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Quality rating of energy of power-supply system

Оценка качества энергии систем электроснабжения

Аннотация. В работе представлены способы оценки и повышения качества выходных параметров системы автономного электроснабжения использованием дополнительных электронных компонентов, снижающих уровень напряжения помех по шинам питания и нагрузки, а также с помощью предложенной методики измерения выходного импеданса (полного сопротивления) импульсного стабилизатора напряжения.

Abstract. This work presents methods for evaluation and improvement of output quality of an autonomous power supply system by using additional electronic components to reduce interference voltage on feeding and output buses and also by using the suggested method for measuring of input impedance of an switching voltage regulator.

Ключевые слова. Современные системы автономного электроснабжения, уровень помех, конденсатор, электромагнитная совместимость, импеданс

Keywords. Modern systems of autonomous power supply, level of hindrances, capacitor, electromagnetic compatibility, impedance

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Modern autonomous power supply systems (MAPSS) have to comply with requirements of size and weight, high efficiency and high electromagnetic compatibility with other electronics. Switching power converters (SPC) which are widely used as primary power supply units are adequate in terms of size and weight requirements and have high efficiency factors. However, excessive interference voltage both on feeding bus and the load bus [4], their main drawback, prevents them from fully complying with output quality requirements. Levels of conducted interference generated by main types of single-ended switching converters are discussed in detail in [1]. It is noted that asymmetric interference on power buses is not substantially dependent on the type of the converter and the measurement point (input or output circuits) but is dependent on the mounting method used and conversion frequency employed.

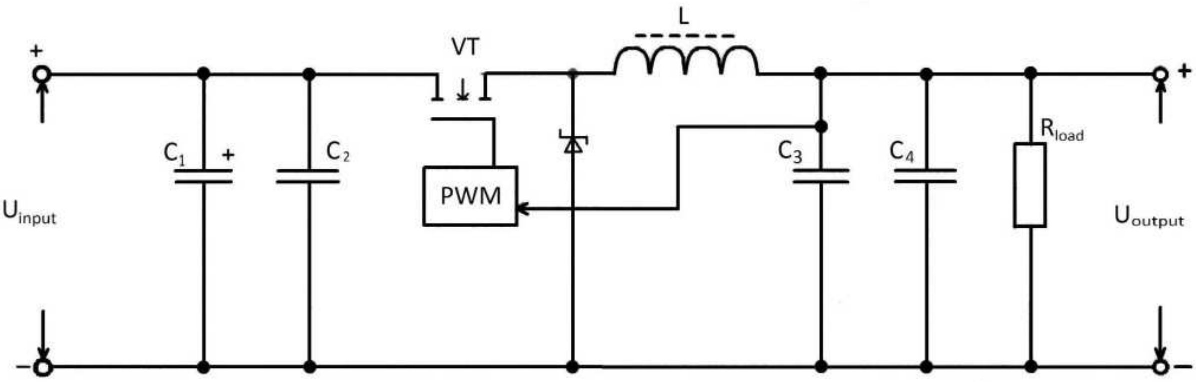

***Fig. 1.** Single-ended power converter, step-down type*

Fig. 1 shows a reducing SPC with conductive heat removal intended for building a MAPSS. Taking into account the results in [1, 3], the level of asymmetrical interference voltage in power buses can be considered elevated versus requirements of GOST R 51527-99. To reduce the level of such interference, an input C-filter and an output LC-filter have to be used, and a Schottky diode used as a bypass diode.

High frequency capacitors should be installed in parallel to large capacity electrolytic capacitors.

To reduce influence of SPC's electromagnetic field upon input and output circuits, the SPC is shielded with aluminum.

The measures taken reduce asymmetric interference voltage at the input and at the output of the SPC (Fig. 2), but it still exceeds the limit stated in GOST R 51527-99.

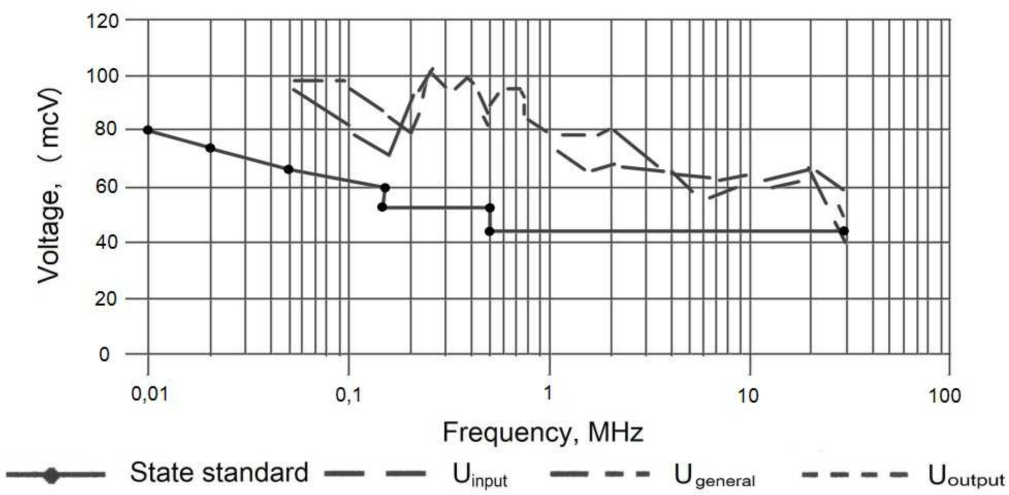

***Fig. 2.** Measured asymmetric interference voltage of SPC in original state*

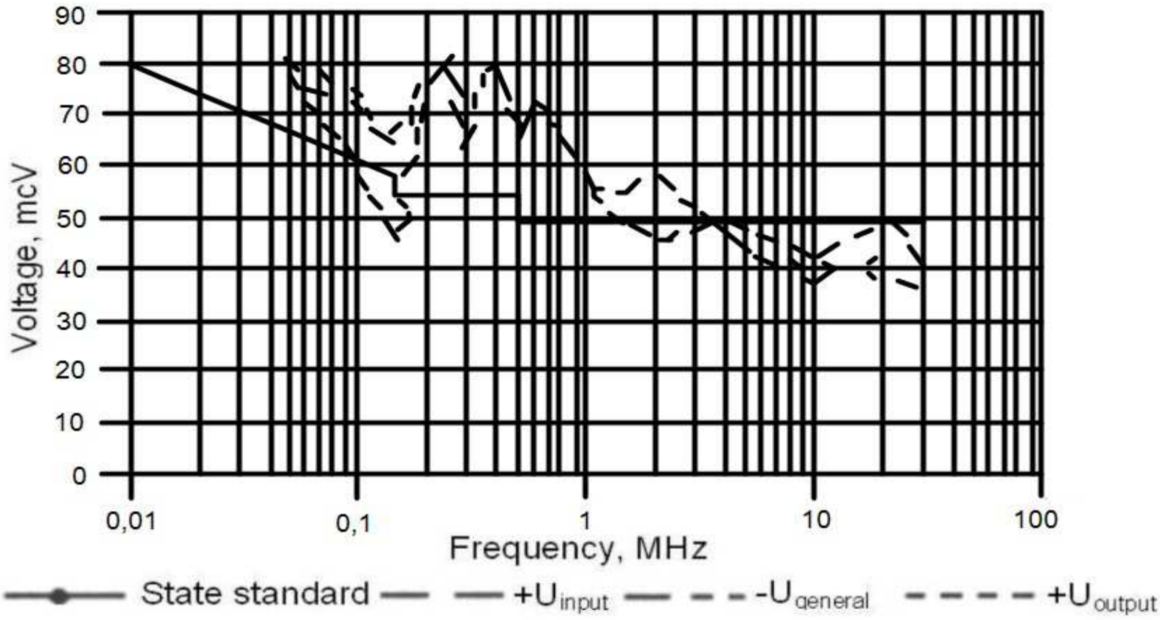

Fig. 3. *Measured asymmetric interference voltage of SPC in aluminum shield*

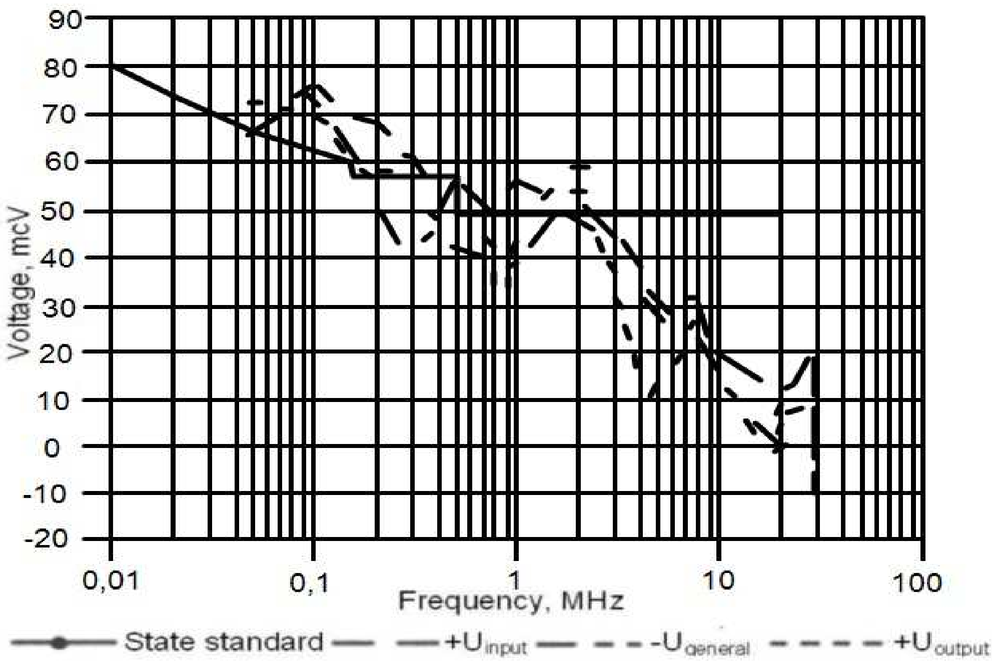

Fig. 4. *Asymmetric interference voltage of SPC in aluminum shield equipped with pass-through capacitor*

In order to achieve further reduction in interference levels, it is advisable to use OKP (ОКП) type 0.047 μF, 125 V pass-through capacitors as output power leads of the converter. This way, the level of asymmetric interference voltage could be significantly reduced (Fig. 4).

Interference levels within the requirement of the GOST are achieved through multi-phase connection of converters in autonomous power supply systems [2].

Besides reduction of interference voltage, measurement of output impedance of switching voltage regulators is important in order to improve output quality in terms of electromagnetic compatibility of autonomous power supply systems.

Switching voltage regulators (SVR) included into an autonomous power supply system usually have a branched network of loads of different purpose. To ensure internal electromagnetic compatibility, the SVR should have specific output impedance according to the technical assignment. Impedance that is too high in some frequency ranges can lead to resonance in the common feeding bus and a fault in operation of the overall system. SVR’s output impedance is therefore an important technical characteristic.

Methods for measuring impedance involve specialized instruments. In this case, the device being measured is considered as a passive two-terminal device. Normally, an SVR includes a regulator which acts as an active filter in the frequency range from zero to hundreds of Hz. Besides that, a passive wideband output filter is used that has a significant inductive component in the upper part of the frequency range. Based on the above considerations, SVR as a whole cannot be viewed as a two-terminal device.

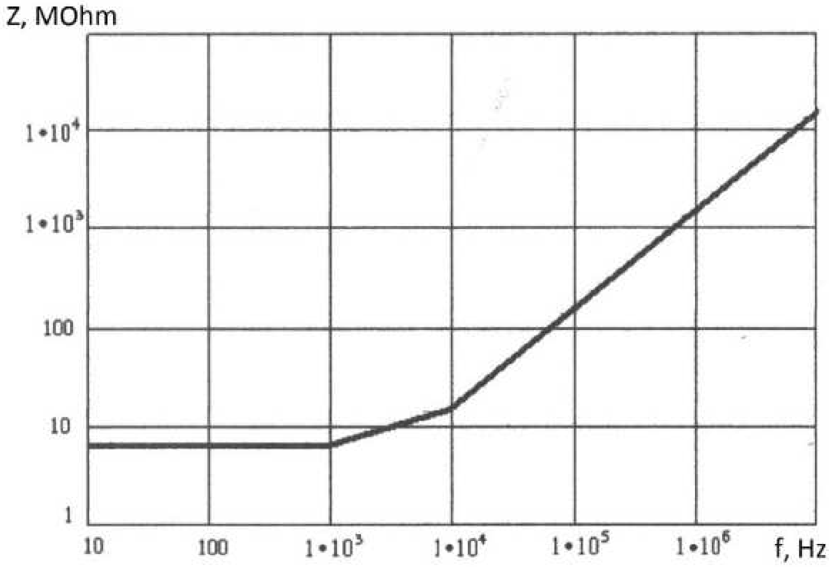

Fig. 5. *Output impedance of a switching voltage regulator*

Fig. 5 shows a typical dependence of complex output impedance for DC voltage converters.

Up to 1 kHz the impedance is determined by operation of the regulating component within the SVR, in the range of 1 to 10 kHz, by the properties of the output filter. Above 10 kHz, parasitic parameters of filter elements become significant.

A method exists for measuring the output impedance of DC converters in the frequency range of 0.009 to 30 MHz. However, there is no method for impedance measurement in the low frequency range.

The objective of the next part of this work is to develop and experimentally validate a method for impedance measurement in the frequency range from a few Hz to a hundred MHz.

Modern instrumentation was used to complete the task: a Tektronix TDS3012B dual-channel oscilloscope, a TCP303 current meter, and a TCPA300 amplifier.

Fig. 6 shows the setup for measuring impedance. TCP303 current meter together with TCPA300 amplifier provide for measuring currents up to 30 A in the range of 0 to 100 MHz.

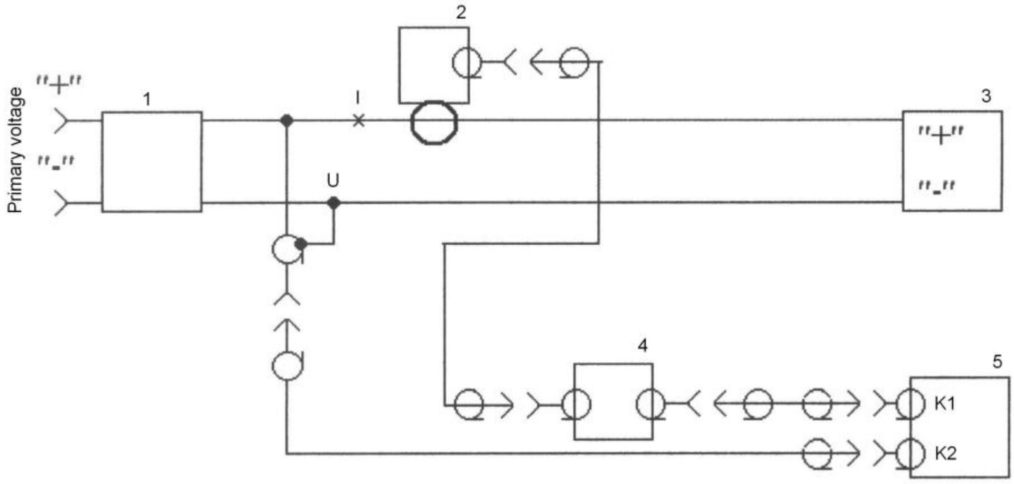

Fig. 6. *Setup for measuring impedance: 1 – SVR under test, 2 – TCP303 current meter, 3 - controlled load, 4 - TCPA303 amplifier, 5 - Tektronix TDS3012B oscilloscope (K1, K2 are channel inputs), U – measured voltage, I – measured current.*

Sine-wave current *I*is created by the controlled load. Voltage ripple U at the output of the converter under test is measured with the oscilloscope.

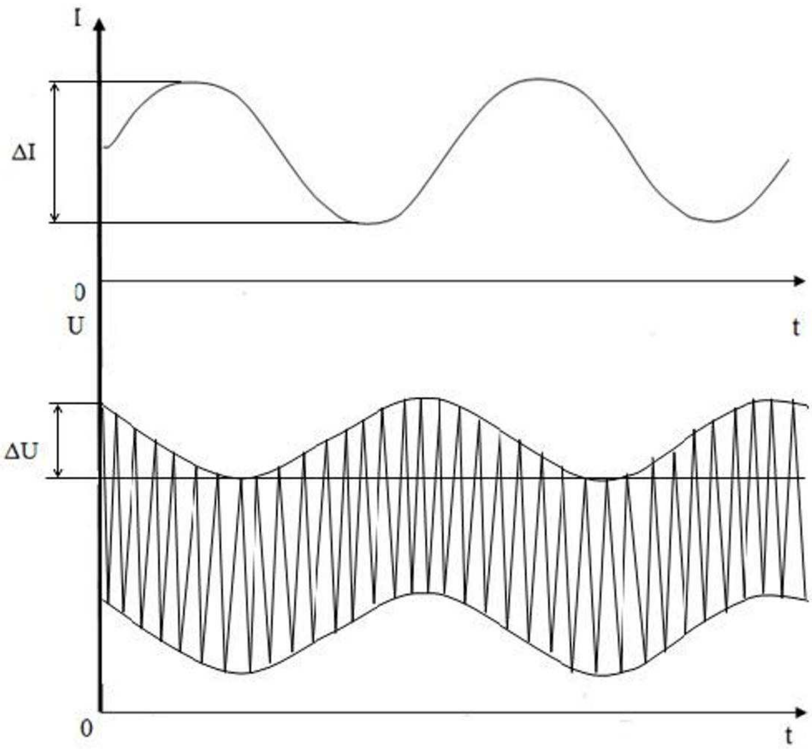

Fig. 7. *Calculation of impedance using cursors*

Fig. 7 shows oscillograms for current and voltage measured simultaneously. Oscilloscope input K2 and amplifier input have an AC coupling. When the frequency changes, phase shift between voltage and current changes as well, as does the ratio of ripple at the frequency at which impedance is measured.

Impedance modulus $|Z_{OUT}|$ at a given frequency is calculated from Ohm's law: $|Z_{ВЫХ}| = \Delta U/\Delta I$, where ΔU is voltage ripple, volts; ΔI – current ripples, amperes.

Output voltage ripple at switching frequency, shown in the figure as high-frequency fill, is not taken into account.

The suggested method therefore makes it possible to measure output impedance of an SVR in the frequency range from a few Hz to a hundred MHz at sine-wave current reaching 30 A in the load circuit. The accuracy of measurement using cursors for the specified type of oscilloscope is within 3%, which is adequate for engineering purposes.

As a summary, combined use of a modified switching power converter and the suggested method for measuring output impedance of a switching voltage regulator make it possible to reliably assess and improve quality of output of autonomous power supply systems [5].

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