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SYSTEM ON CHIP (SOC) ARCHITECTURE IN INDUSTRIAL CONTROL SYSTEM OF HYDRAULIC DAMPER TEST BENCH USING Labview

[1] Hare Ram Jha, [2] Akash Priyadarshi
[1](*Lecturer, Department of Electronics & Communication Engineering, NIT Jamshedpur*)
[2](*Student, B.Tech ,Department of Electronics & Communication Engineering, NIT Jamshedpur*)

Abstract - *The paper presents the universal electronic module used in Industrial Control System (ICS) based on System on Chip (SOC) architecture. It mainly deals with the software and hardware design of chip along with its implementation in hydraulic damper test benches. The paper mainly focuses on the use of a 32-bit RISC micro-controller to test the new or repaired pumps or valves with the help of virtual instrument technology software. The paper also contains the proposed results and observations made for test bench in LabVIEW with the help of PID algorithm.A best design of system on chip architecture is done with minimizing the number of electronic components on same Printed Circuit Board (PCB). Thus, the paper basically emphasizes on the use of different hardware and software components used in chip making and interfacing with a number of required peripherals.*

Keywords **–** *Industrial control system, SOC, Hydraulic damper test bench, LabVIEW, PID algorithm*

1. INTRODUCTION

Technology is modification, usage, in order to solve a problem or improve the pre-existing solution to a problem. It has made man's life more simple and productive in the best possible easy way. An Industrial Control System consists of various control systems used in industrial production, including supervisory control and data acquition (SCADA) system, distributed control system (DCS) and programmable logic controllers (PLC). This system requires continuous monitoring and control of many parameters. An effective industrial control system can be made by use of digital control system from which we gain the advantages of implementation of complex functions, reliability in implementation, cost effective, accuracy([1]).

It consists of digital controller, ADC and DAC. Digital control system with analog counterpart makes the system more flexible.Hydraulic damper test bench is used to test the new or repaired pumps orvalves .Besides it, it mainly includes following testing: Fatigue testing, Monotonic testing, Environment testing, Component testing, High temperature testing, Bio-medical testing, Mechanical thermal fatigue testing. The testing of hydraulic damper and its components can be made on electronic module used for industrial control based on SOC (System on Chip) architecture.The hydraulic damper test bench using mechanical systems only has been obsolete. It is time taking, not very precise and cost inefficient. The electronic module for test bench using SOC architecture has already been proposed using 16-bit microcontroller([2]). However, this paper proposes for the implementation of a 32-bit RISC(Reduced Instruction Set Controller) microcontroller interfaced with hydraulic damper in virtual instrument software known as LabVIEW(Laboratory Virtual Instrument Engineering Workbench)([3]).The use of digital control system on the chip microcontroller is the miniaturized form and also enhances the control system thatintegrate microcontroller processing, input sensor feeding, signal conditioning, peripherals like LCD, keyboards interfacing and outputs. Such control system requires hardware design and software development(C or assembly language). This paper basically presents the design of control system using ARM920T,a 32 bit RISC microcontroller with the modification that can be easily adapted to the specific issue of industrial process.

2. HARDWARE DESIGN

The hydraulic damper test bench was used to be based on mechanical systems only a few years ago. The main components of this system are servo amplifier, servo valve, hydraulic cylinder, load, position transducer.

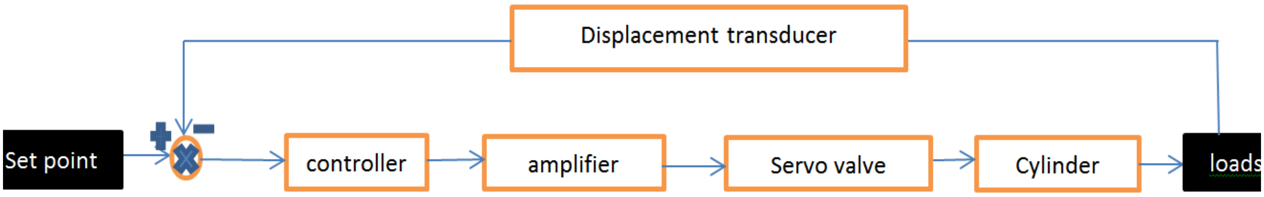
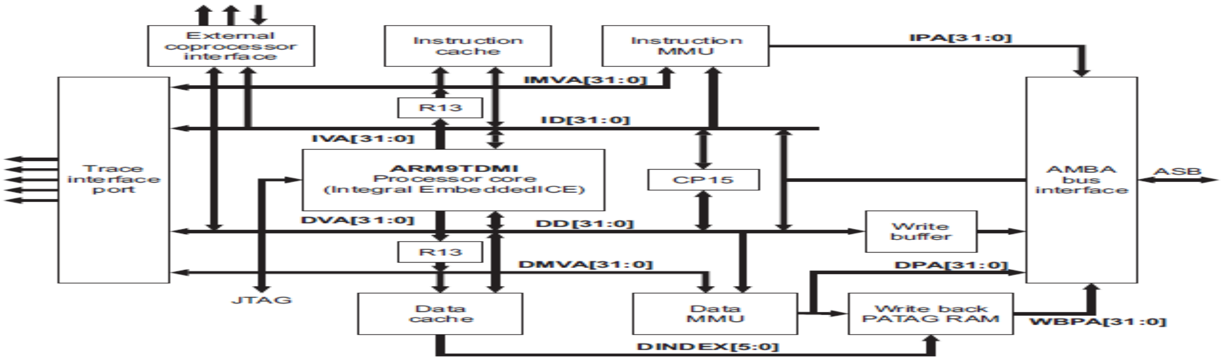


Fig : Block Diagram Of Mechancial Damper System

According to the structure of position control system of hydraulic system efforts were done to create this mechatronic system of hydraulic damper test bench with the better performance that make use of digital control system on the chip microcontroller. Digital controller of this system is ARM920T, a 32 bit RISC microcontroller and the electronic module was developed with this. Module consists of 6 onboard relays, 8 analog inputs, 4 analog outputs,8 digital lines as input or output, keyboard interface, LCD interface, 4 open drain output, LVDT(Linear Variable Differential Transformer), PWM(Pulse Width Modulation) output for servo valve, RS485 interface([1],[5]).



ARM920T function block diagram

ARM920T,a 32 bit RISC microcontroller, is an integral part of this module. High performance processor combining an ARM9TDMI processor core, 16KB instruction and 16KB data caches, an AMBA(Advanced Microprocessor Bus Architecture) bus interface. Considering saving in chip complexity and area, 3.3V device, power consumption,5 stage pipeline based on Harvard architecture.

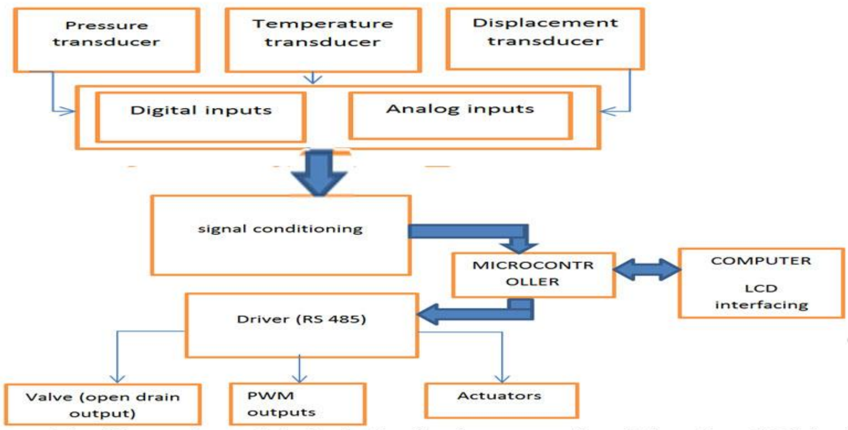


Fig. Electronic module for hydraulic damper test bench based on SOC Architecture

Interface for inductive displacement transducer LVDT(Linear Variable Differential Transformer)sensor for measuring physical parameter such as pressure, force, displacement. LVDT signal conditioning requires pulse

width modulation system, analog to digital converter(ADC),timer, processing power. Excitation frequency range 1-10KHz and the signal is read in digital inputs.

RS485 is used for signal communication, twisted cable, differential signal, transmission speed of 35Mbit/s up to 10 m and 100 Kbit/s upto 1200 m between drivers and receivers. Low pin count drivers bring RS485 to active state.

Relay, electrically operated switch are FET driven consumes 60mA in ON state. To reduce the false interrupts, an extra 10 nF decoupling capacitors, metal oxide varistors (MOVs) in parallel with relays contacts, separate supplies for microcontroller and relays and, finally,a 4, 7V zener diode in parallel with microcontrollers power pin.

PWM output for servo valve, AVR have ADC but do not have DAC, thus PWM output is the closet solution. ARM produces PWM output with the use of various timer and comparator. Connection between actuators(servo valve, dc motor)and output pin is done with the electronic circuit called motor controller or H-bridge to prevent the blow off microcontroller. Driver circuitry uses MOSFETs; PWM frequency should never exceed the switching speed of MOSFET.

Timer (also called as counter)as inbuilt microcontroller peripheral, used to generate accurately time pulse PWM signals. AVR have 8-bit and 16-bit timer. Timer to be used is governed by bit accuracy, mode of operation (fast PWM, phase correct PWM,phase and frequency correct PWM) that varies with actuator, output mode.
16*2 line LCD display interface is done with high drive output through microcontroller.Its interfacing is done through 6 digital lines as inputs and outputs.

3. SOFTWARE DESIGN

The LabVIEW Embedded Module for ARM Microcontrollers is a comprehensive graphical development environment for embedded design([8]). This module builds on NI LabVIEW Embedded technology, which facilitates dataflow graphical programming for embedded systems and includes hundreds of analysis and signal processing functions, integrated I/O, and an interactive debugging interface.
The Embedded Module for ARM Microcontrollers has the following requirements:

- A computer with Windows Vista/XP/2000
- RealView Microcontroller Development Kit including Keil µVision3
- LabVIEW 8.6 with embedded support
- Keil ULINK2 USB-JTAG adaptor

The main steps included in Build, Run and Debug of ARM application is:

1) Creating Front Panel

Fig. Selecting Labels

2) Creating block diagram

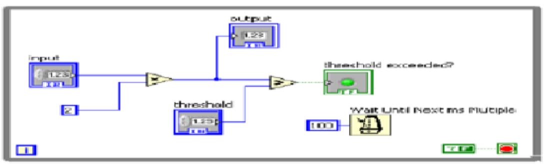


Fig. Creating Block Diagram

3) Building and running application:For faster development of embedded module, a JTAG connector was placed on board. This offers In Circuit Emulation and Programming, as well as advanced debuggingtechniques like step by step execution,register watch, multiple hardware and conditioned breakpoints.

4. Pid Control Algorithm

PID (proportional integrative derivative) algorithm is the most common algorithm used in industry. PIDcontroller determines the output value basically as valve position. It applies the controller output value to the system which in turn drives the process variable towards the set-point value([6],[9]).

PID controller compares PV(process variable) to that of SV(set-point value) to get e(error).
e= SV-PV
Then PID controller calculates the controller action u(t), where K_c is controller gain.
$u(t)= K_c\{ e + 1/T_i(\int_0^t e \cdot dt) + T_d . de/dt) \}$

If the error and controller output have same range,-100% to 100%, controller gain is the reciprocal of oportional band. T_i is the integral time in minutes,called reset time and T_d is the derivative time, called rate time.
For proportional action, the required formula is:$u_p(t)=K$
For integral action, the required formula is: $u_i(t) = K_c(\int^t e\cdot dt)/T_i$
For derivative action, the required formula is: $u_d(t) = K_c(de/dt)\cdot T_d$

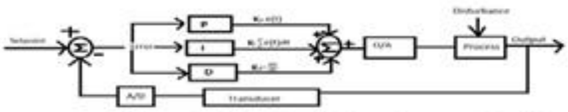
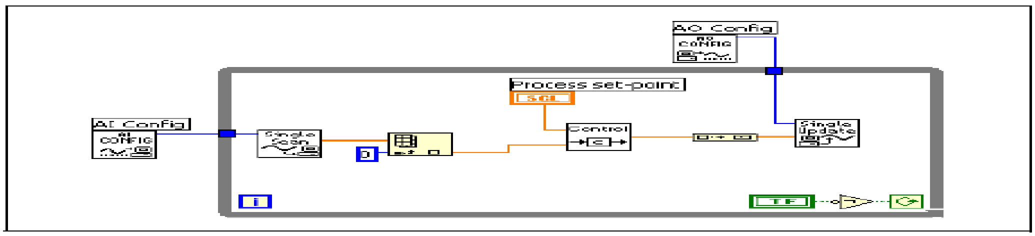


Fig: electronic module consisting of digital control system comprising of PID

5. Simulation And Results

Test for integrated electronic module for mechatronic systems are performed on a hydraulic damper test bench that contains pump unit, linear actuator (hydraulic cylinder) with attached displacement and force transducer. This test is done with the help of PID algorithm in LabVIEW([4],[7]).The DAQ (data acquisition system) with the closed loop makes PID algorithm productive. So, we can use the advanced-levelAQVIs(Virtual Instrument) to configure the analog input and output only once instead of on each loop iteration.



The simulation of damper test bench using ARM920T microcontroller is a proposed one ([9]).One of its basic testing known as water level testing is performed as below.

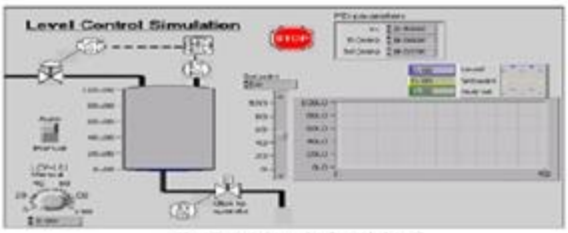


Fig. Front Panel of tank level

he Tank Level VI uses an integrating process with added noise, valve, dead band, lag, and deadtime. The cycle time is fixed at 0.5 s.

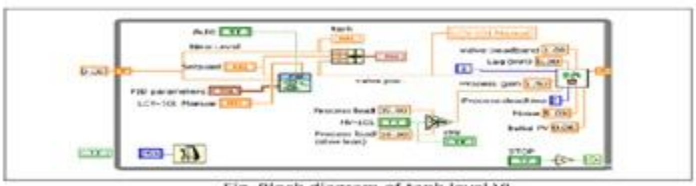


Fig. Block diagram of tank level VI

6. CONCLUSION

The simulations and results shows that the ARM920Ts microcontroller based electronic module for the industrial control system is capable of performing in a more effective way with lower cost, high accuracy, saving in chip complexity and area, lower power consumption. This module requires hardware design(electronic schematics)and software development. It is implemented with PID algorithm that provides autotuning. The work of PID controllers varies from reading sensor to computing the desired output. Integration of all this make the module very flexible and suitable to be implemented in hydraulic application(hydraulic damper test bench).

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7. BIOGRAPHY

Hare Ram Jha had completed his B.Sc (Engineering) in Electronics & Communication Engineering at the R.P.Sharma Institute of Technology, Patna, Bihar (affiliated to Magadh University, Bodh-Gaya, Bihar) (India) in 2007. Presently he is working as a Lecturer & Research Scholar at National Institute of Technology, Jamshedpur, Jharkhand(India).

Akash Priyadarshi is pursuing the degree of B.Tech in Electronics & Communication Engineering at National Institute of Technology, Jamshedpur(Jharkhand,India). He is presently at 3rd year working on the concept of electronic module based on RISC microcontrollers.