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CONCEPTUAL DESIGN OF VACUUM CONTROL SYSTEM FOR ILSF*

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Abstract

Many The Iranian Light Source Facility (ILSF) is a new 3 GeV third generation synchrotron light source facility with circumference of 528 m, which is in the design stage. In this paper conceptual design of vacuum control systems presented. The control system architecture, Software toolkit and controller in device layer are discussed in this paper [1].

INTRODUCTION

The Iranian Light Source Facility Project (ILSF) is a 3 GeV third generation light source with a current of 400 mA which will be built on a land of 50 hectares area in the city of Qazvin, located 150 km West of Tehran. The ILSF storage ring has been designed to be competitive in the future operation years. Iranian Light source facility vacuum control system, contain of controller for Pumps specially ion pump and gauges to read pressure. To implement a successful and reliable system to obtain pressure about 1 $nTorr$ and keep it in storage ring, the vacuum system must be based on distributed intelligence with proper process variable update rate. This paper explain conceptual design of vacuum control system. A summary of ILSF major parameters are listed in the Table 1 [1].

Table 1: Main Parameters of the ILSF Storage Ring

Parameter	Unit	Value
Energy	GeV	3
Circumference	m	528
Emittance	nm.rad	0.27
Current	mA	400
Length of straight section	m	7
Number of straight section	-	20
RF frequency	MHz	100

For current machine design, the concept of antechamber has been chosen. The vacuum chambers will be made of stainless steel and will be baked out before installation. 580 ion pumps, 180 TPS and 100 NEG pump have been foreseen for the storage ring. Different computational methods have been developed to help designers to achieve the necessary low pressure throughout small aperture magnet vessels. Several methods have been employed to calculate pressure profile in different working modes of storage ring. Calculations have shown that the maximum pressure in storage ring will be lower than 1.8×10-9 mbar during operation time.

The interface of each vacuum controller is in the Table 2.

Table 2: Controlling Interface for Vacuum Sub System

Devices	Interface
Ion Pomp controller	Ethernet
Roughing pump controller	PLC
NEG pump controller	PLC
Cold cathode gauges controller	Ethernet
Pirani gauge controller	Ethernet
Valve controller	PLC
Thermometer controller	PLC
Residual gas controller	Ethernet

NETWORK CONTROLLER AND TOOLKIT

All devices and vacuum components in control level should support Ethernet protocol to send data to control room and receive operational commands through the network. However, using well-known protocols increases the risk of penetration into the system.

Controller should designed in such a way to have a minimum latency in send and receive commands from control room.

Since Ethernet protocol is main network line, the mentioned devices must support this protocol or in case of devices which are provided by companies outside of ILSF and do not support main protocols, taking advantage of a converter could be a solution.

Open source and wide usage are the two main factors which have led us to choosing EPICS as a control system toolkit for ILSF.

VACUUM CONTROLLER DESIGN

In order to increase respond time and system reliability, and also to reduce network control traffic, the vacuum system is designed on the basis of distributed control system in which the process of control take place in each controller individually and the results of events or sensitive process variables are being sent to man-machine interface.

Since vacuum system is not majorly involved in data analysis, the main concern in designing the system is focused on its maintenance and prolonging its life time. This clearly indicates the significance of establishing a vacuum control system in favor of layer approach. In other words, the priority is to establish the vacuum control system based on the hardware layer instead of the software layer.

In this system the vacuum equipment is located in the field level and connected to the controllers which lays in safe area and control level and are hart of control by cables.

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Block diagram of vacuum control system is in the Figure 1.

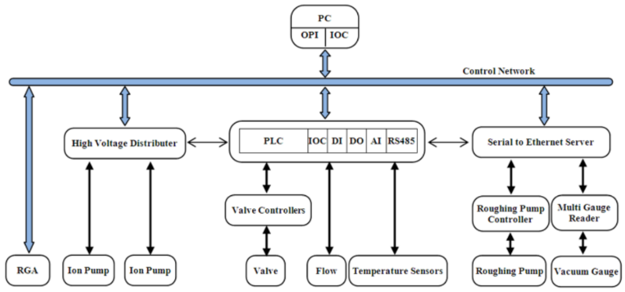

Figure 1: Block diagram of vacuum component and related controller.

A PLC in associate with control network is used to stablish a complete controllable system for vacuum. The main duty of vacuum PLC is control rough pump, the gate valve which work pneumatically and proper reaction against interlocks from controller by digital input output and large number of temperature sensors by analog modules and finally send pressure to control room at the lower rate.

Another important character of vacuum control system is the implementation of object oriented concept in vacuum PLC's. In this approach, equipment lays behind of virtual graphs which describe the dynamic behavior of the system. This character helps us to remove or add different components from and to the vacuum system easily and reduce the consequences of the required programming.

Controllers must be equipped with internal memory to store the values of the setting point and enough Ram for calculation. Also all controllable devices must have an extra communication port for local services and maintenance process.

Connecting an external signal from controller which is in corporate with internal pressure in vacuum chamber to the PLC decrease response time of protection action to prevent vacuum break generally and increase reliability of vacuum system [2].

ION PUMP CONTROLLER

To reach faster to the desired vacuum, increase accuracy of measurement and reduce material consumption, ion pump controller must have an intelligence behavior, i.e. it should set the voltage value of the ion pump based on its current which is related to the pressure on the local ion pump. In other words, voltage has a wave form with respect to local pressure.

Using distributed power supply to control ion pumps has many advantages like control large number of ion pump and as a result reduce costs, number of equipment and occupied space which is considered in the design of vacuum control system.

GAUGES CONTROLLER

Controllers which drive pressure gauges must calculate the rate of pressure change to detect any leak in vacuum chamber and send interlock signal in case of detect any abnormal increase rate chamber pressure.

Due to vacuum pressure break speed and the length of each section the rate of monitoring pressure must be less than 17 ms. However, the rate of reading pressure by gauges, which is pressure dependent, plays the main role in the calculations.

The result of simulation for part of vacuum chamber with a small hole on it by Comsol Multi Physics for different times is in the Figure 2. Each line is correspond to 10 μ seconds.

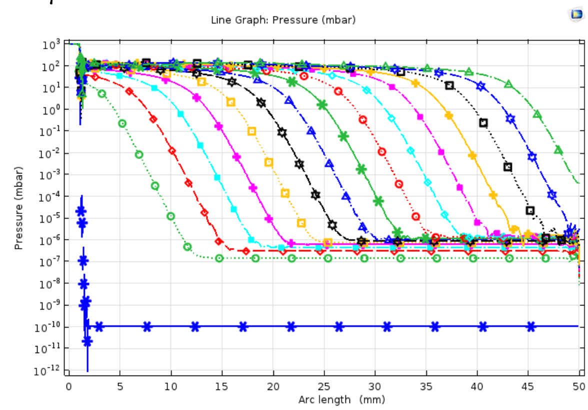

Figure 2: Distribution of pressure in a sample cell by time.

Although pressure monitoring must done in high rate at field level, since vacuum is a slow process it is not necessary to update it with this rate in side of control room.

In order to facilitate the vacuum upgrade process in any time, develop and maintenance, it is necessary to keep this concept open and use a standard, high bandwidth and noise safe protocol to connect different component of vacuum network to each other and control room.

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