Fusion Engineering and Design xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Fusion Engineering and Design

journal homepage: www.elsevier.com/locate/fusengdes

Development of electronics and data acquisition system for independent calibration of electron cyclotron emission radiometer

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HIGHLIGHTS

- Indigenous development of an electronics and data acquisition system to digitize signals for a desired time and automatization of calibration process.
- 16 bit DAQ board with form factor of 90 × 89 mm.
- VHDL Codes written for generating control signals for PC104 Bus, ADC and RAM.
- Averaging process is done in two ways single point averaging and additive averaging.

ARTICLE INFO

Article history:
Received 20 June 2015
Received in revised form 29 April 2016
Accepted 10 May 2016
Available online xxx

Keywords:
Complex programmable logic device (CPLD)
Signal conditioning unit (SCU)
Very high speed integrated circuit hardware description logic (VHDL)
PC104- family of embedded computer standards define both form factor and computer buses

ABSTRACT

Signal conditioning units (SCU) along with Multichannel Data acquisition system (DAS) are developed and installed for automatization and frequent requirement of absolute calibration of ECE radiometer system. The DAS is an indigenously developed economical system which is based on Single Board Computer (SBC). The onboard RAM memory of 64 K for each channel enables the DAS for simultaneous and continuous acquisition. A Labview based graphical user interface provides commands locally or remotely to acquire, process, plot and finally save the data in binary format. The microscopic signals received from radiometer are strengthened, filtered by SCU and acquired through DAS for the set time and at set sampling frequency. Stored data are processed and analyzed offline with Labview utility. The calibration process has been performed for two hours continuously at different sampling frequency (100 Hz to 1 KHz) at two set of temperature like hot body and the room temperature. The detailed hardware and software design and testing results are explained in the paper.

1. Introduction

The electron cyclotron emission radiometer is an effective diagnostic to measure the plasma electron temperature and its thermal distribution. However, to determine the relation between radiometer output and plasma emissivity the system needs to be calibrated. The most common method of calibration is the technique of Hot/cold switch method wherein the output of the radiometer is recorded at two different temperatures i.e. hot and cold. Calibration factors so obtained are used to determine the plasma temperature and its spatial and temporal evolution. The accuracy of calibration thus determines the accuracy of the temperature measurements. Henceforth frequent calibration is done to improve on the method used. Frequent requirement of independent calibration of radiometer and automatization of its process motivated us to design a Multichannel Data acquisition system (DAS) along with SCU.

Our main aim is indigenous development of an electronics and data acquisition system to digitize signals for a desired time. Another aim of this development is to establish an automatization of the calibration process along with the improvement in system sensitivity so that very low signal can also be made detectable. Automatization of calibration process through DAQ will save time, avoids manual error and provides scope for signal processing on acquired data. The DAS is based on Single Board Computer (SBC). The hardware and software design supports the DAS for simultaneous, single shot and continuous acquisition. A Labview based graphical user interface (GUI) provides commands locally or remotely to acquire, process, plot and finally save the data. Offline Signal processing by implementation of averaging technique on the

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http://dx.doi.org/10.1016/j.fusengdes.2016.05.013

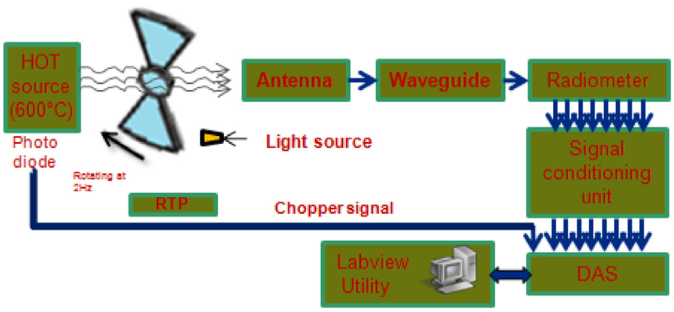

Fig. 1. Block diagram of test set-up of calibration.

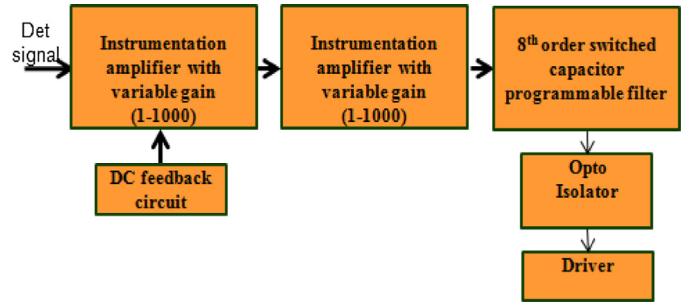

Fig. 3. Block diagram of signal conditioning.

digitized data and their analyzing facilities are coded in another Labview GUI.

2. Experimental set-up

The process of radiometer calibration is the standard technique of Hot/cold switch method. A silicon carbide based black body source that can be heated upto 600 °C acts as the hot body while the room temperature acts as the cold body. The experimental setup is shown by block diagram in Fig. 1. The horn antenna is made to view the two different sources through a chopper arrangement.

The chopper circuit consists of a fan rotating at a speed of 2 Hz that can be varied. Eco-absorber sheets are pasted on the fan wings so that it absorbs the cosmic microwave radiations. A light source and a photo diode arrangement are along with the receiving antenna and black body source. The output of the photo diode so obtained is a square pulse that acts as the reference signal for signal averaging. A thermocouple is used to monitor the temperature from the hot body source. The fan wings are so aligned that they simultaneously cover the receiving antenna and the light source so that the photo diode receives a 0 V reference line as soon as the fan wings move and the antenna is made to view the hot source simultaneously the photodiode records the light source as the high of the square pulse so generated. The 8-channel radiometer output along with the output of the photo diode that acts as the 9th reference channel are acquired in the DAS for the set time and at set sampling frequency. Calibration process has been performed several times for two hours continuously at 1 KHz sampling frequency at hot black body source at constant temperature of 500 °C and RTP. A temperature measurement circuit through thermocouple is also included to monitor the temperature of hot source.

2.1. Radiometer

The ECE radiation is collected by a 20 dBi gain horn antenna and passed on to a band pass filters that provide the input RF of 63–75 GHz [2]. This RF is down converted using a SSB mixer to an IF of 1–12 GHz. The signal is then boosted using a pair of cascaded low noise amplifiers with an approximate gain of 58 dB. An 8- way power divider distributes the input IF into 8 channels which are further frequency selected from 1.4 GHz to 10.5 GHz in a step size of 1.3 GHz using narrow band cavity filters. This frequency selective signal is detected using a Schottky detector followed by the electronics video amplifiers for further processing. Fig. 2 depicts the block diagram of the radiometer system.

2.2. Signal conditioning unit

The SCU unit contains 8 modules. Design of one module is explained by block diagram in Fig. 3. The microwave components used in radiometer has its own offset and as the stages increases the DC offset gets accumulated. This unwanted offset has to be removed. The signal coming from the hot body source is a slow varying signal of vary low amplitude ranges from 1 μV to 200 μV. So both the signal and the undesired offset are amplified with same gain by first stage amplifier. A DC feedback circuit is implemented in first stage for offset removal by using the reference terminal of the instrumentation amplifier (INA).The reference terminal provides a direct means of injecting a precise offset to the output.The voltage on the reference terminal can be varied from negative to positive supply as per the requirement. The 2nd stage amplification is applied to the signal with the DC component already removed. Signal passes through an eight order filter module. The cut off frequency can be changed in four steps. As the same SCU set up is used to install during Aditya tokamak experimental shot. So we insert an

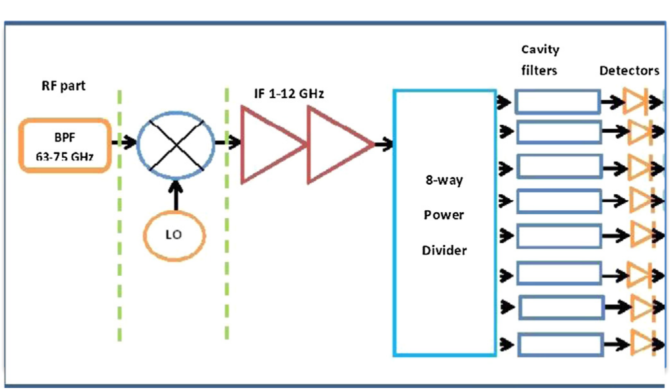

Fig. 2. Block diagram of radiometer.

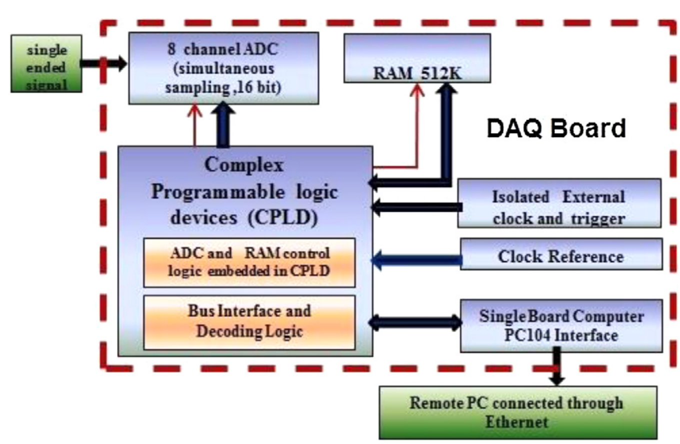

Fig. 4. Block diagram of DAS.

Please cite this article in press as: P. Kumari, et al., Development of electronics and data acquisition system for independent calibration of electron cyclotron emission radiometer, Fusion Eng. Des. (2016), http://dx.doi.org/10.1016/j.fusengdes.2016.05.013