NETWORK NOISE REDUCTION

Evgeny Karpov

The article discusses methods for reducing the penetration of network interference through the power transformer of the power source of the device.

Among lovers of high-quality sound, a lot of myths related to the power supply of equipment circulate. The most interesting thing is that all this is based on real facts, but the lack of their repetition and the non-obviousness of the explanation turns the facts into the category of myths. Any qualified engineer knows that the strange behavior of electronic equipment (let's put aside a direct malfunction and obvious miscalculations in the design) is often associated with interference. Fight this treacherous beast on the finished device - an extremely thankless and difficult task. You need to think about it at the beginning design phase, and the best results are obtained by using preventive measures, since it is almost impossible to make accurate calculations and foresee all situations.

In this short article, I just want to consider one such preventive measure for fight against interference. It is no secret that the mains supply is one of the main sources of interference, and the power transformer is their main conductor in the audio path.

The interference penetration mechanism is quite clear (Figure 1). If two devices are turned on to different points of the power line, then the section of the power line between the switching points can be look like a noise generator.

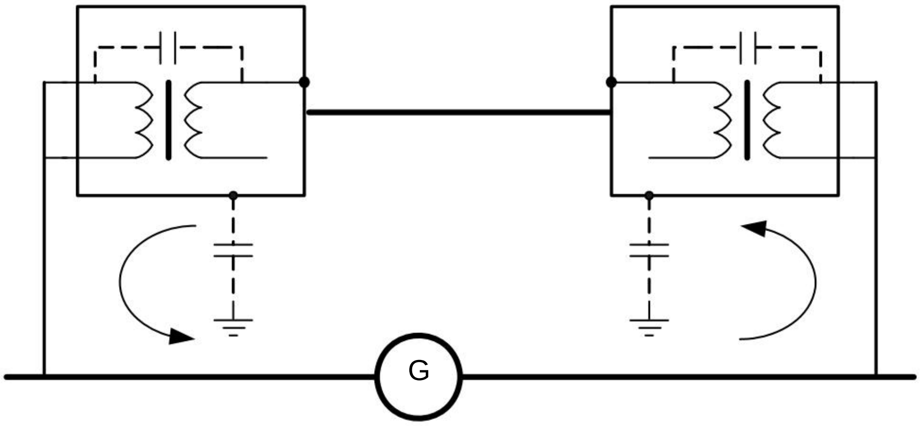

Figure 1

Interference currents flow through parasitic capacitances of power transformers, partially drain through parasitic capacitances of the device to ground and partially flow through the cable connecting both devices. Basically, the interference current flows through the shielding sheath of the cable, but due to the lack of complete symmetry of the communication line, it partially also flows through the signal conductors. It may seem that by connecting both devices to the same power line point, this problem will be solved automatically. (Figure 2).

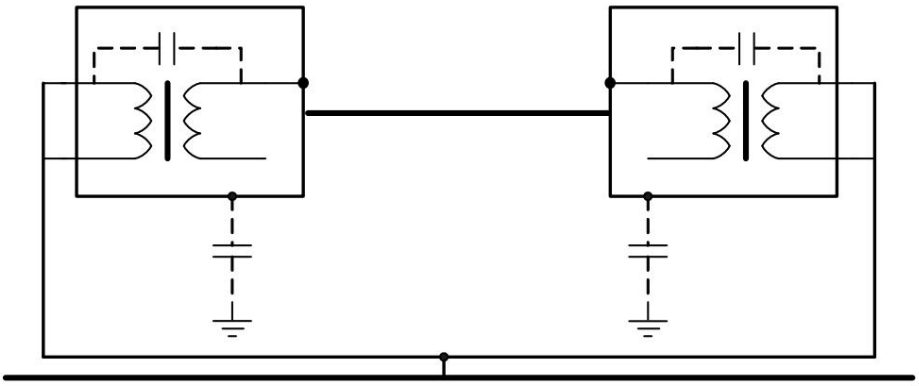

Figure 2

Unfortunately, it is not. Although both devices are powered from the same point, they have different parasitic capacitances to ground. Which leads to the appearance of a potential difference between the devices and, accordingly, to the appearance of equalizing interference currents; their size will be smaller, but the problem is not solved. It should be borne in mind that not only the interference current flowing directly through the signal circuits is terrible, but also the interference currents flowing through screens and structural elements. devices (although to a lesser extent). The fact is that the conductors through which the currents flow chi, they can re-radiate them and become secondary sources of interference.

Non-stationary values of parasitic capacitances relative to the ground and different characteristics of the supply network (asymmetry, noise level) lead to the influence of the length, position and even design of the network cable on the sound that is difficult to explain at first glance. In general, from this superficial consideration of the problem it becomes clear that all ways to reduce the interference currents flowing through the circuits and structural elements of the equipment.

An obvious step to break the circuit of the flow of interference current is to use network filters. The method is widely used, but its effectiveness depends significantly on the implementation. Several important points should be noted here. Firstly, the filter must either be in the device itself or be connected to the device. shielded cable. Secondly, the filter itself must be carefully shielded (which in most cases is not done) and, preferably, grounded. Thirdly, each device must have a custom filter. The use of filters also has a downside, since additional losses are introduced into the power supply circuit of the device. Elements that suppress common mode interference mainly introduce active losses, while elements that suppress the differential component of interference, in addition to active losses, also introduce a reactive component of losses. In some cases, the introduction of additional losses in the power supply circuit of the device can lead to disruption of normal operation. its power source. It should also be taken into account that the filter, as a device containing reactive elements, has its own response to disturbance from the load.

A small clarification should be made here. In general, the network is a source of both differential and common mode noise. The network filter can successfully suppress the interference of both types, but the suppression of the differential component, especially in the region of sufficiently low frequencies, leads to a significant increase in the dimensions of the filter, its cost, and requires mandatory matching of the load parameters with the filter parameters. But to suppress the differential interference in the low-frequency region does not make much sense, since after the transformer there is a rectifier with its own filters that ensure its effective suppression, the maximum that threatens it presence is a slight increase in losses in the transformer. Another conversation is high-frequency noise. Penetrating through the transformer, they disrupt the operation of the rectifier and, successfully bypassing the filter (due to the parasitic parameters of the elements), enter the signal amplification path. Therefore, the main attention is paid to the filtering of differential interference in the high frequency region. But given that the magnitude of the differential noise is quite small, and the transformer itself due to the presence of parasitic leakage inductance and increased losses in steel at high frequencies, it is a filter, often limited only to filtering the common mode component.

The next step (I would say that it should be the first) to reduce the current level of common mode noise penetrating the signal circuits is the introduction of an electrostatic shield into the transformer, which reduces the capacitance of the power transformer. Depending on the gabapower and design, the capacity of a power transformer can vary from 400÷500 to several thousand picofarads (transformer power 30÷600 VA). The introduction of the screen makes it possible to reduce the throughput capacitance approximately by half. Transformer with electrostatic shield connected as shown in Figure 3.

If the secondary winding is shunted with capacitances, then an additional filter is formed (together with the leakage inductance of the transformer) that suppresses differential noise. If the transformer is installed on metal chassis, then it must be installed through insulating pads. Sometimes this requirement is neglected (however, at the cost of some decrease in the screen efficiency), in which case the transformer core is not connected to the internal screen. In most cases, the combined use of an electrostatically shielded transformer and the surge protector is quite a sufficient measure to eliminate any "otherworldly" influence of the mains on the audio path.

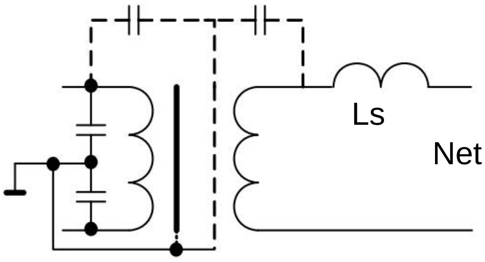

Figure 3

However, if there are devices with high sensitivity in the audio path (phono correctors, microphone amplifiers, etc.), these measures may not be enough. Insufficient suppression of parasitic connections through the supply network can manifest itself in a very unpleasant way, for example, an almost irremovable background may appear. Increasing the complexity of network filters in this case is ineffective (primarily, this is due to the parasitic parameters of the components and installation of the filter itself). A productive way is to further reduce the throughput capacity of the power transformer that feeds the sensitive node. To reduce the throughput capacity, a more complex transformer design with vertical sectioning and a double volumetric electrostatic screen is used (Figure 4). The transformer coil is divided into two parts by a vertical partition, one section is used for the primary winding, the second

- for secondary. The inner surface of the sections must be metallized (the easiest way is to make such coil made of foil fiberglass with soldered seams), section screens are electrically isolated from each other (slit under the middle cheek) and are equipped with longitudinal slot along the entire length to prevent the formation of a short-circuited coil.

A transformer of this design can have throughput capacitance at the level of tens of picofarads. With the joint use of a power transformer such design and network filter brings the source closer power supply by the level of parasitic connections through the network to a battery-powered source. There are two things to keep in mind when designing such a transformer. Firstly, the fill factor of the coil should be taken no more than 0.3. Second, the transformer of this design has an increased (by 15÷20%) leakage inductance. This moment is necessary take into account in the calculation. Although for low power devices, this is rather a plus, since the filtering effect of differential interference is significantly increased. By this principle it is possible to manufacture sufficiently powerful power transformers, but to reduce the inductance

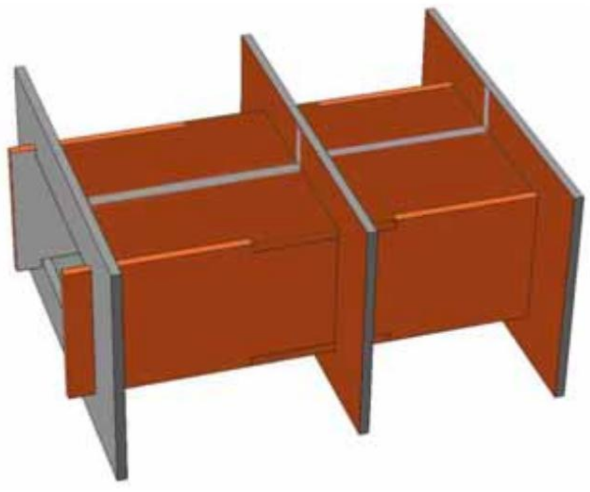
Figure 4

scattering, it is necessary to increase the number of sections, which significantly complicates the design and increases the cost and manufacture of the transformer. Transformer connection options are shown in Figure 5. Option "a" is used if pi

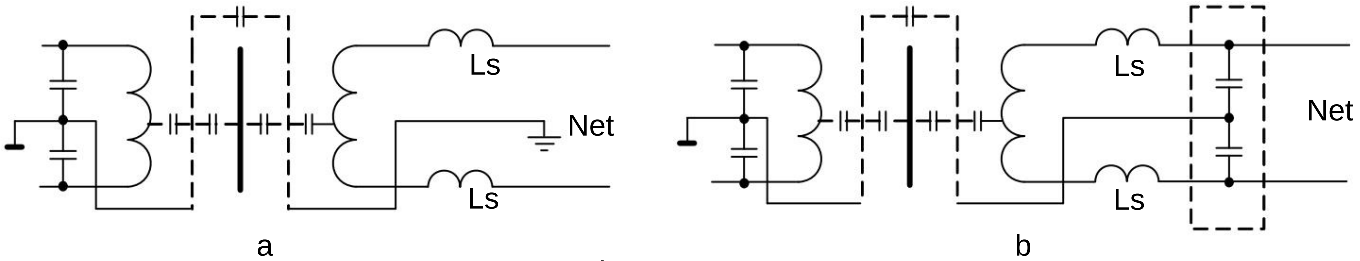

Figure 5

the melting network has an earth conductor and provides the best performance. In the absence of a grounding conductor, the transformer is connected according to option "b". As balancing tanks with primary side of the transformer, you can use the capacitance of the mains filter. As an example (Figure 6) the corrector power transformer is shown. Transformer overall power - 60VA, capacity – 50pF

Figure 6

In principle, a simplified version of double shielding is also possible, when two electrostatic shields are introduced into the transformer, one above the other. The design of the transformer is obtained much simpler, but the degree of decoupling between the primary and secondary side is worse. It is expedient to use this option for powerful galvanic isolation transformers. To connect the screens to the desired point, you need to use a wire large section and minimum length. To

complete the picture, it should be said that there is another version of the design of transformers with a small throughput capacitance - a transformer with a volumetric turn. With such a design of the power transformer, the capacitance can be reduced to units of picofarads. But due to the high complexity and cost of manufacturing in household equipment, such transformers are not used in power supplies.

If the equipment has a high sensitivity, then one more preventive way to reduce the noise level should be used - to ensure the symmetry of parasitic capacitances relative to the common wire of the device. In this case, during the operation of the rectifier, there is no modulation of the parasitic capacitance value with the mains frequency, which reduces the likelihood of a background on device output.

Literature

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