INDUSTRIAL PINCH DIODE FOR FLASH X-RAYS GENERATION USING COMPACT MARX GENERATOR

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INTRODUCTION

A compact Marx generator (225kV, 6kA, 100ns, 150J) has been designed and developed which is made of folded pulse forming line modules (FPFL). The FPFL gives flat top output pulse. Firstly, it was characterized with non inductive aqueous resistive load then connected to relativistic diode. This diode chamber is evacuated with online vacuum system and generated electron pulses are converted into flash X-rays by Bremstrahlung radiation. The Marx generator has the advantages of higher peak power rating, compactness, low cost and reliability in comparison with the conventional pulse-forming network (PFN) Marx. Details of the Marx generator and FXR source are described in following sections.

GENERAL DESCRIPTION

(i) Marx Generator: A 15 stages Marx generator which converts dc charging input to sub-microsecond pulse at the output is developed at APPD, BARC. This is done by charging a number of capacitors in parallel and discharge them in series by a set of switches, thereby adding the voltage across each capacitor that appears across load. Folded pulse forming line is a transmission line in parallel plate geometry. It is a three electrode line in which the central electrode is separated from the outer two electrodes by means of insulating films forming two parallel lines on either side of the central electrode as shown in fig.1. The complete assembly of 15-stage Marx is shown in Fig. 2. The rated open circuit output voltage is 450 KV; however rated current is limited about 6.6 KA on a matched load of 50 Ω because of the additional inductance of Marx circuit. The Marx generator is used as a HV source and flash X-rays tube as a load.

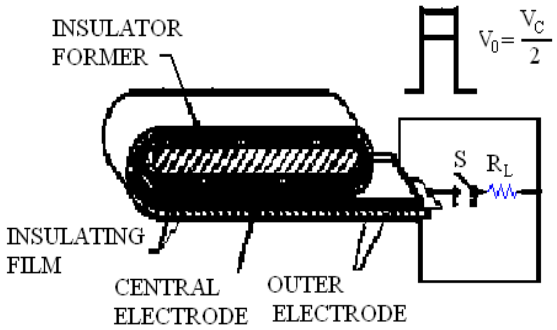

Figure 1: Construction schematic of FPFL.

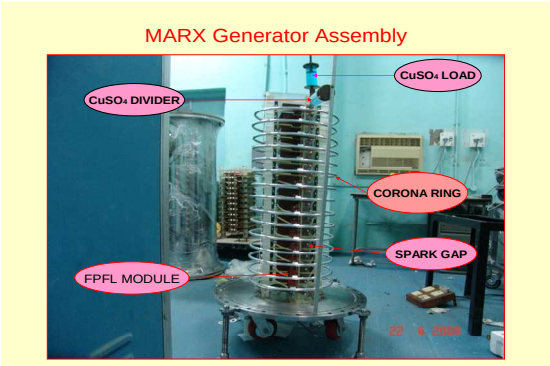

Figure 2: Assembly of 15-stage Marx.

(ii) Flash X-ray Tube: The output of an X-ray tube approximates to an equation of the form:

$$\frac{dD}{dt} = KIV^{\wedge}n \qquad (1)$$

where $\frac{dD}{dt}$ = radiation intensity (dose rate), I = tube current, V = anode-cathode voltage, and K is function of anode material. The radiation intensity, produced by an accelerated beam of paraxial electrons, varies as $V^{2.5}$ over a wide voltage range.

$$V = \frac{Z_L}{Z_L + Z_O} V_O \qquad (2)$$

Where, V_0 = total charging voltage, Z_L= tube impedance, and Z_o = pulsar impedance. The tube current is

$$I = \frac{V}{Z_L} \qquad (3)$$

Technical specifications of Scandiflash Model No. XT 500A X-Ray Tube is given in table 1.

TABLE-I

Descriptions	Ratings
Maximum current	10kA
Minimum current	500A
Maximum voltage	500kV
Minimum voltage	160kV
Pulse duration	25ns-50ns
Source size	25mm
Penetration of steel	(thickness =2.5m) =34mm
Dose/ pulse @1m from the tube window (mR):	24
Dimensions (mm)	441.5 (H) x 265 (Dia.)

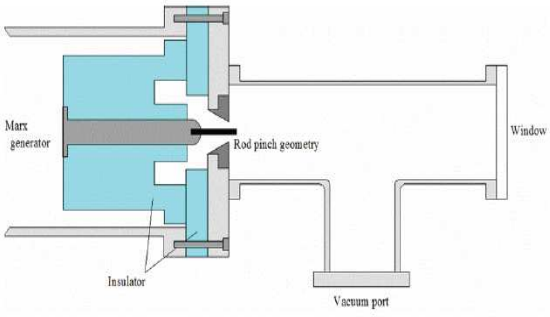

Figure 3: Schematic of Anode-cathode configuration in FXR tube**.**

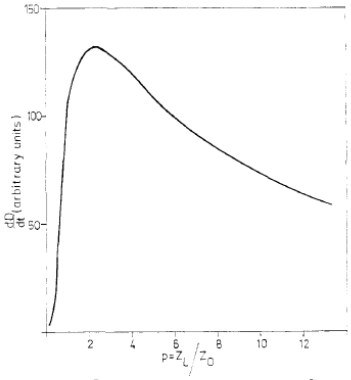

Figure 4: Output dose intensity as a function of tube impedance (*p*).

RESULTS

Plot of dose obtained from X-Ray tube is shown in Fig.4 (a). This tells how the dose varies as voltage applied across the anode-cathode combination is varied.

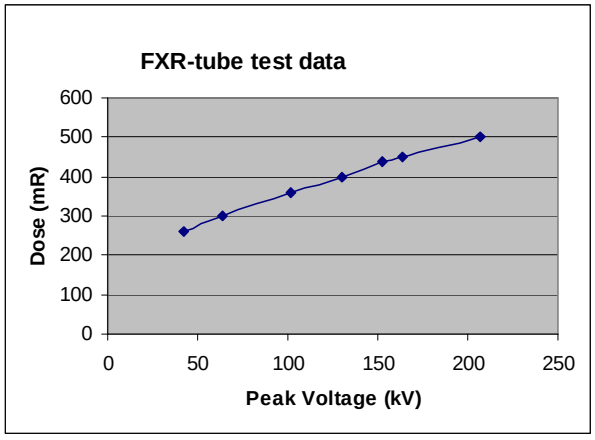

Figure 4(a): Dose versus Peak Voltage (at anode)

Plot in Fig 4 (b) shows the dose obtained at various distances from the centre of the tube. These measurements were done in a lead shielded enclosure with remote control operation of the Marx generator in high pressure gas medium.

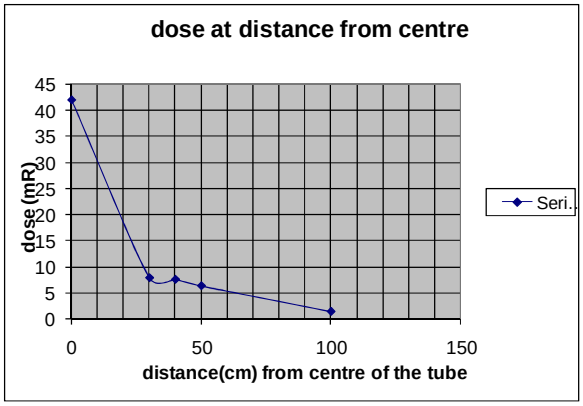

Figure 4(b): Dose versus distance from FXR tube.

(a) Effect of Cathode configuration:

The compact Flash X-rays generator has been characterized for the change in dose due to variation of (cathode radius) Rc/Ra (anode radius).For this study, 16 different combinations of cathode and anode were subjected to high voltage of 26 KV with pressure inside Marx at 1.5kg/cm^2 of nitrogen. All the measurements were taken with the help of pen dosimeters kept at a distance of 5.75cm from the cover of the X-Ray tube and at angles of +30^0, 0^0 and -30^0. When ratio of anode and cathode is varied, two distinct peaks are observed at two values of R_C/R_a. So, dose received at a distance can be optimized by using a combination of anode and cathode of these two ratios which are 3.056 and 5.2084.

CONCLUSIONS

Compact Marx generator fed FXR source has been developed and characterized. It is useful for flash radiography and transient photo reaction studies.

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