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A STABILIZED FEED BLOCK WITH IMPROVED QUALITY INDICATORS

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Summary: *The main advantage of pulse-type voltage stabilizers is considered to be a high useful duty ratio, and such stabilizers allow both reducing and increasing the input voltage. This makes it possible to expand their application range. In order to achieve high operating parameters of radio stations or satellite communication systems, development of telecommunications equipment feeding systems is one of the important issues. In the article, the classic series connection of pulse voltage and compensated LDO-type voltage stabilizers is analyzed, a scheme with further improved quality indicators is proposed, where the high useful efficiency of the feeding circuit is ensured by the application of a pulse stabilizer (DC/DC converter). At the same time, thanks to the application of the LDO stabilizer, it allows to reduce the level of noise and distortions.*

Key words: *voltage stabilizers, noise level, distortion level, differential amplifier, reference voltage source*

INTRODUCTION

In the development of information collection and processing systems, highly flexible measurement devices and information converters play an exceptional role. As is known, information converters are used as a link between the analog and digital parts of the system. Such devices determine the maximum speed of entering information into the system, and finally, the productivity of the measurements made.

EXPOSITION

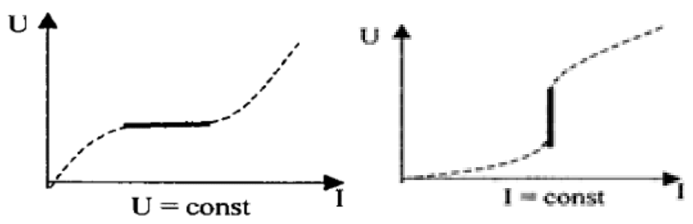
The main directions of development in modern electronics are related to the element base, first of all, the creation and application of new integrated microcircuits. Impulse-type food sources also have a certain influence in fulfilling the requirements of the mentioned systems. Although the fields of application are diverse, several areas where high demands are placed on operational flexibility can be mentioned:

- initial processing of short-term signals, including amplification, discrimination and pulse counting blocks;

- measuring the time intervals between the occurred processes in nano and picoseconds and ensuring their selectivity by time;
- devices for generating pulses with a duration of nano and picoseconds.

The first direction indicated is related to the processing of continuous or pulsed pulse streams. The second direction is mostly found in atomic physics research. The last direction refers to nanosecond electronics with different power and duration. Low-power pulses are usually used for metrological purposes, while high-power short-duration pulses are used to generate electric and magnetic fields, and to operate semiconductor lasers and other pulsed radiation sources. In solving such issues, special requirements are placed on quality indicators, operational stability and stability of pulse power sources, including pulse voltage stabilizers. It is known that voltage stabilizers belong to the group of important blocks of telecommunications devices. Compensated and pulse stabilizers are widely used for stabilizing constant voltage. Each of these types of stabilizers has its advantages and disadvantages, but their joint application allows to establish a supply voltage with the required useful duty factor, as well as a low-cost pulse level and an acceptable noise level (Patel, & Knoth, 2017).

In general, voltage stabilizers used inside food sources can be divided into two groups - parametric and compensated stabilizers. Parametric stabilizers are built on the basis of non-linear elements (stabilitrons, varistors, etc.) that change their parameters under the influence of destabilizing factors (Fig. 1).



a) b)

Figure 1. Volt-Ampere characteristics of nonlinear elements: a – voltage stabilizer; b – current stabilizer

Since compensated stabilizers have voltage feedback, they can significantly reduce their output resistance and keep the output voltage stable. Figure 2 shows the functional scheme of the construction of the compensated stabilizer.

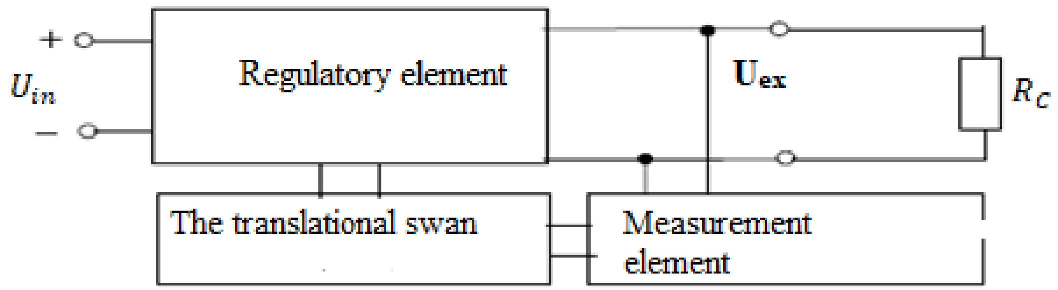


Figure 2. Functional scheme of the compensated stabilizer

The principle of operation of the compensated stabilizer is as follows: inside the measuring element in its circuit, the output voltage is compared with the reference voltage, and a difference signal (mismatch signal) is formed. The difference signal is amplified in the converter unit and becomes a control signal for the control element. Under the influence of this control signal, the internal state of the regulatory element changes so that the output voltage is kept equal to the reference voltage, i.e., a state of equilibrium is established (Fwu, Paxton, Torres, & Sellers, 2018).

The structural scheme of compensated stabilizers is given in figure 3.

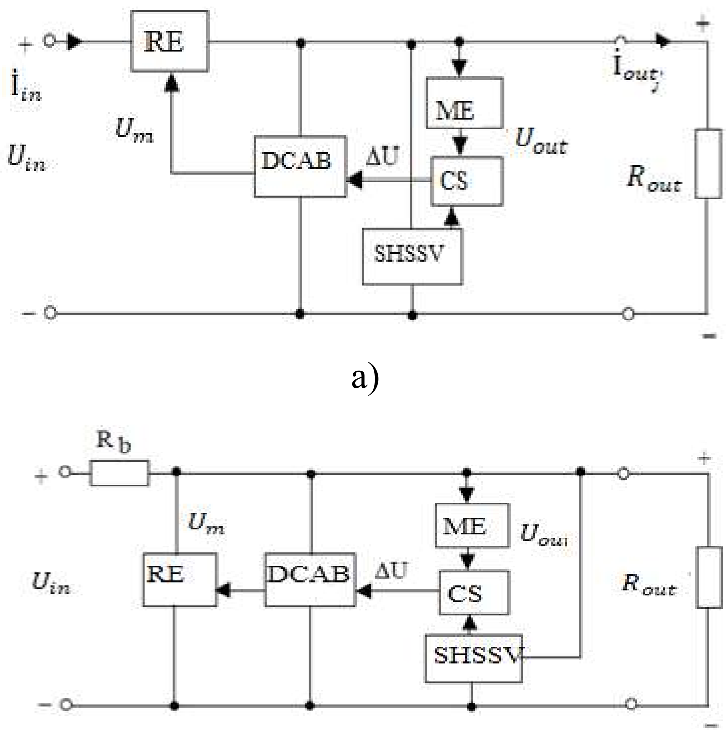


Figure 3. Structural diagram of compensated stabilizers: a) consecutive; b) parallel

Stabilizers with a parallel circuit have a small useful duty factor and such circuits are not widely used. Voltage stabilizers with a series circuit are used to stabilize high-value voltages and currents from variable resistance stabilizer circuits. However, in order to protect the given device from short circuits of the output circuit, it is necessary to select the transistor by satisfying the condition UKE > U_{in}.

ME – in the structural scheme is a regulatory element; DCAB – DC amplifier unit, ME – measuring element; SHSSV – source of high-stability support voltage; CS – comparison scheme; R_{out} – load resistance used at the output; R_b is the ballast resistance that is additionally connected to the circuit. The main task of the CS comparison circuit is to determine the difference of the voltage received at the output from the given Uday – stable reference voltage value and to transfer it to the DC amplifier block in the feedback circuit. This circuit can be built on one or more transistors, or even using connected transistors. In voltage stabilizer devices, it is coordinated with a matched signal amplifier and a reference voltage source. As a measuring element, in most cases, a resistive voltage divider with a simple circuit and connected to the output of the stabilizing device can be used. The main requirement for the size element is that the value of the division coefficient should not change. A variable or adjustable resistor can also be connected to the measuring element circuit, in which case it is possible to change the output voltage over a certain interval. In conventional stabilizer units, the measuring element must be aligned with the DCAB block. It is advisable to apply the differential DCAB scheme in order to increase the stabilization coefficient and reduce the error caused by the temperature change and the variation of the parameters of the elements (Texas Instruments, 2006).

It is possible to use one or more transistors connected according to the Darlington pair scheme as a regulating element, in which case a large input resistance is provided. The value of the current gain of the regulator depends on the required load current and power of the DCAB unit. In cases where the value of the load current is greater than 300-500 mA, the regulating element is installed on the transistor in the circuit through a radiator so that the required heating mode is provided. The geometric parameters of the radiator are determined based on the dispersion power of the regulating element and the condition of heat exchange between the radiator and the environment.

The biggest advantage of pulse-type voltage stabilizers (DC/DC converters) is that a high efficiency can be achieved, and such stabilizers allow both decreasing and increasing the input voltage, that is, adjusting it over a wide range, as well as taking a negative voltage from a positive input voltage. The main disadvantage of impulse stabilizers is the high level of barriers at its output. In addition, pulse stabilizers mainly use inductive elements.

Figure 4 shows the scheme of the pulse stabilizer of the galvanic power source with an integrated microcircuit and increasing the voltage value to +5 Volts.

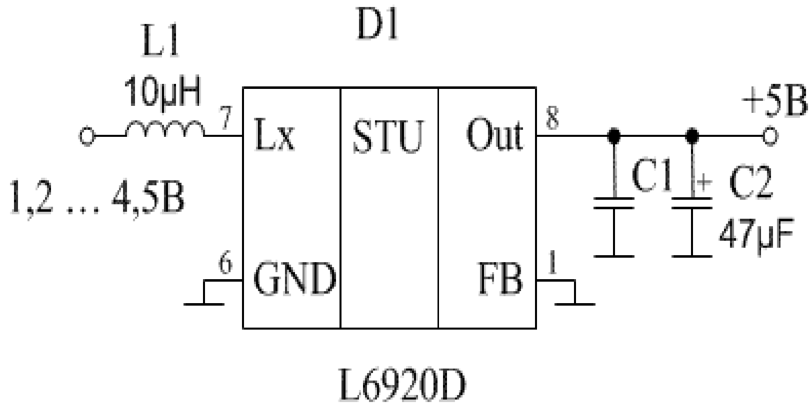


Figure 4. Scheme of the boost pulse stabilizer

Compensation-type stabilizers have fairly low impedance and low noise levels. But these stabilizers have a small useful duty factor, because the current at the input and output of this type of stabilizers is practically the same. The power of the regulating element of these stabilizers is dissipated in the form of heat, which means that the energy loss increases, and a very small voltage drop is required for the correct operation of such a stabilizer. In this sense, the difference between the voltages at the input of the 7805 or 142EH5 chip and its output should be more than 2.5 Volts.

For this purpose, LDO type voltage stabilizers with small voltage drop were created. These stabilizers allow the required voltage to be obtained without problems from a relatively higher initial voltage. Nowadays, it is impossible to imagine the operation of GPS receivers, smartphones, radio stations or satellite communication systems without LDO stabilizers, because in order to achieve high operating parameters of radio frequency amplifiers (LNA), support generators, frequency synthesizers or mixers, a serious approach is required in the development of power systems of telecommunication devices. Figure 5 shows a classic series connection of a pulse voltage stabilizer and a compensated LDO voltage stabilizer. When such stabilizers are connected, the high efficiency of the power supply circuit is ensured by the use of a pulse stabilizer (DC/DC converter), and the LDO stabilizer allows to reduce the level of noise and distortions. A compensating voltage stabilizer with a small voltage drop can be made either in metal-oxide-semiconductor (MOY) type field transistors or when using a bipolar transistor connected according to a common emitter circuit (Meleshko, 2007).

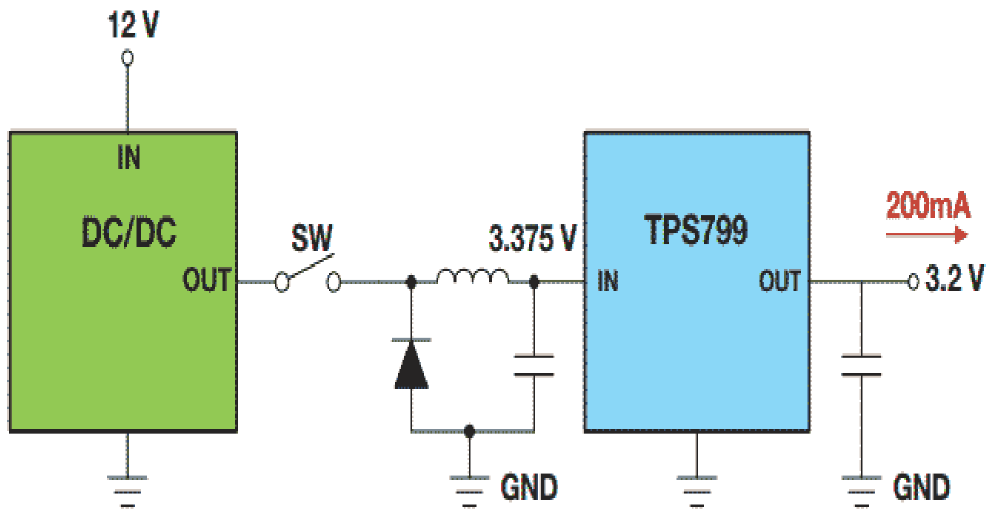


Figure 5. Series connection scheme of pulse and LDO-type voltage stabilizers

The scheme of the LDO stabilizer with the regulating metal-oksid-yarımkeçirici field transistor is given in Figure 6.

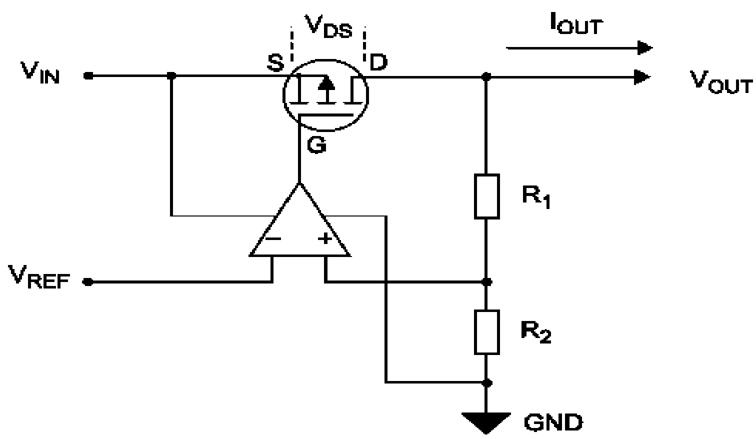


Figure 6. Schematic of an LDO-type stabilizer with a regulating or metal-oxide-semiconductor transistor

Figure 7 shows the diagram of the LT3045 compensating stabilizer of the Analog Devices company as an example of an LDO stabilizer made in a bipolar transistor. In this circuit, a voltage drop occurs between the collector and the emitter of the transistor. This voltage is rarely greater than 0.2 Volts. In stabilizers of the 7805 type, the voltage drop in the two emitter junctions and the output stage of the differential amplifier is determined, which is approximately 2 Volts. Note that in this scheme, the reference voltage source describes the resistance supplied with a current of 100 μA from the output of the current stabilizer. This allows to get rid of the noise generated during the piercing of the p-n junction of the stabilitron. In addition, such a solution allows reducing the current consumption of the voltage source (Savenko, 2006, p. 18).

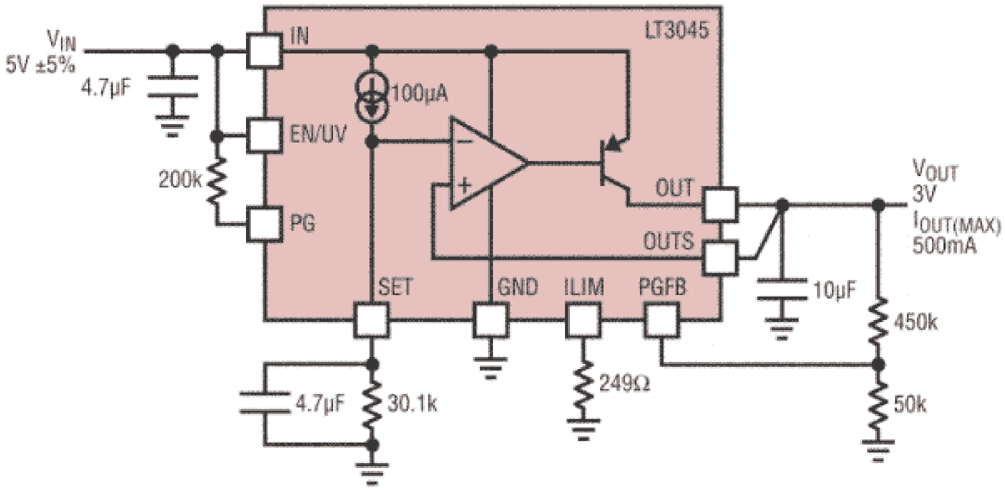


Figure 7. Scheme of LDO-type stabilizer with regulating bipolar transistor

Since LDO stabilizers are surrounded by negative feedback, during their application, a ceramic capacitor with a small equivalent resistance and inductance with a large capacity should be applied at the output to ensure the stability of the device in a wide frequency range. Figure 8 shows the frequency dependence of the pulse coefficient for the LT3045 microcircuit as an example (Volovich, 2006, p. 10).

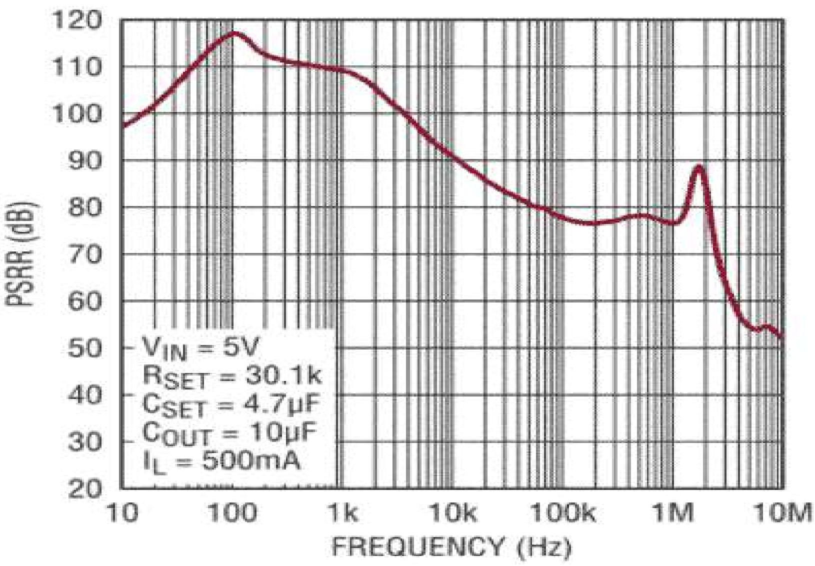


Figure 8. Graphs of the pulse attenuation coefficient at the output of the LDO-type stabilizer

CONCLUSION

From the analysis of the graphs of the ripple attenuation coefficient at the output of the LDO-type stabilizer, it can be seen that the ripple coefficient (dB) indicator for microcircuits of the LT3045 type has its maximum value when the frequency value is about 100 Hs. Due to subsequent increases in frequency, this quantity is observed to decrease. This process can occur due to the inter-cascade capacitances, as well as the mounting capacitance, which were used during the design of the basic circuit of the microcircuit. The value of this coefficient is within acceptable limits when the proposed power source is used for mains frequency devices. During the application of systems with operating frequency above 10 MHs, the value of knock coefficient (dB) drops below 50 dB, which can be evaluated as deviations from the permissible limits (Ugryumov, 2000).

In order to improve the quality indicators required by the series connection scheme of the proposed pulse and LDO-type voltage stabilizers in a wide range, it is possible to additionally apply the specified circuit variants of the circuit of the LDO-type stabilizer with the regulating metal-oxide-semiconductor transistor and the LDO-type stabilizer with the regulating bipolar transistor.

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