Лабораторная работа №31.

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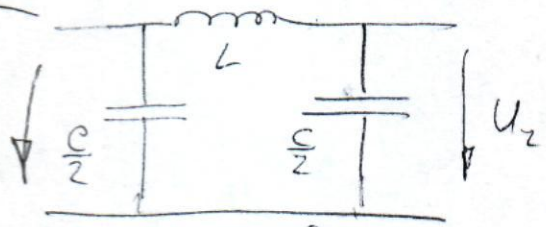
ЭР-3-06

Модель длинной линии

Часть 1

(1)



Дано: $C = 1450$ пФ; $L = 26{,}6$ мГн; $f_1 = 10$ кГц;

$$f_0 = \frac{1}{\pi\sqrt{LC}} = 51{,}954 \text{ кГц};$$

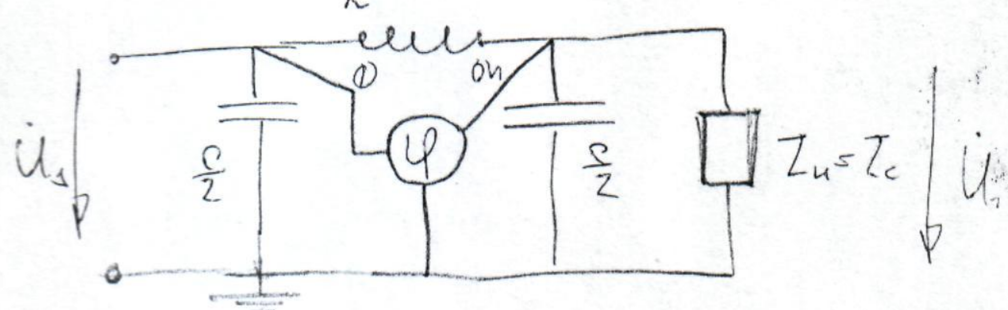
$$\cos B_3 = 1 - 2\frac{f_1^2}{f_0^2} = 1 - 2\frac{10^2\cdot 10^6}{(51{,}254\cdot 10^3)^2} = 0{,}92; \quad B_3 = 0{,}4 \text{ рад}.$$

$$Z_{cп} = \sqrt{\frac{L}{C}}\frac{1}{\sqrt{1-\frac{f_1^2}{f_0^2}}} = \sqrt{\frac{26{,}6\cdot 10^{-3}}{1450\cdot 10^{-12}}}\cdot\frac{1}{\sqrt{1-\frac{10^8}{(51{,}254\cdot 10^3)^2}}} = 4367 \text{ Ом}.$$

(2) $n = 10$ $\quad Z_{cп} = Z_{cч} = 4367$ Ом.

$B_ч = 4$ рад.

(3)



(4) $f_1 = 10$ кГц; $\lambda = cT = 3\cdot 10^8\cdot\frac{1}{10^4} = 3\cdot 10^4$ м $= 30$ км.

$$\lambda = \frac{2\pi}{\beta} \Rightarrow \beta = \frac{2\pi}{\lambda} = \frac{2\pi}{30} = 0{,}21\ \frac{\text{рад}}{\text{км}}, \quad l_1 = \frac{B_3}{\beta} = \frac{0{,}4 \text{ рад}\cdot\text{км}}{0{,}21 \text{ рад}} = 1{,}9 \text{ км}$$

$$Z_c = \frac{\beta}{\omega C} = 4367 \text{ Ом}; \quad l = \frac{B_ч}{\beta} = \frac{0{,}4 \text{ рад км}}{0{,}21} = 19 \text{ км};$$

$$Z_c = \sqrt{\frac{L_0}{C_0}}\ ;\ \gamma = \alpha + j\beta = \sqrt{Z_0 Y_0} = \sqrt{(r_0 + j\omega L_0)(g_0 + j\omega C_0)} =$$

$$= j\omega\sqrt{L_0 C_0}\ ,\ \beta = \omega\sqrt{L_0 C_0}\ ,\ \sqrt{L_0} = \frac{\beta}{\omega\sqrt{C_0}}\ ;$$

$$Z_c = \frac{\beta}{\omega C_0} = 436\ \text{Ом};$$

$$\ell = \frac{\beta_y}{\beta} = \frac{4\ \text{рад. км}}{0{,}21\ \text{рад}} = 19\ \text{км},$$

(5) $Z_н = Z_c$

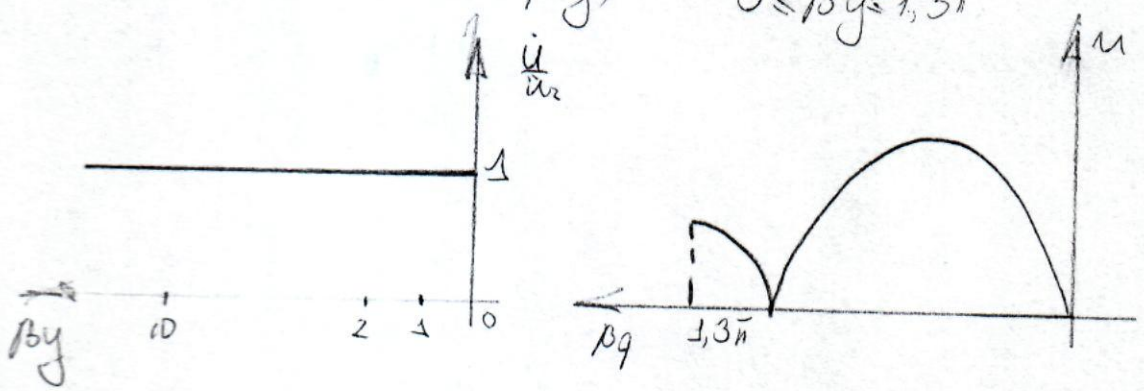
$U = U_{пр}$; $U_{Sпр} = 0$, $I = I_{пр}$; $I_{Sпр} = 0$; $Z_c = \frac{U_2}{I_2} = \frac{U_1}{I_1} = \frac{U}{I}$

$$\begin{cases} \dot{U} = U_2 \operatorname{ch}\gamma y + \dot{I}_2 Z_c \operatorname{sh}\gamma y \\ \dot{I} = \frac{U_2}{Z_c}\operatorname{sh}\gamma y + I_2 \operatorname{ch}\gamma y \end{cases}$$

$$\begin{cases} \dot{U} = U_2 \cos\beta y + j I_2 Z_c \sin\beta y \\ \dot{I} = j\frac{U_2}{Z_c}\sin\beta y + I_2 \cos\beta y \end{cases}$$

Т.К. $I_2 = \frac{U_2}{Z_c}$, ТО $\dot{U} = U_c \cdot \cos\beta y + j U_2 \sin\beta y = \dot{U}_2 e^{j\beta y}$

$U = U_{2m} \sin(\omega t + \beta y)$ $\quad 0 \le \beta y \le 1{,}3\pi$



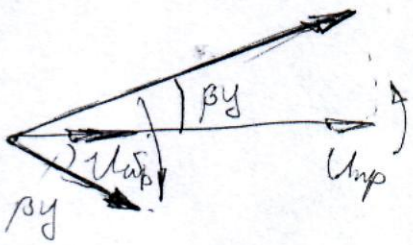
⑥ $R_н = \frac{Z_c}{2}$ $\quad U(x) = U_{пр}(x) + U_{обр}(x)$

$\frac{U_{обр}}{U_{пр}} = \Gamma = \frac{Z_н - Z_c}{Z_н + Z_c} = \frac{2Z_c - Z_c}{2Z_c + Z_c} = \frac{1}{3}$; $3U_{обр} = U_{пр}$

$U(x) = 3U_{обр}(x) + U_{обр}(x) = 4U_{обр}$; $U_{обр} = \frac{U(x)}{4}$;

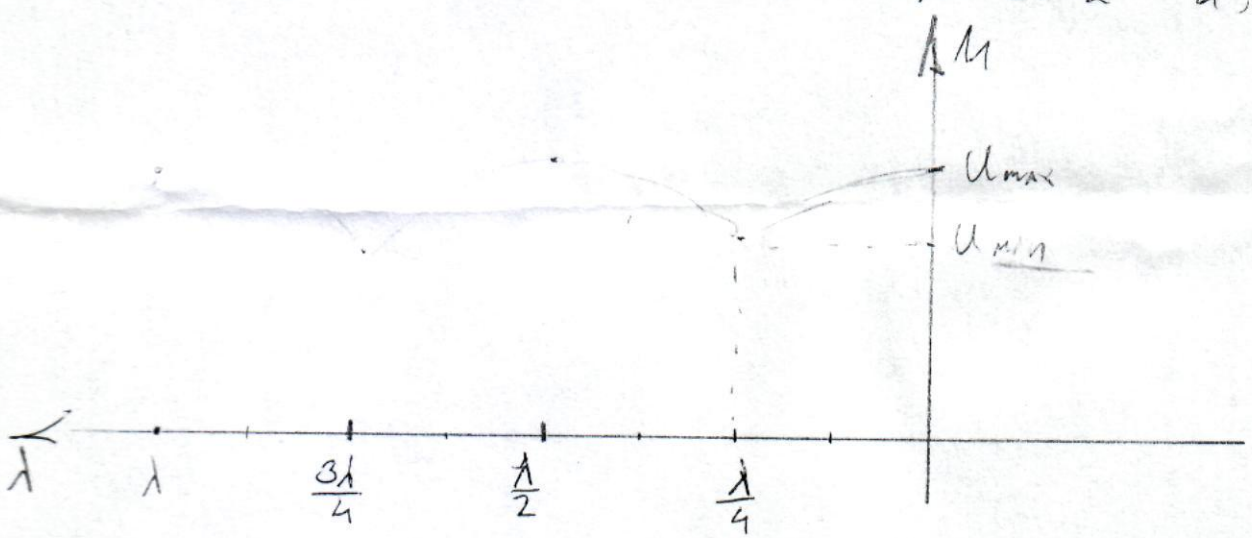
$U_{пр} = U(x) - \frac{U(x)}{4} = \frac{3U(x)}{4}$; Пусть $U(x) = 1$; $U_{пр} = \frac{3}{4}$;

$U_{обр} = \frac{1}{4}$;



$\beta y_{max} = \frac{\pi}{2}$;

$y_{max} = \frac{\pi}{2\beta} = \frac{\pi\lambda}{2\pi 2} = \frac{\lambda}{4}$;

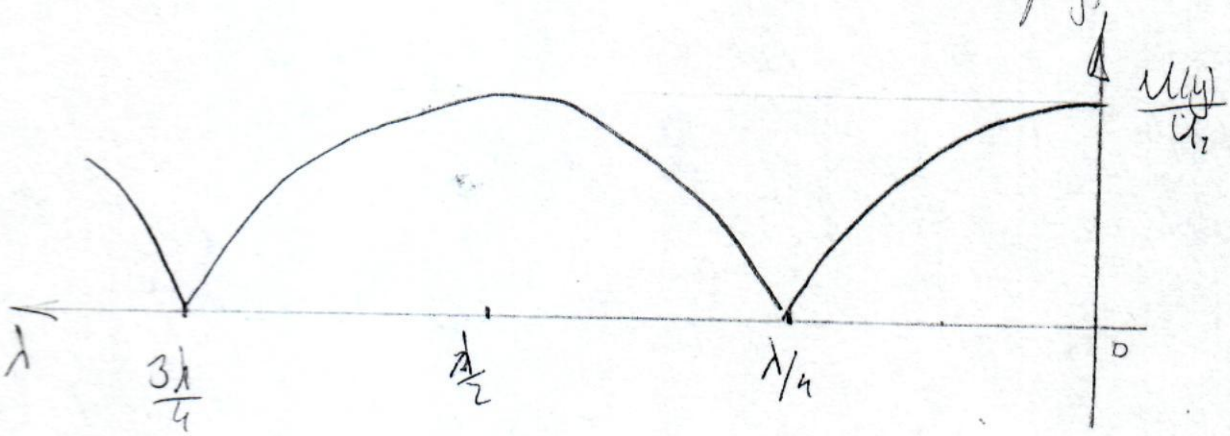


Часть 2

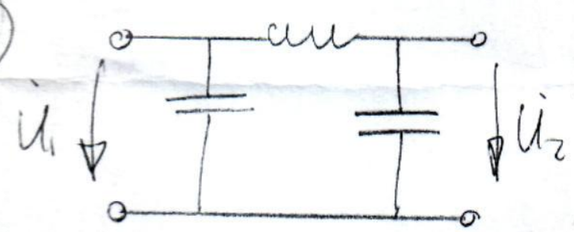
① Холостой ход: $Z_н = \infty \Rightarrow I_2 = 0$;

$U(y) = U_2 \cdot \cos\beta y$;

$\frac{U}{U_2} = \cos\beta y$,



②



$Z_н = \infty$

$$Z_{вх} = Z_в \frac{Z_н + jZ_в \, tg\beta y}{Z_в + jZ_н \, tg\beta y};$$

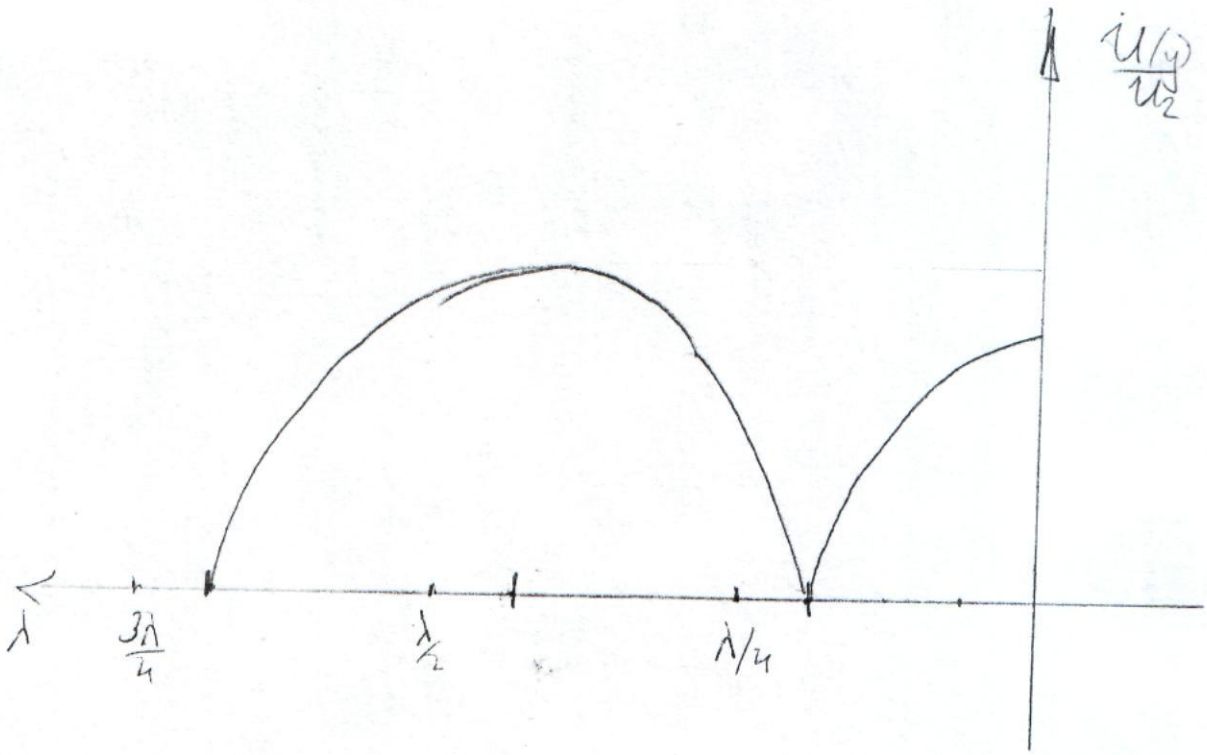
$$Z_{вх} = Z_в \frac{Z_н\left(1 + j\, tg\, \beta y \frac{Z_в}{Z_н}\right)}{Z_н\left(\frac{Z_в}{Z_н} + j\, tg\beta y\right)} = -j Z_в \, ctg\beta y,$$

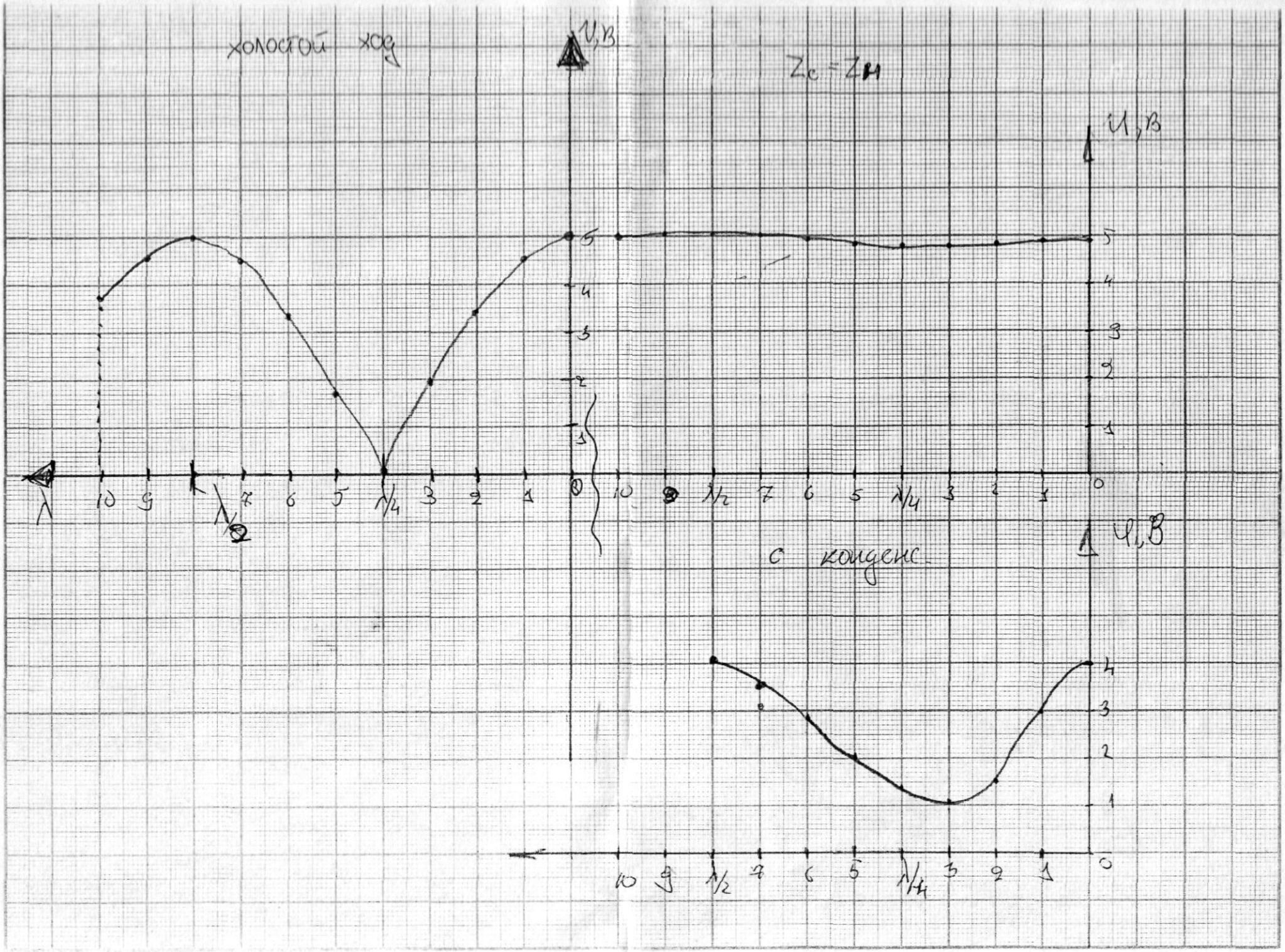
$Z_{вх} = -j 4367 \text{ Ом } ctg\, 0{,}4 = 10328{,}9\angle -90^\circ = -j\,10328{,}9;$

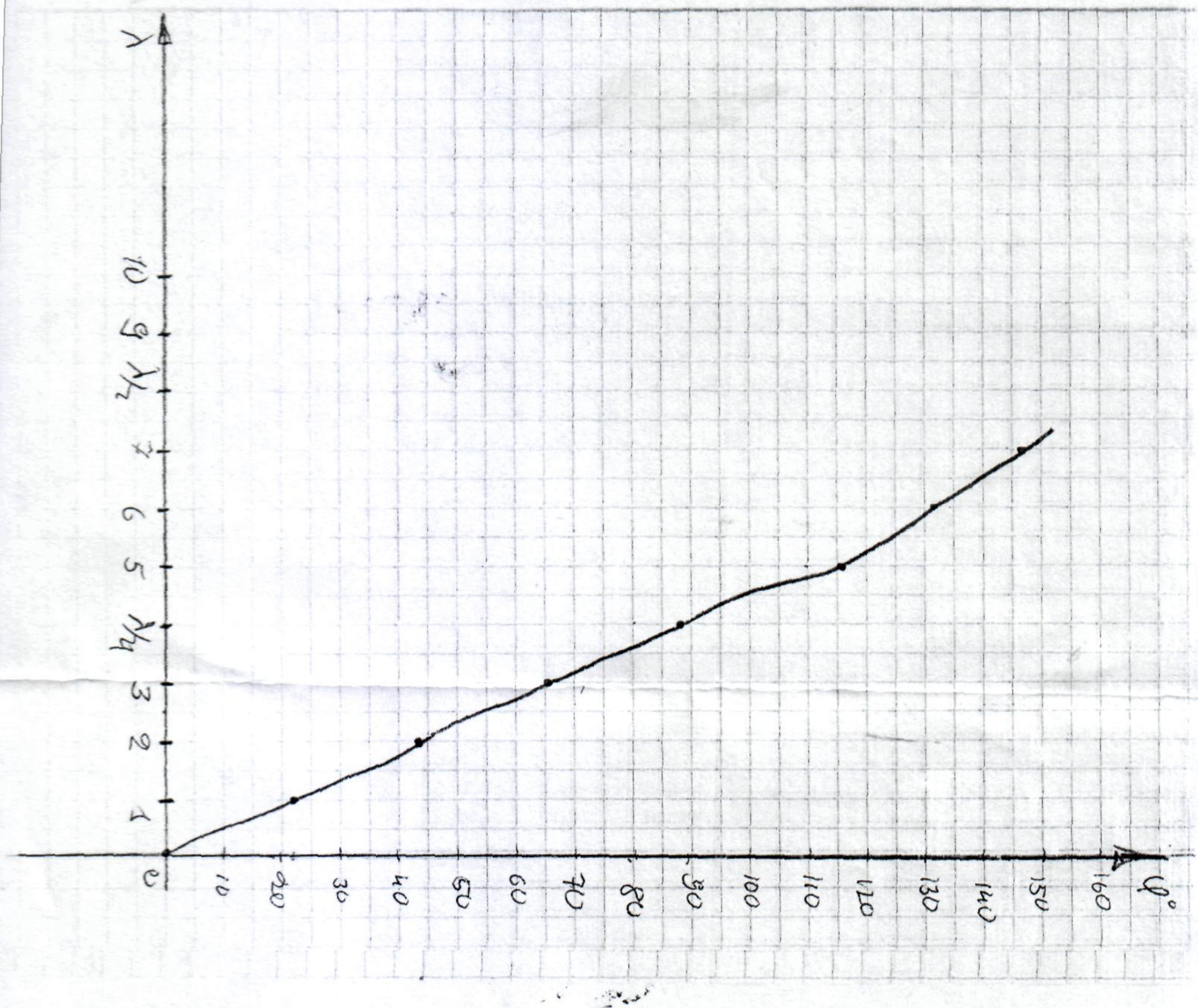
$$U(y) = U_2 \cdot \left[\cos\beta y + j \frac{Z_в}{-j10328{,}9} \sin\beta y\right] =$$

$$= U_2\left[\cos\beta y - \frac{4367}{103289} \sin\beta y\right] = U_2 \sqrt{1 + \left(\frac{4367}{10328{,}9}\right)^2} \times$$

$$\times \sin\left(\beta y - arcctg\left(\frac{10328{,}9}{4367}\right)\right) = 1{,}1\, U_2 \sin(\beta y - 1{,}17)$$


$\frac{U(y)}{2U_2}$
λ
$\frac{3\lambda}{4}$
$\frac{\lambda}{2}$
$\lambda/4$


холостой ход
U,В
$Z_c = Z_н$
U,В
5
4
3
2
1
0
λ
10
9
8
λ/2
7
6
5
λ/4
3
2
1
0
с конденс
U,В
4
3
2
1
0
10
9
λ/2
8
7
6
5
λ/4
3
2
1


λ
φ°
0
1 2 3 λ/4 5 6 7 λ/2 9 10
10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160