A communication sub-system for the ADES

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DECLARATION

I hereby declare that all the material incorporated in this thesis is my own original unaided work except where specific reference is made by name or in the form of a numbered reference. The work herein has not been submitted for a degree at another university.

Signed:

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Elsebi van Sittert

SUMMARY

The McTronX research group has conducted extensive research concerning Active Magnetic Bearings (AMBs). This research involved the establishment of an advanced AMB laboratory to aid in assisting industries that implement AMBs in their applications. This year the McTronX group's focus shifted toward the development of an AMB system to be implemented in the Pebble Bed Modular Reactor (PBMR). The AMB system was designed to be used in a helium blower application. This involved the development of both the mechanical and the electronic components.

The main goal of this AMB system was to develop a completely digital integrated controller which is responsible for the control of the AMB system, from here on referred to as the AMB drive and electronic system (ADES). The need arose for a totally digital system to increase the reliability and robustness of the ADES. These requirements are crucial in a nuclear environment. In order to develop a totally digital system a new issue had to be addressed. This involved the implementation of digital communication.

This project involved the development of a communication sub-system for the ADES. The communication system was divided into two sections, the internal and external communication system. The various interfaces were identified as well as their specifications formulated. The optimum solution was then selected for each of the interfaces by using a design process that involved comprehensive trade-off studies.

The external communication system and the internal communication system were specified and the necessary hardware was procured. An in-house developed protocol was developed and implemented between the internal functional units of the ADES. The designed protocol adhered to the specific needs of an AMB application.

The protocol was extensively tested by carrying out verification and validation tests and evaluation plans. The test and evaluation plans for verification were carried out by making use of simulations and laboratory experiments. Validation of the in-house developed protocol was carried out by analyzing the internal communication system whilst the ADES was controlling the bearing module. During this phase the communication system was also subjected to error conditions.

The protocol proved to be completely functional, robust and reliable, meeting the performance specifications and the requirements. During this project a foundation was laid for digital communication in AMB systems in the McTronX research group.

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Soli Deo Gloria

"but those who hope in the Lord will renew their strength. They will soar on wings like eagles; they will run and not grow weary, they will walk and not be faint. Isaiah 41:31"

Contents

List of figures

List of tables

List of abbreviations

A/D	Analogue-to-digital converter
ADC	Analogue-to-digital converter
ADES	AMB and drive electronic system
ADSL	Asymmetric digital subscriber line
AMB	Active magnetic bearing
ARCNET	Attached Resource Computer NETwork
AWG	American wire gauge
B/s	Bytes per second
BER	Bit error ratio
BERT	Bit error rate tester
bps	bits per second
BRAM	Block RAM
B-SPEC	B specification
CAN	Controller area network
CCITT	Consultative committee on international telephone and telegraph
CMOS	Complementary metal-oxide-semiconductor
COTS	Commercial off the shelf
cPCI	Compact PCI
CRC	Cyclic redundancy checks
DAC	Digital-to-analogue converter
DDR	Double data rate
DPR	Dual port RAM
DSP	Digital signal processor
EIA	Electronic industries alliance
EMI	Electromagnetic interference
ESD	Electrostatic discharge
FCS	Frame check sequence
FEC	Forward error correction
FIFO	First in first out
FPGA	Field programmable gate array
FSM	Finite state machine
Gbps	Gigabit per second
GPIB	General purpose interface bus
HD	Hamming distance

HDL	Hardware description language
I/O	Input/Output
I2C	Inter-integrated circuit
IEEE	Institution of electrical and electronic engineers
IF	Interface
ISDN	Integrated services digital network
ISO	International organization for standardization
LIN-Bus	Local interconnect network
LFSR	Linear feedback shift register
LVDS	Low voltage differential signalling
LVTTL	Low voltage transistor transistor logic
Mbps	millions of bits per second or megabits per second
MBUS	Message-Bus
M-LVDS	Multipoint LVDS
NRZ	Non-return-to-zero
OSI	Open systems interconnect
PC	Personal computer
PCB	Printed circuit board
PCI	Peripheral component interconnect
PCI-X	PCI eXtended
PLB	Processor local bus
PLC	Programmable logic controller
PMC	PCI mezzanine card
PowerPC	Performance optimized with enhanced RISC performance computing
Profibus-DP	Profibus-Decentralized peripherals
Profibus-FMS	Profibus-Fieldbus message speciation
Profibus-PA	Profibus-Process automation
R&D	Research and development
RAM	Random access memory
RISC	Reduced instruction set computer
RS	Recommended standard
RTM	Rear transition module
RX	Receive
SBC	Single board computer
SCADA	Supervisory control and data acquisition
SCSI	Small computer system interface

SDRAM	Synchronous dynamic RAM
SERCOS	Serial Real-Time Communication
SMBUS	System management bus
SNR	Signal-to-noise ratio
SPI	Serial peripheral interface
STP	Shielded twisted pair
TEM	Transverse electromagnetic
TIA	Telecommunication industries associations
TX	Transmit
UART	Universal asynchronous receiver/transmitter
UI	Unit interval
USB	Universal serial bus
USS	Universal serial interface
UTP	Unshielded twisted pair
VHDL	VHSIC hardware description language
VHSIC	Very-high-speed integrated circuit
WAP	Wireless application protocol

List of symbols

C	Capacitance
η	Efficiency
G	Conductance
h	Height
I	Current
L	Inductance
m	Meter
R	Resistance
σ	Standard deviation
t	Time
μ	Mean
V	Voltage
w	Width