Survey on Low Cost Integrated Circuit Design

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***Abstract*- The growing market of mobile, battery-powered electronic systems (e.g. cellular phones, PDA etc.) demand the design of micro electronics circuits with low power dissipation. More generally, as size, density and complexity of the chips continue to increase, the difficulty in providing cooling might either add significant cost or limit the functionality of the computing systems which make use of those integrated circuits. The paper presents study of low cost integrated circuit and its applications. An integrated circuit is a set of electronic circuits on one small plate ("chip") of semiconductor material normally silicon and germanium in rare cases. This may be made smaller than a discrete circuit made from independent components. ICs have two main advantages of performance and cost. Integrated circuits are used in virtually all electronic equipments today and have revolutionized the world of electronics. Computers , mobile phones , and other digital home appliances are now parts of the structure of modern societies , made possible by the low cost of IC.**

***Keywords* - 3-D Integrated circuit, SOC, CMOS, VLSI, ULSI.**

I. INTRODUCTION

Integrated circuits are solid-state devices that have more than one circuit element on them. Transistors, capacitors, resistors, diodes, are the most common elements formed on them ;

There Are Two Types of ICs.
1. Digital IC .
2. Analog/Linear IC (Deals With Analog Data).

Examples:

1. MPU/CPU/Microprocessor (µP) (Digital IC)
2. MCU/ Microcontroller (µC) (Digital IC)
3. Analog ICs Found In Basic Electronic Devices.

A relatively new kind of IC - the MEM, or micro-electromechanical system - adds mechanical structures to the substrate. The best known MEM is the DLP micro mirror image developed. An integrated circuit or monolithic integrated circuit a set of electronic circuits on one small plate ("chip") of semiconductor material, normally GE or silicon. This can be made much smaller than a discrete circuit made from independent components. ICs can be made much compact, having up to several billion of transistors and other electronic components in an area the size of a fingernails. The width of each conducting line in a circuit can be made smaller and smaller as the technology advances; in 2009 it dropped below 100 nanometers, and now is tens of nanometer.

ICs have two main advantages:

1. Cost.
2. Performance.

Cost is low because the chips, with all their components, are printed as a unit by VLSI technology like photolithography rather than being constructed one component like transistor at a time. Furthermore, packaged Integrated Circuits use much less material than discrete circuits.

Performance is much better because the Integrated circuits components switch quickly and consume less power (compared to their counterparts) as a result of the close proximity and small size of the components

Low-Cost Power/Energy IC with Pulse Output : The CS5466 is a low-cost solution for digital power meter applications that features dual Delta-Sigma analog-to-digital converters, an energy-to-frequency converter and energy-pulse outputs on a single chip. The CS5466 is designed to accurately measure and calculate energy for single-phase, two or three-wire power metering applications with minimal external components.

A VLSI design for low power circuit

The growing market of portable (e.g., cellular phones etc.) battery-powered electronic systems demands microelectronic circuits design with ultra low dissipation power. As the integration complexity and size of the chips continue to rise, the difficulty in providing sufficient cooling achieved at various abstract levels. System/Algorithm/Architecture has a large potential for power saving even these techniques tend to saturate as we integrate more functions and techniques on an IC. So optimization at Technology and Circuit level is also very important for miniaturization of Integrated circuits.

Total Power dissipated in a CMOS circuit is sum total of short circuit power, static or leakage power and dynamic power. Design for low-power implies the ability to reduce all three components of power consumption in CMOS circuits during the development of a low power electronic product. In the sections to follow we summarize the most widely used circuit techniques to reduce each of these components of power in a standard CMOS design.

P_{total} = CLVDD2 + tscVDD I_{peak} + $VDDI_{leakage}$

B CMOS

CMOS is, by far, the most common technology used for manufacturing digital ICs. There are 3 major sources in a CMOS circuit for power dissipation.

P = P Switching + P Short-Circuit + P Leakage.

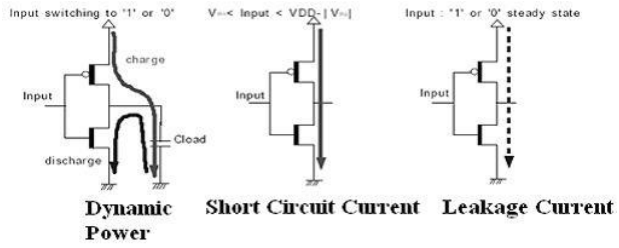

FIG 1: Components of Power in CMOS circuit

P Switching, called switching power, is due to charging and discharging capacitors driven by the circuit. P Short-Circuit, called short-circuits power which is caused by the short circuit currents that arise when pairs of PMOS/NMOS transistors are conducting simultaneously. Finally, P Leakage, called leakage power, originates from sub threshold and substrate injection effects. For older technologies 0.8 µm and above), P Switching was predominant. For deep-submicron processes, P Leakage becomes more vital. Design for low-power implies the ability to reduce all three components of power consumption in CMOS circuits during the development of a low power electronic product. Optimizations can be achieved by facing the power problem from different perspectives: design and technology.

C System-Level Cost Analysis and Design Exploration for Three-Dimensional Integrated Circuits (3D ICs)

Three-dimensional integrated circuit (3D IC) is emerging as an attractive option for overcoming the barriers in interconnects scaling. The majority of the existing 3D IC research is focused on how to take advantage of the power, performance, smaller form-factor and assorted integration benefits that offered by 3D integration. However all such merits ultimately have to translate into cost savings when a design strategy has to be decided: Is 3D integration a cost effective technology for a particular IC design as a result, system-level cost analysis at the early design stage is imperative to help the decision making on whether 3D integration should be adopted. Three-dimensional integrated circuit (3D IC) is emerging as an attractive option for overcoming the barriers in interconnect scaling, thereby offering an opening to continue performance improvements using CMOS technology. In a 3D IC, multiple device layers are stacked together with direct vertical interconnects through them. The direct vertical interconnects are called Through-Silicon Visa (TSVs). Consequently, one of the most important benefits of a 3D chip over a traditional two dimensional (2D) design is the reduction in global interconnects.

D ULSI, WSI, SOC and 3D-IC :

Wafer-scale integration (WSI) is a means of building very large integrated circuits that uses an entire silicon wafer to produce a single "super-chip. WSI one has to consider the normal chip-making process. A single large cylindrical crystal of silicon is produced and then cut into disks known as wafers. The wafers are then cleaned and refined in preparation for the fabrication process. A photographic process is used to pattern the surface where material be supposed to be deposited on top of the wafer. The desired material is deposited and the photographic mask is detached for the next layer. From then on the wafer is frequently processed in this way, putting on layer after layer of circuitry on the surface.

A system on a chip or system on chip (SoC or SOC) is an integrated circuit (IC) that integrates all components of a computer or other electronic system into a single chip. It may contain analog, digital, mixed-signal, and often radio-frequency functions—all on a single chip substrate. SoCs are very common in the mobile electronics market because of their low power consumption. A typical application is in the area of embedded systems.

A three-dimensional integrated circuit (3D-IC) has two or more layers of active electronic components that are integrated both horizontally and vertically into a single circuit. Communication between layers uses on-die signaling, so power consumption is much lower than in equivalent separate circuits. Judicious use of short vertical wires can substantially reduce overall wire length for faster operation.

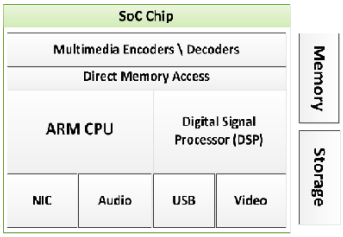

FIG 2: SOC chip content

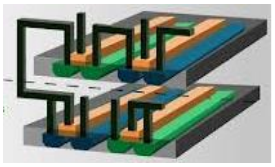

FIG 3: Monolithic 3D IC.

IC History: IC = 2nd Gen., LSI(C) = 3rd Gen., VLSI(C) = 4th Gen(Today's)

ICs and IC families:

1. The 555 timer IC
2. The 741 operational amplifier
3. 7400 series TTL logic building blocks
4. 4000 series, the CMOS counterpart to the 7400 series (see also: 74HC00 series)
5. Intel 4004, the world's first microprocessor, which led to the famous 8080 CPU and then the IBM PC's 8088, 80286, 486 etc.
6. The MOS Technology 6502 and Zilog Z80 microprocessors, used in many home computers of the early 1980s.
7. The Motorola 6800 series of computer-related chips, leading to the 68000 and 88000. Series (used in some Apple computers and in the 1980s Commodore Amiga series).
8. The LM-series of analog integrated circuits.

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