Research article
DOI: https://doi.org/10.18721/JCSTCS.18309
UDC 621.375.026

# SELECTION OF THE OPTIMAL STRUCTURE OF A TRANSFORMER BASED ON SINGLE-TURN ELEMENTS FOR HIGH-POWER SWITCHING TRANSISTOR HARMONIC OSCILLATORS

*V.A. Filin*[1], *Kh.A. Sattarov*[2], *V.A. Yurova*[1,3] ✉, *A.N. Golovin*[1]

[1] Bonch-Bruevich St. Petersburg State University of Telecommunications, St. Petersburg, Russian Federation;

[2] Tashkent Universirty of information technology named after Muhammad al-Khwarizmi, Samarkand branch, Samarkand, Uzbekistan;

[3] North-Western State Medical University named after I.I. Mechnikov, St. Petersburg, Russian Federation

✉ va-yurova@mail.ru

**Abstract.** Most electronic devices use power supplies and signal generators. A rationally designed high-power switching radio frequency (RF) generator usually contains one oscillatory circuit, a transformer and a grounded load. This work presents the rationale and calculations for the proposed structure of an RF transformer for high-power switching harmonic oscillators, based on the connection of unit elements. An analysis of the obtained calculation results was carried out to select the most optimal structure for most practical applications. It has been established that using N single-turn transformers achieves an N-fold gain in the volume and weight of ferrite and copper tubing. However, this gain is not always convenient to implement due to design considerations. The presented calculations confirm that the proposed structure is the most optimal for most practical applications, as it is free from many drawbacks of the classical high-power transformer scheme with multi-turn windings.

**Keywords:** semiconductor electronics, transformer, switching HF generator, power supply, electronic components

**Citation:** Filin V.A., Sattarov Kh.A., Yurova V.A., Golovin A.N. Selection of the optimal structure of a transformer based on single-turn elements for high-power switching transistor harmonic oscillators. Computing, Telecommunications and Control, 2025, Vol. 18, No. 3, Pp. 102–110. DOI: 10.18721/JCSTCS.18309

Научная статья
DOI: https://doi.org/10.18721/JCSTCS.18309
УДК 621.375.026

# ВЫБОР ОПТИМАЛЬНОЙ СТРУКТУРЫ ТРАНСФОРМАТОРА НА ОСНОВЕ ОДНОВИТКОВЫХ ЭЛЕМЕНТОВ ДЛЯ МОЩНЫХ КЛЮЧЕВЫХ ТРАНЗИСТОРНЫХ ГЕНЕРАТОРОВ ГАРМОНИЧЕСКИХ КОЛЕБАНИЙ

*В.А. Филин[1], Х.А. Саттаров[2], В.А. Юрова[1,3] ✉, А.Н. Головин[1]*

[1] Санкт-Петербургский государственный университет телекоммуникаций им. проф. М.А. Бонч-Бруевича, Санкт-Петербург, Российская Федерация;

[2] Ташкентский университет информационных технологий им. Мухаммада ал-Хоразмий, Самаркандский филиал, Самарканд, Узбекистан;

[3] Северо-Западный государственный медицинский университет им. И.И. Мечникова, Санкт-Петербург, Российская Федерация

✉ va-yurova@mail.ru

**Аннотация.** Для большинства устройств электронной техники используются источники питания и генераторы сигналов. Рационально построенный мощный ключевой высокочастотный (ВЧ) генератор содержит обычно один колебательный контур, трансформатор и заземленную нагрузку. В работе проведены обоснования и расчет предложенной структуры ВЧ трансформатора для мощных ключевых генераторов гармонических колебаний, основанной на соединении единичных элементов. Проведен анализ полученных результатов вычислений для выбора наиболее оптимальной для большинства практических применений структуры. Установлено, что при использовании N одновитковых трансформаторов достигается выигрыш в объеме и весе феррита и медной трубки в N раз. Однако этот выигрыш не всегда удобно реализовать из конструктивных соображений. Представленные расчеты подтверждают, что предложенная структура является наиболее оптимальной для большинства практических применений, поскольку лишена многих недостатков классической схемы мощного трансформатора с многовитковыми обмотками.

**Ключевые слова:** полупроводниковая электроника, трансформатор, ключевой генератор ВЧ, источник питания, электронные компоненты

**Для цитирования:** Filin V.A., Sattarov Kh.A., Yurova V.A., Golovin A.N. Selection of the optimal structure of a transformer based on single-turn elements for high-power switching transistor harmonic oscillators // Computing, Telecommunications and Control. 2025. Т. 18, № 3. С. 102–110. DOI: 10.18721/JCSTCS.18309

## Introduction

A rationally designed high-power switching radio frequency (RF) generator usually contains one oscillatory circuit, a transformer and a grounded load. In the generator circuit, the transformer performs two main functions: it converts the voltage (current) to a value determined by the load and isolates the generator from the load by DC voltage or mains voltage (50 Hz). A transformer designed for a given power in the load at a high operating frequency $f$ is an essential element of the circuit, largely determining the performance characteristics, weight-dimention parameters and cost of the generator. The significant value of the parasitic leakage inductance of a classic multi-turn RF transformer for many generator topologies is a factor limiting the operating frequency and energy parameters. For these reasons, improving the electrical characteristics of the transformer, reducing its weight and dimensions is of great practical importance [1–2].

The equivalent circuit of the industrial generator load in the form of an inductor can be represented by a parallel connection of the inductance $L_l$ and the resistive conductance $G_l$ (Fig. 1) with a quality factor $Q_1 = 1/(\omega L_l G_l)$.

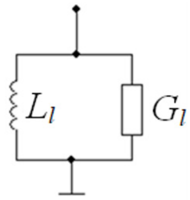


Fig. 1. Generator load equivalent circuit

Tuning the secondary winding circuit of a transformer to resonance allows compensating for the reactive component of conductivity, eliminating reactive currents in the secondary winding and, thus, unloading the transformer. However, in some cases, such a solution may prove impractical, for example, due to the lack of suitable capacitors with a given operating voltage and reactive power, inconveniences in their installation etc. In this case, the secondary winding of the transformer is loaded not on the resistive conductance $G_l$, but on the complex conductance $Y = G_l + 1/j\omega L_l$ (Fig. 1), i.e., when $G_l << 1/\omega L_l$ the load increases almost by $Q_l$ times. Accordingly, the current and oscillation power in the secondary winding increase. The effect of the parasitic leakage inductance $L_{S.C.} = L_2(1 - k^2)$ also increases significantly. The volumes and weights of ferrite and copper will increase by $Q_l$ times, and the geometric dimensions of the transformer – by $\sqrt[3]{Q_l}$ times.

Tuning the entire circuit to resonance is carried out using capacitors connected to the primary winding. For example, the weight of a transformer of an industrial generator with a load capacity of $P_l$ = 60 kW in resonant mode at an operating frequency of $f$ = 66 kHz is approximately 10–15 kg. When the load quality is $Q_l$ = 10 and the capacitors are excluded, the weight of the transformer actually increases to 100 kg. In this case, as in other cases, when the transformer power is increased due to current while maintaining the voltage level or when increasing the operating frequency, difficulties may arise with the implementation of the transformer, since the estimated number of turns of any of the windings may be less than one. There are difficulties with the winding wire, the thickness of which may be too large, phenomena such as skin effect, displacement of current to the boundaries of the wires under the influence of a magnetic field etc. occur.

*The goal of this work* is an attempt to justify and calculate a new structure of an RF transformer for high-power switching generators of harmonic oscillations, based on the connection of single elements, i.e., single-turn transformers of a "cable" design. Such a structure, in the author's opinion, is optimal for most practical applications, since it is free from many drawbacks of the classical high-power transformer scheme with multi-turn windings.

## Single-turn transformers and their connections

When constructing high-power thyristor or transistor RF generators and secondary power sources, in order to simplify and reduce the cost of the design, transformerless primary (mains) power sources are usually used, giving 300, 500 or 600 V of direct voltage at the output. In this case, the increase in power is achieved solely by increasing the direct current, which entails a decrease in the inductance and the number of turns of the primary winding of the RF transformer. At the same time, the dimensions and thickness of the winding wire increase. Under otherwise equal conditions, the influence of the magnetic field on the distribution of current in the magnetic circuit and in the wire (skin effect, eddy currents) increases, which leads to increased losses of electrical energy in the transformer and, accordingly, to its heating.

Similar phenomena occur in the secondary winding of the transformer, especially when a low-resistance inductor consuming high current is connected to it. The skin effect and current displacement to the edges of the winding, caused by the magnetic field, increase as the transformer's operating

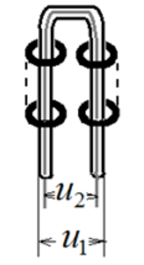


Fig. 2. Single-turn transformer type

frequency rises. If the dimensions of the transformer decrease proportionally to the decrease in the wavelength, then, due to the similarity principle, the relative influence of the skin effect does not change.

Problems with a small (less than one) number of turns and the skin effect can be solved to a large extent by replacing one high-power transformer with a combination of low-power ones, splitting the magnetic field into a number of unrelated magnetic fluxes, i.e., applying the litz wire principle to the magnetic circuit. At first glance, this will lead to a more complex design. However, this complication is insignificant or may even turn out to be a simplification, if single-turn transformers of extremely simple design are used. A single-turn transformer (Fig. 2) is a $U$-shaped copper tube onto which ferrite rings are threaded. This tube is the primary (secondary) winding, and the secondary (primary) winding is a litz wire bundle (or a second copper tube) passed inside the copper tube. This “cable” design of the windings ensures, among other things, a sharp decrease in the leakage inductance of the windings and obtaining their coupling coefficient $k$, amounting as several nines after the decimal point. An important advantage of single-turn transformers is the presence of only one turn in the primary and secondary windings with an air gap between them, ensuring good heat dissipation.

Series-parallel connections of the primary and secondary windings of transformers allow obtaining integer or fractional transformation coefficients. Of course, such a method of voltage transformation is acceptable if the transformation coefficient is not too large and lies within several units; which is typical for generators with inductors and switching sources of secondary power supply with a small transformation ratio. The winding terminals (copper tubes) can be used for mechanical mounting of transformers on strip lines serving as input or output buses.

Fig. 3 shows an example of a connection of four single-turn transformers – series-parallel for primary windings and parallel for secondary windings, and Fig. 4 shows a standard equivalent circuit for such transformer connections.

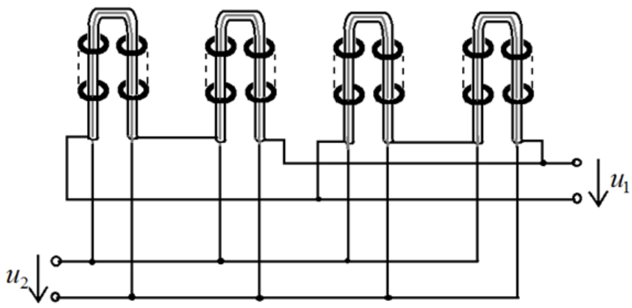


Fig. 3. Series-parallel connection of single-turn transformers

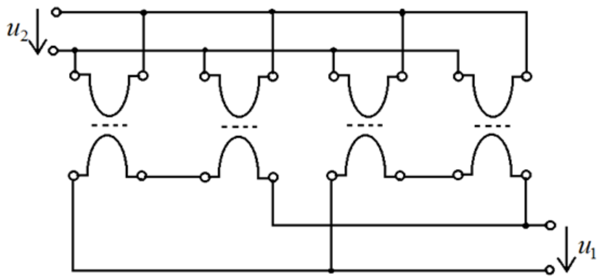


Fig. 4. Equivalent circuit of series-parallel connection

In addition to the very high coefficient of magnetic coupling of the windings they provide, the design methodology for single-turn transformers should be based on the requirement to obtain the necessary transformation coefficient and sufficiently small losses in the magnetic circuit and windings (turns). The transformation coefficient is ensured by selecting the required number of single-turn transformers connected in series-parallel.

For example, the circuit in Fig. 3 provides a transformation coefficient of $n = 0.5$ or $n = 2$, where two transformers can be used instead of four. If we take six transformers and connect three primary windings in series and threes in parallel, and the secondary windings with two in series and three twos in parallel, we can obtain a transformation ratio of 2:3 (or 3:2), etc. In general, for $m{:}l$ transformation, $ml$ transformers are required. In some cases, this is not a significant limiting factor, since the transformers are extremely simple (Fig. 2) and, in addition, if there are power control units, there is no need to strictly maintain the specified (calculated) transformation coefficient.

**Methodology for calculating elements of a single-turn transformer and completing a circuit based on it**

Here is a method for the calculating the elements of a single-turn transformer. No-load losses in the magnetic circuit

$$P_{nl} = \hat{P}_{nl} V_m, \quad \hat{P}_{nl} = P_{m0} \left( f / f_{m0} \right)^{\alpha} \left( B_m / B_{m0} \right)^{\beta}, \qquad (1a, b)$$

where $\hat{P}_{nl}$ is the specific losses per unit volume $V_m$ of the magnetic circuit, $f_{m0}$ = 1 kHz, $B_{m0}$ = 1 T, $P_{m0} = \hat{P}_{nl}$ at $f = f_{m0}$, $B_m = B_{m0}$. The values $P_{m0}$, α, β are given in [3–6], for example, for ferrite 2000NMZ: $P_{m0}$ = 0.178 W/cm$^3$; α = 1.3; β = 1.7. To ensure acceptable values of $P_{nl}$, it is necessary to select a sufficiently small value of induction $B_m$. After selection $B_m$ the cross-sectional area $S_m$ of the magnetic circuit is determined for one turn ($w_1$ = 1) from the following formula:

$$S_m \left( m^2 \right) = U_{m1}(\mathrm{V}) \Big/ 2\pi f (\mathrm{kHz}) B_m (\mathrm{T}). \qquad (2)$$

To ensure sufficiently small losses in a tubular loop, it is necessary that the diameter of the tube be large enough and the ohmic resistance $R_{\sim}$ at the operating frequency $f$ be small enough. This resistance depends on the depth of the skin layer:

$$\lambda (m) = 1 \Big/ \sqrt{\pi f \mu_a / \rho}, \quad \lambda = 0.26\ \mathrm{mm} \quad (\text{copper},\ f = 66\ \mathrm{kHz}), \qquad (3a, b)$$

where $\mu_a = 4\pi \cdot 10^{-7}$ H/m is absolute magnetic constant, $\rho = 1.75 \cdot 10^{-8}$ Ohm·m is the specific resistance of copper.

For small diameter copper wire $d_0 \le \lambda$

$$R_{\sim} = K_{ad} \cdot R_{=}, \;\; R_{=} = \rho l_1 / S_1, \;\; K_{ad} \cong 1 + \left(w^2/15\right)\left(d_0/\lambda\right)^4, \qquad (4a, b)$$

where $R_{=}$ is DC resistance, $l_1$, $S_1$ are the length and the cross-sectional area of the wire in meters, $K_{ad}$ is the coefficient of resistance increase $R_{=}$ due to the skin effect, $w$ is the number of turns of the winding.

The thickness of the copper tube forming the turn, practically for design reasons (mechanical strength) at high frequencies is significantly greater than the skin layer equal to, for example, 0.26 mm (see formula 3b). In this case, the equivalent thickness of the tube, determining its conductivity, can be considered approximately equal to the skin layer depth λ in accordance with formulas (3a, b). We obtain the tube diameter $d$ equal to

$$d(\text{mm}) = S\left(\text{mm}^2\right) \Big/ \pi\lambda(\text{mm}) = I_{m1}(A) \Big/ \sigma\left(\frac{A}{\text{mm}^2}\right) \cdot \pi\lambda(\text{mm}), \qquad (5)$$

where the current density $\sigma = (5–10)(\text{A/mm}^2)$ is taken to be several times greater than when calculating a conventional transformer, since the cooling of the tube turn in the presence of air gaps with ferrite and the second turn is significantly better than with a multi-turn winding. In addition, the mass of the tube is increased due to part of the thickness lying outside the skin layer. For a wire turn in the form of a bundle of litz wire placed inside the tube, formula (5) is also valid at $\sigma = (1...2)\ \text{A/mm}^2$.

The assembly of single-turn transformers is as follows. If we proceed from classical single-turn transformers (one turn in the primary and secondary windings), then with their help it is possible to realize transformation coefficients characterized by an integer number of times. That is 1:$n$ ($n$ = 1, 2, 3, 4, etc.), then n transformers are required for this (or 2$n$, as in Fig. 3). Other combinations are also possible, for example 2:3 (six transformers), 3:4 (twelve transformers) etc. By selecting a transformation ratio close to the required (calculated) one, the output power can be brought to the required value using the control unit (if available).

If these options are unacceptable, then a non-classical transformer can be used, in which only one winding (primary or secondary) is implemented as a single turn in the form of a copper tube, and the other winding (windings) is located inside this tube. For convenience of winding turns, the tube can be cut along its internal diameter. In this case, the current through the joint of the tube halves will be practically absent, since the lines of the electric field and the tube current run along it, and not in the transverse direction. In this case, $U$-shaped ferrites should be used, covering the copper tube in pairs.

This method provides great opportunities for varying the transformation coefficient and the number of windings. At the same time, the advantages of single-turn transformers are basically preserved – a very high winding coupling coefficient, the magnetic litz wire effect (due to the number of connected transformers) and the principle of mechanical fastening of the copper tube (turn) to the strip lines connecting to the generator and load.

**Calculation example**

In all cases, it is convenient to calculate a single-turn transformer based on a winding realized by a copper tube. As an example, we will calculate a set of transformers in a single-turn version for a power of $P_l$ = 60 kW, a frequency of $f$ = 66 kHz, an input voltage amplitude of $U_{m1}$ = 500 V and a transformation coefficient of $n$ = 0.5. Therefore, one of the two pairs of transformers shown in Fig. 4 can be used, with a series connection of the primary and parallel connection of the secondary windings. In this case, on any turn of each of the transformers, the voltage amplitude is $U_{m1}$ = 250 B, the power is 0.5 $P_l$ = 30 kW and current $I_{m1} = P_l/U_{m1}$ = 240 A.

The outer diameter of a copper tube implementing a turn at $\sigma = 8$ A/mm², $\lambda = 0.26$ mm according to formula (5) will be equal to:

$$d = \frac{240A}{8\left(\frac{A}{\text{mm}^2}\right)\cdot\pi\cdot 0.26\ \text{mm}} = 34\ \text{mm}.$$

For reasons of mechanical strength of the transformer, the thickness of the tube wall can be taken equal to 1–2 mm (many times greater than $\lambda = 0.26$ mm) and the internal diameter is no less than 30 mm.

The cross-sectional area $S$ and the diameter $d_0$ of the second turn – the litz wire bundle will be calculated according to (5) at $\sigma = 1$ A/mm² at

$$S = \frac{240A}{1\text{A}/\text{mm}^2} = 240\ \text{mm}^2,\quad d_0 = \sqrt{\frac{960\ \text{mm}^2}{\pi}} = 17.5.$$

A bundle with such a cross-section, taking into account the laying of internal cores and insulation, can be placed inside a tube with an internal diameter of 30 mm. Ferrite rings with external and internal diameters $D_2 = 65$ mm and $D_1 = 40$ mm are suitable for forming a magnetic circuit. The cross-sectional area of the magnetic circuit at $B_m = 0.1$ T according to expression (2)

$$S_\text{m}\left(\text{m}^2\right) = \frac{Um1(\text{V})}{2\pi f(\text{Hz})B_\text{m}(T)} = \frac{250\text{V}}{2\pi\cdot 66\cdot 10^3\,\text{Hz}\cdot 0.1\text{T}} = 6\cdot 10^{-3}\,\text{m}^2.$$

The height $h$ of the ferrite cylinder (Fig. 1) will be equal to

$$h = \frac{S_\text{m}}{D_2 - D_1} = \frac{6\cdot 10^{-3}\,\text{m}^2}{25\cdot 10^{-3}\,\text{m}} = 0.24\ \text{m} = 24\ \text{cm}.$$

Ferrite volume of one transformer

$$V_\text{m} = \left(\frac{\pi D_2^2}{4} - \frac{\pi D_1^2}{4}\right)\cdot 2h = 990\ \text{cm}^3.$$

The volume of ferrite for the entire set (two transformers) will be 1980 cm², which, according to estimates, exceeds the optimal (minimum) volume, since in this case the optimality conditions are not met. This is the price for the design advantages of single-turn transformers.

The inductance of the winding (turn-tube) at $w_1 = 1$, $\mu = 2000$ will be equal to

$$L_1 = \mu_\text{a}\mu\frac{S_\text{m}}{l_\text{m}} = 4\pi\cdot 10^{-7}\cdot 2\cdot 10^3\,\frac{6\cdot 10^{-3}}{0.5(65-40)\cdot 10^{-3}\,\pi} = 384\ \mu\text{H}$$

per set (2 transformers) $2L_1 = 768$ μH. We will get the calculated value of the resistance of the tube turn

$$R_1 = \rho\frac{l_1}{S_1} = \rho\frac{2(h + D_2)}{\pi d\lambda} = 1.75\cdot 10^{-8}\,\frac{0.24 + 0.065}{\pi\cdot 0.034\cdot 0.26\cdot 10^{-3}} = 1.2\cdot 10^{-3}\ \text{Ohm}.$$

Losses in a single transformer tube turn are

$$P_{s.c.1} = \frac{1}{2} I_{m1}^2 R_1 = \frac{1}{2} \cdot 240^2 \cdot 1.2 \cdot 10^{-3} = 34.5 \text{ W}.$$

These losses are about 0.1% of the power of one transformer (30 kW), therefore they are significant only from the point of view of the transformer quality. However, since the turn is made in the form of a sufficiently massive copper tube, open for cooling, the heating factor is also insignificant. This opens the possibility of making the second turn of the transformer not as a litz wire bundle, but as a second *U*-shaped copper tube located concentrically inside the first tube. In this case, the first tube should be cut longitudinally along the diameter into two *U*-shaped halves, inside which the second tube with an insulating gap should be placed. After placement, the joint of the *U*-shaped halves can be soldered, but there should be no significant currents in the joint, since the current lines run along the tube.

In the case under consideration, the transformation coefficient was 1:0.5, which made it possible to use only two single-turn transformers. For other transformation ratios, the number of transformers may be larger. It is important that with an increase in the number of single-turn transformers, their total volume and weight or losses decrease if the operating frequency is high enough and the wall thickness of the tube-turn is significantly greater than the skin layer. This is explained by the fact that with the skin layer thickness remaining unchanged, the equivalent conductive cross-section of the copper tube decreases proportionally to its diameter, while the volume and weight of copper (and ferrite) decreases proportionally to the square of the tube (ferrite ring) diameter.

Thus, when using $N$ single-turn transformers, an $N$-fold gain in the volume and weight of the ferrite and copper tube is achieved. However, this gain is not always convenient to implement due to design considerations. For example, the calculated set of two transformers could be implemented according to the circuit shown in Fig. 4, i.e., from four transformers. In this case, the height of the transformers $h$ would increase from 24 cm to 48 cm, the outer diameter $D_2$ of the ferrite rings would decrease from 6.5 cm to 3.25 cm, and the diameter of the copper tube d – from 3 cm to 1.5 cm. Such a ratio of $h$, $D_2$ and $d$ is hardly convenient from a design standpoint, although it is fundamentally feasible.

Naturally, increasing the number of single-turn transformers (without changing their total power) makes sense only as long as the thickness of the copper tube-turn remains significantly greater than the thickness of the skin layer.

## Conclusion

The paper presents the substantiation and calculation of the proposed structure of the RF transformer for high-power switching generators of harmonic oscillations [7–8], based on the connection of single elements, i.e., single-turn transformers of the "cable" design. The presented calculations confirm that such a structure is optimal for most practical applications, since it is devoid of many of the disadvantages of the classical scheme of a high-power transformer with multi-turn windings. The proposed structure is part of a project to create a device based on *UBPM*-1 [9–10] with the possibility of using it in solar *MPPT DC/DC* converters, solar inverters, uninterruptible power supplies etc.

## REFERENCES

1. **Xin A., Zhang B., Zhu C., Huang L., Fang Z., Liu Y.** Design of a high-frequency irreversible electroporation bipolar pulse generator based on H-bridge inverter with an isolating transformer. *IEEE Transactions on Applied Superconductivity*, 2024, Vol. 34, No. 8, Art no. 9502605. DOI: 10.1109/TASC.2024.3441607

2. **Badrzadeh B., Gustavsen B.** High-frequency modeling and simulation of wind turbine transformer with doubly fed asynchronous generator. *IEEE Transactions on Power Delivery*, 2012, Vol. 27, No. 2, Pp. 746–756. DOI: 10.1109/TPWRD.2011.2181429

3. **Zlobin V.A., Andreev V.A., Zvorono Yu.S.** *Ferritovye materialy* [*Ferrite materials*]. Leningrad: Energiya, 1970.

4. **Korickij Yu.V., Pasynkov V.V., Tareeva B.M.** *Spravochnik po elektrotekhnicheskim materialam* [*Handbook of electrical engineering materials*]. Vol. 3. Leningrad: Energoatomizdat, 1988.

5. **Mihajlova M.M., Filippov V.V., Muslanov V.P.** *Magnitomyagkie ferrity dlya radioelektronnoj apparatury* [*Soft magnetic ferrites for electronic equipment*]. Moscow: Radio i svyaz', 1983.

6. **Kunevich A.V., Podol'skij A.V., Sidorov I.N.** *Ferrity, enciklopedicheskij spravochnik* [*Ferrites, encyclopedic reference*], in 5 vol. Vol. 1. St. Petersburg: LIK, 2004.

7. **Dmitrikov V.F., Shushpanov D.V.** On the issue of capacitively coupled circuits using to explain the mutual influence of wires. *Journal Radioengineering*, 2024, Vol. 88, No. 1, Pp. 15–30. DOI: 10.18127/j00338486-202401-03.

8. **Holmes D.G., Lipo T.A.** *Pulse width modulation for power converters: Principles and practice*. NY: Wiley-IEEE Press, 2003.

9. **Filin V.A., Golovin A.N., Smirnov V.S., Yurova V.A.** Circuit design solution and algorithm of digital control of processes for a universal bidirectional transistor module of switching mode voltage converter. *Journal Radioengineering*, 2024, Vol. 88, No. 6, Pp. 100–109. DOI: 10.18127/j00338486-202406-13

10. **Golovin A., Filin V.** Problems of construction of power stages of VLF transistors radio transmitters. *Actual Problems of Infotelecommunications in Science and Education*, 2023, Pp. 604–607.

## INFORMATION ABOUT AUTHORS / СВЕДЕНИЯ ОБ АВТОРАХ

**Vladimir A. Filin**
**Филин Владимир Алексеевич**
E-mail: filin_vladimir@mail.ru

**Khurshid A. Sattarov**
**Саттаров Хуршид Абдишукурович**
E-mail: s.xurshid@tuit.ru
ORCID: https://orcid.org/0000-0001-6942-0618

**Valentina A. Yurova**
**Юрова Валентина Александровна**
E-mail: va-yurova@mail.ru
ORCID: https://orcid.org/0000-0001-6317-8007

**Alexei N. Golovin**
**Головин Алексей Николаевич**
E-mail: cathseugut@yandex.ru

*Submitted: 30.04.2025; Approved: 14.07.2025; Accepted: 11.09.2025.*
*Поступила: 30.04.2025; Одобрена: 14.07.2025; Принята: 11.09.2025.*