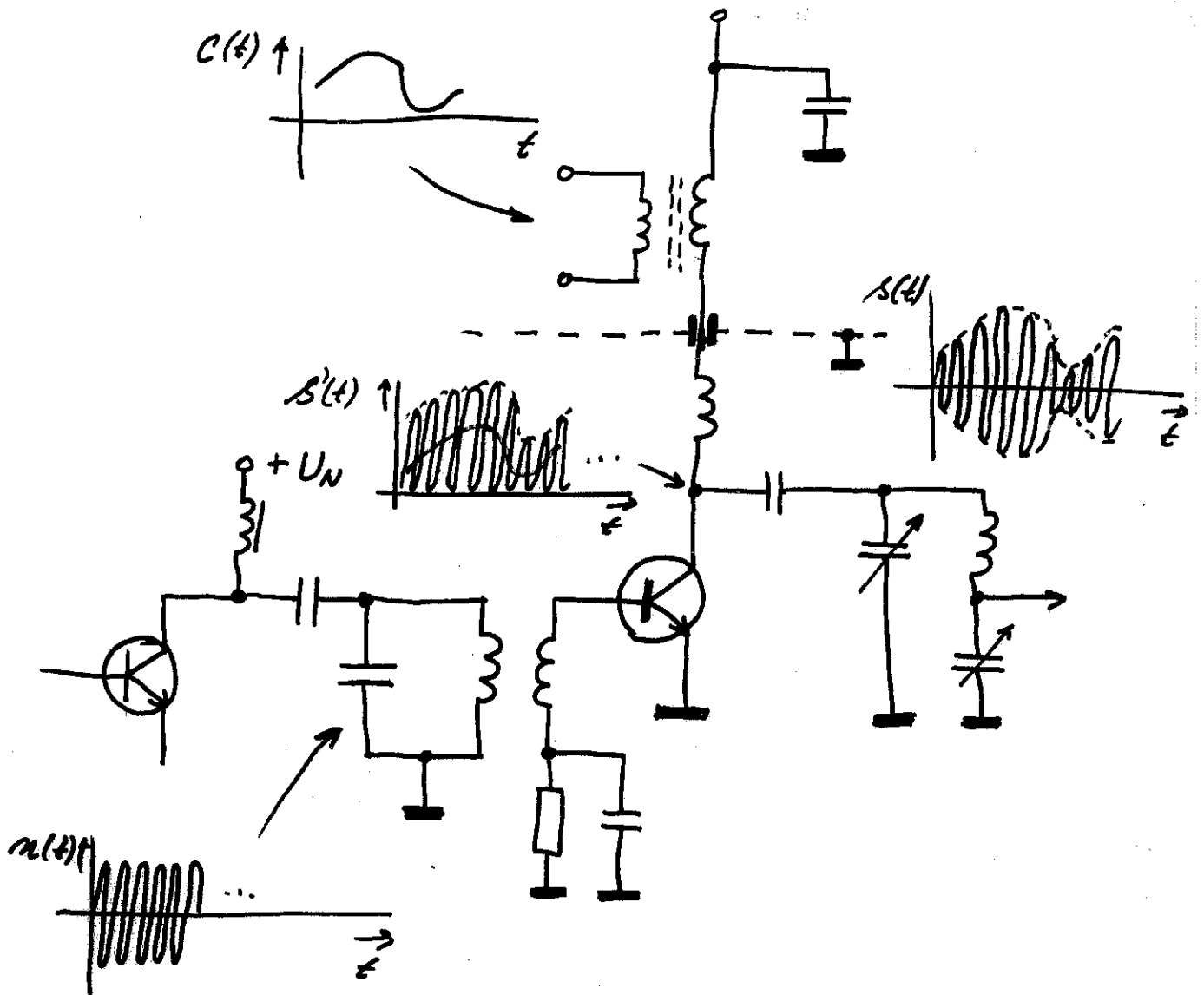


$$n(t) = A \cos \omega_0 t$$

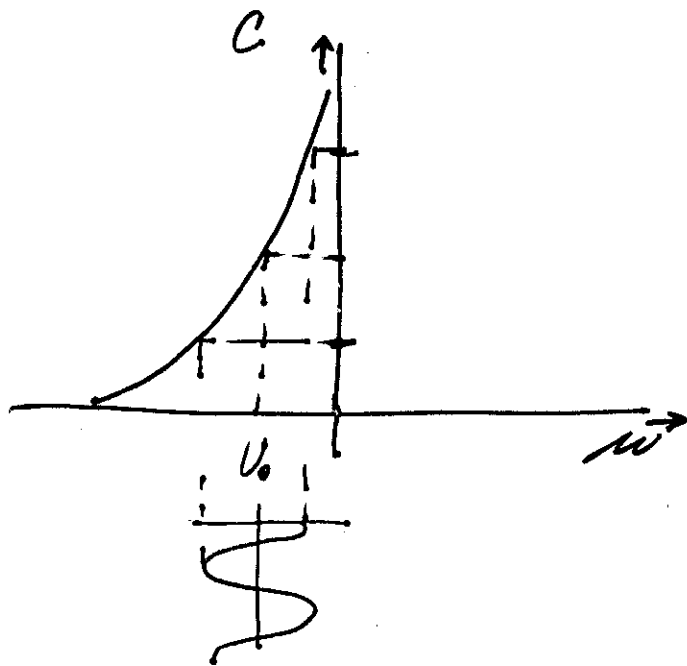
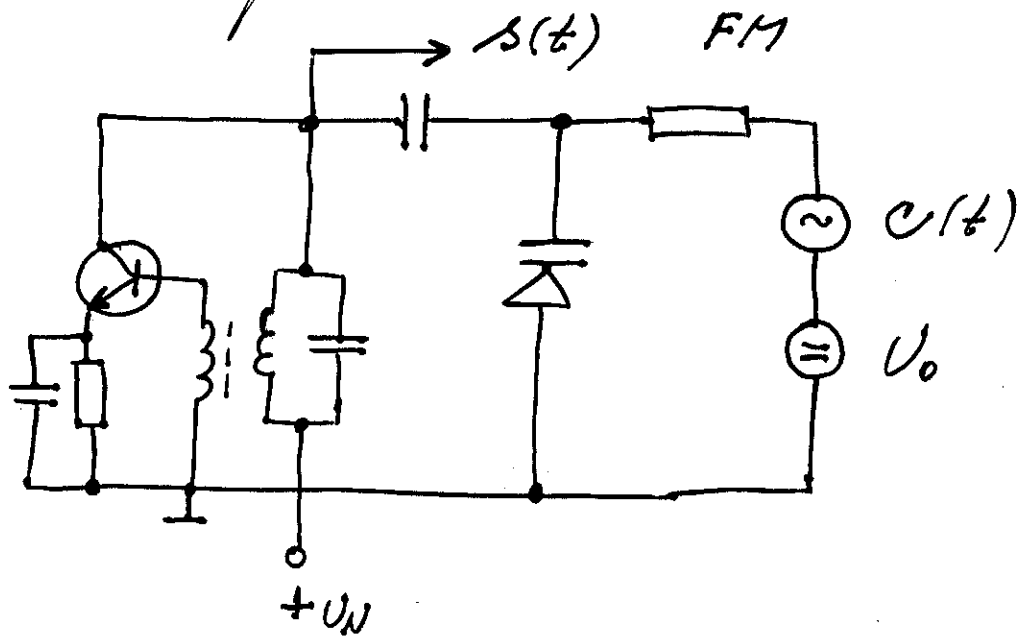


Jednoduchý výřezový AM aktivní modulátor



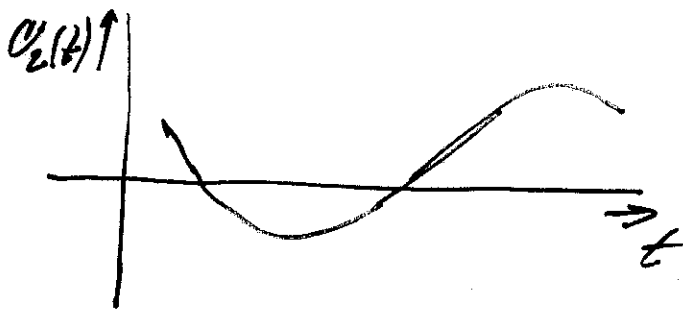
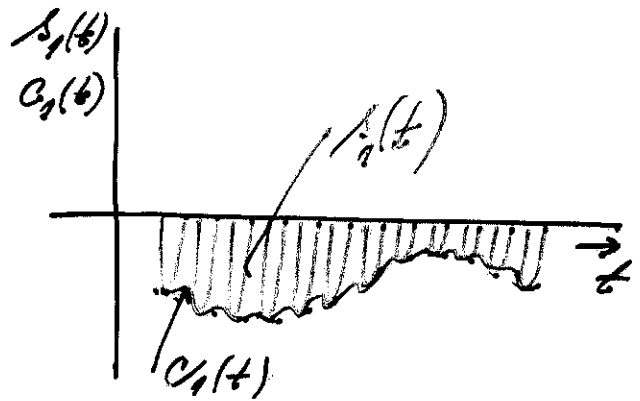
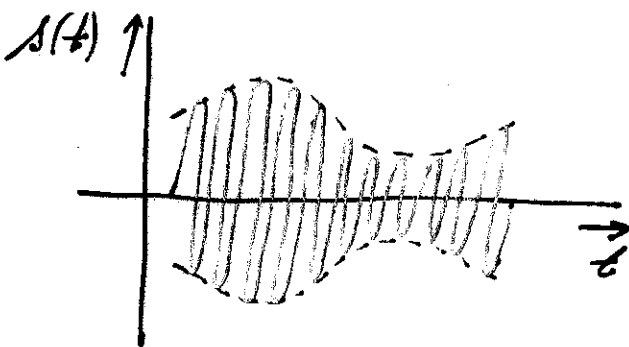
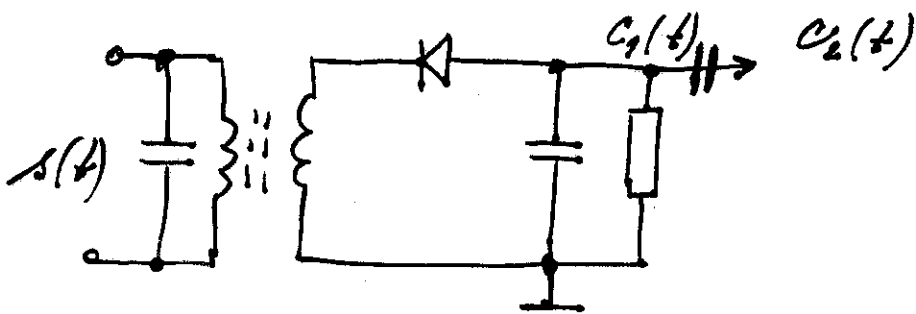


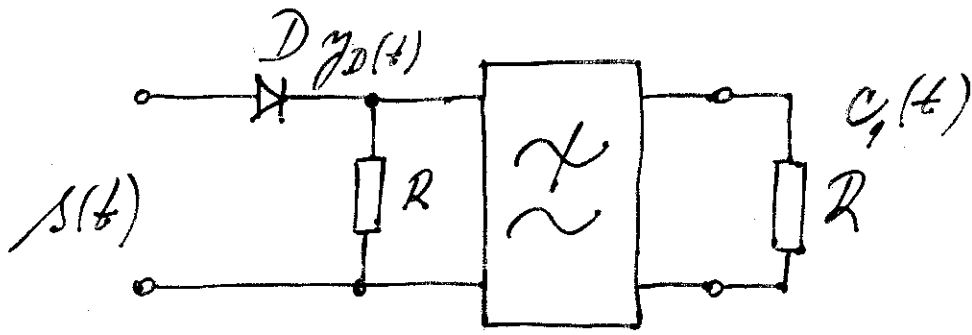
Kvintofonij modelblor



Demodulátor

Demodulátor AM signálu

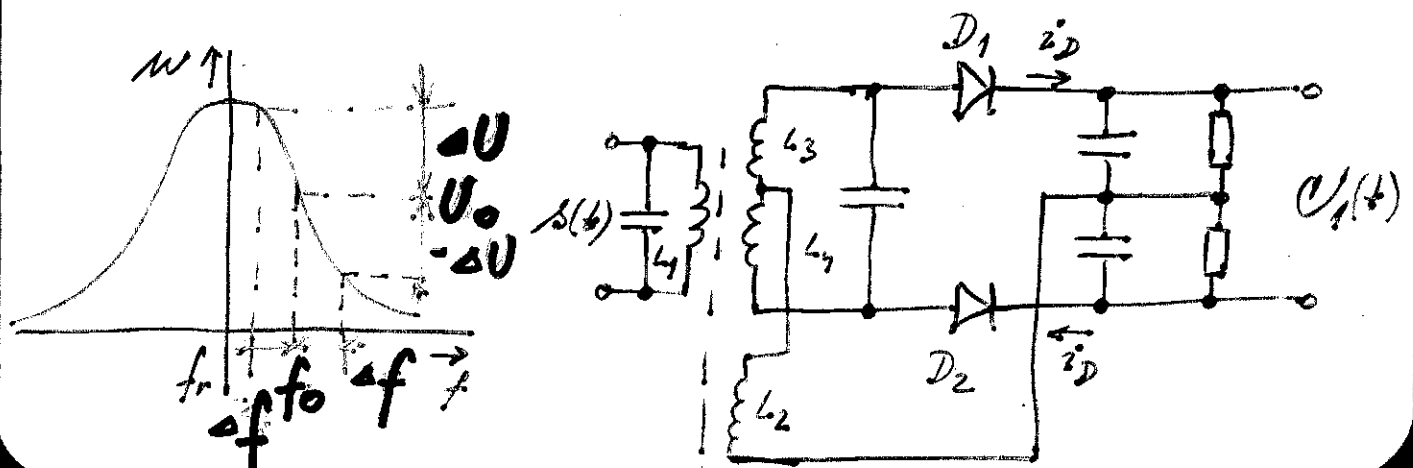




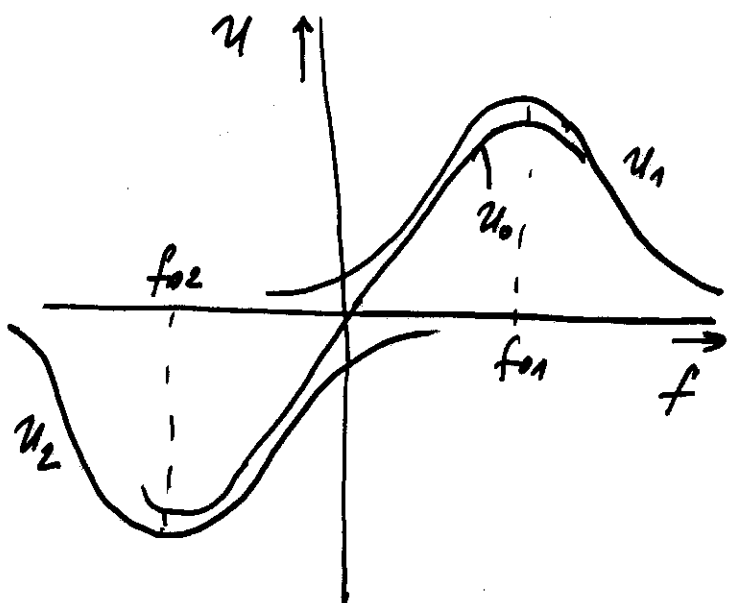
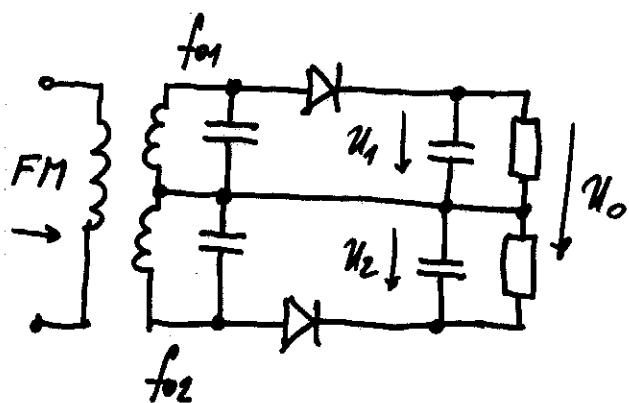
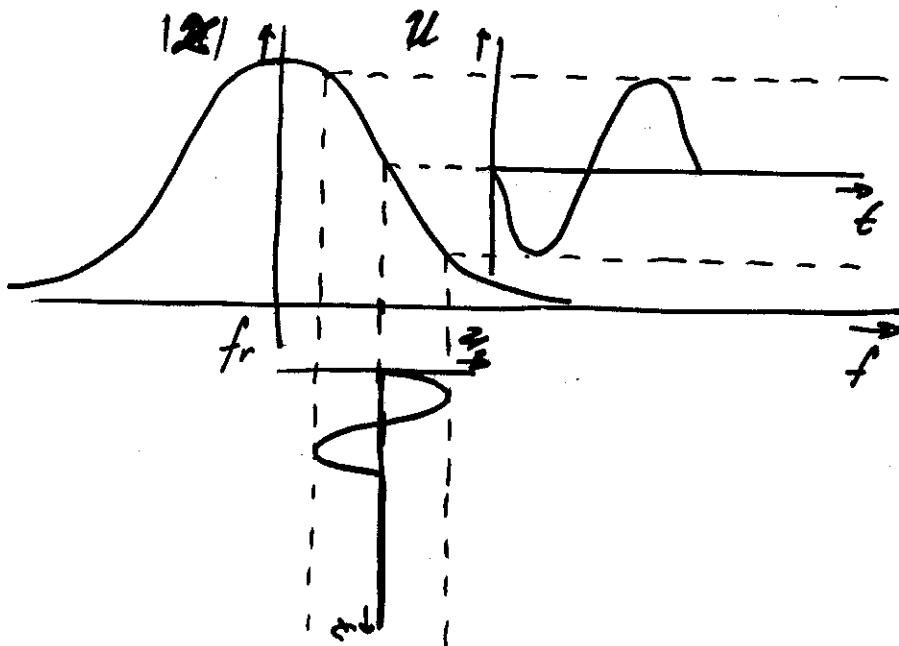
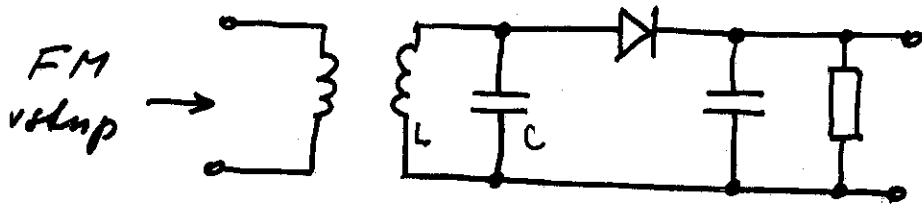
$$\begin{aligned}
 y_D(t) &= a_1 s(t) + a_2 s^2(t) = a_1 \{A + C(t)\} \cos \omega_0 t + \\
 &+ a_2 \{[A + C(t)] \cos \omega_0 t\}^2 = \\
 &= a_1 A \cos \omega_0 t + a_1 C(t) \cos \omega_0 t + a_2 A^2 \cos^2 \omega_0 t + \\
 &+ \underline{2 a_2 A C(t) \cos^2 \omega_0 t} + a_2 C^2(t) \cos^2 \omega_0 t = \\
 &= 2 a_2 A C(t) \cdot \frac{1}{2} \{1 + \cos 2\omega_0 t\} + \dots = \\
 &= \underline{\underline{a_2 A C(t)}} + a_2 A C(t) \cos 2\omega_0 t + \dots
 \end{aligned}$$

Detektor FM signálu

Kmitočtový diskriminátor

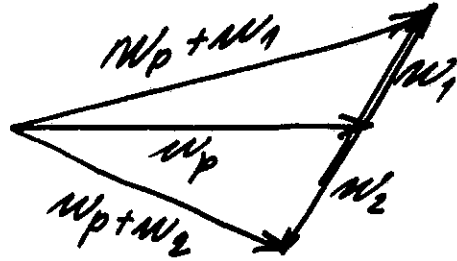
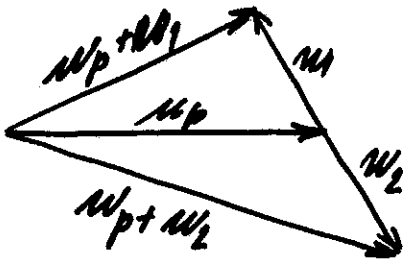
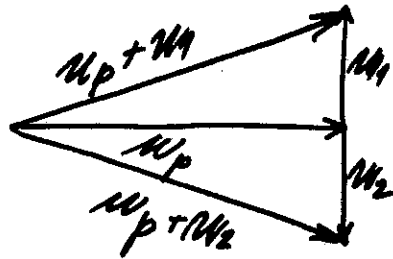
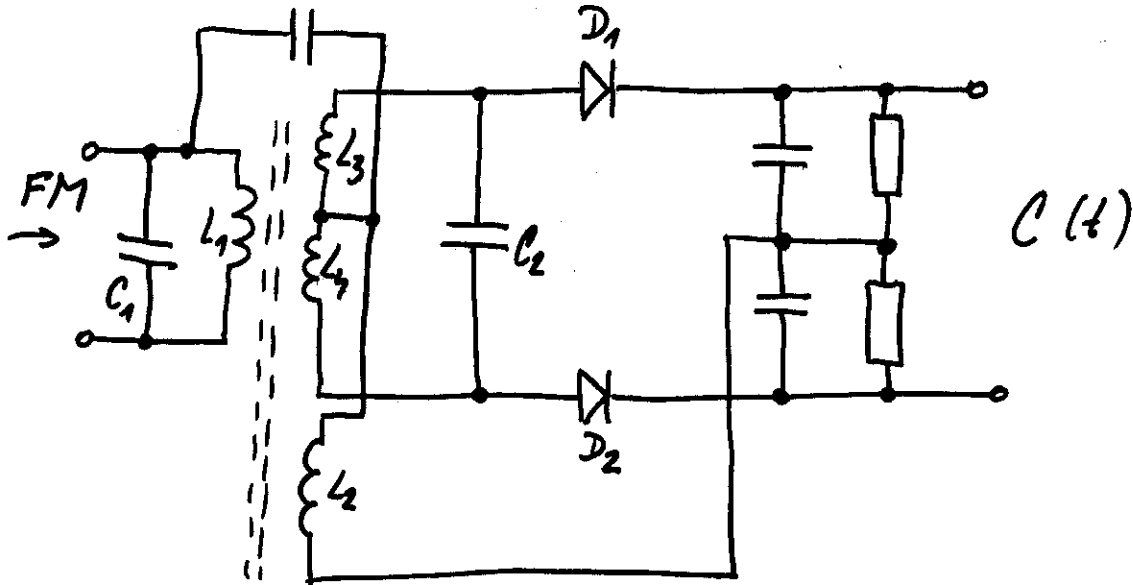


FM demodulátor (zákl. zapojenie)

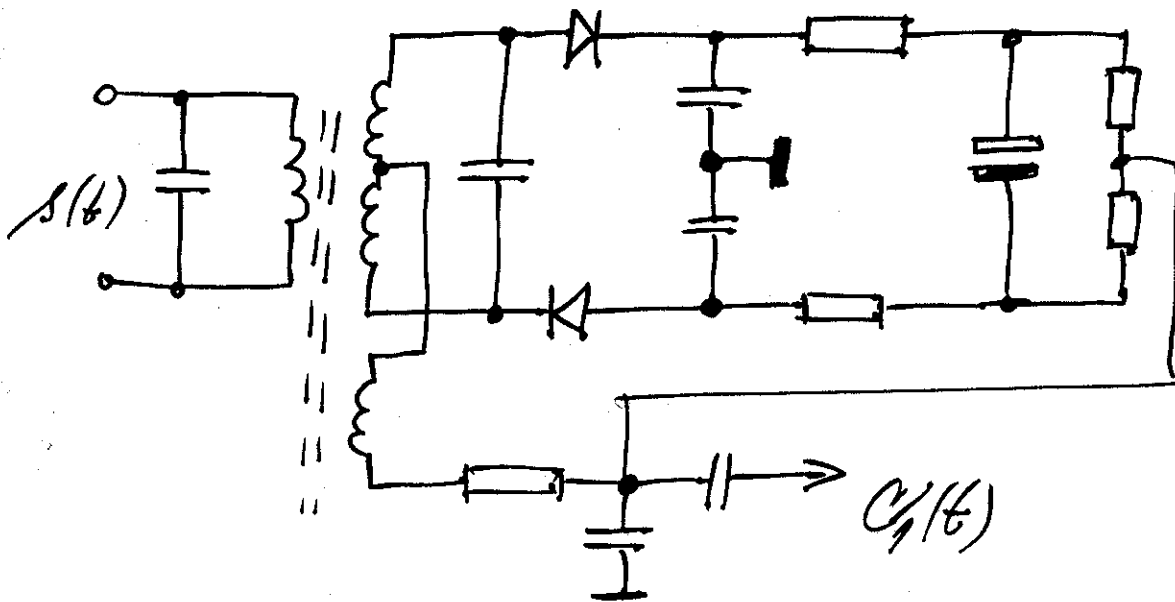


(fázový)

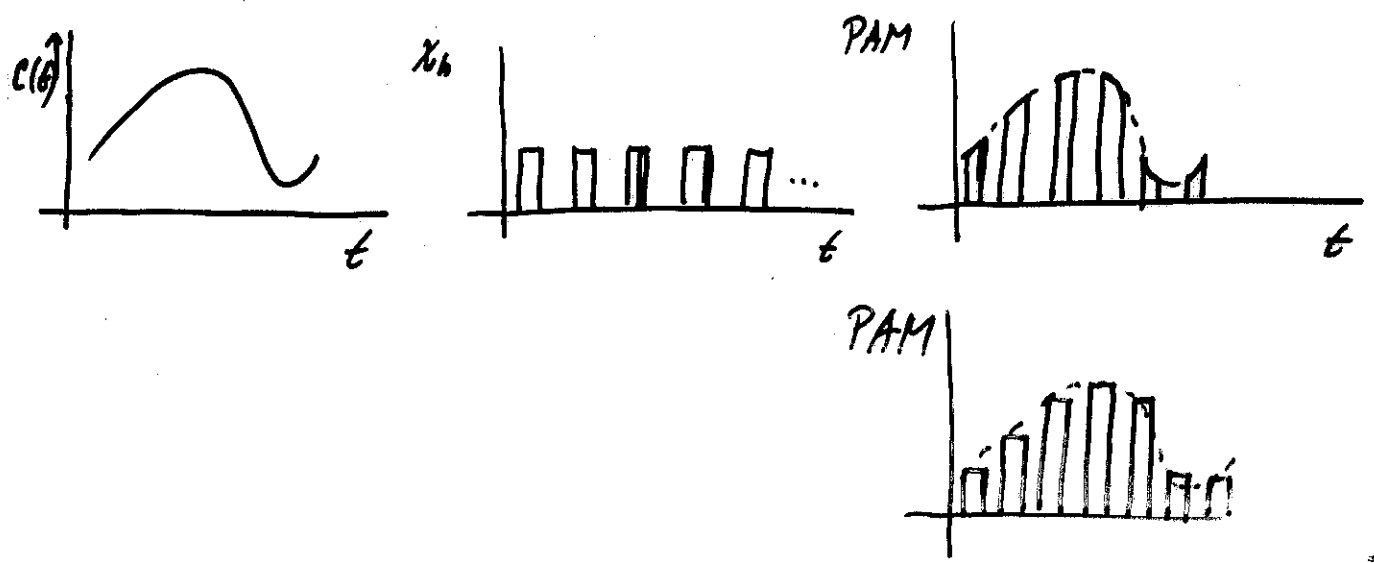
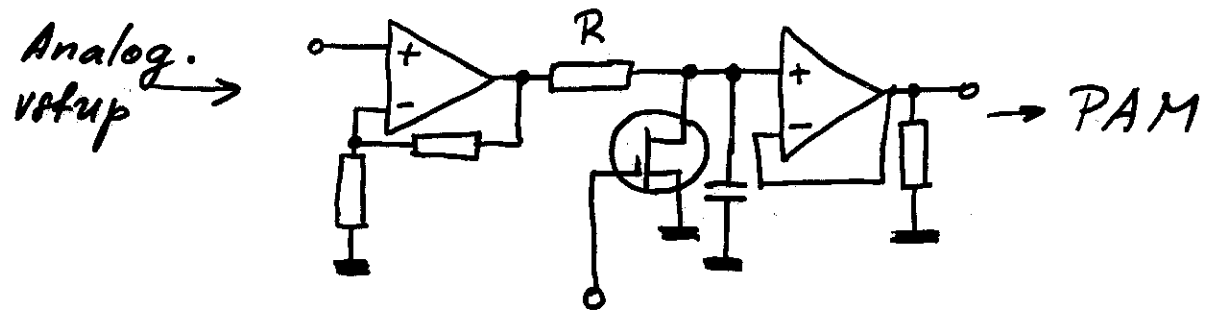
Kmitočtový diskriminátor



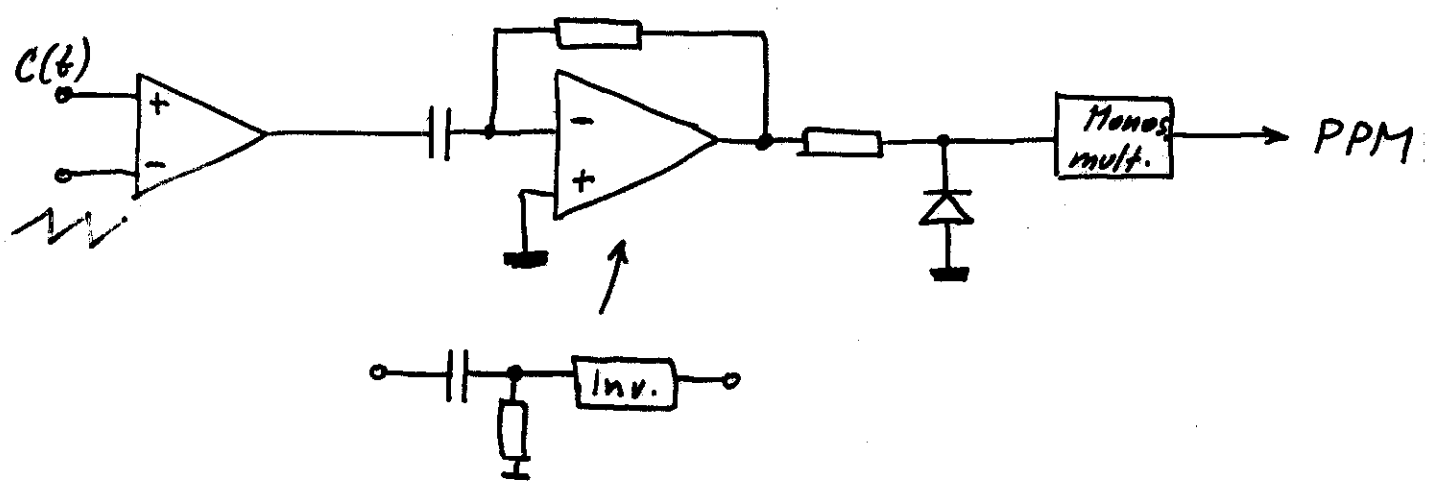
Pomerový detektor



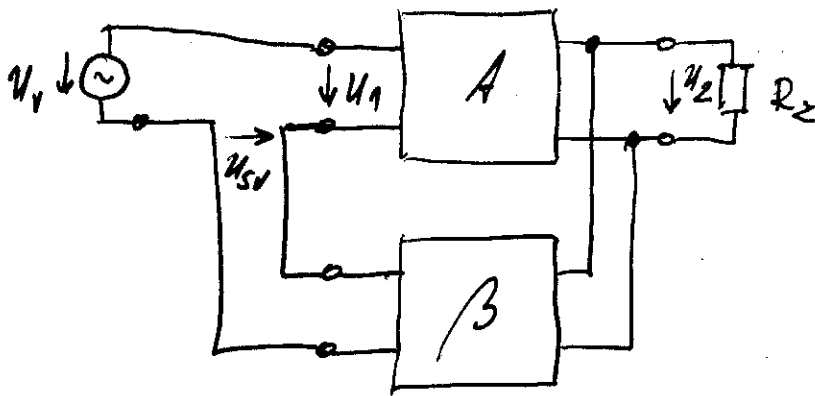
Impulzne amplitúdový modulátor



Impulzne šírkový a impulzne položový modulátor



OSCILATOR 4



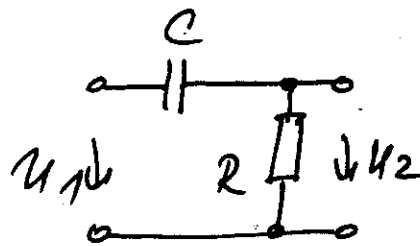
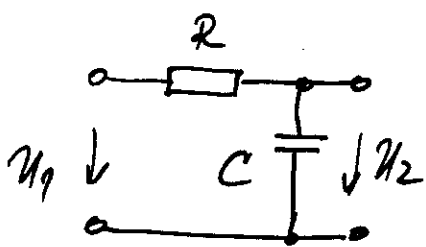
$$AB = \frac{A}{1+AB}$$

$$-AB = \frac{U_{sv}}{U_1}$$

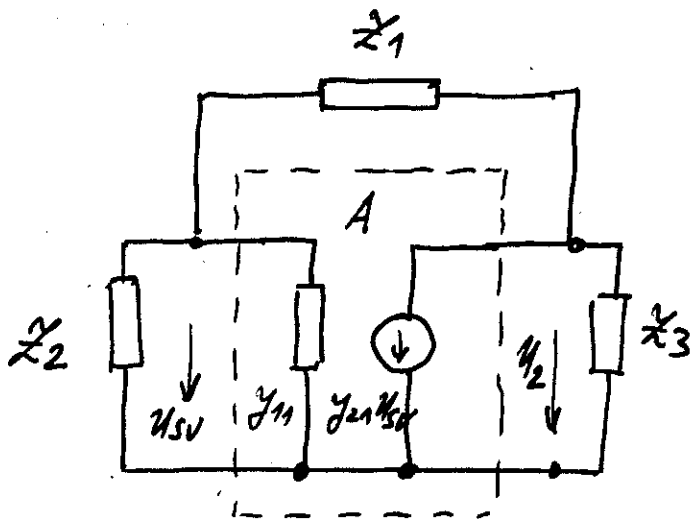
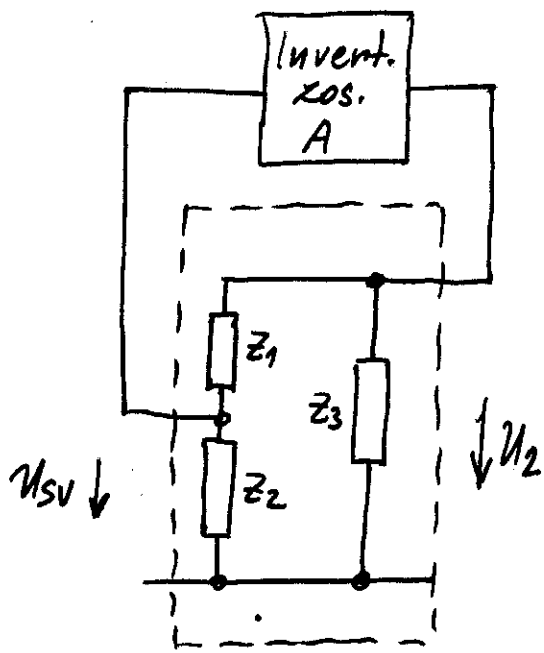
$$-AB = 1 \Rightarrow \left. \begin{array}{l} |AB| = 1 \\ \angle AB = 0 \end{array} \right\} -AB = 1 \angle 0$$

$$\angle A = -180^\circ \Rightarrow \angle B = -180^\circ$$

RC oscillator



$$K_u(\omega) = \frac{U_2}{U_1} = \left| \frac{U_2}{U_1} \right| e^{j\varphi} ; \quad \varphi \in (0^\circ; 90^\circ)$$



Șutășoracia imped. zosil. $Z_3 // (Z_1 + Z_2 // y_{11})$

$$Y_3 + \left[\frac{Y_1 (Y_2 + y_{11})}{Y_1 + Y_2 + y_{11}} \right]$$

$$U_2 = \frac{-y_{21} U_{sv}}{Y_3 + \left[\frac{Y_1 (Y_2 + y_{11})}{Y_1 + Y_2 + y_{11}} \right]} \Rightarrow A = \frac{U_2}{U_{sv}} = \frac{-y_{21}}{Y_3 + \left[\frac{Y_1 (Y_2 + y_{11})}{Y_1 + Y_2 + y_{11}} \right]}$$

$$U_{sv} = U_2 \frac{Z_2 // y_{11}}{Z_2 // y_{11} + Z_1} = U_2 \frac{\frac{1}{y_{11} + Y_2}}{\frac{1}{y_{11} + Y_2} + \frac{1}{Y_1}} = U_2 \frac{Y_1}{Y_1 + Y_2 + y_{11}}$$

$$\beta = \frac{U_{sv}}{U_2} = \frac{Y_1}{Y_1 + Y_2 + y_{11}}$$

$$AB = \frac{-y_{21} Y_1}{\left\{ Y_3 + \frac{Y_1 (Y_2 + y_{11})}{Y_1 + Y_2 + y_{11}} \right\} (Y_1 + Y_2 + y_{11})} = \frac{-y_{21} Y_1}{Y_3 (Y_1 + Y_2 + y_{11}) + Y_1 (Y_2 + y_{11})}$$

Barkhausenova podmienka

$$|A\beta| = 1 ; \varphi_{A\beta} = 0 ; 360^\circ$$

$$z_i = j\omega L_i, \text{ resp. } z_i = -j \frac{1}{\omega C_i}$$

$$Y_i = 1/z_i = 1/jX_i$$

$$A\beta = \frac{-y_{21} X_2 X_3}{y_{11}(X_1 X_2 + X_2 X_3) - j(X_1 + X_2 + X_3)}$$

$$\varphi_{A\beta}(\omega) = -180^\circ - \arctan \left\{ -\frac{(X_1 + X_2 + X_3)}{[y_{11}(X_1 X_2 + X_2 X_3)]} \right\}$$

$$\varphi_{A\beta}(\omega_0) \stackrel{!}{=} 0, \text{ resp. } 360^\circ \Rightarrow X_1 + X_2 + X_3 = 0$$

$$[A\beta]_{\omega_0} = \frac{-y_{21} X_3}{y_{11}(X_1 + X_3)}$$

$$X_1 + X_3 = -X_2$$

$$[A\beta]_{\omega_0} = \frac{-y_{21} X_3}{y_{11}(X_1 + X_3)} = \frac{y_{21} X_3}{y_{11} X_2}$$

$A\beta > 0$ (opävná orientácia usv)

↓

X_3, X_2 rovnaký charakter $\Rightarrow X_1$ opačný

$$A\beta = 1 = \frac{y_{21} X_3}{y_{11} X_2} \rightarrow$$

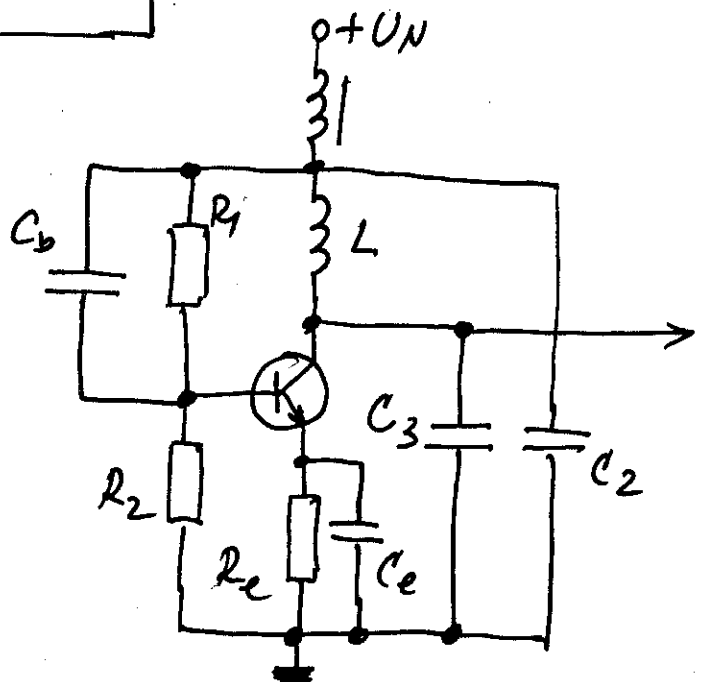
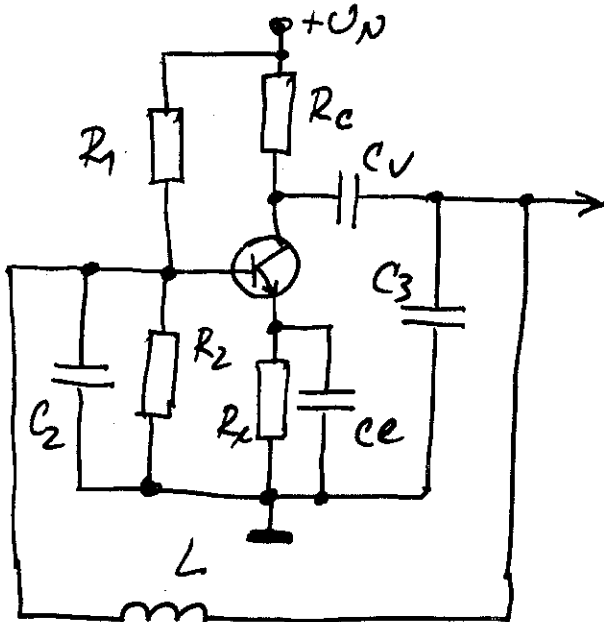
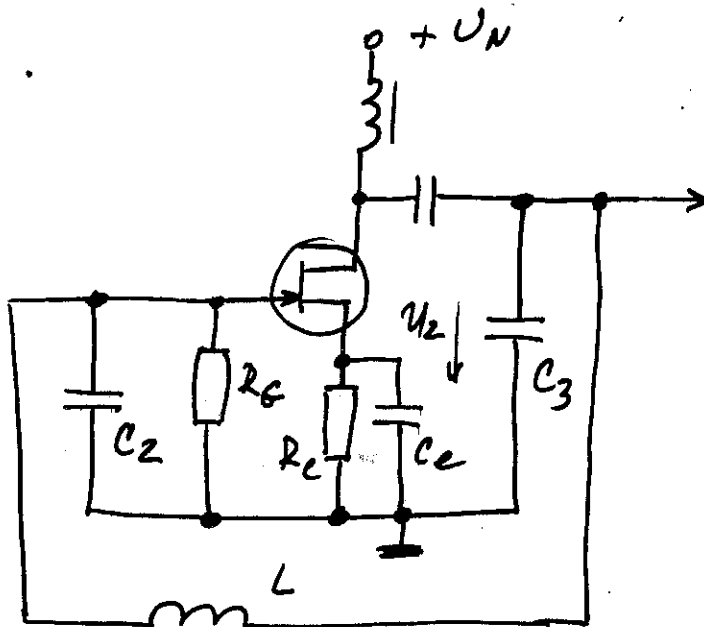
$$X_2 = X_3 \frac{y_{21}}{y_{11}}$$

COLPITTS-oscillator

Z_1 - inductance $\Rightarrow Z_2, Z_3$ capacity

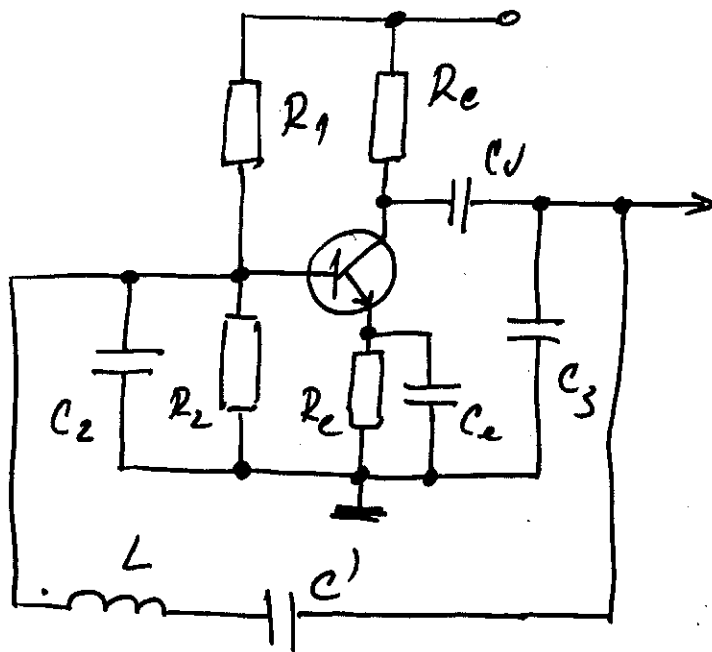
$$C_3 = C_2 \frac{y_{21}}{y_{11}} ; \omega_0 L - \frac{1}{\omega_0 C_2} - \frac{1}{\omega_0 C_3} = 0$$

$$f_0 = \frac{1}{2\pi \sqrt{L \frac{C_2 C_3}{C_2 + C_3}}}$$



CLAPP-ov oscilator

(3)



$$\text{as } C' \ll C_2 \text{ a } C_3 \rightarrow f_0 \approx \frac{1}{2\pi \sqrt{L \cdot C'}}$$

HARTLEY oscilator

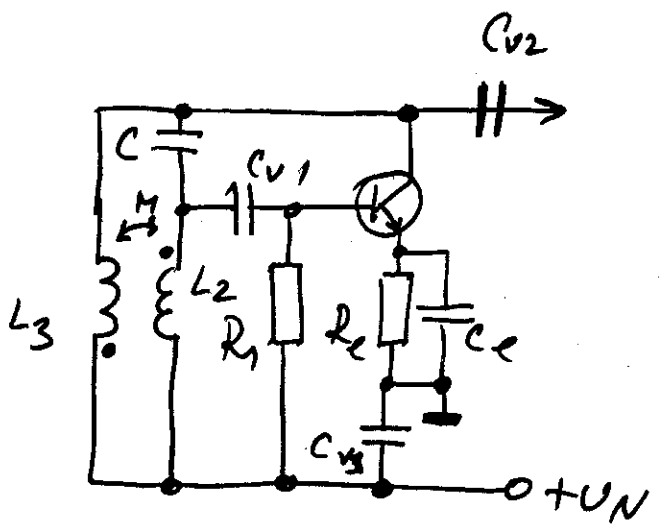
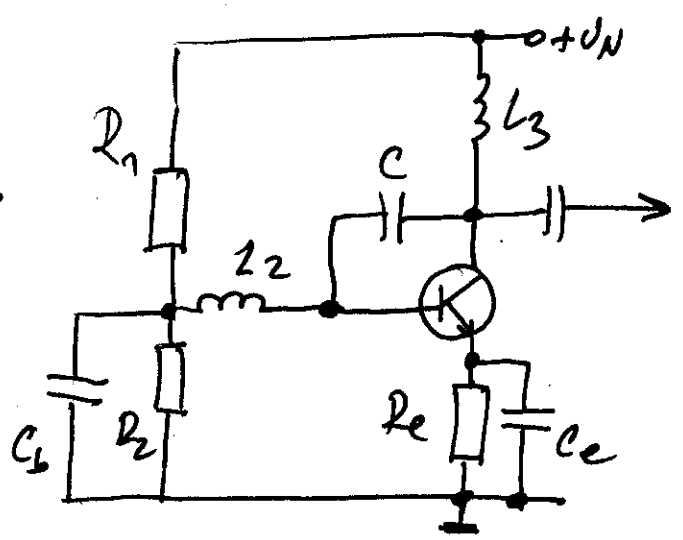
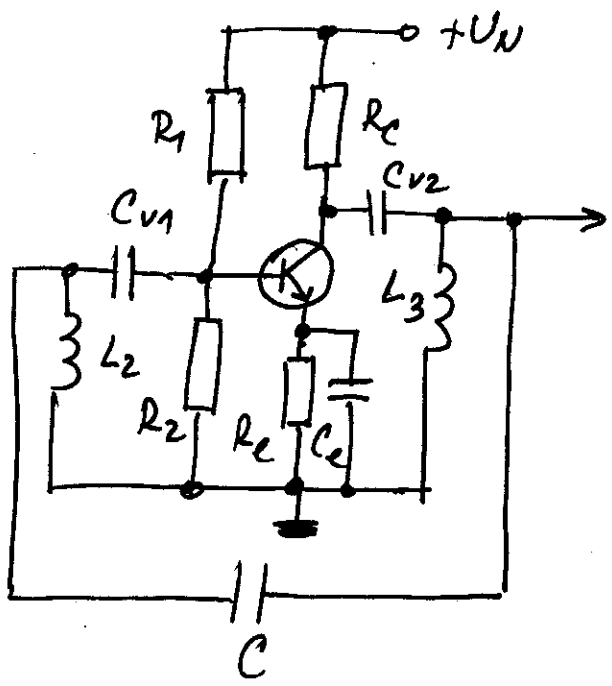
X_1 — kapacita

X_2, X_3 — indukčnosti

$$X_2 = X_3 \frac{y_{21}}{y_{11}} \rightarrow L_2 = L_3 \frac{y_{21}}{y_{11}}$$

$$-\frac{1}{\omega_0 C} + \omega_0 L_1 + \omega_0 L_2 = 0 \Rightarrow$$

$$f_0 = \frac{1}{2\pi \sqrt{C(L_2 + L_3)}}$$



$$f_0 = \frac{1}{2\pi \sqrt{LC}}$$

$$L = L_2 + L_3 + 2M$$

NÁZOV:

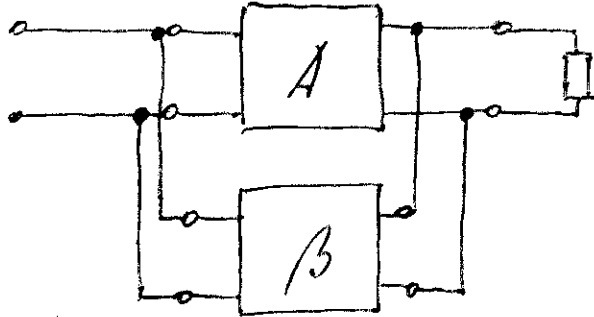
PREDMET:

ROČNÍK:

ČÍSLO:

ČÍSLO ZLOŽKY

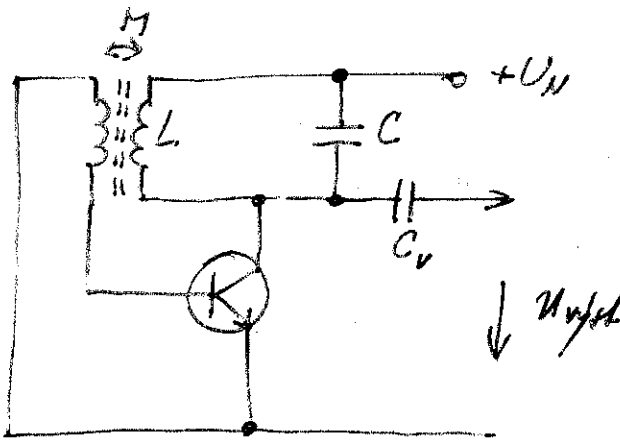
	4	3	a
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$$\beta A = 1$$

LC - oscilátory

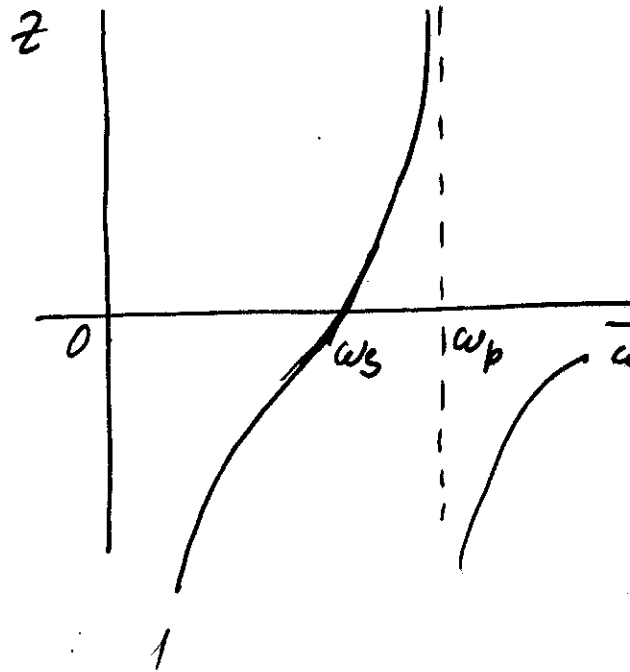
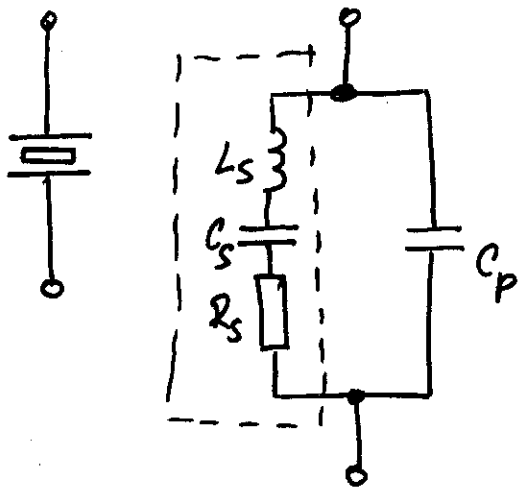
Transformátorový oscilátor



$$U_{\text{výst}} = U_{\text{výst}} \cos \omega_0 t$$

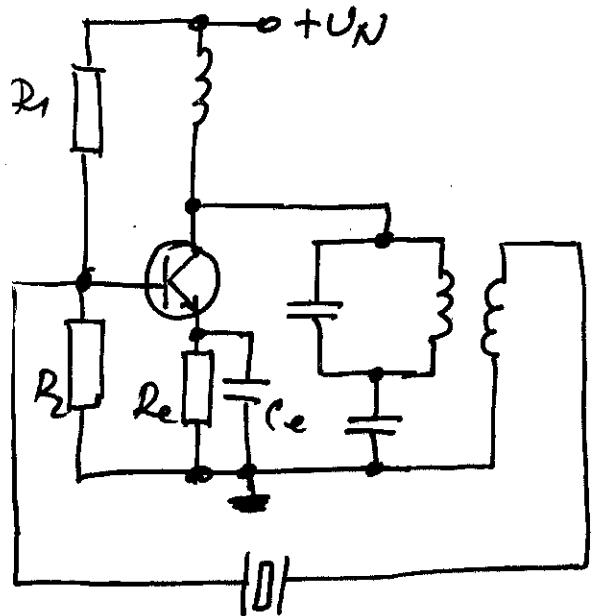
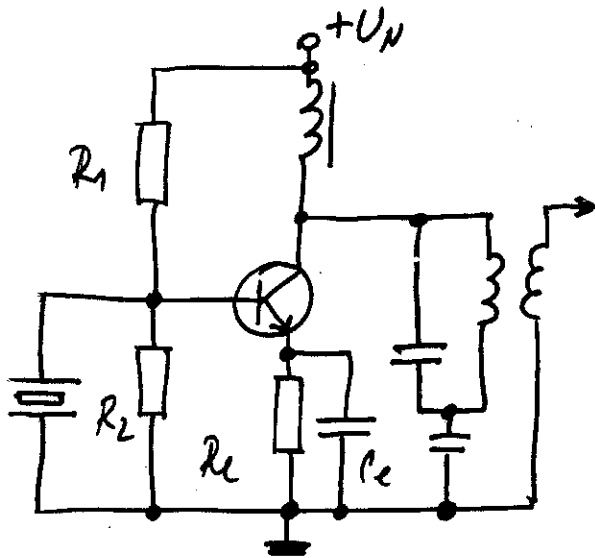
$$\omega_0 = \frac{1}{\sqrt{L(C+C_{ce})}}$$

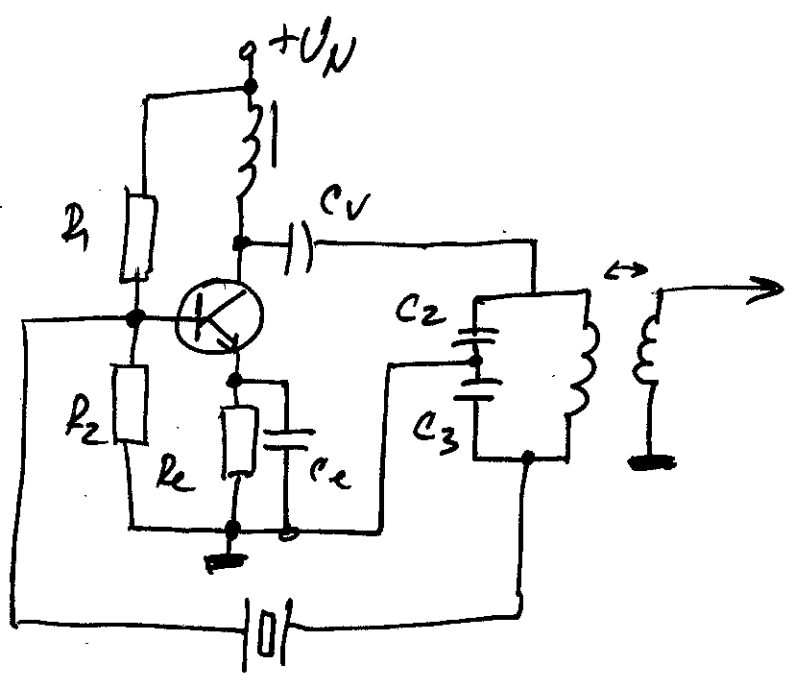
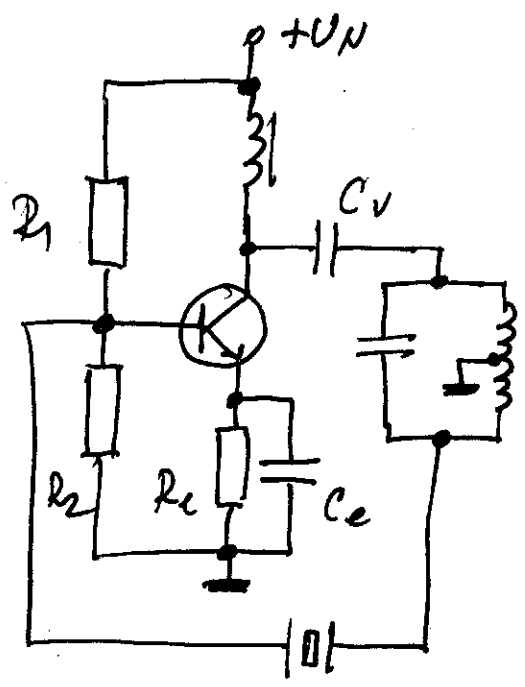
Krystalové oscilátory



$$\omega_s = \frac{1}{\sqrt{L_s C_s}}$$

$$\omega_p = \frac{1}{\sqrt{L_s \frac{C_s C_p}{C_s + C_p}}}$$





NÁZOV:

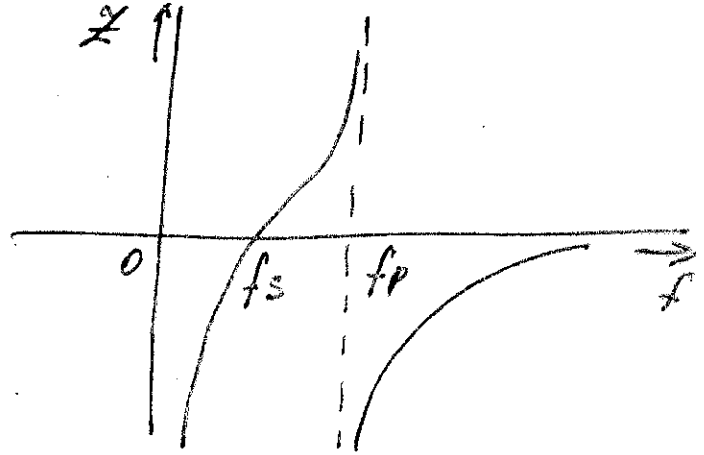
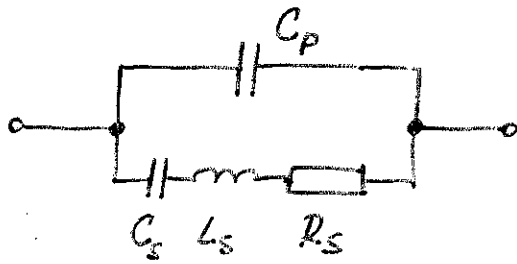
PREDMET:

ROČNÍK:

ČÍSLO:

ČÍSLO ZLOŽKY

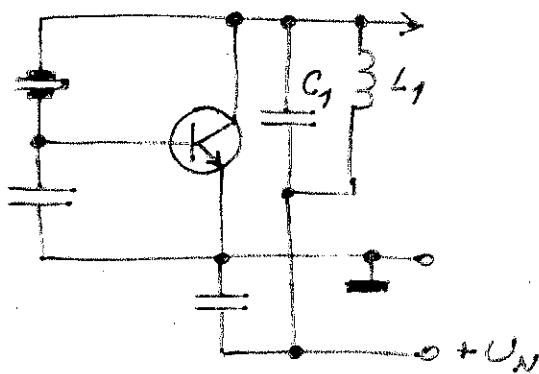
43C



$$\omega_s = \frac{1}{\sqrt{C_s L_s}}$$

$$\omega_p = \frac{1}{\sqrt{L_s \frac{C_s C_p}{C_s + C_p}}}$$

Pierce oscillator



NÁZOV:

PREDMET:

ROČNÍK:

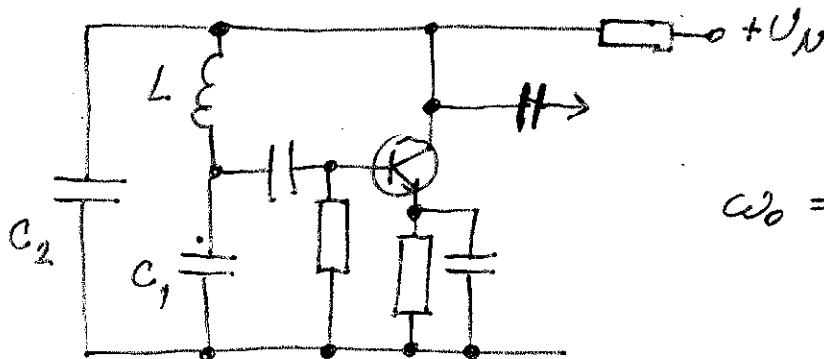
ČÍSLO:

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4 3 6

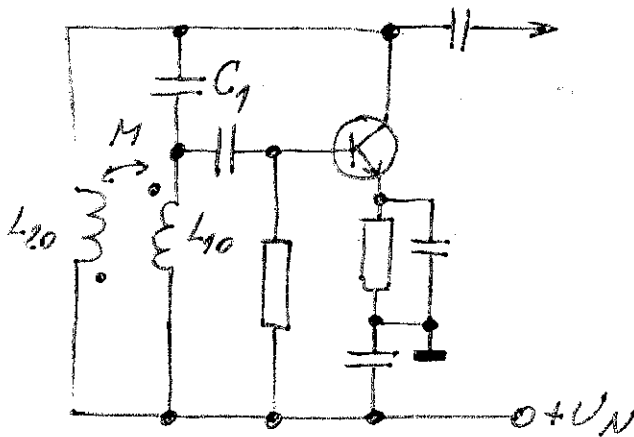
Trojbodové LC oscilátory

Colpittsov oscilátor



$$\omega_0 = \frac{1}{\sqrt{L \frac{C_1 C_2}{C_1 + C_2}}}$$

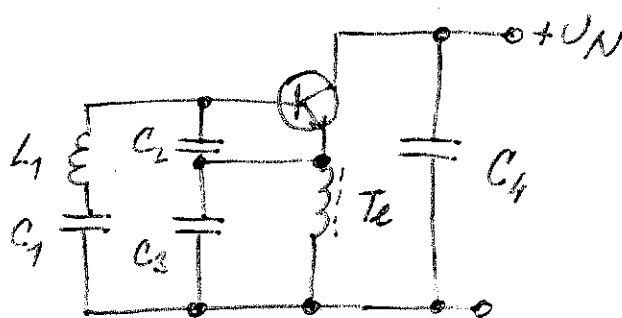
Hartlejev oscilátor



$$L_1 = L_{10} + L_{20} + 2M$$

$$\omega_0 = \frac{1}{L_1 C_1}$$

Clappov oscilátor



$$\omega_0 = \frac{1}{\sqrt{L_1 C_e}}$$

$$C_e = \frac{C_1 C_2 C_3}{C_1 C_2 + C_1 C_3 + C_2 C_3}$$

NÁZOV:

PREDMET:

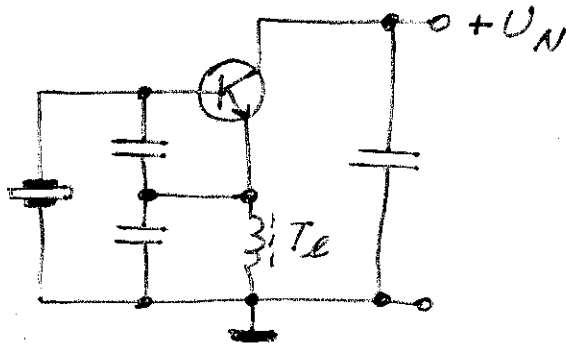
ROČNÍK:

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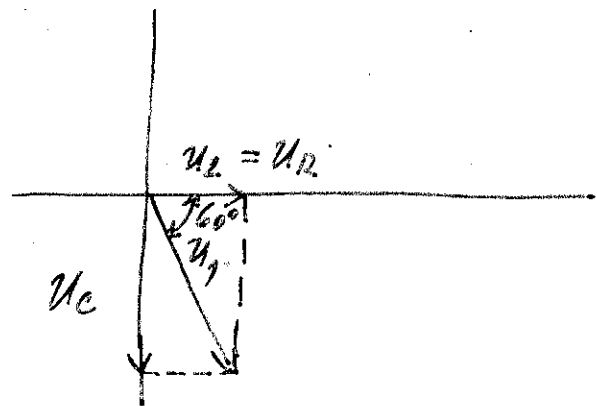
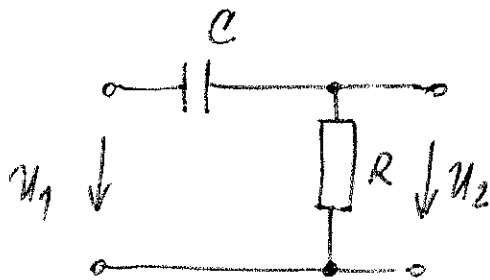
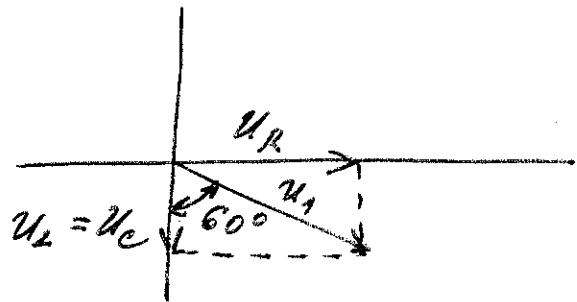
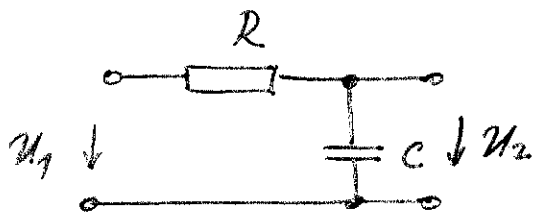
ČÍSLO ZLOŽKY

43d

Clappor oscilátor:



RC oscilatory



NÁZOV:

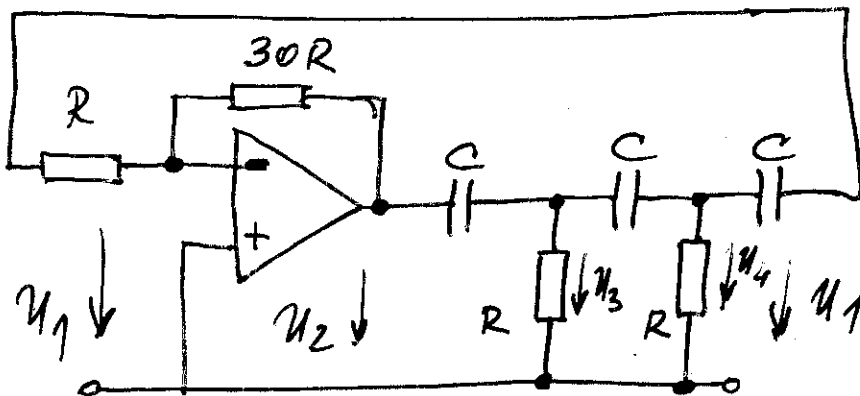
PŘEDMET:

ROČNÍK:

ČÍSLO:

ČÍSLO ZLOŽKY

43e



$$\beta = \frac{U_1}{U_2} = \frac{U_1}{U_3} \cdot \frac{U_3}{U_4} \cdot \frac{U_4}{U_2} =$$

$$= \frac{\omega^3 C^3 R^3}{(\omega^3 C^3 R^3 - 5\omega RC) - j(6\omega^2 C^2 R^2 - 1)}$$

$$\varphi_\beta(\omega) = \arctan \frac{6\omega^2 C^2 R^2 - 1}{\omega^3 C^3 R^3 - 5\omega RC}$$

$$6\omega_0^2 C^2 R^2 - 1 = 0$$

$$\varphi_\beta(\omega_0) = 0 \Rightarrow f_0 = \omega_0 / 2\pi = \frac{1}{2\pi \sqrt{6} CR}$$

potom

$$|\beta(\omega_0)| = \frac{1}{29}$$