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ELEMENTS OF HIGH-VOLTAGE NANOSECOND PULSE GENERATORS ON COAXIAL CABLES

By

P. S. Anan'in, A. G. Sterligov, et al

EDITED TRANSLATION

FTD-ID(RS)T-0374-79 21 March 1979

MICROFICHE NR: FTD-79-C-000420

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English pages: 6

Source: Trudy Nauchno Issledovatel'skogo Instituta Yadernoy Fiziki Elektroniki i Avtomatiki, Issue 2, Moscow, 1972, pp. 97-99

Country of Origin: USSR
Translated by: Sgt Martin J. Folan
Requester: FTD/TQTD
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А а	*А а*	A, a	Р р	*Р р*	R, r
Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

*<u>ye</u> initially, after vowels, and after ъ, ь; <u>e</u> elsewhere.
When written as ё in Russian, transliterate as yё or ё.

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English	Russian	English	Russian	English
sin	sin	sh	sinh	arc sh	sinh^{-1}
cos	cos	ch	cosh	arc ch	cosh^{-1}
tg	tan	th	tanh	arc th	tanh^{-1}
ctg	cot	cth	coth	arc cth	coth^{-1}
sec	sec	sch	sech	arc sch	sech^{-1}
cosec	csc	csch	csch	arc csch	csch^{-1}

Russian	English
rot	curl
lg	log

ELEMENTS OF HIGH-VOLTAGE NANOSECOND PULSE GENERATORS ON COAXIAL CABLES

P. S. Anan'in, A. G. Sterligov, V. G. Tolmachev, Yu. P. Usov

Interest in high-voltage nanosecond pulse generators is growing continually. Nanosecond pulse generators with an amplitude of several dozen kV are widely used in physical experiments and in technology [1]; those of hundreds and thousands of kV are still unique [2].

These generators are used for feeding electrooptic and electron-optic modulators, spark chambers for studying the physics of breakdown of dielectrics, for checking high-voltage pulse devices, etc.

As the forming and transmitting elements in these generators, as a rule, we use radio-frequency coaxial cables; as switches - spark gaps, usually filled with nitrogen at a pressure of 6-10 atm. If the dielectric strength of insulation and wide-band state of coaxial cables turns out to be sufficient for forming pulses with an amplitude of several dozen kV and the pulse front width is less than 1 ns, then with the designing of the gap, we encounter certain technical difficulties, since the condition of wide-bandedness and sufficient dielectric strength of insulation and mechanical strength of the spark gap are contradictory.

One of the schemes of the generator is given in Figure 1. The pulse, at load resistance z_H, occurs after actuation of gap P. In the diagram of Fig. 1,a

$$z_H = \rho;\ t_u = 2\ell v^{-1};\ U_u = 0{,}5 U_o \quad ,$$

where ρ - is the wave resistance of the cable; ℓ - length of the forming cable; v - speed of propogation of the wave along the cable; t_u - pulse width on load; U_o - charging voltage; U_u - pulse amplitude on load; $R_3 >> \rho$ - charging resistance.

The change in pulse width is accomplished by a change in value ℓ.

In the diagram in Fig. 1,b, the pulse width t_u changes with the aid of a shearing gap P_c. The gaps P and P_c are structurally identical, if $\rho < z < \infty$. U_u depends on relationship z_H and ρ, and the length of cable $\ell \geq 0.5\ vt_{max}$ (t_{max}-greatest of necessary pulse widths formed in the circuit). The stability of value t_u is determined by the stability of actuation P_c and is normally equal to several nanoseconds; therefore, the use of this scheme is expedient with t_u several dozen nanoseconds and more.

If stability t_u proves to be insufficient, then it is expedient to use the scheme given in Fig. 1,b [3]. In this scheme, $t_u = 2\ell_{k3} v^{-1}$ (ℓ_{k3} - length of shorted section of coaxial cable, switched in parallel $z_H >> \rho$). A decrease in amplitude of repeated pulses is achieved with the aid of a congruent ρC-network (C - noninductive capacitance, the value of which is determined by the width of formed pulses and by the admissable level of repeated pulses).

The non-standard elements in these circuits are gaps P and P_c, a congruent ρC-circuit, voltage divider Д, used for obtaining the control pulse and a pulse for triggering the shearing gap P_c.

The discharging dèvice is presented in Figure 2. The casing of the gap consists of a central cylinder 1 and two sleeves 5. In the cylinder there is an imput 7 for the cable, along which is fed the igniting pulse, and an aperture for the manometer and a nipple valve, through which, to the gap, the nitrogen begins. Positioned in the sleeves are coaxial inputs for the forming and transmitting cables. The inputs are moved relative to the casing by pinions 3 and 8. Thus, the distances between electrodes 2 and 6 of the gap are regulated. The coaxial leads are hermetically sealed with the aid of bellows 9, an electrical hook-up of the external conductor of the coaxial is accomplished through slipping contacts positioned along the perimeter of the isolator 10.

The electrodes of the gap are made of molybdenum, the housing is brass, the pinions and clamps of steel, the high-frequency tract is silver-plated, and the insulation parts from organic glass.

Along with the normal mode of operation for three-electrode discharges, when the discharger is ignited by removing voltage from the igniting electrode [4], we find possible a mode of igniting the discharger by a feed to the igniting electrode of a pulse with a polarity which is reverse to the polarity of the charging voltage U_o. In this case, the spark gap between the igniting electrode and the electrode connected with the transmitting cable is strengthened. The stability of actuation of the discharger is insured by the inter-illumination of the spark gaps.

If the discharger is used as a shearer, then only the function of the electrodes changes: electrode 2 is made in the form of a trigatron, the other - connected in short with electrode 6. The pulse on the load is transmitted through leads 4 and 7. The pulse for igniting the shearing discharger is removed from the voltage divider Д, passes through the delay line ЛЗ (Fig. 1,b), which gives value t_u, intensifies to 8-10 kV, and is fed to the trigatron.

The congruent ρC-circuit is coaxial. As resistance ρ we use the noninductive resistance TVO-5. The value of capacitance C (Fig. 1,b) is selected from an analysis of the transition process in the circuit with switching on of discharger P. Thus, with t_u=20 nsec, ρ=75 Ω, and with conditions that the maximum amplitude of repeated pulses does not exceed 5% U_u, C=3.25 nf. With the same values for ρ and C and with t_u=2 nsec, the amplitude of repeated pulses is equal to 0.5% U_u. Structurally, capacitance C - five connected in parallel noninductive condensers K-15-4.

The formation of pulses with large width with the aid of a shorted section of cable and ρC-circuit is hardly expedient since, in this case with the accepted amplitude of repeated pulses, it is necessary to increase capacitance C. This leads to an increase in energy commutated by the discharger, and accelerates the wear of the electrodes of the discharger.

The coaxial congruent voltage divider Д has two independent outputs [1]. The high-voltage arm of the divider is formed by capacitance C_1 between the central vein of the divider and the copper plate insulated by a polyethylene film from the divider's casing. The coefficient of voltage division $K=C_2/C_1$. The control pulse is removed with the aid of the coaxial cable from the plate which is positioned in the cylindrical part of the divider, and the pulse for igniting the shearing discharger - from the plate in the cone-shaped transition.

With the use for formation and transmission of a pulse of the RK-50-9-II cable, value u_o can reach 60 kV, and RK-50-II-II - 100 kV. With a frequency of repetition of pulses no greater than several Hertz, we can use, as a source of charging voltage U_o, any low-power high-voltage rectifier.

The three-year experience of using the described elements in the various circuits of generators showed their sufficient reliability, simplicity of adjustment, ability for rapid change of the circuit and operating conditions.

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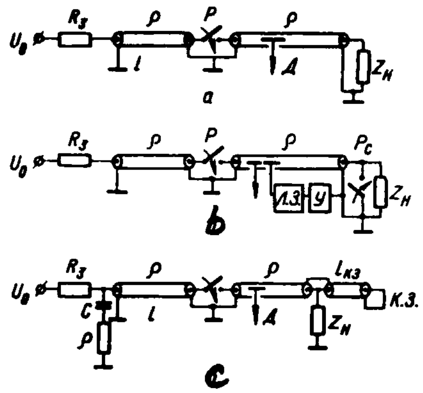

Figure 1. Diagram of the generator.

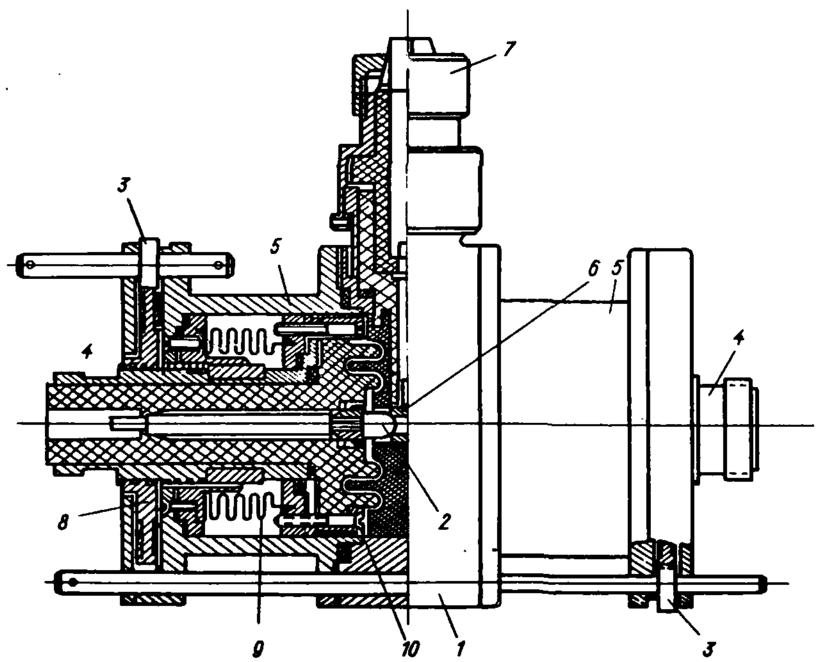
Figure 2. Discharger

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