SYSTEM POWER MICROWAVE IMPULSE COMPRESSION BASED ON DOUBLE FORMING LINE

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Abstract

In this article presents the results of an electrodynamic modeling and optimization of the design of the compressor based on double forming line (DFL), proposed new structure to effectively accumulate and output energy from a multimode resonator with working mode $H^{\square}_{01}$.

THE PRINCIPLE OF OPERATION OF THE COMPRESSOR BASED ON DFL

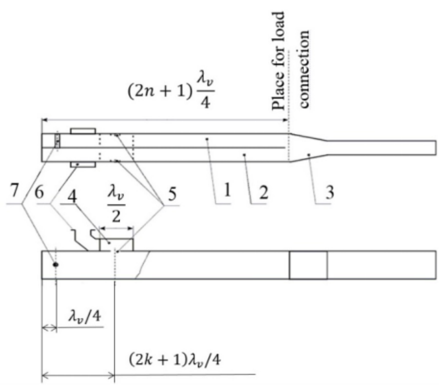

Figure 1: Compressor based on DFL.

In the compressor which bases of the double forming line (DFL) resonator-energy accumulator (see Fig. 1) consists of two waveguides 1, 2 long odd number of quarter-wave [1,2]. On the one hand, these waveguides are shorted, and with the opposite side waveguide 3 is connected to these waveguides, whose height in this location is twice the height of the waveguide drive. A standing wave is excited in the drive so that throughout the process of accumulation of the field in the two waveguides are strictly antiphase. Due to this fact and because of the special choice of the length of the waveguide cross-sectional load connection antinode of the electric field is realized. The waveguide load is excited at the same time load the fields of the two waveguides drive in opposite to the load and the energy does not go (see. Fig. 2 a).

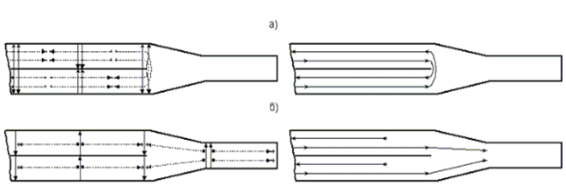

Figure 2: The field structure and scheme of wave propagation in a compressor with DFL. a-accumulation, б-output after $t=l/v_{gr}$.

Switchboard (position 7 in Fig. 1) is placed inside of any waveguides spaced at the distance $\lambda_в/4$ from the shorted end. Its inclusion leads to the fact that the phase of the wave reflected from the left end, changes to π. After a time, l/v_g (see Fig. 2, b), this wave reaches the section connecting the load, radically changes the conditions for the excitation of the waveguide 3, now the waveguide load is exciting in phase by two waves arriving here on the left, both of them rush to the load without reflection. So, the reflected waves in waveguides formed by the trailing edge of the drive, which section returns to the load after a time $2l/v_g$. At this moment all the electromagnetic energy originally stored in two sections of the resonator drive is transmitted to the load.

COMPRESSOR DFL BASED ON MULTIMODE WAVEGUIDES.

Previously worked on the design of single-mode waveguides [3,4,5,6]. The aim of this work is to study the compressor to work with oversized waveguides mode $H^{\square}_{01}$. Compressor design built on the single-mode waveguides have large losses, low dielectric strength, which significantly limits the maximum compression ratio and power of the compressed pulse. The performance parameters of the compressor can be improve by using multimode waveguides with a working mode $H^{\square}_{01n}$. For example, cross-section waveguides increases from 28,5 × 12,6 mm to 72 × 34 mm allows you to raise the compression ratio in 2.65 times and the maximum output power in 6.3 times.

The device power output (see Fig. 3) is H-tee matched two inductive pins.

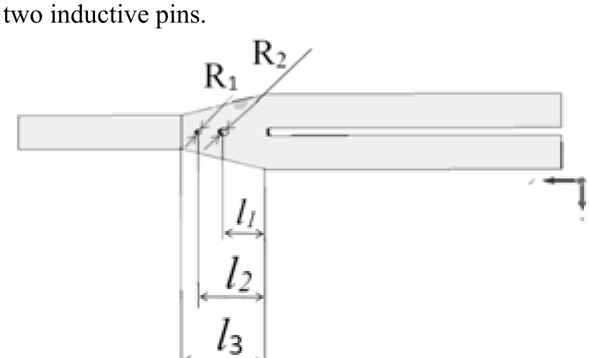

Figure 3: Sketch of the microwave - compressor l_1=53.4 mm; l_2=42.5 mm; l_3=27 mm; R_1=2 mm; R_2=3.2 mm

It is known that in the output device power have to use nonstandard waveguide section 72 × 28,5 mm at the

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operating frequency of 8568 MHz for suppressing parasitic oscillation modes. As the result of optimization of the geometry of the H - tee reflection coefficient on the operating frequency is -35 dB (see Fig. 4). Due to reducing the height of the waveguide to a value of 28.5 mm wave excitation of higher type does not occur in the vicinity of the operating frequency.

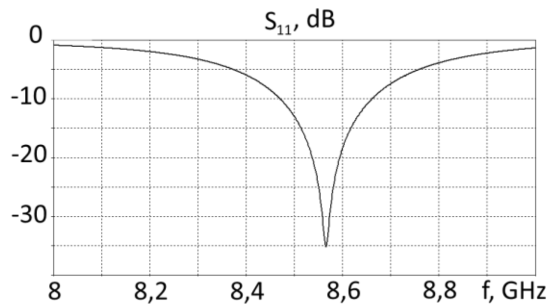

Figure 4. Dependence of the parameter of the scattering matrix S_{11} in the frequency range 8000-9000 MHz using waveguides 72 × 28.5 mm.

Fig. 5. shows the device of power input.

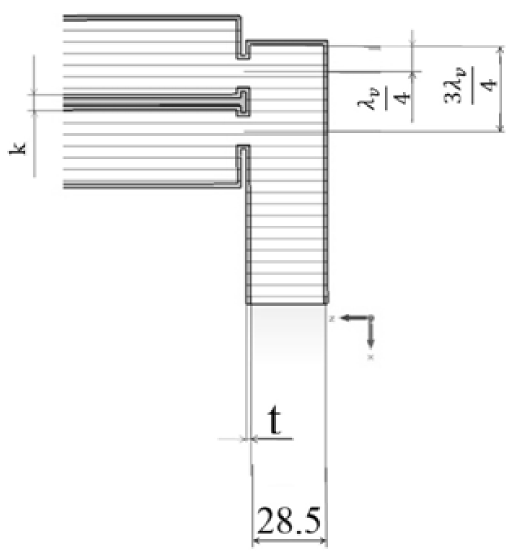

Figure 5: Input device of power. t=0.5 mm; k=6 mm; $\lambda_v = 22.2$ mm.

As can be seen from the calculated distribution of the electric field (see Fig. 6) ,(see Fig. 7) there is modulation of the field of the working modes of waves $H^{\square}_{01p}$ higher types in the resonator – accumulator along the trajectory. A significant part of the energy in the resonator - accumulator is stored in the form of spurious waves.

Figure 6: Trajectory along which investigated the electric field distribution.

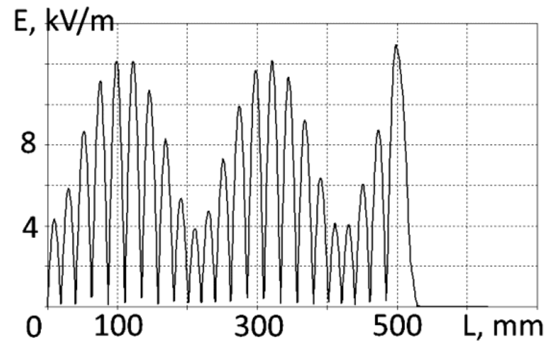

Figure 7: The distribution of the electric field in the resonator - storage along the trajectory.

There were carried out a series of calculations of various designs compressor microwave for suppressing parasitic oscillation modes and reducing the operating wave modulation field $H^{\square}_{01}$.

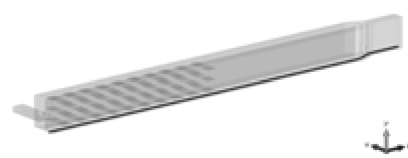

Figure 8: Compressor design I. The curve along which the electric field distribution was investigated.

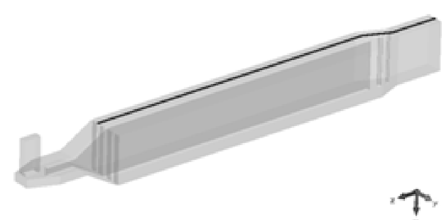

Figure 9: Compressor design II. Curve along which the electric field distribution was investigated.

Modulation ratio of the amplitude of the electric field in the first construction is M = 1.01. In the second structure it is M = 1.08.

For next structures, with another device of exciter, were stored the energy for two lengths (968 and 2,300 mm) was calculated in the waves of higher types, as well as the modulation factor of the amplitude of the electric field.

Design II was examined in two versions: with E-tee on the output waveguide section and section 28.5x12.6 mm 23x10 mm. Also considered the design based on III-E tee on waveguides 28.5x12.6 mm with step-smooth transition.

Fig. 10 shows one of the designs of the compressor. For the design I was used to study the dependence of the modulation M on the distance d between the plates (see Fig. 11).

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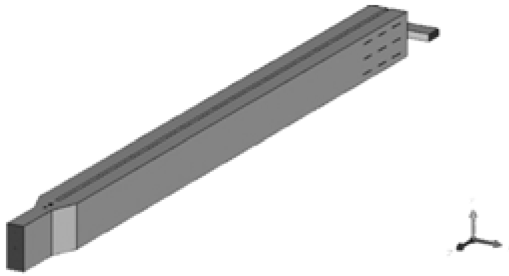

Figure 10: Compressor design I.

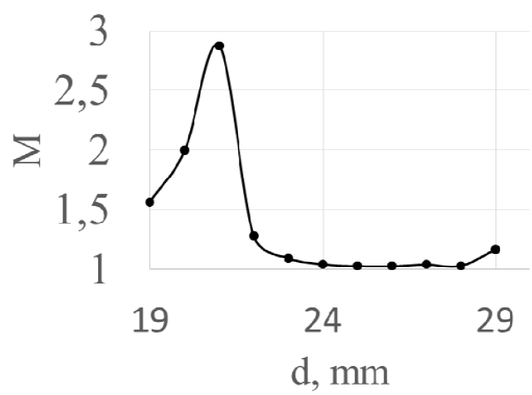

Figure 11: The dependence of the modulation M on the distance d between the rows of plates.

The diagram shows that the optimal distance d between the plates for the design length of 2,387 mm (Figure 10), is equal to 25 mm.

Table 1: Comparison of compressor designs

Type of constructi on	**The modu lation index**	**Stored energy in the parasit es, %**	**Stored energy in the wave of the type $H^{\square}_{01}$, %**	**Length of the resonato r-storage l, mm**
I	1,047	0,06	99,94	2386,98
II 28.5x12.5	1,027	0,01	99,99	968
	1,043	0,02	99,98	2387
II 23x10	1,056	0,22	99,78	969,88
	1,083	0,14	99,86	2386
III	1,026	0,01	99,99	968
	1,040	0,02	99,98	2386
I with 9 rows	1,011	0,05	99,95	968

This chart shows that the design of the compressor with the E-tee on the output waveguides 23x10 mm proved to be worse than others, due to the fact that the transition from the waveguides 23x10 mm to the waveguides 72x34 mm waveguide resonator has a large reflection coefficient (-10 dB). It also shows that the modulation factor and the stored energy in the parasitic forms of oscillations have the lowest values in the design of Design III with a smoothly-step transition. (M=1.04, W_{par}=0.02%W_{full}).

REFERENCES

[1] B.J. Bogdanovich, V.E. Kalyuzhny, E.S. Masunov, A.V. Nesterovich, A.G. Ponomarenko, V.A. Senyukov. The concept of a mobile source of a focused gamma radiation. "Problems of Atomic Science and Technology", Ser. "Physics of radiation effects on electronic equipment", issue 2. Moscow, 2009, p. 73-80.

[2] A.G. Ponomarenko. Device temporal pulse compression of microwave energy. Patent RU № 2293404 since 10.02. 2007.

[3] A.A. Osipov, A.G. Ponomarenko. Device for Time Compression of Microwave Energy Pulses. Patent RU № 2293404 since 10.01. 2013..

[4] A.A. Osipov, A.G. Ponomarenko. Modelling of the process of withdrawal of energy from the microwave radio pulse compressor based on DFL. "Nuclear Physics and Engineering", 2010, vol.1, №5, p. 438-449.

[5] A.A. Osipov, A.G. Ponomarenko, V.A. Senyukov. The equivalent circuit of the plasma column in the microwave cavity. // Scientific session MEPHI - 2010 Collection of scientific papers. - 2010 - Volume 1: Nuclear Physics and Power Engineering. - S. 180-181

[6] B.J. Bogdanovich, A.V. Nesterovich, A.G. Ponomarenko, V.A. Senyukov. Create highly mobile electron accelerators with high acceleration rate. "Nuclear Physics and Engineering", 2010, №2.

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