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Design and Characterization of a Compact 200 kV Marx Generator

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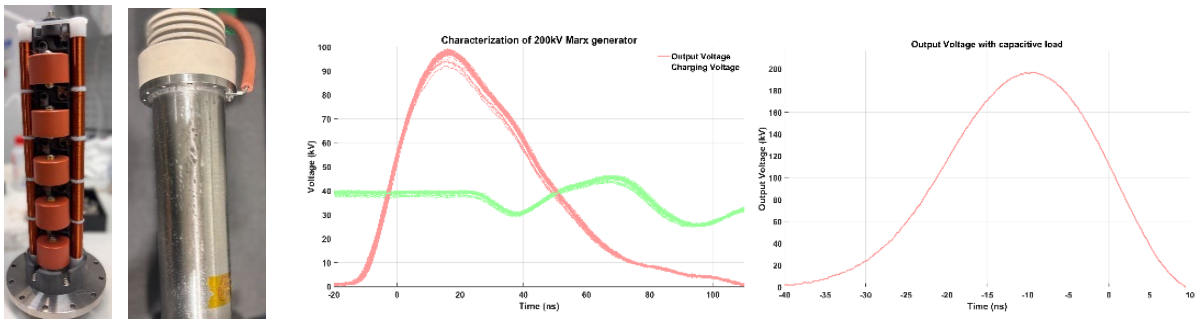
This work presents the design and experimental characterization of a compact Marx generator, working at 200 kV output voltage and optimized for pulse rates up to 100 Hz. The generator is intended to feed peaking circuits and dipole antennas, with direct application in intentional electromagnetic interference (IEMI) studies [1]. The five-stage generator incorporates 940 pF capacitors per stage, and inductors for the charging cycle winded on a 3D-printed nylon structure. Stainless-steel spheres serve as electrodes for the inter-stage spark gap switches, with interelectrode separation controlled using 3D-printed holders. The estimated stray capacitance per stage, primarily due to the spark gaps, is estimated numerically to reach around 3 pF. The entire assembly is housed in a steel cylindrical housing, insulated with sulfur hexafluoride (SF_6) gas and a high-density polyethylene (HDPE) liner. An output isolator made with PEEK supports the output connection into the load. Figure 1a shows a prototype of the presented generator.

The characterization of the presented generator includes pneumatic tests, pulse stability and current and voltage ratings into different loads. A leakage test was performed by pressurizing the generator to 4 bars and monitoring the pressure level over a period of three weeks. A reduction of less than 3.95 bars was verified. To characterize its electrical performance, the generator was connected to a 122 Ω resistive load, and to a capacitive probe. A 0.02 Ω current viewing resistor (CVR), and a high-voltage probe were used to measure the load current and the charging voltage, respectively. The operation stability was assessed within an interval from 10 Hz to 100 Hz, in steps of 10 Hz, with 100 shots in each setting. For the 100 Hz repetition rate case, the percentage standard deviation of the charging voltage reached 1.41% around the nominal 40 kV, while for the output voltage it was 1.47% around the average 98 kV, under matched load conditions. The waveforms are shown in Figure 1b. Figure 1c. shows a sample waveform from an open-load test, across a capacitive probe, showing a peak output voltage close to 200 kV, with an average rise time of approximately 15 ns, and per-pulse energy of around 3.8 J. The presented prototype weighs 9 kg, with a flange diameter of 125 mm, and 436 mm in length. The generator is charged by a battery powered DC power supply, enabling compactness and portability. On going work include replacing the SF_6 with environmentally friendly gases like nitrogen, reducing interelectrode gaps to enhance triggering reliability, increasing the output voltage, and weight reduction.



(a) (b) (c)

Figure 1: (a) Marx generator prototype. (b) Matched load volage and charging voltage waveforms samples from a burst at 100 Hz. (c) Output voltage waveform, from the open-circuit test.

[1] Mayes, J., et al. "Development of a dual-polarity Marx generator designed for pulse charging a dipole antenna," in Proceedings of the IEEE International Power Modulator and High Voltage Conference, 2010, pp. 617-621.