DESIGN AND CONSTRUCTION OF AN ELECTRONIC LEARNING KIT

BY

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2003/15414EE

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NOVEMBER, 2008.

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A THESIS SUBMITTED TO THE DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING,

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DEDICATION

I wish to dedicate this project to God Almighty for making this work a reality and successful through my hardwork and the support of others. I also wish to dedicate this piece to my nephew Owen Ikeji Nobert, for God to bless him abundantly Amen.

DECLARATION

I NMADU DANIEL declare that this work was done by me and has never been presented elsewhere for the award of a degree. I also hereby relinquish the copyright to the Federal University of Technology, Minna.

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ACKNOWLEDGEMENT

My profound gratitude goes to the Almighty God for seeing me through and the completion of this work. In a special way, I wish to recognise the contribution of Mr Nathaniel Salawu, who in no small measure guided me during the course of this project work. My sincere gratitude goes to my parents, Chief & Chief (Mrs). Nmadu Paul, Dr & Dr (Mrs).M.O. Edoga , Mr. & Mrs.Emmanuel Ikeji , Flt. Lt. A.A. Petirin and all that have imparted my life positively.

I also want to appreciate my brother and sisters for their immerse support namely Kelvin, Stella Maris and Sylvia Nmadu. I want to appreciate the untiring effort of my friends namely Gloria, Vivian, Ooja, Tomi, Simisola, Rachael, Ozumba, Shyne, Shabaz, Niggy, Moses, Fishy, Hassan, Jamike to mention a few, I love you all.

May God continue to bless you all, in Jesus name, Amen.

ABSTRACT

The project undertaking emphasizes the usefulness of utilization of embedded computer technology for the learning process of children and adults. It also establishes a form of self-motivating educational involvement. A computerized tool that teaches alphabets, numbers, mathematical symbols, etc is presented as the end result of the design undertaking. The enhancement tool was design out of the need to make learning more interesting and interactive to the target audience that is children. It demonstrates the use of computer hardware and software as agents of computer-assisted learning.

TABLE OF CONTENT

CHAPTER ONE

1.0 INTRODUCTION

What '3Rs' [reading, writing and arithmetic] was to the ancient education, '3Ms' [man, material and methods] is to modern education. Modern education differs from the ancient education quite substantially not only in subject content but also in emphasis and approach. Here 'Man' stands for that (Bio psychological organism which is the centre of all activities in the education).

It has being observed [4] that satisfying learning can not take place unless the nature of the child in the classroom is fully understood by the teachers who are responsible for their learning. Material, invariably points to the subject matter, the syllabus, the content of the course, etc, that capacitate the child to achieve a reasonable degree of mental and physical skills so as to earn a recognizable position in the society.

The present day education has undergone radical changes so far as the 'material is concerned, simply because scientific investigation and inquiries are revealing vast oceans of fact regarding the nature and working of the universe, and the knowledge is doubling itself in each decade. This is why the contents of courses of reading are revised often.

Next is the 'method' the way by which the experiences, informatory material, the knowledge-abstract and factual is transferred to the learners. The method adopted by the teacher in this transfer of 'material' is as important as the other two factors. Teaching becomes a boring and burdensome process if the teacher has not been careful enough in selecting the method. Even the more interesting and valuable subject becomes a sources of frustration for the students if it is badly handled by the teachers. Hence an attempt has been made in this project work to emphasis the latest trends in teaching materials and methods, and the importance of computers [dedicated and otherwise] in the realization of this modern education technique commonly referred to as Computer Aided Education.

1.1 COMPUTER AIDED EDUCATION [CAE]

The traditional form of information transfer between the teacher and the student was always effect in a physical enclosure defined as a classroom. Here, knowledge transmission and reception involved in a one-on-one physical relation. Teaching methods until the advent of computer assisted learning was of this form, the recipient always with the transmitter.

This new form of learning is referred to as 'computer based learning (CBL). This refers to the use of computers as a key component of the educational environment. While this can refer to the use of computers in a classroom, the term more broadly refers to a structured environment in which computers are used for teaching purposes. The concept is generally seen as being distinct form for the use of computers in ways where learning is at least a peripheral element of the experience [e.g computer games and web browsing].

Computer aided education spans several decades, rating back to the invention of the abacus, and has evolved from simple computer man interactivity to a broader spectrum of computer deployment as teaching tools and the use of software as teaching methods.

Various forms of CAE have now been accepted in the disbursement of educational information, examples which are given below;

1. E- Learning;

This is defined as a planned teaching/learning experience that uses a wide spectrum of technologies mainly the internet to reach learners at a distance. Lately in most universities, e- learning defines a specific mode of attendance of courses or programs to study where the student rarely, it ever, attend face to face or for a campus access to education facilities, because they study on line.

2. Computer Based Learning [CBL]

As explained earlier.

3. Computer Based Training [CBT]

CBT is a learning method where a student learns by exciting special training programs on a computer relating to their occupation. CBT is especially effective for training people to use computer applications because the CBT program can be integrated with the application as they learn.

Historically, CBTs growth has been aided by the enormous resources to create a CBT program, and hardware resources needed to run it. However, the increase in PC computing program, and especially the growing prevalence of computers equipped with CDROMS, DVDs, Camera, is making CBT a more viable option for corporations and individuals alike. Many applications now come with some modest form of CBT often called a tutorial. Web-based training (WBT) is a type of training similar to CBT, however it is delivered over the internet using a web browser. Web-based training frequently includes a self paced learning medium though some systems allow for online testing and evaluation at specific times.

1.2 OBJECTIVES OF THE PROJECT

This project work was undertaken with the following objectives in mind;

I. To help pre- scholars and children derive greater sense of involvement in the learning process.

II. To develop an affordable and cost- effective replacement for the traditional wooden slate.

III. To teach the English alphabets [others can be incorporated] which are the first basic elemental in roads into learning the English language.

IV. To demonstrate the utilization of embedded computer hardware and software for teaching.

V. .To establish the realization of a ready to- go replacement for non educational toys.

1.3 SCOPE OF THE PROJECT

The project aims at designing and constructing a device that will visually teach the elemental components of pre- scholar learning framework.

A reduced complexity microprocessor (microcontroller) was wired to a 5*7 alpha metric dot matrix display to form a unit that displays several characters at the touch of buttons designed for the system control. The target user can select any mode (numeric, alphabet, symbols, etc) desired and master such. Since the system is software driven, it is easily recognizable by simply downloading form wave updates via a suitable programming pod to redefine the functionality of the entire system.

1.4 METHODOLOGY

The realization of the electronic teaching aid was effected according to the system layout with the block diagram in fig. 2.1,

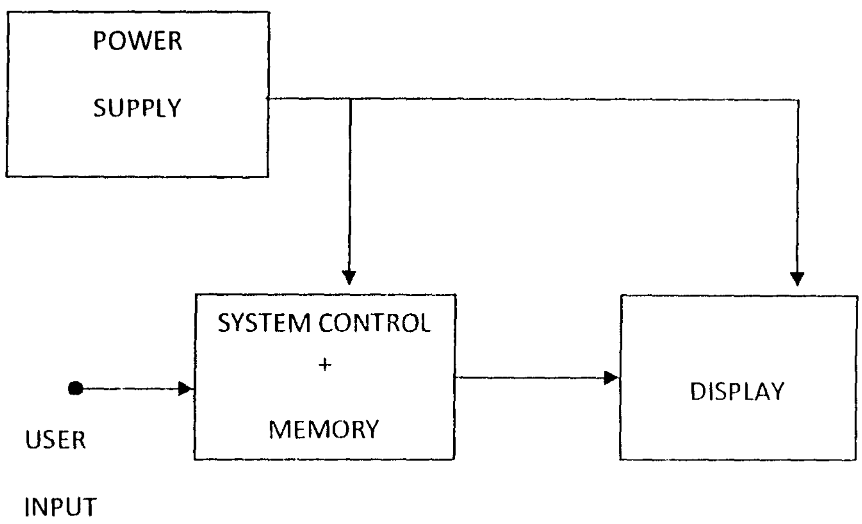

fig. 1: Block diagram of electronic teaching unit.

A portable system was intended and hence a light weigh power supply option was needed. A 9v DC battery cell readily achieved this.

A system controller loaded with the firm wave affected the task of responding to user key process and displaying requested symbols on the dot matrix display.

A dot matrix display constituted the visual output device. It was chosen since it allows the display of any desired symbols, this is done by appropriate bit patterning.

1.5 LIMITATIONS

The design is only visually oriented. No audio feedback was incorporated to introduce the spoken equivalent of the display symbol.

This is a setback as it demands that a teacher be on hand to fill that need. It is also a single digit unit, and hence can only teach alphabets and numbers. It cannot, for example teach counting beyond nine [9]. Words can also not be taught as a multi- digit implementation would be needed.

CHAPTER TWO

LITERATURE REVIEW

2.0 INTRODUCTION

Computer assisted learning, CAL, is not a new phenomenon. This field of education has been growing since the introduction of computers into the learning environment. Starting with the humble digital textbook, CAL has moved into the way of creating a

learning environments, where the participant has the ability and necessary tools to produce their own learning paths and outcomes

2.1 HISTORY OF CAL

In [1] CAL is referred to a computer program or file developed specifically for educational purposes. The technique used throughout the world in a variety of contexts, from pre and primary school aged children to train adults in medicine, law, accounting, etc.

However its use has not been so widespread until recently. In 1980s, the first computer assisted learning became available to university students looking for an alternative to the traditional text book. These programs uses only digital files transferred into a CDROM to give students highly portable and accessible learning materials.

According to [2], the popularization of this form of learning and the increase of personal computers led to the development of widely distributed educational CDROM such as Encarta. As technology continued to grow and with the advent of the internet, information on CAL programs become more interactive, reflecting a social need for flexible learning outcomes. There is now a multitude of CAL plat forms designed for every market from school based entertainment packages to computer based management learning environments [1].

In retrospect, CALs history began in the early 60s when the third generation of digital computers were built and introduced. These systems were cheaper and more reliable than the earlier models. So digital computers became typical facilities in universities and research entries. Consequently, researchers started to find raw fields of applications for the computers and CAL was one of those certainties at the beginning, like other technological productions, CAL systems which are a combination of computer hardware, added special purpose peripherals, and CAL software, has only scientific and academic applications, and are experimental. At that time[3], before other specialists, psychologists used the computer as an ideal tool for conveying programmed instruction, this branch of CAL was called computer.

In 1969, [4] listed about 20 various CAL systems that had been developed in universities and research centers. Obviously these were the first steps and were concentrated on academic goals and had a wise range from a computer based science testing system [5] to one of the earliest and remote educating systems that was developed in Harvard University [6].

During the 70s CAL systems were developed but the development rate was still low, because of technical and also economical limitations especially concerning hardware that was still expensive, massive and mainly without adequate sound and graphic facilities.

In the UK from 1973, the National Development Program in computer assisted learning was founded. This research center had a 5-year plan and a considerable two million pounds budget for developing CAL systems in the UK.

In the middle 70s CAL systems were used in Interventional Computers Limited [ICL] company for operator's training. The project started in 1963 but became operational in 1971 [8] one of the earliest computer-produced AV materials (or as they were later called 'Multi-media') was reported by A.H francis in 1975. These materials were some parts of a long-term project for using computers in the production of educational films.

Around the beginning of the 70s, A+kinson and Wilson [9] suggested that the main problems of CAL systems were:

i. low quality of graphic displays (e.g monochrome monitors)

ii. handling problems of random access audio tapes.

iii. cost of terminal per hour, it was higher than an adequate level for general use.

During the 80's and 90's these and other CAL problems were eliminated by the Digital Revolution. Digital technology development, upgraded hardware facilities and performance and lower prices solved, these problems of low quality, monochrome graphic displays were substituted by video quality and 16million colour displays. Nowadays computing and processing speeds of a typical computer are tens of times higher than the most advanced computer of the 70's. Compact discs (CDs and DVDs) and real sound video peripherals brought multi-media facilities in the PC world. Therefore, as time went by, CAL system designers could develop their ideas and implement them. The results are current CAL system.

2.2 CURRENT CAL SYSTEMS

Currently used CAL systems have the following features;

i. Easy to access- nowadays everybody can get an educational package, which is normally a CD or uses educational web sites. The total cost of a PC and an educational software are cheap enough for most average wage earners and more importantly, to educational center all around the world. The world can bear.

ii. Quality- sounds and graphics are really in high quality

iii. Storage- a normal CD can store up to about 650million characters.

Definitely, CAL systems have made a lot of progress over recent years, although is not the end of the line and systems still have some disadvantages and weaknesses that must be reduced in future. Besides this, future CAL systems must satisfy more expectations.

2.3 FUTURE DEVELOPMENTS

CAL system's development in future years will be concentrated on the following areas;

i. Increasing system performance- this includes higher speed of processing and stronger software. This is a normal performance to current systems and their development policies.

ii. In [10] it was postulated that More- distributed systems-nowadays have modern world wide networks, high speed digital and mobile communications create a strong context for design and implementation of more distributed

CAL systems. Now teleconferencing and non-centralized classrooms will be usual as postulated by Mayadas [10].

iii. Simulation and Visual Reality- new technology [11] allows us to create 3D near to real environments for simulator systems. These will have important roles especially for blind and rarely blind people education.

iv. Special purpose CAL systems for the disabled- whereas typical teaching methods are suitable for normal learners, each sort of disabled has their specials needs, features and appropriate teaching method requirements. For instance, the teaching process of people with severe learning difficulties is mainly based on repeating some simple materials again and again, because the understanding speed of this category is unfortunately low. A multi-media work stations, could hold the teacher by repeating the words and decreases teacher's duty load sharply.

v. Intelligent CAL systems- these systems [12] shall have many sensitive advantages compare to conventional ones. They are direct results of artificial intelligence method.

2.4 CHARACTERISTICS OF AN INTELLIGENT CAL SYSTEM

A brief of review of the characteristics of some implemented ICAL systems will be helpful for understanding their features and abilities.

[13] introduced CALAT, which is an intelligent tutoring system on the World Wide Web [www].Users via a typical web browser on access CALAT systems server. CALAT

is organized by a goal-sub goal scheme and has three types of course wave pages; explanation, exercise and simulation.

[14] have discussed a system for learning Japanese sign language with three dimensional placements of hand motions. This system has been designed for translations from Japanese to sign language and gets Japanese sentences as inputs and generates and shows sign language motion pictures on the screen. Generalizing of such a system could be very useful in the educating of hearing impaired people.

In recent years many attempts have focused on the distributed systems and because of internet standardization, many designers have selected this as a base platform. For instance, [15] have reported or a distributed intelligent system on the web. The system is adaptive and can customize student features and is implemented in calculus teaching.

2.5 ADVANTAGES OF CAL

The use and advantages for this system are endless. For example, teachers are now encouraged to use entertainment computer based learning for introducing students to new or difficult concepts. Times tables or grammar are incorporated into platform games that use positive reinforcement to encourage children move onto new difficulty level. Children are able to pick which times table or grammatical problems they wish to tackle in the session. This interactive element [2] is essential to ensure children feel they have some control over their education.

2.6 DISADVANTAGES OF CAL

Despite it successes, CAL has encountered some problems as well within the business sector, while managers generally understand the benefits of CAL, employees often do not. In a study completed by John Henry, it was revealed that 88.5% of workers thought that CAL is too difficult to use and they cannot see the benefits of implementing such a program [16]. While CAL may encounter some negativity from people resistant to change, there is no doubt that this educational tool is extremely valuable From children and adults, there is much to be saved from CAL's interactive and self motivating format for learning.

CHAPTER THREE

The design work embraces the following different sub-system

I. power supply

II. 8-bit system controller

III. 5×7 dot matrix

IV. User button interface.

3.0 POWER SUPPLY

A 9V DC supply (battery) is detected to provide the system power. The required 5V DC system voltage is derived from the 9V battery source via a 7805 5-volts 1-amp step-down regulator as dissipated in fig 3.0.

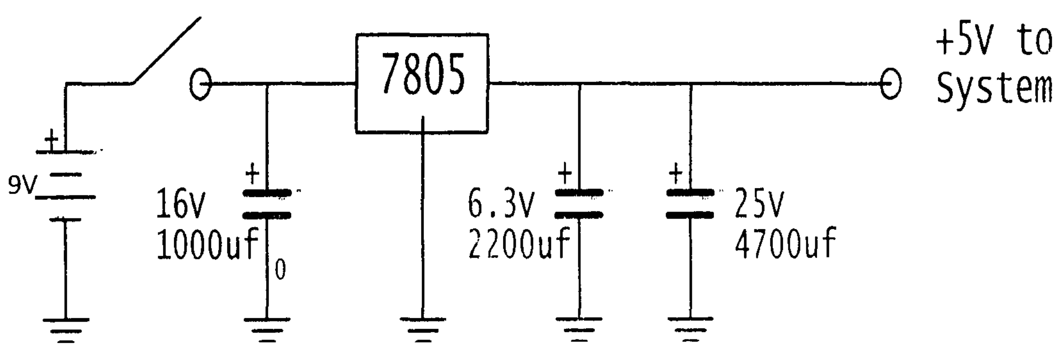

Fig. 3.0: Circuit diagram of a +5V system supply

The 9V DC is regulated down to 5volt DC by the three-terminal device, the 5volts being the system supply voltage. The battery voltage was stabilized by a 1000uf capacitance connected across the input supply rails. The 5-volt supply was buffered by a parallel combination of a 2200uf and 4700uf capacitances.

3.1 8-BIT SYSTEM CONTROLLERS

For controlling the 5×7 dot matrix display and responding to user key inputs, a microcontroller was embedded in the design realization.

An AT89C51 8-bit controller with the following specifications was selected;

- insert 8951 data sheet, hence the controller was interfaced with two buttons for controlling the displayed symbols, and the display.

The controller was interfaced with the LED array over P0, the 5-transistor column drivers over P2, and the up down buttons over P3.2 , P3.3 and P3.0. The device was programmed in assembly language for maximum flexibility and speed.

The controller also stored the look-up tables required for generating the displayed symbols. The controller was run at an external crystal of 12MHz, fielding an instruction cycle time of one micro second.

3.2 The LED (Light Emitting diode)

A light emitting diode (LED) is a type of component that uses electricity to emit incoherent narrow spectrum light when electrically biased in the forward direction of the p-n junction. This effect is a form of electroluminescence, unlike the fluorescent or incandescent lamp, LED lamp requires a very little voltage to regulate the flow of power through the lamp. In LED lamps, the arrangement of LED in the housing unit or LED array promotes perfect illumination intensity with low power consumption.

3.3 5×7 DOT MATRIX

A dot matrix display provides a convenient means of displaying almost any desired symbol since it offers the designer choice of specifying the bitmaps required to generate the displayed symbols. A dot matrix display uses a combination of logic 1 and 0s to produce any desired character.

A dot matrix display consists of LEDs wired in a grid as shown in fig. 3.1:

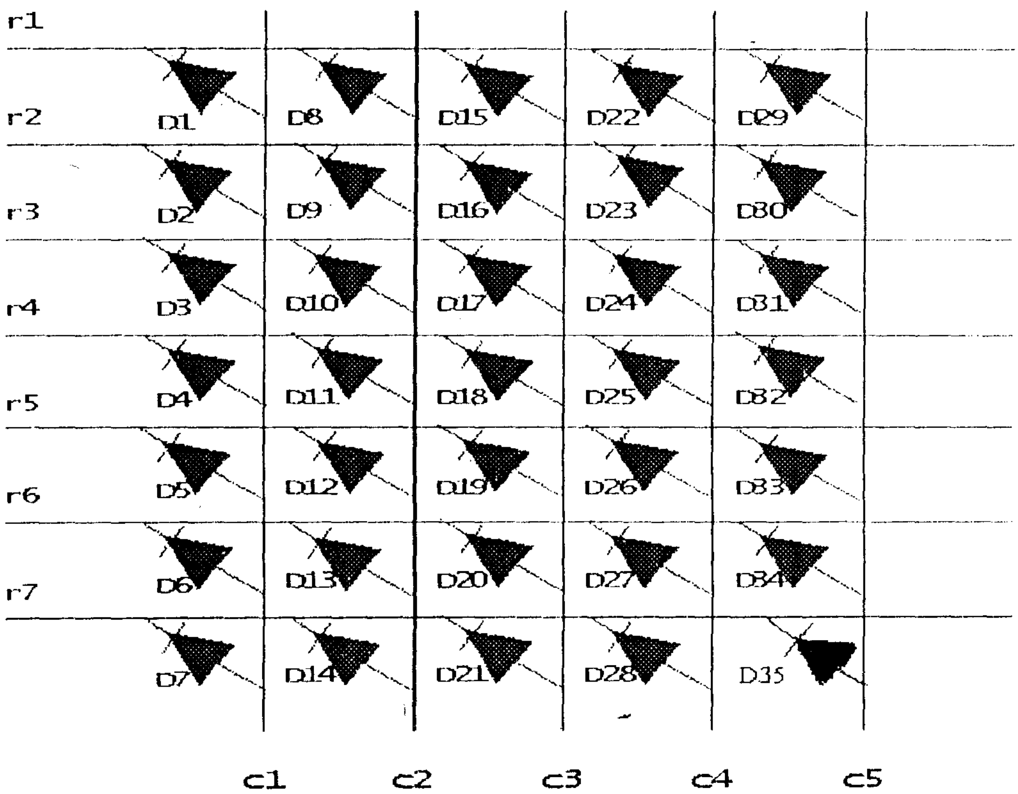

Fig.3.1: 5×7 dot matrix

Writing data to the display consists of the following sequence;

I. turning off the five digit drivers by writing offh to P2.

II. writing offh to P0.

III. writing the required bit pattern of the first byte of the 5-byte ASCII code to the data port, port 0 (zero).

IV. turning on digit driver 1 (one) to forward bias any LED whose cathode is at 0V by reason of the bit pattern on P0.

V. delaying for persistence (for about 10mS)

VI. turning off the digit driver turned on in step 4.

VII. Repeating step 1-6, changing the bit pattern of the 5-byte ASCII data gram.

The diodes were connected in the common anode arrangement, their forward current provided by the PNP digit driver. The individual bits of port 0 (P0) provided the return for the LED currents.

The 5×7 dot matrix display was driven according to the arrangement shown in fig. 3.2;

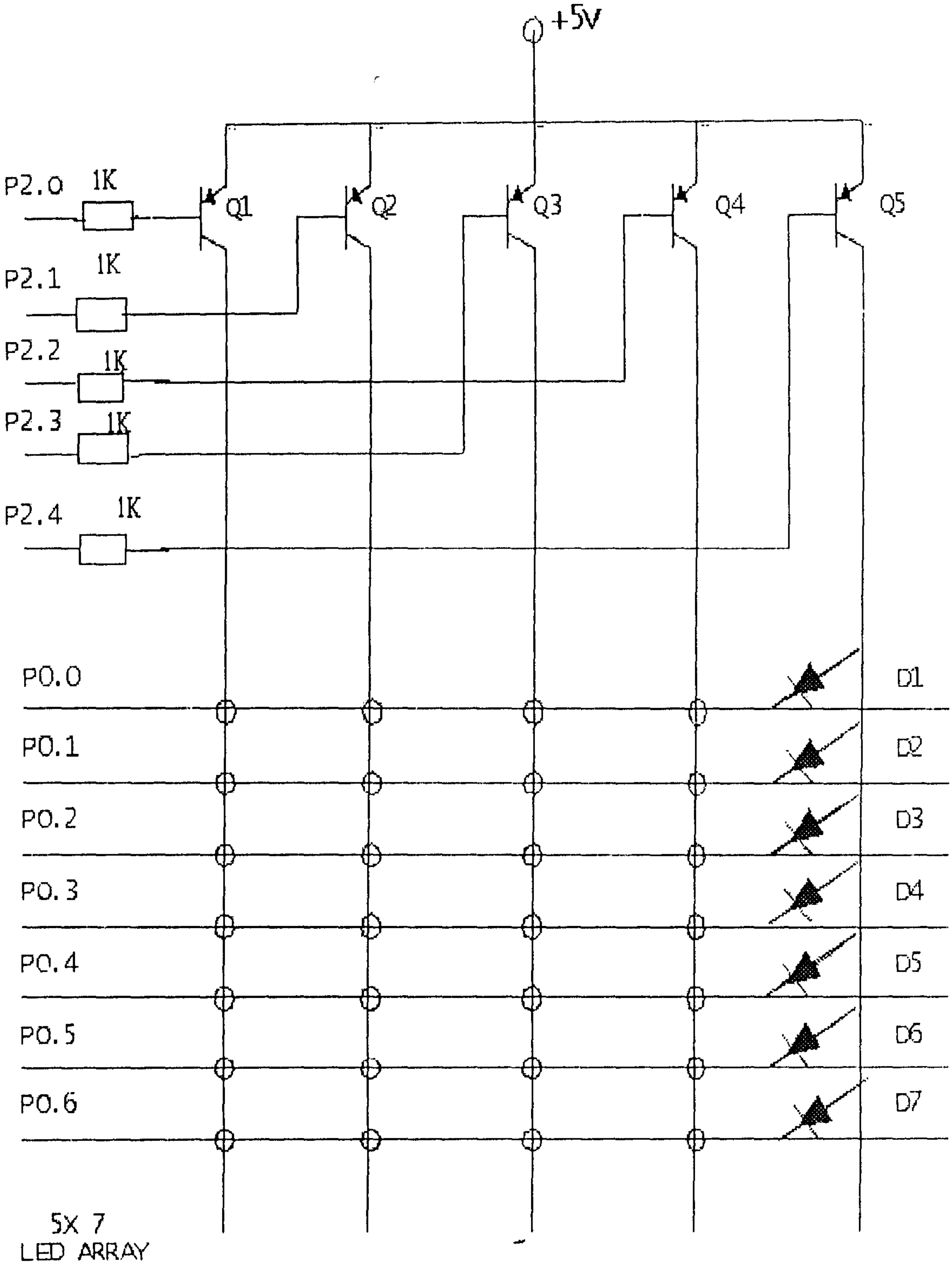

Fig.3.2: Circuit diagram of a column drivers

The transistor drivers were 25A1015GR devices to forward bias the LEDs driven by a transistor, the P2.X pin to which the transistor is connected to its driven low. The P0.X pin for the LED return is driven low. The current through the transistor then flows through the LED via the controller to ground, and causing the LED to glow.

The transistors were chosen to handle the pulsed current through the seven LEDs.

3.4 DESIGN CALCULATION

A nominal 10mA forward current was initially selected for each LED for a 5-column multiplexed display, the current is (10×5)mA for each diodes.

The total row current is thus (50 x 7) mA = 350mA

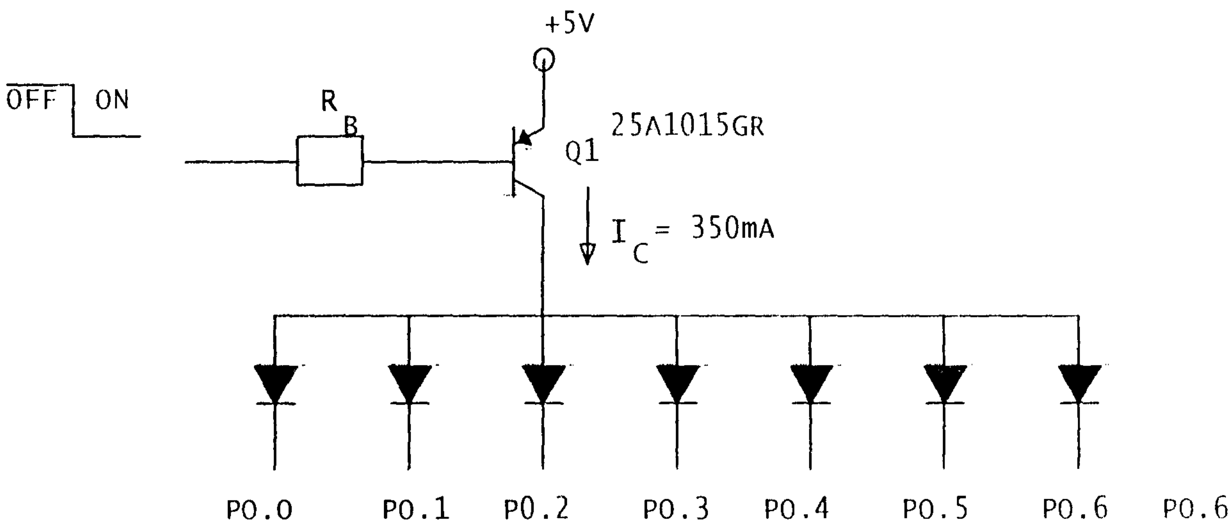

Fig. 3.3: Circuit diagram of a diode column display

R_B was chosen using the expression

$$R_B = \frac{Vcc - V_{BE}}{IB}$$

$Vcc = +5V$; $V_{BE} = 0.7V$

$$I_B = \frac{Ic}{Hfe} \qquad Ic = 350mA$$

$Hfe \approx 200$

$$I_B = \frac{0.35}{200} = 0.00175A$$

$$R_B = \frac{5 - 0.7}{0.00175} = \frac{4.3}{0.00175} \approx 2.51K\Omega$$

The value was reduced to 1KΩ for a brighter display.

3.5 CHARACTER GENERATION

The characters were generated by mapping out the LEDs patterns that define the displayed character.

To display "0" for example, the required 5-byte sequence is 0111110b, 1010001b, 1001001b, 1000101, 0111110b.

The above binary values are written to display row-column-wise, one byte at a time. The human visual system simply smoothens out the lit LEDs.

The character masks were fixed in the program code during assemble time. During system operation (in use), the mask table was referenced and the bit patterns sent to the data-port, the software generating the appropriate control logic to control the row drivers.

3.6 USER MODE

Three buttons were provided for user interactivity. The buttons allow the user to cycle through the displayed symbols. Two buttons provided up/down controls, allowing the displayed character to be advanced to the next, or return to a previously displayed character. The third button allows the selection of different symbol datasets. The incorporated datasets supports:

I. Display of alphabets A-Z, a-z

II. Display of numbers 0-9

III. Display of mathematical symbols

The three buttons were interfaced with the controller over P3.3, P3.2, and P3.O as shown in fig. 3.4

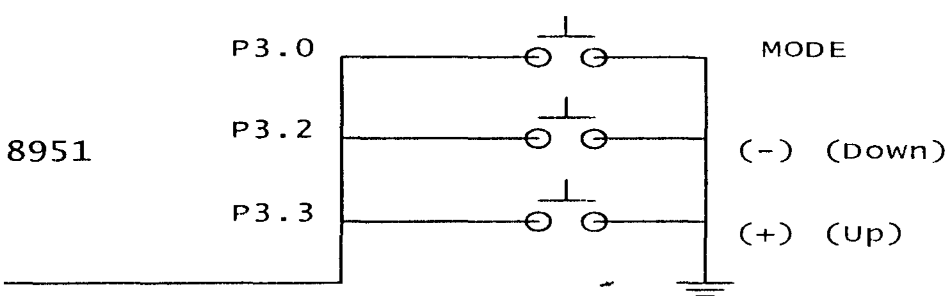

Fig. 3.4: User input buttons

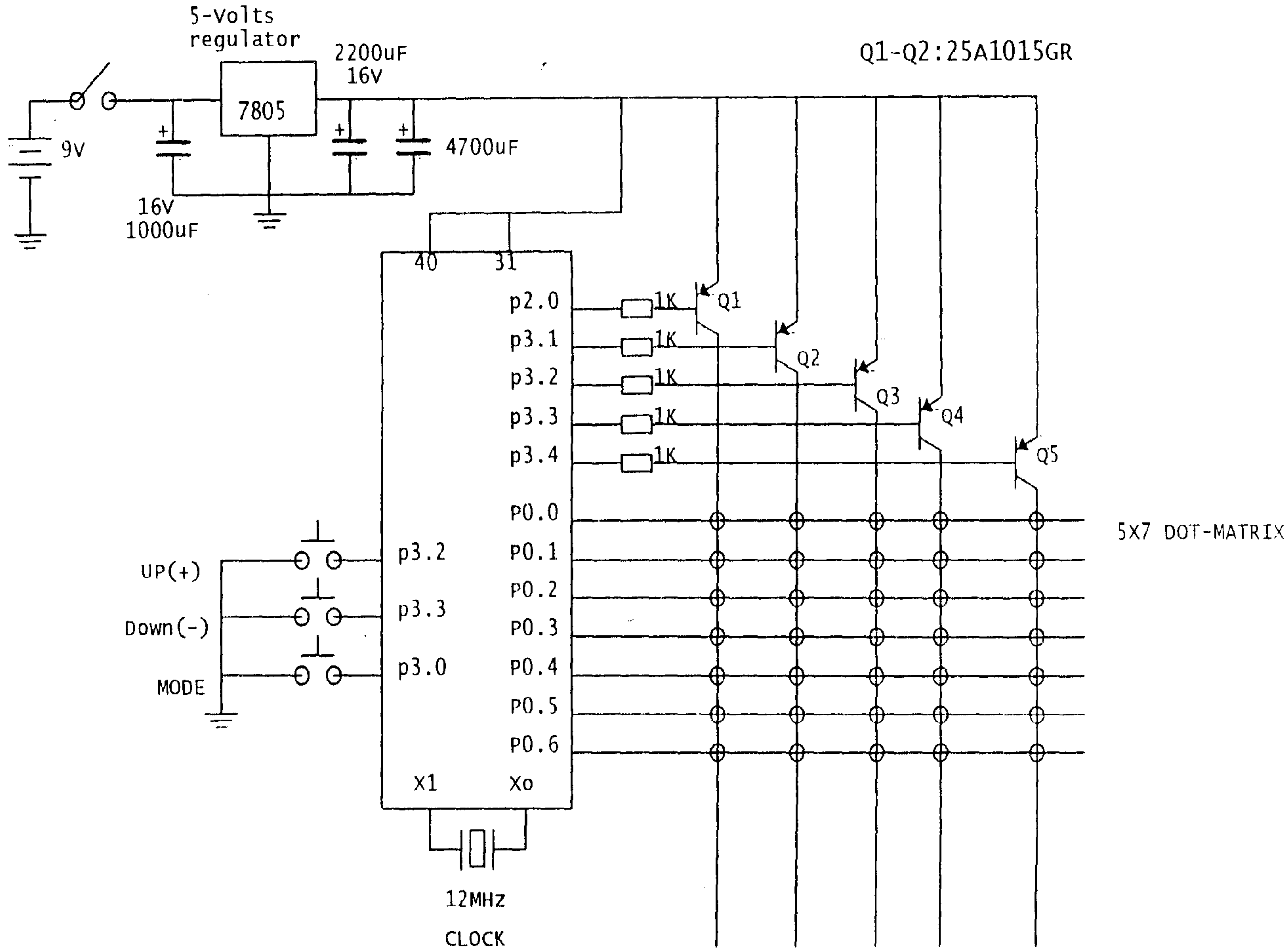

Fig. 3.5: Electronic learning kit circuit diagram

CHAPTER FOUR

TESTS, RESULTS, AND DISCUSSION

The system was designed according to the projected circuit layout. The various components were soldered in place on a small Vero load.The LEDs were arranged in (5×7) and also soldered in place. The 89S51 controller was docketed for code download, an In-system programmer was used.

In system programming, it allows easy code update with the controller still mounted on the target board without necessarily removing A.

The software was assembled using Batronix prog.studio version 6.09 and a parallel port based ISP loader application in order to transfer the Intel ascitlex file to the controller. Various modifications were made to control the software during the programming decisions. The bitmaps were modified for some characters as they displayed a bit different from the desired.

The input keys (switches) were tested to ascertain their intended control functionalities. The three switches were all observed to function.

Due to the software driven system realization, minimal problems were encountered since the hardware had already been proven to work perfectly based on the intended system function.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSIONS

The objective of designing an interactive electronic teaching kit was duly met.

5.2 RECOMMENDATIONS

For better assistance to the user, an audio interactivity scheme should be considered. This would involve an audio chip programmed with verbal representations of the corresponding displayed symbol(s). Another recommendation is the inclusion of user-generated/customized symbols. This requires the incorporation of a semi- permanent storage (FLASH E SQUARE PROM OR PURE E SQUARE PROM). User customization offers a wider symbol database than can be programmed into the unit at design time as it allows the user to update/edit the symbol tables in the field (during usage). The display can be made multi- digit, so larger numerical values can be displayed, and even short- letter words like She, He, Dad etc.

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APPENDIX I

MANUAL OF OPERATION

The unit should be maintained away from sources of heat to prevent deformation of the unit casing. If the unit fails to come on, replace the battery and operate the unit again.

To use the unit, select the display mode using the buttons. Pressing the mode button causes the displayed symbols to cycle through 0-9, A-Z, a-z, and shapes. When the desired symbol table has been selected, use the (+) and (-) keys to step through the available programmed character sets.

The user can return to the previously displayed symbol(s) by using (-) key. Pressing the (+) key advances the displayed symbols, e.g 1-2-3-4, etc.

APPENDIX II

MICRO-CONTROLLER SOURCE CODE

```
INCLUDE 89c51.mc
;**********************************************
num_count data 8
char_Count data 9
symbol_count DATA 10
max_num EQU 9
max_char EQU 51
max_symbol EQU 11
mode data 11
dx_port EQU p2
dport EQU p0
stack EQU 60
dx_Ctrl data 12
plus_key BIT p3.3
minus_key BIT p3.2
mode_key BIT p3.0

;************************************************
org 0000h
start_up:        CLR ea
                 mov sp,#stack
                 acall sys_init
mainloop:        acall write_display
                 ACALL scan_key
                 sjmp mainloop
```

```
;*******************************************************
write_display:          mov a, mode
                        jb acc.0, show_num
                        jb acc.1, show_char
                        jb acc.2, show_symbol
                        mov mode, #1
                        sjmp write_display

show_num:               mov dptr,#num_table
                        mov a, num_count
                        acall write_now
                        ret

show_char:              mov dptr,#char_table
                        Mov a, char_count
                        acall write_now
                        ret

show_Symbol:            mov dptr,#symbol_Table
                        mov a, symbol_count
                        acall write_now
                        ret
;*******************************************************
write_now:              MOV R0,#50
write_loop:             push dpl
                        push dph
                        push acc
                        MOV B,#5
                        mul ab
                        add a, dpl
```

```
                mov dpl,a
                clr a
                addc a, b
                addc a, dph
                mov dph, a
                acall write_data
                pop acc
                pop dph
                pop dpl
                DJNZ R0, WRITE_loop
                ret

;*******************************************************
write_Data:     mov dx_Ctrl,#11111110b
                mov r6,#5
                MOV dport,#0ffh
loop1:          CLR A
                movc a,@a+dptr
                cpl a
                MOV dport,A
                mov dx_port , dx_ctrl
                mov a, dx_Ctrl
                setb c
                rlc a
                mov dx_ctrl,a
                acall delay_2_show
                inc dptr
                djnz r6, loop1
                MOV dport,#0ffh
                MOV dx_port,#0ffh
```

```
                RET
;*****************************************************

scan_key:
set_mode:       JB mode_key, scan_key2
                MOV A, mode
                clr c
                rlc a
                MOV mode,A
                cjne a,#00001000b, go_Again
back_Again:     mov mode,#00000001b
exit_mode:      call write_display
                JMP scan_key2
go_Again:       JNC back_again
                SJMP exit_mode

;*****************************************************
scan_key2:
                JB plus_key, go_2
                mov a, mode
                jb acc.0, plus_num
                jb acc.1, plus_char
                jb acc.2, plus_symbol
                mov mode,#1
                SJMP scan_key2
;*****************************************************
plus_num:       mov a, num_count
                cjne a,#max_num, again1
again2:         mov num_count,#max_num
                ret
```

```
again1:             jnc again2
                    inc num_count
                    ret
;****************************************************

plus_char:          mov a, char_count
                    cjne a,#max_char, again3
again4:             mov char_count,#max_char
                    RET


again3:             jnc again4
                    inc char_count
                    ret
;****************************************************

plus_symbol:        mov a, symbol_count
                    cjne a,#max_symbol, again5
again6:             mov symbol_count,#max_symbol
                    RET


again5:             jnc again6
                    inc symbol_count
                    ret
;****************************************************

go_2:               jb minus_key, exit_scan
                    mov a, mode
```

```
                jb acc.0, dec_num
                jb acc.1, dec_char
                jb acc.2, dec_symbol
                mov mode,#1
                sjmp go_2

dec_num:        mov a, num_count
                jz no_dec_num
                dec num_count
exit_Scan:
no_dec_num:     ret
;****************************************************

dec_char:       mov a, char_count
                jz no_dec_char
                dec char_count
no_dec_char:    ret
;****************************************************

dec_symbol:     mov a, symbol_count
                jz no_Dec_symbol
                dec symbol_count
no_dec_symbol:  ret
;****************************************************
sys_init:       MOV mode,#1
                clr a
                mov num_count,a
                MOV CHAR_COUNT,a
                MOV SYMBOL_COUNT,A
                ret
```

```
;*****************************************************
DELAY_2_SHOW:      MOV R5,#2
RELOAD:            MOV R4,#0
                   DJNZ R4,$
                   DJNZ R5, RELOAD
                   RET
;**************************************************
symbol_Table:
;**************************************************************
DB          008H,008H,03eH,008H,008H,      ; 2b +
DB          008H,014H,022H,041H,000H,      ; 3c <
DB          000H,041H,022H,014H,008H.      ; 3e >
DB          002H,001H,051H,009H,006H,      ;
DB          1111000b,1000100b,1000010b,1000100b,1111000b
DB          023H,013H,008H,064H,062H,      ; 25 %
DB          036H,049H,055H,022H,050H,      ; 26 &
DB          008H,008H,008H,008H,008H,      ; 2d -
DB          020H,010H,008H,004H,002H,      ; 2f /
DB          014H,014H,014H,014H,014H.      ; 3d =
DB          008H,008H,0101010B,008H,008H,; DIVISION
DB          0100010B,0010100B,0001000B,0010100B,0100010B
;**************************************************
num_Table:
DB          03eH,051H,049H,045H,03eH,      ; 30 0
DB          000H,042H,07fH,040H,000H,      ; 31 1
DB          042H,061H,051H,049H,046H,      ; 32 2
DB          021H,041H,045H,04bH,031H,      ; 33 3
DB          018H,014H,012H,07fH,010H,      ; 34 4
DB          027H,045H,045H,045H,039H,      ; 35 5
DB          03cH,04aH,049H,049H,030H,      ; 36 6
```

```
DB              001H,071H,009H,005H,003H,       ; 37 7
DB              036H,049H,049H,049H,036H,       ; 38 8
DB              006H,049H,049H,029H,01eH,       ; 39 9
;****************************************************
char_table:
DB              07eH,011H,011H,011H,07eH,       ; 41 A
DB              07fH,049H,049H,049H,036H,       ; 42 B
DB              03eH,041H,041H,041H,022H,       ; 43 C
DB              07fH,041H,041H,022H,01cH,       ; 44 D
DB              07fH,049H,049H,049H,041H,       ; 45 E
DB              07fH,009H,009H,009H,001H,       ; 46 F
DB              03eH,041H,049H,049H,07aH,       ; 47 G
DB              07fH,008H,008H,008H,07fH,       ; 48 H
DB              000H,041H,07fH,041H,000H,       ; 49 I
DB              020H,040H,041H,03fH,001H,       ; 4a J
DB              07fH,008H,014H,022H,041H,       ; 4b K
DB              07fH,040H,040H,040H,040H,       ; 4c L
DB              07fH,002H,00cH,002H,07fH,       ; 4d M
DB              07fH,004H,008H,010H,07fH,       ; 4e N
DB              03eH,041H,041H,041H,03eH,       ; 4f O
DB              07fH,009H,009H,009H,006H,       ; 50 P
DB              03eH,041H,051H,021H,05eH,       ; 51 Q
DB              07fH,009H,019H,029H,046H,       ; 52 R
DB              046H,049H,049H,049H,031H,       ; 53 S
DB              001H,001H,07fH,001H,001H,       ; 54 T
DB              03fH,040H,040H,040H,03fH,       ; 55 U
DB              01fH,020H,040H,020H,01fH,       ; 56 V
DB              03fH,040H,038H,040H,03fH,       ; 57 W
DB              063H,014H,008H,014H,063H,       ; 58 X
DB              007H,008H,070H,008H,007H,       ; 59 Y
```

```
DB      061H,051H,049H,045H,043H,      ; 5a Z
DB      020H,054H,054H,054H,078H,      ; 61 a
DB      07fH,048H,044H,044H,038H,      ; 62 b
DB      038H,044H,044H,044H,00H,       ; 63 c
DB      038H,044H,044H,048H,07fH,      ; 64 d
DB      038H,054H,054H,054H,018H,      ; 65 e
DB      008H,07eH,009H,001H,002H,      ; 66 f
DB      00cH,052H,052H,052H,03eH,      ; 67 g
DB      07fH,008H,004H,004H,078H,      ; 68 h
'DB     000H,044H,07dH,040H,000H,      ; 69 i
DB      000H,00H,07dH,00H,00H,         ; 69 i
DB      020H,040H,040H,03dH,000H,      ; 6a j
DB      07fH,010H,028H,044H,000H,      ; 6b k
'DB     000H,041H,07fH,040H,000H,      ; 6c l
DB      000H,00H,07CH,040H,40H,        ; 6c l
DB      07cH,004H,018H,004H,07CH,      ; 6d m
DB      07cH,008H,004H,004H,078H,      ; 6e n
DB      038H,044H,044H,044H,038H,      ; 6f o
DB      07cH,014H,014H,014H,008H,      ; 70 p
DB      008H,014H,014H,018H,07cH,      ; 71 q
DB      07cH,008H,004H,004H,008H,      ; 72 r
DB      048H,054H,054H,054H,020H,      ; 73 s
DB      004H,03fH,044H,040H,020H,      ; 74 t
DB      03cH,040H,040H,020H,07cH,      ; 75 u
DB      01cH,020H,040H,020H,01cH,      ; 76 v
DB      03cH,040H,030H,040H,03cH,      ; 77 w
DB      044H,028H,010H,028H,044H,      ; 78 x
DB      00cH,050H,050H,050H,03cH,      ; 79 y
DB      044H,064H,054H,04cH,044H,      ; 7a z
```