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NEW HIGH POWER LINEAR ABC AND PLATFORM

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Abstract

At Varex Imaging Corporation, we have nearly completed a transition to our in-house supply of Accelerator Beam Centerlines (ABC), replacing Varian as a supplier. As one of the last efforts in this program, we are considering changing design of our Linatron® K15, the only standard production unit in the world capable of delivering bremsstrahlung at 12000 R/min at 1 meter by striking a stopping target with a high energy electfgiron beam (EB) at 15 MeV. We plan on changing the operating frequency from 2856 MHz, used by Varian, to 2998 MHz, establishing one common frequency for all our S-Band linear accelerator (LINAC) radio frequency (RF) sources. Various designs are being investigated for the new 15 MeV ABC, including but not limited to two collinear standing wave (SW) sections and a patented combination of SW and traveling wave (TW) sections with reverse feeding of RF power. We have analysed both concepts and present the preliminary analysis results. The platform can be used for running guides at various energy levels from 1 to 20 MeV continuously or selectively changing energy and upgrading the platform to higher average beam power levels. Indeed, operating at high average beam power above 1-2 kW level may require new advanced target development and in the case of e-beam applications, a scan horn will be required for extracting e-beam from vacuum to air.

INTRODUCTION

The side-coupled RF structure has been designed using SUPERFISH and PARMELA computer codes and was targeted to cover specification requirements for the current Linatron® K15 design as well as known medical, industrial, and security screening applications. The new Linatron® K15 design was made to match the current Linatron® K15 specifications operating at an energy of 15 MeV and delivering a dose of 12000 R/min@1m. Two new designs explore colinear dual sections, the first being a patented [1] hybrid reverse radio frequency (RF) feed system using a SW section and TW section (see Fig. 1), while the second is a traditional dual section SW accelerator. We have designed new high-power cavities to accommodate the larger power associated with these options and plan on testing them, which allow us to verify and adjust the accelerator cavity design parameters in a broad electron velocity range, collecting data adequate for building an operational LINAC. Special efforts have been taken to ease cavity and structure tuning and reduce cost of the new designs. A selected design will be integrated into the current Linatron® K15 resulting in a High-Power Platform (HPP) LINAC, a high-energy X-ray source for non-destructive testing (NDT) of large parts and screening of dense cargo. The HPP LINAC will be designed to produce X-ray energies between 1 MeV and 20 MeV with a capability of broad energy regulation, extending beyond the range of commercially available LINACs. The intent is to have an adjustable e-beam spot size, beam power greater than 1.5 kW, hence, higher dose rate. The HPP LINAC design platform at a common 2998 MHz frequency is introduced to utilize available components: different ABCs, RF components, targets, vacuum parts, e-guns, etc. This platform will permit servicing a variety of markets.

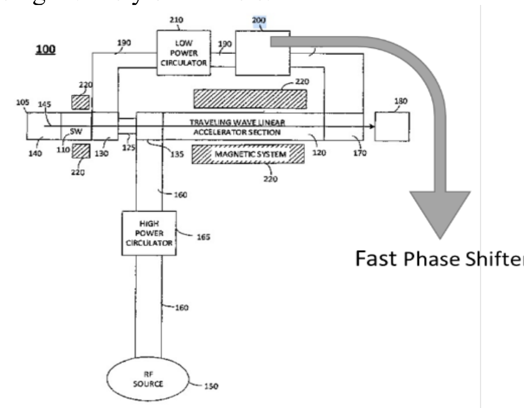

Figure 1: Hybrid Design. US Patent #US10015874.

RESULTS

Each RF ABC design was extensively explored, involving the choice of cell design, power input, and length of accelerating structure. The details of this exploration are described below.

Hybrid SW and TW

The 1st SW section is based on any of the available standard Varex ABCs, in EB energy range from 1 MeV to 9 MeV [2, 4, 10]. The TW section length will be varied, correspondingly. Overall accelerator length can vary from 1 m to 2 m, depending on the chosen injector and TW section parameters. The RF source power input can vary from 3 MW to 7 MW depending on the optimal length and depending on a chosen RF source.

The chosen TW section is a Disk Loaded Wave Guide (DLWG) design of constant impedance. Different lengths effected different parameters of the design and had to be accounted for. Great care was taken into simulating the hybrid design since it is reverse feed meaning power enters the TW section first and is then fed into the SW section. In a sample study, the length of the TW section was chosen carefully to ensure we fed enough power into the SW section.

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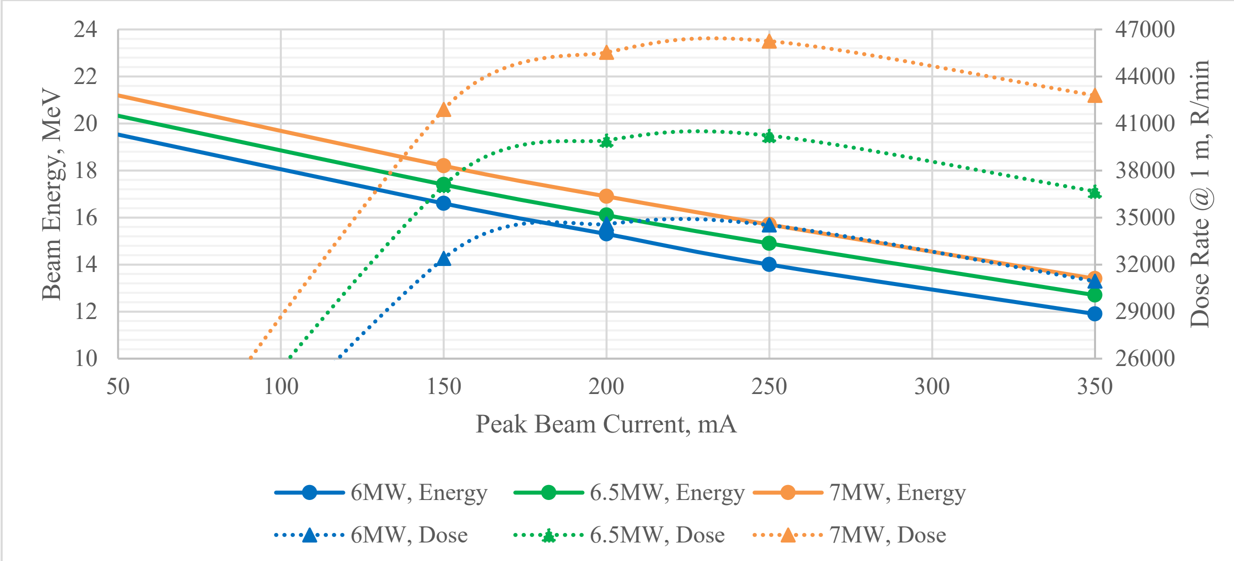

Figure 2: Calculated electron beam loading in High Power Platform ABC at different peak input power.

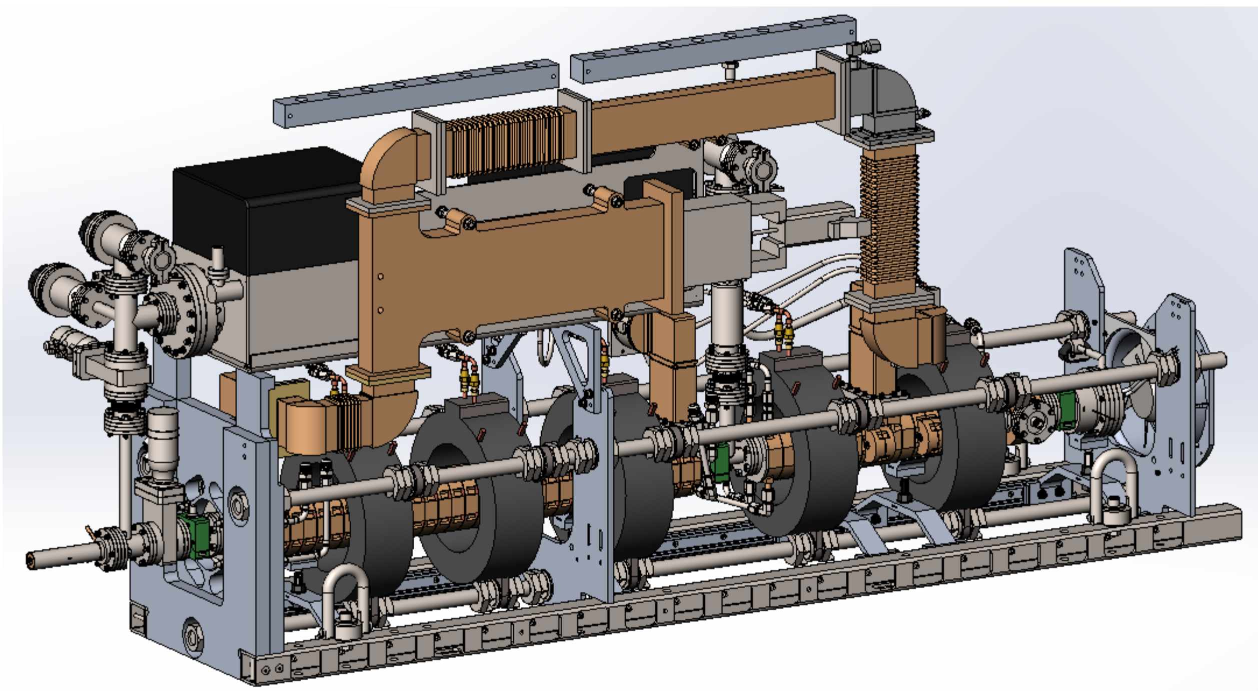

Figure 3: Conceptual design of Varex High Power Platform ABC

We calculated total beam energy and dose for peak beam currents of 0 mA, 150 mA, 200 mA, 250 mA, and 350 mA. Based on this sample design we were able to achieve the desired energy of 15 MeV and a considerably higher dose rate than the current Linatron® K15, as well as the design with two SW sections, at a peak beam current of 150 mA, 200 mA, and 250 mA. We noted that optimal lengths which achieved our desired operating parameters were at 1.02 m, 1.12 m, and 1.27 m. The concept for this design came from US Patent #US10015874 [1] and a schematic of said design can be seen in Fig. 1. The calculated load lines for this design can be seen in Fig. 2. A conceptual design of the HPP utilizing the hybrid ABC design can be seen in Fig. 3.

Two SW Sections

The length and power input for each section was chosen to match or exceed the current K-15 design. Overall accelerator lengths of 1.02 m, 1.12 m, 1.27 m, and 1.37 m were studied comparing total beam energy and dose to determine which length was the best. Given available RF input power, 6 MW, 6.5 MW, and 7 MW values were chosen to determine optimal length. We calculated total beam energy and dose rate for peak beam currents of 0 mA, 150 mA, 200 mA, 250 mA, and 350 mA. Based on this design we were able to achieve the desired energy of 15 MeV and a considerably higher dose rate than the current Linatron® K15 at a peak beam current of 150 mA and 200 mA. We noted that optimal lengths which achieved our desired

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operating parameters were at 1.27 m, 1.12 m, and 1.02 m, correspondingly, for the selected RF input power values.

CONCLUSION

We present preliminary simulation results of our new High Power Linear ABC and Platform design that will replace our current Linatron® K15 LINAC. We developed two options to replace the current Varian design. The first version is a "hybrid" SW-TW design option with reversed feed, and the second one is a traditional one with two SW colinear sections. To further improve beam transmission from a commercially available electron gun, we introduce a pre-bunching scheme.

Our preliminary results indicate both the parallel feed SW structure, and the hybrid ABC will exceed performance of our currently produced Linatron® K15 LINAC as well as enable greater system flexibility, while the hybrid design is expected to achieve even higher beam power and corresponding dose rate at a nominal 15 MeV energy.

The proposed system is designed for high energy, high power non-destructive testing of large objects (e.g., in aerospace industry) with drastically reduced inspection times. A modular design of High-Power Platform also provides a benefit of easier system components replacement in the field, including but not limited to the stopping target.

We plan on testing the SW buncher this Fiscal Year (FY) 2024, with 3 MW, 3 kW magnetron, and full High-Power Platform testing using a klystron will follow in FY2025.

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