Shielding Study of Electrostatic Discharge

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***Abstract* — The electric and magnetic fields radiated by an ESD event are calculated theoretically by using the dipole model. Experiments are performed and the ESD currents are measured for different discharge voltage. In these experiments the electric and magnetic fields are also measured and compared with the theoretical results. Effect of shielding from ESD pulses is studied theoretically and experimentally. The results are compared with the literature wherever possible and agreement is obtained.**

***Index Terms* — Electrostatic discharge, radiated fields, shielding effectiveness, electromagnetic interference.**

I.INTRODUCTION

Static electricity has been a source of problems for users and designers of electronic equipments. In the last few years the problems have increased extremely, because newer electronic devices such as integrated circuits are much more susceptible to ESD problems than previous devices such as vacuum tubes. The aim of this study is to give an insight to the ESD problem by reproducing the ESD currents with different models and also modelling the ESD radiated electric and magnetic fields and supporting these models with the experimental results.

A dipole model is used to calculate the electric and magnetic fields radiated by ESD currents. In this model, ESD spark is idealised as an electrically short, time-dependent, linear source (dipole) situated above an infinite, perfectly conduction ground plane. The electric and magnetic fields were also measured experimentally and theoretical and experimental results are compared. In this way ESD radiated fields are examined. Shielding of the electronic devices is one of the protective methods againts the fields radiated by ESD. The shielding effectiveness is derived by solving the Helmholtz Equation for the given type of the material and shape of the enclosure.

The time domain analysis of the shielding effectiveness is done by considering the outer magnetic field as an impulse which is an ESD pulse. For the special case of two parallel copper plates, the shielding effectiveness is calculated by using the time domain analysis. In addition, by using the experimental setups, the radiated electromagnetic field from ESD is measured from the outside and inside of the parallel plate enclosure and shielding effectiveness is obtained experimentally. Theoretical and experimental results are compared and effects of shielding on the ESD radiated fields are shown both theoretically and experimentally.

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II. MODELLING OF THE ELECTROSTATIC DISHARGE (ESD)

Objects accumulate charge either triboelectrically or inductively [1,2]. Triboelectric charging is a mechanical process whereby relative surface motion transfers the charge. Charge transfer depends on the amount of contact, surface smoothness, humidity, contact pressure, the triboelectric properties of the rubbing materials, and the rate of relative motion. Induction charging is the result of exposing an ungrounded object to an electrostatic field. The voltage difference between the two objects will induce a current, transfering enough charge to equalize the voltages. This rapid transfer of charge is known as ESD. During this process, it causes potentially devastating currents and electromagnetic fields to occur. In the present advanced stage of integrated circuit technologies, ESD is a great threat and have potential destructive effects on chips. The major impact comes from the Human Body ESD events. In a typical environment of shoes and carpets, a charge of about 0.6 μC can be induced on a body capacitance of 150 pF, leading to electrostatic potentials of 4kV or greater [3]. Any contact by the charged human body with a uncharged pin such as an IC pin can result in a discharge for about 100 ns with peak currents in the amperes range.

ESD stress models are designed in order to reproduce the typical discharge pulses that the electronic equipment may be exposed. Three standart models have been developed which are Human Body Model (HBM), Machine Model (MM) and the Charged Device Model (CDM). The names are derived from the origin of the ESD pulses.

The HBM is the ESD test method used in this work. The test method attempts to reproduce an ESD wavefrom generated by the discharge of a human being through a low impedance path.

The discharge circuit was based on the requirements for generating the double exponential pulse which was determined to be a typical of that generated by a charged human body. The rise time of the pulse translates into an effective inductance, and the equivalent LCR circuit is given in ref [1-4].