Bulgarian Academy of Sciences
Space Research in Bulgaria, 6
Sofia . 1990

Functional generator capacity increase via new building elements

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Electrostatic particle analyzers range among the widest spread components of space equipment. There exists a great variety both in construction developments: flat, cylindric or semispheric deflectors, quadripole analyzers, linear focussing and amplifying systems, spherical and cylindric probes, and in the problems to be resolved with them. In any case, the operational principle is based on the fact that a voltage is applied betwen the electrodes of an electrostatic system which generates an electric field of selected parameters (direction and voltage) in a specified area. The charged particles trapped into this area are subject to the field effect, their response is an indication for their examined parameter: charge, energy, and mass.

Under different measurements and configuration, the voltage applied between the electrodes of the system is most diverse in form: linearly varying, sawtooth, exponential, step-like, etc.

Some specific requirements for the electronic space equipment should be met by the voltage generators: small size, light weight, low power consumption, high reliability. Sometimes, however, the maximum values of the voltage are significant, of the order of KW, hence, the above mentioned requirements become a serious problem.

A frequently used approach in the design of such generators employs intermediate convergence into voltage of significantly higher frequency, modulated by a driving signal and amplified via transformer to the necessary level, after which the signal in the secondary side of the transformer is detected to reconstruct the shape of the driving signal. The stabilization of the output amplitude is achieved via a comparing amplifier and a negative feedback.

The criticism with regard to this implementation refers mainly to the transformer, due to its relatively large size and weight, and complicated technological production, especially that of the secondary wiring: large number of wires, high-voltage insulation, etc. The optimum efficiency of the used transformers is obtained below 30 KHz which, in turn, is accompanied by higher values of the filter condenser. The energy losses are thus unjustifiably great, especially keeping in mind that the serviced device is electrostatic, i. e. with almost zero consumption.

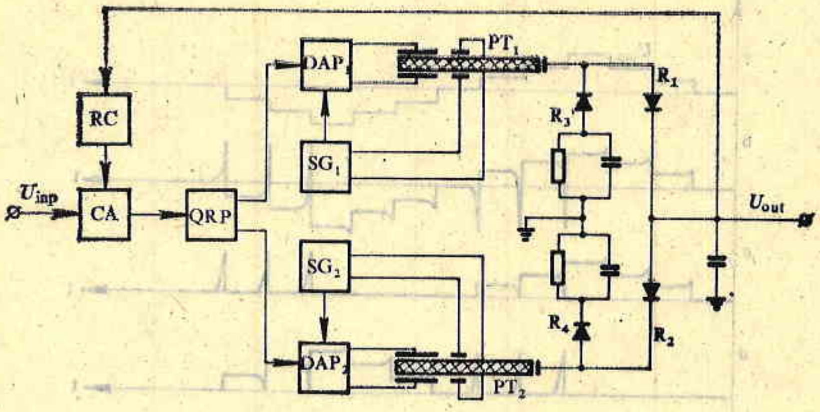

Fig. 1

In the search of new solutions, great prospects are opened by piesoceramics, the material of our century. The use of piesoelectric transformers of voltage with low-charge capacity is quite suitable in electrostatic devices: the components are simple and highly technological, the weight is abruptly reduced, as well as the size and power consumption. The generator described in [1] is of much better qualities than the generators with feromagnetic transformers. The resonance frequencies, being at the same time operational frequencies of the piesotransformers and producing the optimum efficiency together with the maximum coefficient of transmission by voltage, are samples of 30 to 70 mm length and 1 mm thickness within the limits of 30 to 200 kHz.

The converting part of the above two types of generators plays the role of a voltage amplifier. Unfortunately, in both cases the high-voltage amplifiers thus developed do not have all the advantages of the low-voltage electronic amplifiers: they are of single polar output, and the steepness of the descending slopes is significantly worse than that of the ascending ones for the pulse signal reproduction, since it is determined by a time constant of the output circuits throughout the discharge process.

On the basis of piesoelectric voltage transformers a high-voltage amplifire with bipolar output and improved steepness of the descending slopes may be developed [2]. Its block diagram is shown in Fig. 1 and the operation principle is the following: let a bipolar voltage of stepwise form (shown in Fig. 2a) be produced into the low voltage part of the generator (not shown in the Figure). This voltage enters one of the inputs of the comparing amplifier CA, at the other input of which a voltage for negative feedback is supplied from the output of the high-voltage part through the reversive converter RC. In dependence on its polarity, the signal from the CA amplifier output is directed by a dividing circuit to polarity SRP or to the driving input of the first driven amplifier of power DAP_1 (for example, under positive polarity) or to the driving input of the second driven amplifier of power DAP_2 (under negative polarity respectively). This signal modulates the signals from the two oscillator circuits SG_1 and SG_2 which, being amplified in power by DAP_1 and DAP_2, enter respectively the exciting sectors of the piesotransformers PT_1 and PT_2. The frequency of the oscillators SG_1 and SG_2 is maintained even at the respective resonance frequencies of the piesotransformers PT_1 and PT_2

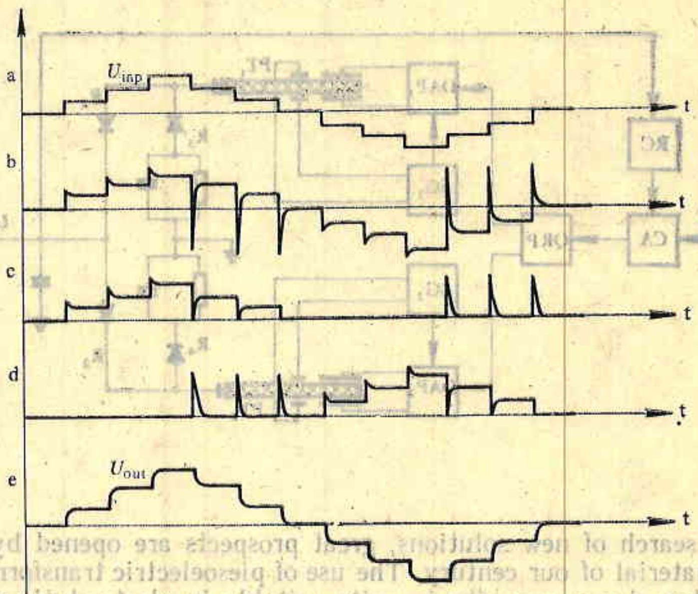

Fig. 2

via the sectors for feedback. For a positive signal with acsending slopes, the driving DAP_1 voltage is zero and PT_2 is not functioning. PT_1 amplifies in resonance mode the signal form DAP_1 which is detected after the output sector of the one-way rectifier for positive polarity R_1. The reconstructed form of the input signal is multiply amplified by voltage, which is defined with the coefficient of transmission of the reversive converter RC.

Thus far, this process does not differ from the performance of known generators. Under descending slopes of the input signal a slow discharge of the output circuits does occur. This delay of the output signal with respect to the input one results in a reverse disbalance at the input of the comparing amplifier CA. The polarity of its output signal changes respectively, namely at the first instant by a value close to that of the supply voltage (Fig. 2c). DAP_1 receives zero at its driving input and PT_1 stops functioning. Then PT_2 starts operating at the output of which a one-way rectifier for negative polarity R_2 is introduced. Thus, active recharge of the output circuits is obtained until the setting of a balance at the input of CA, after which PT_2 is switched off and PT_1 continues its normal performance.

Similar procedures are repeated for the signal of negative polarity at the input, then PT_2 performs normally and the recharging of the output circuits at descending slopes is made via the instantaneous swtching on of PT_1. The piesotransformers PT_1 and PT_2 are not mutually shortened, since their simultaneous operation is not possible and in passive state their output resistance is huge. Supplementary rectifiers R_3 and R_4 are introduced for symmetry. Fig. 2 c, d, e shows the signal shape at the driving inputs of DAP_1 and DAP_2 and at the generator output.

The generator of bipolar output allows to increase the capacity of the equipment and to expand the scope of scientific research, as by one and the same electrostatic device particles of different mass, sign of charge and energy are analysed.

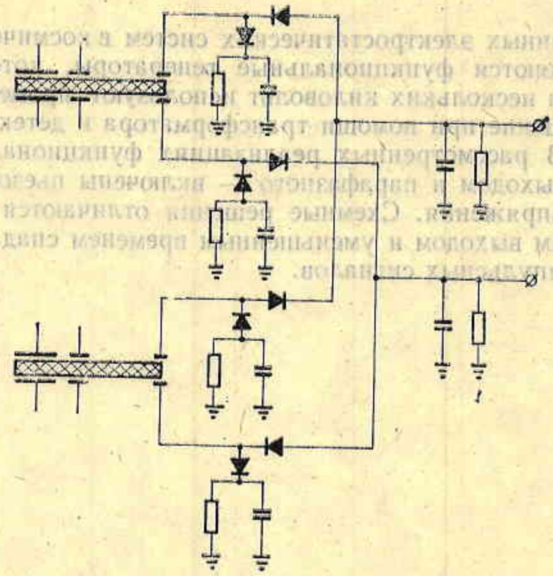

Fig. 3

Using the same block diagram, a paraphase generator [3] may be developed with slight changes. For the purpose, as it is shown in Fig. 3, at each piesotransformer one more output electrode is added, equipotential to the first one, which is simple for technological realization. For the illustrated mode of coupling, two symmetrical paraphase outputs are obtained, as each of them is in addition bipolar and of enhanced fast performance of the descending slopes.

This generator may find applications, for example, in electrostatic deflectors for particle analysis of positive charges as well as of negative. Many applications in other physical instrumentation are possible too.

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Расширение возможностей функциональных генераторов при использовании новых градивных элементов

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(Резюме)

Для питания различных электростатических систем в космической научной аппаратуре применяются функциональные генераторы, которые при напряжениях порядка нескольких киловольт используют промежуточное преобразование, повышение при помощи трансформатора и детектирование выходного сигнала. В рассмотренных реализациях функциональных генераторов — с одним выходом и парафазного — включены пьезоэлектрические трансформаторы напряжения. Схемные решения отличаются от известных своим двухполярным выходом и уменьшенным временем спада фронтов при воспроизведении импульсных сигналов.