ACTIVE ANTENNA ARRAY FOR STUDY THE INTERACTION BETWEEN BROADBAND ELECTROMAGNETIC OSCILLATIONS AND PLASMA

I.K. Tarasov

Institute of Plasma Physics, NSC "Kharkov Institute of Physics and Technology", Kharkov, Ukraine, E-mail: itarasov@ipp.kharkov.ua

The active broadband antenna array is described. It consists of oscillators with the working frequencies that are close enough to the plasma frequencies. The construction of described array permits to use it as a phased array with a fast control of excited wave parameters (frequency, shape, phase velocity, amplitude). The oscillations spectrum measurements were provided and corresponding results are given in this work. The possibility of transfer into stochastic regime was also studied.

PACS: 52.50.Sw

INTRODUCTION

An active antenna array is a multi-element system where each element represents an oscillator coupled with an active element (generator, amplifier) [1]. For all of that using of feeder path on a high power level is excluded. The phased array represents an antenna system composed of elements with independent phase driving.

In our case the phased array is used for generating the broadband oscillations which then would be introduced into plasma to excite the waves in a broad frequency band. For the oscillations frequency band broadening a non-sinusoidal oscillations form was used [2,3]. Another way of the excited oscillations spectrum broadening is using of different type of modulation. It is also effective to use a consecutive switching of a single oscillators and groups (arrays).

A short distance between the plasma and the array components is a necessary condition of the phase array operating with the plasma load. Thus an active elements of the phased array must endure a strong electromagnetic load. Besides, the amplifying elements must be capable of working in vacuum and in a strong magnetic field. All of these requirements were taken into account during the phased array development.

EXPERIMENTAL SETUP

The phased array represents a number of loops which cover the plasma column by the angle of 120˚ from the both sides [4]. The system consists from two sections (Fig.1). Each section contains four oscillators. The length of each section is 20 cm. To avoid a contact with the plasma it was isolated from the sections by cooled limiters. Studied configuration has an external diameter 15 cm while internal diameter was 7,5 cm. The loop diameter was 8,5 cm.

A power amplifier (PA) coupled with the loop (oscillator) represents a fundamental part of the array. These PA may be used as a broadband amplifiers or high-powered pulse generators. The amplifiers were driven by a driving generator which could be a sinusoidal oscillator, a noise generator, an impact generator or a pulse code generator. Each of these generators had a capability of amplitude, phase and frequency modulation.

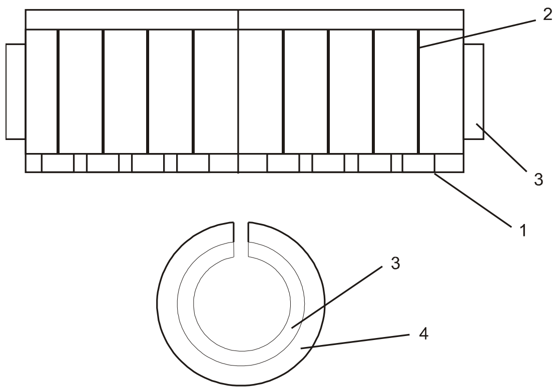

Fig.1. Schematic of the active phased array: 1 – the power amplifier, 2 – a loop antenna, 3 – metal limiter, 4 – array case

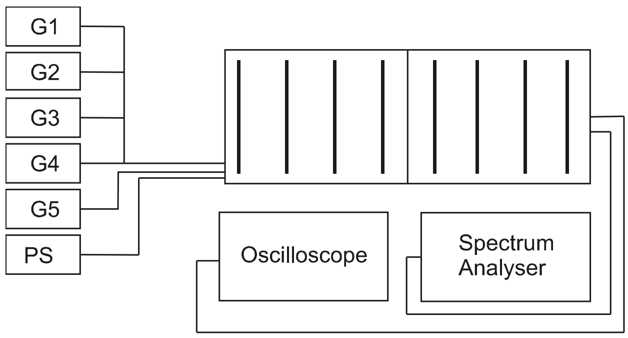

Fig.2. Schematic of the active phase array testing setup

To obtain a driving signal a microcontroller or a personal computer may be used. For PC the transition from one mode to another may be carried out in a short time periods.

The phased array oscillators were capable to work in a several different modes:

1. Cophased mode. The oscillators array works as a single generator.
2. Consecutive mode. The oscillators are switched on by turns.

3. Group-consecutive mode. Oscillators are separated in different groups which are switched on consecutively.

PA was connected with the external devices by feeder, power circuit, power amplifiers control circuits and waveform control circuits.

EXPERIMENTAL RESULTS

The active phased array (Fig. 2) was tested in the vacuum chamber in presence of magnetic field but without the plasma. The signals were received from the outputs of the power amplifiers and magnetic probes.

Following pictures displays the results of the experimental tests.

Fig. 3 displays the oscillations spectrum by a monochromatic sinusoidal driving signal with a MF frequency modulation.

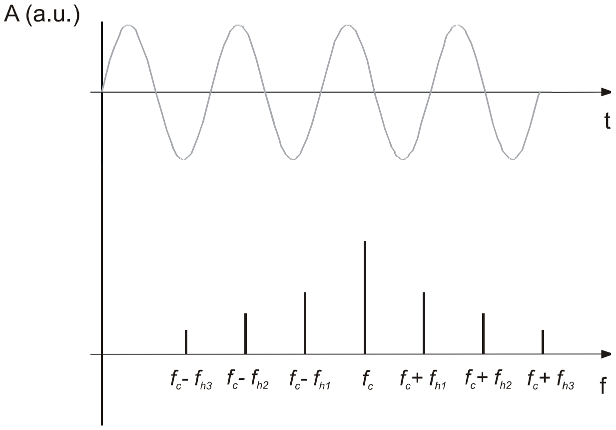

Fig.3. Active phased array oscillations spectrum corresponded to a monochromatic sinusoidal driving signal

The oscillations spectrum obtained by applying a periodically repeated square pulses as a driving signal is presented in Fig.4.

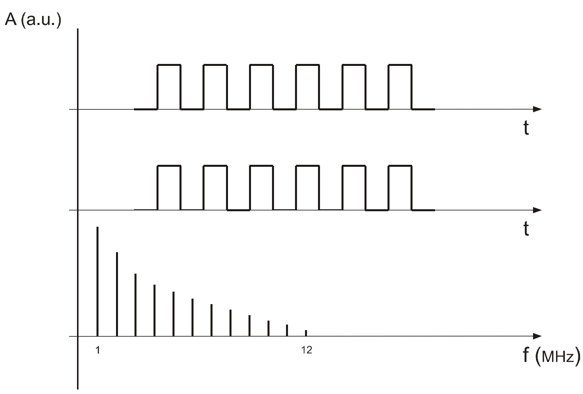

Fig.4. Active phased array oscillations spectrum obtained by applying a periodically repeated square pulses as a driving signal

The oscillations spectra for different delays between the switching on of two separate groups of oscillators (group-consecutive mode) are presented on Fig. 5. The driving signal represents a square pulses. As one could notice, the reducing of aforesaid delay results in the oscillations band broadening.

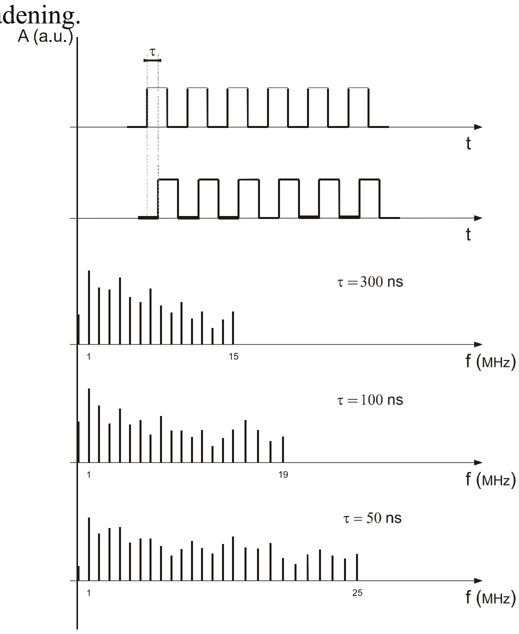

Fig.5. The oscillations spectra corresponded to group-successive mode

Using of square pulses code in capacity of a driving signal enriches the oscillations spectrum in both high and low frequency ranges. Besides, the group-consecutive mode was studied for such type of driving signal (Fig. 6).

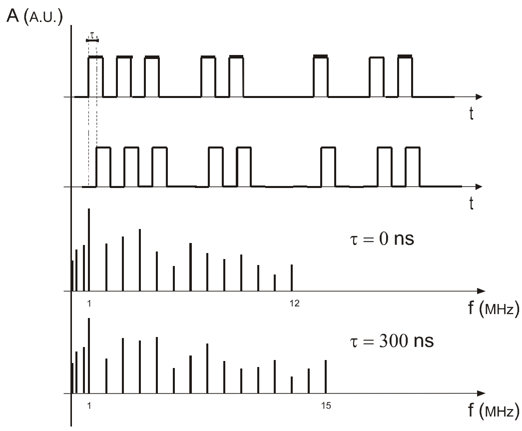

Fig.6. The oscillations spectra corresponded to group-successive mode with the square pulses code as a driving signal

CONCLUSIONS

The results of the active array test leads to following conclusions.

1. The operation of active phased array with a sinusoidal driving signal provided the oscillations excitation with the frequencies lower than 20 MHz and the frequency band which width is 10% of the carrier frequency. The power of the PA output signal in the linear amplification mode is 120 W.

2. When the driving signal represented a periodically repeated square pulses the maximal frequency was 12 MHz and the output power of the PA was 500 W.
3. The frequency range may be broadened to 25 MHz by working in a group-consecutive mode.
4. A power of the load may be linearly varied within the frequency range of 90% of its value.

REFERENCES

1. V.V. Dolzhykow, B.G. Tsybaev. *Active transmitting antennas.* Moscow: "Radio i sviaz", 1984.
2. H.F. Harmuth. *Sequency Theory.* New York: "Academic Press", 1977.
3. S.I. Tsunoda, J.H. Malmberg // *Rev. Sci. Instrum.* 1986, v. 57, N 9, p.2348-2350.
4. A.c. N 1158022, 22.01.1985S. *The way of HF-heating of plasma and the device for its realization/* M. Krivoruchko, I.K. Tarasov, V.A. Bashko.

Article received 10.10.08

АКТИВНАЯ ФАЗИРОВАННАЯ АНТЕННАЯ РЕШЕТКА ДЛЯ ИССЛЕДОВАНИЯ ВЗАИМОДЕЙСТВИЯ МЕЖДУ ШИРОКОПОЛОСНЫМИ ЭЛЕКТРОМАГНИТНЫМИ КОЛЕБАНИЯМИ И ПЛАЗМОЙ

И.К. Тарасов

Описывается активная широкополосная фазированная антенная решетка, состоящая из осцилляторов с рабочими частотами, близкими к плазменным. Конструкция описываемой решетки позволяет использовать ее в качестве фазированной решетки с возможностью быстрого изменения параметров возбуждаемых волн (формы, частоты, фазовой скорости, амплитуды). Представлены результаты измерений спектра возбуждаемых решеткой колебаний при подаче сигналов разного вида на управляющий вход. Также изучалась возможность перехода в стохастический режим.

АКТИВНА ФАЗОВАНА АНТЕННА РЕШІТКА ДЛЯ ДОСЛІДЖЕННЯ ВЗАЄМОДІЇ МІЖ ШИРОКОСМУЖНИМИ ЕЛЕКТРОМАГНІТНИМИ КОЛИВАННЯМИ ІЗ ПЛАЗМОЮ

І.К. Тарасов

Описано активну широкосмужну фазовану антенну решітку, що складається з осциляторів, робочі частоти яких є близькими до плазмових. Конструкція решітки дозволяє використовувати її в якості фазованої решітки з можливістю швидкої зміни параметрів збуджуваних хвиль (форми, частоти, фазової швидкості, амплітуди). Представлено результати вимірювань спектру збуджуваних решіткою частот під час подачі на керуючий вхід сигналів різної форми. Вивчалася також можливість переходу у стохастичний режим.