ANALYSIS OF DISTORTIONS OF A QUASI-HARMONIC SIGNAL WHICH ARE CREATED BY THE PHASE ASYMMETRY OF ITS COMPONENTS

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Izvestiya VUZ. Radioelektronika,
Vol. 32, No. 11, pp. 51-52, 1989

UDC 621.314.26(098)

The use of quasi-harmonic signals is one of the efficient methods for increasing the performance attributes of switching oscillators. The power of the higher harmonics of a 4-step quasi-harmonic (QH) signal amounts to approximately 1%, while the number of the higher harmonic closest to the first harmonic is equal to 15 (see [1]). An optimal method of generating a QH signal is the formation of the signal on the basis of Walsh functions, the output voltage being determined by the expression (see [1]):

$$U_{out}(\theta) = (Y_1 \,\text{wal}(1, \theta) + Y_5 \,\text{wal}(5, \theta) + Y_9 \,\text{wal}(9, \theta) + Y_{13} \,\text{wal}(13, \theta))\, E, \qquad (1)$$

where wal(i, θ) are Walsh functions; Y_i are expansion coefficients.

Using the multiplicativeness of Walsh functions, we represent Eq. (1) in the form

$$U_{out}(\theta) = N_0 E \,\text{wal}(1, \theta)\, \{1 + N_1 [1 + N_2 \,\text{wal}(8, \theta)]\, \text{wal}(4, \theta) + N_3 \,\text{wal}(8, \theta)\}, \qquad (2)$$

where $N_0 = Y_1$; $N_1 = Y_5/Y_1$; $N_2 = Y_{13}/Y_5$; $N_3 = Y_9/Y_1$, whence a block diagram derives for an oscillator (Fig. 1) which generates a QH signal having the frequency f (see [2]).

The difference between the time delays of the signals from SA1, SA2, SA3, as well as the nonidentical electrical length of the paths of the signal having the frequency $4f$, lead to nonfulfillment of Eq. (2) and to the appearance of distortions. The effect of the first cause on the magnitude of the distortions is well known (see [4]) and may be compensated by choosing the phases of the output signals of the control circuit.

Let us consider the influence of the second cause. The output voltage of SA3 is added to the supply voltage of SA1 directly (Fig. 1), as well as in the capacity of a component of the output voltage from SA2. In the presence of time delays in the circuits of SA2, the shape of the oscillator output voltage will be distorted (Fig. 2d). The signal U_{out} at the output will be represented as the sum of an undistorted 4-step signal under these conditions (Fig. 2c) whose spectrum dose not contain harmonics having the numbers 3-13, 19-29, etc., (see [5]), plus a pulse train $U^*(\theta)$ (Fig. 2e); the amplitude of the pulses is equal to EN_3, and their length is determined by the time delay between U_3 and U_4 (Figs. 2a, b).

The expansion of $U^*(\theta)$ into a Fourier series yields the following equation for the amplitudes of the harmonics:

$$\delta_{2k-1} = U_{2k-1}/U_1 = \sin|(2k-1)\,\varphi_8/2|\,\sin[(2k-1)\,\pi/2]\,\sin[(2k-1)\,\pi/4]\,\cos[(2k-1)\,\pi/8], \qquad (3)$$

where $2k-1 \neq |16r \pm 1|$, $r = 0, 1, 2 \ldots$

An analysis of Eq. (3) shows that the equality of the electrical length of the paths of the signals having the frequency $4f$ from SA3 to the supply circuit of SA1 is subjected to very high requirements. Thus, in order for the harmonics having the numbers 3-13 to reach a level of −35 dB the value of ϕ_8 must not exceed five degrees in modulus. This conclusion is valid both for positive and negative values of the quantity ϕ_8 - that is, both for the case of the delay of U_4 relative to U_3 and for the case when U_4 leads U_3.

It should be noted that the distortions considered cannot be eliminated by choosing the time arrangement of the output signals of the control circuit. When necessary, the reduction of the indicated distortions is achieved

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5 December 1988