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An Experimental Method on the EMP Resistance of QLED Device

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Abstract. An experimental method on the electromagnetic pulse resistance of quantum dot light-emitting diode device is researched in this paper. If there is a strong electromagnetic pulse in the environment, the electromagnetic pulse can disturb the QLED device's work or even destroy it through coupling into the cables of the device. The noises could overwhelm the interference wave if using irradiation experiment. So, the equivalent coupling energy is calculated, and the pulse voltage injection experiment method is adopt in this paper. The experiment results supply references to the engineering practice.

1. Introduction

Along with the high information level, more and more weapons depend on high-performance devices. The nanometer device with high integration is the typical example. Lots of microelectronic technology are used into weapons which brings low voltage, low power consumption, broad band, but vulnerability in the strong electromagnetic pulse environment.

Another feature of information-based equipment is human-machine interaction ability. For example, advanced military aircraft can show information of battlefield environment, combat objective, flight parameters, and hostile aircraft status. As the important element of the military equipment, display device is the major unit of getting combat information and commanding troops. People will lose the most effective interactive way with the electronic equipment if display device was disabled.

QLED will be the research direction of the display device, and it will be marching towards the market [1-3]. So, the electromagnetic pulse resistance of QLED device is the inevitable research for the military electronic equipments. If there is a strong electromagnetic pulse in the environment, the electromagnetic pulse can disturb the QLED device's work or even destroy it through coupling into the cables of the device [4-5]. The noises could overwhelm the interference wave if using irradiation experiment. So, the equivalent coupling energy is calculated, and the pulse voltage injection experiment method is adopt in this paper. This experiment method will be meaningful to the research of QLED's failure mechanisms in the strong electromagnetic pulse environment and its reinforcement.

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2. Transmission Line Model

Through pre-phase research of QLED device in the strong electromagnetic pulse environment, the major electromagnetic coupling channel is the connection lines. The strong electromagnetic pulse coupled into the connection lines as a high pulse voltage and a high pulse current. The pulse voltage and the pulse current injected into the QLED device through the connection lines, and disturb the QLED device's work or even destroy it.

The connection lines always be placed along the ground. So, the electromagnetic coupling analysis of the connection lines can take the overhead ground cable's electromagnetic coupling model as the circuit model [6]. The schematic diagram is shown in fig.1.

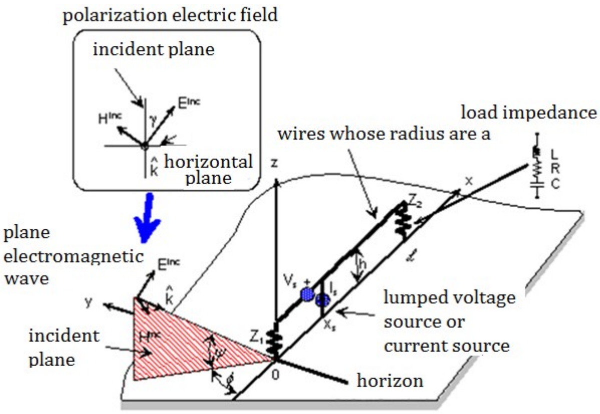

Figure 1. Transmission line calculation model schematic diagram

Taking the electromagnetic pulse parameters for high-altitude nuclear explosion in IEC standard as the example [7]. The field intensity waveform is shown in fig.2. The maximum value is 20kv/m.

$$E_{\max} = 5.00 \times 10^4 \mathrm{V/m}$$
$$t_r = 2.5\mathrm{ns}$$
$$t_w = 23\mathrm{ns}$$

$$E(t) = \begin{cases} 0 & t \le 0 \\ E_{\max} \cdot k\left(\mathrm{e}^{-\alpha t} - \mathrm{e}^{-\beta t}\right) & t > 0 \end{cases}$$

$$k = 1.3$$
$$\alpha = 4.0 \times 10^7 (\mathrm{s}^{-1})$$
$$\beta = 6.0 \times 10^8 (\mathrm{s}^{-1})$$

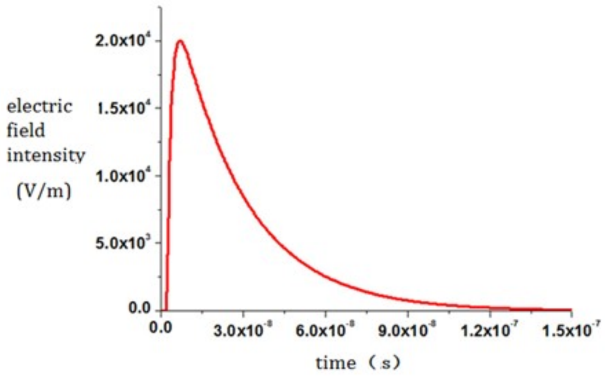

Figure 2. Incident plane electromagnetic wave

The length of the QLED's connection line is taken as 15cm, and the height from the zero potential is 5cm. The load of the transmission line model is matched. The plane electromagnetic wave's incident angels are $\Phi=0°$,$\Psi=90°$,$\gamma=0°$. The direction of the electric field intensity is parallel with the connection line in this incident angels, and the coupled energy of the connection line is the highest. The coupled voltage and current wave are shown in fig.3 and fig.4. The coupled energy is 1.9×10^{-5}J.

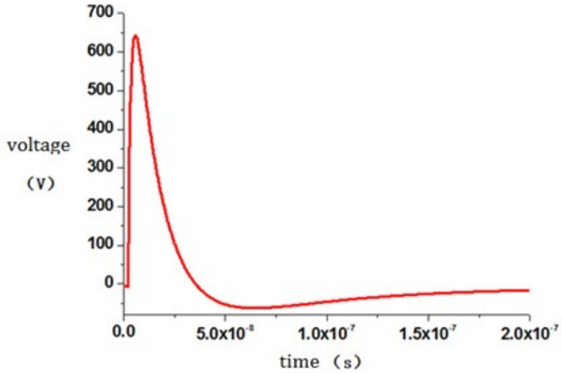

Figure 3. Coupled pulse voltage on the terminal load

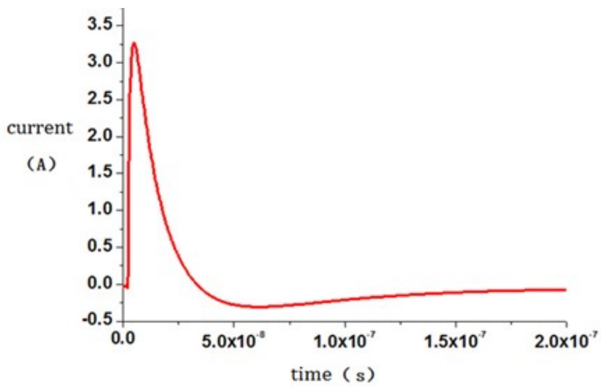

Figure 4. Coupled pulse current in the terminal load

3. Experimental Design

Because the QLED device is in the exploratory stage, and there is no relevant electronic system yet. What's more, the noises could overwhelm the interference wave if using irradiation experiment. So, the pulse voltage injection experiment method is adopt in this paper. Fig.3 shows us that the maximum

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coupled voltage value is about 650V. In this experiment, 700V is adopted. The rise time of the pulse voltage is 2ns, and the pulse width is 100ns. The experimental voltage and current wave are shown in fig.5 and fig.6. The total energy is 2.23×10^{-4}J which is higher than the actual coupled energy under the electromagnetic pulse's irradiation of 20kv/m. The damage modes of the QLED device under the electromagnetic pulse's irradiation are overvoltage breakdown and energy deposition burning. So, if the QLED device can work normal under the pulse voltage in fig.5, it can work normal under the electromagnetic pulse's irradiation of 20kv/m. If the QLED device is destroyed under the pulse voltage in fig.5, the reinforcement of the QLED device under the strong electromagnetic pulse becomes necessary. If the QLED device with reinforcement can work normal under the pulse voltage in fig.5, it will be work normal under the electromagnetic pulse's irradiation of 20kv/m.

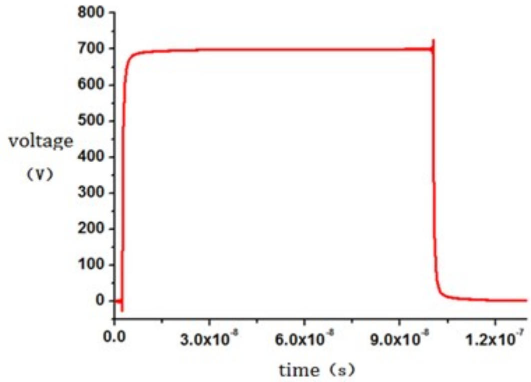

Figure 5. Experimental voltage wave on the terminal load

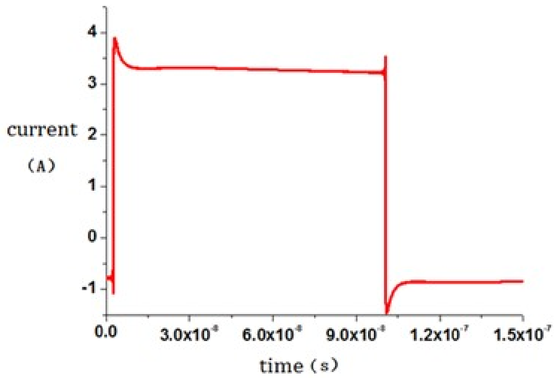

Figure 6. Experimental current wave in the terminal load

4. Conclusion

The QLED device is a vulnerable electronic device under the strong electromagnetic pulse. But the QLED device is in the exploratory stage, and there is no relevant electronic system yet. The experimental method of QLED device under the strong electromagnetic pulse is a problem. An equivalent pulse voltage injection experimental method is adopted in this paper, and the equivalent parameters are calculated through the transmission line model. The experimental method proposed in this paper offered data reference for the reinforcement of the QLED device in the future research.

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