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Impact of the Supply Voltage Reduction and Process Variability on the SRAM Static Noise Margins

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Abstract

In scaled technologies the impact of lowering the supply voltage in order to ensure low leakage power leads to a decrease in the ability of the SRAM memories to retain the memorized state. Also, the process variability may impact significantly the memory retention reliability of the cells. The paper analyses the impact of lowering the supply voltage on the robustness of a 6T Static Random Access Memory (SRAM) cell, both in saturation and sub-threshold regimes. The Static Noise Margin (SNM) is evaluated analytically and compared with HSPICE simulations for 130nm, 90nm, 65nm and 45nm Berkeley Predictive Technology Models (BPTM). In addition, the impact of process variations 6T SRAM cell using Monte Carlo simulations (in 45nm BPTM) is analyzed. Our results show that the Static Noise Margin is dependent on the technology, varies nonlinearly with the supply voltage and is strongly influenced by the process variability. The minimum supply voltage required to assure memory retention is also estimated.

1. Introduction

Reducing the standby current, which is due to different leakage currents, is critical in low-power design. At the circuit level, leakage reduction can be achieved by controlling the voltage of different device terminals. SRAM leakage power can be effectively reduced by lowering the supply voltage (VDD) to its standby limit, as indicated by Qui et al. in [2]. Reducing the supply voltage influences the cell's robustness. This robustness can be expressed in terms of immunity to noise which can be quantified as the amount of voltage noise at the internal nodes necessary to flip the cell's state, and is usually referred to as the static noise margin (SNM). The value of the minimum supply voltage that preserves the data stored in a SRAM cell provides an estimation of the maximum achievable leakage reduction for a given technology.

The firs part of the paper describes a method to estimate analytically the static noise margin of 6T-SRAM cell in sub – and above – threshold regimes. The results are validated by HSPICE simulation, using Seevinck's graphical method [1]. Through the years, various methods of computing the static noise margin were proposed. Seevinck et al. [1] and Bhavnagarwala et al. [3] developed expressions for above – threshold static noise margins and Calhoun and Chandrakasan [4] and Welling and Zory [5] developed expressions for sub – threshold static noise margins. In [1] the authors describe an explicit analytic expression for the static noise margin based on long channel models as a function of device parameters and supply voltage. [3] studies the SRAM cell static noise margin reduction due to intrinsic threshold voltage fluctuations in uniformly doped minimum geometry MOSFETs. The work described in [5] investigates stability aspects of sub-threshold SRAM cells, deriving analytical expressions for the SNM as a function of circuit parameters, operating conditions and process variations. The noise margin of SRAM cells in low power conditions such as low supply voltage and source-body bias is experimentally determined, using a graphical approach in Cseveny et al. [6] and Hook et al. [7]. Calhoun and Chandrakasan [4] analyse the dependence of SNM on supply voltage, temperature, transistor sizes and global process variation in a commercial 65nm technology.

This paper builds on previous work examining the influence of lowering the supply voltage of a SRAM cell on its robustness (noise immunity), both in above– as in sub– threshold regions taking into account the short channel effects in MOSFET scaling, as velocity saturation and channel length modulation. The result of channel length modulation is an increase in current due to Short Channel Effects (SCE) when the Drain-Source voltage increases.

The second part of the paper analyses the influence that the variability of process parameters has on the static noise margin of 6T-SRAM cell.

The dimensions and the physical parameters of fabricated transistors can vary significantly from the designer's layout. These variations can be caused by non-uniform conditions during the dopant deposition or diffusion (dopant concentration), variability of the oxide thickness and by limited resolution of the photolithographic process (effective channel length and width). Devices manufactured in nanometric CMOS technologies experience increasing parameter variations as the technology is scaled down. The

Increasing Systems' Availability through Agents and Reconfigurable Systems

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Abstract

In this article, we propose a distributed use of software-based self-testing, where intelligent agents are responsible for the transfer of software routines to the distributed processors, which in turn will be able to execute the routines and test/repair the corresponding subsystem. This distributed strategy is flexible, reusable and re-programmable.

1. Introduction

Plain BIST and BISR are not well suited for the testing, diagnosis and repair of heterogeneous, distributed and geographically scattered systems, such as nationwide telecommunications or energy distribution systems. Such a system is presented in figure 1.

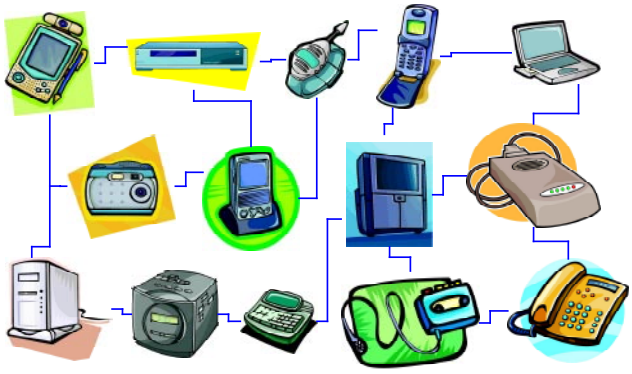

Figure 1. Heterogeneous distributed system with many subsystems.

Decentralization of test and repair greatly reduces the communicational overhead and increases the flexibility and reliability of the testing system itself. The multiagent approach is only natural to such a problem, as multiagent societies are naturally heterogeneous, decentralized and distributed.

An *agent* is, as implemented here, a piece of software capable of independent existence within an environment provided for it, which is able to communicate with entities similar to it, to unaidedly accomplish the work assigned to it and also to travel between geographically separated locations in its environment. Figure 2 presents the main characteristics of software agents.

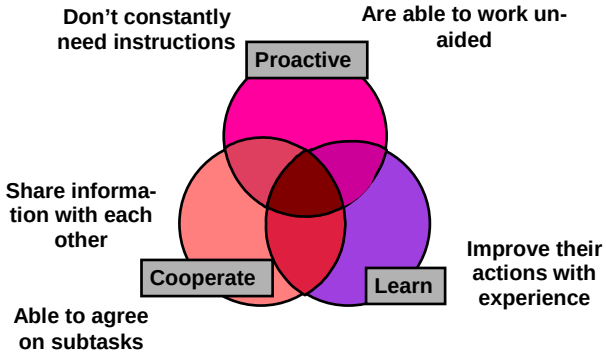

Figure 2. The main agent characteristics.

The agents' communication capabilities and mobility lead to the concept of *multiagent society*, which is here a distributed collection of interacting, mobile agents, residing in different parts of the multiagent environment. We shall call a multiagent society whose main actor is the tester agent a *testing society*. Most DBIST approaches [1]-[5] use a central control authority to start/stop the remote BIST tests, to generally organize the DBIST process and gather together the results. There are also distributed, decentralized testing techniques, some involving agents [6], [7].

We present an agent society whose agents test the components (processors, memories, etc) of subsystems in a distributed system. The agents are used for the transfer of embedded software portions to the subsystems for the effective execution of BIST sessions. Agents enable the BIST functions of these subsystems, therefore the distributed BIST nature of the solution. The agents may also repair the subsystem, for example if there is a backup processor installed.

2. Agent-based DBIST and DBISR of processors and their peripherals

2.1. Generalities

The IEEE 1232 family of standards, analyzed in [8], describe common exchange formats and software services for reasoning systems used in system test and diagnosis. The goal is to make the data exchange between two different diagnostic reasoners easy. The standard also defines software interfaces, for the use of external tools that can access the diagnostic data in a consistent manner. It allows exchanging diagnostic information and embedding diagnostic reasoners in any test environment.

Radiation Hardening of a 20-bit Optical Shaft Encoder to 1 MGy

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Abstract

This article describes the original radiation hardening method, based on thermal regeneration, that is applied to an absolute optical shaft encoder for the purpose of increasing its total dose tolerance to 1 MGy(SiO_2).

1. Introduction

Civilian nuclear material reprocessing industry provides environmental conditions among the most severe and aggressive for any kind of equipment. Electronic systems must be suitably hardened to withstand ionizing radiation. Electronic components lifetimes are sharply limited which constrains the deployment of electronic systems in reprocessing cells.

The use of systems such as optical shaft encoders for remote handling or cranes has allowed the development of closed-loop control systems that facilitate the task of operators, and improve significantly production efficiency.

Previous works have shown the possibility to design electronic systems able to withstand the high gamma radiation environment of these facilities [1][2]. One such system is the angular position encoder CANARIS, developed by the CEA for AREVA NC purposes [3]. This absolute encoder operates at total doses of up to 150 kGy(SiO_2) and has been successfully implemented in several cells of the reprocessing facility at La Hague since 1999.

Recently, in order to reduce operating costs, AREVA NC asked for increasing the encoder's lifetime under irradiation conditions. This article describes the innovative hardening method, based on in-service thermal regeneration of electronic components, applied to the encoder to increase its total tolerance up to 1 MGy(SiO_2).

2. Encoder design

CANARIS is a multiturn-type absolute optical encoder that supplies the angular position of a shaft coupling or driveline in digital form. Figure 1 shows the final prototype of the encoder, which is manufactured by Codechamp. Each binary position code comprises 20 bits, 10 of which specify the position per turn (1024 points/turn) and 10 the number of turns (up to 1024).

Encoding relies on a set of finely etched glass disks that are scanned by infrared photoemitter-receiver pairs. Mechanical gearing provides the demultiplication capability required to encode the number of turns.

Figure 1: Prototype 2nd version of CANARIS, with its leaktight, decontaminable housing. Overall dimensions are 125mm x 85 mm.

Figure 2 shows the architecture of the CANARIS encoder. This system uses DMILL (Durci Mixte sur Isolant Logico Linéaire) application-specific integrated circuits (ASICs) for its most complex angular position coding function. Signals supplied by its optical components are converted by these circuits to a 28-bit pattern that is transmitted via a synchronous serial interface (SSI), using RS485 line drivers.

A two-stage power supply was selected for the encoder, with a switching power stage to absorb input voltage fluctuations and a linearly-regulated stage for ASIC voltages.

Current generators supply the infrared photoemitters with current that is high enough to counter radiation-induced photoreceiver sensitivity loss.

Experimenting with the secure control of a robot over TCP/IP

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Abstract

An authentication protocol, based on cryptographic techniques, is implemented and used in the communication necessary for the control of a mobile robot over a public network. The robot is connected via an 802.11 wireless network to a local computer; however the control of the robot is done from a remote host over TCP/IP and in this way the information involved in the control scenario may be exposed to several security risks. The application fits in the context of a remote controlled system and the interest in using cryptographic techniques in this area has drastically increased in the last years. Instead of using standardized solutions, such as the SSL, we use as a new approach an authentication protocol based on one-way chains. The advantage of this approach is that only simple cryptographic primitives, such as hash functions and message authentication codes, are needed. Experimental results are presented, and the results show that it is feasible to use such a protocol since transfer rates and computational overhead are kept at the desired level for the control scenario. An analysis of the performance of the protocol based on the line utilization rate is done. Also, we give a partial solution for the treatment of communication delays.

1. Introduction

As pointed out by many recent papers the use of cryptography in the field of control systems is a major challenge, as these systems need to communicate over public networks where information is exposed to adversaries [5], [6]. The difficulty in using cryptographic techniques in control systems is twofold, first from the requirements over the equipments and second from the involvement in the dynamics and accuracy of the control system itself. Therefore, the first problem that must be solved is that the use of cryptography requires computational power or communication resources that may not be available. For this purpose different protocols were proposed, such as for example [20] which can be used to assure cryptographic security on the communication line between Supervisory Control and Data Aquisition (SCADA) equipments. As for the second kind of problems, the issue that must be solved is that communication over the public networks, or over any unreliable network, can introduce communication delays, or even uncertainties regarding the arrival of commands and responses. For this purpose several control techniques were developed that can deal with such kind of uncertainties, an example is in [13].

Our interest is the first type of concern, namely the development of efficient cryptographic protocols, which require low computational power. We avoid the use of standardized solutions, such as the TLS or SSL as we are not interested in an encrypted communication line to assure the confidentiality of the information and instead we are interested in assuring the authenticity of information. It is commonly acknowledged that in industrial control systems authenticity is much more important than confidentiality as information can not be used as long as there is no guarantee over its source and freshness. For this purpose we propose and use a class of authentication protocols based on one-way chains which significantly differs from the SSL paradigm. The merit of this approach is first as an experiment from which we can draw certain conclusions on the efficiency of such protocols. And second, the use of such a protocol does not require an asymmetric encryption function, as the SSL. Therefore this approach can be used where asymmetric encryption has to be avoided and only simple one-way functions are affordable.

This paper extends our previous result from [10]. In addition to [10] we will also make an analysis of the protocol performance based in line utilization rate. More, we will give a potential solution for the treatment of communication delays which are caused by the unreliability of the network.

The paper is organized as follows. In section 2 we describe the application setting, and in section 3 a solution for dealing with delays is outlined. The cryptographic protocol is presented in section 4. Implementation details are in section 5, while in section 6 we give some experimental results. Section 7 holds a performance analysis for the protocol while section 8 holds the conclusions of our paper.

2. Application setting

An X80 robot connected to a local computer via a WiFi 802.11 communication link is used. Several relevant technical details about the robot are resumed in what follows; the manufacturer website can be found at [21] for more details on this device.

The robot stands on two wheels with 18 cm diameter, each of them connected to a 12V DC-motor that can be controlled independently. The built-in commands allow three types of control for the two DC motors: open loop Pulse-Width Modulation (PWM),

Optimal Control of Pumped-Storage Hydro Power Plants

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Abstract

The paper is trying to present the possible operational aspects for a pumped storage power plant. There are presented the possibilities of the study of operational regimes of the plant using experiments performed on lab equipment. The extrapolation of the lab results to the real plant is done using certain criteria of hydraulic similarities. In the end, it is proposed an algorithm for optimization of the plant operation, with the goal of efficient usage of hydraulic energy.

1. Introduction

During the time of low electrical demand in the power grid, for load balancing, it is necessary to stop or reduce the power generation in some power plants or store the excess energy. The solution of pumped storage stores energy in the form of water, pumped from a lower elevation reservoir to a higher elevation using the low-cost off-peak electric power from electrical grid to run the pumps. During periods of high electrical demand, the stored water in a higher elevation reservoir is released through turbine. Pumped storage hydroelectricity is a type of hydroelectric power generation used by some power plants. Reversible turbine/generator assemblies act as pump and turbine (usually a Francis turbine).A lot of conventional run-of-the-river hydroelectric plants can be modified as combined pump-storage plants.

The capital costs and the presence of appropriate geography for upper reservoirs are critical decision factors. But this system may be economical, because it flattens out load variations on the power grid, permitting coal-fired plants and nuclear power plants that provide base-load electricity to continue operating at peak efficiency. In these situations the thermal power plants reduce the use of costly fuels.

Along with energy management from the central dispatcher, pumped storage systems help control electrical network frequency and provide reserve generation. Moreover, pumped storage plants, like other hydroelectric plants, can respond to load changes within seconds, in comparison with thermal plants that are much less able to respond to sudden changes in electrical demand.

The first use of pumped storage hydroelectric plants was in the 1890 in Italy and Switzerland. In the 1930 reversible hydro turbines became available. These turbines could operate as both turbine-generators and in reverse as electric motor driven pumps. New variable speed machines with higher efficiency were created. These machines generate in synchronism with the network frequency, but operate asynchronously, as motor-pumps, with variable speed, for greater efficiency of the pumping process.

The control system of pumped-storage plants must ensure an efficient balance between pumped costs and fuel cost of thermal plants over a certain time horizon.

This control system must have high levels of flexibility including:

- Operating close to the turbine's optimal efficiency point, which results in a significant increase in global plant efficiency;
- Operating in a wider head range, increasing the availability of the hydro plant;
- Regulation of the amount of energy absorbed in pumping mode and facilitating energy storage when power levels available on the power grid are low in addition to reducing the number of starts and stops of thermal plants;
- Helping to regulate the network frequency or voltage in pumping mode;
- Improved reliability and maintenance and increased lifetime, avoiding operation modes prone to hydraulic instability or cavitation.

This paper is trying to present the possible operational aspects for a pumped storage plants. The theoretical problems were studied using experiments performed on lab equipment. The extrapolation of the lab results to the real plant is done using certain criteria of hydraulic similarities.

2. Optimisation Methods

The optimization problem of hydro power plants involves the use planning of a limited water resource available for hydro generation, over a period of time.

Most hydroelectric plants are multipurpose facilities since it is necessary to meet certain obligations other than power generation (maximum elevation, danger of flooding, minimum plant discharge, irrigational and navigational commitments). [1].

Other distinction among hydro power systems is the number of hydro power plants and reservoirs on the

Development and Application of a PID Auto-Tuning Method for the Identification and Control of Wastewater Treatment Processes

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Abstract

This paper presents an application regarding a recently developed extension of the widely used relay-feedback PID auto-tuner. The proposed method consists of two steps: process identification and controller design. First, a non-iterative procedure is suggested for identification of one point on the process Nyquist curve. A second-order model (SOS) is obtained and then used for PID controller design based on the internal model principle (IMC). For the identification of the point on the Nyquist curve a relay in the feedback loop (as used in standard auto-tuning) which operates on the integral of the error is used. The method is illustrated on an application to a wastewater treatment process. In the considered process, the wastewater is treated in order to obtain an effluent having the substrate concentration within the standard limits. The performances of control algorithms are illustrated by simulation results. The influence of changing a design parameter in the desired closed loop behavior is shown.

1. Introduction

PID control has been the state of the controller art since the 1950's and is still the predominant method in use today. Their popularity is justified by the following advantages: they have a simple structure, their principle is well understood by instrumentation engineers and their control capabilities have proven to be adequate for most control loops. According to a 'Control Engineering' [1] 1998 study, single loop controllers account 64% of all the applications, while multiloop, 36%. The classical feedback control systems represent 85% of the total, feedforward control 6%, and the cascade control 9%. PID controllers, although having a simple structure, are by far the most used controllers in control systems. They can be found in both categories of systems resulted from developing technologies and automation and control systems products: DCS and PLC. Most of the control strategies (cascade control, feedforward control etc.) were developed based on the classical PID control systems concept. In a study published in 2001[2], K.J. Astrom states that, in the industrial applications, more than 90% of the control loops are PID control based. Therefore, despite the rapid evolution of hardware components in the last 50 years, the conventional PID controllers are still the most used controlling equipment in industrial applications. However, the technological progress has determined important changes in design solutions, especially due to the provision of supplementary functions. Thus the current PID controllers are far different to the ones 50 years ago. For the industrial process control there are numerous types of commercial digital controllers with PID structure and facilities like self-tuning and auto-tuning. Although there is certain confusion among the PID controllers manufacturers due to the significance of the used terms, the auto-tuning concept represents the use of automatic tuning techniques, the procedure being usually activated by the user through commands from the front panel or from the supervising system for the controllers that also have serial communication. Self-tuning usually represents the adaptive adjusting techniques of the tuning parameters which operate permanently, both at start-up or at setpoint changes and in normal operation conditions.

On the other hand, despite the extraordinary theoretical progress in the fields of control systems in the last 20 years, engineers who effectively work in the industrial environment consider most of these theories as esoteric and of little relevance in solving the practical problems that occur in the control of industrial applications. Most of the knowledge related to PID controllers has been kept secret by the manufacturers. In the same time, in the academic environment, the trend of considering the PID controller a field with little research opportunities has grown.

The last years show a strong revival of the interest related to PID controllers and there is no doubt that this field has turned to be attractive to the researchers. Many publications have appeared in this field. Commercial PID controllers with auto-tuning functions have been used since the beginning of the 80's [1,2,3,4,5], due to the development of microelectronics which made it possible to incorporate the programs necessary for auto-tuning. One of the reasons for the increased interest in PID controllers is the development of new techniques and methods of estimation and auto-tuning [6,7,8].

Hybrid Model for Virus Spreading

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Abstract

Epidemic propagation models have been applied on modeling the propagation of viruses. Some mathematical models and computer simulations deal with the spatial distribution of susceptible along a line, across a lattice or over a network to overcome the inaccuracies due to the assumption of random mixing of the population. The viral propagation is determined by intrinsic characteristics of the network. This paper presents an intelligent model for avian influenza spreading based on a modified mathematical SIR model, in combination with Bayesian networks and Cellular Automata. The simulation applies on the Romania territory map. Since the avian influenza didn't present the mutation to be transmitted from a human being to another human being, in this paper a hybrid model is developed to be used, for simulation maters, in a virtual situation when this virus is transformed into a pandemic.

1. Introduction

Since the 1920's, stochastic models of epidemics have been used for viruses spreading modeling and simulation. Epidemic propagation models [1] have been applied on modeling the propagation of viruses [8]. Simulation models have been used to discuss the influence of the network topology ([9]; [20]; [12]).

A pandemic is an epidemic of infectious disease that spreads through human populations across a large region. According to the World Health Organization (WHO), a pandemic can start when three conditions have been met:

- The emergence of a disease new to the population.
- The agent infects humans, causing serious illness.
- The agent spreads easily and sustainable among humans**.**

Virtual experiments are conducted by varying the type of topology, the number of nodes, density and isolation ([21]; [4]). Experiment results show that random graph topology generated by the same density and isolation as real world data set could be used on modeling the viruses' propagation. The authors of ([7]; [8]) are among the first who propose epidemiology-based analytic models. Their studies, however, are based on topologies that do not represent modern networks. In [16] a study of the Code Red worm propagation was presented, but did not attempt to create an analytic model. The more recent studies from ([12]; [13]; [14]; [15]; [2]; [3]) focused on epidemic models for power-law networks. The viral propagation is largely determined by intrinsic characteristics of the network.

This work aims to develop a general analytic model of avian influenza virus propagation and based on this model a system that will help to prevent the spreading in the populated area and to warn the population. This paper is proposing the use of existing models to determine the avian influenza spreading for Romania. A similar system exists in SUA, HPAI (Highly Pathogenic Avian Influenza), which with the program for pandemic response are part of the National Strategy for pandemic influential.

Study of the behavior of a worm during its propagation phase is important for several reasons. One is the creation of early warning systems that can detect a propagating worm, and in an ideal case also can give preliminary propagation analysis and perhaps even a captured specimen. Today such systems do not exist and significant work will be needed to turn them into a reality ([10]; [19]).

The paper is structured into tree main parts: first the model for virus spreading is presented, in the second part the simulation results are presented and last in the conclusions and futures works the comparison with Hong Kong flue spreading is presented. The Hong Kong virus was selected for comparison because is the most recent pandemic virus and both viruses has similar root. As future work the virtual life inside of the populated are can be use to monitor the influence of the individuals characteristics to the masses and simulate different types of viruses spreading.

Numerical Simulation of the Cavitational and Thrombogenic Potentials of Mechanical Heart Valves Using ANSYS-CFX

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Abstract

The paper presents one of the most recent results obtained by the biomedical engineering team from Cluj-Napoca Technical University, in collaboration with the University of Sheffield, UK, in regard to medical devices design for cardiovascular applications. A multi-physics and multi-scale modelling approach on the closure dynamics of a bileaflet prosthetic heart valve is presented. The paper also presents a recent collaborative initiative, of any of the most representative European institutions involved in the development of new medical devices for cardiovascular applications, to set up a Marie Currie Initial Training Network (ITN) focused on Cardiovascular Engineering of Medical Devices. The Technical University of Cluj Napoca has been invited to participate to this MC ITN, as a network participant, with two individual research projects related to valves design and assessment.

1. Introduction

Cardiovascular engineering is one of the success stories in Bioengineering. A specific example of successful cardiovascular engineering applications is the design analysis of prosthetic heart valves. Although existing techniques, including mechanical heart valves (MHV) and biological valves (BV), have stood the test of time there are still some important issues to solve regarding thrombogenecity of MHVs and life-time duration for biological valves. New endovascular techniques such as percutaneous heart valves are being developed to avoid open heart surgery [1] with the design and implementation of these devices still in a developmental phase [2]. The application of modelling and simulation to the study of existing and novel devices can certainly help to address these issues and significant work remains related to the assessment and behaviour of these valves under patient-specific conditions and with reference to pharmacological intervention for these patients

More recently, Computational Fluid Dynamics (CFD) has emerged as a promising tool, which, alongside experimentation, can yield insights of unprecedented detail into the hemodynamics of prosthetic heart valves. For CFD to realize its full potential, however, it must rely on numerical techniques that can handle the enormous geometrical complexities of prosthetic devices with spatial and temporal resolution sufficiently high to accurately capture all hemodynamically relevant scales of motion [3]. Valve function is driven by interaction between the blood (fluid) and the motion of solid valve structure. In order to examine such systems computationally it is necessary to consider both the solid and the fluid phases simultaneously, which requires a fluid-structure interaction (FSI) analysis. Recent computational models have used both custom and commercial codes such as ANSYS-CFX, ANSYS-Fluent and LS-DYNA. These have been applied to the study of native mitral [4] and aortic [5] valves and also to determine the fluid dynamic performance of valve prostheses [6].

The effects of the heart, vasculature and the systemic response to the changing physiological environment are often not included within local 3D models of valve function. Multi-physics and multi-scale modelling brings new insight by allowing such interactions to be investigated *in silico*. The use of FSI analyses has highlighted the need for improved and interactive boundary conditions. Solutions include FSI analyses coupled with lumped parameter

Knowledge Discovery from SCADA/HMI System's Database

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Abstract

Knowledge discovery in databases is an interactive process of discovering non-trivial, previously unknown and potentially useful information from a huge collection of databases. Data mining framework is a step of knowledge discovery process, but also referred to knowledge discovery in databases. The techniques of data mining are widely used in research and application to look for relationships and knowledge that are implicit in large volumes of data and are interesting in the sense of impacting an organization's practice. Hence, the article proposes to use the techniques of data mining to extract knowledge from the SCADA/HMI system's database.

1. Introduction

The SCADA/HMI system is an industrial measurement and control system consisting of a central host or master, one or more field data acquisition and control or remote units and a collection of standard and/or custom software used to monitor and control remotely located field data elements. This kind of system exhibits predominantly open-loop control characteristics and utilizes predominantly long distance communications. Some elements of closed-loop control and/or short distance communication may also be present [1].

The SCADA/HMI system collects and archives large volumes of raw data, which potentially contain hidden and possibly useful knowledge. These real-time data, recorded to ensure the ability to trace the energetic process, can also be used to optimize the SCADA system management performance information through post-processing [2]. The classical approach in measurement data post-processing, e.g. databases querying using SQL, cannot produce satisfied results. Data mining techniques represent a suitable approach to analyze hydroelectric power plant data, and to support decision making in order to improve energy manufacturing, planning and control operations, based on the following reasons: handle massive distributed databases, find patterns automatically, and present patterns as rules.

2. Background – SCADA/HMI system's structure

The SCADA/HMI system implemented for the hydroelectric power plants cascade is structured in several main hierarchical levels. On the plant floor level there are several PLCs Profibus connected, intelligent measuring devices Modbus connected and the process computers network. The plant computer network LAN consists in a process interface computer – Human Machine Interface (HMI) and a communication one managing the communication with the dispatching level.

At the dispatching level there is a computer network, which ensures the global cascade dispatching, the resources management and the data visibility to the different functional departments. At this level the database server (DBS) is located. The connection between the plant floor level and the dispatching level is based on TCP/IP protocols, which ensure the data packages delivery without errors. The communication channel is a telephone-leased line, using modems for data communication.

The SCADA system provides functions for monitoring, control, over-limit alarm and data acquisition. Digital signals representing power switches status, equipment functional status, relay-based protection loops, substation distribution units, and utilities status, analogue parameters representing electric parameters, powers, energies, flows, pressures, water-level are acquired in a primary well-defined structure composed by historical acquisition files.

The data files are converted through a program – *DB_Dispecer* - (written and executed under LabWindows CVI 7.1) in relational databases implemented in Microsoft SQL Server 2005. The functions executed by DB_Dispecer program are:

- every 5 seconds automatic scanning of the historical acquisition files, the events reports files, the configuration files for reading of the new emerged data;

Feedback Signals Estimation of an Induction Drive with Application to a Small Wind Turbine Generator

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Abstract

Among renewable energies the solution of utilizing wind energy conversion systems is now in a growing trend. A valid choice for operation of such systems may be the use of the induction machine. This study presents modeling and simulation of a stand-alone induction drive with application to a small wind turbine generator system. The model of the induction machine is written in terms of fluxes as state variables and is used to design several estimator models that can provide the correct feedback signals for the vector control of a wind energy conversion system. The estimation of magnetic flux, electromagnetic torque and rotor speed is based on stator currents and stator voltages in case of the Extended Kalman Filter(EKF) estimator and in the case of the U_s-I_s estimator. The third estimator developed uses as measurements two stator voltages and the rotor speed. Simulation results are provided indicating good estimator design and operation.

Index Terms — induction generator, wind turbine system model, estimator simulation, Kalman Filtering

1. Introduction

In recent years the rapid development of digital signal processors (DSP) based systems and the decreasing cost of power electronics allowed the complex models and control algorithms of AC machines to become popular for a large range of applications. Among renewable energies the solution of utilizing induction generators for wind energy conversion systems is now in a growing trend. Currently, a wide spread control concept is that of a variable speed rotor with pitch regulation, and this concept is combined with both direct drive and geared drive trains the latter dominating the wind market.

A valid choice for operation at variable speed may be the use of induction machine. An induction motor can operate as a generator in super synchronous speed raised by an overhauling type of load, or by lowering the inverter frequency below the machine speed, when there is a converter-fed machine drive. Continuous regenerative operation of a drive is possible if the load machine is a source of power, such as in a wind generation system.

In this paper the model of the induction machine is written in terms of fluxes as state variables. This model is then used to design an Extended Kalman Filter (EKF) based estimator that can provide the correct feedback signals for the vector control of a wind energy conversion system. Also two other estimator methods are shown with good simulation results, one is based on stator voltages and stator currents (U_s-I_s) and one is based on stator voltages and rotor speed (U_s-ω).

The sensors employed to obtain state feedback information for the field-oriented control (FOC) are usually expensive, hard to mount and provide usually inadequate measurements because of the defective and aggressive environment where they act.

For the elimination of these errors several methods where proposed. One of them is the EKF algorithm which is presented in this work. For high speed operation the U_s-I_s estimator is also valid choice.

2. Wind turbine system description

In Figure 1 is shown a basic wind turbine system that converts the wind energy into mechanical energy which at its turn is used by an electric machine to generate power. The basic configuration consists of the wind turbine blades, the drive train, the induction generator and the AC-AC converter (not shown in Figure 1 to connect the system to the grid.

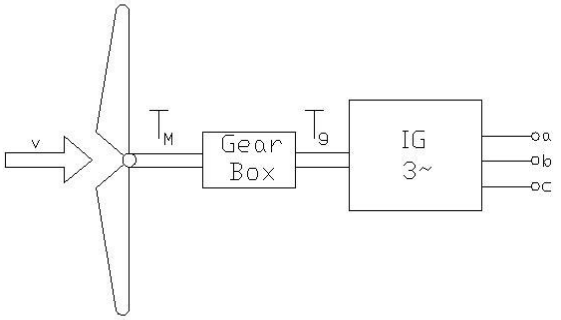

Figure 1. Basic wind turbine model

2.1 Wind turbine Model