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***Abstract*—Redundancy at the device/transistor-level has been proposed as the most effective way to improve reliability (as early as 1956). With the exceptional reliability of the CMOS transistors the semiconductor industry was able to fabricate, research on device-level redundancy has dragged for several decades. However, with the increasing sensitivities to noise (both intrinsic and extrinsic) and variations (due to the massive scaling) of CMOS transistors, interest on device-level redundancy has been reviving during the last decade. In this paper we investigate transistor sizing as a method that can significantly reduce the probability of failure due to threshold voltage variations, while having almost no impact on the area. For a given reliability target, we try to identify several transistor sizing combinations for optimizing the trade-off between reliability and the traditional power-area-delay optimization parameters. The simulation results will show that adjusting the sizing of the nMOS and pMOS transistors can have dramatical effects on reliability (e.g., improving the reliability of classical NOR-2 gates by more than *five orders of magnitude* while also reducing the occupied area by about 10%).**

Keywords—Relaibility, CMOS gate, MOS transistor, variation, sizing, optimization.

I. INTRODUCTION

Over the last few decades the semiconductor industry has relied on CMOS scaling as the basis for its unprecedented growth. Scaling CMOS transistors was always used to implement *faster*, *smaller* and *cheaper* circuits. However, with sizes quickly approaching ten nanometers, this spectacular journey is starting to fade as facing *several* fundamental limitations. One of these is the randomness of the exact locations of doping atoms [1], leading to device-to-device fluctuations in key parameters, including the *threshold voltage* (V_{TH}). ITRS [2] predicts that *reliability* issues are going to be one of the greatest threats to scaling. Therefore, VLSI designers will have to consider *reliability* as an essential part of their design strategies—in addition to *area*, *power*, and *delay*.

The well-known approach for improving reliability is to incorporate redundancy [3], [4]. Normally, hardware redundancy relies on voters and includes among others the well-known: modular redundancy, cascaded modular redundancy, and multiplexing (including von Neumann multiplexing [3], enhanced von Neumann multiplexing [5], [6], and parallel restitution [7]). Redundancy can also be done at the system-level, the circuit-/gate-level, or the device-level. In [8] we have shown that improving reliability from the device-level can be much more effective than trying to improve reliability from the gate-level. Moreover, when adding gates and/or devices (i.e., increasing spatial redundancy), it is customary to expect increased area and connectivity which would lead to increased power and heat. This implies that one should expect that adding more devices and/or gates to improve reliability will negatively affect area and power. Lucky, as we will show in this paper, this is widespread misconception.

In this paper we will investigate in details transistor sizing for a few standard CMOS gates as an alternate method to improve reliability while minimally impacting on area and power dissipation. Instead of the classical CMOS sizing that aims at maximizing performance (minimizing delay), this paper exhibits other sizing options that are aimed towards optimizing the trade-off between reliability and the traditional power-area-delay design parameters. The paper is organized as follows. The effect of transistor sizing (area) on CMOS threshold voltage variations (V_{TH}) is presented in Section II. Section III explains the effect of transistor sizing on the ON current and the associated dynamic power dissipation. Simulation results are presented in Section IV followed by concluding remarks in Section V.

II. THRESHOLD VOLTAGE VARIATIONS

One of the fundamental limitations of the bulk MOSFETs is the accuracy of reproducing V_{TH} over the large number of transistors in a chip. This is mainly due to the random fluctuations of both *the number of dopants* and of *their physical locations*. Simulation results presented in [1] have showed that V_{TH} variations could be approximated by a Gaussian distribution with standard deviation:

$$\sigma_{V_{TH}} \approx t_{ox} N_A^{0.4} / (L_{eff} W_{eff})^{0.5}, \quad (1)$$

where t_{ox} is the oxide thickness, N_A is the channel doping, and L_{eff} ($L \times a$) and W_{eff} ($W \times a$) are the effective length and width of the channel. Recent atomistic simulation results [9], [10] have suggested that σ for minimum size (i.e., L = 1, W = 1) 35 nm nMOS transistors is 30.28±0.05 mV. Consequently, eq. (1) can be used to estimate σ for a transistor of another size a:

$$\sigma_{V_{TH}}(a) = \frac{30.28 \times 35}{a \times \sqrt{L \times W}} \times \frac{t_{ox}(a)}{t_{ox}(35)} \times \left[\frac{N_A(a)}{N_A(35)} \right]^{0.4} \text{[mV]}. \quad (2)$$

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Abstract—**This paper studies the intranet-based networking and communications systems of the Computer Numerical Control (CNC) machine. By determining the system's overall framework and the main function modules, the program of the communication software and processing management software is accomplished.**

Keywords-CNC machine tools; the overall framework; information exchange; Process management software

I. INTRODUCTION

The CNC machine tool is the mainstream equipment in contemporary machinery manufacturing. With the widespread use of computer technology and network technology, the networking and integration of the CNC machine tools has become an inevitable trend and direction. The CNC machine tools must have a bi-directional, high-speed network communication capability to ensure that the information will flow smoothly on the factory level in the communication infrastructures or between communication infrastructures to the upper.

At present, numerical control system in factory is very complex and incompatible with each other. At the same time, since the environmental constrains the long-distance transmission among plants, it is not easy for the transfer of workpiece's machining. Numerical Control (NC) program management general uses the document management form. Since establishing a different directory to store numerical control management procedures on the computer will result in a volume expansion program, the chaos of the program version and difficulty to find problems, there are hidden dangers for the program to call safe custody. This will cause processing problems by error program calls. The relatively backward manual management does not provide the features such as automatic conversion of different machining processes which you want to convert, so it must be manually entered by the technical staff, and greatly contain the versatility and processing efficiency.

There are some overseas NC networking software applications used in China. But they do not meet the general CNC machining workshop practice of the small and medium processing enterprise, because the program is too large and expensive.

II. THE OVERALL IDEA AND THE TECHNOLOGY PROGRAM

After finishing the work of collecting adequate information to determine the Intranet-based networking and communications systems of (CNC) machine, the paper constructs the local area network(LAN) of CNC machining workshop by the integrated use of communication technology, network technology, carries out the effective management of information of the system in NC processing workshops and expands the functions (CNC) machine. Intranet is used as a platform for the system to network multiple CNC machine tools and CNC equipment. The system achieves the automatic management of NC plant processing and the collection of processing information. And it can also attain the simulation of the path for NC machining process according to the processing program.

A .General networking and communication program of Intranet-based CNC machine tools

Through studying the domestic current operating mode in CNC machining manufacturing plant, with development of the Internet/Intranet network, a general networking and communication program of Intranet-based CNC machine tools will be discussed, as shown in Fig1.

The overall program is divided into three levels: LAN among the numerical control equipments in workshop, Intranet of factory and Internet network (remote network). In addition to network connecting medium, the system is composed of CNC equipment, serial communications server, DNC host, Web servers, database servers, switches, routers and other departments' host.

which is composed of Web browser, Web server-side software, and database server.

Every workstation on the LAN send the service request to the DNC server (WEB server) through browser, obtain information services about cutter management, equipment management, document management, and communications management, and then complete the share with the server data, information delivery, as well as the line editing and checking of NC program. Finally DNC server sends the HTML document back to the workstations, and each workstation can finish control, query and other operations.

III. THE KEY POINT OF TECHNOLOGY AND INNOVATION

A. The key technology

1) Building the network by intranet technology based on TCP / IP protocol, that can view information of CNC machining through Web page mode.

2) Using serial communication to read and write processing program, it is an effective solution to bottlenecks for the NC machine tool's program storage, conversion and other technical. This adapts to a variety communications requirements of CNC machine tool, as well as the actual needs of the domestic enterprises.

B. The key point of Innovation

1) The CNC communication software breaks the limit that under the serial mode the number of networking CNC machine tools can not reach up to 256. This facilitates the network expansion.

2) As supporting CNC machine tools with FANUC LAN interface, the communication program can make a collection of information by exporting macro variable, and report through numerical control system. It can gather information into a database, and accomplish automation management and equipment condition monitoring of the NC machining workshop process.

IV. CONCLUSION

CNC networking and communications systems use intranet technology with TCP / IP protocol as the overall framework to build the networks. Since the core communication components between CNC machining workshop and CNC machine tool communications is serial server, which transfers and manages the program by reading and writing the serial port of CNC machine tools, the communication system has a strong adaptability and is reliable for transmitting information.

NC program management system uses the SQL Server database technology to storage achieve information, so it can automatically deliver and manage the processing information and program. This is according with the current development of the domestic CNC machine tools and CNC machining workstation.

The system discussed in the paper could be universally applied to all domestic enterprises for the CNC machining equipment management and processing program management, and its low cost, reliability, network management and convenient, are especially suitable for CNC machining in small and medium enterprises with good market prospect .

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