AN IT AID FOR COMPUTER - EQUIPPED CLASSROOMS

Essam A. Koshak [1] **and Fouad M.-A. Dehlawi** [2]

1: Engineer, Makkah Distribution Network, Saudi Electricity Company.
2: Associate professor, Electrical and Computer Engineering Department, King Abdulaziz University.

fdehlawi@kaau.edu.sa

ABSTRACT

The modern classrooms are usually equipped with multiple computers for teachers' and students' use. To enhance the educational use of these computers, a new tool is needed that provides the sharing of screens from the teacher's computer to the students' screens and vice versa. This screen sharing can be categorized in three different operating modes controllable by the teacher's station. First, Individual Learning (Stand-alone Mode): Every student sees his own screen. Second, Group Teaching (Teaching Mode): Every student sees the teacher's screen. Third, Evaluation and Testing Mode: The teacher sees selected student's screen. Several solutions do exist. Some are based on software utilizing local area networks, while others are solely hardware-based, that redirect the computer monitor's video signals regardless of the operating system or platform. A better way to ensure flexibility of switching an array of inputs and outputs of video signals is by using crosspoint switches that are driven by a microcontroller. This paper discusses the design and implementation of a microcontroller-based video switcher. The most widely used video standard in personal computers is the VGA and its derivatives. VGA line consists of two groups, analog (red, green, and blue) and digital (horizontal and vertical synchronizing signals). Therefore, two different types of crosspoint switches are needed (analog for video and digital for sync). This paper discusses the design of the switches that were implemented and controlled by a microcontroller. The microcontroller was programmed to send control signals to change the status of each switch in the switcher to achieve the desired operating mode based on commands issued from the keypad. The system was designed, implemented and tested to work with 5 PCs. It provides the three operating modes and can be upgraded for more PCs.

Keywords: *computer classrooms, video switch, video switcher, microcontroller-based.*

VGA   VGA

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VGA

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1. INTRODUCTION

Computer laboratories are inadequately integrated in the educational process, even with the use of a computer projection screen. The following are important questions: How many precious hours have trainees wasted trying to read a washed-out projection screen? How often have students been distracted by computer games while important concepts were being presented in class? How many instructors have lost control of their classes due to the lack of a feedback system between the trainer and trainees? On the other hand, how often has an advanced student been turned-off as the teacher goes over basic material for the third time? How difficult has it been for the teacher to share one student's problem with the entire class? One can clearly see that the need for properly integrated classrooms with new tools, specifically designed to improve the teaching of complex software or multimedia application. This can be achieved by sharing the screen from the teacher's computer with the students' screens and vice versa. One way to achieve this is by using a hardware device; a microcontroller-based video switcher for the classroom video systems [Robotel 1999] [Applied 2002]. A software-based solution utilizing computer networks such as LAN (Local Area Network) may provide computer screens sharing in a classroom, but it will consume most of the network resources and it will slow the network down considerably. Another disadvantage is its dependence on the operating system.   Other products are providing software solutions such as NetOp School® [Danware 2002] and Screenwatch from Applied Computer Systems, Inc. [Applied 2002] and Altiris Vision® [Altiris 2001].

The objective of this paper is to discuss the implementation of a microcontroller-based system to manage several PC screens. The system provides screen sharing between the instructor's computer (station) and the students' computers. The concerned screen sharing, which is controlled from the teacher's station, can be categorized by three different operating modes:

1- Individual Teaching (Stand-alone Mode): Students control their own displays without any interference or observation of their screens.

2- Group Teaching (Learning Mode): The teacher's screen is displayed on every student's monitor. When the instructor wants the students to see a certain step in a program while he explains it, he puts it directly on their screens. They see what the instructor wants them to see

clearly and in real-time. Instead of trainees struggling to see a common projection screen, they will have a perfect view of the instructor teaching the material on their own monitors.

3- Evaluation and Testing Mode: The instructor can have continuous feedback on a specific student's progress at any time. This is achieved by monitoring a selected student's screen on the teacher's display.

The PC conveys the information to the screen via video signals. The most popular and practical PC video standards in the market nowadays are VGA (Video Graphics Array) video standard and S-VGA (super VGA). The VGA signal consists of five lines that are divided into two groups, analog (Red, Green, and Blue) and digital (horizontal and vertical synchronizing). [Rosch, 1997] [Extron, 1999]

To ensure flexibility of switching an array of VGA lines is by using crosspoint switches. Figure 1 is an example of a 4x4 crosspoint switch.
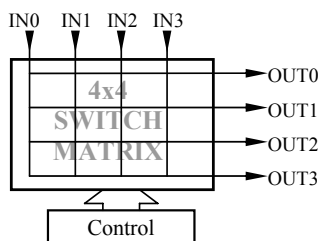

Figure 1: 4x4 Crosspoint Switch

A cross-point switch allows for each output to be independently connected to any input and any input to be connected to any or all outputs. The crosspoint switch contains a digitally controlled matrix of number of switches that connect a single input to any, or all, output channels. This crosspoint switch consists of 16 switches, allowing for more options when connecting an input to any or all outputs. . Crosspoint switch significantly reduces component count, board space, and cost instead of using discrete switches [Hall, 1999], [Universal, 1999].

Two different types of crosspoint-switches must be considered in this project. One being an analog (video) crosspoint switch for the RGB (Red, Green, Blue) lines and the other is a digital crosspoint switch for the synchronizing lines. This paper elaborates on the selection and design of the two crosspoint-switches.

A microcontroller is needed to control this switcher, which in turn performs the predefined operating modes from the teacher's station. It sends programmed control signals to change the status of each switch in the switcher to achieve the desired operating mode. The teacher selects the required mode using a keypad and views the choices on an LCD screen.

2. HARDWARE

In this section, the design of the hardware aspect of the system will be addressed. In order to achieve the smooth sharing of computer screens in the classroom, a switcher must be designed to switch the VGA signals flowing from the PC's video adapters to the monitors. The complete system layout is shown in figure 2.

Instructor Station

CU

Microcontroller
Based Video
Switcher

Students Stations
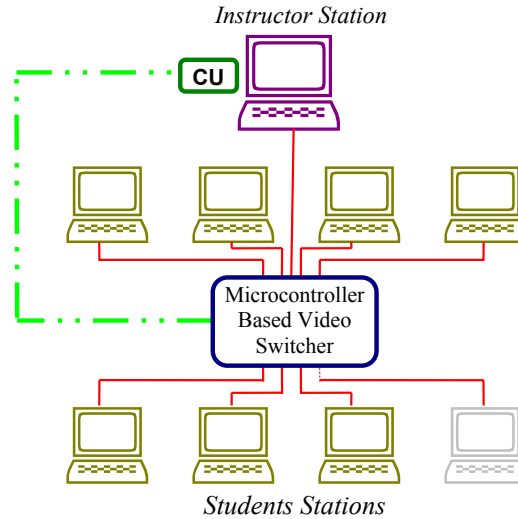
LEGEND	
Item	**Description**
CU	*Control Unit:* *Consists of: keypad for input and LCD for display.*
——	*Video Path: two video paths each consisting of:* *5 lines for RGB, H-sync and V-sync*
— ·	*Control Lines to link CU with video switcher*

Figure 2: System Layout Of The Microcontroller-Based Video Switcher In A Classroom

2.1   Video Cross-point Switch

The target is to get hardware that can crosspoint-switch RGB signals for a group of PCs while at the same time being cost effective and readily available in the market. Video switching ICs can be grouped into four categories: basic video switches, crosspoint switch building blocks, video multiplexers and crosspoint switches.

The simple video switches were immediately eliminated from being an option because of the massive hardware needed to satisfy our specifications. Crosspoint building blocks are not chosen because, although they meet the bandwidth requirement, too many IC blocks would be

needed to make the required crosspoint switch matrix. The multiplexer option has the same excessive hardware problem as the building blocks mentioned above and this problem is compounded by having to design a control circuit to manage a great number of the multiplexers' select-lines. Therefore, we have chosen a single chip video-crosspoint switch. [QuestLink, 1999]

For example the IC MAX456 is a single chip meeting the requirement for the 8x8 crosspoint switch matrix, but its bandwidth, 35MHz, is not wide enough for the needed video (as VGA bandwidth exceeds 100MHz at high-resolution modes). Some chips made by Analog Devices satisfy both the bandwidth and matrix requirements. The AD8116 was chosen because it has the largest crosspoint switch matrix, 16x16, thus allowing 5 PCs to each send and receive three RGB signals. Its operating bandwidth is 200 MHz. It is daisy-chainable to create switch arrays above 512 x 512. It employs a serial interface for programming the state of the crosspoint array [Analog, 1999].

The AD8116 has a gain of +1 for all configurations. If a signal is applied to the inputs, it will be properly terminated for 75 ohms. This will create a signal level of 1x (arbitrary units). A signal level of 1x will also appear at any programmed output. Since AD8116 evaluation board is used, and a cable is run from the AD8116 board to a monitor, there are a series 75 ohms resistor on the board and a 75 ohms termination resistor in the monitor. This will divide the 1x signal at the output pin by 2 resulting in a dim picture (loss of brightness on the monitor). This can be overcome by increasing the brightness setting of the monitor to reach a viewable clear display. A better solution is to use a gain-of-2 video buffer such as AD8079. We opted for the video buffer option. Because of incorporating wide-band amplifiers, printed circuit board (PCB) parasitics can affect the overall closed-loop performance. If a ground plane is to be used on the same side of the board as the signal traces, a space (5 mm min) should be left around the signal lines to minimize coupling. Line lengths in the order of less than 5 mm are recommended. If long runs of coaxial cable are being driven, dispersion and signal loss must be considered. This board was made locally in Jeddah for AD8079 (SO-IC with 1.27 mm between pins) taking the above PCB layout considerations to minimize crosstalk [Analog, 1999].

2.2   Digital Cross-point Switch

Having chosen the correct hardware to switch video (red, green and blue) signals, the next step was to choose the appropriate hardware for the second group of VGA signals, namely the digital (vertical and horizontal synchronizing) signals. The synchronizing lines of VGA system are carrying TTL (transistor-transistor logic) signals. This section deals with the best method to crosspoint switch many VGA horizontal and vertical synchronizing lines.

Building an 8x8 crosspoint-switch from combinational logic circuits would be an enormous task. Firstly, constructing a gigantic truth table of 16384 lines (8 inputs + 6 select lines, 8 outputs). Secondly, minimizing a function of 8 variables. Finally, a large number of combinational circuits will be required even with the use of PLDs (programmable logical

devices). Another way to implement this digital crosspoint switch is by using digital multiplexers. This option was avoided because a large number of IC's were needed as discussed in the analog type (section 2.1).

The optimum way to implement a digital TTL crosspoint switch for synchronizing lines is to use a single chip, digital crosspoint switch. However, such an IC was not commercially available due to the lack of demand for TTL crosspoint switches. Instead, there are many ECL crosspoint switches for digital applications. For example, the National Semiconductor CLC018 is an 8x8 digital crosspoint switch, but supports ECL only. Due to these limitations, a low cost, analogue crosspoint switch, capable of handling TTL voltage levels from 0 to 5volts was incorporated into the project to fill the void of an 8x8 digital TTL crosspoint switch.

The previously chosen AD8116 video crosspoint switch, used for switching the RGB lines, could also be used to crosspoint switch the TTL synchronizing lines, but this will increase the cost of the project. Although the AD8116 was tested and successfully switched the synchronizing TTL lines, if it is used it will consume too many ports, thus decreasing the number of connectable PCs to three. Such a miniscule number of PCs is simply not acceptable. Searching for other analog crosspoint switches, the Harris CD22M3493, an 12x8 analog crosspoint switch, was selected [Harris, 1999]. Its block diagram is shown in figure 3.
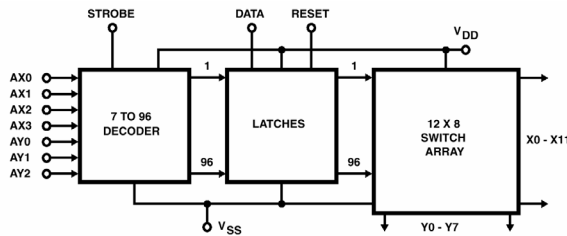

Figure 3: Harris CD22M3493 Block Diagram

The Harris CD22M3493 fulfills the requirements for being a low cost analog crosspoint switch and possesses a large enough matrix of switches to support an adequate number of PCs to be used in the project. Although, by the time of writing this paper and after implementing the project, Lattice GDS22/18/14 programmable digital switch matrix was introduced in the market, the Harris CD22M3493 is cheaper and performs the required function (albeit awkwardly).

2.3 Microcontroller

The requirement in this project is to get a microcontroller capable of programming (controlling) the AD8116 and CD22M3493 discussed in the previous sections. Table 1 lists the features required in this project. Since our control application is not speed-intensive, most

of the commercially available microcontrollers could be used. We selected the Z-World CM7200 microcontroller module together with a 12-button keypad and a one-line LCD display [Z-World, 1999].

Table 1: Main Features of Required Microcontroller

	Feature (Resource)	Requirement in this project
1	Bus Width	Prefer 8 bit data bus and any size address bus
2	Programming Memory	Around 100K byte total
3	Data Memory	
4	Parallel Ports	One parallel port
5	Serial Ports	Not required (if simulated by one bit on the parallel port)
6	A/D and D/A converters	Not required
7	Reset circuitry and watchdog timers	"Nice to have" feature
8	Programming framework	Prefer high level programming language under PC environment.
9	I/O Hardware Alternatives	Keypad and LCD for setting operating mode and displaying it
10	Development Tools	Minimal requirement

2.4   Overall System Hardware

As discussed in section 2.1, the AD8116 16x16 video crosspoint switch was selected. This 16x16 size can be used for five PCs only (5xRGB = 5x3 = 15 video signals). For these 5 PC's there are 5 vertical synchronizing lines and 5 horizontal synchronizing lines. As described in Section 2.2, the Harris CD22M3493 12x8 crosspoint-switch was chosen in this project for switching the synchronizing signals. So, two of this Harris ICs are used in the project.

To program the video crosspoint switch serially, only three control lines are needed. To program the digital cross point switch, CD22M3493, nine control lines are needed for each. An interface was needed between these switcher ICs and the microcontroller. Two 8255 PPI (Programmable Peripheral Interface) ICs were used to provide these ports from the microcontroller [Bergsman, 1994].

Table 2 shows the distribution of these ports over the 1st 8255 used in the project while table 3 shows the distribution of the remaining ports over the 2nd 8255.

Table 2: 1st 8255 Connection With The Switcher

IC	1st 8255									
Port	A				B			C		
Pin	A_3	A_2	A_1	A_0	B_2	B_1	B_0	C_2	C_1	C_0
Pin	AX3	AX2	AX1	AX0	AY2	AY1	AY0	**DATA**	**UPDATE**	**CLK**
Port	X axis				Y axis					
IC	1st Harris CD22M3493							AD8116		

Table 3: 2nd 8255 Connection With The Switcher

IC	2nd 8255										
Port	A				B			C			
Pin	A_3	A_2	A_1	A_0	B_2	B_1	B_0	C_3	C_2	C_1	C_0
Pin	AX3	AX2	AX1	AX0	AY2	AY1	AY0	STROBE	DATA	STROBE	DATA
Port	X axis				Y axis			2nd		1st	
IC	2nd Harris CD22M3493							Harris		Harris	

The interfacing circuit of the two 8255's to the two Harris ICs and AD8116 was designed following the connections in tables 2 and 3 above. The PCB fabricator, TraxMaker® software developed by MicrCode Engineering was used to design the board layout and to get the optimum wiring routes [MicrCode, 1999]. Two-sided PCB board of this circuit was designed using this program. This board was fabricated locally and it was working perfectly. Figure 4 shows the interfacing and synchronizing switcher board schematics.
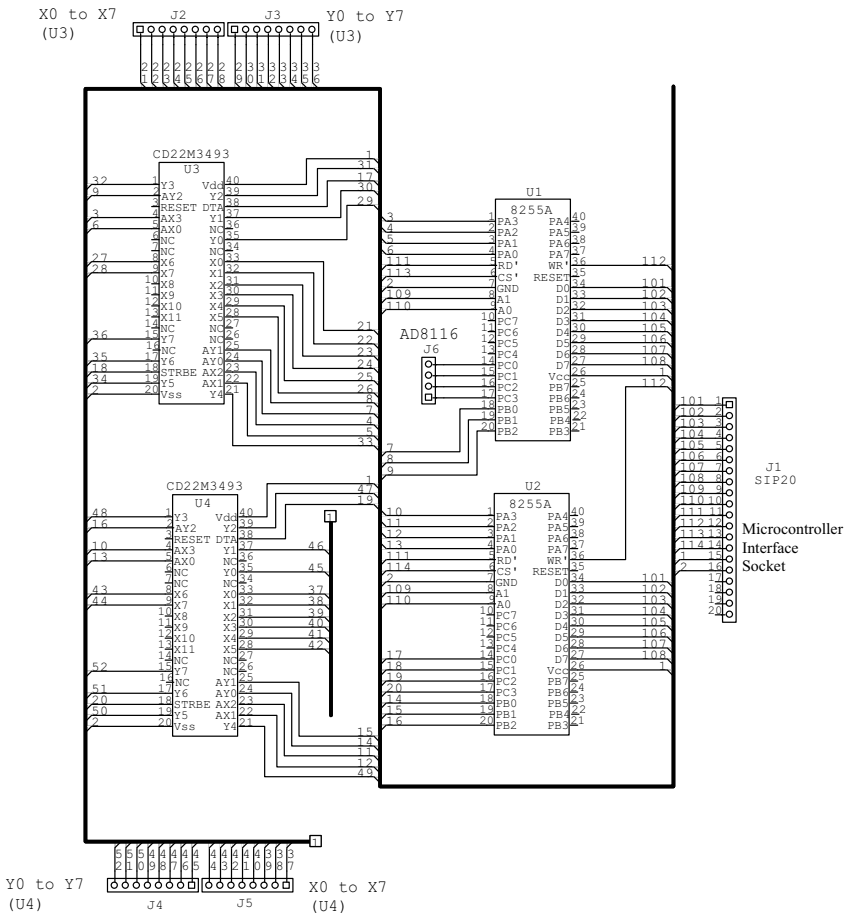

Figure 4: Interfacing And Sync. Switcher Board

Finally, both groups of the VGA signals of the 5 PCs were connected to their respective integrated circuits, the RGB lines to the AD8116, and the horizontal/vertical sync lines to the Harris X-axis and Y-axis.

3. SOFTWARE DESIGN

Custom coded software was written to achieve the three operating modes. This was developed using the high-level Dynamic C language on the PC and then uploading it to the microcontroller flash EPROM. The program manages all of the signals going in/out the switcher. Figure 5 shows the keypad layout of the Z-World microcontroller. The legend to provide the functions of the three operating modes is shown in figure 6. The program flowchart is given in figure 7.   This is a simple control program that manipulates 8255 bits to provide control words to the AD8116 serially. It also controls the select lines of the CD22M3493. The program compiled to a size of around 16 Kbytes.
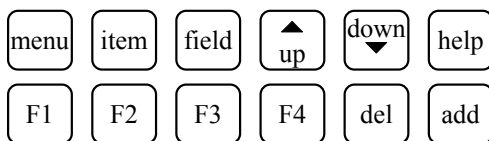
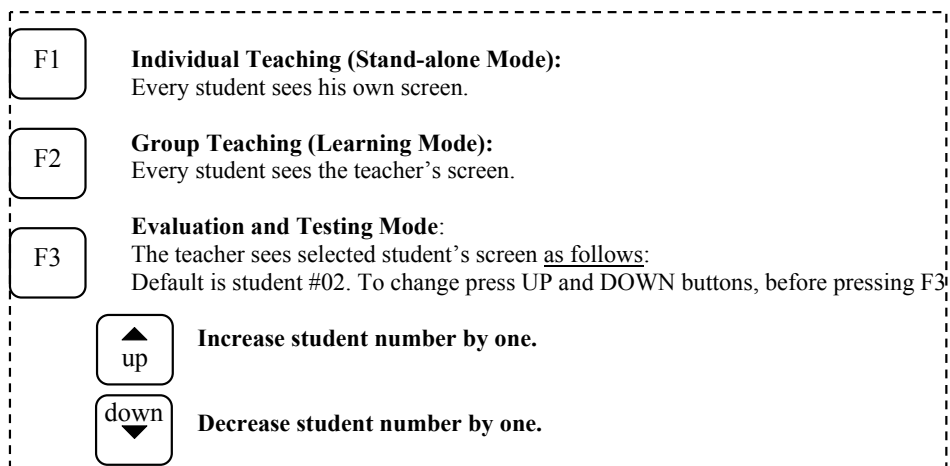Figure 5: Z-World Cm7200 Keypad Module Layout
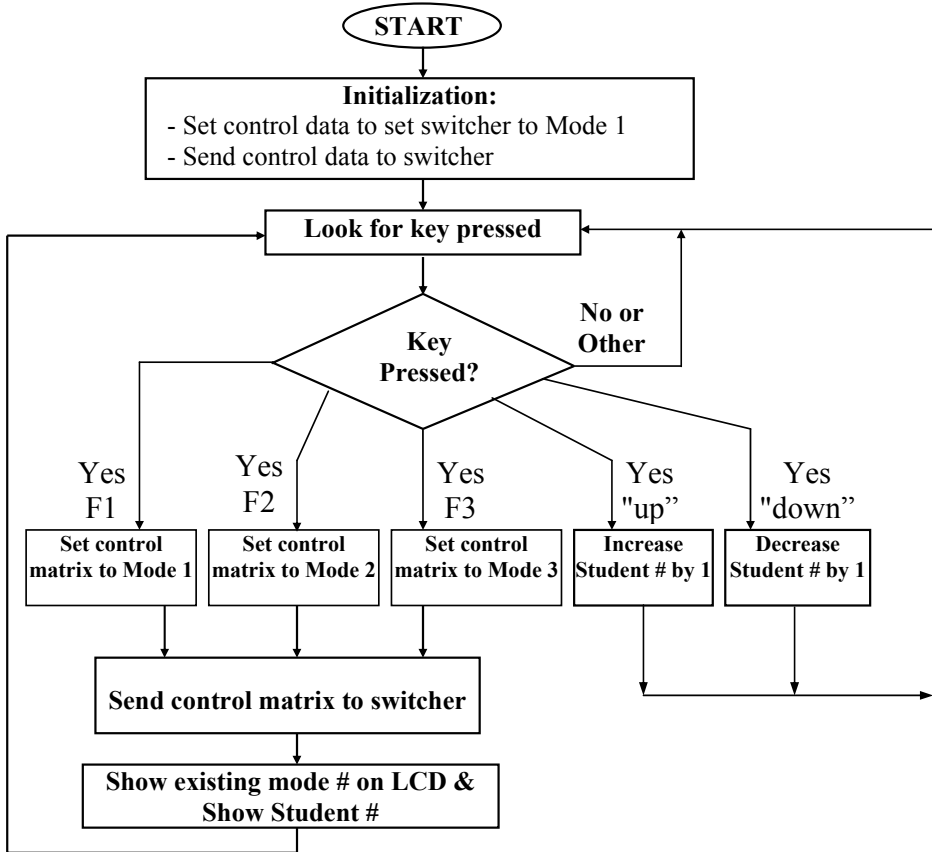
Figure 6: System Keys Functions (User's Guide)

Fig 7: Video Switcher Program Flow Chart

4. CONCLUSION

The hardware was built and the software was stored in the flash EPROM of the microcontroller. The system was tested and the software was debugged. All of the three proposed modes ran successfully without a problem. Since the switcher is a crosspoint switch, modifying the program source code can provide more functions and operating modes. For example, sub-group mode (a small group of students sharing one screen) can be programmed.

Instead of using the Z-World CM7200 evaluation board with LCD and 12-button keypad, CM7200 could be used with 6 keys and two 7-segment LEDs showing the student number for mode 3. This reduces the hardware size and makes the control unit more portable.

The system can be upgraded to work with 8 PCs by adding one 8x8 crosspoint video switcher IC such as AD8108. For realistic classroom size (16, 32 PC's), one can use multiple AD8116 arranged in 5 planes (R, G, B, H, V) and in two dimensional daisy chains.

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