"Electronic Throttle"

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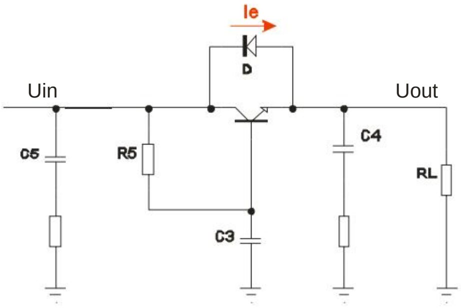
The article discusses the features of the electronic power filter and the possibility ness of its use in sound-reproducing equipment.

The motive for writing this short article, on the one hand, was the uncompromising wars on the network on this topic, and on the other hand, repeated private explanations to readers site. When the number of these clarifications exceeded a reasonable level, I decided to issue them in the form of one hundred ty and put an end to this issue.

In general, this article is not aimed at specialists in the field of electronics, but at amateurs. I I will try as simply as possible, without delving into mathematical jungle, to show the features of the electronic filter. And also to draw the attention of readers to typical errors in its use.

The most commonly used and repeatedly described in the literature filter circuit with a load which in the emitter circuit is shown in Figure 1.



Picture 1

In fact, the circuit can be considered as the simplest tracking stabilizer. The function of the reference voltage is performed by the voltage across the capacitance C3, since the rate of change of the capacitance voltage is determined by the time constant of the RC filter (R5, C3), which is chosen much more network period. And the transistor works as a regulating and comparing element. In general, it is quite obvious that the level of pulsations at the base is determined by the parameters of the same filter, and, to a large extent, the level of these ripples determines the level of ripple of the output voltage. Also, the parameters of the used transistor [1] affect the ripple suppression coefficient. I want to draw the attention of readers that the value of the output capacitance C4 has little effect on the ripple level, since the emitter follower has a low output resistance. The choice of the value of the resistor R5 in such a circuit cannot be arbitrary, since its value is set by the necessary current of the transistor base at a given load. Maximum

the value of R5 makes it difficult to obtain a small level of ripples on the capacitance C3. In fact, the decrease ripple level requires an increase in capacitance C3 or the use of a multi-section filter, which complicates the circuit. The voltage drop across the resistor R5 due to the current flow of the base of the transistor leads to the fact that the voltage across the capacitor C3 is noticeably lower than the input voltage, which directly affects the filter efficiency. From all these considerations, it can be concluded that one of the negative factors that worsen the filter parameters is the presence of the base current.

It may seem that a simple mechanical replacement of a bipolar transistor with a MOSFET with sufficiently large steepness allows to solve many problems. No gate current It seems that it allows you to significantly increase the resistor R5, reduce C3 and get a higher ripple suppression coefficient by reducing the ripple in the gate circuit.

Unfortunately, many people do this (Figure 2), and this is just a disaster. Scheme ceases work normally - the ripple suppression coefficient drops significantly and the filter, along the way, becomes a broadband noise generator.

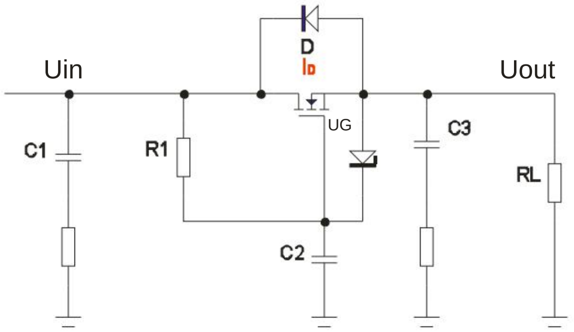


Figure 2

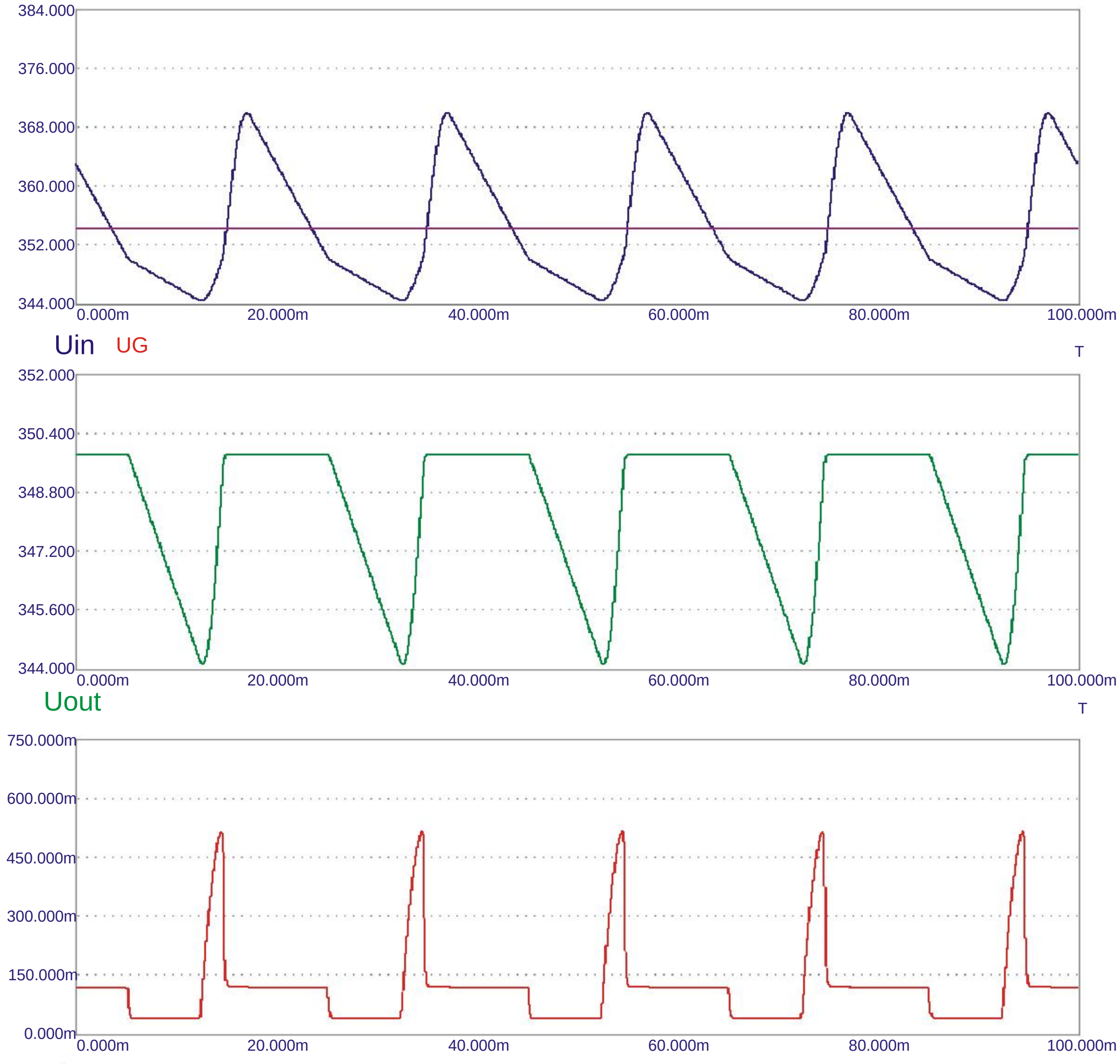


Figure 3

Why this happens can be clearly seen from the graphs shown in Figure 3.

Since the gate current of the transistor is close to zero, the gate voltage becomes close to the average unrectified value of the input voltage. The average voltage at the filter output will be less than the input approximately by the value of the threshold voltage of the transistor. As long as the voltage at the input of the filter exceeds the output, the filter operates normally. As soon as the input voltage drops below the output voltage, the output capacitance begins to drop, and the gate voltage remains almost constant. As the voltage increases
drain gate (rises), the transistor leaves the linear mode and turns into a switch. Both capacitances are connected to the rectifier. The voltage across the output capacitance continues to drop. When on

the input voltage begins to increase, through the low resistance of the open transistor, a fast charge of both capacitances begins (which gives a current surge). As the voltage across the output capacitance rises, the transistor exits the switching mode and goes into the linear mode.

What we have as a result: an increased level of ripples at the filter output, significant pulsed currents in its circuits, jumps in the internal resistance of the filter, and modulation of the equivalent capacitance in time with the ripples. Such a situation will inevitably arise, but the degree of increase in ripples and the amplitude of peak currents can vary greatly depending on the value and the ratio of capacitances, the reduced resistance of the rectifier, the parameters of the transistor. By the way, a similar situation can also arise when using bipolar transistors (for example, composite) with a very high current transfer coefficient.

To avoid such an abnormal behavior, it is necessary to ensure that the output the voltage will always be less than the input by the amount of ripple (when using powerful bipolar transistors, most often this is obtained automatically). In the simplest case, it is sufficient to introduce another resistor into the circuit (the switching options are shown by the dotted line), which forms

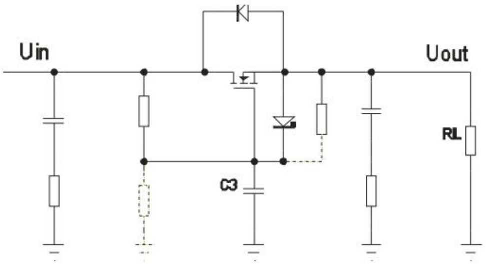


Рисунок 4

gate in the gate circuit (Figure 4). In principle, this is quite a predictable requirement, since the filter is an active device, and for its operation in a linear mode, it is necessary to have some voltage reserve for regulation. Of course, the introduction of an additional resistor slightly worsens the filtering properties, but there are enough methods to compensate for this. The divider can be made sufficiently high-resistance, but one should not forget about the presence of leakage currents in gate circuit and protective zener diode. The divider current must exceed the total leakage current (at maximum operating temperature), at least an order of magnitude.

A separate issue is the choice of the difference between the input and output voltage. In addition to the obvious components: ripple level (at maximum load current) and threshold voltage transistor, two more components must be taken into account - short-term network instability (about this is often forgotten, and completely in vain) and the voltage drop at the rectifier output when the load current changes (in particular, the magnitude of the signal current). Accurate accounting of all components is quite cumbersome, but in most practical cases it is sufficient to provide a difference between input and output voltage of 20÷25 volts.

Still, it must be remembered that the mechanism of operation of the electronic filter and the LC filter with completely different, they have different rigidity of output characteristics and different response to air disturbance, both from the load side and from the network side.

The rigidity of the electronic filter is higher, both due to the absence of active resistance to inductor losses, and because the output energy can be quickly obtained both from the rectifier filter capacitance and directly from the network. When the current consumption fluctuates, the occurrence of an oscillatory process in the source is excluded. The positive properties of the filter include and the fact that its efficiency drops little when filtering the 50 hertz component in the rectifier voltage (occurs as a result of a slight asymmetry in the rectifier and the network itself).

The level of the noise component in the output voltage of the electronic filter is higher than with LC filter, the spectrum of the noise component is wider. Short-term transition to the mode is possible "hiccups" at large power surges, which is accompanied by a sharp increase the level of ripple and high-frequency noise in the output voltage. A rather important point is also the source circuits through which the signal current flows. In the LC filter, the signal current mainly flows precisely through the output capacitor (except for the lowest frequency region), and in the electronic filter, a significant part of the current will flow both through the capacitance circuit of the rectifier filter, and partially through the rectifier itself in a much wider frequency domain. In general, this is an undesirable factor.

In general, the use of an electronic filter *(correctly functioning)* is quite possible in circuits that consume a constant average current, and which are not subject to increased requirements for power supply noise (power amplifiers operating in class "A", preamplifiers with a small gain). It is undesirable to use it in circuits with significant fluctuations in the consumed current (for example, amplifiers operating in class "AB").

In conclusion, I want to note that the electronic filter is a half measure. The need to have the voltage pass on the regulating element negates its advantages in terms of efficiency, and the need for a cooler negates the advantages in terms of dimensions. A noticeable gain is obtained only in the mass. Indirect confirmation of this is the very rare use of such solutions in real devices. Since

active power components are introduced into the source, it is advisable to implement complete stabilizer. A slight increase in cost gives a qualitative jump in the parameters of the power supply system of the device.

Literature

1. Isakov Yu. A. et al., Fundamentals of industrial electronics. - K .: "Technique", 1976.
2. Power sources of radio-electronic equipment: Handbook - M .: "Radio and communication", 1986