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ANALYSIS AND VLSI IMPLEMENTATION OF DIP BASED CONTROL AND MONITORING SYSTEM FOR DISPLACEMENT IN CONTROL VALVES

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Abstract

Process industries require supervisory control and data acquisition systems (SCADA) or distributed control systems (DCS) depending upon geographic distribution of the plant instrumentation. Remote operation of the hazardous field needs quite a good amount of instrumentation support for control as well as monitoring purposes. The various parameters to be monitored are pressure, flow, level, displacement, speed etc. Sensors are to be installed at hundreds of locations to bring the details of signals to the operator station. In refineries, chemical industries and power stations etc a constant level is maintained in furnaces, boilers etc. In particular let us take the case of raw material mixing in a chemical industry in a furnace and processing. During the chemical processing there is possibility of sudden expansion of contents inside the huge container. And also there is a possibility of gas/bubbles generation and level may instantly go high. This may burst the container. To avoid this level of expansion is continuously monitored inside the container through ultrasonic detectors. The signal is fed to PLC. The PLC immediately gives control signal to control valve to open and drain out the required quantity from the container and maintain the level.

. This paper proposes a FPGA based new architecture for high-speed comparison of image according to the threshold value. This method exploits compare the sample image with reference

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image, if changes occur control signal will generate to monitor the parameters. The design based on using FPGA for the hardware implementation of the architecture using VHDL. FPGA Spartan 3E starter Kit has been used for the hardware implementation. The proposed method is an improvement over traditional software package based approaches in that of image comparison. This system gives real time display of various field images super imposing on the animated mimic diagrams in computer monitor, which is not possible in the old environment with analog sensors.

Keywords:Sensors, DIP, VHDL, FPGA

1. INTRODUCTION

Most industrial plants are hazardous in nature. The technical development in Electronics, Information technology, Image processing and industrial computers resulted in the development of remote control and monitoring the plants. Remote operation field needs quite a good amount of instrumentation support for control as well as monitoring purposes. Nowadays plant size has grown bigger which needs control of many parameters like flow, level, pressure, speed, temperature, displacement, vibration etc., Sensors like RTDc, Thermocouple, strain gauges, tachometers, LVDT's etc generates analog signals. Errors in these sensors are prone to happen which are discussed below. Hence getting accurate results are not possible [1]. So many correcting methods are to be employed. A new technique to solve these problems is to use Digital Cameras in place of analog sensors. The digital images are taken and continuously transmitted to the operator station. Digital image processing paves way for generating control signals by comparing the just received image with the standard image already stored inside the computer. Past Environment in Factories the Operator station acquires data (Pressure, flow, level, temperature, speed) and indicates in analog recorders [2]. The disadvantages are slow, High capacity not possible and manual shut down possible. In the present environment in Industries the Data acquisition from transducer in analog form, A/D conversion, Data to computer to convert the data into engineering units, Compared with the set values, Generate alarm for abnormalities and viewed the site location separately in TV [3]. Manually generate control signals or automatically generate control signals through D/A converter for controlling the physical parameters based on transducer signals [4]. The defects in present environments are transmission error happens for signals from long distance (i.e.; signals from transducer are in analog form). Transducer themselves many times give erroneous signals. Decisions based on signals from transducers. Also defects in present environment is different types of sensors for different parameter. (i.e. SG for Pressure, RTD for temp, LVTD for displacement, tachometer for speed [5-7]. Manually viewing field images in TV and selecting control action is confusion. Human fatigue, sleepiness can end up in errors [8-10].

The proposed work is photographs (field images) taken through web camera (digital signal) connected to computer. Superimposing of actual images in the mimic diagram. The analog values are acquired through PLC & displayed in the mimic diagram. The field images (just received) are compared with the Standard images already stored in the computer. Control action is initiated when both images matches. SCADA/DCS control made easy through PLCs based on the control signal from the computer automatically. Control action is reliable. Slowly analog transducer can come to a halt. The emerging DIP technologies will revolutise the present control system. Very high capacity plants can be controlled.

This paper discusses the FPGA implementation of DIP based online control and monitoring system. In Section II, the characteristics and factor influencing of analog sensors are presented. In Section III, factors influencing the choice of transducers are discussed. In Section IV, proposed systems are discussed. In Section V and VI, result and conclusions are drawn.

2.**CHARACTERISTICS AND FACTOR INFLUENCING OF ANALOG SENSORS**

2.1. INPUT CHARCTERISTICS

Type of input and operating range: The foremost consideration for the choice of a transducer is the input quantity is going to measure and its operation range. The type of input, which can be any physical quantity, is generally determined in advance. A physical quantity may be measured through use of a number of transducers. The upper limit is decided by the transducer capability is while e the lower limit of range is normally determined by the transducer error or by the unavoidable noise origination in the transducer. In fact the transducer should maintain a good resolution throughout its operating range. Ideally a transducer should have no loading effect on the input quantity being measured. The magnitude of the loading effects can be expressed in terms of force, power or energy extracted from the quantity under measurement for quantity under measurement of working of the transducer. Therefore, the transducer, that is selected for a particular application should ideally extract no force, power or energy form the quantity under measurement in order that the latter is measured accurately.

2.2 TRANSFER CHARACTERISTICS

The transfer characteristics of transducers require attention of transfer function, error and response of transducer to environmental influences. The transfer function of a transducer defines a relationship between the input quantity and the output. In general, the sensitivity of transducer is not constant but is dependent upon the quantity. The error can be split into three components, which are scale error, dynamic error and error on account of noise and drift, the scale error comprises of four different types of error like zero error is the output deviates from the correct value by a constant factor over the entire range of the transducer, sensitivity error occurs where the observed output deviates from the correct value by a constant value, non-conformity is pertains to case in which the experimentally obtained transfer function deviates from the theoretical transfer function for almost every input. In the special case of a theoretical linear relationship between input and output quantities, this error is called non-linearity or non linear distortion and hysteresis is the output of a transducer not only depends upon the input quantity but also upon in input quantities previously applier to it. Therefore, a different output is obtained when the same value of input quantity is applied depending upon whether it is increasing or decreasing. For decreasing values for the same value of the input quantity. Dynamic error is occurring only when the input quantity is varying with time. This is on account of the fact the systems contain energy storage elements and due to this the output cannot follow the input exactly but with a time lag. The dynamic or measurement error can be made small by having a small time constant. It should be understood that the dynamic error is a function o time. Noise and drift signals originating from the transducers vary with time and are superimposed on the output signal. The high frequencies cut off are the two specifications that describe the response of a transducer to a variable frequency sine wave input applied to it. For a reasonably, linear transducer, a sine wave input yields a sine wave output. The performance of the transducer is fully defined by its transfer function and errors, provided that the transducer is in constant environments and not subject to any disturbances like stray electromagnetic and electrostatic fields, mechanical shocks and vibrations temperature changes, pressure and humidity change, changes in supply voltage and improper mechanical mountings. If transducers are subjected to the above environmental disturbances, which they are, precautions are taken, so that changes in transfer function and resulting error s therefore do not occur

2.3FACTORS INFLUENCING THE CHOICE OF TRANSDUCERS

The transducers are many times selected on the basis of operating principle used by them. The operating principles used may be resistive, inductive, capacitive, optoelectronics, piezoelectric etc. The transducer must be sensitive enough to produce detectable output. The transducer should maintain the range requirements and have a good resolution over its entire range. The rating o the transducer should be sufficient so that it does not break down while working in tits specified operating range. High degree of accuracy is assured if the transducer does not require frequent calibration and has a small value for repeatability. It may be emphasized that in most industrial applications, repeatability is of considerably more importance than absolute accuracy. A further factor is to be taken into account when measuring mechanical quantities. The transducer should maintain the expected input out relationship as described by its transfer function so as to avoid errors. The transducer should meet the desired time domain specifications like peak overshoot, rise time, settling time and small dynamic error. The transducer should have high input impedance and a low output impedance to avoid loading effects. It should be assured that the transducer selected to work under specified environmental conditions maintains its input-output relationship and does not break down. The transducer should be minimally sensitive to unwanted signals and highly sensitive to desired signals. The ruggedness both of mechanical and electrical intensities of transducer versus its size and weight must be considered while selecting a suitable transducer. The electrical aspects that need consideration while selecting a transducer include the length and type of cable required. The transducer should exhibit a high degree of stability to be operative during its operation and storage life. Apart from low static error, the transducers should have a low non-linearity low hysteresis, high resolution and a high degree of repeatability.

3.PROPOSED SYSTEMS

3.1Monitoring and Control of Displacement

In refineries, chemical industries and power stations etc a constant level is maintained in furnaces, boilers etc. In particular let us take the case of raw material mixing in a chemical industry in a furnace and processing. During the chemical processing there is possibility of sudden expansion of contents inside the huge container. And also there is a possibility of gas/bubbles generation and level may instantly go high. This may burst the container. To avoid this level of expansion is continuously monitored inside the container through ultrasonic detectors. The signal is fed to PLC. The PLC immediately gives control signal to control valve to open and drain out the required quantity from the container and maintain the level.

The control valve action depends upon the LVDT attached to the stem of the control valve. The stem movement for opening changes the signal level in the LVDT which is monitored by the computer.

Table 1 – Shape based feature vectors for the different images

Type of Image	Shape based feature vector				
	Contrast	Homogeneity	Mean	Standard Deviation	Entropy
Partially closed	0.0356	0.9822	0.0211	0.1437	0.1475
Fully closed	0.0374	0.9813	0.0221	0.1470	0.1531
Fully opened	0.0239	0.9881	0.0218	0.1466	0.1524

Afterwards when the required level is reached, the stem closes and LVDT sends the signal to computer for information. Here the replacement of LVDT is suggested with digital camera. The various stem positions are photographed and stored inside the computer as different standard images in terms of shape based edge feature vector using contrast, homogeneity, mean, standard deviation and entropy. Depending upon the level in the container the PLC sends signals to move the stem to a particular position. This is photographed by web camera and forwarded to computer. This current image is matched with the standard image and verified. After the required time PLC sends the signal to close the stem. This position is again photographed and forwarded to computer. This current image is also matched with the standard image and verified. The following Figure 1, Figure 2 and Figure 3 show the various stem positions of control valve images. Table 1 explicates the shape based feature vectors for the different standard images.

Figure 1 Fully Opened

Figure 2 Fully Closed

Figure 3 Partially Closed

4.VLSI IMPLEMENTATION AND ITS RESULT

The Image comparison Algorithm plays a major role in measuring various physical parameters. While measuring the physical parameters, it is noted that comparison speed is low. To improve the comparison speed of this algorithm it is necessary to implement this algorithm in VLSI using VHDL. The following section illustrates the detail of VLSI implementation of Image Comparison Algorithm and its results.

4.1 INTRODUCTION

A case of level measurement is considered. A digital camera installed near the boiler drum in a Thermal power station takes continuous photographs of water levels and forward the digital image signal to the computer at regular interval. These images are compared with standard image stored inside the computer with suitable algorithm. Based on the matching of received image with the standard image, control action is initiated. It proposes a FPGA based new architecture for high-speed comparison of image using bit matching algorithm. This method exploits compare the sample image with reference image. If any mismatches, control signal will generate to monitor the parameters. The design is based on using FPGA for the hardware implementation of the architecture using

VHDL. FPGA Virtex 4 XC4VSX35 has been used for the hardware implementation. The proposed method is an improvement over traditional software package based approaches in that of image comparison.

This system gives real time display of various field images super imposing on the animated mimic diagrams in computer monitor, which is not possible in the old environment with analog sensors.

4.2 METHODOLOGY

The proposed architecture consists of two memory unit, control unit and data comparison unit which are shown in figure 4. One memory is used to store the Current image data from the digital camera and the memory is used to store the standard images. The image comparison unit is used to compare the current image to the standard image. The algorithm used in the image comparison unit is bit matching algorithm. The data comparison unit has the ability to compare a image of size 256 *256 with parallel computation. When compare with other algorithms bit matching algorithm have very less hardware complexity and high speed. When current image matches the standard image, the control signal is generated and it is given to the PLC for further action. When current image does not match the standard image, no signal is generated. The FPGA which is used to implement this architecture is Virtex 4 XC4VSX35 Which is a high speed DSP application supporting FPGA designed by Xilinx.Fig.4 explains the proposed System Architecture.

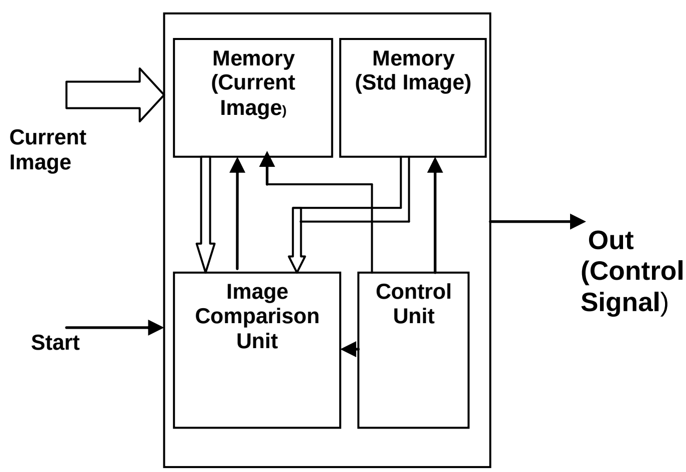

Figure 4 Proposed System Architecture

4.3 RESULTS

Simulated Environment:

Family: Virtex 4

Device: XC4VSX35

Synthesis Tool: XST (Verilog/VHDL)

Package: TQ144

Simulator: Model Sim SE-VHDL

Image Size: 256*256

RAM size: 2 GB

Processor: Core2Duo

Figure 5(a, b, c, d) indicates the output of proposed system in detail. This output has technology schematic, timing Report, simulation report and power analysis.

a. Technology Schematic:

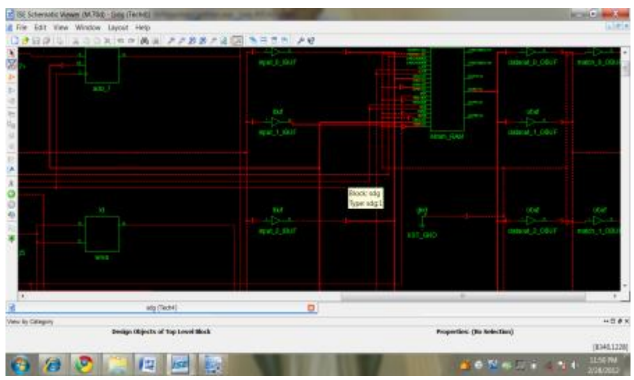

Figure 5 (a) VHDL Output of Proposed System (Technology Schematic)

b. Timing Report:

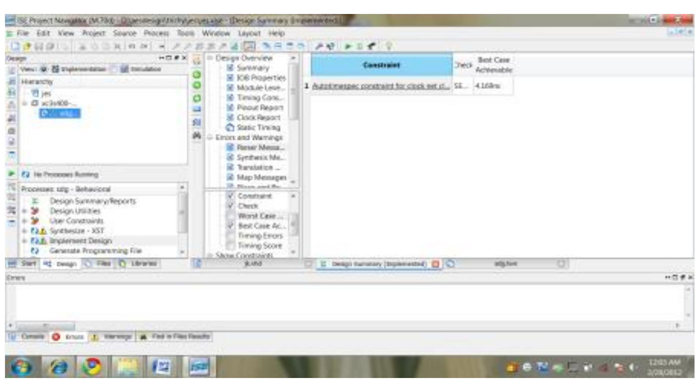

Figure 5 (b) VHDL Output of Proposed System (Timing Report)

c. Simulation Result:

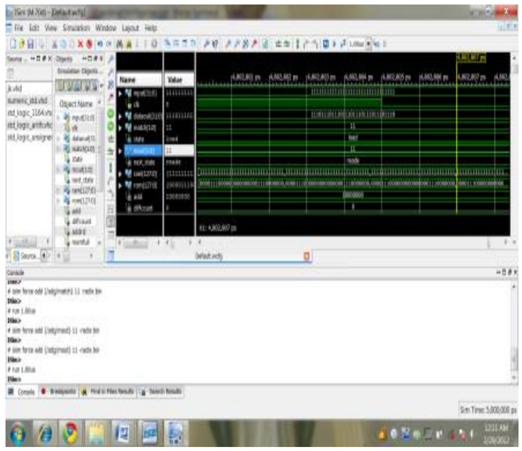

Figure 5 (c) VHDL Output of Proposed System (Simulation Result)

d. Power Analysis:

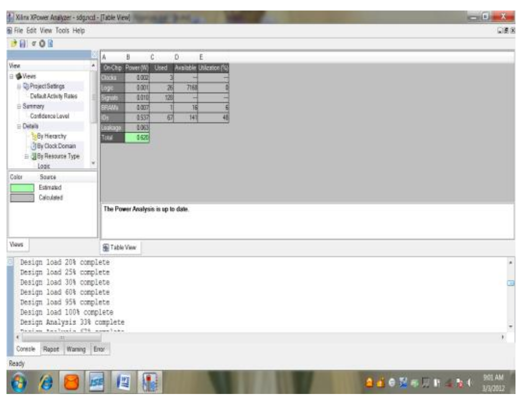

Figure 5 (d) VHDL Output of Proposed System (Power Analysis)

5. CONCLUSION

In this paper presents a new methodology for designing high speed image comparison by using FPGA and reduced the comparison time. If we comparing the image by based on threshold value in MATLAB and other technique it will take more time but our methodology guarantees to reduced the time by comparing the image. The very aim of the paper is to replace the sensors. This paper is focused on the measurement of displacement in control valve at the boiler opening.

The main objective of the project is to support speedy comparison of images. Even though, comparison algorithms are successful at software level, better results can be achieved by implementing in hardware.

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