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Tokamak Magnetic Control Simulation: Applications for JT60-SA and ISTTOK Operation.

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ABSTRACT

Abstract en ingles

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RESUMO

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Palavras-chave:

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Parole chiave:

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Figure 2.2 TCV SCD. Real-time network nodes connection. The nodes configurations are shown together with the typical diagnostic and actuator systems to which they are connected [3]. 6

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LIST OF ABBREVIATIONS

@TODO: Review variable lists as writing the thesis

- AC - Alternating Current
- ADC - Analog to Digital Converter
- ATCA - Advanced Telecommunications Computing Architecture
- CREATE - Consorzio di Ricerca per l'Energia, l'Automazione e le Tecnologie dell'Elettromagnetismo
- DAC - Digital to Analog Converter
- EO - Electronic Offset
- IST - Instituto Superior TÃl'cnico
- LQR - Linear Quadratic Regulator
- MARTe - Multi-threaded Application Real-Time executor
- MIMO - Multiple-Input Multiple-Output
- PCS - Plasma Control System
- PF - Poloidal Field
- PID - Proportional - Integrative - Derivative
- SCD - Systéme de Contrôle Distribué
- XSC - eXtreme Shape Controller
- WO - Wiring Offset

LIST OF VARIABLES

@TODO: Review variable lists as writing the thesis

VARIABLES:

- I_p - Plasma current
- B_p - Poloidal magnetic field
- μ_0 - Vacuum permeability

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INTRODUCTION

1.1 TOKAMAK PLASMA CONTROL

1.2 BEHIND THE PLASMA CURRENT

1.3 THESIS OUTLINE

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PLASMA CONTROL SYSTEMS

2.1 OVERVIEW OF CONTROL SYSTEMS

The control of plasma position, shape and current among other parameters is one of the crucial engineering problems for present and future magnetic confinement devices. The Plasma Control Systems (PCS) lead with the overall control of fusion devices being responsible also for the plasma configuration and scenarios algorithms [2, Chapter 8]. Currently different PCS's are use in the tokamaks around the world. In this chapter the "DIII-D-like" PCS, the Systéme de Contrôle Distribué (SCD) and the Multi-threaded Application Real-Time executor (MARTe) will be approach, this last one being of special interest due to its extensive utilization in this work.

2.1.1 *DIII-D Plasma Control System*

Early documentation regarding the PCS in DIII-D[1] reefers to digitalization of analog signals transmitted to a high speed processor executing a shape control algorithm and then writing the result to a digital to analog converter for driving the controlled systems . The real-time computer used allowed to performed operations with vectors and matrices required for the plasma shape control algorithm [1]. Figure 2.1 shows the block diagram of the DIII-D PCS 30 years ago.

Blablabla

2.1.2 *Systéme de Contrôle Distribué*

The TCV distributed control system uses a modular network of real time PC nodes liken by a real time network to provide feedback control over all of the actuator systems. Each node consists of a Linux PC either embedded on a Compact-PCI module or as a desktop computer with Intel CPU. A real time CPU-only node is dedicated to the real time equilibrium reconstruction and fast Fourier transforms for MHD detection. [3]

1 DIII-D is a D-shape tokamak operated by General Atomics in San Diego, California.

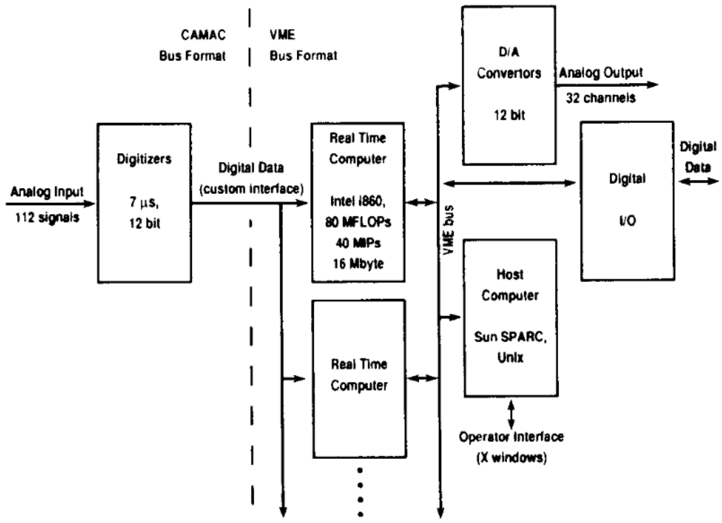

Figure 2.1.: DIII-D digital PCS in 1991 [1].

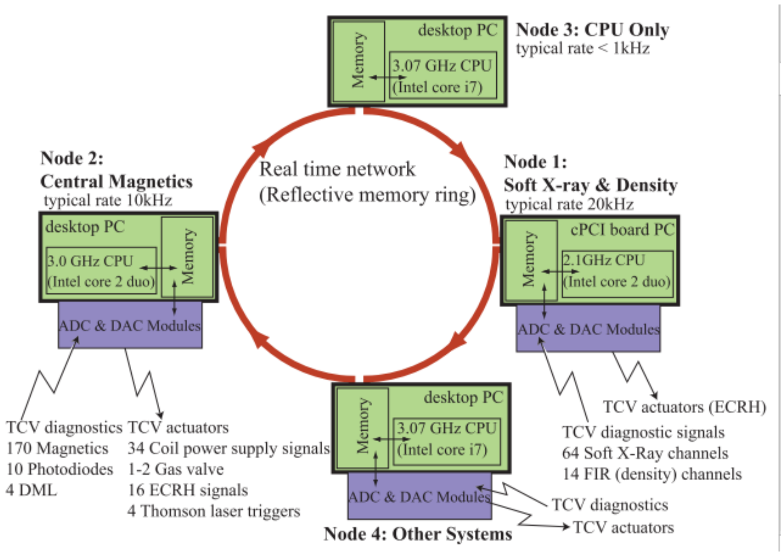

Figure 2.2.: TCV SCD. Real-time network nodes connection. The nodes configurations are shown together with the typical diagnostic and actuator systems to which they are connected [3].

2.2 MARTE FRAMEWORK

MARTe was developed in order to standardize general real-time control systems for the execution of control algorithms. MARTe framework is based on a multiplatform C^{++} library. [4]

2.2.1 *MARTe architecture*

2.2.2 *Hardware containers*

2.2.3 *MARTe 2.0*

2.3 EQUILIBRIUM AND CONTROL ALGORITHMS

2.3.1 *PID control*

2.3.2 *Multiple-Input Multiple-Output control*

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JT60-SA CONTROL DESIGN

3.1 MACHINE DESCRIPTION

3.2 CREATE TOOLS

3.3 CONTROLLER DESIGNS

3.4 QST TOOLS IMPLEMENTATION

3.5 SIMULATION RESULTS

4

ISTTOK

4.1 MACHINE DESCRIPTION

4.2 DIAGNOSTICS AND ACTUATORS

4.3 ATCA-MIMO-ISOL BOARDS

4.3.1 *Hardware layout*

4.3.2 *Real-time integration software*

4.4 PLASMA CURRENT MAGNETIC FIELD

Retrieving the contribution of the plasma current in tokamaks ...

The methods of correction of the magnetic error fields due to inaccuracies of tokamak manufacturing and assembly are considered. The problems of the plasma position and shape reconstruction based on magnetic field measurements are discussed.

4.5 PLASMA CENTROID POSITION DETERMINATION

5

ISTTOK RESULTS

5.1 IMPLEMENTATION OF THE GENERAL APPLICATION MODULES

5.1.1 *PID control implementation*

5.1.2 *Multiple-Input Multiple-Output control implementation*

5.2 RESULTS

5.2.1 *PID control and LQR control results*

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CONCLUSIONS

bla bla bla

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DEMONSTRATIONS