Investigation of the Impact of the Supply Voltage Form in Cable TV Amplifiers

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Abstract – **The supply block of highway cable TV amplifiers is a source of electromagnetic disturbances which spread throughout the entire cable TV network. It is proved that the most expedient approach is to use converters in power blocks, commutation in them is effected by zero current. Said converters work with trapezium contour of current and voltage. In this case the power at the moment of switching on of commutation transistor is close to zero while at switching off losses are inconsiderable and are determined by the commutation capacity. The trapezium form of both voltage and current brings about to decrease in electromagnetic disturbances due to supply.**

Keywords – **CATV, supply voltage**

I. Introduction

Cable TV and other areas of telecommunications industry entered a stage of introducing new digital infrastructures. The latter are known as "data highways" and could offer a set of multimedia, communications, information and amusement services. Power supply of these systems is an integral part of such infrastructures. It is also necessary to ensure effective and reliable solution of feed from one end to the other.

The form of voltage, its capacity and frequency of net supply is still under development. In other to ensure the necessary power to the units included in the net with a certain level of voltage and lower level of electromagnetic disturbances, it is recommendable to feed voltage with trapezium form, which differs from sinusoidal. Normally a supply voltage of 60-90 V and frequency of 50 (60) Hz is used as it guarantees a good blend of safety, increased load capacity, corrosion, level of electromagnetic disturbances and transmission losses [1-3] without any comment of these properties. In [4] are shown some of the indisputable advantages in terms of minimizing the "scissors" effect of current and the high multiplier of power.

Fig. 1 presents the form of supply voltage with its basic components. Fig 2 shows a simplified chart of the resonance converter of the supply unit employed in the popular type of highway amplifiers which are manufactured in the west. It is evident, however, that with trapezium form of supply voltage the so-called "mild commutation" of powerful transistors

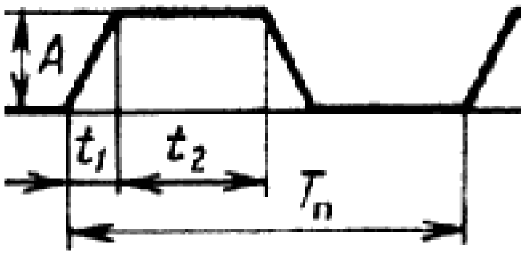

Fig. 1. Supply voltage waveform

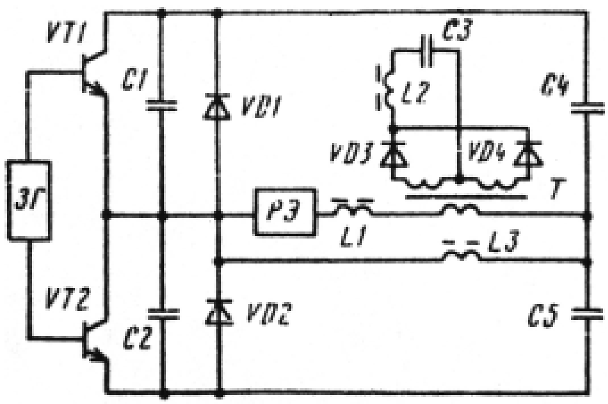

Fig. 2. Resonance converter of the supply unit

will be ensured. The time chart of switching of these transistors in this circuit is shown in Fig. 3 the rate of increment of current has an unchangeable time constant which is determined by the inductance L1 of the primary side. It provides a comparatively quick increment of current up to its functional value. Likewise inductance L2 is used in the same way, but included in the secondary side.

The presence of commutation condensers C1 and C2 as well as inductance's L1 and L3 allows the change of switch-off (cut out) voltage for the power transistors VT1 and VT2, namely, the voltage of the the transistor opened earlier goes up to the level of supply voltage whereas the voltage of the transistor that was closed earlier goes down to zero (Fig. 3) That state is kept in the course of a definite time period until the dissipation of the energy accumulated in the coils of the chokes L1 and L3. Opening of transistor whose collector's voltage reaches zero does not cause commutation losses. It is evident that in this case power losses at the time of starting the transistors are close to zero and at the time of cut-

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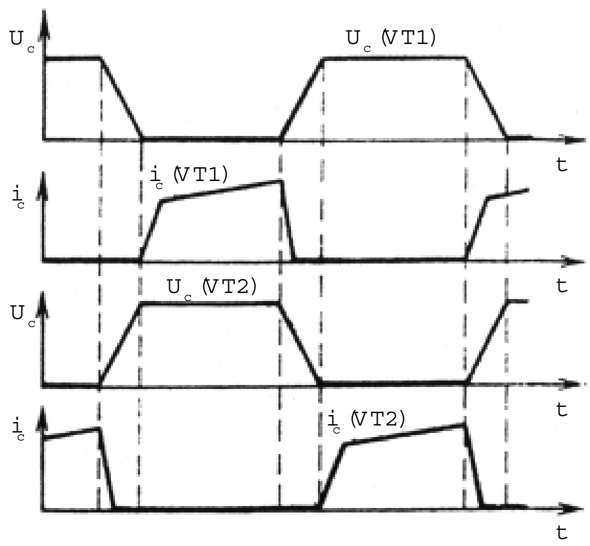

Fig. 3. Time chart of switching of the transistors

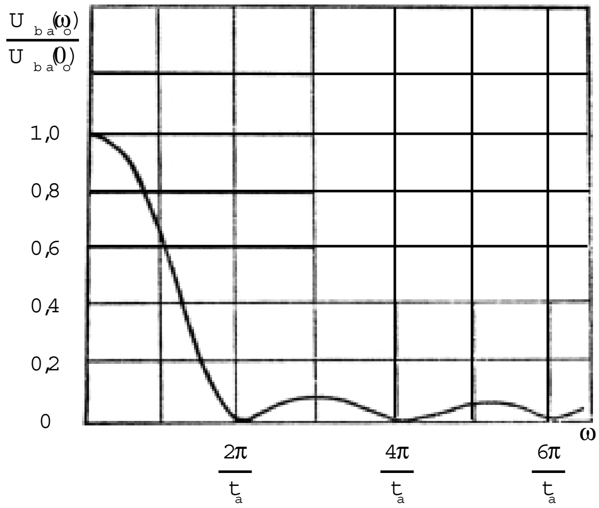

Fig. 4. Spectrum density module

out these losses are inconsiderable and are determined by the commutating condensers. Because of the trapezium form of the supply voltage of such type of rectifier unit it is possible to switch off the short circuit mode at the power transformer output in switching the diodes of the output rectifier. Such form of supply allows to considerably reducing electromagnetic disturbances created by the rectifier unit of highway amplifiers that are used in CATV.

Evaluation of noise resistance at the output of the supply unit of the pulse transducer in cable amplifiers can be carried out in the following way. The range of disturbances in rated voltage of the pulse transducer is determined by the expression:

$$U_{\text{out}_i}(S) = K_i(S)U_{\text{in}}(S) \quad (1)$$

where $K_i(S)$ is the transmission function of the converter; $U_{\text{in}}(S)$ is the function of disturbances in the network.

Expression (1) corresponds to that case when at the moment $U_{\text{out}_i}(S)$ all transition processes in the transducer are complete. If they are still going on then the range of disturbances in rated voltage is to be determined by

$$U_{\text{out}}(S) = \sum_{i=1}^{n} U_{\text{out}_i}(S)e^{-t_i s} \quad (2)$$

where t_i corresponds to backward holding of $U_{\text{in}_i}(S)$ in relation to the beginning of reading. Spectrum characteristics of rated voltage in network disturbances impact will be determined by the expression (1):

$$20\lg|U_{\text{out}_i}(j\omega)| = 20\lg|K_i(j\omega)| + 20\lg|U_{\text{in}_i}(j\omega)| \quad (3)$$

where $K_i(j\omega)$ is the transmission function of the converter; $U_{\text{in}_i}(j\omega)$ is the function of network disturbances. Having in mind (2) we can express it:

$$20\lg|U_{\text{out}}(j\omega)| = 20\lg|\sum_{i=1}^{n} U_{\text{out}_i}(j\omega)e^{-t_i j\omega}|. \quad (4)$$

By using expressions (3) and (4) it is possible to chart the spectrum characteristics of network disturbances of rated voltage of pulse voltage converters.

For better evaluation of the parameters of the voltage pulse or the transistor current it is good to use the generalized charts of spectrum characteristics. If we know the particular pulse parameters we can obtain equivalent spectrum density of Niquist bandwidth [5]:

$$U_{\text{out}}(\omega) = U_{\text{out}}(j\omega) = \frac{8A}{t_i\omega^2}\sin\frac{\omega t_i}{8}\sin\frac{3\omega t_i}{8}. \quad (5)$$

For trapezium shaped pulses (Fig. 1) there is a graphic display of the spectrum density module in Fig. 4. This module could be conditionally divided into three areas (low, medium and high frequencies) with two break frequencies f_1 and f_2 and the corresponding amplitudes A_1 and A_2 (see Fig. 5) as follows:

$$\begin{aligned} u_{\text{lf}} &= 126 + 20\lg A(t_1 + t_2) \\ u_{\text{mf}} &= 116 + 20\lg A - 20\lg f \\ u_{\text{hf}} &= 106 + 20\lg(A/t_1) - 40\lg f \end{aligned} \quad (6)$$

Table 1 contains analytical expressions for frequency characteristics obtained from the generalized charts and also the amplitudes and frequencies of transmission with the various parameters of trapezium voltage.

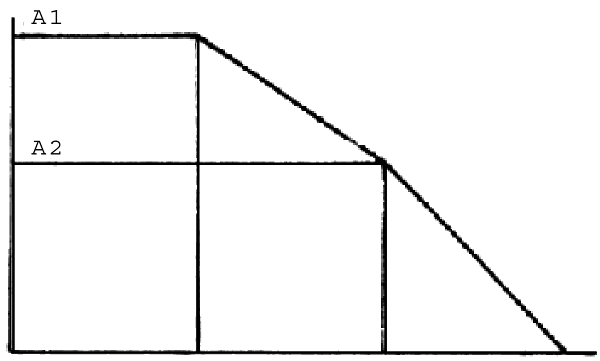

Fig. 5. Spectrum density module three areas

Table 1.

Duration, μs		Amplitude A_1, A_2 $\left[\text{dB}/\frac{\mu\text{V}}{\text{MHz}}\right]$ and refraction frequencies f_1, f_2 [kHz] at amplitude A [V]					
t_1	t_2	90		60		30	
		A_1/f_1	A_2/f_2	A_1/f_1	A_2/f_2	A_1/f_1	A_2/f_2
0.1	40	213.6/7.9	161.5/3200	207.6/7.9	155.4/3200	186.7/7.9	134.6/3200
1		213.8/7.7	181.4/320	207.8/7.8	175.4/320	186.9/7.8	154.6/320
5		214.6/7.08	196/60	208.6/7.1	190/60	187.6/7.1	168.4/60
0.1	18	206.7/17.6	161.5/3200	200.7/17.6	155.4/3200	179.8/17.6	134.6/3200
1.0		207.1/16.8	181.5/320	201.1/16.8	175.5/320	180.2/16.8	154.6/320
0.1	9	200.7/35	161.5/3200	194.7/35	155.4/3200	173.8/35	134.6/3200

II. Conclusion

On the grounds of the results obtained the following conclusions can be drawn:

1. Voltage and current passing through the transistors of the pulse transducers of the power supply unit of the highway cable amplifiers appear to be a major source of electromagnetic disturbances. The level of electromagnetic disturbances depends on the amplitude and shape of the voltage pulses and the current passing through power transistors. The alternating transistor current creates a prevailing magnetic field and the changing potential creates electric field.

2. With the increase of the duration of the fronts of the trapezium shaped supply pulses the frequency range of the spectrum characteristics move toward the side of low frequencies, for instance if the duration of the front is changed from 0.1 to 5 μs then the frequency of refraction f_2 will shift from 3200 to 60 kHz; in other words its change will be approximately 50 times.

3. Increase in duration of supply voltage front causes a decrease of the disturbances' amplitude for high frequencies and also causes a minor increase in lower frequencies. At the same time, however, the increase in the duration of the pulses's front will cause a corresponding increase in the commutating transistors, hence the lower efficiency coefficient

4. With the increase of frequency translation, i.e. with the decrease in the duration of voltage pulses, the amplitude of disturbances is slightly decreased for lower frequencies. For example, with a change of pulse duration from 40 to 9 μs the amplitude of disturbances goes down from 213.6 to 200.7 dB/μV/MHz, but remains unchanged for medium and high frequencies.

5. The increase of the front of the trapezium shaped supply voltage will cause a decrease in the intensity of disturbance creation. If this is accompanied by a solution of the problem for reducing the power losses then the technical parameters of supply units will be boosted considerably.

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