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Research Article

Generator of Modulated Signals on Transistor Element with Punch Effect

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Abstract We propose a generator of modulated signals on a transistor whose amplitude of the output signal is regulated by the operating voltage and the value of the input signal, and the power of the frequency of the input signal.

Keywords generator, transistor, output signal, power

1. Introduction

At present, the attention of researchers is drawn to the development of high-frequency silicon and arsenide gallium diodes [1], which can be used to create generators and devices with nanosecond fronts. To start them you need diodes with a sharp recovery and accumulation of charge. However, their application to launch high-speed laser semiconductor emitters, control optical switches on Pockels cells and Kerr was difficult, and in some cases unacceptable [2].

In addition, elements creating pulses with controlled amplitude and duration are in demand for the design of electronic blocks of musical instruments, automatics and signaling devices for vehicles, as well as household automatics, light controllers and temperature [3].

Improvement of regulatory elements is possible on new physical principles and mechanisms of their functioning. Thus, the principle of phase control is used in power control devices. The change in power is realized by controlling the moment of switching on the thyristor (triac) with respect to the transfer of the mains voltage through zero, which is controlled by the capacitor and resistors connected to the control electrode. The charging speed of the capacitor is controlled by a variable resistor. Despite the fact that such a method of power control is widely used, however, it does not give the desired control for luminaires, and for the manufacture on this principle even simple control devices requires a large number of elements [4].

In this paper we propose a generator of modulated signals on a single transistor element with the punch effect.

Experimental and Discussion

The transistor element is designed as follows. On silicon substrate of n^+-type the *n*-type epitaxial layer with a carrier concentration of $5\cdot10^{16}cm^{-3}$ and thickness of 6÷10 μm is grown. Further, in the epitaxial layer by means of diffusion of boron *p*-type base region is formed with thickness of 2.0÷2.5 μm with carrier concentration of $2\cdot10^{17}cm^{-3}$. Then, by diffusion of phosphorus into the base region a strongly-alloyed n^{++}-type emitter region with carrier concentration of $5\cdot10^{20}cm^{-3}$ and thickness of 1.5 μm is obtained. As a result, two rectifying junctions are formed in the end structure, i.e. one with $n^{++}p$ -junction, and the other with *p-n* -junction. This configuration is structurally similar to the bipolar transistor, in which a strongly-doped n^{++} -type region could be regarded as an emitter, and p -type region as a base whereas *n*-type region as a collector.

Current-voltage curves of $n^{++}pnn^{+}$ - structures in reverse bias is shown on Fig.1.

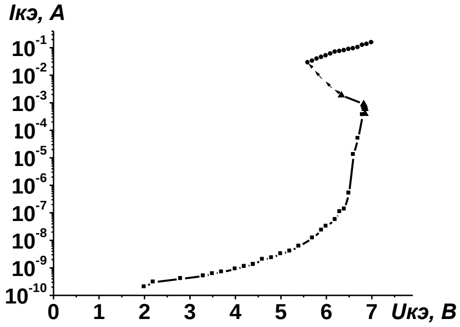


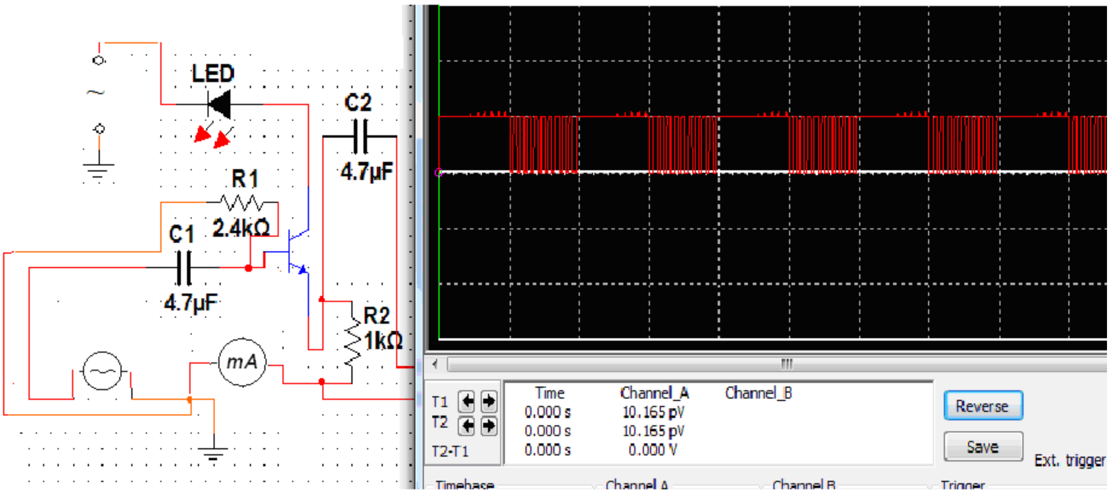
Figure 1: Volt-ampere curve of $n^{++}pnn^{+}$ -structure in the back displacement mode

In the locking mode of $n^{++}-p$ -junction, as the voltage increases, the reverse current increases steadily until it reaches 10^{-7} A and then one witnesses the sharp increase in the current value and succeeded by negative differential resistance region, which is then replaced by a positive increase in the current value.

The basis of the transistor element is -structure with ohmic contact to the base region of the p-type. That is, it is structurally analogous to a bipolar transistor structure, in which a heavily doped region of type can be taken as an emitter, and a region of type for a base and a region of type for the collector.

In this thin-base structure, we observed a punch effect [5]. In particular, in the regime of locking the transition with a heavily doped region, the expansion of the space-charge regions occurs up to the closing of directly and backwardly shifted transitions [6]. Namely, in the regime of closing adjacent transitions, the current is limited by the resistance of the direct-shifted pn junction, and the power dissipated is insufficient for irreversible breakdown. The resistance of a locked-in transition is less than that of a direct-transfer transition, where the number of generated carriers is limited (constant).

Due to the small capacity, ultra-fast response is provided, and high conductivity with a small area (600x600 μm^2) meets the requirements of miniaturization. Thus, the limiting frequency of the transistor current transfer coefficient for a circuit with a common emitter is not less than 120 MHz; maximum emitter-base voltage at a given reverse current of the emitter and open collector circuit 4 ÷ 6 V; Se is the emitter junction capacitance less than 5 pF; tk is the time constant of the feedback loop at a high frequency: no more than 500 ps..



	Time	Channel_A	Channel_B
T1	0.000 s	10.165 pV	
T2	0.000 s	10.165 pV	
T2-T1	0.000 s	0.000 V	

Figure 2: Electronic circuit of the generator of modulated signals on a transistor-structure

The electronic circuit of the generator of modulated signals on a transistor-structure is shown in Fig. 2. In this generator, the supply voltage, with one half-period provided by the LED, is 6 volts. With respect to the LED, the emitter junction is in the locking mode. A modulated signal is supplied to the base electrode from a generator of corresponding pulses (sinusoidal, trapezoidal or rectangular shape) with a voltage less than one volt. The output signal is removed from the load and fed to the next link, in our case an oscilloscope.

Thus, the proposed electronic circuit provides modulation of the input (sinusoidal, rectangular, etc.) signal using a single bipolar transistor with low-voltage power.

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