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HIGH VOLTAGE E-GUN UPGRADE

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Abstract

A typical commercially available thermionic triode e-gun operates in 10-15 kV range. Certain linac accelerating structures may benefit from higher voltage injection. Based on commercially available low voltage e-guns, Varex Imaging High Energy Sources Group has developed an e-gun that could operate in extended range of voltages from 10-40 kV and provide high adjustability of injecting beam parameters. The new e-gun can be utilized with both triode and diode options.

DESIGN

A typical triode thermionic e-gun for a linear particle accelerator has parameters listed in Table 1 [1].

Table 1: A typical thermionic e-gun manufactured by Nisshinbo Micro Devices Inc.

Parameter	Value or Type
Cathode type	Dispenser cathode (Barium impregnated cathode)
Cathode diameter / Area	6.3 mm / 0.32 cm^2
Heather voltage	6.3 V
Heater current	1.6 A
Current density	10 A/cm^2
Cathode voltage	-15 kV

Some of the existing Linatron Accelerator Subsystems produced by Varex Imaging, require e-beam injection of up to 40 kV. Therefore, the typical commercially available e-gun will not work with these subsystems. In process of accelerator beam centerline (ABC) development [2-7] that will replace Varian manufactured beam centerlines (BCL), Varex Imaging High Energy Sources group utilized a mass produced commercially available thermionic triode e-gun, and developed an adapter which will help the e-gun to operate at higher voltages. To accomplish this goal, multiple design and assembly changes were made. Simulations show that a linac accelerating structure designed for S-band operating frequency, will benefit from higher voltage e-beam injection in its buncher section.

First, an interface was developed to increase maximum voltage which the e-gun could reach without arcing between components. This increase in maximum voltage required an increase in electrical insulation. To do this, the High Energy Sources team designed a package in which the e-gun was isolated by vacuum from the surrounding environment. Further changes to the assembly were made to accommodate the change in electron optics resulting from the high voltage.

TESTING

To test the high voltage e-gun assembly, a new e-gun test fixture was built (see Fig. 1). The diode e-gun was utilized for the prototype. The stand included a vacuum sealed e-gun attached to a specifically designed anode aperture that will accommodate change of e-gun beam geometry. A toroid current monitor was placed at the input of the e-gun. A resistive current monitor was mounted at the output of the stand. The complete assembly passed vacuum leak detection test and was baked out at 350 °C. Together with a high voltage e-gun driver capable of producing up to 30 kV DC high voltage, this test stand configuration allowed transmission of measurements to an external data base. No external electric or magnetic fields were present during testing.

Low voltage performance was similar to the results of e-gun operation without the adapter, and the e-gun achieved higher voltages relative to the standard e-gun. However, at higher voltages, arcing occurred, but the system did stabilize and the arcing subsided. Unfortunately, the gun driver failed when 27 kV high voltage was reached.

Figure 1: Test Fixture with E-gun installed.

RESULTS

Despite difficulties in testing, the results have good agreement with expectations. See Fig. 2 for test data results.

Maximum current transmission from the e-gun cathode to the output of the stand (gray line on the chart) was about 6%. Maximum peak output current (orange line on the chart) was 50 mA at the maximum pulsed e-gun current of about 800 mA. While the observed values are specific to the configuration of the anode aperture,

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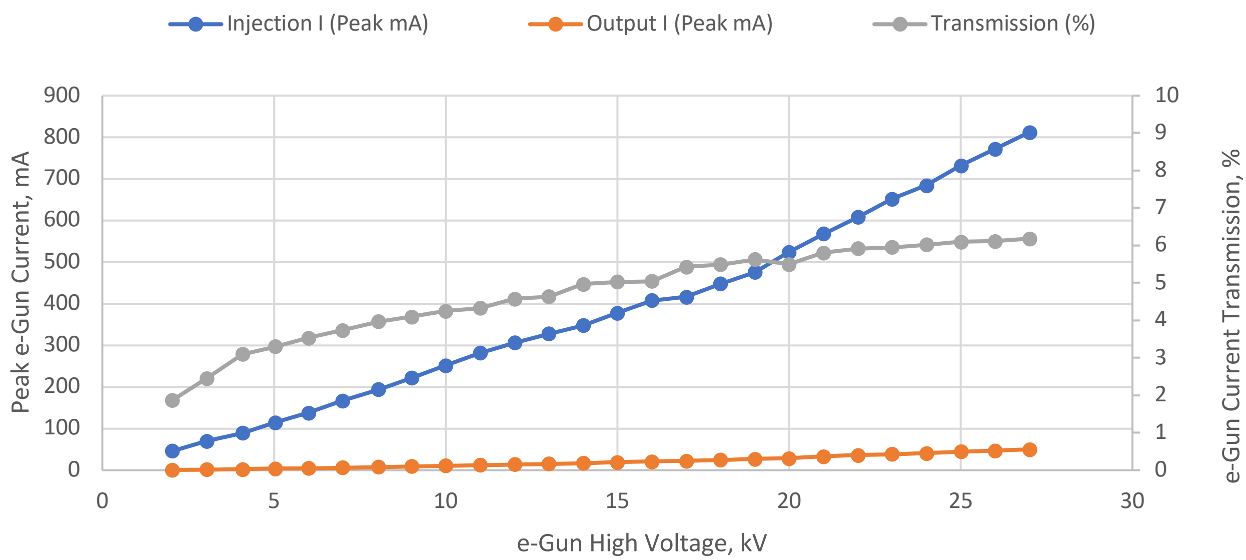

Figure 2: High Voltage E-Gun Test results: Input Current, Transmitted Current and Fixture Transmission versus voltage.

the results agree with the low voltage e-gun performance operating in 10-15 kV high voltage range. At the same moment, output current measurements showed continuous e-gun current transmission improvement with increase of e-gun high voltage beyond the standard e-gun specification. As an example, e-gun current transmission value was measured as 4.25% at 10 kV, and 6.18% at 27 kV. The E-gun output in its current configuration increased by about 1.5 times between 10 kV and 27 kV operation.

CONCLUSIONS

The current e-gun adapter design made it possible to utilize a standard off-the-shelf 10-15 kV thermionic e-gun in an environment where an e-gun driver will supply higher DC high voltage. This is an excellent proof of concept for the high voltage e-gun upgrade. Testing demonstrated the e-gun can operate at 27 kV, almost twice of the standard e-gun. While this is a huge leap in e-gun development industry and utilization, further research and development is required to eliminate arcing in the standard e-gun and premature failure of the gun driver while running stably at high voltage of up to 40 kV.

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