Development of a Real-time Error-detection System : The Case study of an Electronic Jacquard

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Abstract: Any system has the possibility of an error occurrence. Even if trivial errors were occurred, the original system would be fatally affected by the occurring errors. Accordingly, the error detection must be demanded. In this paper, we developed a real-time error detection system would be able to apply to an electronic Jacquard system.

A Jacquard is a machine, which controls warps while weaving textiles, for manufacturing patterned cloth. There are two types of mechanical and electronic Jacquard. An electronic Jacquard is better than a mechanical Jacquard in view of the productivity and realizability for weaving various cloths. Recent weaving industry is growing up increasingly due to the electronic Jacquard. But, the problem of wrong weaving from error data exists in the electronic Jacquard.

In this research, a real-time error detection system for an electronic Jacquard is developed for detecting errors in an electronic Jacquard in real-time. The real-time system is constructed using PC-based embedded system architecture. The system detects the occurring errors in real-time by storing 1344 data transferred in serial from an electronic Jacquard into memory, and then by comparing synchronously 1344 data stored into memory with 1344 data in a design file before the next data would be transferred to the Jacquard for weaving. The information of detected errors are monitored to the screen and stored into a file in real-time as the outputs of the system. In this research, we solve the problem of wrong weaving through checking the weaving data and detecting the occurred errors of an electronic Jacquard in real-time.

Keywords: Electronic Jacquard, Real-time System, Embedded System, Error Detection, Synchronization, System Programming, PC interface, Single Board Computer

1. INTRODUCTION

Any system has the possibility of an error occurrence. Even if trivial errors were occurred, the original system would be fatally affected by the occurring errors. Accordingly, the error detection must be demanded. In this paper, we developed a real-time error detection system would be able to apply to an electronic jacquard system.

A Jacquard is a machine, which controls warps and wefts while weaving textiles, for manufacturing patterned cloth. A present method of manufacturing patterned cloth is simply having a cloth dyed with mordant. This method cannot put various patterns delicately on the textile. And, this method occurs environmental pollution and generating pollutant by using mordant, inflicts injury on the human body. However, The Jacquard can weave good qualitative and delicate textiles with various patterns, because a Jacquard is using yarns were dyed in the grain. And, the Jacquard not affect to the human body.

There are two types of mechanical and electronic Jacquards. An electronic Jacquard is better than a mechanical Jacquard in view of the productivity and realizability for weaving various cloths. Recent weaving industry is growing up increasingly due to the electronic Jacquard. But, the problem of wrong weaving from error data exists in the electronic Jacquard. This problem occurs by the generated heat in operation or by the induced noise in data transfer, as long as electrical signals control of the behavior of an electronic Jacquard.

Fig. 1. The Picture of Electronic Jacquard System

Fig. 1 is a picture of an electronic Jacquard system. Jacquard, an electronic Jacquard controller, and a loom compose this system.

In this research, a real-time error detection system for an electronic Jacquard is developed for detecting errors in an electronic Jacquard system in real-time. The real-time system is constructed using PC-based embedded system architecture.

In this research, for detection of occurring errors of an electronic Jacquard in real-time, the real-time system must have compared 1344 data transferred in serial from an electronic Jacquard with 1344 data in a design file before the next data would be transferred to the Jacquard for weaving. For that reason, we research into the real-time system, which

has to be solved problems of synchronization and timing for exact error detection in real-time. Then we design and realize the proper hardware and software on the basis of the research, and verify the performance of the developed system in this research.

Constitution of this paper is as follows. In chapter 2, the structure and operation of an electronic Jacquard are described. There is description of the design of a real-time error detection system for an electronic Jacquard, which is applied a single computer based PC interface and a system programming technology, in chapter 3. In chapter 4, there are realization and experimentation of the performance of the real-time error detection system designed in chapter 3. In chapter 5, there are the experimental results of the developed system. And the last, a conclusion of this paper is described in chapter 6.

2. THE STRUCTURE AND OPERATION OF AN ELECTRONIC JACQUARD

2.1 The Structure of an Electronic Jacquard

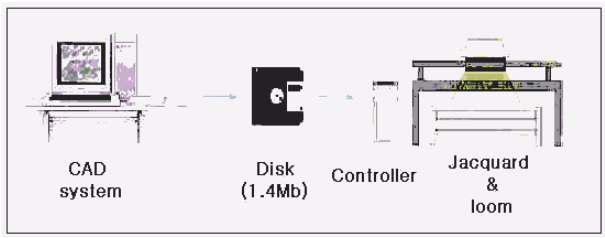

Fig. 2. The Basic Structure of an Electronic Jacquard

Fig. 2 shows the basic structure of an electronic Jacquard. Weaved pattern of the textile, called a design file is designed by a Computer Aided Design (CAD) program using a computer system. A design file, which is designed by a CAD program, is stored in a floppy disk. The controller of an electronic Jacquard system is loading a design file from floppy disk, and saving the design file to a storage device of the Jacquard system (e.g., hard disk). The controller of an electronic Jacquard system is transferring design data from a floppy disk or a storage device to the Jacquard, and having suitable control for the situation of operations of the Jacquard. The Jacquard is observing the transferred signals from the controller of an electronic Jacquard, and moving the appropriate hooks. And then, the practical weaving is performed at a loom.

2.2 The Operation of an Electronic Jacquard

The main shaft of the electronic Jacquard is connected to main shaft of its loom. An electronic Jacquard puts a pattern on the textile by controlling of the warps and the wefts at a specific timing that its loom is weaving cause rotation of the main shaft of its loom. Fig. 3 shows the basic operation of an electronic Jacquard.

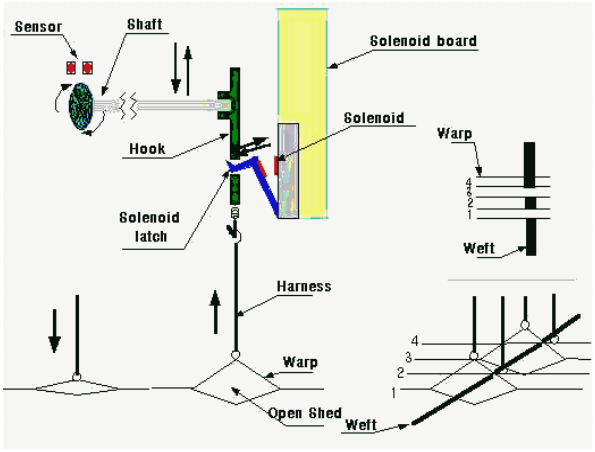

Fig. 3. The Basic Operation of an Electronic Jacquard

Like Fig. 3, the open-shed of a warp is opened or closed by a wire, called harness of a loom. The pattern is made when the weft goes through into the open-sheds in this time. Exactly, there is not directly controlling of the warp. The solenoid switches control of a vertical movement of the hook that is connected to the warp with the harness. Therefore, The pattern is weaved properly with design data on the textile by the open-shed of the warp is opened or closed.

Transferred data from the controller of an electronic Jacquard are transferred 1344 data in serial at each pick. 1344 data have been transferred all to each solenoid, and then the controller of an electronic Jacquard drives the solenoids in parallel simultaneously, controls of the open-sheds.

We referred in chapter 1, the problem of wrong weaving from error data exists in the electronic Jacquards. This problem occurs by the influence of the generated heat by the solenoids driving or by the influence of the induced noise in data transfers. This becomes the factor to bring the weaving productivity decreases.

3. DESIGN OF REAL-TIME ERROR DETECTION SYSTEM

In this chapter, we design the real-time error detection system for an electronic Jacquard. The real-time system is designed to solve the problems explained previous.

The specification, which the real-time error detection system for an electronic Jacquard must contain are as follows:

- The main controller using ISA Bus Interface
- The clock selector for synchronization
- The memory to store error informations
- Convenient user interface

3.1 Main Controller

The main controller is designed to control the flow of data and signals between each block perfectly. We applied a system programming technology, which is systematic and efficient for real-time error detection. The main controller uses the output signals (CLK1, DATA1, STROBE) from last solenoid board to the input signals. The STROBE signal

among these signals, is used for an interrupt request signal (IRQ) to set error detection timing. The main controller modifies control signals so that blocks (clock selector, address generator, and memory block) operate suitably for each situation.

3.2 Clock Selector

The clock selector is designed to select a clock signal transferred from last solenoid board or the other clock signal generated from the main controller, because data transferred from last solenoid board and the other data transferred from the main controller for error detection can be asynchronous. We solve the problem of synchronization by selecting the suitable clock for each situation.

3.3 Memory

It uses two Random-Access-Memory (RAM) that is the real-time error detection system developed in this paper. One of RAM is used for storing 1344 data transferred from last solenoid board. The other of RAM is used for storing error informations, which are found by comparing design data transferred from last solenoid board, and stored into memory with the other design data in a design file transferred from the main controller.

3.4 User Interface

We design a text-based user interface that consists of hierarchical menus by applying a system programming technology in the real-time error detection system developed in this paper. The tool of the programming is C language on Disk Operating System (DOS). Input device is a keypad not to be a keyboard, and output device is a Liquid Crystal Display (LCD) panel not to be a monitor. The menus are designed to the hierarchical structure, so that users can operate easily without reading the manual.

4. THE SYSTEM REALIZATION AND VERIFICATION

In this chapter, we implement really the real-time error detection system for an electronic Jacquard designed in previous chapter, and verify the performance of the real-time error detection system.

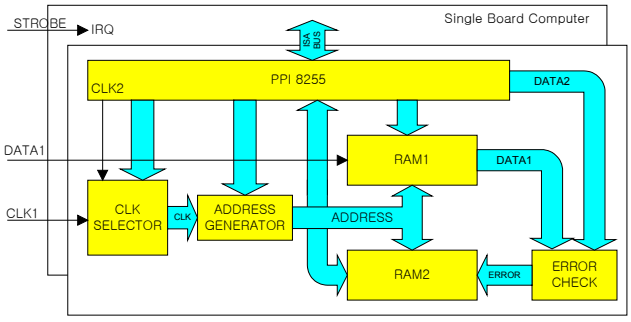

Fig. 4. The Block Diagram of a Real-Time Error Detection System for an Electronic Jacquard

The block diagram of the real-time error detection system for an electronic Jacquard developed in this paper is shown as Fig. 4.

AT compatible 80386SX Single Board Computer (SBC) is used as the main controller in the real-time system developed. We apply the ISA bus interface technology in various PC interface technologies, in order to design a control board for a special purpose. A LCD panel and a keypad are used for user interface. The LCD interface is implemented without especial hardware by supporting in SBC by setting up BIOS.

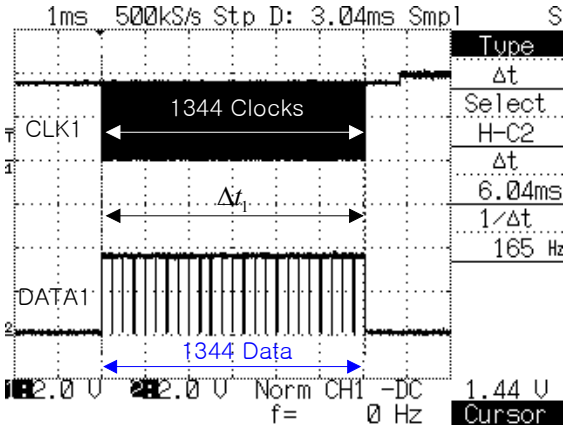

Fig. 5. The Waveforms of CLK1 and DATA1

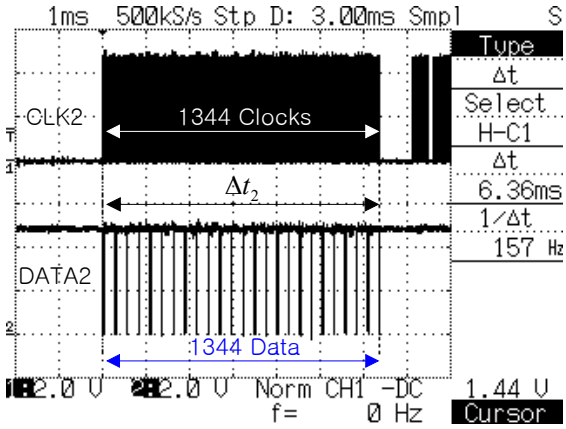

Fig. 6. The Waveforms of CLK2 and DATA2

The storage device is not a hard disk of cylinder type but a flash-disk of IC type called Disk-On-Chip. Because of an efficiency of the industry spot, we use the flash-disk that the bulk is smaller than a hard disk. The operating system (DOS), software developed in this paper, and design files are stored in the flash disk. And we use a 3.5" 1.44MB Floppy-Disk-Drive (FDD) to store new design files from the outside.

Fig. 5 and Fig. 6 show the synchronization problem that is explained previous. Total transfer time which signals (CLK1, DATA1) transferred from last solenoid board are transferred

Total transfer time of signals (CLK1, DATA1) transferred from last solenoid board is shorter about 0.32 *ms* than the signals (CLK2, DATA2) from main controller, and the signals transferred from last solenoid board is finished transferring data faster than the signals transferred from the main

controller. Here, Number of clocks during a cycle are 1344 for each clock signal (CLK1, CLK2). Hence, there are asynchronous about 0.253 μs every clock cycle.

In this paper, the problem such as this, is solved by dividing into 3 timing steps as follows:

Step 1.

In the Interrupt-Service-Routine (ISR) by the STROBE signal as an Interrupt-Request (IRQ) signal, the RAM1 set to write mode. Then, 1344 data transferred in serial from last solenoid board (DATA1), which are synchronized with the clock signal from last solenoid board (CLK1), and are stored into the RAM1.

Step 2.

If the DATA1 transferred from last solenoid board all are stored into RAM1, then the main controller generates the other data in a design file (DATA2) and the other clock signal (CLK2). The RAM1 set to read mode, and the RAM2 set to write mode. And then, synchronize with the CLK2.

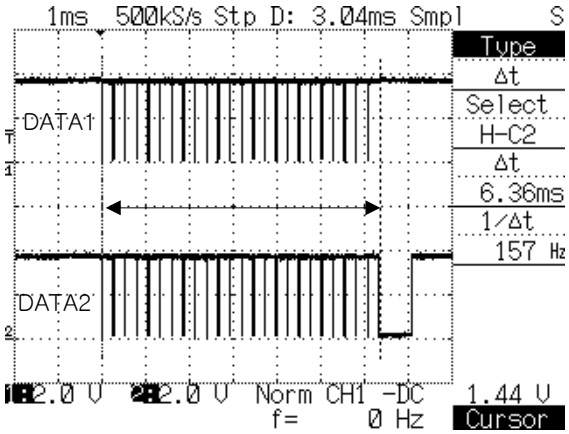

Fig. 7. Synchronized DATA1 and DATA2

The waveforms of synchronized DATA1 and DATA2 is shown Fig. 7. The data signals are synchronized perfectly if we try to compare Fig. 7 with Fig. 5 and Fig. 6. At the synchronized situation, the error informations whether or not error occurred in each hook, are detected in real-time by comparing 1344 data stored into RAM1 (DATA1) with 1344 practical data in a design file, and the error informations are stored into the RAM2, simultaneously.

Step 3.

The RAM1 is disabled, and the RAM2 set to read mode. The developed system reads the error informations stored into the RAM2, and confirms whether error occurred. If the error is confirmed, the developed system records the information of error (Pick and Hook number) to a file in real-time.

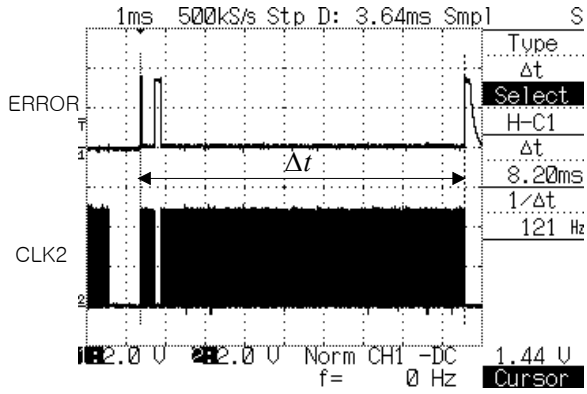

Fig. 8. Reading Error Informations

Fig. 8 shows that the real-time error detection system developed in this paper, reads the error informations by synchronizing with the CLK2 signal. The part of high-level are the part of error occurred. The total time of reading and processing 1344 error informations, is longer about 1.84 *ms* than the total time of writing error informations, because the developed system processes the information of the error occurred part (Pick and Hook number) in real-time.

The above facts, by the operation to be divided into 3 timing steps, we implement the real-time error detection system for an electronic Jacquard, which detects the occurring errors in present data in real-time before the next data would be transferred, and stored the information of error data.

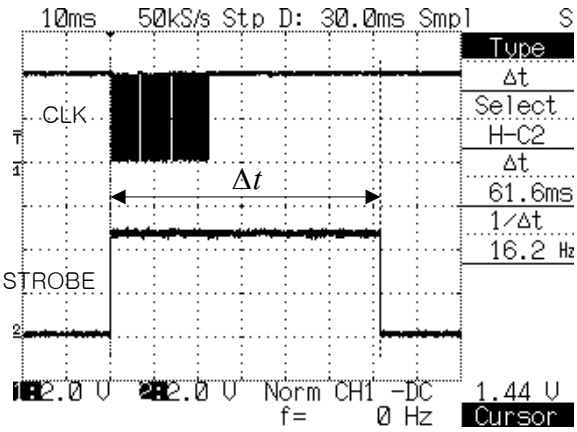

Fig. 9. The Waveforms of CLK and STROBE

Fig. 9 shows the waveforms of the STROBE signal as an Interrupt-Request (IRQ) signal and the output signal of the clock select block (CLK). The exactly classification of the CLK signal into each step is shown as Fig. 9.

At the time of an interrupt request by the STROBE signal, the Jacquard weaves only one pick once. A pick is composed of 1344 hooks. So, real-time error detection system developed in this paper, detects and stores error informations for only one pick once. At the point which 3 timing steps all finish, the pulse width of the STROBE signal has sufficient reserve at this point. This expresses that the system could process another task.

The things to describe until now are about the hardware implementation and verification. Now, we describe about the software implementation for the hardware to operate suitably in various situations.

The environment for development of the developed software is as follows. Microsoft DOS (MS-DOS) is used as the Operating System (OS). And the programming language is C language for the hardware control, which is efficient and effective. We apply the system programming technology for stability of the developed system and for the developed system to deal appropriately with given situations or conditions. The developed system performs the tasks and functions by using the software and hardware interrupt on ROM-BIOS and DOS.

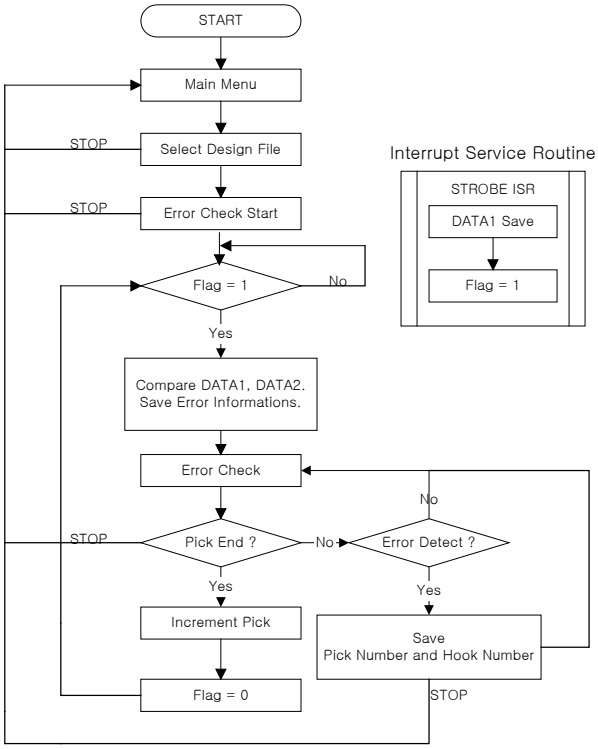

Fig. 10. The Flow Chart of Program

Fig. 10 shows the flow chart of program developed to process error detection in real-time.

Fig. 11. The Picture of Developed System

5. THE EXPERIMENTAL RESULTS

Table 1. Processing Time Table

Number of Errors	0	56	232	462	672	1012
Processing Time [ms]	21.4	21.6	22.2	23.0	23.6	24.8

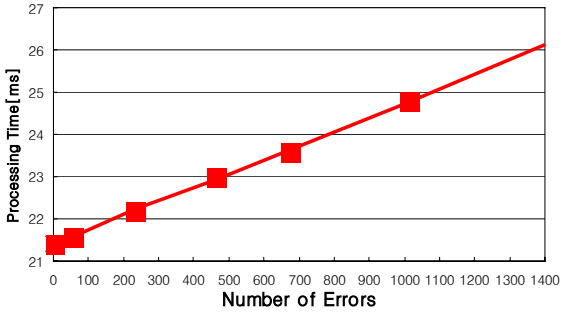

Fig. 12. Number of Errors vs. Processing Time Graph

Table 1 and Fig. 12 are the experimental results of measuring the processing times for each number of errors occurred. Fig. 12 shows that the errors increase, then the processing time increase linearly. The processing time of no error occurred is 21.4 ms . Consequently, the processing time for 1344 errors occurred (all hooks are fault) is as follows.

$$26ms - 21.4ms \cong 4.6ms \quad (1)$$

And the processing time for each error is

$$\frac{4.6ms}{1344} \cong 3.423\mu s \quad (2)$$

We found that though 1344 hooks are all fault, the system has sufficient margin for error detection by comparing Fig. 9 and Eq. (1).

6. CONCLUSION

In this paper, the real-time error detection system for an electronic Jacquard developed in this paper is constructed using PC-based embedded system architecture. We solve the problem of wrong weaving through checking the weaving data and detecting the occurred errors of an electronic Jacquard in real-time by applying a PC interface technology to the developed real-time system. As a result, the occurrence rate of weaving errors decreases and the weaving productivity increases.

The developed system is possible to detect error occurred with very high speed. And, the developed system is possible to apply without modification though the electronic Jacquard system is enhanced more 1344 hooks. This is expandability of the developed system. The main clock frequency of SBC For the controller of an electronic Jacquard is not necessary same with the main clock frequency of SBC for the developed real-time system. This is flexibility of the developed system. However, the developed system can detect errors, but the

system cannot follow on error detection automatically.

Our future works are, the developed system to be able to follow on error detection automatically, and the developed system to be included on the controller of an electronic Jacquard. As a result, we will operate only the controller of an electronic Jacquard for error detection automatically, and the system to be able to correct errors, then a fault-tolerant system should be implemented.

The means of this paper are in the things to apply the real-time system, which must finish given tasks within given time to an electronic Jacquard system, to implement the real-time system, and to verify the performance of the applied system by experiment.

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