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Power Flow in the RITS-6 Accelerator*

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Abstract. The Radiographic Integrated Test Stand (RITS-3) accelerator has been upgraded from three to six inductive voltage adder cells. The new RITS-6 accelerator can produce currents of 120 kA at voltages in excess of 10 MV. Prior to fielding experiments on radiographic diodes, power flow studies were performed using a blade load cathode to terminate the 11-meter long MITL (magnetically insulated transmission line). Three different geometries were studied: 1) A straight coaxial MITL with a 38-cm diameter anode and a 6.8-cm diameter cathode stalk; 2) A 130-cm diameter by 150-cm long anode chamber was added to the 38-cm anode. The 6.8-cm diameter cathode stalk was unchanged; 3) With the large anode chamber, a 58-cm diameter knob was attached to the cathode stalk about 13 cm upstream from the A-K gap. Scans of A-K gaps from short circuited to a gap large enough to provide line limited flow were done with each of the MITL geometries. Currents in the anode and cathode were measured at positions along the length of the MITL. In addition, capacitive voltage monitors mounted in the vacuum measured the cell voltage and the MITL voltage. This paper will present the results of the power flow measurements and make comparisons with calculations done with the particle-in-cell code Lsp [1] and theoretical calculations by Creedon [2] and Mendel [3].

INTRODUCTION

The RITS accelerator [4] was built as a test bed for research and development of pulsed power drivers and radiographic diodes. The pulsed power development is complete and RITS is now a reliable, low jitter, low pre-pulse accelerator. RITS has recently been upgraded from a three IVA cavity system (RITS-3) to a six cavity system (RITS-6), doubling the output voltage from 5.5 MV to 11 MV. Currently RITS-6 is limited to operation at voltages less than 10 MV until licensing as an accelerator facility can be obtained from the US Department of Energy. Prior to fielding radiographic diodes on RITS-6, an understanding of and the characterization of the power flow in the cavities and magnetically insulated transmission lines (MITL) is essential to the development of small spot size, high dose radiographic diodes.

TEST SET-UP

Four different configurations of the output end of the accelerator were fielded. The first, shown in Figure 1, was a 38-cm radius anode with a 6.8-cm radius hollow-cylinder cathode. Anode and cathode currents were measured at positions E, F, and G. The second and third configurations, shown in Figure 2, had a 130-cm diameter by 150-cm long anode chamber was added to the MITL. The two configurations differ by the 58-cm diameter knob added to the cathode stalk. This configuration is similar to those used by the Atomic Weapons Establishment radiographic facilities. In addition to the E, F, and G monitoring positions, current monitors were

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positioned before and after the knob. The final configuration added a taper or cone to the cathode from the beginning of the large anode chamber extending to the knob. A capacitive voltage monitor was located on the anode at position E.

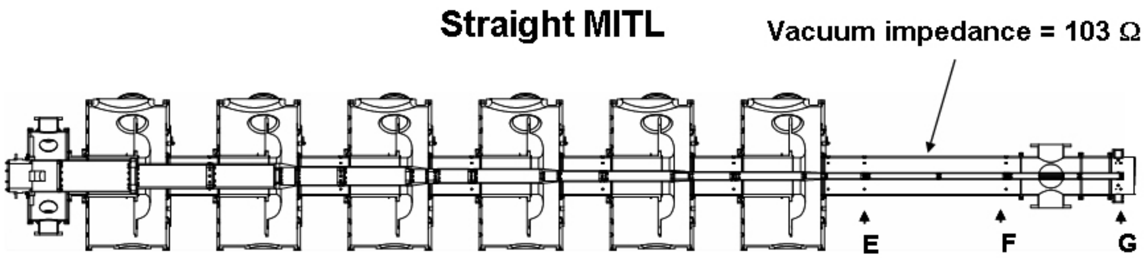


Figure 1: Cross section of the RITS-6 cavities and MITL. Anode and cathode currents are monitored at positions E, F, and G.

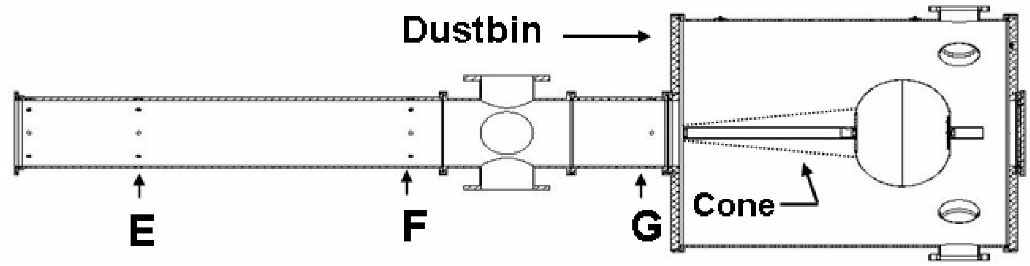


Figure 2: Cross section of the large anode chamber with the knob and the cone added for the final configuration.

RESULTS

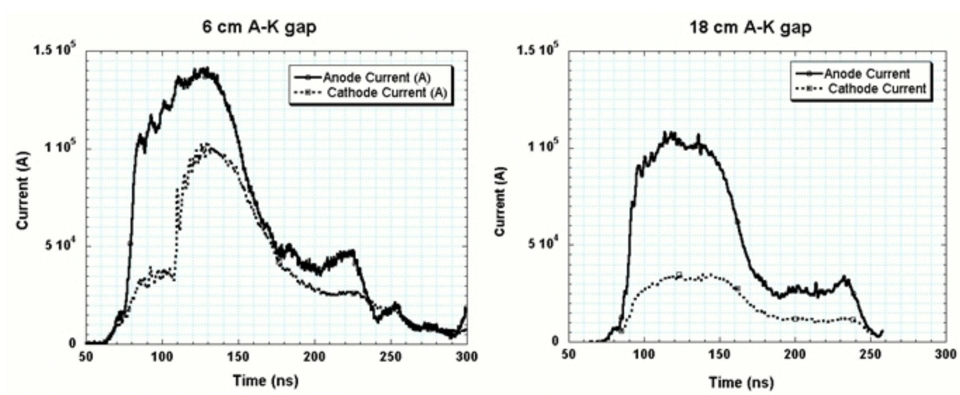


Figure 3: Anode and cathode currents at position E for 6 and 18-cm A-K gap spacings.

For the straight MITL, Figure 3 shows the anode and cathodes currents measured at “E” for 6 and 18 cm gaps. For the 18-cm gap, the MITL operates in a self-limited mode with no reflections in the MITL. However, for the 6-cm gap, there is a large reflection in the cathode current as a result of retrapping some of the MITL sheath current. The amplitude and the speed of the retrapping wave is dependent on the amount of impedance mismatch at the load. The 6-cm gap has a wave travelling back down the MITL at 0.55 times the speed of light while the speed with a 10-cm gap is 0.23c. Figure 4 is a graph of the anode and cathode currents and the load voltage calculated by Lsp [5]. By undermatching the MITL impedance substantial sheath current can be retrapped with only a small penalty in reduced voltage.

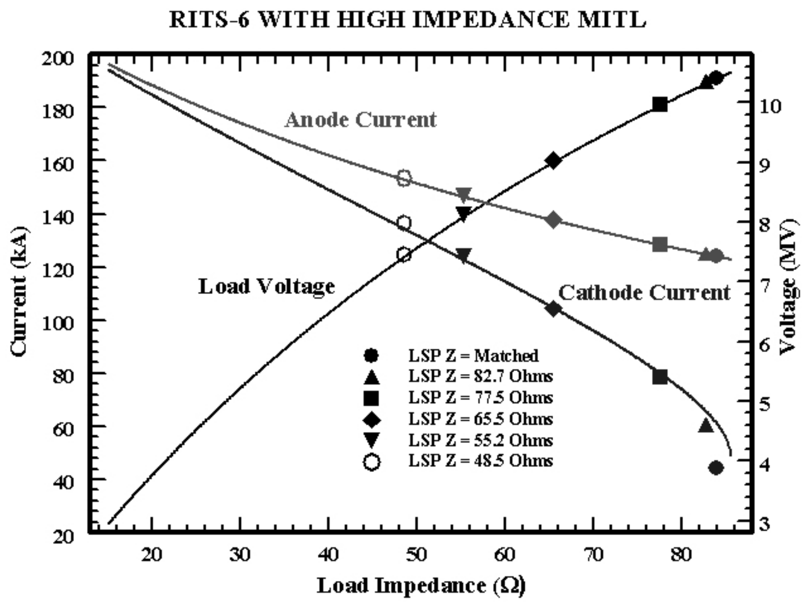
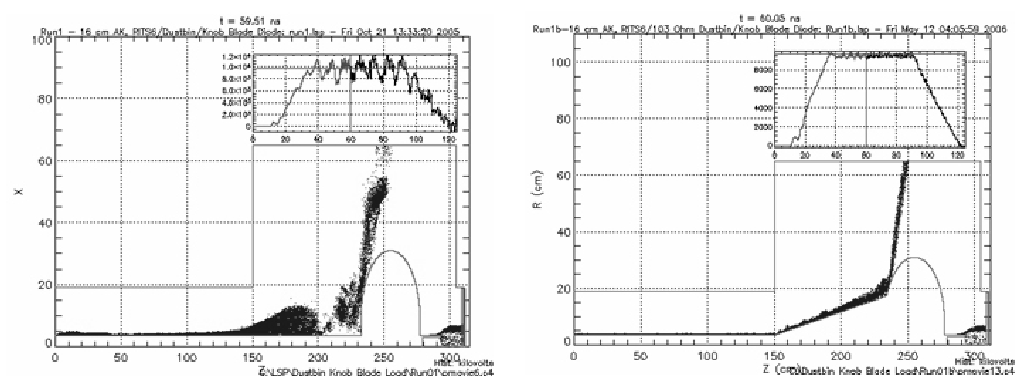


Figure 4: Lsp generated currents and voltage for a mismatched MITL.

Figure 5a shows Lsp runs for the case with the large anode chamber and the knob and figure 5b has the cone installed. Without the cone the electron flow is turbulent; with the cone the flow is much more laminar. On each of the graphs is a plot of the A-K voltage. The oscillations in the voltage are reduced by an order of magnitude with the addition of the cone. Experimentally, the reduction in current oscillations in the A-K gap is only a factor of three to four.



(a) (b)

Figure 5: Lsp calculations of electron flow, (a) without a smooth transition to the knob and (b) with a cone transition to the knob.

The frequency of the oscillations compare favourably; both have 125 MHz and 500 MHz components. Figure 6 shows the radiation measured for each configuration. The 125 MHz oscillations are present but not the 500 MHz.

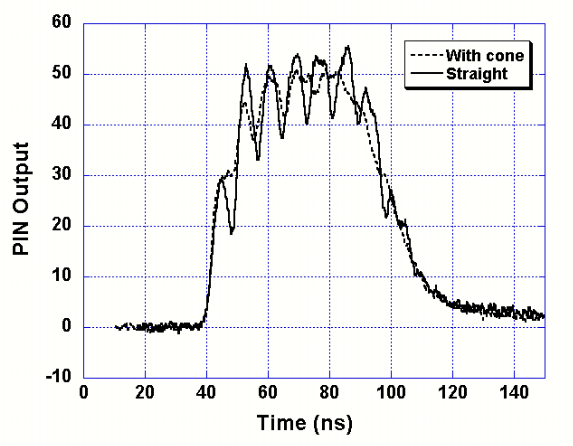


Figure 6: Radiation output for the cases of with and without the cone transition to the knob.

CONCLUSIONS

RITS-3 has been successfully upgraded to RITS-6 and is providing a reliable test-bed for power flow research and radiographic diode development. Power flow measurements have been made and Lsp simulations run for geometries expected to be used in the diode development. Comparisons of simulations with experimental data show a good correlation. And, finally, simulations of geometry configurations showing improvement in beam behaviour were experimentally verified. It is anticipated that increasing voltages to 11 to 12 MV will still show good correlation between experiments and simulations.

REFERENCES

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