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FUSION-8860; No. of Pages 6
ARTICLE IN PRESS
Fusion Engineering and Design xxx (2016) xxx–xxx
Contents lists available at ScienceDirect
Fusion Engineering and Design
journal homepage: www.elsevier.com/locate/fusengdes

# Data acquisition and control system for SMARTEX – C

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## HIGHLIGHTS

- We have developed control and data acquisition system for Nonneutral Plasma experiment named as SMARTEX – C.
- The hardware of the system includes a high current power supply, a trigger circuit, a comparator circuit, a PXI system and a computer.
- The software has been developed in LabVIEW®.
- We have presented the complete time synchronization of the operation of the system.
- Results obtained from the equipment has been shown.

## ARTICLE INFO

*Article history:*
Received 18 June 2015
Received in revised form 22 June 2016
Accepted 13 July 2016
Available online xxx

*Keywords:*
Aspect ratio
Non-neutral plasma
Data acquisition and control
LabVIEW
Diocotron
Capacitive probes

## ABSTRACT

A PXI based data acquisition system has been developed for Small Aspect Ratio Toroidal Experiment in C – shaped geometry (SMARTEX – C), a device to create and confine non-neutral plasma. The data acquisition system (DAQ) includes PXI based data acquisition cards, communication card, chassis, Optical fiber link, a dedicated computer, a trigger circuit (TC) and a voltage comparator. In this paper, we report the development of a comprehensive code in LabVIEW® – 2012 software in order to control the operation of SMARTEX – C as well as to acquire the experimental data from it. The code has been incorporated with features like configuration of card parameters. A hardware based control sequence involving TC has also been developed and integrated with the DAQ. In the acquisition part, the data from an experimental shot is acquired when a digital pulse from one of the PXI cards triggers TC, which further triggers the TF – power supply and rest of the DAQ. The data hence acquired, is stored in the hard disc in binary format for further analysis.

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## 1. Introduction

Modern and powerful oscilloscopes with fewer channels can fulfill the requirement of acquiring the experimental data and transfer it to computers with interface mechanisms like GPIB, Ethernet, USB, RS232 etc. However as the data-channels grow, the acquisition system demands many such oscilloscopes. The task of synchronization and data handling becomes tedious as well. The acquisition based upon a dedicated DAQ (*e.g.*, CAMAC, VME, VXI and PCI/PXI based systems) with large number of channels, sufficient acquisition rate, storage and its front-end integration with a suitable computer program shows improvement in the quality of the data thus acquired.

Since a PXI based hardware configuration fulfills the requirements as stated above, we have chosen the same to develop the data acquisition and control system for SMARTEX – C on the PXI [1] platform. The subsequent sections in this article describe the experimental setup, the development of electronic control system and operation–sequence, PXI based hardware configuration and LabVIEW® based software for the system.

## 2. Experimental setup

The schematic diagram of the SMARTEX – C device [2] is shown in Fig. 1. It consists of a torus of rectangular cross section (inner radius $R_i = 5$ cm, outer radius $R_o = 22$ cm, height = 32 cm) with a small aspect ratio $\left(\frac{R_o+R_i}{R_o-R_i}\right) \sim 1.6$. During operation, the device is maintained in ultrahigh vacuum range $\leq 5 \times 10^{-9}$ mbar. The con-

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http://dx.doi.org/10.1016/j.fusengdes.2016.07.010
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Please cite this article in press as: Y.G. Yeole, et al., Data acquisition and control system for SMARTEX – C, Fusion Eng. Des. (2016), http://dx.doi.org/10.1016/j.fusengdes.2016.07.010

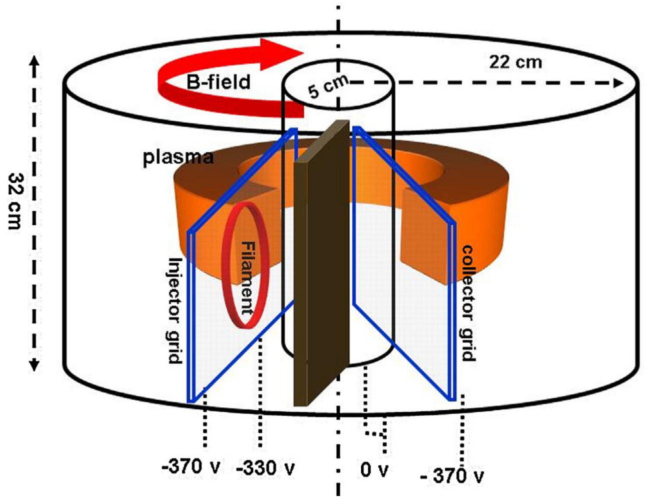


**Fig. 1.** Schematic view of SMARTEX-C vacuum vessel [2].

ducting walls of the device (trap) are electrically grounded. The electron injector consists of a negatively biased circular tungsten filament 10 cm in diameter concentric with the minor axis with a negatively (−370 V) biased 'injector-grid' mounted in front of the filament. Another grid, also maintained at −370 V called the "collector-grid" has been mounted behind the filament. An electrically floating stainless-steel plate separates the two grids. The filament biased at about −330 V heated with a steady current ~18A causes thermionic emission. When the injector grid is grounded (0 V) for ~50 μs, the electrons are injected (pushed) in to the trapping region between the two grids (Injection). The injector grid is switched back to −370 V to stop further injection followed by grounding the collector grid (charge dump) after a preset hold-time duration in order to measure the trapped charge and other activities of the trapped charge. This mode of operation is called the 'Inject – hold – dump.'

In the other mode "Inject – hold – natural loss," the collector grid is maintained at −370 V. Eventually the trapped charge is lost to the walls of the vessel in spontaneous manner due to several loss mechanisms.

This device thus creates a non–neutral plasma of electrons and confines them for few seconds in the presence of a toroidal magnetic field ($B_{TF}$) of ~400 G. The magnetic field is calculated at minor axis using the following formula

$$B_{TF} = \frac{0.2NI\,(A)}{R\,(\text{cm})}\ \text{Gauss} \tag{1}$$

Here, $N$ (= 20) and $R$ (= 13.5 cm) in Eq. (1) are respectively the number of turns in the TF coils and the major radius of the torus. A current transformer (DCCT) around one of the conductors feeding $B_{TF}$ coils, monitors the current I (A) supplied by the TF power supply. Eight wall probes have been mounted around one poloidal plane at a toroidal location in order to obtain complete information of poloidal modes of the plasma and one in a different toroidal location to look for any toroidal activity.

In a plasma shot, information of $B_{TF}$ ($t$), the injector pulse height and width, frequency and amplitude of diocotron oscillations and the charge collected thereafter $q_{coll}(t)$ have to be acquired and stored. It is possible to take multiple plasma shots during steady $B_{TF}$ pulse. These goals lead us to design the PXI based DAQ in the following framework:

(a) Channels that require fast sampling:

- Acquisition of injector (width ~50 μs) and collector grids' (width ~10 μs) square pulses (−370 V to 0 V) with rise time ~100 ns equivalent to 10 MHz, sampling rate ~30 MS/s
- Acquisition of the signals from 9 wall (Capacitive) probes with signal frequency *i.e.*, typical diocotron frequency ~100 kHz and amplitude ~1 mV–200 mV. High ~20 MS/s for harmonic analysis but slow sampling rate ~1 MS/s for Diocotron oscillations

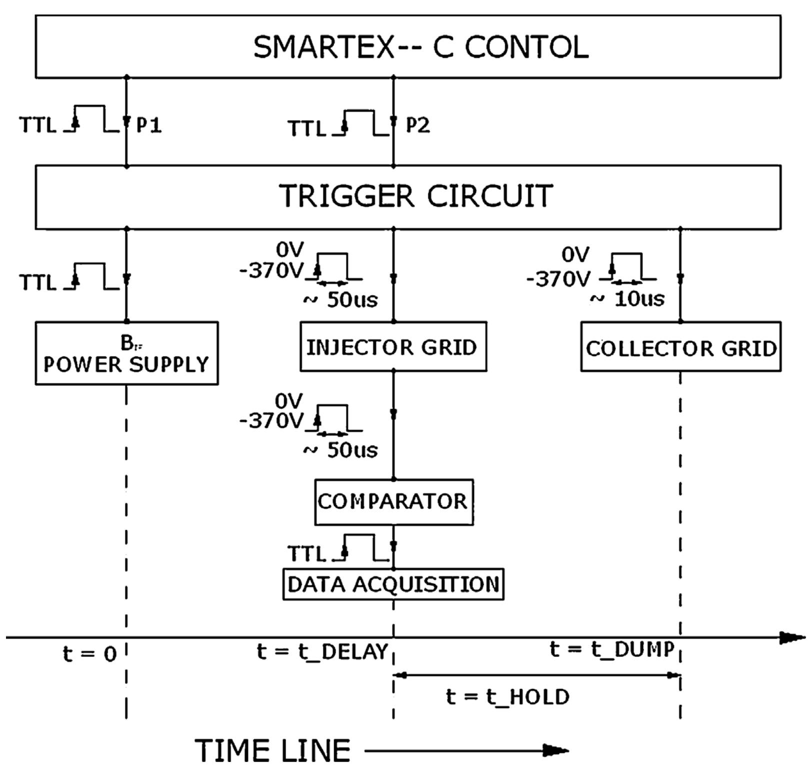


**Fig. 2.** Synchronization of trigger circuit, power supply & Injector/Collector grids with DAQ.

Please cite this article in press as: Y.G. Yeole, et al., Data acquisition and control system for SMARTEX – C, Fusion Eng. Des. (2016), http://dx.doi.org/10.1016/j.fusengdes.2016.07.010

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