PRECISE VARIOMETER PULSE FORMING NETWORKS

V. E. Ermel, A. V. Muratov, Y. V. Solovyev
Efremov Scientific Research Institute
of Electrophysical Apparatus
189631 Metallostroy, Leningrad, USSR

Abstract: Precise variometer pulse forming networks (PFN) for linear accelerator modulators are presented. Presented PFNs consist of 8-10 cells and generate high voltage pulses with top nonlinearity 0.1-0.5%, pulse power 15 MW, average power 15-65 kW and pulse length 7-9 μsec. Variometer construction, realizing magnetic coupling of cell inductance coils, is discussed.

Introduction

To improve charged particle bunches energy spectrum one must minimize top nonlinearity of RF generator modulator pulse. Our approach to this problem was with particular customers in mind. These customers are high energy physicists and tomograph manufacturers.

Total pulse top nonlinearity (ripple, rise pulse revoltage, top fall)is usually corrected by means of passive RLC correction circuit or increasing the PFN cells number. Here we are going to talk about linear modulators with mutual magnetic coupling of PFN cell coils. Pulse top shape was corrected by self- and mutual inductances variation [1,2].

Variometer Pulse Forming Networks

Variometer PFN is a number of LC cells connected in series,cell inductance coils being magnetically coupled. Variometer PFNs differ not only in its construction , but also method for inductance variation.

One of the variometer engineering concepts is variometer with variable mutual inductance and constant self- inductance[1]. Such variometer consists of cylindrical stator inductance coil with spherical rotor inductance coil inside it. Rotation of the latter varies the angle between the magnetic axes of the coils and thus varies mutual coil inductance. Self-inductances in this construction are constant. The other concept is a variometer with simultaneous variation of self-inductance and mutual inductance [2]. Such variometer, for example, consists of two plate inductance coils, magnetic axes are coaxial, with plate electromagnetic screen between them. Moving of the screen or its rotation on axle that is perpendicular to the coils axis will result in simultaneous self-inductance and mutual inductance variation.

Variometer PFN Modulators

Pulse modulator scheme for klystron KIU-111 is presented on fig.1.

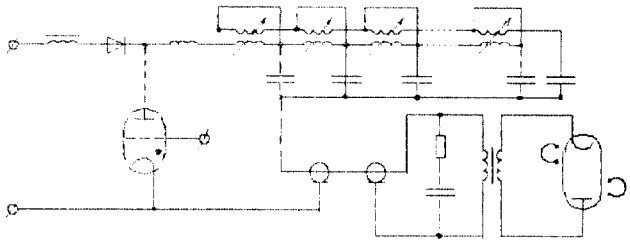

Fig.1. Variometer PFN linear modulator.

We have chosen the modulator with full PFN discharge through a hydrogen thyratron on a pulse transformer secondary winding, connected to the klystron. Every PFN cell consists of a capacitor and a variometer, the first variometer coil connects the capacitor of the same cell to the fore coming cell capacitor, the second variometer coil connects the capacitor of the same cell to the next cell capacitor. PFN consists of nine cells, the cell capacitance is equal to 0.02 μF. Electromagnetic screens are placed between the variometer inductance coils (fig.3a), and the screen rotation on axle perpendicular to coils axis results in self-inductance and mutual inductance variation. Terms of PFN reactance regulation is 15%. Capacitor charging voltage equals to 20 kV. Modulator output voltage is 55 kV, peak power 15 MW, pulse length 6 μsec, pulse rise and fall times are 0.8 μsec, pulse repetition rate is 150 Hz. Pulse top nonlinearity is 0.4-0.5%. The pulse modulator is connected to a pulse transformer by means of a cable connection line, in order to decrease top ripple a RC cirquit, connected in parallel with the pulse transformer, is used.

To increase the terms of PFN reactance regulation, double screens were used. In such modified PFN inductance coils are placed on the same axis, and screens are placed not only between cell variometer coils,but between variometers too. inductance coils and electromagnetic screens are of plate type to increase the mutual inductance (fig.3b). Terms of PFN reactance regulation in this case were increased to 30%, pulse top nonlinearity was the same.

A modulator for a 25 kW average power klystron was constructed including a number of single magnetically coupled inductance coils (fig.2).

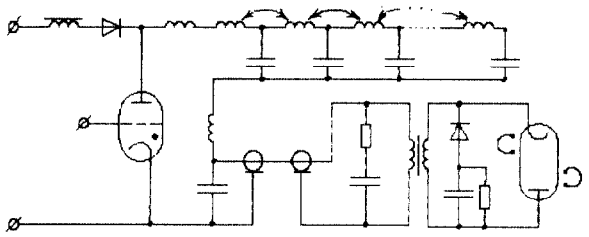

Fig.2. Linear modulator with single magnetically coupled coils.

These coils are coaxial , and self-inductance and mutual inductance of the coils are varied simultaneously by means of rotating short-circuited turn, placed on an axle perpendicular to coils axis (fig.3c). Another variometer construction uses double short-circuited turn (fig.3d).

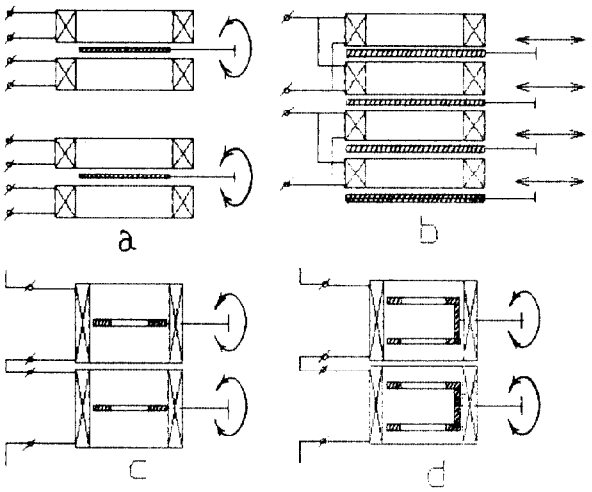

Fig.3. Variometers:
a. rotor screen;
b. plate screen;
c. shot-circuited turn;
d. double shot-circuited turn;

Terms of PFN reactance regulation is 15% for the first construction , 18% - for the second. PFN capacitor charging voltage is 40 kV. Modulator output pulse voltage is 55 kV, peak power - 15 MW, pulse length 9 μsec, pulse rise time 1.2 μsec, pulse fall time 2 μsec, pulse repetition rate 600 Hz. Pulse top nonlinearity is 0.3-0.4%. To decrease top pulsation LC circuit was installed in series with cable line and RC circuit was connected in parallel to pulse transformer primary winding. Diode -capacitor correction circuit was installed in parallel to klystron and resulted in decreased top pulsation and pulse top nonlinearity to 0.1-0.2%.

Conclusions

We have shown that it is possible to decrease pulse top nonlinearity by a factor of 5-10 by means of variometer PFN in klystron linear modulator.We hope that increasing PFN cells quantity will lead to decreasing pulse top nonlinearity to a level less than 0.1%.

Acknowledgements

We would like to thank V.V.Ushakov, S.P.Aristarkhov, A.S.Toropov, V.N.Voznyuk for cooperation in experimental works.

References

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