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Sweep Generator for Probe Experiment Onboard Meteorological Rocket

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The velocity and maximum altitude of meteorological rockets, e. g. of the "Centaurus" type [1], are much smaller in comparison with those of the geophysical rockets, e. g. of the "Vertical" type. Whereas at an altitude of $H = 100$ km the velocity of meteorological rockets is about 1 km/s and they reach an altitude of $H_{max} = 150 \div 180$ km, the rockets we use for probe experiments reach an altitude of $H_{max} = 1{,}510$ km and at $H = 100$ km their velocity is about 8 km/s [2, 3].

The principle of operation of the block circuits of the Bulgarian measurement instruments launched until now in irrecoverable containers of the geophysical rockets "Vertical" 3, 4 and 6 (in 1975, 1976 and 1977) are given in [4, 5]. In an experiment with a meteorological rocket a full V-A characteristics from the collector of a spheric ion trap (SIT) from retarding to saturation region may be obtained at much smaller voltage amplitudes of the sweep voltage of the outer grid of a trielectrode SIT (U_{SIT}) in comparison with the amplitudes used until now of $U_{SIT} = (+15 \div -5)$ V [6].

According to our calculations, the necessary voltage U_{SIT} is symmetric to the zero (container body) with an amplitude $(+1 \div -1)$ V. As the potential to which the body will be charged may reach $+3 \div 4$ V, a saw-tooth voltage (wave) generator (SWG) circuit is used for obtaining U_{SIT} with a variable amplitude — over a period of U_{SIT} $(+5 \div -5)$ V.

Besides that, the service control system in experiments with meteorological rockets is simplified — there are no onboard commands for simultaneous as well as synchro-impulses.

The telemetric system is also of limited capacity, and the sweep voltage U_{SIT} is not telemetrically controlled, as had been the case in the experiments carried out until now.

Consequently, in the design of a SWG we must pay attention first of all to the amplitude stability of the voltage generated, because instability in the period may be judged from the duration of the V-A characteristics clearly differentiated from one another.

In accordance with the above requirements on the qualities of the sweep generator for SIT installed on a meteorological rocket, we propose an amplitude-stabilized symmetric SWG made with integrated circuits. The complete electric circuitry of the SWG is shown on Fig. 1, and the time-diagrams at certain concrete points are given on Fig. 2.

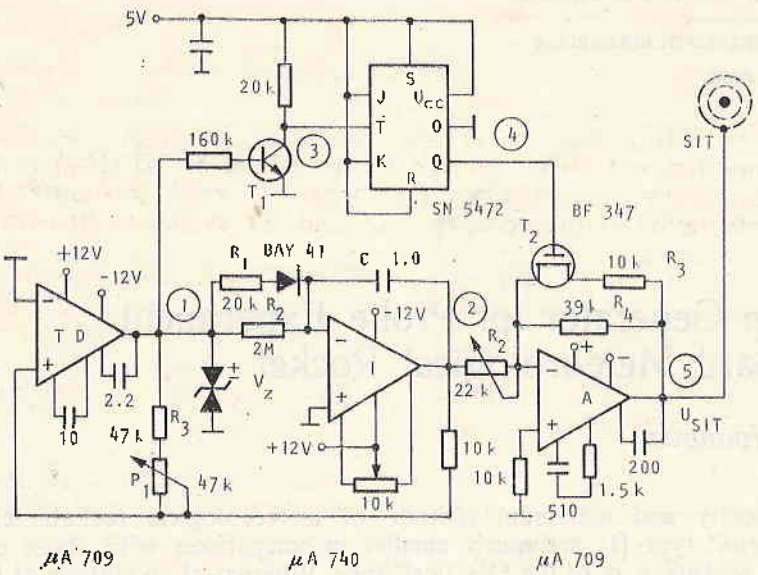

Fig. 1. The complete electric circuitry of the SWG

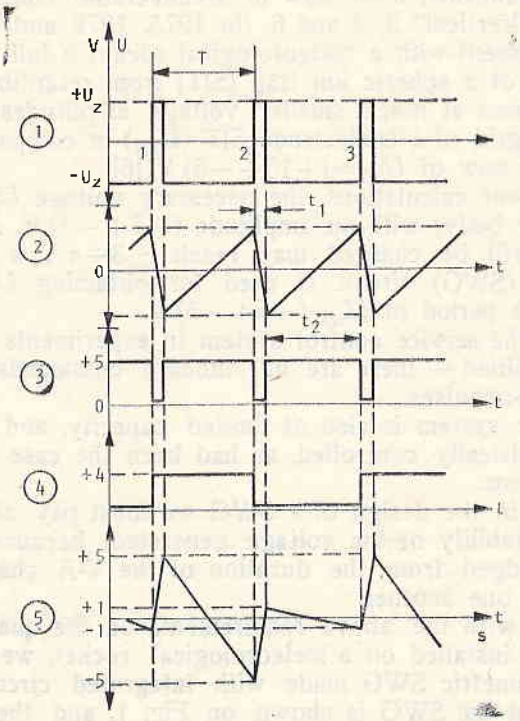

Fig. 2. The time diagrams at concrete points

The first step of the SWG is a threshold detector TD (comparator), while the second one is integrator I — both of them with operational amplifiers μA 709 and μA 740. The voltage at the output of TD (point 1) switches from $-U_z$ to $+U_z$ when the linearly increasing voltage at the output of I (point 2) becomes sufficiently positive so that the point A voltage rises above zero. The symmetrical and stable voltage at the output of TD (U_{TD}) is maintained by two equal Zener diodes oppositely connected, which guarantees the precision of integration of the voltages $\pm U_z$ and the symmetry of both threshold levels of switching.

The U_{TD} voltage is switched from $+U_z$ to $-U_z$ when the much more rapidly decreasing (linearly) voltage from the output of I (U_I) during the reverse run of the SWG (t_1) becomes sufficiently high so that the voltage at point A goes below zero.

The value of the potentiometer for the adjustment of the frequency of U_{SIT} is selected in such a way that the necessary period $T=1$ s shall be within the limits of ± 0.3 s.

The change of U_I in the positive direction (direct run t_2) is much longer in time, compared with t_1, because the time constant of the capacitor C in the feedback of I changes with the change of polarity of U_{TD} ($\pm U_z$). When $U_{TD}=+U_z$, C discharges mainly through the resistor R_1 and a diode in series, and the time constant R_1C is much smaller when $R_1 \ll R_2$. When $U_{TD}=-U_z$ the capacitor C is charged through R_2 much more slowly with a time constant R_2C. The values of R_1 and of R_2 are selected in such a way that at fixed levels $\pm U_z$ the reverse run shall be 1% of the direct one (in this case $t_1 \ll 10$ ms).

The transistor T_1 (buffer, invertor and limiter) forms the necessary voltage (point 3) for the command of the trigger J-K (logical integrated circuit SN 5472) according to clock input.

One of the outputs of the trigger (Q) feeds voltage (point 4) for the command of the key of a field transistor (FET-BF 347), connected in the feedback circuit of the inverting amplifier (A) of the voltage from I. In this way over one period the resistor R_3 is connected parallel to R_4 and the coefficient of amplification of A decreases five times (point 5) according to the requirements for the amplitude, as mentioned in the beginning.

The adjustment and fine tuning of the amplitude of the voltage U_{SIT} is done with the potentiometer P_2.

The circuit has been designed at the Central Laboratory for Space Research of the Bulgarian Academy of Sciences and the tests carried out with it demonstrated stable operation in a wide range of temperatures.

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Генератор развертки для зондового эксперимента на метеорологической ракете

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(Резюме)

Зондовый метод исследования плазмы с помощью сферической ионной ловушки широко применяется при прямых космических измерениях. В сообщении коротко рассмотрены особенности эксперимента на метеорологической ракете в сравнении с использованными до сих пор для ионосферных измерений с болгарской зондовой аппаратурой геофизическими ракетами „Вертикаль". Применяется триэлектродная ловушка, к внешней сетке которой приложено пилообразное напряжение для получения характеристики зондового тока. Представлена принципиальная схема примененного генератора пилообразного напряжения с переменной амплитудой, разработанная на основании поставленных специфическим экспериментом требований.