The paper deals with design of slow generator of periodic waveforms the shape of which can be changed. The generator with the period adjustable by control signal could provide wide application.

Keywords:
genenerator, programmable waveform, converter, frequency range, period, control signal

1. Introduction

The generator is primarily determined to form various periodic courses that should control the mechanical devices simulating various responses, vibrations and changes of parameters. It could be utilized e.g. in medical or other areas.

To reach the most wide range of its utilization we regarded that beside its reliability and precision it has to be easily realizable with the lowest possible price, it could be portable or unit-built so that some of its features could be changed.

2. Block Scheme of Generator

Brief description of function-scheme is given in Fig. 1.

Let us consider e.g. 8-bit D/A converter. The memory has 8 outputs and 8 inputs. Binary counter counts on 8 figures. To form one output period \( u_2 \) \( 2^8 \) pulses from bistable trigger circuit are needed.

If we use \((u/f)\) converter, which will be dealt later, the range of frequencies is from 0.1 Hz to 10 kHz, then output periodical course \( u_2 \) has the highest frequency \( f_{\text{max}} = 20 \text{ Hz} \) \( (T_{\text{min}} = 50.0 \text{ ms}) \) and the lowest frequency \( f_{\text{min}} = 9.8 \times 10^{-4} \text{ Hz} \) \( (T_{\text{max}} = 17.1 \text{ minutes}) \). One period of waveform is composed from \( 2^8 \) values that must not be sufficient at some applications.

The more precise results we have achieved using 12 bit D/A converter and corresponding circuit. This has enabled reaching the further shifting to the lower frequency of period \( u_2 \).

In this case \( f_{\text{max}} = 1.2 \text{ Hz} \) \( (T_{\text{min}} = 0.83 \text{ s}) \) and \( f_{\text{min}} = 1.22 \times 10^{-4} \text{ Hz} \) \( (T_{\text{max}} = 2.27 \text{ hours}) \). The number of discrete values of the period of \( u_2 \) is \( 2^{12} \).

If we want to form e.g. output waveform \( u_2 \) in the shape of 10 damped waves then 102 discrete values appropriate to one quarter period cause 1% inaccuracy.

The high precision can be reached by use of 16 bit circuits or by connection with two 8-bit branches according to Fig.2.

Let us consider \((D/A)\), and \((D/A)_2\) 8-bit converters. From \((D/A)\), come out \(2^8\) voltage levels. To each of them the further \(2^8\) values are added so we get \(2^{16}\) values of \( u_2 \). In our case of periodic oscillation waveform about 1600,0 values for one quarter period are gained and the inaccuracy is less than 0.06 %.

Minimal period \( T_{\text{min}} = 13.1 \text{ s} \) \( (f_{\text{max}} = 0.076 \text{ Hz}) \) and \( T_{\text{max}} = 15 \text{ days} \).

To achieve the greater universality of the device we used converter \((u/f)\), at the input \( u_1 \). The connection is described later and it enables the changes of input frequency in four decades in the range from cca 10 Hz to 200 kHz.

In this case period of input voltage \( u \), \( T_{\text{min}} = \approx 0.3277 \text{ s} \) \((f_{\text{max}} = 3.05 \text{ Hz})\) and \( T_{\text{max}} = 55 \text{ min} \) \((f_{\text{min}} = 3.05 \times 10^{-4} \text{ Hz})\).

Connection diagrams according to Fig. 1 and Fig. 2 are not drawn because they can be easily formed in agreement with catalogue of details, except for converter \((u/f)\) represented in the first case by integrated circuit LM...
13700A, eventually LM 11700A produced by the firm National Semiconductors. This converter enables frequency changes from 0.1 Hz to 10 kHz caused by control voltage \( u \) from 1 V to 10 V with linearity higher than 0.1 %.

Amplifiers with current generators was taken from the catalogue of the firm given above.

![Fig. 1](image1.png)

**Fig. 1**
Block scheme of generator controlled by external signal
- \( u/f \) - voltage-to-frequency converter
- BKO - bistable trigger circuit
- CT - counter
- NO - zero setting circuit
- M - memory
- D/A - digital-to-analog converter

![Fig. 2](image2.png)

**Fig. 2**
Block scheme of very precise and slow generator controlled by external signal
- \( u/f \) - voltage-to-frequency converter
- D - frequency divider
- CT - counters
- NO - zero setting circuit
- M - memories
- D/A - digital-to-analog converters
- SC - summary circuit

The second converter \( u/f \) (it can replace the first one and vice versa yielding the changes of generator parameters) was composed from two integrated circuits of the firm KTE and this scheme with informative values is given in Fig. 3.

Details used in schemes in Figs. 1 and 2 were bistable trigger circuits - MH 7493, D-counters MH 7493, CT-2x MH 7493, EPROM - MH 82716, accumulator MHB 8282, C/A - MDA C08C, MAC01, MAC156.

In Fig. 4 there is a function generator that we have composed of two integrated circuits LM 13700 or LM 13700 A, LM 11700 A developed by the firm National Semiconductors. They consist of their own operational amplifiers and current generators controlled by the input control voltage. The frequency range is wider than 4 decades from 20 Hz. The scheme of the operational

![Fig. 3](image3.png)

**Fig. 3**
Voltage-to-frequency converter \( u/f \) - LM 231 produced by the firm National Semiconductors

![Fig. 4](image4.png)

**Fig. 4**
Analog-to-digital converter composed of two integrated circuits
- LM 13700 or LM 13700 A, LM 117 A

3. Conclusions

The article deals briefly with the design of programmable waveforms generator, parameters of which could be changed yielding the considerable accuracy of required waveform, especially long-lasting and by control signal adjustable period that could provide wide application.

The further details concerning converters \( A/V \), and \( A/D \), enabling this period control can be found in catalogues of given firms [1], [2]. In cases where there is no necessity to control the frequency by control signal it is possible to disconnect these circuits and replace them by precise pulse generators.

4. References