# Design of a PC Driven Selection Box for a Jacquard Mechanism on a Conventional Carpet Weaving Loom

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**Abstract — in this work, a study on replacing design pattern feeding system of a classical jacquard mechanism with that of a computer controlled electronic unit is presented. This unit is named as the Selection Box (SB). Selection Box is composed of a set of solenoid matrixes. Selection Box is modelled to replace perforated cards in a classical jacquard mechanism. Solenoids are controlled with an IBM Personal Computer. A full Application Software package in C++ (HL) is developed in order to feed Weaving Pattern drawn in a bitmap format to the Selection Box. Objectives of the Application Software are presented. All hardware components are put into a Model Set-Up and tested with the Application Software.**

**Index Terms — Punch Card, Jacquard Mechanism, Solenoid Matrix, Loom, Weaving Pattern.**

## I. INTRODUCTION

Jacquard mechanism is responsible for feeding the design pattern to the loom on which it is installed. Mechanically the loom itself must follow the jacquard mechanism. The speed of the loom is hence extremely dependent upon the jacquard mechanism. The more the speed of the jacquard mechanism is, the more the speed of the loom. Thus increasing the speed of the jacquard mechanism is an important factor in increasing the speed of the loom. Modern jacquard mechanism employs electronic system and replaces the classical punch card mechanism [1].

Selection Box (SB) is an external electronic unit and driven by a PC. It simulates punch card in the electronic jacquard mechanism for each stroke of a loom for a given pattern.

Electronic jacquard mechanism is sold at an ultra high price because of the technology and know-how lying behind the Selection Box. The technology includes not only the Selection Box electronic but also the operating software (HL) [1].

In literature there exists extremely limited publication concerning Selection Boxes. This is quite understandable because the underlying technology is remarkable and very expensive. Leading companies, for instance, Takemura [3] and others do not make more publication about their technologies. Academically, there are again very limited studies on the subject.

The objective of this study is therefore to perform a basis work for the modernisation of a conventional jacquard mechanism, in that perforated punch card feeding system is replaced by a Selection Box. The aim is also to device the means available by the nowadays PC technology into the design of the Selection Box.

In the rest of this work the basic system for the design of the Selection Box is going to be introduced. An automation diagram is presented to visualise the entire system. How system components interact with each other is then explained. Design considerations of the Selection Box are presented. Although Design of the Application Program is not the concern of this study, targets and characteristics of the Application Program are highlighted [2]. Communication of HL with Selection Box is also presented.

PC addressable low level Lath Module (LM) is designed firstly. It is the main component of the Selection Box and also the central part of the basic system. Its construction and operating principle are discussed in details. How a signal from a PC is obtained and amplified for an external use is then briefly explained. After that, networking of selection boxes is shortly mentioned.

Finally The Model Set-Up for the design of Selection Box is constructed. All hard and software requirements are tested on this Model Set-Up.

## II. OVERVIEW

Fig.1 shows an overall look on the basic system under consideration. As the Figure reveals, the system is composed of hard and soft components. Hard components are listed as a controller (PC) and a Selection Box. SB is further composed of

1. System bus
2. Sufficient number of PC Addressable Low Level Signal Latch Module
3. Solenoid array for each LM.

PC is the controlling unit and provided with an extra I/O card. This card should support minimum of three outputs and one input port each having eight-bit length. They are the basic interfaces between system bus and the PC. Because there are many commercial cards with multiple in/out ports, details of I/O card implemented in this study is not shown in Fig.1

The system bus itself is composed of address, data and control busses. Address bus has a length of 16 bits and hence requires two output ports. Its addressing capacity is 64 K-Byte and is fully adequate for the practical needs. Data bus requires one output port. It is the bus on which the process data of one byte is transmitted from PC to the system. Control bus is the bus that carries feed back signals from latch modules to PC in order to achieve synchronisation between PC and SB.

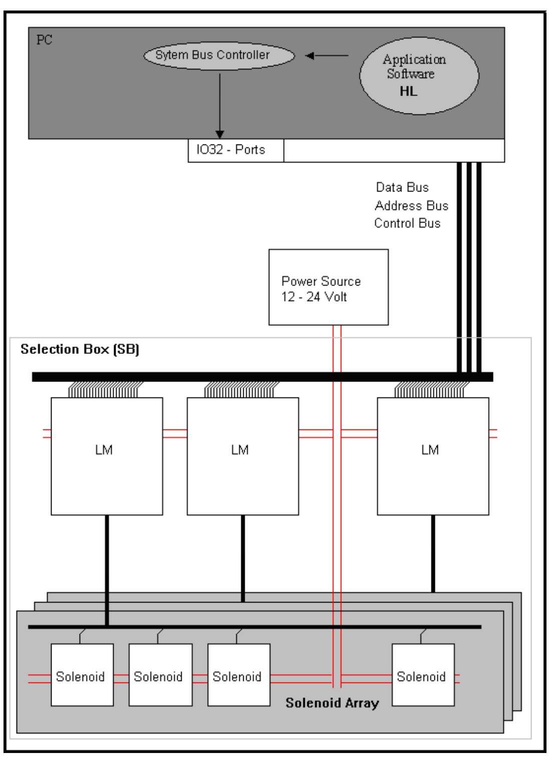


Fig.1 Automation Diagram Showing Soft and Hard Components

PC Addressable Low Level Signal Latch Module is the driving module for the solenoid array. Each LM has an array of solenoids. They form together a Solenoid Matrix in SB.

LM amplifies TTL (low level Transistor-Transistor-Logic) signals and feeds solenoids. The block circuit of LM and its operation is closely explained in section IV.

To run the entire system, the controlling software is to be installed. It is the application program HL (HL stands for the abbreviation of HALI, meaning carpet in Turkish). HL constitutes the soft part of the system. Since the discussion of HL is not in the scope of this work, we explain only the objectives of HL for the sake of consistency.

The application program HL must run on the PC to govern the entire process. The objectives of HL are laid down as follows

1. It must supply user interfaces to interact with the user asynchronously and support all administrative functions.

2. It must decode a standard picture file (bmp) and convert it to a convenient data structure (Image Matrix).

3. It must progress Image Matrix to set corresponding signals at corresponding I/O ports.

4. It must receive feedback signals from Latch Modules.

5. It must monitor the entire process by evaluating feedback signals.

## III. COMMUNICATION

HL communicates with system bus over an internal module *System Bus Controller*. This is an independent soft module. As its name implies, it controls system bus. It requires installation of hardware module IO32 in PC. IO32 is a 32 bit I/O card (see section VII). HL is also responsible for setting address bus and data bus for each entity in the image matrix with corresponding values. Three 8-bit digital output ports and one 8-bit digital input port are used to communicate with LM. Once data lie on data bus and its address on address bus, the value on data bus is latched by the corresponding LM module to the address pointed by the instant value at the address bus.

Both HL and System Bus Controller communicates over pre-defined interface. Internally, HL delegates all function calls regarding with system bus on the System Bus Controller. System Bus Controller is responsible for calling its own system bus manipulating functions. They are functions for selecting, setting and resetting of the solenoids. Because System Bus Controller communicates directly with hardware module IO32, changing the address of hardware module in PC requires resetting of the System Bus Controller. The resetting action can also be performed by the Application Program HL.

## IV. PC ADDRESSABLE LOW LEVEL SIGNAL LATCH MODULE

PC Addressable Low Level Signal Latch Module is the central part of the Selection Box and shown in Fig.2. LM is identified by its unique module address. The module address is set by the jumper arrangement in the module. The module address space (Address bus A1), ranging from 0 to 255, is selected by the eight-bit address comparator. The LM has six latch-ICs in order to control 6x8=48 solenoids. Each latch-IC sits on the data bus. To activate corresponding Latch-IC in the selected module, three address lines (the first three least significant bits of the Address bus A2) are decoded.

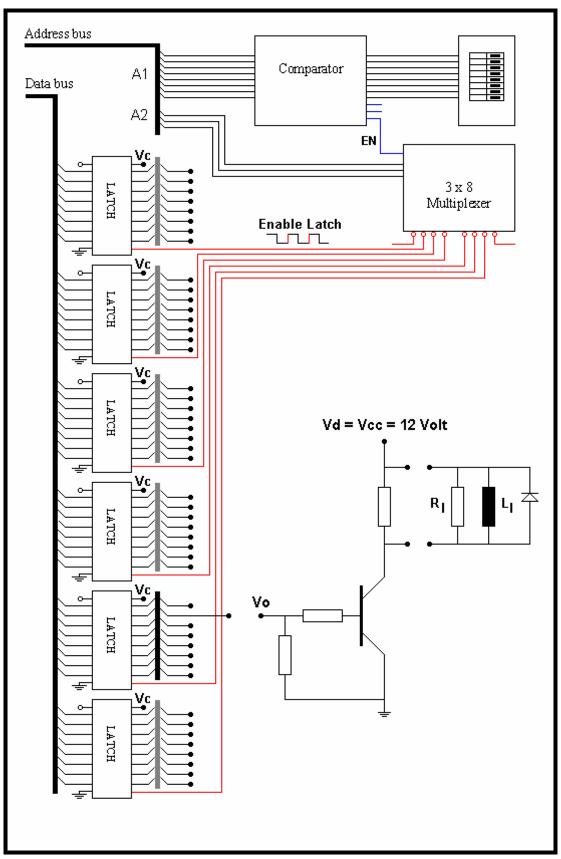


Fig.2 PC Addressable Low Level Latch Module

Selection of a single solenoid takes place as follow. If the data lying on the address bus A1 is equal to the fixed module address, the address comparator enables the 3 x 8 – decoder in that the signal EN is set to high. Otherwise decoder remains inactive. The enabled 3 x 8 - decoder decodes the first 3-bits of the address bus A2 and enables corresponding Latch-IC [4]. Once the Latch-IC is enabled, signal (data) available on data bus is latched by the Latch-IC to the output.

Signal, available at the output side of Latch-IC (Vo), is amplified through the driving voltage (Vd). This amplified signal is our objective signal to be used by the process. The amplification degree is totally dictated by the process under consideration.

## V. SIGNAL AMPLIFICATION

External load requires external power source. Depending upon the process being controlled, the characteristic of the external load circuit varies. For most of processes, the external circuit is of amplifier type.

We amplify low level signals to drive solenoids. We do not go into details of amplification because the subject has already been discussed in a variety of engineering text books [5 -6]. We suffice us by presenting driving circuit for a single solenoid (Fig.3). A Darlington transistor is used to drive the solenoid directly by a TTL signal. The characteristics of a Darlington transistor is that, it is formed from a couple of transistors. Because of high current amplification, it is generally used to drive external device by a Low Level Control Signal coming from PC or TTL control circuit.

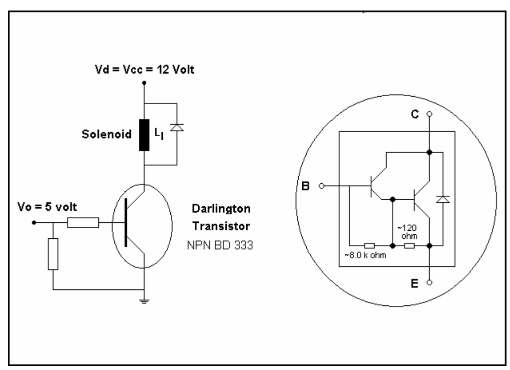


Fig.3 Driving Circuit for the Solenoid.

## VI. NETWORKING SELECTION BOXES

Selection boxes are used not only as a single unit. They can also be linked together to form a network. Networking is necessary either if a loom having many selection boxes and is to be controlled by a single controller (PC) or number of looms, each having a single selection box, are to be linked via the single controller. In both cases networking brings more efficiency to the overall system in utilizing resources. For even more efficiency, such a network is integrated with the CAD system by providing the necessary CAD software running on each controller.

In case of more controllers, CAD system becomes a distributed system. Networking of selection boxes is done through a controller set. Such a system is best suited for the production of carpets, curtains, warp-knit laces and etc. where large-size jacquard patterns are prevailing.

Fig.4 shows networking selection boxes. Number of selection boxes attached is dependent upon the capacity of the controller.

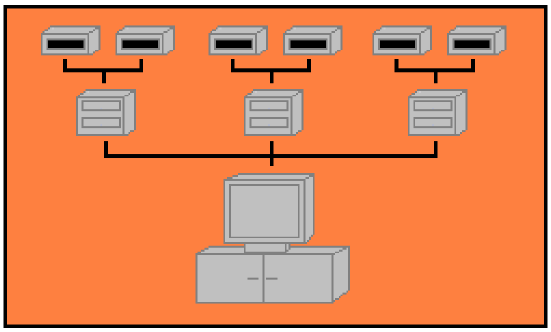

Fig.4 Networked Selection Boxes through a Controller Set.

An on-line CAD system can also be established by combining the system with the suitable CAD software. There are plenty of such CAD software packages. A large capacity hard-disk and enough memory allow storing of a large number of patterns. Depending upon the capacity of the system, arrangement of various patterns, layouts, drawings and setting of repeating parameters can easily be worked out on a controller monitor.

## VII. IO32 CARD AND SYSTEM BUS

Communicating with ports is performed either through operating system or through direct programming by a high level programming languages. Under windows operating system, the system command,

*Copy 12 lpt1 / b*

yields a binary equivalent of 12 to be copied to the printer port lpt1. This command is however only valid for the ports defined in the operating system. Access on the additional ports through the system command is not possible.

Programming with high level languages gives more flexibility. C++ provides powerful libraries to program hardware of a PC. By including these libraries in an end application (Application Program), all functionality will be passed to the end application. Communicating with a port sitting in an address space of a PC is hence nothing else than including a couple of statements in the quell code of an end application. The function

int *_outp*(unsigned short *portnumber*, int *databyte*)

for instance, causes value contained in *databyte* argument to be written to the port identified by *portnumber*. Here type indicator int shows that function *_outp* returns an integer value after successfully calling the operation. The returned value is equal to output data if the call does not fail. Otherwise the returned value is negative.

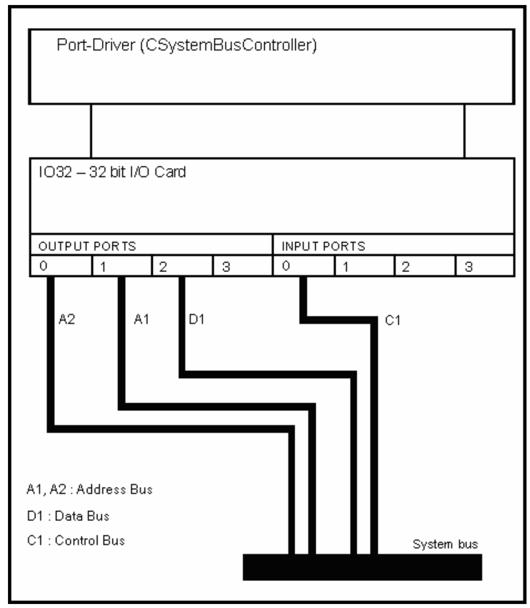


Fig.5 32 Bit I/O card as system bus interface and its driver

Both function arguments *portnumber* and *databyte* are in-parameters and passed to the function. *Portnumber* identifies the port with which the function should operate. It is a place holder for the physical address of the port. *Databyte* is the data which will be sent to the port identified by *Portnumber*. The port argument *portnumber* can be any unsigned integer in the specified range 0 - 65,535. The data argument *databyte* is limited to any byte in the range 0 – 255.

IO32 is a 32 bit digital I/O card installed in PC. It has four byte digital input and four byte digital output ports. It serves as System a bus (Fig.5). System bus is an external bus and implemented to communicate with the solenoid matrix pattern feeding system.

System bus is expressed in terms of address, data and control bus. Address bus is connected to first two output ports of IO32 card. It has a length of two bytes. Data bus is connected to third output port of IO32 card. Its length is one byte. Control bus is connected to first input port of IO32 card. It has a length of one byte.

A dynamic link library is developed to drive the System bus. In this library, the C++ class *CSystemBusController* implements necessary functionality to activate desired solenoid in solenoid matrix. The member function *CellWrite* performs the activation. Additional member functions such as *Open* and *PortWrite* are used as helper functions.

## VIII. DISCUSSION & CONCLUSION

In general followings can be counted as advantages of the electronic jacquard mechanism over the conventional jacquard mechanism.

1. Stroke time of a loom is strongly dependent on the jacquard mechanism attached. The cycle time of the jacquard mechanism is determined not only by the inertia of the mechanism itself, but also the pattern feeding rate. Selection Box is far faster than punch card system and has less overall inertia. Looms having electronic jacquard mechanism are hence faster than looms having a conventional jacquard mechanism.

2. Pattern change on a loom having a conventional jacquard mechanism is a time consuming job. Each pattern has its own punch card set. Holing pattern on punch cards brings additional cost and has its own business. Installing new pattern punch card set on a loom requires considerable amount of labour time and skilled labour force. This increases the overall cost of the end product. Pattern change on a loom having an electronic jacquard mechanism is on the contrary, performed through the operating software. It is a matter of a couple of mouse clicks. It reduces therefore, related cost and saves considerable time.

3. Not only the change of pattern but also the continuous mode of operation on a loom having electronic jacquard mechanism saves labour. This reduces the overall production cost.

The Selection Box (SB) developed in this study promises all the advantages mentioned above. Because leading companies have released very limited information about the technology of their selection boxes, a comparison can only be done from the functional perspective. Followings are the functions fulfilled by the Selection Box developed in this study.

1. Due to modular design of Latch Module and Solenoid array, SB can be extended to have required number of needles ranging from 400-1400. Controlling these needles is performed through the Application Software HL. For the practical point of view, there is no limit to the number of needles dictated by the electronic of SB and its Application Software HL.

2. Signal amplification in SB is fully separated from signal creation. Since how amplified signals are going to be proceeded by an extern process have no effect on a signal creation, SB can alternatively be based on other actuator technologies instead of a solenoid matrix technology without requiring great modification in the Application Software. This maintains forward compatibility of the base system.

1. Application Software HL can be modified and integrated with a suitable CAD system. This is a pure software issue and does not require any hardware change.

4. Selection boxes can be networked for multiple requirements. Depending upon the size and construction of a loom, more than one SB can be placed to equip the same loom. Application Software is able to control more than one SB simultaneously.

5. Application Software HL is responsible for the signal creation in TTL level by making use of the standard interface electronics. It utilises all available resources of a PC.

6. HL performs not only the signal creation to feed to the Selection Box for the pattern, but pattern modification, pattern analysis and even pattern creation too. For pattern creation, windows standard picture editor is integrated into the HL environment.

7. HL is developed by the object oriented software technology. It means it can be upgraded without de-installing the existing system. It eases maintenance and durability of the system.

Up to this point, we mainly discussed the technical aspects of the selection box we developed. It is the vital to make a cost analysis and compare with selection boxes available in the market.

An electronic jacquard mechanism controlling 254 non symmetric yarn threads in carpet looms is sold, depending upon the market condition, at a price between 75.000 – 130.000 $. This amount is almost the same as the entire selling price of a loom with a punch card jacquard mechanism manufactured in Turkey. A quick financial analysis shows that the row cost of a solenoid feeding system for such a jacquard mechanism developed in this study is no longer expensive than 5.000 $. The difference is very huge and paid only for the know-how and technology.

The estimated number of classical looms used in domestic industry is about 20.000[7-9]. This is an enormous amount. If we think that only 25 percent of this amount will be equipped with electronic jacquard mechanism in following five years, this costs us 5.000 x 2 x 75.000 = 750.000.000 $. This calculation is based on the assumption that each loom requires minimum of two units of jacquard mechanism and the unit price is the minimum price available in the market. In reality, the cost is much more than this.

Based on the simple calculation above, it would be gained a saving of 140.000.000 $ annually if we use the Selection Box developed in this study instead of getting it from the international market. The resources thus saved can be invested in any other sector. This saving makes it possible to employ 1.400 workers per year considering a mean amount of investment per worker is about 100.000 $.

As a result it could be stated that, we developed a Model Set-Up for the modernisation of a classical jacquard mechanism. In this Model Set-Up, a prototype for the Selection Box is realised. The Application Software is developed. This prototype for the Selection Box must be later integrated to the classical jacquard mechanism. The punch card feeding system of a classical jacquard mechanism is hence replaced by the Selection Box we developed.

The Application Software for the Selection Box reads the Weaving Pattern from a medium. Weaving Pattern is itself stored in standard windows bitmap format. The colour spectrum of the Weaving Pattern is determined. Signals are created and fed to the Selection Box for each row of the Weaving Pattern.

Finally we can conclude that a base work has been performed on converting conventional jacquard mechanism into the electronic jacquard mechanism in that punch card feeding system is replaced by a PC controlled Selection Box. All is at a cost of less than one tenths of the international market price.

## VIII. SYMBOLS & ABBREVIATIONS

| | | |
|---|---|---|
| $L_l$ | : | Load Inductance, Solenoid Inductance. |
| $R_l$ | : | Load Resistance. |
| Vo | : | TTL Signal Voltage. |
| Vc | : | TTL Signal Voltage. |
| Vd | : | Driving Voltage. |
| Vcc | : | Driving Voltage. |
| SB | : | Selection Box. |
| LM | : | Latch Module. |
| PC | : | Personal Computer. |
| A1 | : | Address Bus. |
| A2 | : | Address Bus. |
| D1 | : | Data Bus. |
| C1 | : | Control Bus. |
| IC | : | Integrated Circuits. |
| HL | : | Application Program. |
| I/O | : | Input / Output. |
| IO32 | : | 32 Bit Input / Output Card. |
| TTL | : | Transistor-Transistor-Logic. |

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