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Design and development of slot-0 controller for EM-diagnostics

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ABSTRACT: A new design of Microcotroller-TMS320F28335 based control card is being design and developed. This card is used to control and monitor the parameters of the analog signal conditioning cards which are used to measure the different plasma characteristic of the upcoming globally challenging and competitive Tokamak, SST-1 in the Institute for Plasma Research.
The characteristics of the long time plasma may change in a large dynamic range and the number of diagnostic channels are in more than two hundreds, so the remote controlling of some parameters of the signal conditioning electronics such as amplifier gain, automatic testing is very essential. The existing card, which is based on 8 bit architecture with very limited features. This necessitates the need of new design with more advanced features to accommodate all required features. The details of this new design will be described in this paper.

KEYWORDS: TMS320F28335 (Digital signal controller), CAN(Controller area network) protocol, LabVIEW, PWM.

1 INTRODUCTION

INSTITUTE FOR PLASMA RESEARCH is a pioneer and globally reputed organization in the field of plasma and fusion research.The sun and the universe consists of plasma, the fourth state of matter. To create, confine and to control the plasma in a laboratory is extremely challenging. Such a machine is called tokamak. SST-1 (SUPER CONDUCTING STEADY STATE TOKAMAK) is being indigenously built and in the stage of completion in IPR. In this machine plasma will be created for long time about 1000 seconds. To study the characteristics of plasma, different diagnostic tools are used. ELECTRO MAGNETIC DIAGNOSTICS (EM) is one of the important tool to study about plasma. The signal conditioning instrumentation for these diagnostics are fully indigenously designed and developed in the electronics section of the institute.The characteristics of the long time plasma may change in a large dynamic range and the number of diagnostic channels are more so the remote controlling of some parameters of the signal conditioning electronics such as amplifier gain, or automatic testing is very essential.

The existing slot-0 controller card (Based on P80C592) has many limitations like; there is no provision for offset calibration, attenuation, time stamping, storing of default settings, etc. These limitations, inspired for the development of new control card. Texas Instruments make TMS320F28335 based new Control card which is under development, has many advanced features. This facilitates to design a new compact card which meets all the required specifications. The key features of the newly selected controller are, 32-bit architecture, In-built flash memory (256KB),Integrated peripherals- SPI, CAN, I2C, UART etc,In-built 64KB RAM,In-built DSP for signal processing,Integrated 12-bit ADC ,Fast interrupt response manager, 12-bit ADC module for implementing extra on-board features like temp sensing etc, Up to 88 shared GPIO pins for full remote control parameter implementation,3-timers with 32-bit each for implementing timing applications like time-stamping application for event management.

2 DEVELOPMENT OF SLOT-0 CONTROLLER CARD

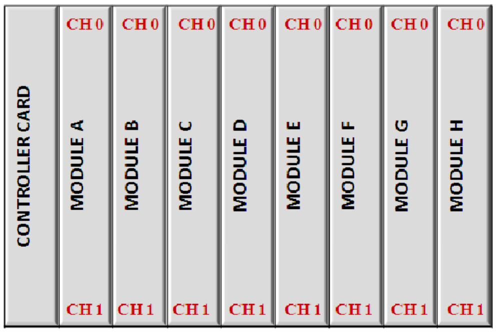


Fig. 1. Instrumentation chassis diagram

In EM-diagnostics, there are 12 chassis arranged in 19 inch racks.In every chassis there are 8+1 modules, which are also known as slots. The 1st module is known as slot-0 which is the controller-card and other 8 slots contain analog module.Slot-0, the micro controller card can control and monitor all the parameters of the analog modules. Each chassis consists of one Slot-0 micro controller card, and up to eight SCS analog modules. Each analog module consists of two channels so one chassis can accommodate maximum 16 channels.All slot-0 cards of different chassis are connected in single CAN network and connected to a remote PC host PC also. USB-to CAN convertor is used in the pc end. LabVIEW based GUI is developed and available in the host PC. The diagnostics user can access this interface to set any parameter of the analog module.

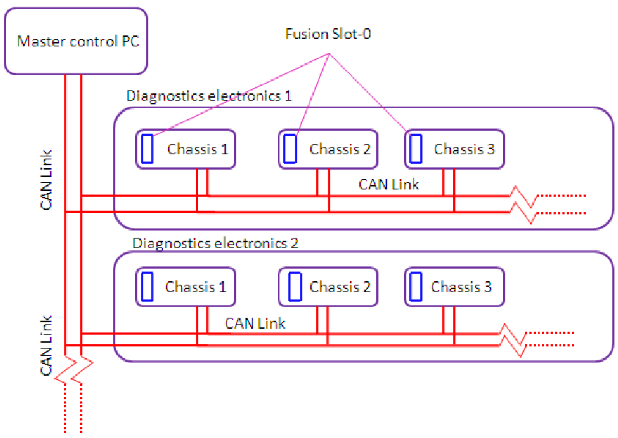


Fig. 2. Signal conditioning block diagram

The design of new slot-0 controller card will be 3U size instead of 6U. It will increase the number of available chassis in a rack.These slot-0 will contain TMS320F28335 (digital signal controller), FPGA,level translator,etc.Slot-0 controller card can control these analog modules like Gain/Attenuation, Saturation detection, Offset calibration, Test-mode.The paper describes about controlling of gain analog module and offset calibration for remote operation.

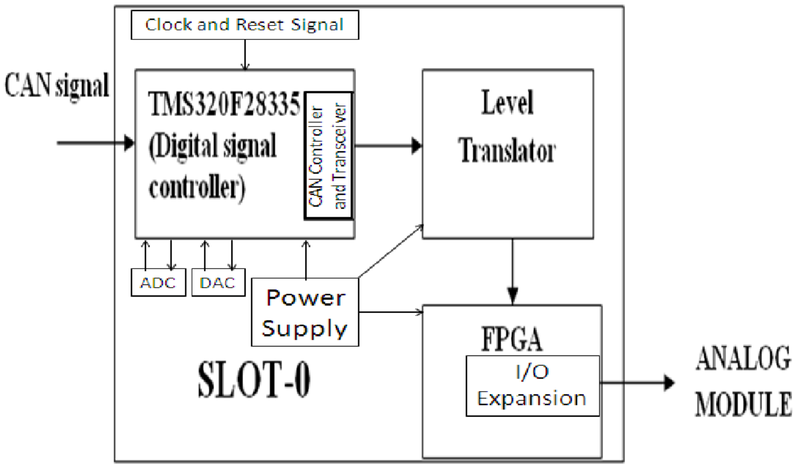


Fig. 3. New slot-0 block diagram

2.1 STANDARDIZED CODE

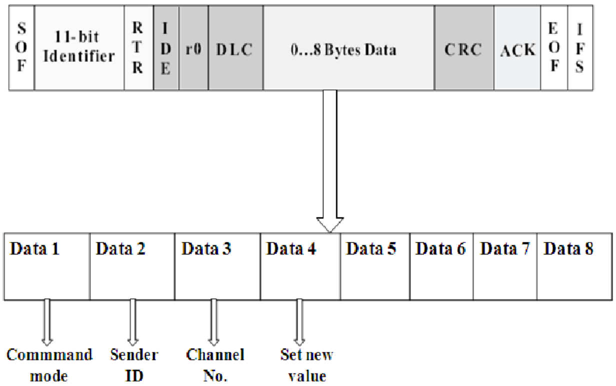


Fig. 4. Standardized data packet

Data 1 is Command Code.This data define the different command to be executed; a maximum of 256 different commands can be coded through out the network. The different commands presently implemented are:

00 = gain/attenuation
01 = offset calibration
02 = test mode on/off etc.

Data 2 contain sender ID, data 3 will contain channel no of analog module, data 4 will contain the new value of analog parameter, which has to be changed and others are undefined.

2.2 LabVIEW CAN Program Flow

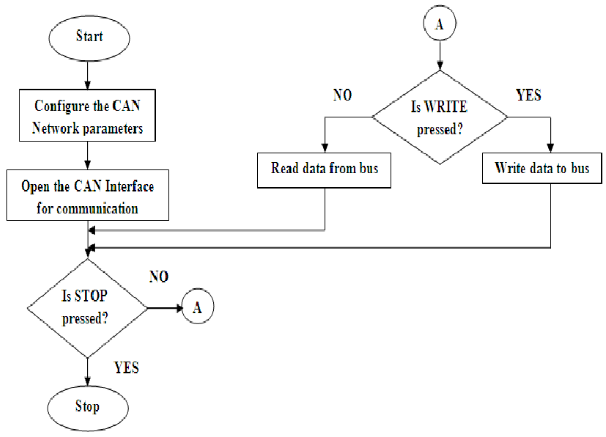


Fig. 5. LabVIEW CAN program flow

2.3 Gain Control Module

Gain control module used consists of the PGA203 and PGA202 IC. Each IC requires two bits as inputs, which by the standard followed at IPR is in the 4th byte of CAN data. PGA203 takes two bits as inputs and provides gain steps of 1, 2, 4 and 8 and PGA202 takes two bits as inputs and provides gain steps of 1, 10, 100 and 1000.

EX: - for the input of 400mvpp , the output will be:

Table 1. Gain table

Control bits		output
A1	A0	
0	0	400 mvpp
0	1	800 mvpp
1	0	1.6 vpp
1	1	3.2 VPP

2.4 Offset Calibration

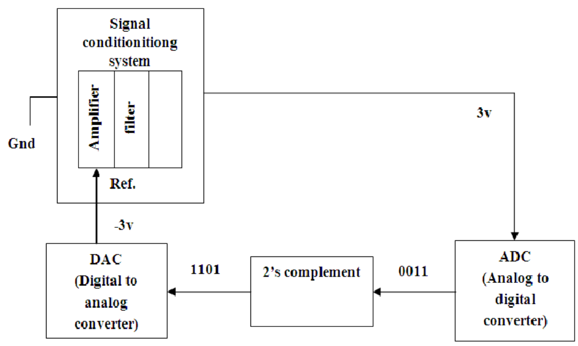


Fig. 6. offset calibration block diagram

As in above figure,to eliminate the offset error the output of signal conditioning system is converted to digital value using ADC.This digital value is complemented and converted to analog through DAC and then given as input refernce to amplifier of signal conditioning system. This EVM module has unipolar ADC, so we get only positive voltages.This limitation will be reduced in SLOT-0.In TMS320F28335, ADC has 16 inputs with 12-bit digital output. PWM is digital output signal with binary amplitude, 0 or 1 as in analog 0V or 3V. By changing set-point we can change duty cycle of PWM so we get according final analog output is obtained from PWM via internally connected LPF.

3 SIMULATION RESULTS

3.1 CAN FRONT PANEL

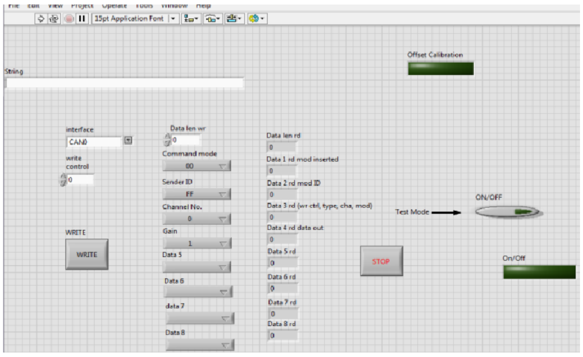


Fig. 7. CAN front panel

3.2 GAIN PARAMETER RESULTS

3.2.1 CAN FRONT PANEL FOR GAIN

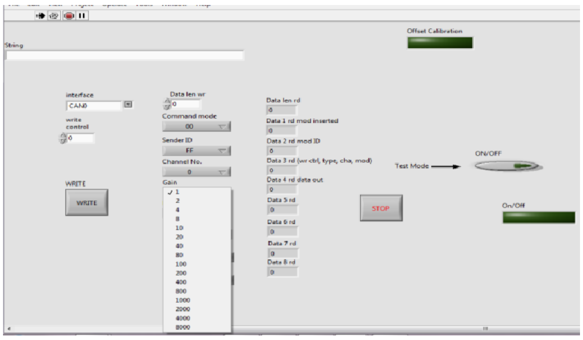


Fig. 8. CAN front panel for GAIN

3.2.2 Setup for Gain control

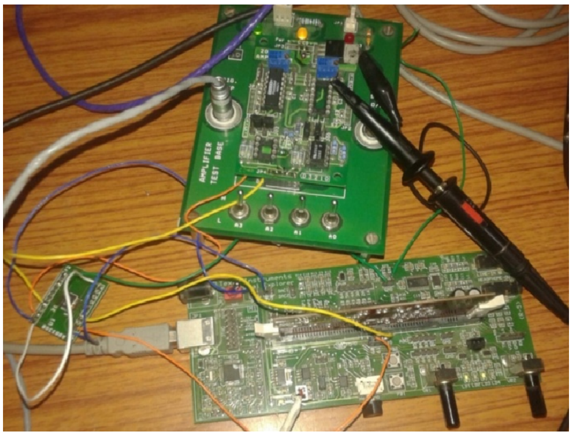
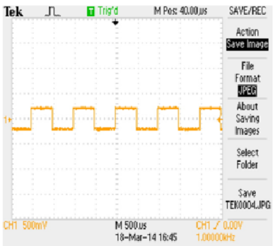
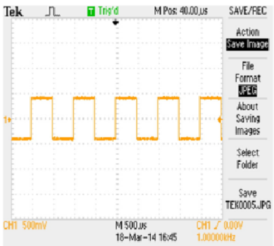


Fig. 9. Setup for Gain control

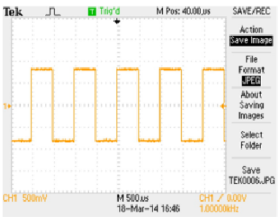
3.2.3 Gain control results



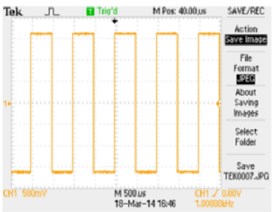
400 mVpp Square Wave(Gain 1)



800 mVpp Square Wave(Gain 2)



1.6 Vpp Square Wave(Gain 3)



3.2 Vpp Square Wave(Gain 4)

Fig. 10. Gain control results

3.3 OFFSET CALIBRATION RESULTS

3.3.1 CAN FRONT PANEL FOR OFFSET CALIBRATION

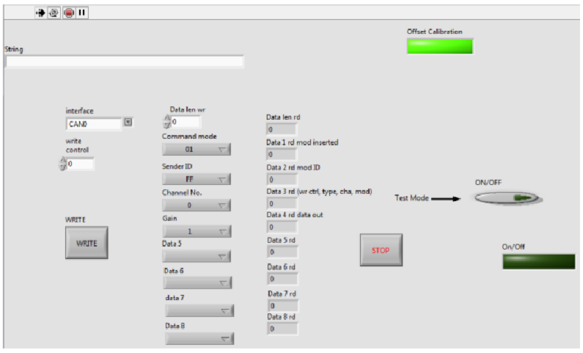


Fig. 11. CAN front panel for offset calibration

3.3.2 2'S COMPLEMENT RESULT

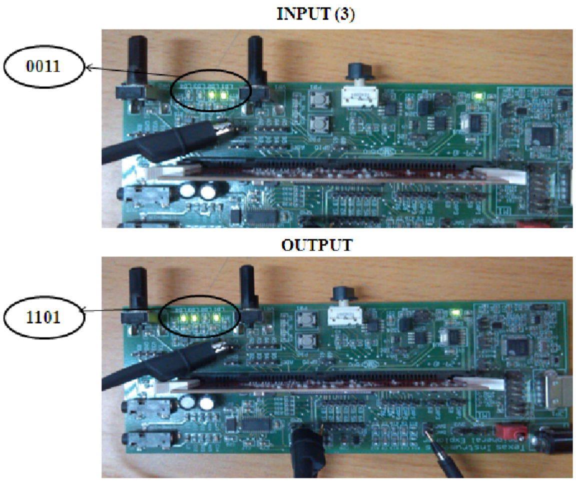


Fig. 12. 2's complement Result

3.3.3 DAC AND PWM RESULTS

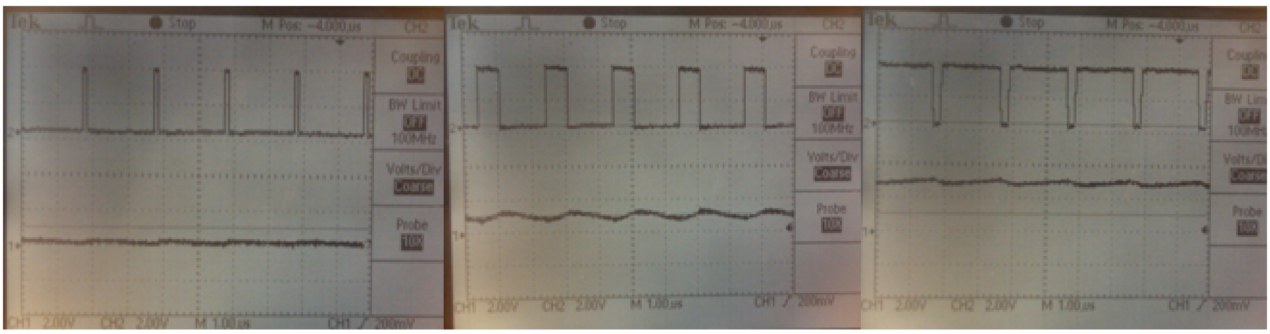


Fig. 13. DAC and PWM results

4 CONCLUSION

This paper presents the development of a new design of Slot-0 microcontroller card based on TMS320F28335 for controlling the parameters and monitoring the status of ananlog signal conditioning cards which are used as plasma diagnostics measurement instruments in the institute. This paper also describes the use of CAN (Controller Area Network) protocol in scientific application for remote controlling of isntrumetns. The basic features of the new slot-0 card are tested with available board from texas instruments. Emebeded coding is also successfully done in Code Composer Studio. CAN protocol networking is established. All the required framework has been successfully established.

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