Light emitters for high-speed optoelectronic digital-to-analog conversion

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Abstract The paper is devoted to the study of the constructing possibility of a digital converter systems based on new optoelectronic principles that will expand the frequency range of the conversion, as well as increase the resolution, thereby improving accuracy. The functional scheme and basic configuration options of radiating elements in digital-to-analog converters are considered. A possible layers block diagram of the light emitting transistor with a quantum well between the base and the emitter is presented.

1. Introduction
One of the main elements in digital processing systems are digital-to-analog (DAC) and analog-to-digital (ADC) converters, since the speed and accuracy of the system largely depend on them. The main drawback of parallel-type digital-to-analog converters is the reduction of the system digit capacity while increasing the conversion speed, which makes it necessary to use lower work speeds. The solution of this problem can become the transition from electronic devices to optoelectronic converters, where digital-to-analog conversion will be performed in an optical form and, accordingly, the speed of operation will be inversely proportional to the rise time of the optical signal of optoelectronic emitters.

2. Functional diagram of optoelectronic parallel DAC and ADC
The simplest implementation of an optoelectronic parallel DAC and ADC is the functional diagram presented in Figure 1 [1] and Figure 2 [2,3].
The location of the LEDs in the module is carried out according to the following rule: the LED corresponding to a smaller discharge of the optoelectronic digital-to-analog converter is located at a distance greater than the previous one. We can distinguish the following options for the formation of a set of LEDs: linear, matrix and spiral [4].
By increasing the distance $l$, in accordance with Figure 3, the light flux of the LED, reflected from the mirror, will be proportionally shifted relative to the photodiode. Thus, by changing the distance $l$ between the LEDs $2_1$, $2_2$ ... $2_N$ and the photodetector 4, a weight proportional to the digital binary discharge is created. The total flux received by the photodiode is directly proportional to the value of the code, the value of the analog signal from the output of the amplifier 5 is directly proportional to the light flux of the set of LEDs $2_1$, $2_2$ ... $2_N$ [4].

3. Types of emitters in optoelectronic converters

When implementing such structures, the issue of light emitters of optoelectronic digital-to-analog converters capable of operating in the gigahertz range remains unresolved. The main type of light emitter used in optoelectronic conversion systems is LED. Its advantages include high efficiency of electrical to optical energy conversion; wide radiation direction; sufficiently high speed; ability to work both in pulse and continuous mode; high reliability and durability; small size. Gallium phosphide or GaAsP solid solution is most often used for the manufacture of visible radiation spectrum LEDs. Silicon, gallium arsenide or AlGaAs solid solution is often used for near IR diodes.

Quantum dots also have great potential for practical application. This is primarily due to the ability of control and vary the effective band gap when resizing. This will change the optical properties of the system: the wavelength of luminescence, the absorption region.

To create a light-emitting diode, a monolayer of quantum dots is placed between layers having p- and n-type conductivity. In this capacity, conductive polymer materials can be used, which can be easily combined with quantum dots.

The dependence of the energy spectrum on the size gives a huge potential for the practical application of quantum dots. Quantum dots can find applications in optoelectronic systems such as light-emitting diodes and flat light emitting panels, lasers, solar cells and photovoltaic converters, as biological markers, i.e. wherever variable, wavelength-tunable optical properties are required.

With the implementation of such structures, the question of emitting devices of optoelectronic digital-to-analog converters that are capable to operate in the gigahertz range remains unresolved. LEDs and quantum dot-based light emitters at the moment can not provide a sufficiently high working speed due to design features [5]. Developments are underway to create light-emitting transistors that have several advantages over LEDs: high temperature stability (temperature control is not required), which means there are practically no lattice vibrations; low current consumption (due to the amplifying properties of the transistor); etc.

The paper proposed a new layout of light emitters layers, which is a bipolar light-emitting transistor, containing a quantum well between the base and the emitter. The block diagram of the element layers is shown in Figure 4 [6].
Figure 4. Block diagram of the light-emitting transistor layers

4. Conclusion
In order to increase the speed of signal conversion without reducing the bit width, it is possible to use optoelectronic DAC and ADC. An emitter capable of operating in the gigahertz range can be a light transistor in which a quantum well is located between the base and the emitter.

References
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