Framework for Automated Dobby Based Fabric Design System

Farhan Khalid, Tasweer Ahmad, Ali Khalid

Abstract—The main goal of this research is to develop an electronic dobby system that would have better performance than mechanical dobby. The system developed during this research work, is installed on the loom to design weave patterns in the fabric. This system is designed using Arduino development interface. Electronic dobby system has lower price/performance ratio, improved energy efficiency and user friendly interface. The pattern can be designed on any imaging software in computer (MS Paint or CAD software). Then, this design pattern is stored on SD card. Arduino based programmer performs data transfer from SD card to EEPROM with a USB interface. This EEPROM is attached to driving card that operates the dobby. The goal of this research work is to encourage the researchers in Pakistan to devise digital control of mechanical systems which are already installed in local industry.

Index Terms— Dobby, Jacquard, Arduino, Textile Automation, Electronic Dobby, Microcontroller

1. Introduction

The embedded technology has found widespread applications in different domains. More advancement is being incorporated in already developed systems. These microelectronic systems have lower price/performance ratio. Many microelectronics (embedded systems) environments have replaced a number of mechanical systems, hydraulic systems and analogue control systems. The microcontroller based systems are economical, more reliable, fast and have improved functionality [1].

According to the oxford dictionary, Dobby is defined as "A mechanism connected to a loom for weaving small patterns similar to but simpler than those produced by a Jacquard loom" [2]. The first Dobby/Jacquard was invented by Joseph-Marie [3]. Although, mechanical dobby system did not have a programmable device but it played an important role in textile industry.

Manual (mechanical) Dobby is a device that is used to create small patterns for weaving on fabric using punching cards which are used as storage of patterns, when these punching cards are passed through the machine; it lifts the shaft of the machine according to hooks inserted in punching card and weaves the pattern on the fabric [7].

The pattern may be a design or a brand name, which could be as minimum as 8 hooks or as large as 72 hooks. Dobby/Jacquard is installed on top head of the machine and its speed is synchronized with the speed of machine (loom), as different weaving machines (looms) operate at different frequencies (RPMs). Most machines use Dobby/Jacquard having speed range from 40 RPM to 90 RPM, which is normal speed in manual looms. It is also interesting to know that Dobby/Jacquard led the foundation of modern computers, where punching card hole with hook inserted, represents binary one while only hole represents binary zero [4]. These punching cards are considered as storage of memory. One can use punching card to make previous pattern.

Yousif et. Al. [5] has proposed an Electronic Dobby System, which could overcome the drawbacks of mechanical Dobby. This idea was implemented using Peripheral Interface Controller (PIC), Keypad for inputs and LCD/LEDs for display of outputs.

While in this paper an effort has been made to implement the concept of electronic dobby presented by [5] in a textile industry with its full-fledged working, and we are able to develop such a framework which has completely replaced mechanical dobby system. In this framework, design patterns are created in MS Paint or CAD Software, then these patterns are stored on EEPROM using SD Card. Arduino Uno reads these patterns from EEPROM and then M4 Card attached with Arduino, weave these pattern on fabric.

2. Literature Review

Automation of mechanical dobby is achieved using control system to optimize productivity of fabric. Control system provides high degree of accuracy in process and reduces human intervention in the working of machine. It also increases functionalities of machine beyond human capabilities. This may include working under unusual or dangerous conditions [11].

Joseph Marie created first automated machine. This machine was a jacquard which was controlled by punching cards. Punching cards were used as permanent storage of designs [12]. With increasing demands and competition in the industry many companies developed simple or complex systems that replaced old dobby.

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In contrast to mechanical dobbies where punching cards are used for designing of patterns or brand names, the electronic dobby with Computer Aided Designing (CAD) is used for designing patterns or brand names. The design created by CAD is transferred to EEPROM by using some protocol (e.g. I2C used) and interface (e.g. USB). CAD is an important tools used in textile industry. It helps making patterns for both type Mechanical or Electronic dobbies or jacquards. It helps to create punching cards for mechanical dobbies and also images for electronic dobbies [14].

In this research, data transfer to electronic dobby is carried out using I2C protocols. The I2C is a protocol that allows a master device to initiate communication with a slave device. Multiple slave devices can be connected with master devices for data transfer. The bus is controlled by master device. The master devices define the rules for data exchange between devices [15].

3. Problem Statement

Main drawbacks of mechanical Dobby are:

I. It is bulkier and heavier in size. (about 80 Kg)
II. Add more load to the machine (rotor) and motor drags more power to operate it, hence is power inefficient.
III. Process of making punching cards is time consuming
IV. One punching cards represents one pixel on the fabric, so to generate long pattern (about 1000) needs 1000 punching cards which will take large space and become a very complex.
V. Making punching cards need lots of attention and visualization.
VI. By increasing the speed of the loom greater than 60 RPM, Thread breakage (Tb) begins to increase.
VII. Difficult to locate defective punching card if some punching cards is damaged during operation.

3.1 Proposed Solution

The proposed solution to the problem is to make an electro-mechanical system that tackles above mentioned challenges efficiently and is also cost-effective. The electronic dobby/Jacquard has two major design parts:

1. Electronic Design
2. Mechanical Design

The proposed electronic design is shown below:

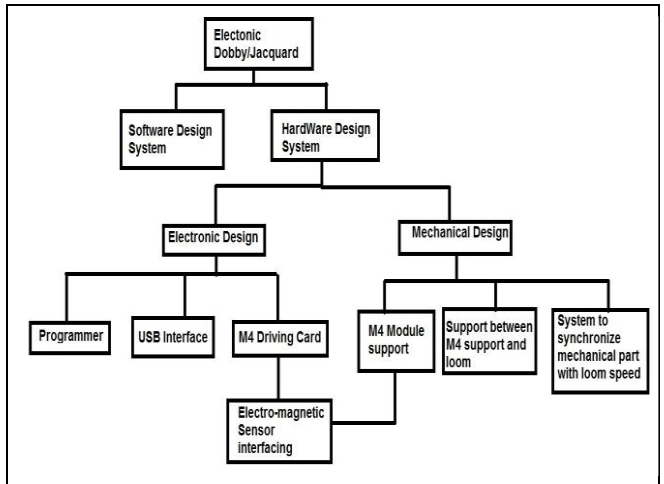

Fig. 1.Block Diagram of Proposed Dobby Design

3.1.1 Proposed Electronic Design

- Pattern can be designed on any imaging software that can generate BITMAP file. (Windows Paint, Photoshop etc).
- A Visual Basic or Matlab based Software design that will convert BITMAP image into TEXT file.
- Computer to EEPROM interface is made using Arduino Development Environment (Arduino UNO is used).
- A USB interface is provided to EEPROM, which is compatible with both driving card and computer to EEPROM interface.
- Magnetic proximity sensor is used to measure speed of machine.

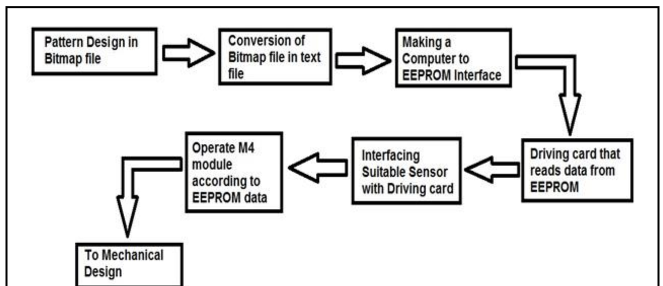

Fig. 2.Block Diagram of Electronic Dobby

3.1.2 Proposed Mechanical Design

Mechanical Design has following basic structures:

1. M4 loom stand and its support structure
2. Shaft (That connects circular plate, with gear casting)
3. Gear Castings (That synchronize electronic dobby with the speed of loom)
4. Bearing (To minimize friction)

4. Sensor and Programming Environment

Algorithm for controlling of electronic dobby is programmed using Arduino Uno. Arduino is used because it is inexpensive, supports many protocols and on chip testing of code [8]. Ar-

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duino Uno is open-source and a lot of help, related to interfacing, is available online [9].

Fig. 3.Arduino Uno Board

Magnetic proximity sensor is best suitable sensor used in textile [11]. It works on non-contact detection of magnetic materials for sending signal. So, there is no effect of friction on machine, increasing life of sensor and efficiency of machine [10]. It is used to synchronise the speed of mechanical design with the M4 driving card.

Fig. 4.Magnetic Proximity Sensor

5. System Design

5.1 Software Design

First of all, Software Design of electronic jacquard system is discussed. It consists of two parts:

1. Designing of pattern using imaging software
2. Conversion of image to binary text file

MS Paint or CAD is used as pattern designing software. Following is pattern that is designed in MS Windows Paint.

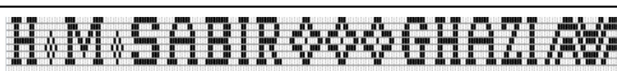

Fig. 5.BitMap Design of Pattern

Second part is the software that converts BITMAP images to text file, for this .NET frame based software is created, which converts images in text file and saves the data in “data.txt” file in C:\ drive of the computer.

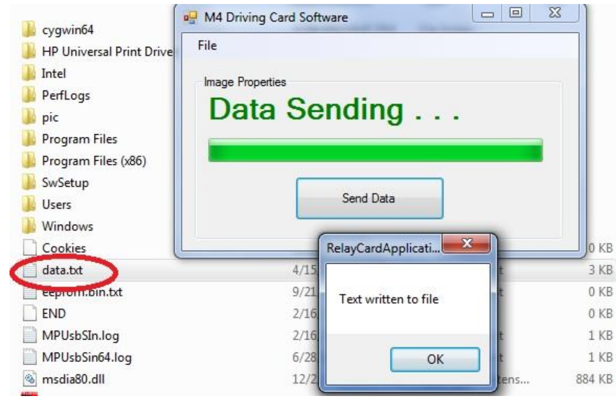

Fig. 6.Software for converting BITMAP to binary

5.2 Electronic Design

The image is now ready to transfer to EEPROM. For this purpose, an SD card to EEPROM interface has been designed. It is quite handy to transfer data to SD card, when SD card is connected to programmer. It detects “data.txt” file in SD cards and counts the number of values exist in file. After that it transfers all its contents into EEPROM. One can verify successful transmission of data by serial monitor on EEPROM.

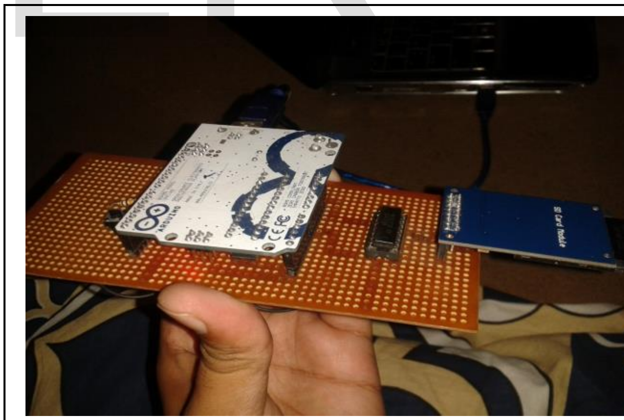

Fig. 7.Programmer Circuit for Storing Pattern

The operating voltage for SD card is 3.3V logic while microcontroller operates at 5V logic. To make it compatible to system, level shifter CD4050BE, is used for compatibility of different level of voltages [25]. Following is the proposed USB interface of EEPROM.

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Fig. 8.USB EEPROM interface

EEPROM interface is provided such that it uses the same address in both programmer and the M4 driving card. The device address used is 0x50. In programmer, it is required to transfer data fast so we use page transfer of data, which takes 1–2 seconds to transfer all data in the EEPROM. While in driving card M4 module is operated according to each byte of EEPROM with speed information given by sensor, so we read data byte by byte.

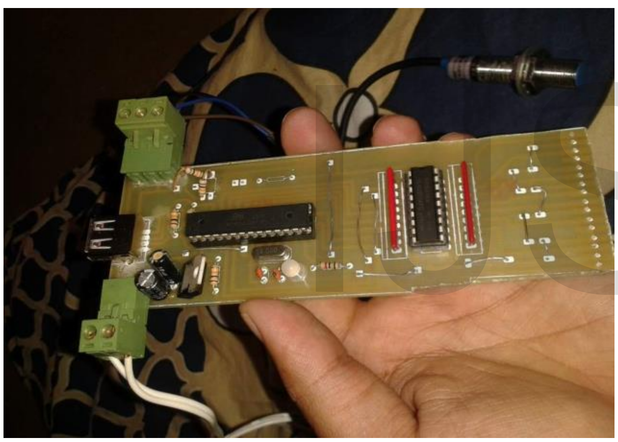


Fig. 9.M4 Driving Card Circuit

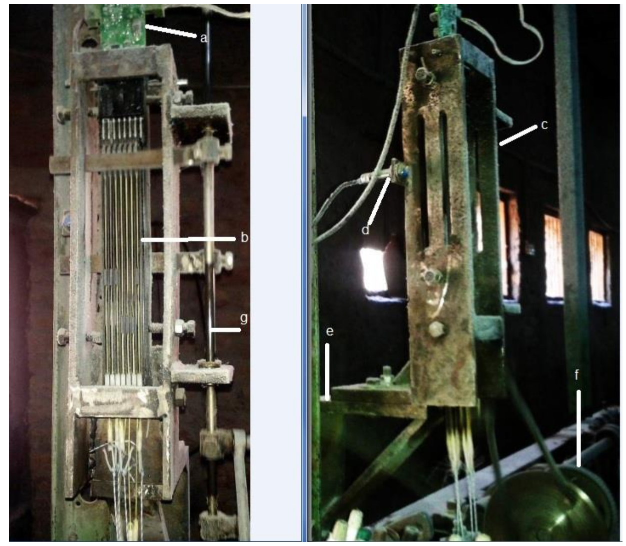
5.3 Mechanical Design

Mechanical design consists of two designs.

1. Interfacing with electronic design
2. Interfacing with loom

The first design creates interface for M4 driving card, M4 module and magnetic proximity sensor with mechanical design, are used to synchronize the speed of electronic design with the mechanical design. While second design creates interface between loom and mechanical design that synchronizes the speed of loom and mechanical design.

Following are the details of mechanical design structure.



(a) (b)

Fig.10.(a) Front and (b) Side View of First Part of Mechanical Design

The figure above depicts the front and side view of mechanical design of electronic dobby. The components highlighted are,

a) M4 driving card (used for pull down the threads).
b) M4 dobby/jacquard module.
c) M4 module support
d) Magnetic proximity sensor interfacing with M4 module support.
e) Dobby support stand
f) Synchronization of dobby speed with speed of loom.

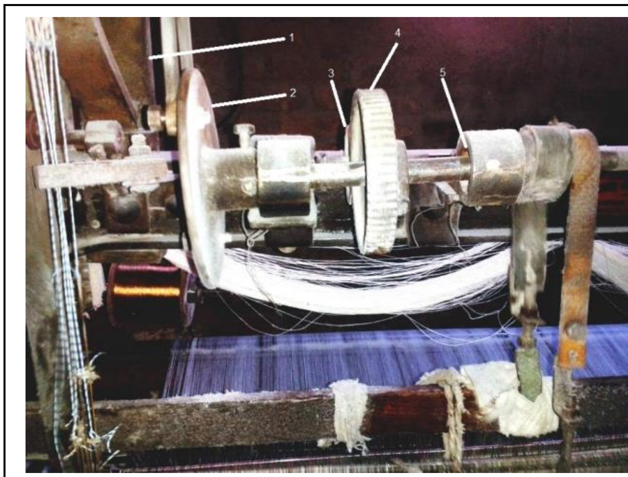


Fig.11.Second Part of Mechanical Design

Details of highlighted components of mechanical design are:

1. Dobby supports stand (used as joint between dobby and the loom).
2. Circular plate for transfer of motion.

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3. Small gear casting (Connected to loom shaft).
4. Large gear casting (Connected to dobby).
5. Bearings (To minimize friction).

The following image is shown for pattern designing on fabric.

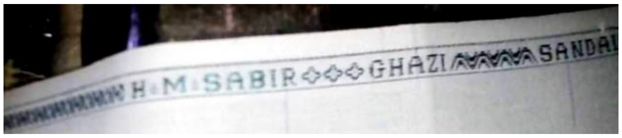

Fig.12. Pattern Designing on Fabric

6. Experimental Results

The table below shows the energy calculation for three cases, the first case is where no dobby is attached to the loom, second when mechanical dobby is installed on the loom and third case is the energy calculation of electronic dobby. It can be clearly understood that about 81KWH of energy is saved for each dobby operation.

TABLE 1
ENERGY CALCULATION

System Used	Current (Amp)	KVA	Power Factor (p.f)	KW= KVA* p.f	KWH/month= KW*20hrs* 26days
Without Dobby	12.35	2.717	0.85	2.309	1200
Mechanical Dobby	13.81	3.038	0.85	2.582	1342
Electronic Dobby	12.97	2.853	0.85	2.425	1261

The table below shows the money saved for 90 machines installed on test unit. About PKR=123,930/- is saved per month if we replace mechanical dobby with electronic dobby. And system will cover its instalment cost in 7.3 months.

TABLE 2
COST AND PAYBACK TIME OF ELECTRONIC DOBBY SYSTEM

Power Saved by one Electronic Dobby/month (Mechanical Dobby KWH – Electronic Dobby KWH)	Total KWH Saved = Power Saved by one Unit x 90Units	PKR Saved = Total KWH Saved * 17 PKR/KWH	Replacement Cost of Electronic Dobby = Price of One Electronic Dobby * 90 Machines	Payback Time of Electronic Dobby System
81 KWH	7290KWH	123,930 PKR	900,000 PKR	7.3 Months

Following graphs below depicts a comparison of efficiency of electronic and mechanical dobby at different speed.

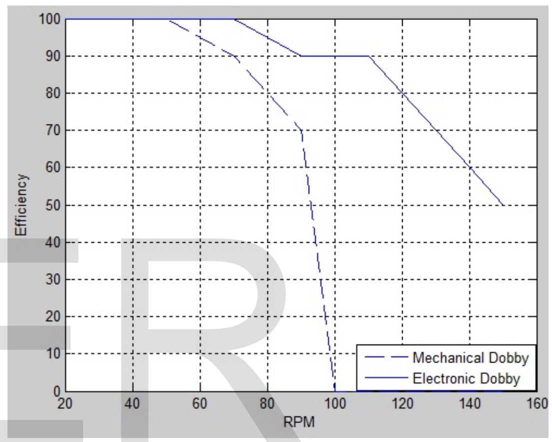

Fig. 13.Comparision of Efficeincy and Speed of Mechanical and Electronic Dobby

The above graph shows efficiency versus RPM characteristics of electronic and mechanical dobby machine. The dotted line shows the response of mechanical dobby while the solid line shows response of electronic dobby. It can be easily realized that at a lower speeds of 50 rpm both machines give 100 percent efficiency, but when the speed is increased beyond 50 rpm, their efficiency begin to decrease and at a of speed 100 rpm the mechanical dobby stops working.

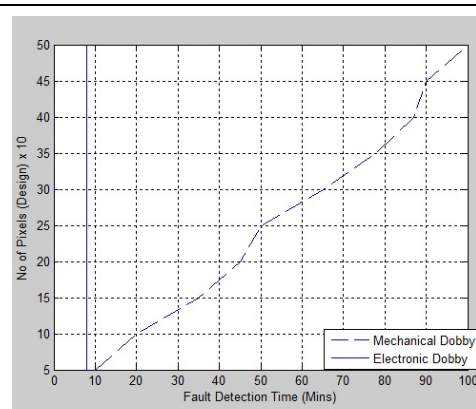

Fig. 14.Comparision of Design Size and Fault Detection Time

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The above graph shows fault detection time versus No. of pixels characteristics. Fault detection is very difficult in mechanical system as increasing number of pixels will increase length of punching card chain. If we are using 400 punching cards, then we will have to check all these cards. While in electronic system, it is quite handy to replace any faulty pattern. Fault detection and replacement of faulty part will not take more than 10 minutes time.

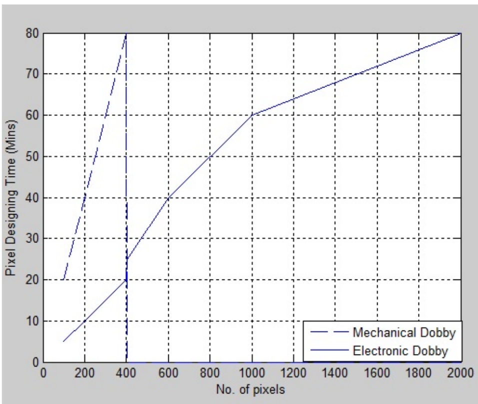

Fig. 15.Comparision of Pixel Designing Time and Number of Pixels

In mechanical systems, we have to carefully visualize and design punching card and it is quite difficult and time consuming. While in electronic system, one can easily use any imaging software to generate BITMAP design and can generate as many designs as needed. Also design is stored in EEPROM device, there is no issue of space for storage of punching cards.

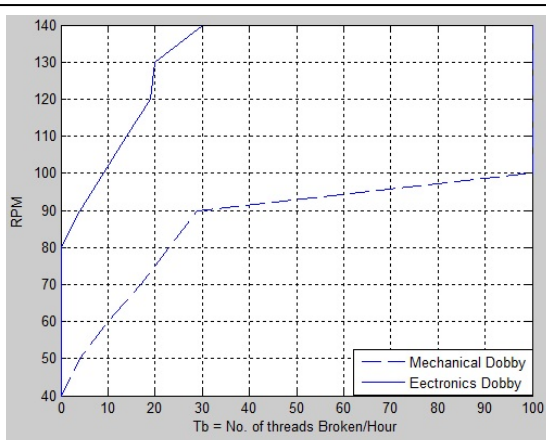

Fig. 16.Comparision of Speed of Mechanical and Thread Breakage

The graph above depicts number of threads breakage versus speed characteristics. It can be observed that in electronic system, no thread is broken until the speed of 80 rpm of the machine. But with the mechanical system thread breakage is too much at 80 rpm. It has an increasing trend at higher speed but at the speed of around 90 rpm its stops working and its thread breakage sharply increases.

7. Conclusion

The Electronic test unit replaced at R.K. Textiles, Faisalabad is found to be economical and performs better as compared to Mechanical Dobby System. This Electronic Dobby system would be able to pay back its cost in about 7.3 months. Moreover, this Electronic system is much lighter in weight, takes lesser volume and easy to dismantle and deploy at any place. Electronic Dobby system can operate even at higher speed than that of 90 rpm, where mechanical dobby can barely achieves a speed of 90 rpm. Also, Electronic Dobby is 2.3 times more power efficient than mechanical Dobby system.

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