Algorithm for defining the limits possibilities of a system for cable television with the aim of minimal nonlinear distortions

Oleg Borisov Panagiev[1]

Abstract: **An algorithm, by which it is possible to explore the limits possibilities of a system for cable television, depending on the number of the transmitted programs (channels) and number of the amplifiers connects in series in the cable distribution network (CDN), is created. The defining of the maximum number of the channels and the amplifiers lead to minimizing of the nonlinear distortions. The results from algorithm are presented graphically (three-dimensional graphics), by using the program product MAPLE**.

Key words: **cable television, nonlinear distortions, tolerance, optimization, nonlinear products (NP).**

I Introduction

When designing the system for cable television with the aim of minimal nonlinear distortions, it is necessary to optimize the number of the transmitted programs (channels) and the number of the amplifiers connected in series from the Head End to any point of CDN. It is know that, with the increase of the number of programs, the level in the exit of every amplifier has to decrease with:

$$\Delta U_N = x \lg(N-1) \qquad (1)$$

x = 10 with asynchronous of carrier frequencies
x = 7.5 with PLL
x = 5 with synchrony of the carrier frequencies (HRC – Harmonically Related Carrier)
N – nummber of the programes (channels).
Also, with the increase of the number of amplifiers connected in series it is necessary to decrease the output level of the respective amplifier by

$$\Delta U_M = y \lg M \qquad (2)$$

M – number of amplifiers connected in series to the point, including which the output level of the signal of the amplifier (or following number of the amplifier) is measured.
y - coefficient, depending on the abstand used when designing.
y = 10 with IMA2 and CSOA;
y = 17 with XMA and IMA3;
y = 18 with CTBA;
y = 20 with CXMA;
A criterion is introduced, by which the values of the parameters N and M are optimized so that, with a given value of each of them (N or M), the other one can be defined, according to this criterion, and then the nonlinear distortion are minimal

II. Criterion and algorithmus for defining the limits possibilities

1. Criterion for one amplifier

The maximum output level of the cable amplifier is defined by the formula

$$U_{out\,max,1} = U_{out,2} - \Delta U_n \left[dB\mu V\right] \qquad (3)$$

where $U_{out,2}$ is the output level of the amplifier with two programs (it is given in the catalogue of the producer of the amplifier).

The minimal level of the cable amplifier is given by the formula.

$$U_{out\,min,1} = N_{75} + NF + G + \frac{S}{N} \;, \left[dB\mu V\right] \qquad (4)$$

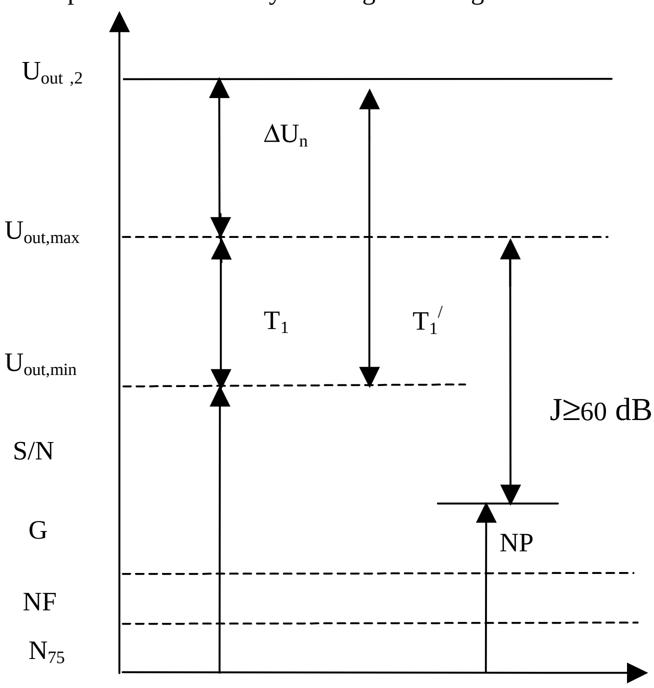
where N_{75} is the channel thermal noise
NF- the noise figure of merit
G - Gain of the amplifier in dB.
S/N - Signal-to-noise ratio dB.

The difference between the maximum and minimum output levels is the criterion for minimal nonlinear distortions.

$$T_1 = U_{out\,max,1} - U_{out\,min,1,} \left[dB\right] \qquad (5)$$

$$T_1 = U_{out,2} - x\lg(N-1) - N_{75} - NF - G - S/N ,[dB] \qquad (6)$$

this criterion is called tolerance and its connection with the other parameters of the system is given in fig.1.



[1]O. B. Panagiev is a system engineer at the Technical University of Sofia, e-mail: ctv@alpha.tu-sofia.bg

Fig.1.

2. Criterion for M amplifiers when there are a large number of cable amplifiers connected in series (fig.2), the formulas for their output level are.

$$U_{out\,\max,M} = U_{out,2} - \Delta U_N - \Delta U_M, [dB\mu V] \quad (7)$$

$$U_{out\,\min,M} = N_{75} + NF + G + S/N + 10\lg M, [dB\mu V] \quad (8)$$

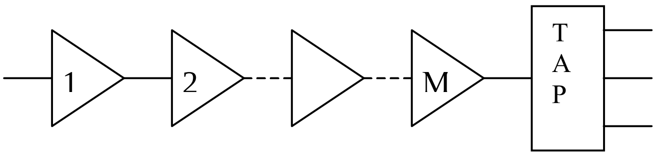


Fig .2.

$$T_M = U_{out\,\max,M} - U_{out\,\min,M}, [dB] \quad (9)$$

$$T_M = U_{out,2} - \Delta U_N - \Delta U_M - N_{75} - NF - G - S/N - \Delta U_{S/N}, [dB]$$

where $\Delta U_{S/N} = 10\lg M$.

$$T_M = T_1 - \Delta U_M - \Delta U_{S/N}. [dB] \quad (10)$$

By T_M=0 the maximum number of the amplifiers connected in series can be defined (fig.3), i.e.

$$U_{out\,\max,M} = U_{out\,\min,M} = U_{out,opt} \quad (11)$$

Then (10) turns into this:

$$0 = T_1 - \Delta U_M - \Delta U_{\frac{S}{N}}, [db] \quad (12)$$

$$T_1 = \Delta U_M + \Delta U_{\frac{S}{N}} = y\lg M + 10\lg M = (y+10)\lg M = \lg M^{y+10}, [dB] \quad \text{i.e.} \quad (13)$$

$$T_1 = \lg M^{(y+10)}, [dB] \quad (14)$$

After the antilogaritming of (14), for the number of the amplifiers connected in series, it is derived.

$$M = 10^{\frac{T_1}{y+10}} \quad (15)$$

As in the expression for T_1 the number of programs is present, the connection between M and N is given by using (15), with defined parameters of the amplifiers.

3. Criterion for n channels in number.

For the derivation of an analytical expression for N, the expression (10) will be used, the equation calculated in relation to N, with the assumption of M=const.

$$U_{out\,\max,M} = U_{out\,\min,M}, \text{ in order to be } T_M = 0. \quad (16)$$

$$U_{out,2} - \Delta U_M - \Delta U_n = N_{75} + NF + G + \tfrac{S}{N} + \Delta U_{\frac{S}{N}} \quad (17)$$

$$U_{out,2} - \Delta U_M - N_{75} - NF - G - \tfrac{S}{N} - \Delta U_{\frac{S}{N}} = \Delta U_n \quad (18)$$

After replacing:

$$U_{out,2} - N_{75} - NF - G - \tfrac{S}{N} = T_1', \quad (19)$$

it is derived:

$$T_1' - T_1 = \Delta U_n, [dB] \quad (20)$$

It is replaced by /1/ in the above expression

$$T_1' - T_1 = x\lg(N-1), [dB] \quad /к/ \quad (21)$$

the logarithmic equation is calculated in relation to N.

$$\frac{T_1' - T_1}{x} = \lg(N-1) \quad (22)$$

$$(N-1) = 10^{\frac{T_1' - T_1}{x}} \quad (23)$$

$$N = 10^{\frac{T_1' - T_1}{x}} + 1 \quad (24)$$

4. Algorithm

On the basis of the formulas derived above, an algorithm (fig.4) is created for defining of the boundary potentialities of the system in relation to N and m with.

$T_M = 0$ and the parameters of the amplifiers: $N_{75}, NF, G, S/N, U_{out\,\max,2} = U_{02}$.

It is assumed that the amplifiers are equal parameters.

In fig.5. is given a graphic of the dependence $T_M = func(N, M)$ in the three-dimensional space for the following values of:

N_{75}=2 dBμV; NF=6 dB; G=27 dB; S/N=46 dB; M=100; N=100; x=7.5; y=10.

The calculation of T_M and the drawing of the graphic is done by the program product MAPLE.

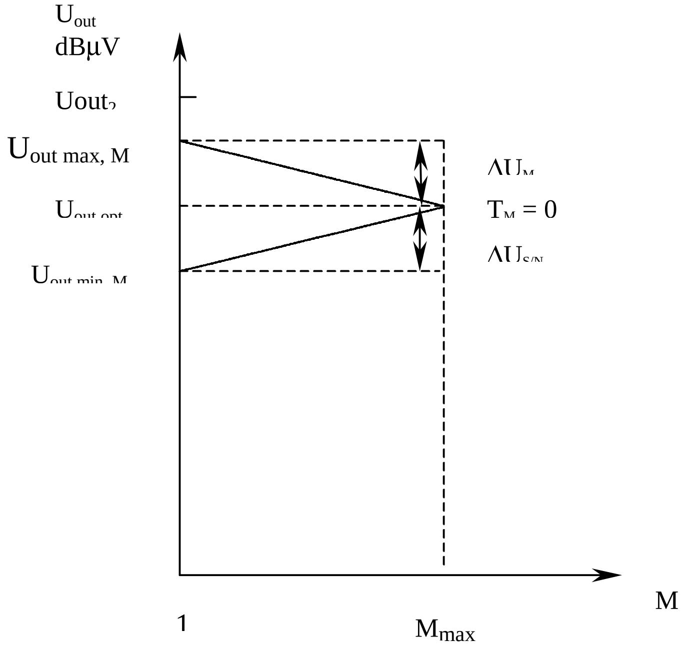
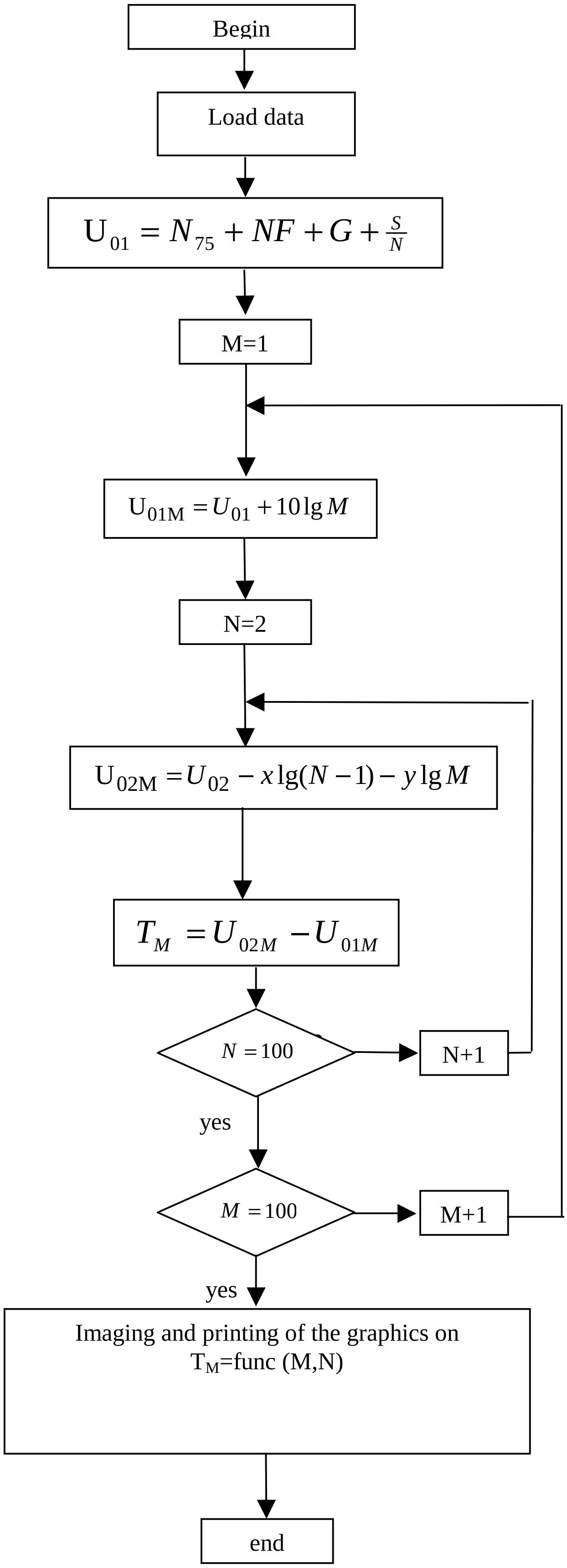


Fig. 3

Fig.4.



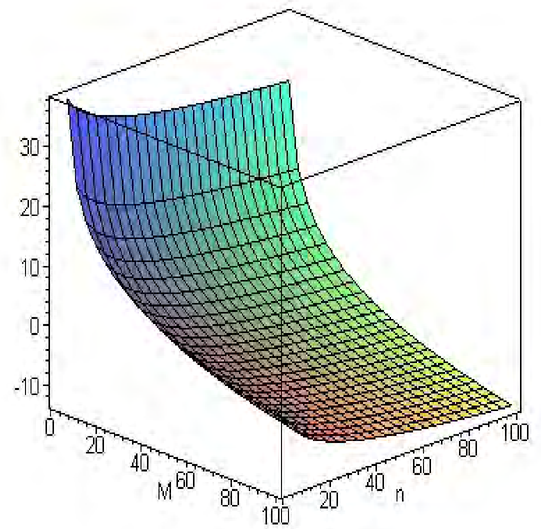


Fig.5.

III. Conclusion

The defining of maximum number of channels and amplifiers, lead to minimizing of the nonlinear distortions.

With the increase of the number of the channels in CATV, the maximum output level decreases.

By asynchronous carrier frequencies of image, transmitted in CATV, $U_{out,opt}$ decreases compared to HRC and IRC systems. To get a larger optimal level, it is necessary to work with an amplifier, the nominal output voltage of which is the highest possible and at the same time with a high gain.

The optimal output level of a given amplifier does not depend on its following number, or the number of amplifiers, but it depends on their parameters: nominal output voltage, Gain and noise figure of merit.

IV. References

[1] D. Dobrev , L.Yordanova,” Receiving on radio- and TV programs by means satellite and cable”, Electron – invest, 1996

[2] Kathrein antenen. Electronic CTV – U 11.92

[3] Simons K.A. The optimum gain for a CATV line amplifier. Proc. IEEE, 1970.

[4] www.analog.com