TRANSFER CHARACTERISTIC OF BROADBAND TV AMPLIFIER DETERMINATION BY MEANS OF FREQUENCY SPECTRUM

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ABSTRACT

The paper describes the calculation and determination of nonlinear transfer characteristic of broadband amplifier which is approximated by polynomial of the third order by means of higher harmonic components of output signal frequency spectrum and subsequent display and checking of nonlinear transfer characteristic with the aid a software in the Matlab program.

1 INTRODUCTION

Maximum TV signal output level of the active equipment (broadband amplifiers) in the cable TV networks is limited by nonlinear distortion. Nonlinear distortion is caused by nonlinear dependence of output signals on input signals of these active equipments and increases with input signal level.

If harmonic signal with particular frequency is transmitted into the broadband amplifier, which substitutes the carrier frequency of the picture TV channel, except for basic components having identical frequency with frequency of input harmonic signal, higher harmonic components also develop. The curve of nonlinear transfer characteristic of broadband equipment can be determined by values of these products.

2 SYSTEM MODEL

The frequency of input harmonic signal can be generally random, but it is preferable to locate it approximately in the middle of transmitted frequency band of the approximated amplifier. The output signal will have infinite number of members theoretically in nonlinear system. Manufacturers usually present the highest voltage level in amplifier output as V_{2MAX} for the ratio of nonlinear products accumulation of value -60dB. Amplifier transfer characteristic can be generally represented by a polynomial:

$$e_{out} = A \cdot e_{in} + B \cdot e_{in}^2 + C \cdot e_{in}^3 + D \cdot e_{in}^4 + ..., \quad (1)$$

$$e_{in} = E \cdot \cos(\omega \cdot t) \tag{2}$$

where A,B,C,D… are coefficients of amplifier transfer characteristic
$\omega = 2\pi f$
f is the frequency of input harmonic signal
E is the value of input harmonic signal

The spectral components of identical frequency can develop from different expressions of transmission function. Every component of the output signal, represented by such an expression, is a product of nonlinear distortion

It is possible to simplify the formula for transfer characteristic of approximated amplifier by a polynomial of the third as follows:

$$e_{out} = k_1 \cdot e_{in} + k_2 \cdot e_{in}^2 - k_3 \cdot e_{in}^3 \tag{3}$$

where k is a real positive or negative constant after simplification

The formula for individual harmonic components of output signal can be obtained after substitution of equation (2) in equation (3) and after mathematical modifications. Then the output signal of the approximated amplifier is given by

$$e_{out} = DC + H_1 \cos(2\pi f \cdot t) + H_2 \cos(4\pi f \cdot t) - H_3 \cos(6\pi f \cdot t). \tag{4}$$

where DC is a direct-current component $DC = \left(\frac{k_2 E^2}{2} + \frac{3k_4 E^4}{8} \right)$ (5)

H_1 is the first harmonic component $H_1 = \left(k_1 E - \frac{3k_3 E^3}{4} \right)$ (6)

H_2 is the second harmonic component $H_2 = \left(\frac{k_2 E^2}{2} + \frac{k_4 E^4}{2} \right)$ (7)

H_3 is the third harmonic component $H_3 = -\frac{k_3 E^3}{4}$ (8)

The experimental measurements were made under laboratory conditions. The harmonic signal of generator (GEN) was fed into input of broadband amplifier (BBA). The voltage supply of the amplifier was effected by means of a stabilized power source (PS). The curve of nonlinear transfer characteristic of amplifier changes subject to voltage supply reduction and it is then easier to measure nonlinear distortion. The output signal in the

amplifier output was measured by means of a spectral analyzer (SA). The spectral analyzer makes it possible to display frequency spectrum and to measure individual harmonic components of signal. The block diagram of experimental measuring site is displayed in figure 1.

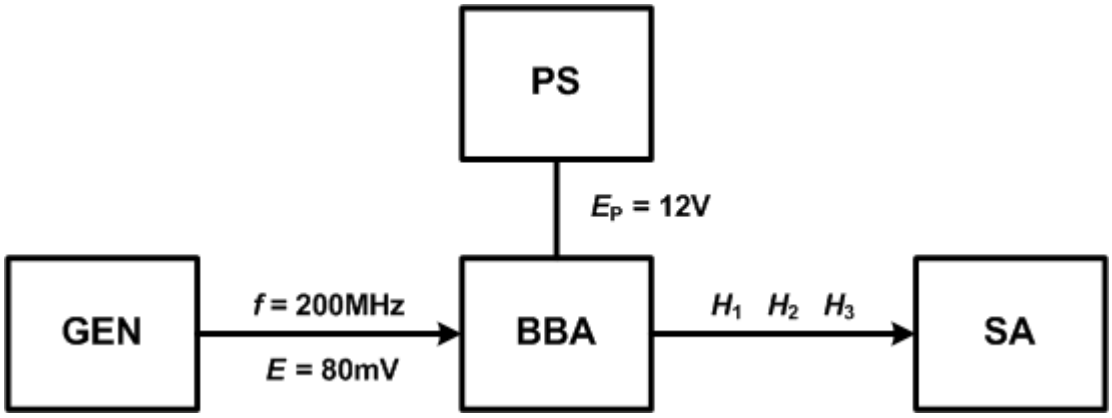


Fig. 1: *Block diagram of measuring site*

It is possible to calculate the coefficients of nonlinear transfer characteristic of the approximated broadband amplifier (3) from measured values of harmonic components levels (first, second and third harmonic components) and from input signal level. The equations for individual coefficients have been derived from equations (6), (7) and (8) and are given by:

$$k_1 = \frac{H_1 + 3H_3}{E} \tag{9}$$

$$k_2 = \frac{2H_2 - 8H_4}{E^2} \tag{10}$$

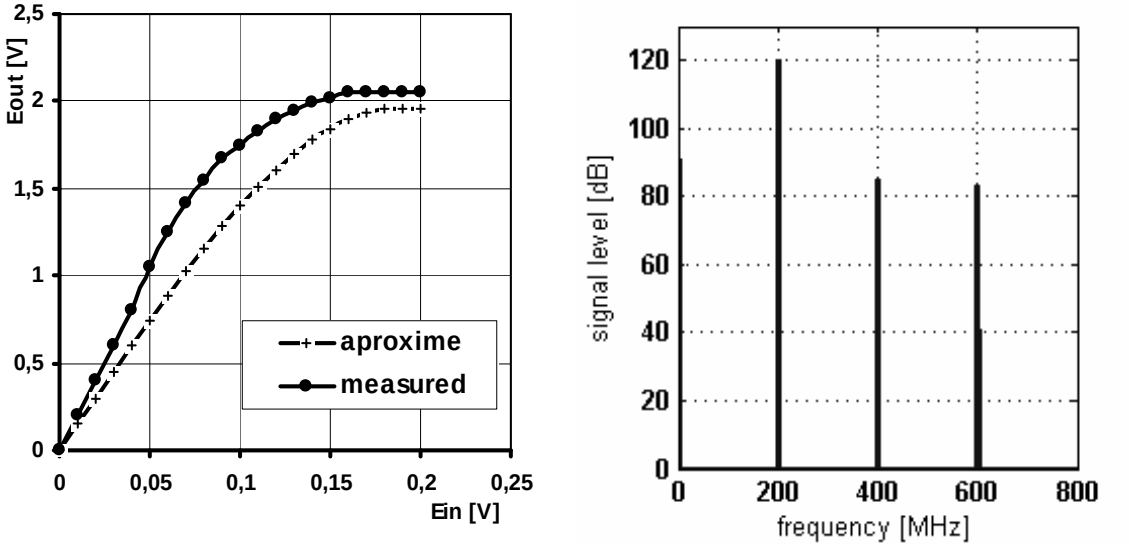
$$k_3 = -\frac{4H_3}{E^3} \tag{11}$$

3 THE EXPERIMENTAL RESULTS

The harmonic signal with frequency f = 200MHz and value level 80mV was fed into input of broadband amplifier K1-60 with parameters: gain 30dB, noise number 4dB, voltage supply +12V, current 100mA and overfeed 107dBμV/-60dB. The voltage supply of amplifier was set at the value E_P = 12V. The experiment was measured for the voltage supplies 6V and 4V by reason of deterioration of transfer characteristic of the amplifier. Value levels of the first, second and third harmonic spectral components were measured at amplifier output. Then the individual coefficient values were calculated according to equations (6), (7) and (8) and subsequently the transfer characteristic of approximated broadband amplifier was calculated according to equation (4).

A model of the approximated broadband amplifier for transmission signal simulation was created in Matlab. A simplified transfer characteristic (according to equation (3)) was used for the amplifier model in Matlab. It is possible to display frequency spectrum of output signal and transfer characteristic of approximated broadband amplifier (figure 2a,b) after substitution of coefficient values and input signal level value. Thus it is possible to simulate

relevant broadband amplifier and its influence over synchronous broadcasting of more TV signals, which are combined in a single direct broadband channel and hence to determine the parameters - ratio of the carrier frequency of the picture level to intermodulation products accumulation of the second order – C/CSO and the third order – C/CTB. The frequency spectrum of broadband amplifier output signal is displayed in figure 2b.



a) b)

Fig. 2: *a)Transfer characteristic of amplifier b) Frequency spectrum of output signal*

The error of approximated transfer characteristic of broadband amplifier compared to measured transfer characteristic of real amplifier (figure 2a) is approximately 15%. It would be necessary to use an amplifier approximated by a polynomial of higher order to obtain a smaller error, but approximation by a polynomial of the third order is sufficient for the determination of amplifier transfer characteristic.

4 CONCLUSIONS

This paper presents measurement of nonlinear transfer characteristic of TV broadband amplifier by means of higher harmonic components of output signal frequency spectrum and a subsequent calculation of approximated transfer characteristic coefficients. This method is useful for example for determination of amplifier basic properties and subsequent simulation of broadcasting of more TV signals, which are combined in a single broadband channel.

ACKNOWLEDGEMENTS

This work has been supported by the doctoral project of the GACR (Czech Science Foundation) No. 102/03/H109 „Methods, Structures and Components of Electronic Wireless Communication“ and with the support of the research plan MSM0021630513 „Electronic Communications Systems and Technologies of New Generation“.

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