PERFORMANCE TEST OF A 600 KV BLUMLEIN MODULATOR FOR AN X-BAND KLYSTRON RELEVANT TO JAPAN LINEAR COLLIDER

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Abstract

An X-band klystron modulator using new types of Blumlein and magnetic-pulse-compression (MPC) techniques was developed relevant to the future Japan Linear Collider (JLC) project. In order to realize a compact modulator, helically wounded conductors were adopted for the inner and middle conductors of the triaxial Blumlein. Output pulses with a voltage of 606 kV, a pulse length (flat-top) of 106 ns and a rise time of 130 ns were successfully generated during a preliminary test using a dummy load with a rather high impedance of 650 ohms.

Introduction

As a post-TRISTAN project an e^+e^- linear collider in the TeV region has been proposed as the JLC (Japan Linear Collider) project by KEK.[1,2] In order to realize a facility of reasonable scale, an accelerating gradient of the order of at least 100 MV/m is required. Achieving this high gradient requires a high-power microwave source with a peak output power of ~150 MW/m at a frequency of 11.4 GHz.[2] The development of a high-power X-band klystron using conventional technology was started for this purpose.[3] For this X-band klystron, a special modulator is required which has higher output voltages and generates square-wave pulses with a shorter pulse length (~200 ns), compared with conventional ones. Since it is difficult for a conventional PFN-type modulator to realize a short rise time (~100 ns) and flatness in pulse flat-top, because of the stray capacitance and leakage inductance of the step-up transformer, we have developed a Blumlein-type modulator which meets the demands of the X-band klystron.

In this paper, we describe the characteristics of the Blumlein-type modulator and the results of its performance tests.

Modulator specifications

The specifications of the X-band klystron modulator are listed in Table 1.

Table 1

Specifications of the X-band klystron modulator.

output pulse voltage	600 kV
Output pulse current	920 A
Output impedance	650 Ω
pulse rise time	less than 100 ns
Pulse length (flat-top)	longer than 100 ns
Pulse height deviation from flatness	less than 2 %
Pulse repetition rate	200 pps

The output impedance of the modulator is strongly dependent on the microperveance of the klystron. Since we are in the very first stage of the X-band klystron development, we have to be prepared for any change in its design. Further, in order to reduce the construction costs of the future linear collider, simultaneous power feeding to several klystrons from a single modulator is considered. These are two main reasons for the relatively low output impedance of the modulator.

Modulator description

A simplified circuit diagram is shown in Fig. 1. This modulator comprises a Blumlein, a magnetic switch, a charging saturable reactor and a pulse transformer. An initial pulse with about a 1 μs pulse length and a peak voltage of several 10 kV is stepped-up to 600 kV by a step-up transformer; the Blumlein then is charged.

The Blumlein has a double concentric structure and comprises an inner, a middle and an outer conductor. The inner and middle conductors form the inner transmission line, and the middle and outer conductors form the outer one. In order to

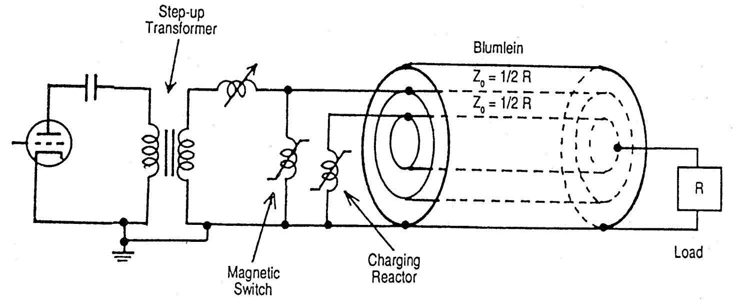

Fig. 1 Simplified diagram of the Blumlein-type modulator.

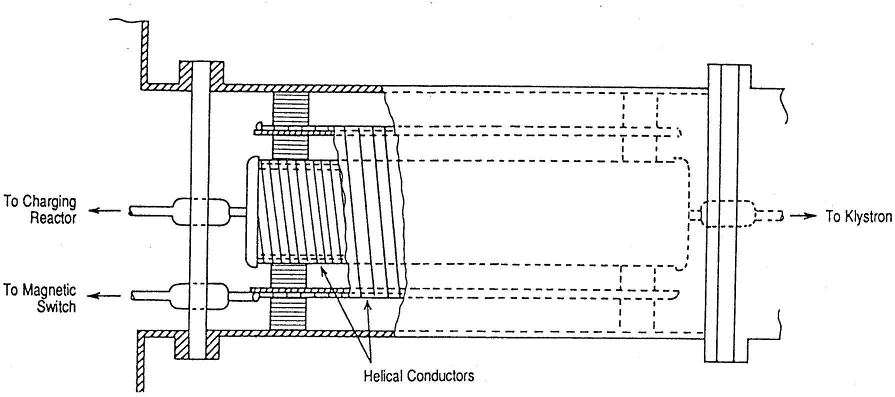

Fig. 2 Structure of the Blumlein.

realize a compact, high-impedance Blumlein, a helical structure was adopted for the inner conductors of the Blumlein. Figure 2 shows the structure of the Blumlein. The number of windings for these helical conductors was so designed as to cancel their resultant magnetic flux in order to make sure of its Blumlein action. The design parameters of the Blumlein are listed in Table 2.

Table 2

Parameters of the Blumlein.

Number of windings of the inner conductor	30
Diameter of the inner conductor	290 mm
Number of windings of the middle conductor	22
Diameter of the middle conductor	400 mm
Diameter of the outer conductor	550 mm
Line length	1 m
Characteristic impedance	325 Ω
Transit time	150 ns

The magnetic switch is connected to the middle conductor from the outer ground conductor. The saturable reactor is connected to the inner conductor from the ground. This configuration enables us to minimize the prepulse during the charging period.

Performance test

A preliminary test was performed in order to confirm the above-mentioned design. The magnetic switch was set in a SF_6 gas-filled tank in order to reduce the stray capacitance; the other components were all set in oil-filled tank. The input voltages of the Blumlein were measured by capacitive-type voltage dividers. A 650 Ω ceramic resistor was used as a dummy load.

Figures 3 and 4 show the input- and output-side voltage waveforms of the Blumlein, respectively. The input with a 1.0 μs pulse width and a 696 kV peak voltage has been successfully modulated to the output pulse with a peak voltage of 606 kV. As the expanded output voltage waveform shows in Fig. 5, a pulse flat-top length of 106 ns satisfies the requirement. On the other hand, a pulse rise time of 130 ns is rather longer than we expected. Further investigations are necessary to obtain a shorter rise time.

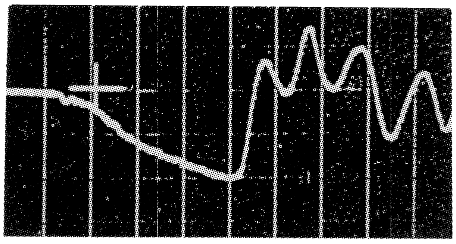

Fig. 3 Input voltage of the Blumlein.
(vert. 350 kV/div., hor. 200 ns/div.)

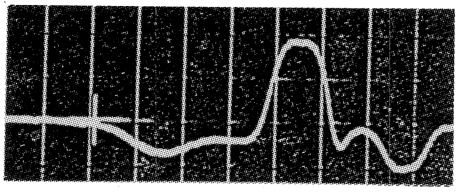

Fig. 4 Output voltage of the Blumlein.
(vert. 350 kV/div., hor, 200 ns/div.)

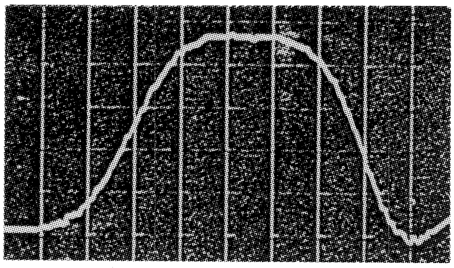

Fig. 5 Expanded output voltage of the Blumlein.
(Vert. 125 kV/div., hor. 50 ns/div.)

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