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EVALUATION OF NOISE IMMUNITY OF MONOIMMITTANCE LOGIC L-ELEMENT "AND"

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ОЦІНКА ЗАВАДОСТІЙКОСТІ МОНОІМІТАНСНОГО ЛОГІЧНОГО L-ЕЛЕМЕНТА „І“

Purpose. The evaluation of noise immunity limit and searching ways to improve the noise immunity of the monoimmittance logic element "AND", which uses inductive immittance as the information parameter, are the main research task.

Methodology. The scheme of the monoimmittance logic L-element "AND" and its mathematical models were developed. The computer modeling of such destabilizing factor dependences was done: the instability of wave resistance of the transmission line segments, the instability of the segment length of the transmission line, the quality factor of the inductive input impedances.

Findings. The circuit of the monoimmittance logic L-element "AND" and its real and ideal mathematical models were offered. The main destabilizing factors were defined. Analytical forms of quantitative evaluation of noise immunity under the influence of various destabilizing factors were proposed. The noise immunity of the main information parameter to the influence of destabilizing factors was researched and recommendations on the choice of parameters in order to achieve the maximum noise immunity were offered.

Originality. The ideal and the real mathematical models of the monoimmittance logic L-element "AND" were developed and the new universal analytical forms for the noise immunity coefficients of the monoimmittance logic elements under the influence of various destabilizing factors were proposed. These forms provide the opportunity of adequate computer modeling of the monoimmittance logical L-element "AND".

Practical value. The concept of the monoimmittance logic L-element "AND" was founded and the main destabilizing factors (the instability of wave resistance of transmission line segments; the instability of lengths of transmission line, change of the quality factor of inductive input impedance), leading to decrease in the noise immunity of the logic element, were identified. On the basis of the developed mathematical models research on basic parameters (reactive and resistive components of the output impedance) was done in the range of changes: Q-inductive input impedance (20 ÷ 100 units); wave impedance (50 ohms ±0.5); transmission line segments length instability (±0.1 mm). Recommendations regarding the selection of optimal parameters of the monoimmittance logic L-element "AND" in order to achieve maximum noise stability were formulated.

Keywords: *logic gate, inductive impedance, destabilizing factors, noise immunity*

Introduction. A significant role in scientific research is given to the evaluation of noise immunity of digital electronics [1] because sufficient noise immunity is one of the main conditions for the stable operation of digital circuits. Researching noise immunity allows determining boundary conditions for circuits operation and estimating the sensitivity of the circuits to parasitic factors [2]. Noise immunity is particularly important in the design of devices on microstrip transmission lines [3] and miniature digital electronics [4]. Estimation of noise immunity is a necessary stage in the design of immittance logic elements and circuits [5].

Immittance logic elements use resistive, inductive or capacitive immittance and combinations thereof as the

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information parameter. It is capable to carry out logical operations on a carrier signal frequency [6]. In practice it is more appropriate to use monoimmittance logical elements using one parameter: resistance – (R-element), capacitive immittance – (C-element) or inductive immittance – (L-element). Monoimmittance logic elements have high performance and energy efficiency, but less noise immunity than multimmittance logic elements. Therefore, the analysis of methods for improving noise immunity of monoimmittance logic elements requires additional research.

Objective of the article is to estimate noise immunity of the monoimmittance logical element "AND". To achieve this purpose the following tasks are to be solved:

1. Substantiation of the scheme of monoimmittance logic L-element "AND" and development of its mathematical model.
2. Research of influence of destabilizing factors on characteristics of the monoimmittance logic L-element "AND" and evaluation of its noise immunity.

Substantiation of the scheme of the monoimmittance logic L-element "AND" and development of its mathematical model. The information parameter of the monoimmittance logic L-element (Fig. 1, *a*) is an inductive impedance "X_L", and the logic state of this element is characterized by a range of values of this parameter.

The logical "1" corresponds to the range $X_L^{(1)} > X_{L0}$, and logical "0" corresponds to the range $X_L^{(0)} < X_{L0}$, where X_{L0} is inductive limit of logic level. The principle of operation of the monoimmittance logic L-element "AND" can be described as a truth table, which is shown in Fig. 1, *b*.

The electric scheme of possible embodiment of the monoimmittance logic L-element "AND" is shown in Fig. 2, *a*.

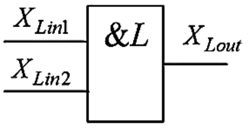
The output inductive impedance of the circuit, if length of transmission line segment is $l = n \cdot \lambda/2$, where $n = 1, 2, 3\ldots$; λ is a length of electromagnetic wave in the transmission line, is

$$X_{Lout} = X_{L3} + \frac{X_{Lin1} \cdot X_{Lin2}}{X_{Lin1} + X_{Lin2}}. \qquad (1)$$

Equation (1) describes the ideal immittance transfer characteristic of the circuit which is represented in coordinates X_{Lin1} and X_{Lin2} as a family of equilateral hyperboles, whose position can be adjusted by the value of the inductor X_{L3} (Fig. 2, *b*).

The range of input impedance is limited by logic level "0": $\left(0 \div X_{Lin.H}^{(0)}\right)$, and by logic level "1": $\left(X_{Lin.L}^{(1)} \div X_{Lin.H}^{(1)}\right)$. To provide noise stability of the scheme, let us set the upper limit of logic level "0" at the scheme output by condition $X_{Lout.H}^{(0)} < X_{Lin.H}^{(0)}$. The lower limit of this level $X_{Lout.L}^{(0)} = 0$. In view of the imposed restrictions, the work area of the monoimmittance logic L-element "AND" is defined by the shaded squares "0" and "1" in Fig. 2, *b* (if $X_{L3} \to 0\Omega$), in accordance with the truth Table shown in Fig. 1, *b*.

In practice, parameters of the real monoimmittance logic L-element "AND" will differ from the parameters of the "ideal" element due to the influence of destabilizing factors.

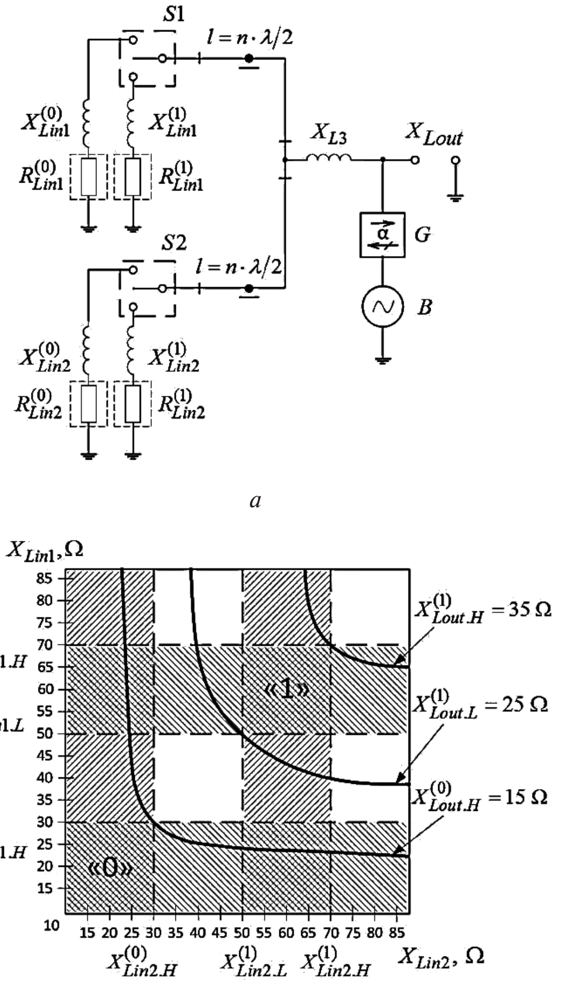


a

X_{Lin1}	X_{Lin2}	X_{Lout}
0 $X_L < X_{L0}$	0 $X_L < X_{L0}$	0 $X_L < X_{L0}$
1 $X_L > X_{L0}$	0 $X_L < X_{L0}$	0 $X_L < X_{L0}$
0 $X_L < X_{L0}$	1 $X_L > X_{L0}$	0 $X_L < X_{L0}$
1 $X_L > X_{L0}$	1 $X_L > X_{L0}$	1 $X_L > X_{L0}$

b

Fig. 1. Scheme (a) and the truth table (b) of the monoimmittance logic L-element "AND"



a

b

Fig. 2. Electric circuit (a) and the immittance transfer characteristic of monoimmittance logic L-element "AND" (b) (S1 and S2 are virtual switches; B is SHF oscillator; G is gate)

To ensure the noise immunity in the real element, the boundary between the logic "0" and "1" is determined by the range of values X_{Lin} and X_{Lout} (Fig. 2, *b*)

$$X_{Lin.H}^{(0)} < X_{Lin} < X_{Lin.L}^{(1)};$$

$$X_{Lout.H}^{(0)} < X_{Lout} < X_{Lout.L}^{(1)}.$$

Thus, the range of possible values of the inductive impedance, which corresponds to the logical "0" and "1", is equal for the input impedance

$$0 < X_{Lin}^{(0)} \le X_{Lin.H}^{(0)}; \quad X_{Lin.L}^{(1)} < X_{Lin}^{(1)} < \infty.$$

For the output impedance it is

$$0 < X_{Lout}^{(0)} \le X_{Lout.H}^{(0)}; \quad X_{Lout.L}^{(1)} < X_{Lout}^{(1)} < \infty.$$

In the real monoimmittance logic element output impedance of the transmission line segment is

$$\overline{Z}_{out} = \frac{\overline{Z}_{in} + j \cdot \mathrm{tg}\beta}{1 + j \cdot \overline{Z}_{in} \cdot \mathrm{tg}\beta} = \mathrm{Re}\,\overline{Z}_{out} + j \cdot \mathrm{Im}\,\overline{Z}_{out}, \qquad (2)$$

where

$$\mathrm{Re}\,\overline{Z}_{\text{âûõ}} = \overline{R}_{out} = \frac{\overline{R}_{in} \cdot (1 - \overline{X}_{in} \cdot \mathrm{tg}\beta) + \overline{R}_{in} \cdot \mathrm{tg}\beta \cdot (\overline{X}_{in} + \mathrm{tg}\beta)}{(1 - \overline{X}_{in} \cdot \mathrm{tg}\beta)^2 + (\overline{R}_{in} \cdot \mathrm{tg}\beta)^2}; \qquad (3)$$

$$\mathrm{Im}\,\overline{Z}_{out} = \overline{X}_{out} = \frac{(1 - \overline{X}_{in} \cdot \mathrm{tg}\beta) \cdot (\overline{X}_{in} + \mathrm{tg}\beta) - \overline{R}_{in}^2 \cdot \mathrm{tg}\beta}{(1 - \overline{X}_{in} \cdot \mathrm{tg}\beta)^2 + (\overline{R}_{in} \cdot \mathrm{tg}\beta)^2}; \qquad (4)$$

$\beta = 2\pi l/\lambda$ is phase constant;

$$\overline{R}_{out} = \frac{R_{out}}{Z_0}; \quad \overline{X}_{out} = \frac{X_{out}}{Z_0}; \quad \overline{X}_{out} = \frac{X_{out}}{Z_0}; \quad \overline{X}_{in} = \frac{\mathrm{Im}\,Z_{in}}{Z_0},$$

where Z_0 is the wave impedance of the transmission line segment.

With regard to (2–4), it follows that the reactive component of the output impedance of the real monoimmittance logic L-element "AND" is described by the expression

$$X_{Lout} = X_{L3} + \frac{(X_{Lout1})^2 \cdot X_{Lout2} + X_{Lout1} \cdot (X_{Lout2})^2 + (R_{Lout1})^2 \cdot X_{Lout2} + (R_{Lout2})^2 \cdot X_{Lout1}}{(R_{Lout1})^2 + 2 \cdot R_{Lout1} \cdot R_{Lout2} + (R_{Lout2})^2 + (X_{Lout1})^2 + 2 \cdot X_{Lout1} \cdot X_{Lout2} + (X_{Lout2})^2}, \qquad (5)$$

where

$$X_{Lout1} = Z_0 \cdot \frac{(1 - X_{Lin1}/Z_0 \cdot \mathrm{tg}\beta) \cdot (X_{Lin1}/Z_0 + \mathrm{tg}\beta) - R_{Lin1}^2/Z_0 \cdot \mathrm{tg}\beta}{(1 - X_{Lin1}/Z_0 \cdot \mathrm{tg}\beta)^2 + (R_{Lin1}/Z_0 \cdot \mathrm{tg}\beta)^2}; \qquad (6)$$

$$X_{Lout2} = Z_0 \cdot \frac{(1 - X_{Lin2}/Z_0 \cdot \mathrm{tg}\beta) \cdot (X_{Lin2}/Z_0 + \mathrm{tg}\beta) - R_{Lin2}^2/Z_0 \cdot \mathrm{tg}\beta}{(1 - X_{Lin2}/Z_0 \cdot \mathrm{tg}\beta)^2 + (R_{Lin2}/Z_0 \cdot \mathrm{tg}\beta)^2}; \qquad (7)$$

where Z_{01}, Z_{02}stand for the wave impedance of the first and the second transmission line segments.

Similarly, the resistive component of the circuit output impedance is calculated by

$$R_{Lout} = R_{L3} + \frac{(R_{Lout1})^2 \cdot R_{Lout2} + R_{Lout1} \cdot (R_{Lout2})^2 + R_{Lout1} \cdot (X_{Lout2})^2 + R_{Lout2} \cdot (X_{Lout1})^2}{(R_{Lout1})^2 + 2 \cdot R_{Lout1} \cdot R_{Lout2} + (R_{Lout2})^2 + (X_{Lout1})^2 + 2 \cdot X_{Lout1} \cdot X_{Lout2} + (X_{Lout2})^2}; \qquad (8)$$

$$R_{Lout1} = Z_0 \cdot \frac{R_{Lin1}/Z_0 \cdot (1 - X_{Lin1}/Z_0 \cdot \mathrm{tg}\beta) + R_{Lin1}/Z_0 \cdot \mathrm{tg}\beta \cdot (X_{Lin1}/Z_0 + \mathrm{tg}\beta)}{(1 - X_{Lin1}/Z_0 \cdot \mathrm{tg}\beta)^2 + (R_{Lin1}/Z_0 \cdot \mathrm{tg}\beta)^2}; \qquad (9)$$

$$R_{Lout2} = Z_0 \cdot \frac{R_{Lin2}/Z_0 \cdot (1 - X_{Lin2}/Z_0 \cdot \mathrm{tg}\beta) + R_{Lin2}/Z_0 \cdot \mathrm{tg}\beta \cdot (X_{Lin2}/Z_0 + \mathrm{tg}\beta)}{(1 - X_{Lin2}/Z_0 \cdot \mathrm{tg}\beta)^2 + (R_{Lin2}/Z_0 \cdot \mathrm{tg}\beta)^2}. \qquad (10)$$

Expressions (5–10) are the mathematical model of the real monoimmittance logic L-element "AND". With its use it is possible to make an analytical assessment of the noise immunity.

Research of influence of destabilizing factors on characteristics of the monoimmittance logic L-element "AND" and evaluation of its noise immunity. From the analysis of expressions (5–10) it follows that the main destabilizing factors that impact the operation of the monoimmittance logic L-element "AND" are:

- the instability of the wave resistance Z_0 of the transmission line segments;

- the instability of the transmission line segments length Δl;

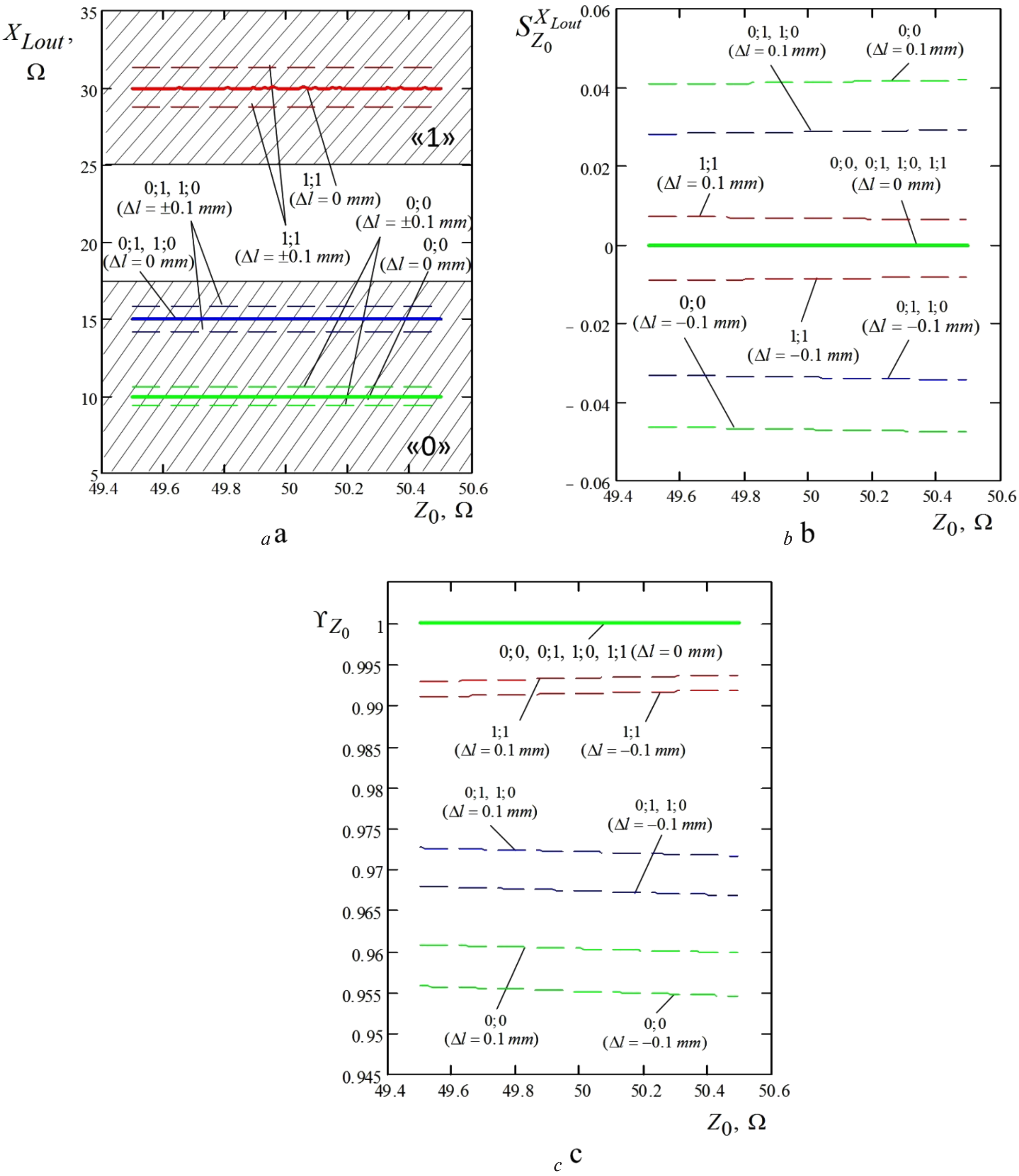
- the quality factor of the inductive input impedances $Q = X_{Lin}/R_{Lin}$.

The objective of this research is estimation of influence of these destabilizing factors and finding ways to minimize them.

For the comparative assessment of the immittance noise immunity of the logic element let us use normalized parameters – coefficients of the noise immunity of the output reactive impedance X_{Lout}: under influence of the instability of the wave resistance Z_0 of transmission line segments $\Upsilon_{Z_0} = 1\Big/\left(1 + \left|S_{Z_0}^{X_{Lout}}\right|\right)$; under the quality factor of the inductive input impedances $\Upsilon_Q = 1\Big/\left(1 + \left|S_Q^{X_{Lout}}\right|\right)$; under the instability of the transmission line segments length $\Upsilon_{\Delta l} = 1\Big/\left(1 + \left|S_{\Delta l}^{X_{Lout}}\right|\right)$, where $S_{Z_0}^{X_{Lout}} = \dfrac{\partial X_{Lout}}{\partial Z_0} \cdot \dfrac{Z_0}{X_{Lout}}$; $S_{\Delta l}^{X_{Lout}} = \dfrac{\partial X_{Lout}}{\partial \Delta l} \cdot \dfrac{\Delta l}{X_{Lout}}$ is the sensitivity of the output reactive impedance under influence of destabilizing factors. The range of variation of these coefficients is $0 \le \Upsilon \le 1$.

For modeling operation of the circuit in conditions close to real ones, let us designate a value of the wave resistance Z_0 of transmission line segments, the length of the transmission line segment l and the quality factor of the inductive input impedances Q taking into account the technological process errors. We suppose that the impedance of the transmission line segments $Z_0 = 50 \pm \pm 0{,}5\Omega$, the instability of the segment length of the transmission line $\Delta l = \pm\ 0{,}1$ mm (this is analogous to error due to instability of frequency of the reference oscillator signal in 0.033 %) and the quality factor of the inductive input impedances $Q = 5 \div 10$. The modeling has been done for the possible states of the logic element – for the input logic levels (0; 0), (0; 1), (1; 0) and (1; 1), where according to Fig. 2, *b* the input logic level "0" means the reactive impedance input $X_{in} = 20\Omega$, and the input logic level "1" means the reactive impedance input $X_{in} = 60\Omega$. The frequency of the reference oscillator signal is $f = = 10$ GHz.

The modeling results are presented in Fig. 3–5.



a a

b b

c c

Fig. 3. Graphics of the output reactive impedance X_{Lout} (a), sensitivity of the output reactive impedance $S_{Z_0}^{X_{Lout}}$ (b) and the noise immunity coefficient Υ_{Z_0} (c) depending on the wave resistance instability Z_0 of the transmission line segments

The investigation of influence of the instability of the wave resistance Z_0 of the transmission line segments on the output reactive impedance X_{Lout} of the logic element (Fig. 3, *a*), the sensitivity of the output reactive impedance $S_{Z_{01}}^{X_{Lout}}$ (Fig. 3, *b*), the noise immunity coefficient Υ_{Z01} (Fig. 3, *c*) was carried out for the cases of the ideal length of the transmission line segment ($\Delta l = 0$) and the instability of the transmission line segment length $\Delta l = \pm 0.1$ mm.

From the graphs in Fig. 3 *a*, *b*, it follows that the output reactive impedance X_{Lout} hardly depends on the instability of the wave resistance Z_0 of the transmission line segments in the range of 50 ± 0,5Ω in the cases of the perfect length ($\Delta l = 0$), and the non-ideal length ($\Delta l = \pm 0.1$ mm) of the transmission line segment. Coefficient of the noise immunity in this case is 1 for $\Delta l = 0$, and for $\Delta l = \pm 0{,}1$ mm the value of this coefficient is not less than 0.955.

To evaluate the sensitivity of the output reactive impedance X_{Lout} of the logic element to influence of the quality factor Q of the inductive input impedances we

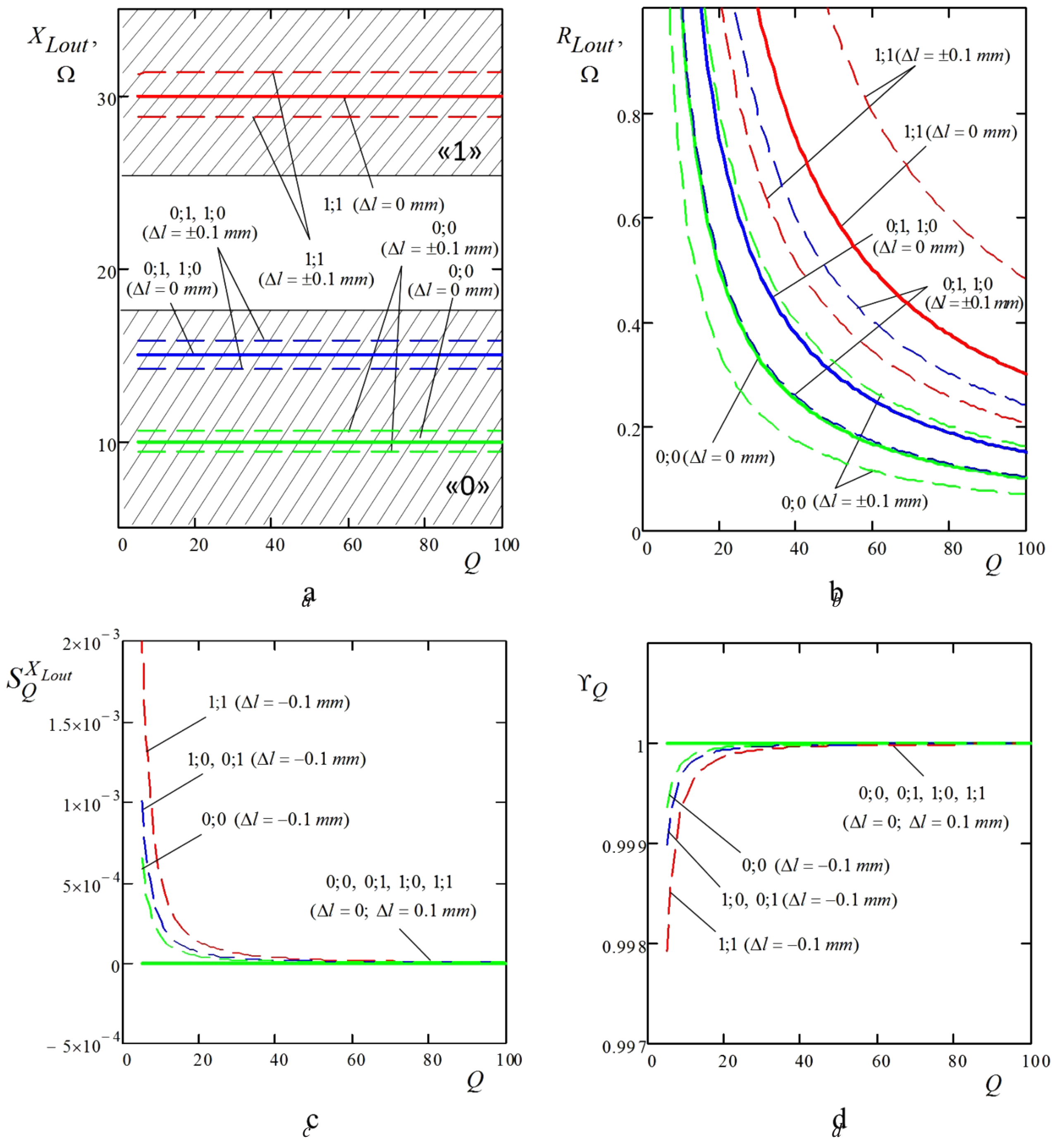


Fig. 4. Graphics of the output reactive X_{Lout} (a) and resistive R_{Lout} (b) impedances, sensitivity of the output reactive impedance $S_Q^{X_{Lout}}$ (c) and the noise immunity coefficient Υ_Q (d) depending on the quality factor Q of the inductive input impedances

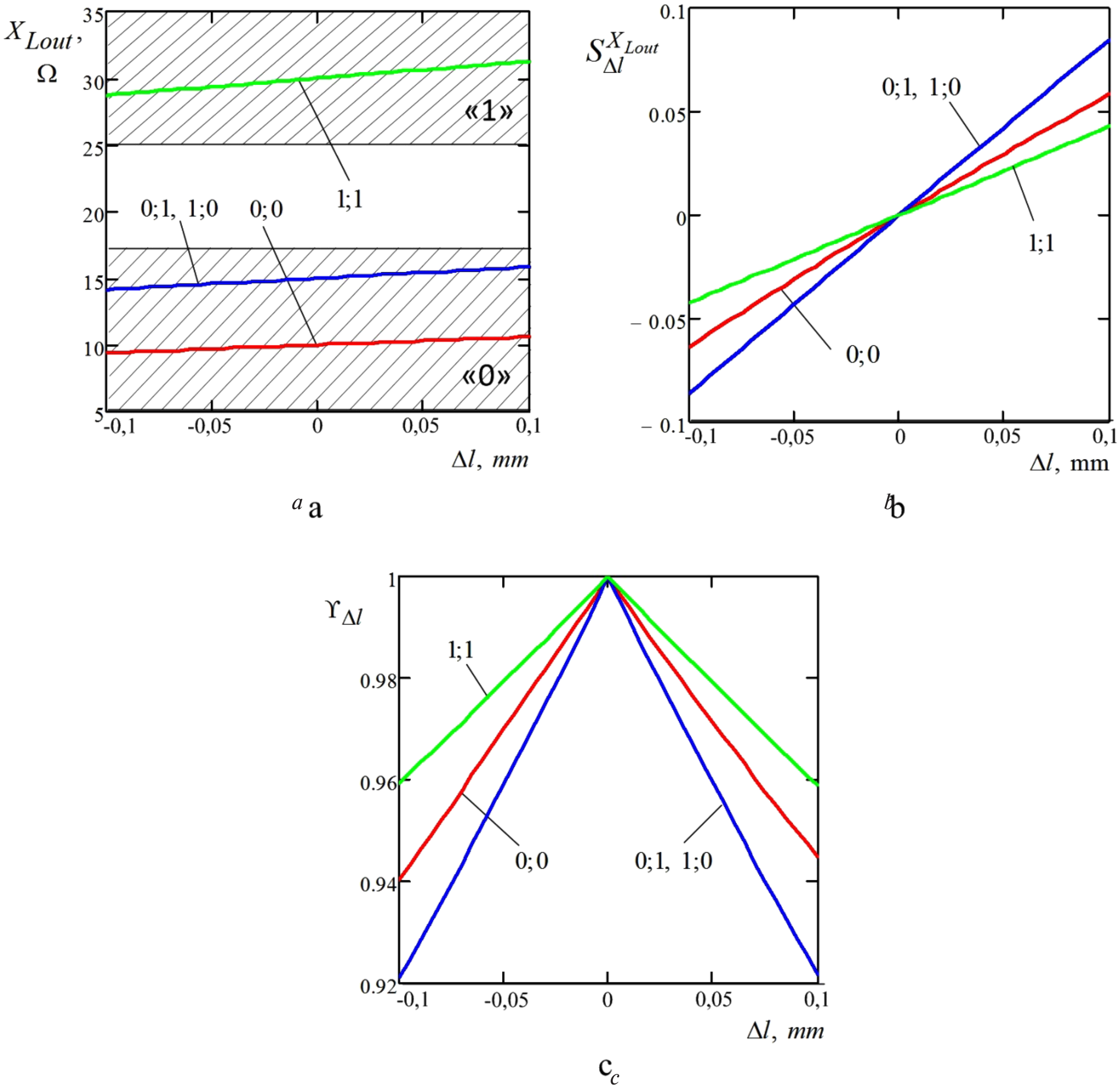


Fig. 5. Graphics of the output reactive impedance X_{Lout} (a), sensitivity of the output reactive impedance $S_{Z_0}^{X_{\text{đèõ}}}$ (b) and the noise immunity coefficient Υ_{Z_0} (c) depending on the length of the transmission line segment Δl

will assume that $Z_0 = 50\Omega$. Evaluation was carried for two cases of the transmission line segment length instability: $\Delta l = 0$ and $\Delta l = \pm 0.1$ mm. Fig. 4 shows the dependence of the output reactive X_{Lout} and resistive R_{Lout} impedances, the output reactive impedance sensitivity $S_Q^{X_{Lout}}$ and the noise immunity coefficient Υ_Q on changing the quality factor Q of the inductive input impedances for the input logic levels (0; 0), (0; 1), (1; 0) and (1; 1).

Graphs in Fig. 4, *a, c* show that the output reactive impedance X_{Lout} hardly depends on the input inductive impedance quality factor Q change in the range (5 ÷ 100) in cases of the ideal ($\Delta l = 0$) and the non-ideal ($\Delta l = \pm 0.1$ mm) length of the transmission line segment. The noise immunity coefficient in this case has a value of at least 0.998 (Fig. 4, *d*). With the growth of the quality factor Q the value of the output resistive impedance R_{Lout} decreases (Fig. 4, *b*) in all cases of the length instability of the transmission line segment.

Fig. 5 shows graphs of the resistive and reactive output impedance dependences on change of the length of the transmission line segment Δl, and sensitivity of the output reactive impedance $S_{\Delta l}^{X_{Lout}}$ and the noise immunity coefficient $\Upsilon_{\Delta l}$ on change of the length of the transmission line segment Δl for the input logic levels (0; 0), (0; 1), (1; 0) and (1; 1) ($Q = 100$ and $Z_0 = 50\Omega$).

The graph in Fig. 5 shows that with the error of implementation of the transmission line segment length $\Delta l = 0 \ldots \pm 0.1$ mm the output reactive impedance X_{Lout} does not exceed the boundaries of logic levels "0" and "1". The graph of sensitivity of the reactive impedance output $S_{\Delta l}^{X_{Lout}}$ in Fig. 5, *b* shows that the output reactive impedance X_{Lout} changes by no more than 8 %. The noise immunity coefficient in this case has a value of at least 0.92 (Fig. 3, *c*), and linearly decreases with an increasing implementation error of the transmission line segment length Δl.

Conclusions. Investigations of the influence of destabilizing factors (change of the wave resistance Z_0 of the transmission line, the implementation error of the transmission line segment length Δl, the quality factor of the inductive input impedances Q) on the transfer characteristic of the logic monoimmittance L-element "AND" shows that:

1. Changes in the value of the wave resistance Z_0 have almost no effect on the output reactive impedance of the circuit, the magnitude of the relative sensitivity in this case does not exceed 5 %. The output resistive impedance of the circuit does not depend on the wave resistance Z_0.

2. A change of the quality factor of inductive input impedances Q causes a change of the output reactive impedance X_{Lout} by no more than 2 %. The output reactive impedance R_{Lout} decreases with an increase of the quality factor Q.

3. With the implementation error of the transmission line segment length $\Delta l = 0 \ldots \pm 0.1$ mm the output reactive impedance X_{Lout} changes by no more than 8 % and does not exceed the boundaries of logic levels "0" and "1". The output resistive impedance R_{Lout} in the range of the implementation error of the transmission line segment length Δl does not change.

The noise immunity coefficient of the monoimmittance L-logic element "AND" in all the above cases is not less than 0.92.

Thus, it follows that in order to ensure high noise immunity of the circuit it is necessary to seek to reduce the implementation error of the transmission line segments length and to increase the stability of the reference oscillator frequency. The quality factor of the inductive input impedance corresponding to logic "0" and "1" should be over 20.

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Мета. Оцінка запасу завадостійкості та визначення шляхів її підвищення моноімітансного логічного елемента „І“, що використовує в якості інформаційного параметру індуктивний імітанс.

Методика. Розроблена схема моноіммітансного логічного L-елемента „І“ та його математичні моделі. Проведене комп'ютерне моделювання залежності основних параметрів моноімітансного логічного L-елемента „І“ від основних дестабілізуючих факторів: нестабільності хвильового опору відрізків лінії передачі, нестабільності довжини відрізків лінії передачі, добротності вхідних індуктивних імпедансів.

Результати. Обґрунтована схема моноімітансного логічного L-елемента „І“. Визначені основні дестабілізуючі чинники, запропоновані аналітичні форми кількісної оцінки завадостійкості при впливі різних дестабілізуючих факторів. Досліджена завадостійкість основного інформаційного параметра від впливу дестабілізуючих факторів, сформульовані рекомендації щодо вибору параметрів моноімітансного логічного L-елемента „І“ для досягнення найбільшої завадостійкості.

Наукова новизна. Розроблені ідеальна й реальна математичні моделі моноімітансного логічного L-елемента „І“ та запропоновані нові універсальні аналітичні форми для коефіцієнтів завадостійкості моноімітансних логічних елементів, що забезпечують можливість адекватного комп'ютерного моделювання розробленого моноімітансного логічного L-елемента „І“.

Практична значимість. На підставі розроблених математичних моделей проведене дослідження основних параметрів (реактивної та активної складових вихідного імпедансу) у діапазоні змін: добротності вхідних індуктивних імпедансів (20 ÷ 100 од.); хвильового опору (50 ± 0,5 Ом); нестабільності довжини (±0,1 мм) відрізків лінії передачі. Сформульовані рекомендації щодо вибору оптимальних параметрів моноімітансного логічного L-елемента „І“ для досягнення найбільшої завадостійкості.

Ключові слова: *логічний елемент, індуктивний імпеданс, дестабілізуючі чинники*

Цель. Оценка запаса помехоустойчивости и определение путей ее повышения моноиммитансного логического элемента „И“, использующего в качестве информационного параметра индуктивный иммитанс.

Методика. Разработана схема моноиммитансного логического L-элемента „И“ и его математические модели. Проведено компьютерное моделирование зависимости основных параметров моноиммитансного логического L-элемента „И“ от основных дестабилизирующих факторов: нестабильности волнового сопротивления отрезков линии передачи; нестабильности длины отрезков линии передачи; изменения добротности входных индуктивных импедансов.

Результаты. Обоснована схема моноиммитансного логического L-элемента „И“. Определены основные дестабилизирующие факторы, предложены аналитические формы количественной оценки помехоустойчивости при воздействии различных дестабилизирующих факторов. Иследована помехоустойчивость основного информационного параметра от влияния дестабилизирующих факторов, сформулированы рекомендации по выбору параметров моноиммитансного логического L-элемента „И“ для достижения наибольшей помехоустойчивости.

Научная новизна. Разработаны идеальная и реальная математические модели моноиммитансного логического L-элемента „И“ и предложены новые универсальные аналитические формы для коэффициентов помехоустойчивости моноиммитансных логических элементов, обеспечивающие возможность адекватного компьютерного моделирования разработанного моноиммитансного логического L-элемента „И“.

Практическая значимость. На основании разработанных математических моделей проведено исследование основных параметров (реактивной и активной составляющих выходного импеданса) в диапазоне изменений: добротности входных индуктивных импедансов (20 ÷ 100 ед.); волнового сопротивления (50 ± 0,5 Ом); нестабильности длины (±0,1 мм) отрезков линии передачи. Сформулированы рекомендации по выбору оптимальных параметров моноиммитансного логического L-элемента „И“ для достижения наибольшей помехоустойчивости.

Ключевые слова: *логический элемент, индуктивный импеданс, дестабилизирующие факторы*

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