A STUDY OF BEAM BLOW-UP IN THE TOHOKU LINAC

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Abstract

In order to understand beam blow-up phenomenon in the Tohoku electron linac, we have measured the frequency components contained in the accelerated electron beam. The results showed that the beam blow-up took place only at 4302.6 MHz.

Introduction

The Tohoku 300 MeV electron linac has been designed to have two sections, namely, a high-current section (A) and a high-energy section (B). The section A consists of eight accelerating structures each of which is about 1 meter long. The section B consists of twelve ones each of which is about 2 meter long. The starting current of beam blow-up is inversely proportional to the third power of the accelerating structure length according to Wilson's theory[1]. Each accelerating structure of the linac has the shorter effective length than its actual one for HEM_{11} mode. The starting currents of our case were expected to exceed the designed values of 0.6 and 0.25 A respectively. At the early operation of the linac, beam blow-up was observed unexpectedly. It has occured first at the end of the accelerator and has been recognized to be different type beam blow-up from regenerative one and to be the same observed at Stanford[2]. Additional five quadrupole magnets have increased beam current up to the present values of 0.35 A in the high-current section and 0.11 A in the high-energy section.

Measurement of beam blow-up

Recently we measured the beam blow-up using the newly designed frequency detector. Fig.1 shows the block diagram for the measurement of frequency components induced by the electron beam.The electron beam passes through the co-axial wave-guide (39D) and induces rf power. The frequency components of the rf power are analyzed by trans-mission type wave-meter which has been calib-rated for various modes. If necessary, the ade-quate low-pass filter is put in front of the cavity.

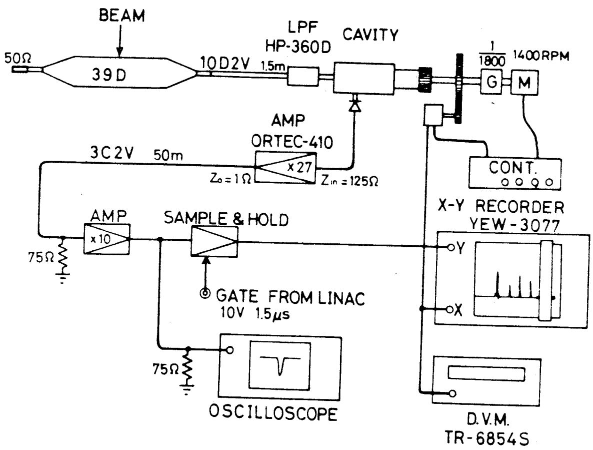

Fig.1 Block diagram for measurement of frequency components.

The detected video signals are amplified, sampled and holded. The axial length of the cylindrical cavity is known by the helical potentiometer. The amplitudes of the video signals are recorded by X-Y recorder vs. the voltage from the potentiometer. Fig.2 shows the resonant frequencies for various mode vs. the axial length of the cavity, and Fig.3 shows many frequency components obtained from the beam which was modulated by beam blow-up without low-pass filter. Labels A to E denote frequency regions to which each component belongs. Six peaks are found around 4.3 GHz in this figure. These frequencies are described as $f_b \pm n \cdot \Delta f$ where f_b means frequency of beam blow-up oscillation and $\Delta f = 2f_b - 3f_0$ means beat frequency between the second harmonics of f_b and the third harmonics of accelerating frequency (f_0 = 2856 MHz). Using this relation, we can know the frequency of beam blow-up precisely. Fig.4 shows this relation and indicated f_b = 4302.6 MHz. Many peaks which are seen in Fig. 3 are reduced into Fig.5 and we conclude that the beam blow-up took place only at 4302.6 MHz.

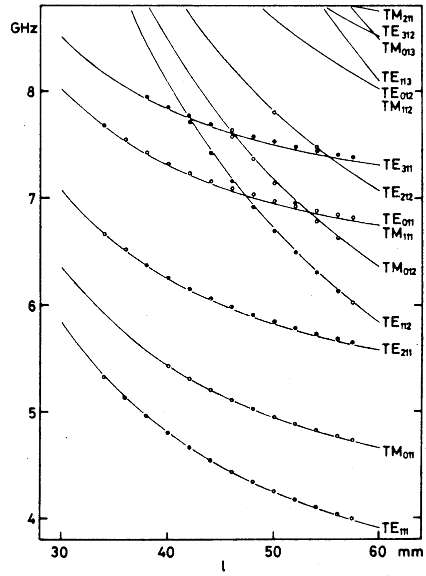

Fig.2 Various mode resonant frequencies vs. axial length of the cavity.

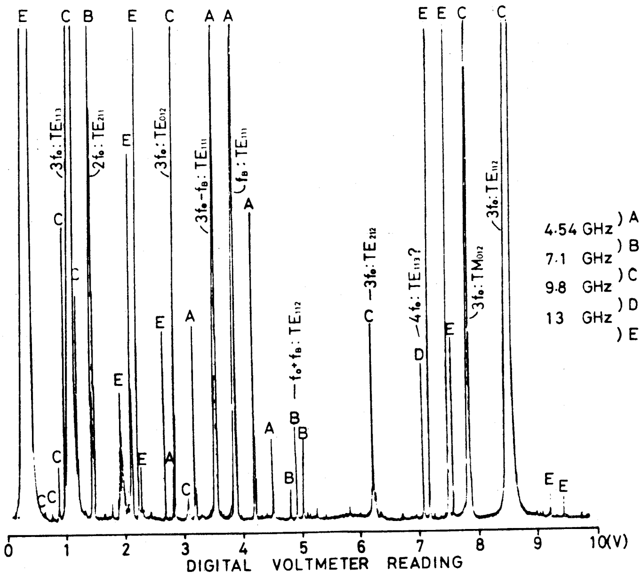

Fig.3 Frequency components involved in the beam modulated by BBU.

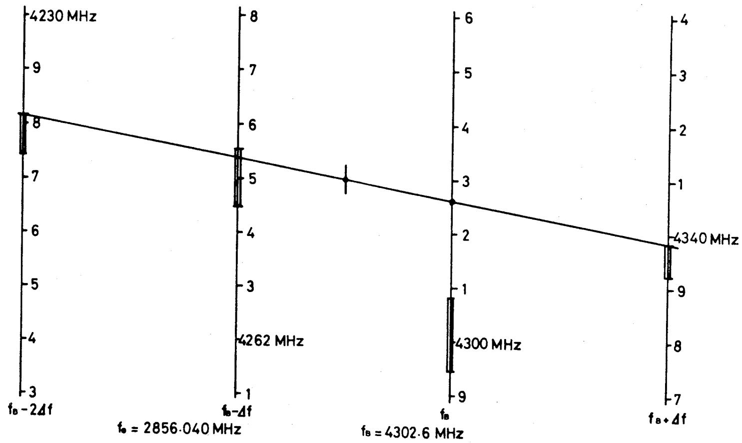

Fig.4 Precise determination of BBU frequency.

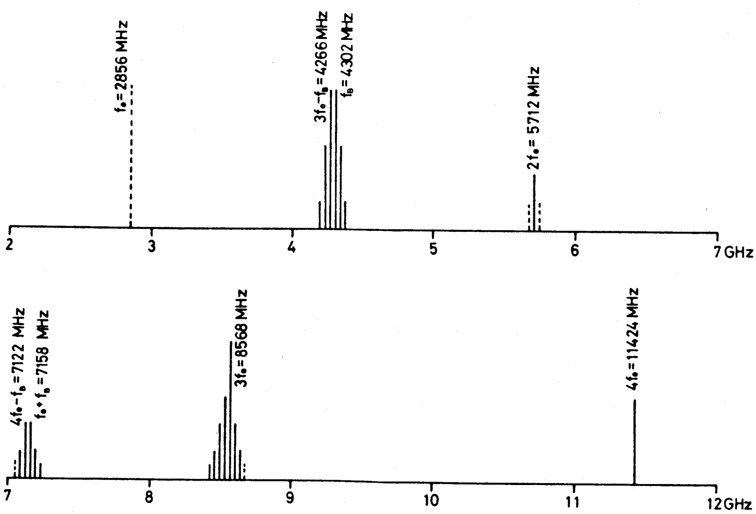

Fig.5 Frequency spectrum of the beam with BBU.

References

1) P. B. Wilson : Stanford High Energy Physics Laboratory report HEPL-297 (1963).
2) R. H. Helm, G. A. Loew and W. K. H. Panofsky : The Stanford Two-Mile Accelerator ed. by R. B. Neal (W. A. Benjamin, New York, 1968) p. 163.