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A Blumlein type modulator for 100MW-class X-band klystron

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Abstract

To achieve the high efficiency in the X-band pulsed klystron modulator for the main linac in Japan Linear Collider, a new modulator with the Blumlein type PFN was designed and fabricated. Two identical 12-stage PFN's of the 23 ohm characteristic impedance are set on the both sides of the 1 to 7 step-up pulse transformer. Simulations showed that with this pulse transformer, 500 ns 560 kV pulse of 200 ns rise time could be obtained with the droop of 2%. The design and some test results of the Blumlein type modulator and the pulse transformer are presented.

Introduction

At the present status of the design studies and the R&D works dedicated to the next generation of the electron- positron colliders, the necessary output power of the RF power sources in the X-band range is still under discussions(REF-1)(REF-2). As X-band main linac's in JLC(Japan Linear collider), the accelerating structure with the filling time less than 100 nsec is considered. Therefore, considering the multi bunch operation of this linac's, the RF power duration is around 100-200nsec is required in the accelerating structures. This means that the RF power source should produce the 100MW class RF peak power with the duration of 400-800nsec, even with the RF pulse compression system of the factor 4. This RF pulse is much shorter than that of the present S-band linac's which is typically a few micro-sec. In KEK, we have utilized conventional modulator with the 1 to 15 pulse transformer to drive the present 100MW class X-band klystrons(REF-3)(REF-4). This conventional modulator has revealed sufficient performance as for the test of the X-band klystron named XB-72K, but as the possible driver for the future linear collider pulse shape especially it's rise time was not sufficiently fast to assure the efficiency necessary for the future linear collider. A new Blunlein type modulator and new 1 to 7 step up pulse transformer was designed and fabricated.

Design and parameters

Table-1a) and 1b) show the circuit design and the parameters of the Blumlein type PFN and 1 to 7 pulse transformer parameters, respectively. The output voltage was decided same as the present modulator, thus the same charging system and the thyratron switching tube is utilized. One specific feature of this circuit different from an ordinary Blumlein circuit, is that the primary winding of the pulse transformer is kept at the charging voltage of 80 kV. As shown in the Table-1a), the inductance and the capacitance of the PFN are much smaller than those of the ordinary PFN's of S-band modulators. By setting the primary winding at the charging voltage as shown in Fig-1), the ground lines can be always kept at the ground potential, and this can minimize the undesirable effects of the stray inductance and capacitance of the PFN circuits those are not so small compared with the circuit constants themselves. The configuration of PFN's can be achieved symmetrically as shown in Fig-2a and 2b). This symmetric configuration is expected to keep the stray capacitance and

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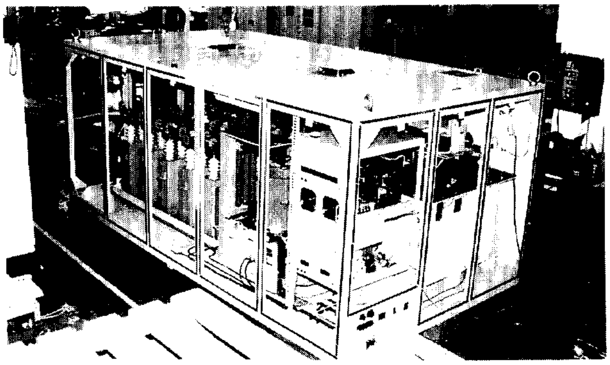
TABLE-1a) PFN Specifications

Impedance	23 Ohms
Charging Voltage(Max.)	86 kV
Pulse Width(Total)	700 nsec
No. of stages	12 stages (x2sets)
Inductance/one stage	340 nH
Capacitance/stage	2.9 nF

Table-1b) Pulse transformer

Step-up ratio	1/7
Leakage L.	830 nH
Stray capacitance	4 nF
Loss at 200pps(Hysteresis)	100W
(Eddy Current)	1000W
Rise time(Trans. only)	~100ns
Fall Time(Trans. only)	~200ns
Sagging(500ns width)	2.8 %
Core material	Si-Fe 25microns

Fig-2a,b) PFN and discharge circuit



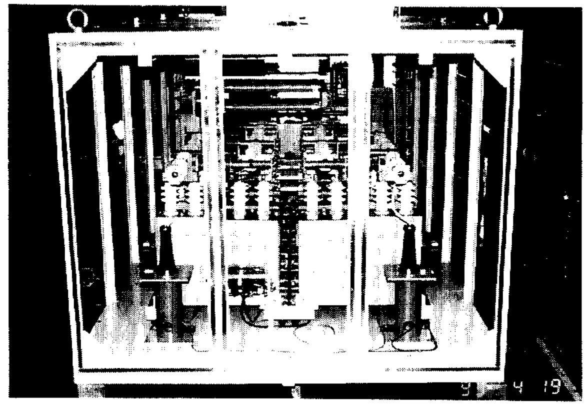


Fig-3a) Equivalent circuit for "SPICE" simulation

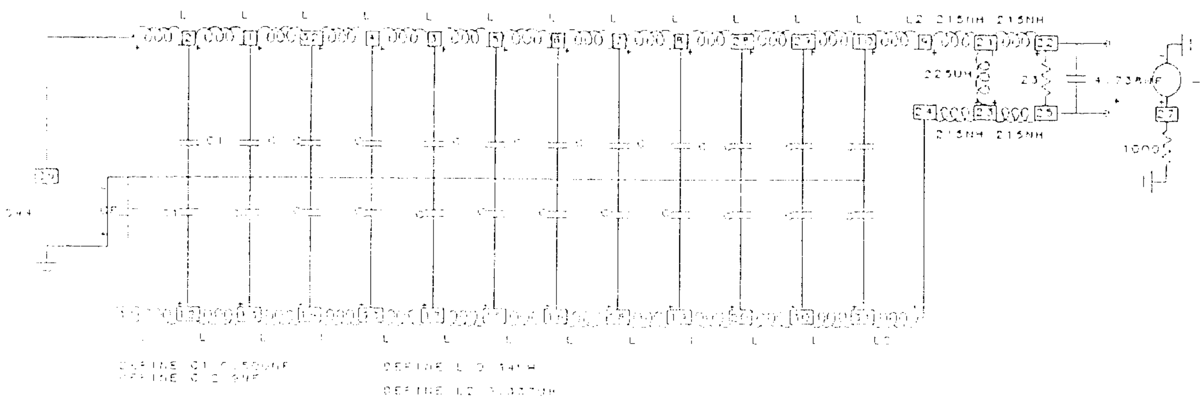
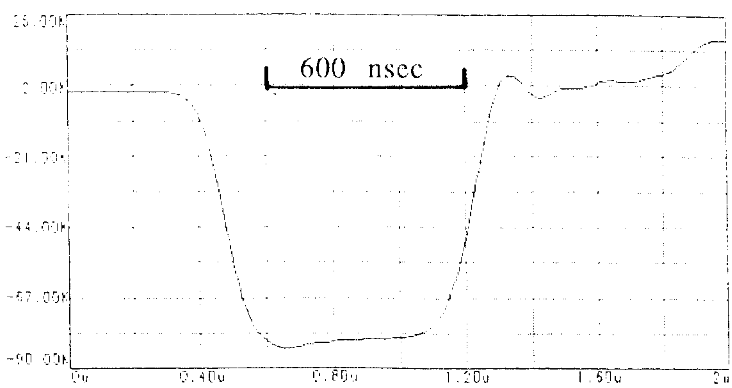


Fig-3b) Pulse shape by "SPICE"



inductance practically equal in each two PFN's of the Blumlein structure.

As the pulse transformer design, as shown in Table-1b), ordinary core material such as Si-Fe of thickness of 25 microns which is currently available in the market has sufficient performance concerning the hysteresis and eddy current losses. One specific feature of this pulse transformer mentioned above is that the primary winding is always kept at the charging voltage (80 kV), and this could be achieved by setting the insulation distance between the core and the secondary winding respectively, without sacrificing other performances such as stray capacitance or leakage inductance those affect to the output pulse shape. This transformer is used in the insulation oil tank as usual for this kind of high voltage pulse transformers.

The circuit simulation was carried out by the use of "SPICE" code. The equivalent circuit for the simulation including the pulse transformer is shown in FIG-3a), and this equivalent circuit includes the stray inductance and capacitance of the pulse transformer, but the stray inductance of the capacitance are neglected. The calculated pulse shape is also shown in the FIG-3b), and the rise time around or less than 200 nsec was achieved.

Fabrication of the Blumlein type PFN

The fabrication of this PFN was carried out in Ishikawajima-Harima Heavy Industries Co., Ltd.. As shown in Fig-2), the PFN's and their casing have been completed, and the first high voltage test with the dummy load is scheduled to the end of May.

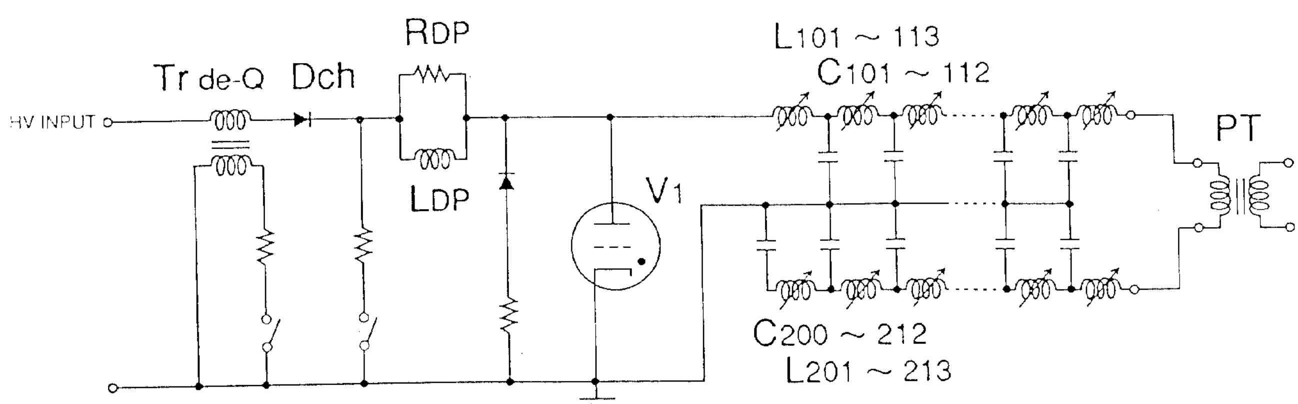
Discussions

The stray inductance of the capacitors may limit the rise and fall time of this PFN system. The main source of this stray inductance is the lead wire which is located in the insulation ceramics of the capacitar. To avoid this problem, PFN circuit should be placed in the insulation oil tank and wirings in the PFN should be made as short as possible.to decrease The primitive design work on this subject are under progress.

Refernces

1)"JLC-1", ed. by JLC group, KEK Report 92-16(1992)
2)K.Takata. " Proc. of HEACC92", Hamburg(1992)p.811.
3)H.Mizuno et al.,KEK Preprint 92-122(1992)
4)M.Akemoto et al.,"Proc. of the 1991 IEEE particle Accelerator Conference", San Francisco, p.1040(1991)

Fig-1) Blumlein PFN



L101-103=340nH. C101-112=2.9nF
L201-213=340nH. C201-212=2.9nF

V1 Thyratron(CX1937A; EEV)