Semiconductor Devices and Circuit

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***Abstract*: The main aim of this investigation is to assess the suitability of modern power semiconductor devices for pulse power applications. Pulse power system involves the storage of energy, which is released in form of high power pulse to the load by means of a switching device. Hence the basic components of pulse power system are an energy storage element, a switch, and a load circuit. The energy storage is usually either an inductive or capacitive nature. The limiting device in a pulse power system is often the switch, which limits the pulse peak power and the repetition rate.**

***Keywords*: Semiconductor electronics, Device designing, Circuit development, Analog Design, Development and Analysis.**

1. Introduction

The switch element in this case is very special and falls into two basic categories: 1-Vacuum and gas filled switching tubes, 2-Solid-state (semiconductor) switches. The conventional approach in pulsed power designs is to use spark gap and gas filled switches such as thyratron and ignitron, because they truly possess the required characteristics for high power application. However, these devices have limited lifetime, high cost, low repetition rate and high losses. On the other hand high power semiconductor devices have under gone continued improvement in switching speed, voltage and current ratings and thus are replacing the conventional gas filled devices in some applications. Solid state devices are considered environmental friendly since they do not contain nasty gases and have perceived higher reliability than gas filled devices. In this paper, a complete overview of vacuum and gas filled switches and solid-state switches will be given. Very rarely these types of power semiconductor devices are characterised for pulse power applications and so the task of dimensioning a device simply from the datasheets is somewhat difficult and time consuming. Different methods for assessing their suitability will be described and a new technique to rapidly dimension the semiconductor device for pulse power application will be presented.

A. *Semiconductor devices*

Semiconductor devices are electronic components that exploit the electronic properties of semiconductor materials, principally silicon, germanium, and gallium arsenide, as well as organic semiconductors. Semiconductor devices have replaced thermionic devices (vacuum tubes) in most applications.

B. *Semiconductor Electronics*

Semiconductor devices are manufactured both as single discrete devices and as integrated circuits (ICs), which consist of two or more devices—which can number in the billions—manufactured and interconnected on a single semiconductor wafer (also called a substrate).

Semiconductor materials are useful because their behavior can be easily manipulated by the deliberate addition of impurities, known as doping. Semiconductor conductivity can be controlled by the introduction of an electric or magnetic field, by exposure to light or heat, or by the mechanical deformation of a doped monocrystalline silicon grid; thus, semiconductors can make excellent sensor.

C. *Device design*

All transistor types can be used as the building blocks of logic gates, which are fundamental in the design of digital circuits. In digital circuits like microprocessors, transistors act as on-off switches; in the MOSFET, for instance, the voltage applied to the gate determines whether the switch is on or off. Transistors used for analog circuits do not act as on-off switches; rather, they respond to a continuous range of inputs with a continuous range of outputs. Common analog circuits include amplifiers and oscillators. Circuits that interface or translate between digital circuits and analog circuits are known as mixed-signal circuits.

Power semiconductor devices are discrete devices or integrated circuits intended for high current or high voltage applications. Power integrated circuits combine IC technology with power semiconductor technology, these are sometimes referred to as "smart" power devices. Several companies specialize in manufacturing power semiconductors.

D. *Circuit development*

Integrated circuit design, or IC design, is a subset of electronics engineering, encompassing the particular logic and circuit design techniques required to design integrated circuits, or ICs. ICs consist of miniaturized electronic components built into an electrical network on a monolithic semiconductor substrate by photolithography

E. *Analog design*

Before the advent of the microprocessor and software based design tools, analog ICs were designed using hand calculations and process kit parts. These ICs were low complexity circuits, for example, op-amps, usually involving no more than ten transistors and few connections. An iterative trial-and-error process and "over engineering" of device size was often necessary to achieve a manufacturable IC. Reuse of proven designs allowed progressively more complicated ICs to be built upon prior knowledge. When inexpensive computer processing became available in the 1970s, computer programs were written to simulate circuit designs with greater accuracy than practical by hand calculation. The first circuit simulator for analog ICs was called SPICE (Simulation Program with Integrated Circuits Emphasis).

F. Uses and examples of semiconductor device

As a discrete component, a semiconductor is used as optical sensors, power devices, light emitters, and also including the solid-state lasers. The semiconductor examples include the following: Op-amps, Resistors, Capacitors, Diodes, Transistors.

2. Results

Semiconductor device, electronic circuit component made from a material that is neither a good conductor nor a good insulator (hence semiconductor). Such devices have found wide applications because of their compactness, reliability, and low cost. As discrete components, they have found use in power devices, optical sensors, and light emitters, including solid-state lasers.

The conductivity of a semiconductor is generally sensitive to temperature, illumination, magnetic fields, and minute amounts of impurity atoms. For example, the addition of less than 0.01 percent of a particular type of impurity can increase the electrical conductivity of a semiconductor by four or more orders of magnitude (i.e., 10,000 times). The ranges of semiconductor conductivity due to impurity atoms for five common semiconductors.

3. Conclusion and discussion

To design any electrical circuit, either analog or digital, electrical engineers need to be able to predict the voltages and currents at all places within the circuit. Linear circuits, that is, circuits wherein the outputs are linearly dependent on the inputs, can be analyzed by hand using complex analysis. Simple nonlinear circuits can also be analyzed in this way. Specialized software has been created to analyze circuits that are either too complicated or too nonlinear to analyze by hand. Circuit simulation software allows engineers to design circuits more efficiently, reducing the time cost and risk of error involved in building circuit prototypes. Some of these make use of hardware description languages such as VHDL or Verilog.

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A semiconductor material has an electrical conductivity value falling between that of a conductor, such as metallic copper, and an insulator, such as glass. Its resistivity falls as its temperature rises; metals behave the opposite. Its conducting properties may be altered in useful ways by introducing impurities ("doping") into the crystal structure. When two differently-doped regions exist in the same crystal, a semiconductor junction is created. The behavior of charge carriers, which include This chapter covers different methods of semiconductor device modeling for electronic circuit simulation. It presents a discussion on physics-based analytical modeling approach to predict device operation at specific conditions such as applied bias (e.g., voltages and currents); environment (e.g., temperature, noise); and physical characteristics (e.g., geometry, doping levels). However, formulation of device model involves trade-off between accuracy and computational speed and for most practical operation such as for SPICE-based circuit simulator, empirical modeling approach is often preferre Semiconductor devices and Circuits. S.KURUSEELAN Semiconductor Theory â€¢ Materials â€“ Classified based on conductivity â€“ Conductor â€“ Good â€“ Insulator â€“ Poor â€“ Semi conductor â€“ in between. â€¢ based on the number of valence electrons (electrons in the. outermost orbit) â€“ Conductor has 1 or 2 electrons in the outermost orbit â€“ Insulator has completely filled outermost orbit â€“ Semiconductor has partially filled outermost orbit Energy Band â€¢ The range of energy possessed by an electron of an atom. â€¢ Valance band â€“ range of energy possessed by valance electrons. â€¢ Conductors â€“ valance electrons are loo Power Semiconductor Devices â€“ Key Components for Efcient Electrical Energy Conversion Systems. 1.1 Systems, Power Converters, and Power Semiconductor Devices. In a competitive market, technical systems rely on automation and process control to improve their productivity.Â Basic circuit theory and component design proves that higher switching frequencies will lead to smaller passive elements and lter components. Hence, all converter designs strive to increase switching frequen-cies to minimize overall converter costs. However, as will be discussed in the next sections, higher switching frequencies impact converter efciency.