SIGNAL AMPLITUDE INSTABILITY OF DIRECT DIGITAL SYNTHESIS GENERATOR

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Annotation

Direct digital synthesis (DDS) generators are becoming more and more popular today. DDS aim is to receive a signal of a random form with the given parameters. Most often generators, based on DDS, are used for sinusoidal signal formation.

Generated by DDS generator signal is highly precision. Signal parameters (frequency, amplitude and phase) are known in every time moment. Generator output signal is formed in digital and analog forms, therefore the structure implementing the DDS must contain a digital-to-analog converter (DAC) and a smoothing filter.

However, DDS generators suffer from amplitude instability in case when frequency is specified as a fractional value.

Analysis of amplitude instability

For research of amplitude instability, analysis is conducted on example of a math model of a sinusoidal signal. For this purpose, modeling software Mathcad is used.

Functional diagram of the DDS generator, shown in figure 1, consists of phase accumulator (PA), read-only memory device (ROM) and DAC. This diagram generates sinusoidal signal with a given frequency. Output signal frequency is defined by two parameters: frequency of a clock signal and binary number, which is written down in frequency register.

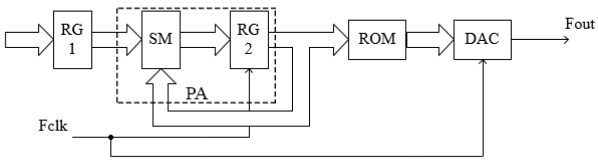

Figure.1. Function diagram of DDS generator

The considered signal is determined by formula (1):

$$v(j) = 511 \cdot \sin\left(j \cdot 2\pi \cdot \frac{f_{clk} \cdot q}{2^n} \right), \qquad (1)$$

where j – number of a clock interval; f_{clk} – frequency of the clock signal; q – decimal equivalent of binary number, determining signal frequency; n – digit capacity of phase accumulator.

Output signal frequency is determined by formula (2):

$$f_{out} = \frac{f_{clk} \cdot q}{2^n} = \frac{1}{T}, \qquad (2)$$

where T is a period of output signal.

To simplify the analysis taking into account formula (2), the signal is defined by means of the period by formula (3):

$$v(j) = 511 \cdot \sin\left(j \cdot 2\pi \cdot \frac{1}{T} \right). \qquad (3)$$

In figure 2, signal formed according to (3) at period T equals 13 clock intervals is shown.

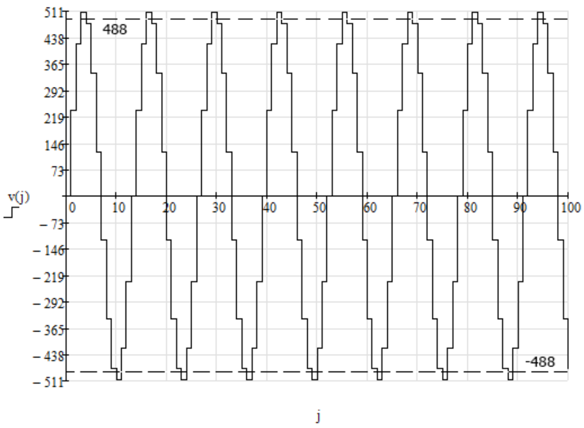

Figure 2. Signal with frequency $f = 1 / 13$ kHz

In figure 2, boundaries, limiting positive and negative peaks of signal, are shown.

It is shown that value of amplitude at set period $T = 13$ ms is 507.274 mV.

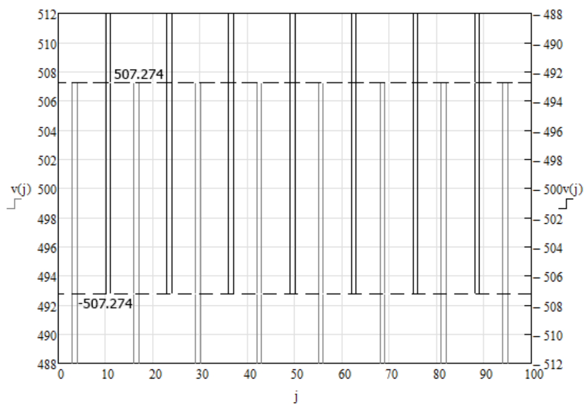

Figure 3. Positive and negative peaks of half-waves with a frequency of $f = 1 / 13$ kHz

In figure 3, peaks of positive and negatives half waves of sinusoidal signal are shown by different colors.

From figure 3 it follows that at a preset value of the period amplitude doesn't change. Amplitude remain invariable if the period is equal to any integer number, but as soon as the period is a fractional number, amplitude starts to change, as it is shown in figure 4 where the period of T equals 13.05 clock intervals.

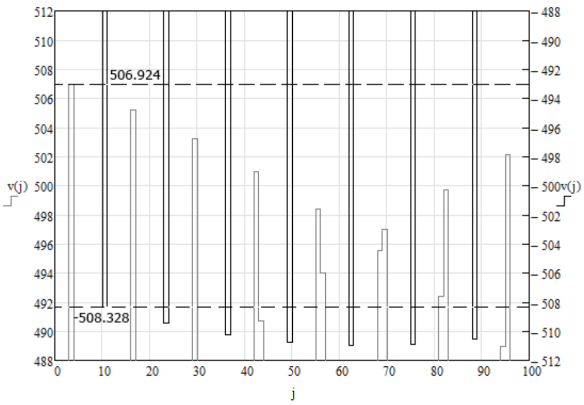

Figure 4. Combining positive and negative peaks of half-waves at the frequency f = 1 / 13.05 kHz

From figure 4 one can see that positive and negative peaks change in opposite directions: minimum of the negative half-waves corresponds to maximum of the positive ones.

The analysis of amplitude instability is carried out at different frequencies. Thus, the period is chosen from the following set of fractional numbers, which are chosen as a result of the preliminary research: (13.01; 13.02; 13.05; 13.09; 13.1) ms.

For the analysis of amplitude instability subject to the number of clock interval amplitude of positive and negative peaks of signal half-waves and the absolute value of the difference between them are calculated. The obtained data are presented in table 1.

With accordance to obtained data, graph of dependence of the amplitude on the number of clock interval (fig. 5) is constructed.

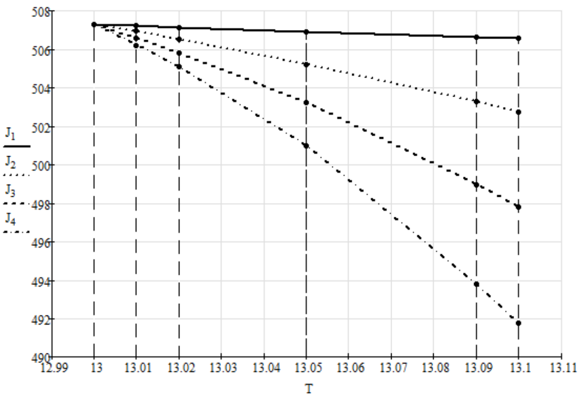

Fig. 5. Dependence of amplitude on the number of clock interval

In figure 5 dependence of the amplitudes of positive peaks of signal half-waves on the quasiperiod is shown by different types of lines: J1 line is a dependence on the first quasiperiod, J2 line – on the second, J3 line – on the third, J4 – on the fourth quasiperiod.

Table 1. Values of amplitude

	Period, ms	Amplitude of positive peaks, mV	Amplitude of negative peaks, mV	Difference of amplitudes, mV
$j_1 = 3, j_2 = 10$	13	507.274	-507.274	0.000
	13.01	507.205	-507.500	0.295
	13.02	507.136	-507.718	0.582
	13.05	506.924	-508.328	1.404
	13.09	506.635	-509.041	2.406
	13.1	506.561	-509.201	2.64
$j_3 = 16, j_4 = 23$	13	507.274	-507.274	0.000
	13.01	506.899	-507.782	0.883
	13.02	506.507	-508.252	1.745
	13.05	505.227	-509.437	4.21
	13.09	503.284	-510.496	7.212
	13.1	502.757	-510.669	7.912
$j_5 = 29, j_6 = 36$	13	507.274	-507.274	0.000
	13.01	506.581	-508.053	1.472
	13.02	505.831	-508.739	2.908
	13.05	503.237	-510.251	7.014
	13.09	498.994	-511.000	12.006
	13.1	497.796	-510.963	13.167
$j_7 = 42, j_8 = 49$	13	507.274	-507.274	0.000
	13.01	506.251	-508.311	2.060
	13.02	505.107	-509.179	4.072
	13.05	500.955	-510.769	9.814
	13.09	493.773	-510.549	16.776
	13.1	491.690	-510.082	18.392

Note: ji – number of a clock interval corresponding to positive and negative half-waves of peaks of a sinusoidal signal.

Conclusion

As a result of the conducted research it is revealed that amplitude instability decreases with change of the number quasiperiods, and the difference between positive and negative peaks of a signal increases almost twice. The worst amplitude instability from analyses values of the period is observed with period *T* = 13.1 ms and equal 3 % of nominal value.

The received results will make use for further connected with a problem of amplitude instability.

References

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