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SURVEY ON AN EMBEDDED SYNCHRONIZED DAQ USING ARM AND FPGA MODULE

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ABSTRACT

Data acquisition system plays an important role in the field of modern technology. Often Data acquisition system is abbreviated as DAS (or) DAQ. The idea behind the DAQ is to sample the data which represents real-time conditions and to convert it in a digital form in which computers and processor can manipulate it. Each application has its own design and its structure. Hence in this paper, a survey of an RT Data acquisition system has been presented. DAQ is capable of carrying around 300 channels of RT DAS, a static test facility for on board systems, high speed acquisition and redundant systems. At present, different application in DAQ softwares is developed using the LabVIEW for real-time acquisition, analyzation and to display.

Keywords: *Data Acquisition, FPGA, Embedded System, Real-Time System, ARM Controller*

1. INTRODUCTION

Data acquisition is performing a very essential role in the modern industry controlling system. Often DAS are typically a variety of embedded acquisition system which consists of an 8-bit soul fragment. These systems are accomplished by measuring precision speed, ability to analyze and processes the data in Real-time, and the capacity of data storage. The Hardware of Data-Acquisition system embraces signal conditioning and interconnecting devices based on PCI module. The basic idea behind the Data-Acquisition system is to convene all the constraints in the current trends. There are varieties of systems available on the support, which performs Data acquisition along with categorization but at very high rates. Embedded system interacts repeatedly with its atmosphere and carries out a variety of tasks, by definite timing constraint to meet the desires of system performance. The Processors have low power consumption and small size with a high instruction throughput. Data-Acquisition Systems are hybrid electronic devices with the major role of interfacing the digital signal to the atmosphere.

In real time, assets consumption comprises a blend of software as well as hardware that has the ability to interrelate the substaintial performance with the processor externally and this interrelation must be adequately high-speed as to confine and conserve the vital in sequence interconnected to the event.

The objective of our Data acquisition is to integrate the signal conditioning, data acquiring and processing function into a distinct board based embedded system. It has twelve simultaneously acquiring channels, 250KS/s per channel and supplies the standard signal for testing the global system. Embedded Data acquisition system, which was developed using the Advanced RISC Machine Processor (Cortex MP core), FPGA behaves like a target to an embedded system. ARM Processor who acts as the central DAQ System is used as the controlling system that reins the devices connected to it. Depending upon the sensor equipment used, signal diction and processing more integrated applications have emerged. In signal processing, FPGA is the control unit, and all the control logics are finished by hardware with high speed, low-cost and strong flexibility [11],[39],[34]. Nowadays Data acquisition is used based on microcontroller unit. The data that may be analog or digital form are filtered, processed and send to different display devices using proper interfaces but in the microcontroller based system the processing is done in the microcontroller unit. To overcome the

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drawbacks such as low processing speed, poor usage of memory, embedded field uses ARM and FPGA as the main controlling unit in the Data acquisition system. Both Processors have their own advantage in the application field. ARM is mainly used in an embedded control and other applications. FPGA has an ability to implement the signal processing and developing a system using System on chip. The main advantage of FPGA is the flexibility. In present FPGA is fully equipped with hard and soft core processors and capable of supporting all industrial Real-time Ethernet Protocols.

The data-acquisition system acts as the central point in complex systems in which numerous signals must be sampled, monitored and recorded in real-time. External devices with digital and analog outputs can be connected directly to the system which provides high-speed, isolated, serial, analog inputs and dedicates to Data acquisition system [1],[2],[10].

2. IDAQ USING ARM AND FPGA IN DAQ CARD

DAQ (Data acquisition) is defined as the process of taking a real-world signal as input. The functions of Data acquisition system involves the personal computer, Transducers, signal conditioning and DAQ hardware. A Physical phenomena represents the real-world signal. Transducers convert the sensed signal into electrical signals that can be processed by the DAQ system. For example, IC sensors convert temperature into an analog signal that an ADC can measure. In each case, the electrical signals produced are proportional to the physical parameters they are monitoring. The real-world sensors and transducer output signals that must be conditioned before a DAQ board or device can effectively and correctly acquire the signal. This front-end pre-processing, which is generally referred to as signal conditioning that includes functions such as filtering, electrical isolation, multiplexing and signal amplification in which low-level signals are amplified to increase the resolution and reduce noise. The Personal Computer which is used for Data acquisition system will radically affect the maximum speed and performance while continuously acquiring and transferring the data. Data acquisition hardware consists of Signal processing/transfer and Signal Converting/data buffer. The limiting factor for acquiring large amounts of data is often the hard drive.

The design and the interconnection of a new Data acquisition system prototype is emerging based on FPGA and ARM technology. This System provides a continuous and quasi real-time data transferring capability. The intention of this work is to obtain a high integrated level architecture that allows signals simultaneously to attain conditioned signals according to the external clock and triggers, then processed and transferred to data servers in a real-time [4],[7].

The integrated data acquisition system is based on an industrial PC with 20 slot ISA Passive Back Plane. The CPU is a single card Pentium90 with 32MB RAM, on board hard and floppy disk controllers plus a Small Computer System Edge. The biased DAQ Hardware is a mixture of commercially available boards and AOD Design boards.

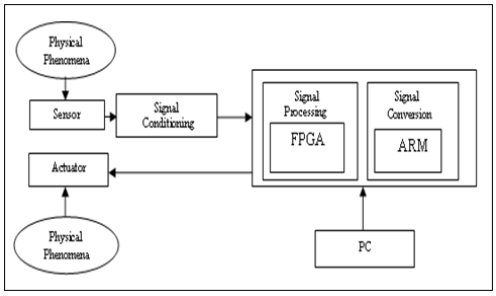

Figure 1: Data Acquisition System

The DAS integrates signal conditioning, data acquiring, data collecting and processing system onto the single board based embedded system. The modern DAS depends on Advanced RISC Machines (ARM) and Field Programmable Gate Array (FPGA) technology that has been developed in order to take the continuous Data acquisition and real-time data transmission. The system is accomplished by collecting and processing multichannel audio sources without the need of a PC and storing them into a storage device. They intend to use system on chip technology and hardware/software co-design to integrate all functions needed by this application into a single FPGA. The FPGA is embedded into signal converter and buffer. The ARM Processor which acts as the central DAS is used as the controlling system that manages the devices connected to it and acquires the data from the altered subsystem [12],[18],[19],[20]. The external devices are connected to the ARM Processor through RS232 serial port. ARM Processor combined with embedded Real-time OS realizes the Data acquisition system and transmits remotely through

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the wireless communication which can be used in wider industrial fields.

2.1 ARM and FPGA Module

The embedded data acquisition system consists of three parts: information sensors, acquisition controller and transfer module. Information sensor module includes tri-axis accelerometer, digital gyroscope, gauss digital magnetometer, impact detector, GPS device, Video cameras and microphones etc. The acquisition controller is based on FPGA together with DDR2 SDRAM and solid-state storage disk (SSD) which consist of NAND flashes. The signal processing and transfer module comprises Cortex, L2cache, memory, serial port, network and USB Controller.

The DAQ System integrates the signal conditioning, data acquiring, data collection and processing function into a distinct board based embedded system. With DMA, the main control module receives the acquired data from signal converting module [9],[14],[20],[22]. The ARM supports a four-channel DMA controller located between the system bus and peripheral bus with no restrictions. The ARM Processor and FPGA are interconnected by an External Bus Interface (EBI).

FPGA component is the central part of the imperfection processing system, includes all the digital circuit elements. Throughout the design, where the system on chip is emphasized, the FPGA part achieves all the essential process, digital logic together with the adder, comparators, buffers, PLL, Counters, MUX and USB edge reason. After execution we get a lithe digital part and flexibility, by simply updating the FPGA program in compliance with the requirements. Different systems can be supported on the same hardware by uploading a new programming onto the FPGA [15],[16]. So it is proper to use as a controller chip in Real-time imaging system . In collecting module, an FPGA is the control unit and all the control logics are finished by hardware with high speed, Low-Cost and strong flexibility.

As the core processor in the system, the FPGA is responsible for collecting the data acquired by each sensor. The data are processed in FPGA and then buffered in DDR2 module or saved in SSD directly. When needed, the data is loaded from the SSD and sent to the internet database server or portable wireless device. The design demands for multi-channel buffering sensor's data is inadequate to meet the on-chip demand. The system uses DDR2 SDRAM as the extended buffer. DDR2 SDRAM cannot support, read and write data simultaneously for the address bus which is shared by read and write operation. In order to avoid the complication in the structure, the DDR2 SDRAM is a package in the form of FIFO (First in First out). This supports the user to attain a modest, standard interface and the function of R/W operation to DDR2 SDRAM.

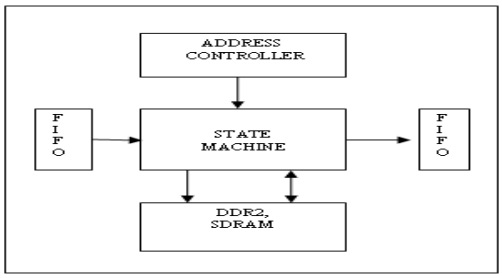

Figure 2: FPGA Module

The ARM module contributes an outstanding variety of products based on Cortex-M processors, which provides better performance, peripherals and softwares are more comfortable compared to earlier designs. The Cortex MP Core processor delivers efficient power and performance with high functionality. The integrated signal processing features of the Cortex MP Core simplify the development of software application, by offering a processing device and single tool Chain, when compared to architectures containing separate application's processors. Many of the high performance signals processing instructions for the Cortex MP Core processor can be taken advantage through the compiler.

The requirements for the design of both single and multiprocessor refers to the new ARM processors. The MP Core implementation of the processor offers advanced feature of lower power consumption. The circuit of acquisition hardware using the multi modulation circuit to modulate the I^2C channel signals (including the corresponding signal conversion, signal processing etc.,) this makes the signal collected from multichannel that meets ARM9 core requirements [21],[22],[25],[43]. In order to achieve the whole working setup, the host computer monitors and on-site display touch screen show all the required information.

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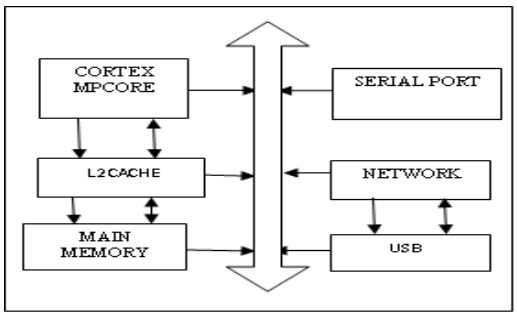

Figure 3: ARM Module

2.2 LabView for Data Acquisition

LabVIEW is a graphical programming circumstances with the intention of making it uncomplicated to obtain information from sensors. The heart of the NI design platform integrates all the tools that engineers and scientists need to assemble an extensive variety of applications drastically. Therefore it provides tools to resolve present exertion and the competence for future innovation faster and more efficiently [16]. Driver software with an intuitive application programming interface makes a huge impact on implementing a project on time with Low cost. NI-DAQ driver software goes isolated in advance of an essential DAQ driver to express increased productivity and performance.

LabVIEW is an exact software for Data acquisition. The software is used to control or drive the hardware. To analyze the inclusive Data acquisition the PC convert the software to the Data acquisition hardware with the intention of the middle layer which is formed between the application software and hardware. Driver software act as a middle layer of software for effortlessly communicating with the hardware. Appropriate to this it increases the speed and improves the system performance, it can also even generate code based on our configuration, making it faster and easier to develop critical operations. Application software is used for analysis and the presentation capabilities to drive the software.

The Data acquisition system is intended to run without a UPS support and situations of its switch off without a proper shutdown cannot be avoided both operating systems had to be properly configured to avoid damage of operating system files and to ensure trouble-free booting under all circumstances. The MS Windows XP Embedded operating system boots similarly from its compact flash card and to avoid writing to this memory during operating system run the embedded enabling feature called Enhanced Write Filter (EWF) is configured for this card.

The software tools used for the embedded system have been written in the C++ object oriented programming language. The software is developed and cross compiled for the ARM architecture on a host system using cross tools. For FPGA it allows the user to be able to interface to a PC for data restoration and monitoring. Now a day's LabVIEW platform is a best software in which inbuilt code is provided. The platform interface with the ARM and FPGA based DAQ card. The tools available with it prove very beneficial in developing application faster and easier. The main benefit of the Data acquisition system is DAQ card can be connected in LAN for analysis from remote terminal present on the LAN. DAQ card can be connected to the internet so that data can be accessed from any internet connected computer.

National Instruments (NI) which is a leading industry in DAQ has recently provided PCI and PCI extensions for instrumentation DAQ card with FPGA such as the NI LabVIEW FPGA Module. FPGA is only used for limited purposes such as timing and triggering or reconfigurable control algorithms. DAQs involving FPGAs can be redesigned while mounted on a target system to reach fine tuned performance (or) to reroute a faulty circuit to a new place. The recently introduced high capacity FPGA allows the integration of multiple components on a single chip. In addition, it can have all the processing, storage and input-output capabilities that are needed by a DAQ system. The LabVIEW Application builder is a very useful tool when we are designing an application that runs on the system that does not have LabVIEW installed on it. Tools of LabVIEW, Application Builder builds the application exe which is an executable file as well as an installer that can be installed on any machine with required specifications.

3. INTEGRATED DAQ SYSTEM

The integration of distinct operations on PC into a DAQ system can be made by treating single board computer system in a analogous way that hardware substance are treated. During suspicious propose, an insignificant regular edifice is used similar to a software bus with the purpose of linking a set of hardware specific code exacting by the varieties being used. A basic communication protocol combines with little compact readout routine

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consequence of a system as a high-speed data readout device.

ARM and FPGA processors are the mainly flexible components in the embedded system design and it achieved the reliability through hardware and software technology. The processor has 16 bit address bus and data bus with external clock input and reset signal. The write operation is indicated as (WE_O) write enable and the read operation as read enable (RE_O). Data path and control unit are the two main parts which consist of general purpose register, control signal, multiplex for both input and output operation. The control signal which comprises of muxes, clock enable of register, ALU and shift register [9]. The SDRAM is a memory block used to store data which required to hold programs and execute programming instruction. It comprises of set of address and data lines which serves for both input and output of the data to the location that is specified by the address line. An I/O buffer with higher impedance capability in a bidirectional buffer.

These processor form RISC architecture and high level programming language. Hard and soft core processor are the different type of processor implemented in FPGA. Several factors influence an embedded processor implementation include obvious and concrete system requirement. The component on the FPGA board includes an analog multiplexer, buffer, analog to digital converter, SDRAM and FIFO. These further components are used for interfacing both the output to the PC and inputs to the chip. The input data is multiplexed, digitized and stored in SDRAM. The data from the ADC is stored in SDRAM in consecutive locations. The FPGA is used to reduce the bandwidth of the external data by implementing an appropriate filter using the soft processor implemented in the FPGA. Then the data are taken by the FPGA and it is framed as per the Ethernet protocol. The information is conveyed to the SDRAM in the Ethernet Controller. For FPGA it allows the user to be able to interface to a PC for data restoration and monitoring. Now a day's LabVIEW platform is a best software tools in which inbuilt code is provided. The platform interface with the ARM and FPGA based DAQ card. The tools available with it prove very beneficial in developing application faster and easier.

The Hard Processor System (HPS) consists of a dual core ARM cortex, FPGA. Programmable logic is provided by a recast of peripherals and a multiport memory controller [21],[22],[23],[43]. The advantages is to reduce the cost, power and to save the more FPGA asserts for application specific convention logic. FPGA logic supports DDR2, SDRAM, Address controller, FIFO devices with integrated error correction cable. It support for high reliability and safety critical applications.

FPGAs integrates an ARM based hard processor system which comprises single/multiprocessor, various peripherals and memory interfaces within the FPGA fabric. This fabric is incorporated with a high bandwidth. High throughput data paths among the HPS and FPGA framework make available an integrated performance, which is not achievable in two chips solutions [3],[26]. The fixed interconnection among the HPS and FPGA fabric provide more than 100GBPS Peak bandwidth with integrated data coherency connecting the processor and the FPGA.

Table 1: Comparison between Standard and Real-time Data acquisition

Features	Standard Data acquisition	Real-time Data acquisition
Objective	Strategic Decision-Making	Tactical Decision-Making
Data acquisition	Application oriented	Information accessibility oriented
Load Cycle	1/Day.....1/Week	1/Minute.....1/Hour
Resource Consumption	Processing normally	Permanent resource consumption

Real-time Data acquisition System supports every day decision-making. It also supports tactical decision making by allowing to send data to the FIFO and storage in SDRAM then transfer to serial port etc. The data is stored persistently in BW. The real-time Data acquisition wants to transfer data to BW at more regular intervals than standard Data acquisition. It transfers upto data required to be regularly available for analysis and reporting. The standard Data acquisition is request oriented where as Real-time Data acquisition is data availability oriented. The time duration is entirely slow when compared to RT Data acquisition system. Comparison table is shown above between standard and Real-time Data acquisition system.

The advantages of ARM based SOC FPGA are reduced system power and board size, less expensive, improved system performance via high bandwidth interconnects between the processor and FPGA. The system Power is reduced by

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assimilating distinct processors and digital signal processing (DSP) functions into a single FPGA.

4. APPLICATIONS OF IDAQ

In many real world applications, multichannel Data acquisition (DAQ) is needed for the purpose of surveillance, monitoring and control and this gathered information can be accessed through the internet and made available through the standard web browser.

In biomedical applications, an electroencephalogram (EEG) or an electrocardiogram (ECG) system can simply require five to ten nodes for each patient, and each node normally requires more number of 200 samples per second. It is not special for other vital sign monitors to be attached to a patient, and several patients may allocate the same room [1],[2],[28]. The density of consumption may be as high as 50 to 100 nodes in a small area. An essential issue in such real-time systems is the wireless communication protocol. All nodes must consume the available bandwidth effectively.

In educational laboratory, the cost of the DAQ cards and computers is substantially limiting the number of stations that is available to students and making it difficult for students to complete their assignments. Since the lab assignments require access to the DAQ lab hardware and software, students often find themselves competing for access to the DAQ Computer.

In Industrial and consumer application person have been replaced by unmanned strategy that will obtain data and convey the data back to the base. The control devices with the purpose of substituting for a supervisor in a multisite job operation [13],[17],[29],[30]. A particular person can observe and even interact with the ongoing work from a single base station.

In the computer aided laboratory, instrumentation that is currently running in the laser metrology laboratory. The experiment is part of the research project and focuses on monitoring strain in concrete blocks with various types of sensors. The setup consists of eight concrete specimen cast from different concrete mixes that are arranged in two groups of four Specimens. One group is tensioned by a steel bar while another group is left untension after casting and curing.

In automobile application the main factors (environment, vehicle and driver) of traffic accidents, we increase the sorts of sensor. The more intuitive information forms like audio/video are recorded in the system. The design utilizes various MEMS (Micro-Electromechanical systems) sensors, impact detector to detect the running state of the vehicle. Prevailing GPS is applied to acquire the position and velocity of the vehicle. The System also collects the driver's operation activity such as clutch/brake/throttle/steering/lights/speaker and so on, in order to judge the behavior validity of driver. Acquisition system is installed on a passenger car, sensors collects varieties of signals under setting trigger conditions, then FPGA processes data from an acquisition system through network connection.

In industrial automation Data acquisition systems are often used for the purpose of process monitoring [31],[35],[36],[38]. Our team is specialized in control of fast industrial processes and then arose a need for a Data acquisition that would help to analyze the behavior of the industrial process and to choose an appropriate control system. Another intended purpose of the Data acquisition system was the utilization of a monitoring system that would help to tune the applied control system.

In industrial application, unmanned aerial vehicles are administered manaully through PC with the suitable command to the processor installed inside the UAV from the ground station. Teledenistometer sensor is used to generate data which can be read constantly and can be accumulated in a buffer which can be altered according to the application by the operator [37],[38],[40],[42],[43]. An UAV is used for collecting data using sensors from the seabed and to transmit commands for driving over the sea floor. By knowing its position using GPS and the collected information is sent back to the operator using a standard Web browser for further processing.

In Data acquisition, the supervisory control is the general function to remotely observe different processes which it gather and analyzes data in real time. Several pipes are used to fill the tank and it is difficult for the supervisor to monitor all the pipe simultaneously. So that SCADA software is installed in PC to monitor and control the devices from a remote place.

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In Military application GPS is used widely for systematically tracking. The main function of the GPS unit is to collect the data by transmitting and receiving signals for further statistics and analysis. In highways, industrial GPS is used to track the number of the automobiles and uses this data to determine the time when the highway is busy [24],[41],[42],[43]. In navigation systems GPS use maps to help uses establish their accurate position. GPS Software executes responsibilities like locating a unit or decision away from one point to another using GPS co-ordinator.

5. CONCLUSIONS

In this paper, the Hardware Data acquisition system integrated with Signal conditioning, Signal Converting/Data Buffer and Signal process/transferring in Single board. A few new technologies are introduced into this system such as Cortex MP Core, FPGA. Thus the standard DAQ system is an application oriented and its system processing is normal compared to the Real-time DAQ system which is an Information accessibility oriented. The measured signal waveforms are displayed in the LabVIEW front panel. The main advantages of the Real-time Data acquisition System offer low cost, low power consumption, reduced board size, high speed with higher accuracy, reliability, efficiency and strong flexibility.

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