NON-LINEAR DISTORTION OF DIGITAL SINEWAVE GENERATOR WITH STEP AND STEP-LINEAR APPROXIMATION

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The paper presents an investigation of the spectrum of digital sinewave generator signal. Non-linear distortion of digital sinewave with step and step-linear approximation is analyzed. The non-linear distortion is calculated according to amplitude of the main harmonic. Different values of non-linear distortion are obtained by changing the number of linear sections and number of steps in a section. The main contribution of the paper is the investigation of the spectrum of the step-linear approximated sinewave signal. The investigation of the NLD shows that in many applications there is no need the approximated signal to be filtered before use.

Keywords: spectrum, non-linear distortion (NLD), sinewave generator, step approximation, step-linear approximation.

This paper continues the investigation of step and step-linear approximation of digital sinewave generator signal [2,3]. The focus here is on spectra and non-linear distortion (NLD) of the approximated sinewaves.

The spectrum of the step-approximated signal is given on fig.1.

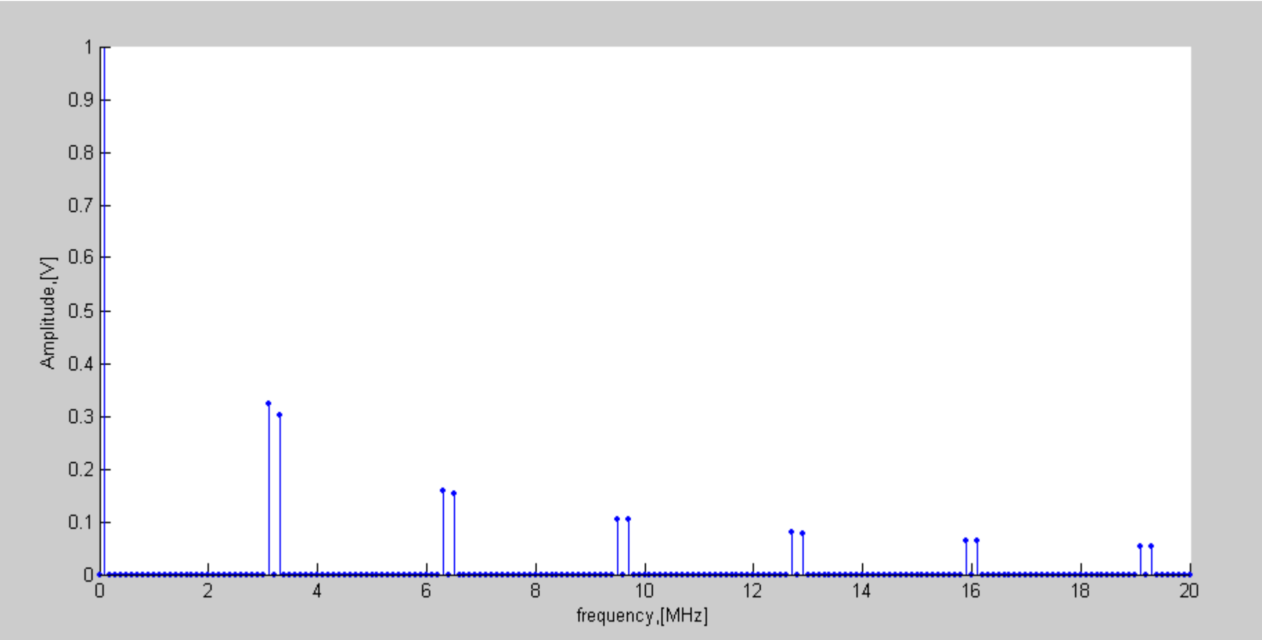

Fig.1. Spectrum of the step approximated signal with 32 steps

The amplitude of the main harmonic is near 10 V and it is not shown on the figure in order to be visible the amplitudes of the rest harmonics. The frequency of the high harmonics is given by the following formula:

$$f_{ci} = n * f_d \pm f_{sin}, \qquad (1)$$

where

f_{ci} – frequency of a high harmonic;

f_d – sampling frequency;

f_{sin} – sinewave frequency;

$n = 1, 2, 3...$

The spectrum on fig.1 is for sinewave approximated by 32 steps with main frequency 0.1Mhz, so the sampling frequency is *32*0.1=3.2Mhz*. The frequency of the second harmonic is *3.2-0.1=3.1MHz*. The next harmonic is with frequency *3.2+0.1=3.3Mhz*. The amplitudes of the two harmonics around the sampling frequency differ each other. The harmonic with smaller frequency is with greater amplitude compared to the other one. This can be explained with the fact that during the pulse width the amplitude has a constant value. The situation is the same around the multiples of the sampling frequency [1].

The spectrum of the step-linear approximated signal is shown on fig.2. The signal is approximated with k=8 linear sections and m=4 steps in each linear section, so that the number of steps along the period of the sinewave is again 32. In this case a couple of harmonics appears not only around the sampling frequency and its multiples, but

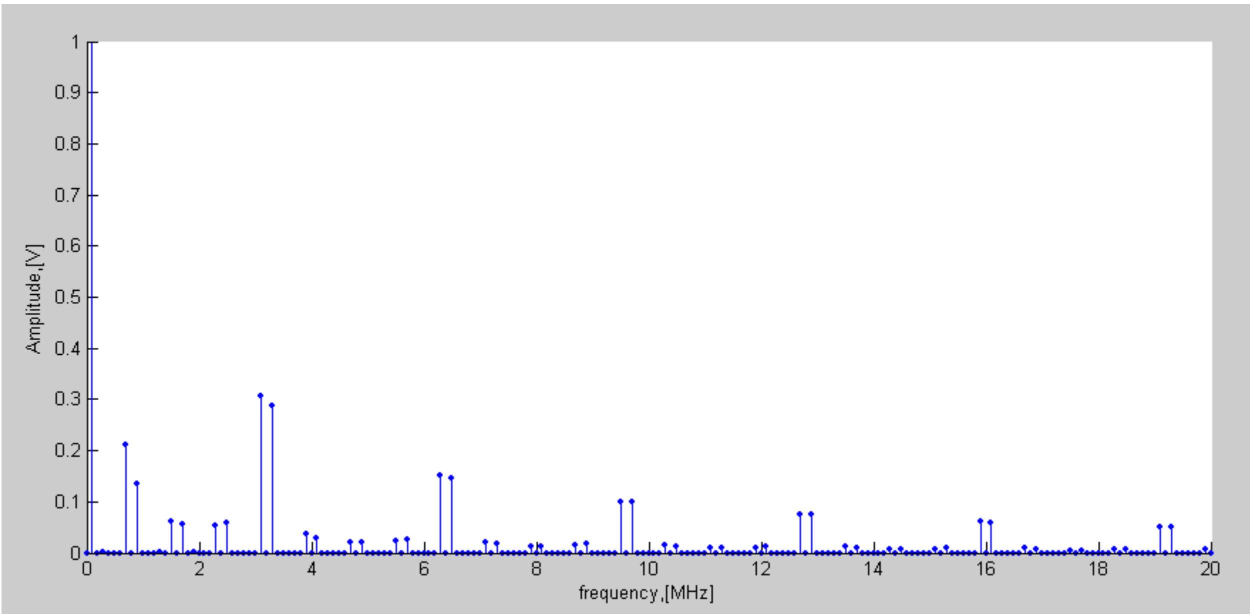

Fig.2. Spectrum of the step-linear approximated signal with 32 steps
(8 linear sections and 4 steps in every linear section)

also around frequencies, calculated by the following formula:

$$f_k = i * f_d + n * f_d / m \qquad (2)$$

where

f_k – frequencies defined by the number of steps in one linear section;

f_d – sampling frequency;
$i = 0, 1, 2, \ldots;$
$n = 1, 2, \ldots, m-1.$

On fig.3 are given the family curves for the amplitude of the main harmonic. For each curve parameter is the number of steps in a linear section – *m*. By increasing *m* and *k* the amplitude tents to the desired amplitude – 10 V.

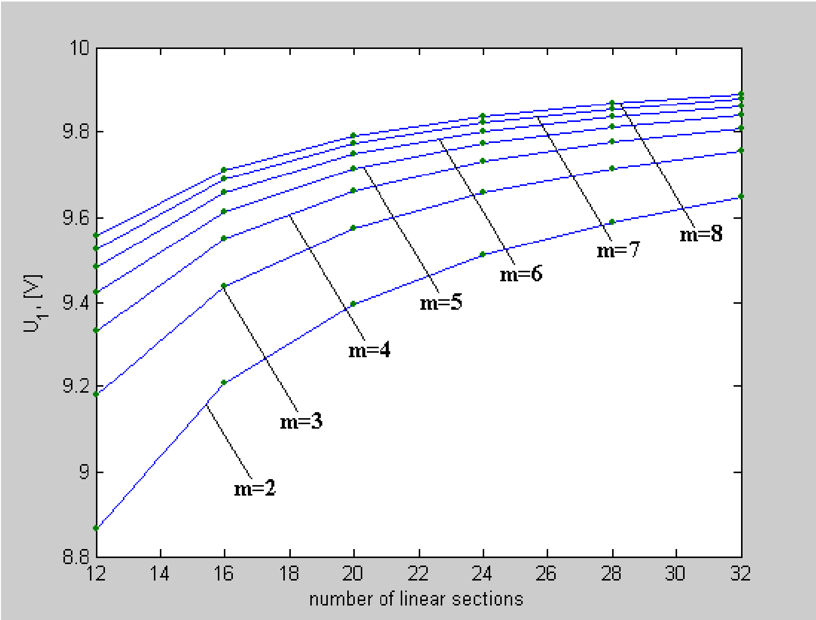

Fig.3. Family curves for the amplitude of the main harmonic

As a criteria for a good approximation very often is used the coefficient of NLD. The coefficient is calculated by the following formula for the coefficient of NLD:

$$NLD = \frac{\sqrt{\sum_{i=2}^{\infty} U_i^2}}{U_1}.100,[\%]$$

Changing values of the number of linear sections – *k* and number of steps in each linear section – *m* gives the family of curves for the coefficient of NLD, shown on the fig.4. It is obvious that the NLD for *m*=6, 7 and 8 do not differ very much, especially for number of linear sections more than 24. From these curves according to the needed values of the NLD can be chosen *m* and *k*.

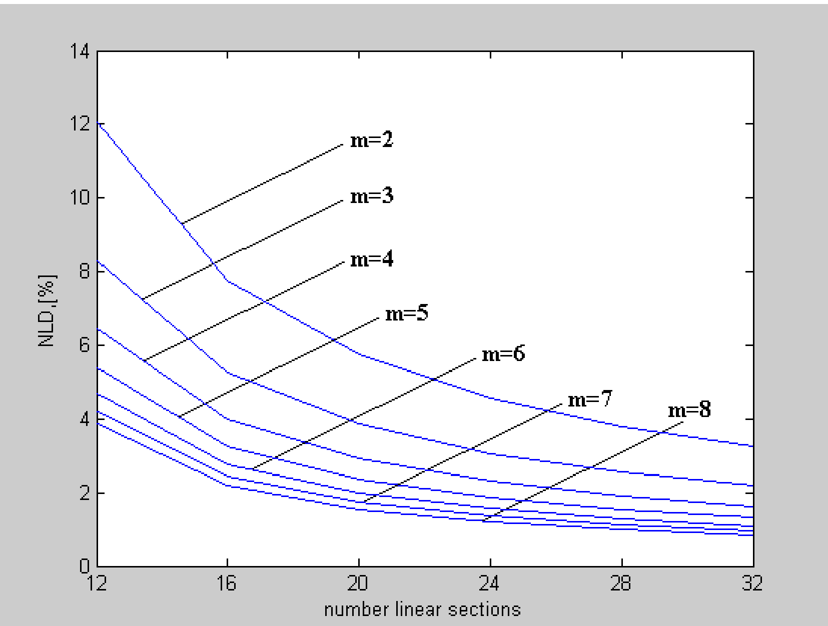

Fig.4. Family curves of the coefficient of NLD

Some of the results including step approximation are given in Table 1. The given data are obtained by choosing the same total number of steps for the two regarded methods of approximation. For the step-linear approximation are given 2 couples of values for *m* and *k*, resulting the same total number of steps.

Table1

Step-linear approximation			Step approximation	
k	m	Non-linear distortion, [%]	m	Non-linear distortion, [%]
4	2	7.77	24	7.57
3	3	8.29		
6	4	2.31	80	2.39
5	5	2.37		
6	8	1.20	160	1.16
9	5	1.15		
8	8	0.83	224	0.82
9	7	0.82		

From the table is seen that the NLD do not differ considerably so the choice of the method of approximation must be done according to another criteria [3].

CONCLUSIONS

The main contribution of the paper is the investigation of the spectrum of the step-linear approximated sinewave signal.

The investigation of the NLD shows that in many applications there is no need the approximated signal to be filtered before use.

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