Resonant ulse Compression for Generating Ultra-Short High Power Pulses in HF Band

P.Yu. Chumerin, V.N. Slinko, A.Yu. Hovaev

Nuclear Physics Institute , 2-a Lenin ave., Tomsk,634050, Russia

Abstract – The resonant pulse compressor meant for amplification of peak power of meter wavelength band generators due to time energy compression procedure was developed and created for the first time. Implementation of the helical slow wave structure in the compressor resonant system allowed to decrease dimensions in the meter wavelength band. Pulses having the radio frequency 36.6 MHz and three oscillations pulsewidth at –3 dB level were obtained. The power amplification was 12 dB.

Procedures of radiated pulses energy compression are used in different applications. When the peak power value is of fundamental importance the procedure of time energy compression of radiated pulses at an generator output by using resonant pulse compressors is employed [1]. The principle of compressor operation is storing of HF energy in waveguide or coax resonant lines and discharging this energy in a form of shorter and higher power pulses than those at an input. A gaseous switch located in a T-junction moves the compressor from a storage mode to energy extraction mode. Resonant working mode in a resonant line is the fundamental mode or some higher mode but in the T-junction the mode is fundamental only. Compressors with T-junctions and gaseous switches were used for creation of nano- and picosecond pulse microwave generators in the band width 300 MHz to 36 GHz of pulse power level within 1-1000 MW [2-4]. Compressor's overall dimensions can not be smaller than a wavelength of a working mode in considered resonant line. So compressor dimensions become very important parameter for microwave time compression employment of creation generators with output pulse width of one to several HF carrier frequency oscillations in the band width [3].

One way the problem can be come over is the usage of slow wave resonant sections. In this case the overall dimensions decrease is reversely proportional to the increase of the phase velocity factor. Required values of the factor for meter wavelength band compressors are in the range 5…100. Helical slow wave structure is well known among the row of structures providing this factor value.

The objective of the presented work was creation the pilot version of the resonant pulse compressor based on the helical slow wave structure in the meter wavelength band and experimental study of its operation.

The experimental setup with the resonant compressor containing the helical slow wave structure is shown in fig.1. The interference switch of the resonant compressor system is the T-junction of the shielded copper ribbon helix line and the coax line section. One arm of the tee has the length equal to half wavelength the structure and is short circuited. It is coupled to the exciting generator by a loop formed partly by an inner conductor of an input coax line and partly by a section of the helix. The other symmetrical tee arm has a break in the inner helical conductor which is necessary to create a capacitance gap of the switch. The length of this arm and parameters of the gap are chosen to provide the total phase shift 2π during the storage process and π during extraction. These phase shift value maintain canceling of the waves coming from the symmetrical arms and falling to the tee area in the storage process and adding waves in phase in the coax tee arm in the extraction process. The phase inversion is caused by HF discharge formation in the capacitance gap when E-field reaches its critical value. The tee arm meant for energy extraction from the compressor resonant system is connected to a matched load. In front of the load the calibrated pick up loop is located which transmits check signals from the line to an oscilloscope. The outward conductor of the helical coax resonant line was the copper pipe of the 90 mm diameter.

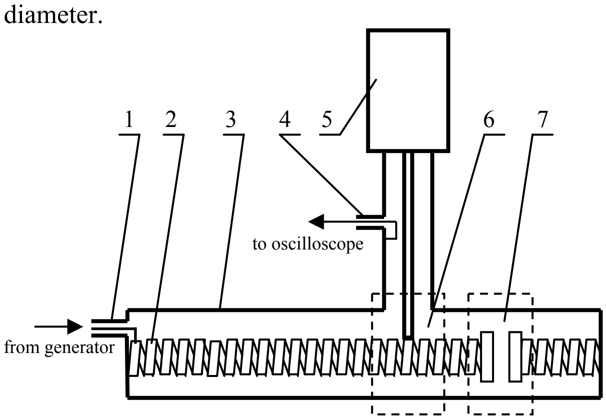

Fig.1. Resonant pulse compressor. 1-exciting loop; 2-inner helical conductor; 3-outward shield conductor; 4-pick up loop; 5-matched load; 6-T-junction; 7-capacitance switch gap.

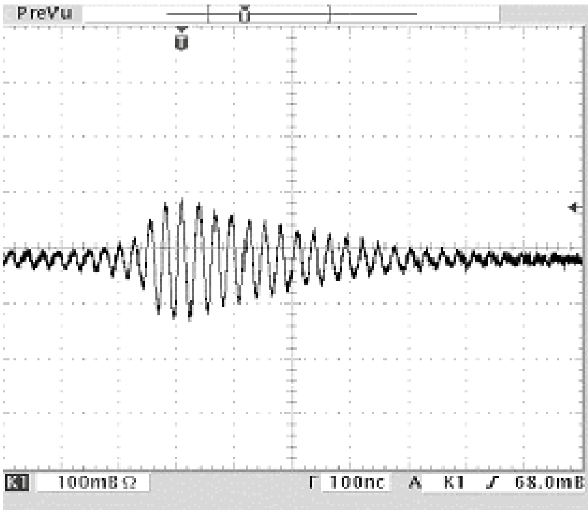

Fig.2. Pulse waveform at the resonant compressor output.

The compressor resonant system was fixed for the frequency of 36.6 MHz and had the outrinsic Q-factor 500. The wave impedance of the coax helical line was 350 Ohms, the coax output side tee arm – 150 Ohms.

The output pulse amplitude and shape were measured by the oscilloscope TDS 2024. The compressor amplification factor was determined by comparing the signal amplitude measured at the exciting generator output with the signal amplitude measured at the compressor output by the same one calibrated pick up loop. The oscillogram of the formed pulse is shown in fig.2. Experiments showed the obtained pulses had the power of 160 kW, pulsewidth 75 ns at –3 dB level which is equal to three oscillations of the HF carrier. The amplification factor was 12 dB. The repetition rate depended on the exciting generator rate and was 10 Hz. The maximum length of the resonant system was 80 cm. Estimations shown that similar resonant system design but on the basis of ordinary coax line would give the length of 6-7 m.

So for the first time the resonant compressor design for the wavelength range 1…100 m was implemented. The decrease of overall dimensions was due to usage the helical slow wave structure in the resonant system. The output radiation parameters of the experimental version of a compressor prove that the resonant pulse compression procedure can be used for amplification of the generator pulse power up to several tens at the decrease of the pulsewidth up to one or several periods of HF carrier oscillations.

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