POWERFUL DRIVER

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A diagram of a lamp driver with a large output voltage is given.

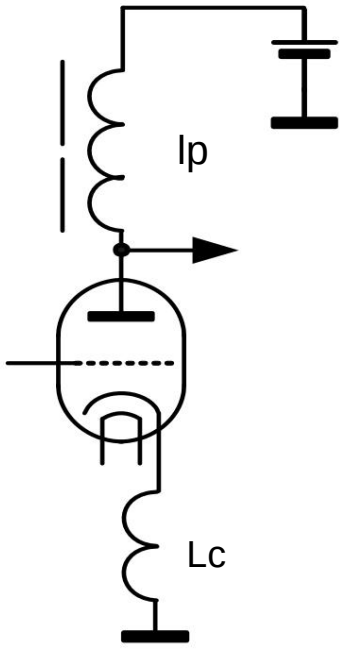
The impetus for the design of this circuit was the need to excite an output high-power triode in a single-ended amplifier. A certain limitation in the choice of driver scheme was
possibility of operation of the output lamp in the mode with grid currents. It should also be taken into account that to excite powerful triodes, a rather large output voltage range is required, reaching a value of 100–150 volts.

In such cases, a driver with a transformer output is traditionally used. by the most
its main advantage is the simplicity of the circuit, and the main disadvantage is the presence of an output
transformer. So and so trying this scheme to the task, I came to the conclusion that it would not be possible to solve the problem with a blow to the forehead. There were significant conflicts between the
parameters for linearity and frequency properties and technical feasibility of implementation
transformer. Here
it should be taken into account that the transformer is actually not a matching one, and in terms of electromagnetic modes it is closer to the output one with all the ensuing consequences.

I wanted to get a driver stage that would retain the main properties of the transformer stage - the presence of amplification and low output DC resistance, but the output transformer would be technically feasible.

I decided to go the unconventional route, and the choke output stage was taken as the basis. First of all, he attracted me by the fact that there is only one winding on the core. Accordingly, this makes it possible, with the same dimensions of the core, to significantly increase the magnetization inductance and shift the frequency range down. Or reduce the dimensions of the transformer and its
parasitic parameters and, accordingly, shift the frequency range up. Of course, you can take a compromise. In the general case, the gain of such a cascade for a single-stage
driver is not enough (to get an acceptable sensitivity of the entire amplifier), and for
two-stage circuit - it is already redundant.

Since we already have a winding assembly, then nothing prevents us from making a two-winding inductor and introducing cathode coupling into the cascade (Fig. 1). With this we kill three birds with one stone - we get the desired gain, increase the linearity of the cascade, reduce it
running resistance. When
using high-power triodes (or pentodes in a triode
turned on), the depth of local feedback is very small and does not observe
any negative consequences
sya.



Picture 1

The next step, which will allow us to relax the requirements for
choke, is the removal of the winding Lp from the DC circuit
(Fig. 2). The effective μ of the core depends on the gap and, consequently,
on the bias ampere turns. Taking out the main part
turns of the inductor, you can significantly reduce the bias
core, since the cathode winding has a much smaller
number of turns. An increase in effective μ allows additional
reduce the dimensions of the inductor and its parasitic parameters with a
constant value of the magnetization inductance, and at the same time,
maintain the single-cycle operation of the core. Via source
current Ip, the variable current component of the signal does not flow, and its
the main task is to provide the desired lamp mode at a constant
current. This statement is quite true when using high-quality cascode sources.

current. In any case, it is not possible to detect any negative effect of such an inclusion.
elk.

If you look closely at the equivalent circuit of the cascade for alternating current, it is obvious that the upper terminal the anode part of the AC inductor is grounded, because the power supply has (should have) zero output resistance. This is true for both the first and second scheme. Since now the constant component of the lamp current does not flow through the anode part of the inductor winding, we have every right to connect this point to a common wire (Fig. 3).

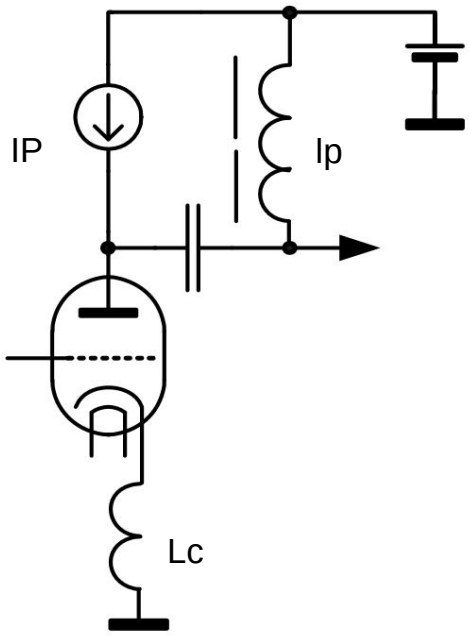


Figure 2

In this form, the circuit already has the necessary properties and, as a bonus, a new additional quality appeared - the signal current during generally does not flow through the power supply circuit, but closes along the chain: lamp, inductor, capacitance. Since the currents circulating in this circuit are small in magnitude, the decoupling capacitance rating turns out to be small, which gives rise to possibility to use high quality film container. The capacitance located in the power supply now performs only the function of filtering the supply voltage and does not affects the sound quality. It became possible to connect the output of the cascade directly to the grid of the output lamp and apply the bias voltage to the output lamp directly through the inductor winding without additional circuits. I want to draw the attention of readers that all these structural transformations did not change the equivalent circuit of the cascade by alternating current, it's all the same - a choke stage.

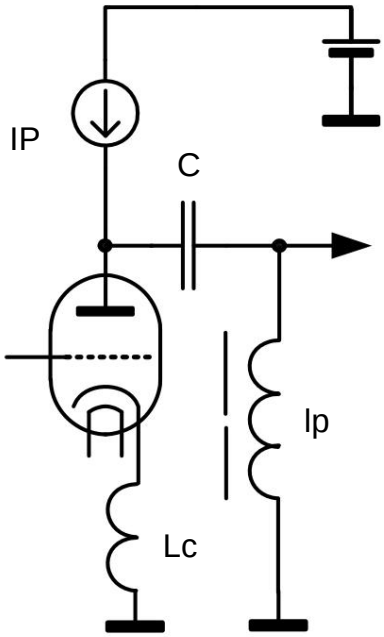


Figure 3

For the newly acquired qualities of the cascade had to pay increased supply voltage, since the current source must remain in linear mode at maximum am output signal range.

Despite the fact that all manipulations led to the simplification throttle and reduce its dimensions, the requirements for it remain very stringent. This is especially true for your own containers. The frequency of resonant phenomena occurring in the choke should be as far as possible from the audio frequency range. In this case, the surge that occurs on the transient response of the cascade is quite easy to suppress. In general, these The requirements and are also valid for a classical transformer stage, but the constructive implementation of a choke with a reduced self-capacitance is simpler. An example of a constructive The implementation of the throttle is shown in Figure 4.

Using a dynamically powered cascade at the input in conjunction with a modified choke cascade, it is possible to implement a linear driver with sufficient power and margin amplification to drive almost any output tube.

The actual complete circuit of the driver is shown in Figure 5, and its main electrical parameters are given below. The parameters were measured at a load equivalent of 10 kOhm, load capacitance

- 200pF and the output voltage range - 140V.

Gain Maximum Peak-to-Peer	124
output voltage frequency response (5Hz÷50kHz)	170V -1.5dB
Slew rate	12V/µS
output voltage Harmonic distortion	0.6%
Output impedance Input impedance	600ohm 47kOhm

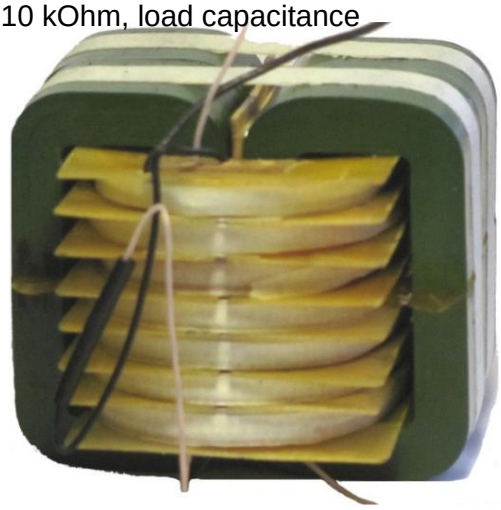


Figure 4

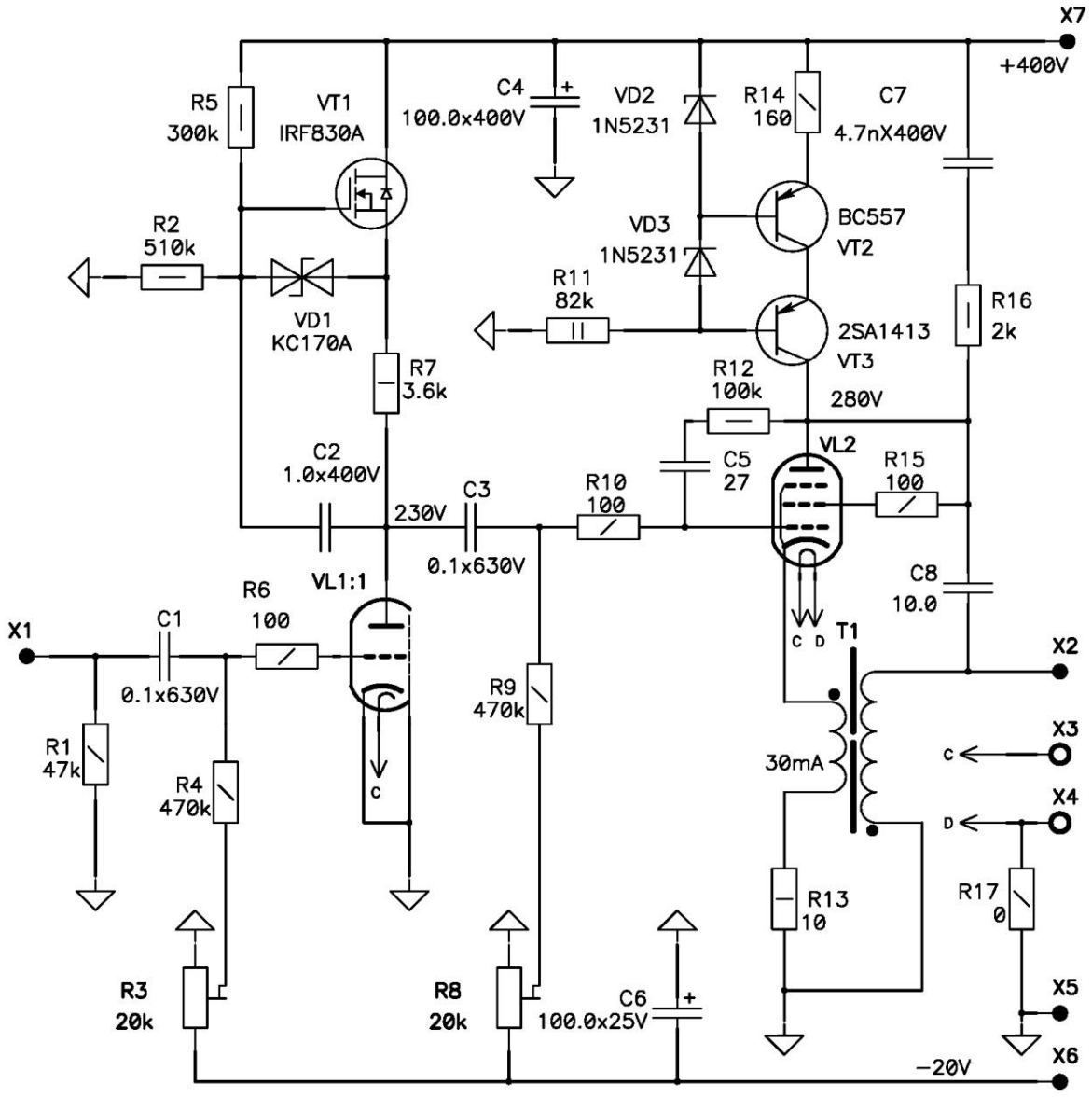


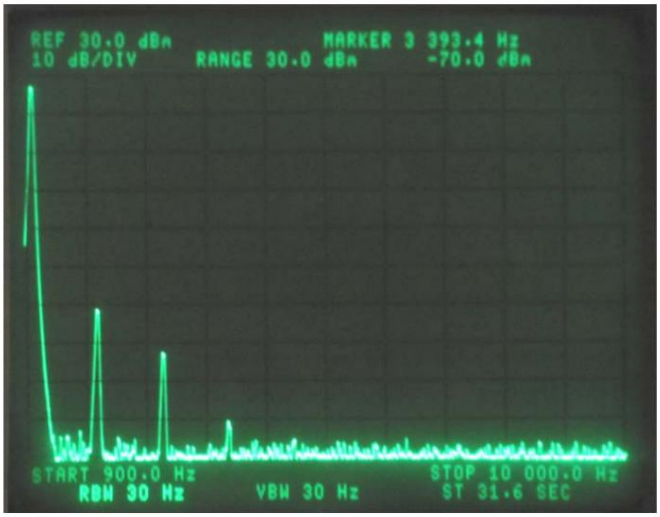
Figure 5

The first stage is implemented according to the scheme with dynamic power supply and has already been described many times in previous articles. I can only repeat that when using lamps with a wide opening of anode characteristics (6N8S, 6N23P, 6N1P, etc.), it allows you to get a large output voltage range with exceptionally high linearity (a lamp was used in the circuit 6N1P).
In the throttle stage, a 6P14P lamp was used in triode switching. The lamp works with high quiescent current (~30mA), and the output stage already has quite noticeable output power - about one watt. Resistor R13 is needed exclusively for measuring the quiescent current and can be excluded. The chain C7, R16 serves to suppress resonance phenomena in the inductor at high frequencies and is selected in accordance with the actual parameters of the inductor. The chain C5, R12 serves to correct the frequency response of the cascade at high frequencies (more than 70kHz), and its parameters are also related to the parameters of the inductor. Transistor VT3 must be installed on cooler with an area of about 150 cm2 .

Both stages operate with a fixed bias, the circuits of which are powered by a separate source. Of course, it is better to use stabilized sources to power the driver, although during the tests, a conventional rectifier with a CLC filter at the output was used.

The choke is wound on two cores ShL-16x20 made of steel 3425 with a thickness of 0.08mm, full core clearance - 0.11mm, 7 vertical sections. The output (anode) winding contains 302x7 + 302x7 turns with PEL-2 wire Ø 0.2mm, cathode winding contains 127x7 turns with wire PEL-2 Ø 0.27mm and is placed between the halves of the output winding.
The magnetizing inductance of the inductor is about 35H, self-capacitance is about 50pF. Throttle it is desirable to shield.

Below (Figures 6, 7) are spectrograms of the output signal of the driver at two levels nyah output voltage - 50Vrms and 25Vrms, respectively.



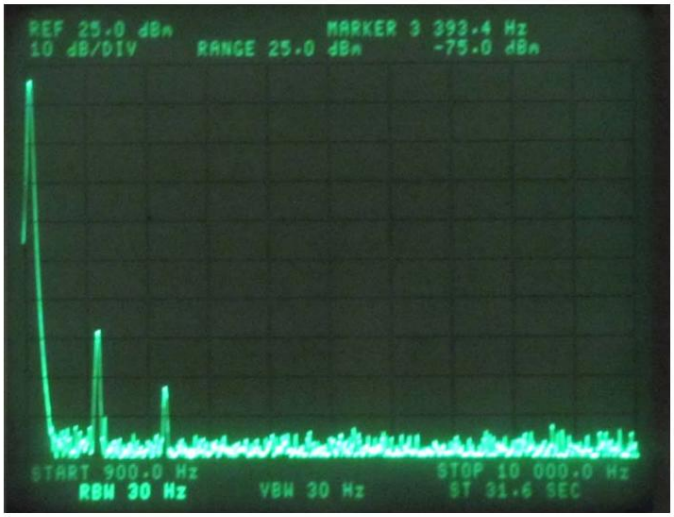


Figure 6 Figure 7

(Vertical scale - 10dB one large cell of the scale) In general, distortion is typical for any single-ended amplifier - the second harmonic prevails, the higher harmonics quickly decay, and their number is small. The most important is the low overall level of distortion. This requirement was one of the defining ones, as it allows to "concentrate"
the main distortion in the output stage and simplify the optimization of the amplifier parameters.

Figure 8 shows the output signal when excitation of the amplifier by a bipolar pulse signal with steep fronts (~20nS). Duration leading and trailing front are slightly different, it is the phenomenon is typical for any one-cycle circuits due to their initial asymmetry. But, since the amplifier has a high output slew rate
voltage and the difference in slew rates between
leading and trailing front does not exceed 5÷7%, su
significant effect on the sound quality is not
renders.

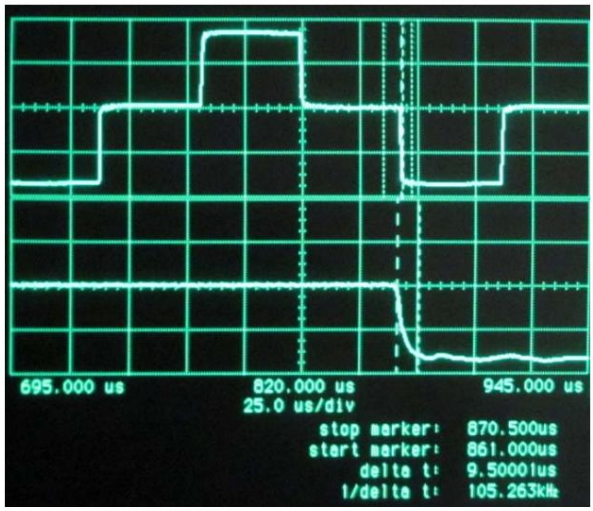


Figure 8

There are no special requirements for mounting the amplifier, the choice of the type of parts is according to “taste” and the depth of the pocket. Lamp 6P14P can be replaced by EL84 or similar without damage for the amplifier parameters, but the possibility of replacing 6N1P with imported lamps with similar parameters must be checked on the finished device.

In conclusion, I want to say that this article is not so much a description of the finished device (although the driver is very good both objectively and subjectively), how much is the presentation of the idea itself. And in some the degree of refutation of the opinion of a part of the "specialists" that everything has been in lamp technology for a long time invented ÿ.