SLICER

T.M.

PC EXPANSION BOARD

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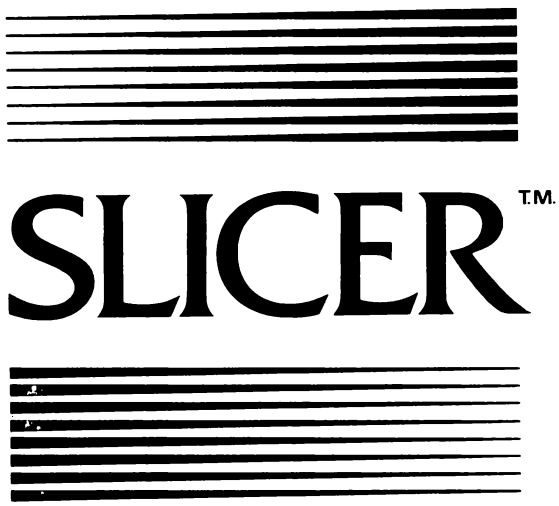
THE SLICER PC EXPANSION BOARD



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TECHNICAL SPECIFICATIONS

PC COMPATIBLE VIDEO SYSTEM
Video system based on 6845 type CRT controller provides PC compatible video system. Two 6264 type 8k by 8 memories are used which allows up to four pages of text. An additional graphics mode allows the use of this memory as a bit mapped 640 by 200 screen. Video output is seperate sync or composite sync. Seperate sync outputs are PC compatible.

PC COMPATIBLE KEYBOARD INPUT
A connector for a PC type keyboard is provided. The software provided recognizes this as the console keyboard. Keyboard scan codes are also provided.

PC EXPANSION BUS
Two PC type cardslots are provided for expansion of IO or for addition of color graphics cards. Circuitry converts the fast 16-bit SLICER bus to the slower 8-bit PC bus. Memory refresh is not supported on this bus.

SOFTWARE
Two EPROMs contain all the neccessary routines to run this board. The SLICER debug monitor automatically detects the presence of the board and uses it as the console device.

PARTIAL KITS AVAILABLE

BARE	EASY	
	x	1. HD6845 SP CRT controller
	x	2. Two HM6264-15 video rams
	x	3. SCB2673B video attribute controller
	x	4. 74LS322A shift register
	x	5. Keyboard connector
	x	6. Video connector
	x	7. Resistor packs (2)
	x	8. 1N5230 diode
	x	9. 74HC04
x	x	10.PALs (4)
x	x	11.Crystals (2)
x	x	12.EPROMs, software and character generator (3)
x	x	13.Resistor, 36 ohm
x	x	14.Power connector
x	x	15.Circuit board, multi-layer
x	x	16.Documentation

THEORY OF OPERATION

MEMORY

The PC Expansion Board has two type of on board memory. First is the EPROM which holds the programs for running the board. The EPROM may be one of four types, 2732A, 2764, 27128 or 27256. There are two devices required since the 80186 CPU requires data in 16 bit chunks. U11 is the even addressed EPROM and U10 is the odd addressed EPROM. Both EPROMs must be of the same type otherwise you may likely find out how not to "burn" an EPROM! The type of EPROM determines how JP9 and JP10 must be jumpered. The following chart should assist you:

EPROM Type	JP9 Jumpers	JP10 Jumpers
2732A	none required	pin 2 to pin 3
2764	pin 2 to pin 3	pin 2 to pin 3
27128	pin 2 to pin 3	pin 1 to pin 2
27256	pin 1 to pin 2	pin 1 to pin 2

Pin 1 on these jumpers is closest to pin 28 of U10, the odd EPROM, on both of these jumpers. As on the SLICER board if a 2732A type device is used, pins 1, 2, 27 and 28 in the socket must be left empty.

This memory is selected when the programmed mid-range chip select, /MCS1 is active. For normal operation this region starts at absolute address C8000H. The size of the region is programmable.

The second type of memory on the PC Expansion Board is the monochrome video memory. The address for this memory is decoded by the decoder PAL, U9. The normal range for this memory is from B0000H to B7FFFH. This is a 32k region although only 16k is present. This memory is covered in more detail in the video system theory of operation.

PC Keyboard Port

A very simple circuit provides the interface to a PC compatible keyboard for the SLICER. These keyboards operate over a serial link in order to minimize the number of wires required.

Quite simply these keyboards shift their data out serially with a set of clock and data lines. On the receiving side the clock is cleaned up by a couple of 74LS74 flip flops (U46) and is used to shift the data into a receiving shift register, a 74LS322A (U47), until the shift register is full. At this point the keyboard data line is pulled low by an open collector gate, a 7407 (U14), and the 80186 is interrupted. The interrupt handler reads the keyboard code, then resets the shift register and interrupt flip flop 74LS74 (U45), and decodes the key code.

One important thing to realize is that these keyboards do not give ASCII codes, but rather a "scan code" which actually tells what key was pressed or released. This is true for all keys, even shift and control, and requires the software to keep track of what keys are down, etc.

PC EXPANSION BUS

The PC expansion bus on the SLICER PC Expansion Board consists of two IBM PC type card slots and the neccessary logic to convert the 16 bit SLICER bus to an 8 bit PC type bus. This is no small task as the bus timing is significantly different for the two busses. The SLICER CPU operates at up to 8 MHz while the IBM PC operates at 4.77 MHz. In addition the PC performs two bus cycles to do a single 16 bit memory or IO operation since the bus on the 8088 CPU is only 8 bits wide.

The solution to the conversion problem consists of a synchronizer, a little state machine (i.e. Rhode Island), and a handfull of TTL glue. When a bus cycle is requested on the PC expansion bus the synchronizer starts the state machine which simulates 8088 type signals. The s ynchronizer consists of two 74LS74s (U49 and U50) that, with their four flip flops ensure only one bus request occurs and also hold the processor until the operation is done.

The state machine is a single PAL which simulates the timing of the PC bus. It provides ALE, /IORD, /IOWR, /MEMRD and /MEMWR signals to the PC bus. The PAL is a PAL16R4, which has internal registers that make it ideal for a state machine of up to 16 states. The state machine also controls the buffering and latching of data on the PC bus.

When the 80186 CPU addresses the IO locations or memory region given to the PC expansion bus one of the following occurs depending on the type of transfer the 80186 is doing:

Type 1 Transfer: Byte operation on lower half of CPU bus

80186 signals this with /BHE = 1 and A0 = 0

State machine does one 8088 bus cycle with IO.A0 = 0
Data is transferred by U8 for write, U7 for read.

Type 2 Transfer: Byte operation on upper half of CPU bus

80186 signals this with /BHE = 0 and A0 = 1

State machine does one 8088 bus cycle with IO.A0 = 1
Data is transferred by U6 for write, U5 for read.

Type 3 Transfer: Full 16-bit transfer.

80186 signals this with /BHE = 0 and A0 = 0

State machine does two 8088 bus cycles, back to back,
the first with IO.A0 = 0, the second with IO.A0 = 1.
Data is transferred by U6 and U8 for writes, and by
U5 and U7 for reads.

For a read operation U5 and U7, both 74LS373s, latch the data for the CPU. For write operations the data is transferred by U6 and U8, which are 74LS244s. When the state machine finishes its cycle it gives a DONE signal which allows the 80186 to continue and resets the synchronizer. With this method the 80186 is slowed only for PC bus operations and not for normal execution.

PC Bus Addressing

The IO and memory address ranges given to the PC expansion bus are determined by the decoder PAL, U9. The IO address range given the bus is from 0380H to 03FFH and the memory address range is from B8000H to BFFFFH, where the color video board normally resides. Within the IO address space there are some reserved locations which are used by the monochrome video system. These are addresses 3B0H through 3BFH.

The actual upper four bits of the PC expansion bus address are not derived directly from the CPU address bus. These can be set under software control so that peripherals that have hardware address decoding set to another memory region may still be accessed. The port which controls this is also the keyboard control port, which must be treated with care! Normally these must be left pointing to the video memory area. Any routine which changes these should disable interrupts, change them, put them back then enable interrupts so that keyboard input does not interfere with the operation, causing strange results.

PC Bus Limitations

The SLICER PC expansion bus was designed primarily to support PC type color graphics boards and simple IO devices. It does not support the DMA or interrupt structure of the IBM PC bus. Since the IBM PC uses DMA to refresh its memory this means that PC DRAM boards will not work with the SLICER. We don't feel this to be a great loss since this is slow memory and is only 8 bits wide anyway.

VIDEO SYSTEM

The PC Expansion board video was designed to emulate the video of the IBM PC to as great a degree as possible, yet to take advantage of the new VLSI video controller chips available and to take advantage of the increased speed of the 80186 and its 16-bit bus.

THE CRT CONTROLLER

The basic CRT controller is the Hitachi HD6845 SP, which is very similar to the 6845 used by the IBM PC, but is somewhat enhanced. The register structure and use is identical for the two parts, but the Hitachi part defines some of the un-used bits to control additional functions. If you really want to dig into these I suggest you obtain a data sheet for the part from Hitachi. This same part is also made by Synertec under a slightly different part number: SY6545.

The function of the CRT controller is to sequentially access the video memory to put data on the CRT on a regular basis (50 Hz for the PC monitor). It is clocked by a clock signal called CCLK, the character clock, the frequency of which determines the rate at which new characters are put on the screen. The CRT controller also determines the timing characteristics of the display. Features such as the frame rate (how often the screen is refreshed), the width of the horizontal sync and vertical sync pulses the number of characters on a line and the number of rows on the screen are all programmable parameters within the crt controller. If multiple pages of video memory are supported the CRT controller also determines which page is displayed and what the page boundries are. The cursor location and type is also a programmed function of the CRT controller. It may be a single line, a block, or somewhere in between and it may be programmed to blink at one of two rates or not to blink at all.

In order to be IBM compatible the CRT controller is a peripheral on the 8-bit 8088 type bus portion of the PC expansion board. It occupies the same I/O location as on the PC monochrome board, that is I/O addresses 3B4H and 3B5H. At location 3B4H is the 6845 index register which points to the 6845 data register which is to be accessed at 3B5H. This means that both index pointer and data may be written in one 80186 cycle. For example, the cursor type is programmed in the 6845 registers R10 and R12. In particular bits 5 and 6 of R10 describe the following four options:

bit 5	bit 6	
0	0	No blinking
0	1	No cursor
1	0	Blink at 1/16 frame rate
1	1	Blink at 1/32 frame rate

The current value of R10 is 0BH, so to make the cursor blink at a relaxed pace the value 6BH sould be programmed. This can be done in one operation with the following short assembly language routine:

```
CURS_BLINK:     MOV     AX,0A6BH        ;REGISTER 10=A, DATA=6B
                MOV     DX,03B4H        ;ADDRESS OF HD6845 SP
                OUT     DX,AX
END
```

One thing to note when programming this circuit is that it is impossible to read most of the data registers. Thus you may need to consult a software listing to obtain the original values for some of these registers. For your reference the following table may be used as a guide as these are the values in use at the time of writing.

Register	Value
RØ	61H
Rl	5ØH
R2	52H
R3	ØFH
R4	19H
R5	Ø6H
R6	19H
R7	19H
R8	Ø2H
R9	ØDH
RlØ	ØBH
Rll	ØCH
Rl2	FFH
Rl3	FFH

Registers Rl2 and Rl3 differ from the PC in two ways. First, since the PC monochrome board has only one plane of video memory these registers are never changed on the PC. For the SLICER PC expansion board these registers allow access to the additional four pages of video memory. The second difference is that the starting address of the display is actually one greater than the programmed value in these registers. This is because the video pipelining is shorter for the video data than it is for the cursor signal and if not programmed as such the cursor will be one character out of position at all times. Since the register is never programmed on the PC we felt that the additional expense associated with lengthening the pipeline was not worthwhile.

VIDEO MEMORY

Two HM6364-l5 static RAM devices store the character data and the attribute data for the display. These are 8k by 8 CMOS static RAM devices and are static sensitive and should thus be treated carefully! It turns out that they're also quite expensive. The board is actually designed to accomodate both these and the cheaper 6ll6 type 2k by 8 devices. If 6ll6s are used the jumpers JP7 and JP8 must be changed to allow this. These jumpers are configured as follows:

JP7 and JP8	Memory Type
pin 1 to pin 2	6ll6 2k by 8
pin 2 to pin 3	6264 8k by 8

Refer to the component legend page in the schematics for the locations of these jumpers. They are adjacent to the RAM chips, U23 and U24 with pin 3 closest to pin 28 of the devices. NOTE: since 6ll6s are 24 pin devices and 6264s are 28 pin devices the socket will not be filled when using 6ll6s. These devices work like EPROMS in that it is the top 4 pins (pins 1,2,27 and 28) that must be left empty.

The video memory is organized as 16 bit words, where the lower byte is the ASCII character to be displayed and the upper byte is the attribute byte for that character. With the 8k by 8 memory devices this gives a total of 16k video memory, which may be used as four seperate pages of 2000 characters each, with attributes for each character. Both character and attribute can be written in a single bus cycle.

CPU access to the video memory is controlled by a synchronization and arbitration circuit which will allow the CPU essentially unlimited access to the video memory while preventing display flicker and hash as is sometimes seen on other (ed: inferior) systems. The three flip flops on U42 and U43 (both 74LS74s) accomplish most of this arbitration and synchronization. The edge trigger characteristics of the flip flop is used to ensure that only one CPU access is performed at a time and that it occurs at the appropriate time slot for CPU access to the memory. The CPUOK signal is true when the CPU has access to the memory. At this time the address multiplexers: U19, U20 and U21 (74LS157) switch the address from the CRT controller to the CPU address bus as inputs to the video RAM.

For a read operation the data is latched by two 74LS373 devices, U16 and U18, so that it will remain stable for the CPU since the video system must get on with the business of refreshing the screen. Since the character rate is the dot clock divided by 9, and since the CPU has 5/9 of a cycle to access the video memory this gives an access time of about 310 nsec. In special graphics mode (explained later) this is reduced to 250 nsec. For a write operation the timing and operation is the same except that the data is not latched, but is buffered by U15 and U17, both 74LS244s.

Video Pipeline and Character Generator

The data from the video character RAM, U23, is latched in a 74LS374 U26 at the end of a video access cycle. This data forms part of the address for the character generator, U34, a 2732A or 2764 type EPROM. The remaining addresses to the character generator come from the CRT controller in the form of a character row address. The row address describes which horizontal row of the character is being displayed. The character generator takes the ASCII character and the row address and produces the dot pattern which is to be sent to the CRT. This data is a single byte from the data outputs of the EPROM. To be PC compatible the character should be 9 bits wide. The extra bit is created from the upper three bits of the ASCII character and the upper bit from the character generator output. Basically, the ninth bit is the same as the eighth bit if the character is C0H or greater. This allows characters, like block graphics, to extend to meet the adjacent characters without a gap in between. The creation of this bit is done by a PAL, U30. This PAL also controls a number of other video related functions.

The video attribute data is routed to a PAL, U27. Here the attributes such as underline, highlight, and reverse video are decoded to behave as the PC does.

Video Attribute Control

Signetics provided another good video circuit when they made the SCB2673 Video Attribute Controller. The VAC takes the parallel video data from the character generator, latches it, combines it with the attribute data, adds the cursor and blanking signals and serializes it into two data streams for the CRT. It also generates the character clock, CCLK, from the dot clock, DCLK, by dividing DCLK by 9 (or by 8 in the special graphics mode). This circuit is U35 on the PC expansion board.

The character blink is generated by a 74LS393, U41, which should be about 2hz. For a faster blink a 74LS390 may be used. These circuits are used as divide by 32 or divide by 20 counters to divide the frame rate down to the blink rate. This blink signal is used by the VAC.

Video Output

The four video signals, HSYNC, VSYNC, NORM VIDEO and HIGHLIGHT go to a 74LS86 exclusive OR where each signal may be inverted or non-inverted to drive either a composite video monitor or a seperate video monitor as is normally used with the IBM PC. The inverting or non-inverting of the video signals is made by jumpering pins on JP1. With no jumpers in place the video signals are inverted. For operation with a PC type monitor one jumper needs to be in place from pin 1 to pin 2. Consult your monitor manual if you are unsure or what polarity is required. These outputs are TTL compatible and are brought to the DB-9 video connector, J6, as well as to a 10 pin header connector, J10.

For composite video the norm video and highlight video signals must be inverted, thus JP1 pin 5 must be jumpered to pin 6 and pin 7 must be jumpered to pin 8. In addition to this the 74LS86, U57, MUST (!) be changed to a 74LS136, which is an open collector exclusive or gate. To complete the composite video circuit JP1 pins 9 and 10 as well as pins 11 and 12 must be jumpered together.

In summary:

	JP1 Jumpers	U57
	==========	===
Seperate PC Type Video	1 to 2	74LS86
Composite Video	5 to 6	74LS136
	7 to 8	
	9 to 10	
	11 to 12	

Some reprogramming of the CRT controller will most likely be required for operation with composite video. The PC type monitors have a frame rate of 50Hz while most composite monitors require a frame rate of 60Hz for proper display. It may also be necessary to change the dot clock crystal, Y1.

PC EXPANSNION BOARD SOFTWARE

VIDEO SECTION

Calls to video display routines are made as in the IBM PC. Routines are accessed via interrupt 10H. Interrupt is made with function code in AH and parameters in AL, BX, CX, DX. Generally video routines do the same function with the same entry and return comditions as on the IBM PC. Exceptions are noted below. Most software which use the IBM video rom calls will run with the Slicer expansion board without modification.

Rom Calls

AH=0 Set mode
- AL = 0 40x25 BW (on color card)
- AL = 1 40x25 Color (on color card)
- AL = 2 80x25 BW (on color card)
- AL = 3 80x25 Color (on color card)
- AL = 4 320x200 Color graphics (on color card)
- AL = 5 320x200 BW graphics (on color card)
- AL = 6 640x200 BW graphics (on color card)
- AL = 7 80x25 BW (built in)
- *** Mode 7 is default.
- *** Most other rom calls do not work with modes 4 and 5. Use this call only to initialize the 6845 for these modes.

AH=1 Set Cursor Type
- CH = start line of cursor.
- CL = end line.
- *** Alpha modes only

AH=2 Set Cursor Position
- DH = Row.
- DL = Column.

AH=3 Read Cursor Position

Returns
- DX = Cursor Position.
- CX = Cursor Type.

AH=4 No Operation

AH=5 No Operation

AH=6 Scroll Up
- AL = Number of Lines. (0 means all)
- CX = Top, left corner.

DX = Bottom, right corner.
- BH = Attribute for blank line
- *** Alpha modes only.

```
AH=7   Scroll Down
  AL = Number of Lines. (Ø means all)
  CX = Top, left corner.
  DX = Bottom, right corner.
  BH = Attribute for blank line
  *** Alpha modes only.

AH=8        Read Character
returns
  AL = Character.
  AH = Attribute.
  *** Alpha modes only

AH=9   Write Attribute/Character
  AL = Character.
  BL = Attribute. (Alpha mode only)
  CX = Character count.

AH=1Ø  Write Character
  AL = Character.
  CX = Character count.

AH=11  Set Color Palette
  BH = Color palette.
  BL = Color ID

AH=12  No Operation (eventually write dot )
AH=13  No Operation (eventually read dot )

AH=14       Write TTY
  AL = Character.
  Cursor position updated after write.
  Special action on AL = CR, LF, BS, BEL.

AH=15 Current Mode
Returns
  AL = Mode (see function #Ø).
  AH = Number of characters per row.

*** Slicer addition
AH = -1 Write TTY With Expanded Escape Sequences
  AL = Character.
  Makes memory mapped video look like a serial terminal.
  The characters and character sequences on the next page have
  special effects.
```

CR, LF, BS as you would expect
ESC Y r c position cursor at row r, column c. r and c are in
           binary with offset 32.
ESC A   Cursor up
ESC B   Cursor down
ESC C   Cursor right
ESC D   Cursor left
ESC E   Erase screen (and home cursor)
ESC H   Home cursor
ESC I   Reverse line feed
ESC J   Erase to end of screen
ESC K   Erase to end of line
ESC b   Set foreground color
ESC c   Set background color
ESC d   Erase from beginnig of screen
ESC l   Erase line
ESC o   Erase from beginning of line
ESC L   Insert line
ESC M   Delete line

Video Software Notes

The following differences between the IBM's int 10 and the Slicer's int 10 should be noted:

Modes 4 and 5 are only supported in functions 0 and 15.

On the Slicer, there is only one text page in each mode. On the IBM the alpha modes have multiple pages.

Read character (function 8) only works in alpha modes.

Read and write dot are not implemented.
(Hey, this is an early version. Who uses these things anyway?)

KEYBOARD SECTION

Rom calls for the keyboard are via interrupt 16h, as on the IBM PC.

Rom Calls

AH=0 Read Character.
Returns
AL = Character.
AH = Scan code.

AH=1 Read Status.
Returns
Z = if character not ready.
AL = Preview of next character.

AH=2 Shift Keys
Returns
  AL = Bit set for each shift (cntl, alt, lock) key pressed.

*** New, for the Slicer.
AH = -1 Read Eight Bit Character.
Returns
  AL = Character.
  If a non-ascii (function, alt, home etc.) is pressed then Ø is
  returned this time, and the scan code will be returned next time.
  This one lets you use function keys with operating systems.

AH = -2 Set Bits on Port 3ØØh
  AL = Mask of bits to set

AH = -3 Reset Bits on Port 3ØØh
  AL = Mask of bits to reset

IO Address 3ØØH has bit outputs which control an assortment of things on this board. This present state of this port can not be read, so it is generally not possilbe to change just on bit. Functions -2 and -3 do the required bookkeeping so you can play with the individual bits

Control-Alt-Del is not implemented (use the hardware reset). Scroll lock, print screen and similar things are not implemented.

OTHER INTERRUPTS

Software for the IBM PC which use interrupt 1ØH and interrupt 16H should work as expected on the Slicer. (We have not found any software which needs the few interrupt 1Øh features not yet implemented on the Slicer.) This does not mean that all IBM software will work on the Slicer. Here are some things to watch out for.

Far jumps or calls to the IBM rom. I know of no one who is doing this, but it is conceivable.

Basic. There is no basic in the Slicer roms.

Absolute memory references. Some software looks at the memory locations where the IBM has the type-ahead buffer, current cursor position, current video mode etc. These things are not in the same locations on the Slicer. This information can be obtained via rom calls.

Other interrupts. The IBM rom has interrupt entries other than video and keyboard. (Disk, printer, cassette, etc.) The operating system provides easier access to these devices, but the rom calls are still often used.

Direct hardware control. Slicer video and keyboard hardware matches. Other devices are at different addresses. (Again, why not use the operating system)

Copy protection. Disks which must be booted to run will not work. These disks have their own operating system, and so they can't find the disks on the Slicer. Copy protection schemes often need to access the floppy disk controller directly.

Interrupts 11H, 12H, 13H, 17H, 1AH are partially implemented on the Slicer. Software which call these interrupts may work - no guarentee.

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SLICER BOARD EPROMS

On boot a check is made for memory mapped video. If the expansion board is present then it becomes the console output device. A check is made for an expansion keyboard. If one is present then it becomes the official console input device. Otherwise the console is assumed to be serial port A. Input and output for the debug monitor and the rom calls CONST, CONIN, CONOUT will go to the appropiate device. CPM86 and MSDOS use the rom calls so they will find your console. A jumper on pins 3 and 4 of JB2 overrides all this and forces serial port A to be the terminal. A jumper on pins 1 and 2 of JB2 is required to use the video board.

CONIN uses interrupt 16H function #-1. CONOUT uses interrupt 10H, function #-1, mode #7. (See above.) Debug monitor, CPM86, and MSDOS will still work if you switch modes with interrupt #10H, function #0. (Most software assume 80 columns, so the 40 column modes may look strange.)

NOTES FOR PROGRAMMERS

The expansion board console functions use a lot more stack space than the corresponding serial port functions. It is possible that software which runs with a serial terminal may bomb on the video board because of stack overflow. The IBM rom calls use a lot more stack space than the Slicer expansion board calls, so there will be no stack problems with software which runs on the IBM PC.

Not all of the RAM on the expansion board is needed for video memory. Some of the extra is used by the roms. Present cursor position, type ahead buffer, shift key state, current video mode are some examples of information store in ram. This stuff starts at (decimal) offset 16000 in the video ram. (So don't go blindly filling video ram with junk.)

PC EXPANSION ASSEMBLY INSTRUCTIONS

Assembly of this board should prove to be realitively easy, especially for those of you who have assembled some of our other kits. The proceedor is similar, so you may find yourself skipping over parts of the instruction simply because you've read them before.

So lets get right down to the business at hand.

Before you fire up your soldering torch and blaze away you should obtain all of the items on the following list of assembly tools:

Soldering Iron.....25-40 watt with fine tip!
Rosin core electronic solder
Volt/Ohm meter
Component Lead Trimmer
Small Screwdriver

Also useful:

A flat piece of soft 1" thick foam at least as large as the PC Expansion board. Put the printed circuit board on top of it. It is now easy to insert components with long leads: the leads just penetrate the foam.

And:

A flat piece of wood, metal or other material at least as large as the PC Exppansion board. Put it on top of the components when you are ready to turn the board over for soldering.

Bare Board Checkout

Begin your assembly with a careful visual inspection of your board. Look for shorts and broken traces checking with the ohm meter if in doubt. If needed, consult the schematics to verify any connection. Once your visual check is complete, use the ohm meter to check that there are no shorts between any of the power lines by measuring the resistance between the power input connections at the location for the power connector. These checks may seem trivial, but might save much grief later! Power and ground are internal and should be impossible to short. Refer to power connector configuration diagram toward the end of this section.

********** CHECK IT NOW! **********

If it is shorted, CALL US about a getting a repalcement.

Diodes, Resistors

[] Insert diode: 1N5230 OBSERVE POLARITY !
   Location: D1

[] Insert discrete resistor: 1k ohms (brown, black, red)
   Location: R1 (By IC 14 - upper center of board)

[] Insert discrete resistors: 47k (yellow, violet, orange)
   Locations: R2,R4

[] Insert discrete resistor: 47 ohms (yellow, violet, black)
   Location: R3

[] Insert discrete resistors: 1.5k (brown, green, red)
   Locations: R5,R6

[] Insert discrete resistor: 3.9k (orange, white, red)
   Location: R7

[] Insert discrete resistor: 4.3k (yellow, orange, red)
   Location: R8

[] Insert discrete resistor: 75 ohm (violet, green, black)
   Location: R9

[] Insert discrete resistor: 37 ohm (orange, violet, black)
   Location: R10 (1/2 watt)

[] Insert discrete resistor: 2.2k (red, red, red)
   Location: R15 (1/2 watt)

[] Solder and trim components

All resistors are 1/4 watt unless noted otherwise.

Sockets

When installing IC sockets, it is important to match the socket orientation with that of the circuit board silkscreen legend. It is also important to use good soldering techniques to avoid solder bridges and cold solder joints, both of which will provide headaches later. Try not to use too much or too little solder.

Should you use sockets? Opinions vary wildly. The full PC Expansion kit comes of course with sockets for all ICs, but should you use them? Consider this: Sockets are marvelous if you have a problem, suspect an IC and want to remove it. At that moment you are grateful for the presence of a socket, in particular if changing the IC solves the problem.

What if you remove an IC and find that a pin was bent and not inserted? You found the problem of course, but are you still grateful, particularly if you spend hours tracing the fault? This particular problem seems to occur more frequently than the problem of bad ICs.

Sockets can help to solve problems, but they also create problems. I compromise: I use sockets for the large and expensive ICs. All other ICs I solder into the board.

Keep one thing in mind: If you ever have to remove a soldered IC, do not go to any great length to remove the IC undamaged, it is preferable to destroy the IC and not the board in the removal process.

We recommend the following sockets be used as a minimum:

[] U9 PAL 9 (3 - 8 pin sockets or 1 - 24 pin "skinny dip" socket)

[] U10,U11 2732 (even and odd ROMs) - 28 pin socket

[] U22 HD6845SP - 40 pin socket

[] U23,U24 HM6264P - 28 pin socket

[] U27 PAL 27 - 20 pin socket

[] U30 PAL 30 (3 - 8 pin sockets or 1 - 24 pin "skinny dip" socket)

[] U34 2732 (character generator) - 28 pin socket

[] U35 SCB 2637B - 40 pin socket

[] U53 PAL 53 - 20 pin socket

[] U57 74LS86 or 74LS136 - 14 pin socket

[] U36 74HC04 --- VERY STATIC SENSITIVE !!!!

[] Insert the rest of the IC sockets if you wish to use them.

[] Solder components

Put your flat piece of material on top of the assembly to stop the sockets from falling out, turn the board over and solder the sockets.

Soldering the ICs

Now is the time to solder the ICs if you choose that route. Insert the following ICs:

[] 74LS245 U1, U2

[] 74LS244 U3, U4, U6, U8, U13, U15, U17, U28

[] 74LS373 U5, U7, U16, U18, U48

[] 74LS139 U12, U55

[] 7407 U14

[] 74LS157 U19, U20, U21

[] 74LS374 U25, U26

[] there is no U29 !!!

[] 74LS32 U31, U32, U51

[] there is no U33 !!!

[] 74LS04 U37, U38

[] 74LS163 U39

[] there is no U40 !!!

[] 74LS393 U41

[] 74LS74 U42, U43, U45, U46, U49, U50

[] there is no 44 !!!

[] 74LS322A U47

[] 74LS08 U52

[] 74LS02 U54

[] 75452 U56

[] 74LS86 or 74LS136 U57 - I recommend a socket on this one

[] SPARE U58

[] SPARE U59

[] Solder components

Capacitors

[] .01 mfd ceramic C1

[] .1 mfd ceramic C2, C4, C6, C8..C10, C12, C14..C17, C19..C27, C29..C37, C39, C41, C61, C62, C71

[] 10 mfd tant. C3, C5, C7, C11, C13, C18, C28, C38, C40
OBSERVE POLARITY !

[] 100 pfd ceramic C51, C52, C55, C57

[] 20 pfd ceramic C53, C54

[] jumper C56

[] 220 pfd ceramic C58, C59, C60

[] Solder and trim components

Resistor packs

[] RN1 does not exsist !!!

[] RN2 1K - 10 PIN
Make sure pin one is properly orientated.

[] RN3 10K - 6 PIN (pin 1 is indicated by square shaped solder pad)

[] Solder components

Connnectors, Jumpers

[] J1 Data bus 40 pin double header

[] J2 Address/control bus 50 pin double header

[] J3 62 position card edge connector

[] J4 62 position card edge connector

[] J5 Keyboard connector (DIN type)

[] J6 Video connector (D-sub type)

[] J7 Power connector

[] J8 4 pin single header

[] J9 10 pin double header

[] J10 10 pin double header (video connector)

[] JP1 12 pin double header

[] JP7 3 pin single header

[] JP8 3 pin single header

[] JP9 3 pin single header

[] JP10 3 pin single header

[] Solder components

Crystals, Transistors

[] Y1 16 meg crystal

[] Y2 14.318 meg crystal

[] Q1 2N2224 (transistor)

[] Solder components

Now insert the following chips in their appropiate sockets. Caution should be used as these chips are static sensitive.

[] PAL18L4 (PAL 9)	U9
[] 2732 (odd)	U10
[] 2732 (even)	U11
[] HD6845SP	U22
[] HM6264P	U23, U24
[] PAL12H6 (PAL 27)	U27
[] PAL20L10 (PAL 30)	U30
[] 2732	U34
[] SCB2637B	U35
[] 74HC04	U36
[] PAL16R4 (PAL 53)	U53

CONNECTOR INFORMATION

J1, J2, Expansion Interface

J1

input	expansion in	1	!	2	+5V
Bidirectional	data 15	3	!	4	+5V
bidirectional	data 14	5	!	6	+5V
bidirectional	data 13	7	!	8	+5V
bidirectional	data 12	9	!	10	+5V
bidirectional	data 11	10	!	12	+5V
bidirectional	data 10	13	!	14	+5V
bidirectional	data 9	15	!	16	+5V
bidirectional	data 8	17	!	18	+5V
bidirectional	data 7	19	!	20	+5V
bidirectional	data 6	21	!	22	ground
bidirectional	data 5	23	!	24	ground
bidirectional	data 4	25	!	26	ground
bidirectional	data 3	27	!	28	ground
bidirectional	data 2	29	!	30	ground
bidirectional	data 1	31	!	32	ground
bidirectional	data 0	33	!	34	ground
no connection		35	!	36	ground
output	/buffer enable	37	!	38	ground
input	input enabled	39	!	40	ground

J2

output	A0	1 !	2	A1	output
output	A2	3 !	4	A3	output
output	A4	5 !	6	A5	output
output	A6	7 !	8	A7	output
output	A8	9 !	10	A9	output
output	A10	11 !	12	A11	output
output	A12	13 !	14	A13	output
output	A14	15 !	16	A15	output
output	A16	17 !	18	A17	output
output	A18	19 !	20	A19	output
output	DT-/R	21 !	22	/BHE	output
input	DRQ	23 !	24	SASI-DRQ	output
output	/WR	25 !	26	/RD	output
output	/S0	27 !	28	ALE	output
output	/S2	29 !	30	/S1	output
input	/WAIT	31 !	32	/LCS	output
output	Timer1 Out	33 !	34	Timer0 Out	output
input	Timer0 In	35 !	36	/DEN	output
output	/PCS5	37 !	38	/PCS6	output
output	/MCS0	39 !	40	/PCS4	output
input	INT3	41 !	42	/MCS1	output
output	16 MHz clock	43 !	44	INT2	input
output	3.6864MHz clock	45 !	46	ground	
output	CPU clock	47 !	48	ground	
output	/Reset	49 !	50	ground	

J7, Power Connector

```
-12V   ground    +5V    +12V     -5V    N.C.    N.C.  Timer out
 O       O       O       O       O       O       O       O
   <--        power supply        -->
```

J9, interupts

Jumper two pins furthest left.

JP1, video output type

Jumper two pins furthest left for PC compatible video output.

JP7, video RAM type
==========
Jumper upper two pins for 6264 type 8k by 8 RAM

JP8,video RAM type
==========
Jumper upper two pins, same as JP7.

JBlØ, eprom type
==========
Jumper bottom two pins.

Sources and Part Numbers for Ribbon Connectors

Connectors for ribbon cables are made by many manufactures. The parts numbers given here are for TB Ansley as sold by Hallmark, a nation wide distributor for electronics parts, and for Digi-Key, a distributor who sells in particular to the hobbyist. Their brand is Robinson Nugent.

Here is the address of Digi-key:

High Way 32 South
P.O. Box 677
Thief River Falls, MN 56701

Tel. 1-800 346 5144
1-218 681 6674

Female connectors to the SLICER:

Type	Pos	Ansley	Digi-Key	Used for:
	40	609-4000M	R306-ND	SLICER, expansion interface
	50	609-5000M	R307-ND	SLICER, expansion interface

Cross reference of parts

C1	.01	mfd	ceramic cap.
C2	.1	mfd	ceramic cap.
C3	10	mfd	tantalum cap.
C4	.1	mfd	ceramic cap.
C5	10	mfd	ceramic cap.
C6	.1	mfd	ceramic cap.
C7	10	mfd	tantalum cap.
C8..C10	.1	mfd	ceramic cap.
C11	10	mfd	tantalum cap.
C12	.1	mfd	ceramic cap.
C13	10	mfd	tantalum cap.
C14..C17	.1	mfd	ceramic cap.
C18	10	mfd	tantalum cap.
C19..C27	.1	mfd	ceramic cap.
C28	10	mfd	tantalum cap.
C29..C37	.1	mfd	ceramic cap.
C38	10	mfd	tantalum cap.

C39	.1 mfd ceramic cap.
C40	10 mfd tantalum cap.
C41	.1 mfd ceramic cap.
C50,C51, C55,C57	100 pfd ceramic cap.
C52,C54	20 pfd ceramic cap.
C58..C60	220 pfd ceramic cap.
D1	1N5230 or similar 5V zener diode
J1	40 pin double header
J2	50 pin double header
J3	62 position card edge connector
J4	62 position card edge connector
J5	DIN type connector
J6	9 pin D-sub type connector
J7	8 pin power connector (male and female sections)
J8	4 pin single header
J9	10 pin double header
J10	10 pin double header
JP1	12 pin double header
JP7	3 pin single header
JP8	3 pin single header
JP9	3 pin single header
JP10	3 pin single header
Q1	2N2224 transistor
R1	1k 1/4 watt resistor
R2, R4	47k 1/4 watt resistors
R3	47 ohm 1/4 watt resistor
R5, R6	1.5k 1/4 watt resistors
R7	3.9k 1/4 watt resistor
R8	4.3k 1/4 watt resistor
R9	75 ohm 1/4 watt resistor
R10	36 ohm 1/2 watt resistor
R15	2.2k 1/2 watt resistor
RN2	1k 10 pin resistor pack
RN3	10k 6 pin resistor pack
U1, U2	75LS245
U3, U4, U6, U8, U13, U15,U U17, U28	74LS244
U5, U7, U16, U18, U48	74LS373
U9	PAL18L4 (PAL 9)
U10, U11	2732
U12,U55	74LS139

U14		7407
U19, U20, U21		74LS157
U22		HD6845SP
U23, U24		HM6264P
U25, U26		74LS374
U27		PAL12H6 (PAL 27)
U30		PAL20L10 (PAL 30)
U31, U32, U51		74LS32
U34		2732
U35		SCB2673B
U36		74HC04
U37, U38		74LS04
U39		74LS163
U41		74LS393
U42, U43, U45, U46, U49, U50		74LS74
U47		74LS322A
U52		74LS08
U53		PAL16R4 (PAL 53)
U54		74LS02
U56		75452
U57	*	74LS86 or 74LS136

* 74LS86 for seperate video and 74LS136 for composite video.

Y1	16 meg. crystal
Y2	14.318 meg. crystal

Parts list

Capacitors

2	20 pfd ceramic	**C53, C54**
4	100 pfd ceramic	**C51, C52, C55, C57**
3	220 pfd ceramic	**C58..C60**
1	.01 mfd ceramic	C1
34	.1 mfd ceramic	C2, C4, C6, C8..C10, C12, C14..C17, C19..C27, C29..C37, C39, C41, C61, C62, C71
9	10 mfd tantalum	C3, C5, C7, C11, C13, C18, C28, C38, C40

Connectors

3	80 pin double headers
1	20 pin single header
1	8 pin male power connector
1	8 pin female power connector
1	9 pin D-sub type connector (Video connector)
1	DIN type connector (Key board connector)

Crystals

1	16 meg crystal
1	14.318 meg crystal

Diodes

1	1N5230 or similar	D1

IC's

3	2732	U10, U11, U34
1	7407	U14
1	74HC04	U36
1	74LS02	U54
2	74LS04	U37, U38
1	74LS08	U52
3	74LS32	U31, U32, U51
6	74LS74	U42, U43, U45, U46, U49, U50
1	74LS86	U57*
1	74LS136	U57*
2	74LS139	U12, U55
3	74LS157	U19, U20, U21
1	74LS163	U39
8	74LS244	U3, U4, U6, U8, U13, U15, U17, U28
2	74LS245	U1, U2
1	74LS322A	U47
5	74LS373	U5, U7, U16, U18, U48
2	74LS374	U25, U26
1	74LS393	U41
1	75452	U56
1	HD6845SP	U22
2	HM6264P	U23, U24
1	PAL12H6 (PAL 27)	U27
1	PAL16R4 (PAL 53)	U53
1	PAL18L4 (PAL 9)	U9
1	PAL20L10 (PAL 30)	U30
1	SCB2673B	U35

* 74LS86 used for seperate video output.
* 74LS136 used for composite video output.

Resistors and resistor packs

1	36 ohm 1/2 watt resistor	R10
1	47 ohm 1/4 watt resistor	R3
1	75 ohm 1/4 watt resistor	R9
1	1k 1/4 watt resistor	R1
2	1.5k 1/4 watt resistors	R5, R6
1	2.2k 1/2 watt resistor	R15
1	3.9k 1/4watt resistor	R7
1	4.3k 1/4 watt resistor	R8
2	47k 1/4 watt resistors	R2, R4
1	1k 10 pin resistor pack	RN2
1	10k 6 pin resistor pack	RN3

Sockets

6	8-pin or 2 24-pin (.300" spacing)	U9, U30
1	8-pin	U56
17	14-pin	U14, U31, U32, U36..U38, U41..U43, U45, U46, U49..U52, U54, U57
6	16-pin	U12, U19..U21, U39, U55
20	20-pin	U1..U8, U13, U15..U18, U25..U28, U47, U48, U53
5	28-pin (.600" spacing)	U10, U11, U23, U24, U34
2	40-pin	U22, U35

Transistor

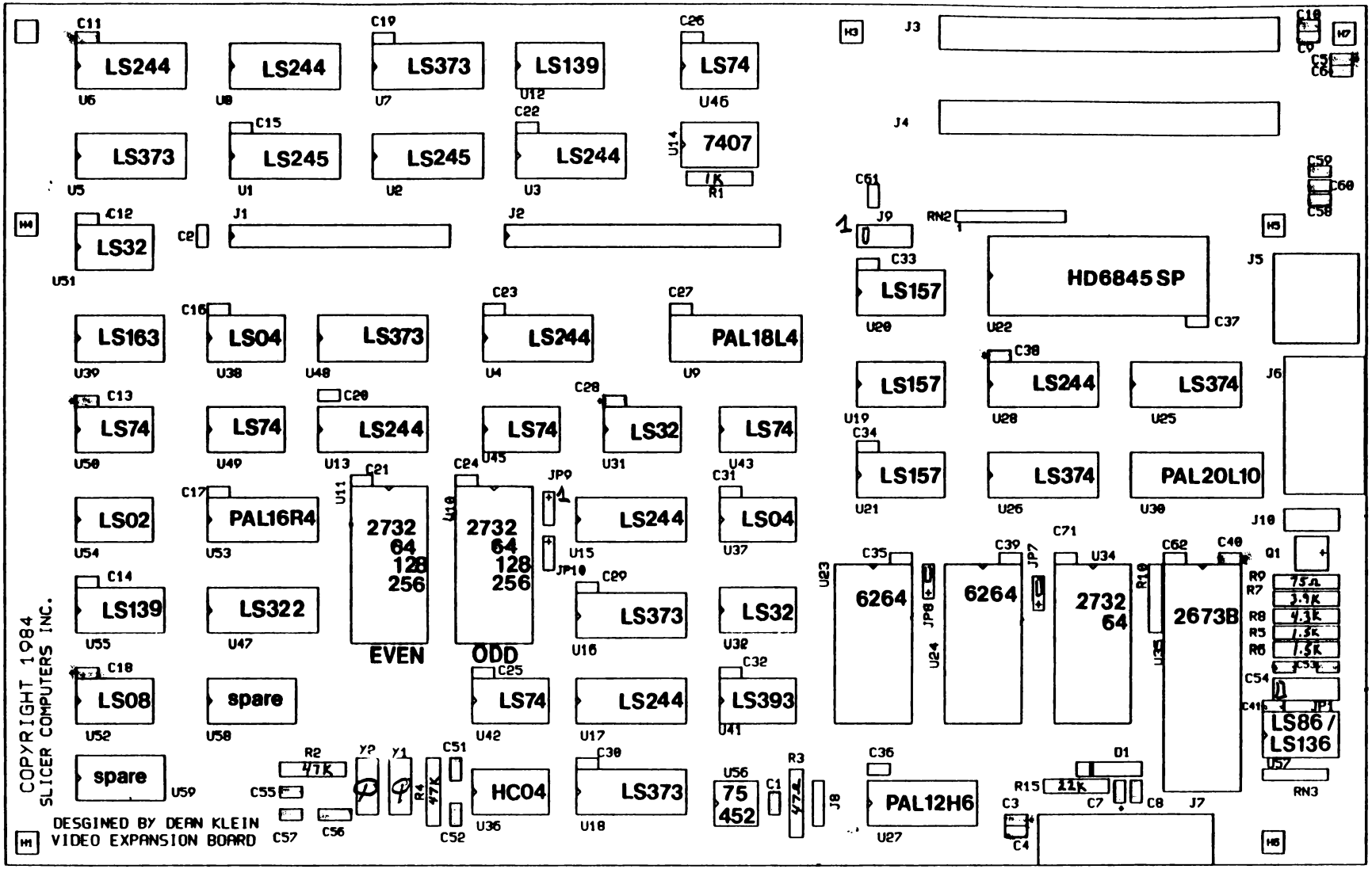
1	2N2222	Q1

```
PAL18L4
PAL9
DECODER
SLICER COMPUTERS INC, MPLS. MN
A16 A15 A11 A10 A9 A8 A7 A6 A5 A4 PALCS GND
 S2 PCS6 MCS1 DEN /CS2 /CS1 /MMA /BDEN A19 A18 A17 VCC

/MMA=/DEN*S2*A19*/A18*A17*A16*/A15
/CS2=/S2*/A15*/A11*/A10*A9*A8*A7*/A6*A5*A4
/CS1=/DEN*S2*A19*/A18*A17*A16*A15+
      /DEN*/S2*/A15*/A11*/A10*A9*A8*A7
/BDEN=/DEN*/PCS6+/DEN*/MCS1+
      /DEN*S2*A19*/A18*A17*A16+
      /DEN*/S2*/A15*/A11*/A10*A9*A8*A7

DESCRIPTION
```

```
PAL12H6
PAL27H 5/7/85     V1.1
SLICER COMPUTERS INC. MINNEAPOLIS, MN 55418

RA3 RA2 RA1 RA0 VAT6 VAT5 VAT4 VAT3 VAT2 GND
VAT1 VAT0 ABLANK ARVID AHILT AUL UL VA12 /CHMODE VCC

VA12=/RA3*RA3
UL=
AUL=RA3*/RA2*RA1*RA0*/VAT2*/VAT1*VAT0*/CHMODE
AHILT=VAT3*/CHMODE
ARVID=VAT6*VAT5*VAT4*/CHMODE
ABLANK=/VAT6*/VAT5*/VAT4*/VAT2*/VAT1*/VAT0*/CHMODE+
       VAT6*VAT5*VAT4*VAT2*VAT1*VAT0*/CHMODE
DESCRIPTION
```

```
PAL20L10
PAL30
VIDEO SYSTEM CONTROLLER
SLICER COMPUTERS INC. MINNEAPOLIS, MN 55418
A0 WRB RDB BHEB CCLK IOA13 VA12 CHMODE VAT7 CA7 CA6 GND
CA5 P14 VDB7 /CPUOK /BIN /VDB8 /ABLINK /VROE /VAD12 /WHB /WLB VCC

IF(VCC) /VROE=/CPUOK+CPUOK*/RDB
IF(VCC) /ABLINK=CHMODE*/VAT7+/CHMODE
IF(VCC) /VDB8=/CA7+/CA6+/VDB7
IF(VCC) /BIN=CPUOK*/WRB
IF(WHB*/WHB) /VDB7=/VDB7
IF(VCC) /WHB=CPUOK*/WRB*/BHEB
IF(VCC) /WLB=CPUOK*/WRB*/A0
IF(VCC) /VAD12=/CPUOK*/VA12+CPUOK*/IOA13
IF(WHB*/WHB) /CPUOK=/CPUOK
DESCRIPTION
```

```
PAL16R4
PAL53
PC BUS CONTROLLER VER2.Ø
SLICER COMPUTERS INC. MINNEAPOLIS, MN 55418
CK CLK AØ BHE S1 S2 RDY CS OE GND
OE1 /RDWR /RD /FF1 /FF2 /FF3 /FF4 /DONE /ALE VCC

/FF1:=/FF3*/FF2*/FF1*/CS+/FF3*FF2*/FF1+
      /FF3*FF2*FF1+FF4*FF3*FF2*FF1*/CS+
      /FF4*FF3*FF2*FF1*/CS
/FF2:=/FF3*/FF2*FF1+/FF3*FF2*/FF1+/FF3*FF2*FF1+
      FF3*FF2*FF1*/CS*BHE+FF4*FF3*FF2*FF1*/CS
/FF3:=/FF3*FF2*FF1*RDY+FF3*/CS*BHE+FF4*FF3*/CS
/FF4:=/FF4*FF3*FF2*FF1*/BHE+FF4*/CS+/FF4*/FF3*/FF2*/FF1*/CS*AØ*/BHE
IF(VCC)/RDWR=/FF3*FF2
IF(VCC)/RD=/FF3*FF2*/S1
IF(VCC)/ALE=/FF3*/FF2*FF1*CLK
IF(VCC)/DONE=/FF4*FF3*FF2*FF1*BHE+FF4*FF3*FF2*FF1
DESCRIPTION
```



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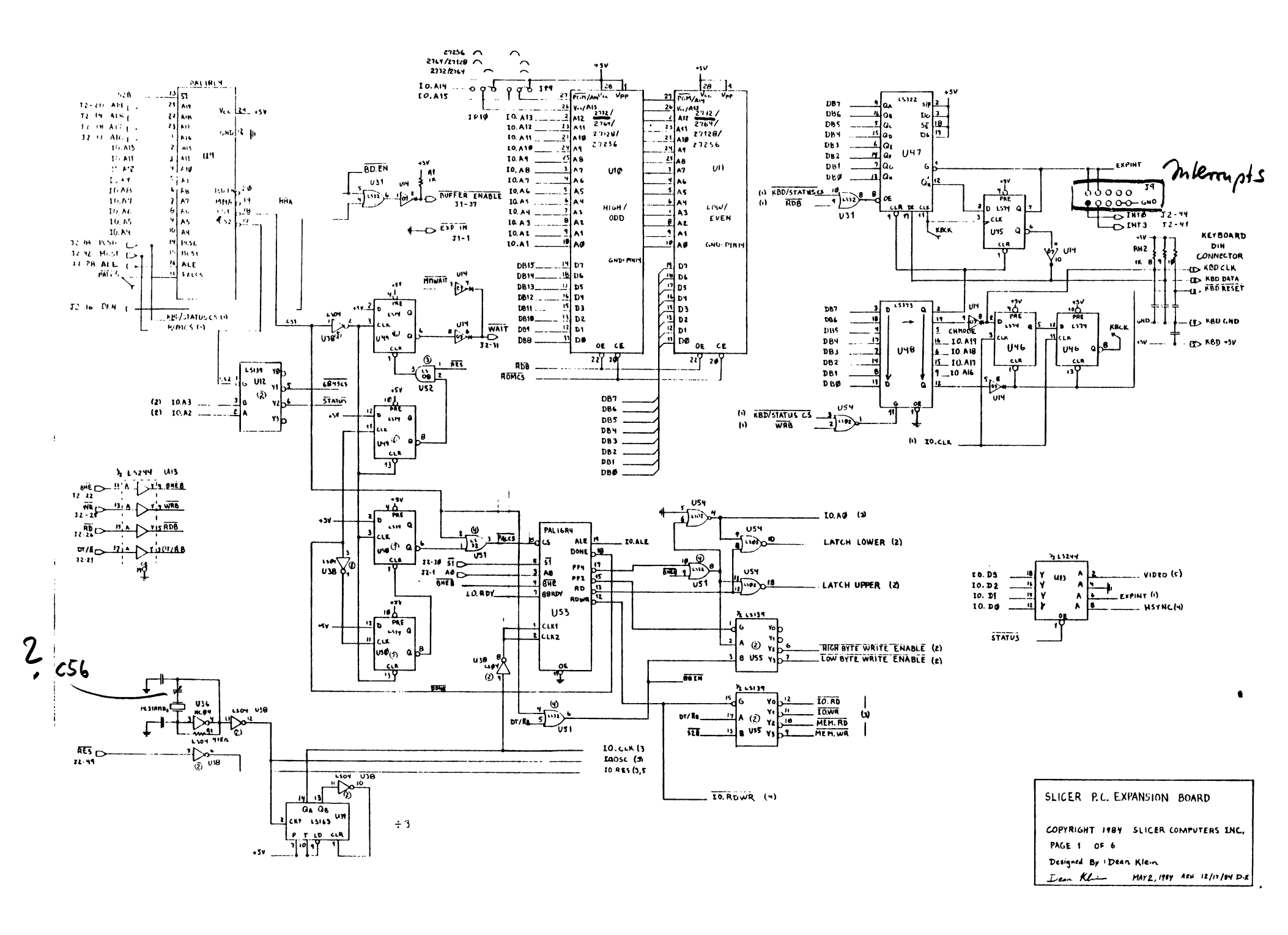

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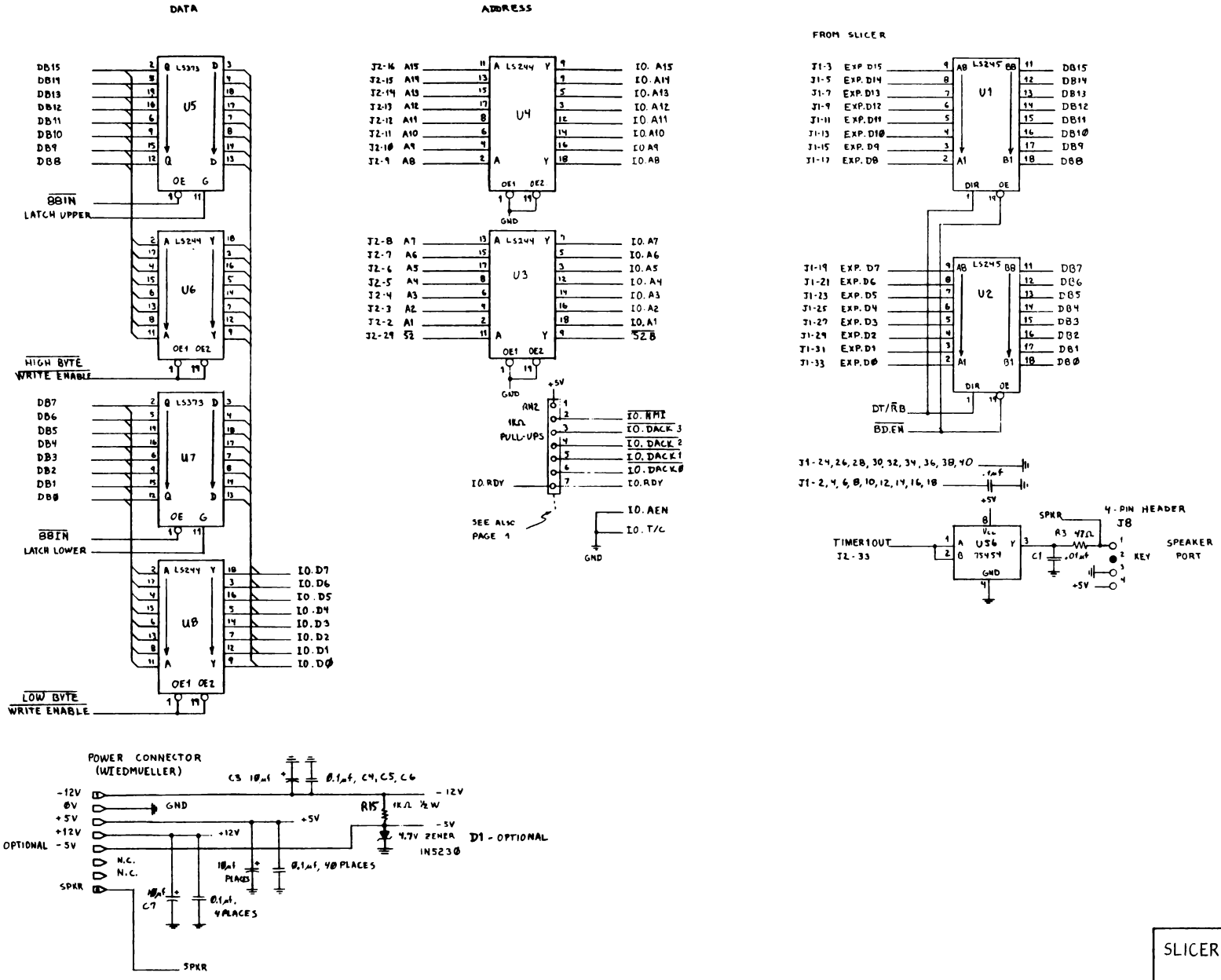

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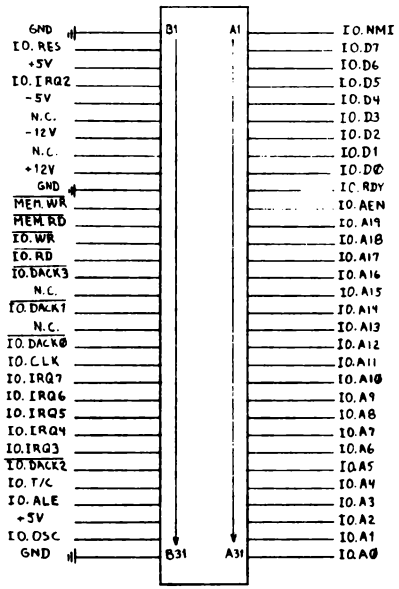
IO CHANNEL CONNECTORS (2)



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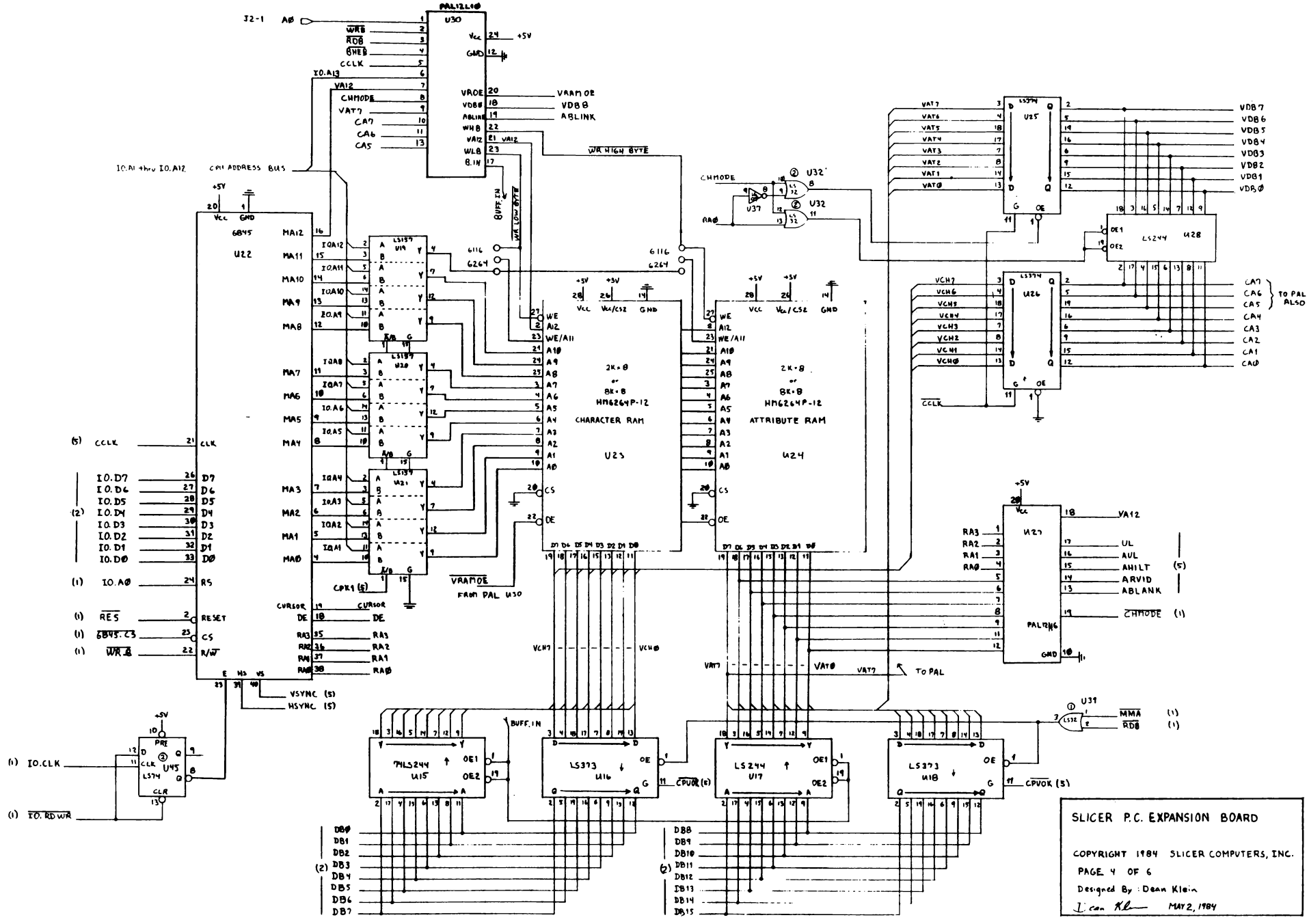
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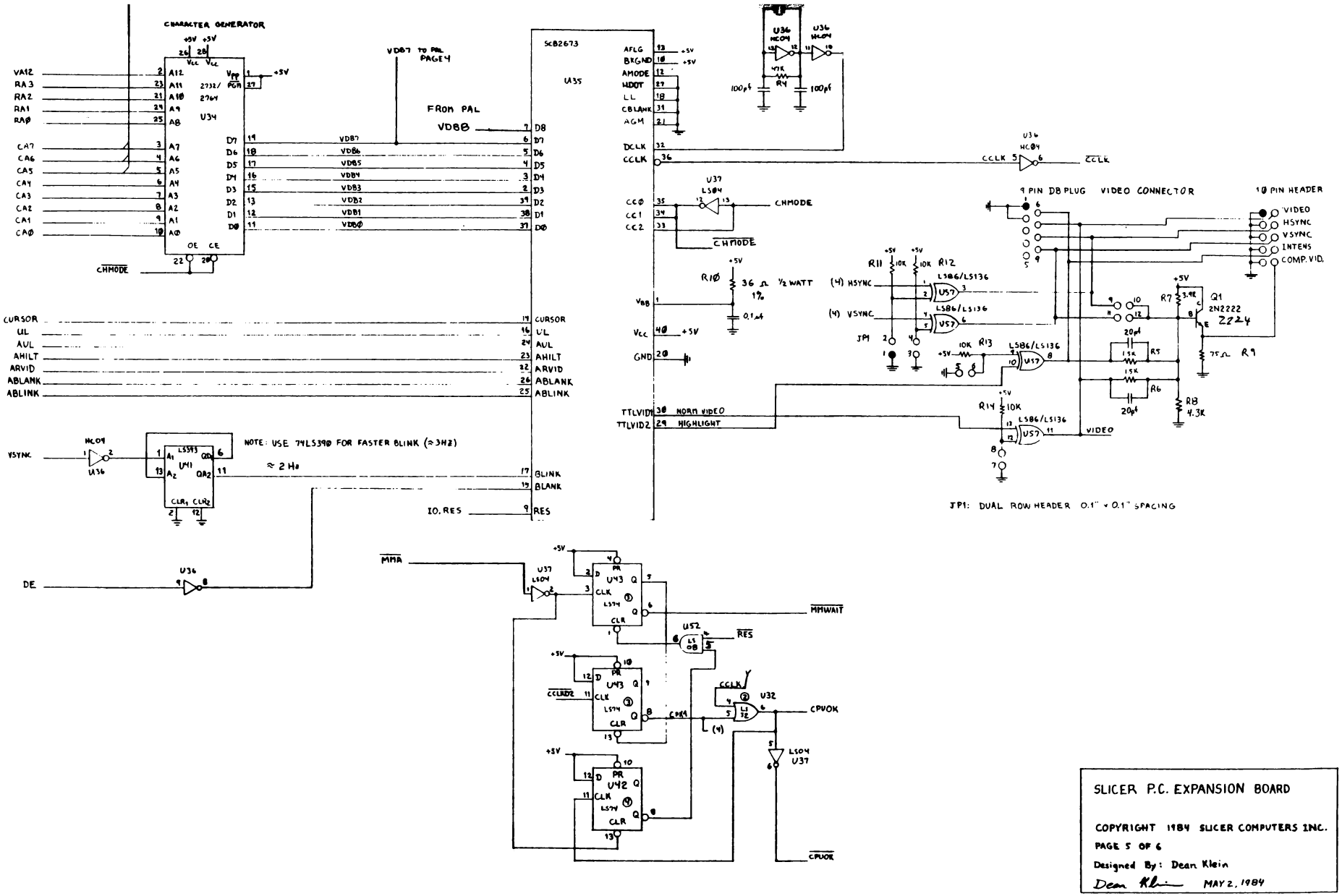
MAY 2, 1984
PAL12L10 U30
6845 U22
CHARACTER RAM U23
ATTRIBUTE RAM U24
2K x 8 or 8K x 8 HM6264P-12
LS157 U19
LS157 U20
LS157 U21
LS374 U25
LS374 U26
LS374 U27
LS244 U28
LS32 U32
LS32 U39
LS74 U45
74LS244 U15
LS373 U16
LS244 U17
LS373 U18
PAL12H6
WR HIGH BYTE
WR LOW BYTE
BUFF IN
VRAM OE
VDB0
ABLINK
CHMODE
VRAMOE
FROM PAL U30
TO PAL
TO PAL ALSO
CPURD (5)
CPUWR (5)
VSYNC (5)
HSYNC (5)
MMA (1)
RDB (1)
IO.A0 thru IO.A12
CPU ADDRESS BUS
IO.CLK
IO.RD WR



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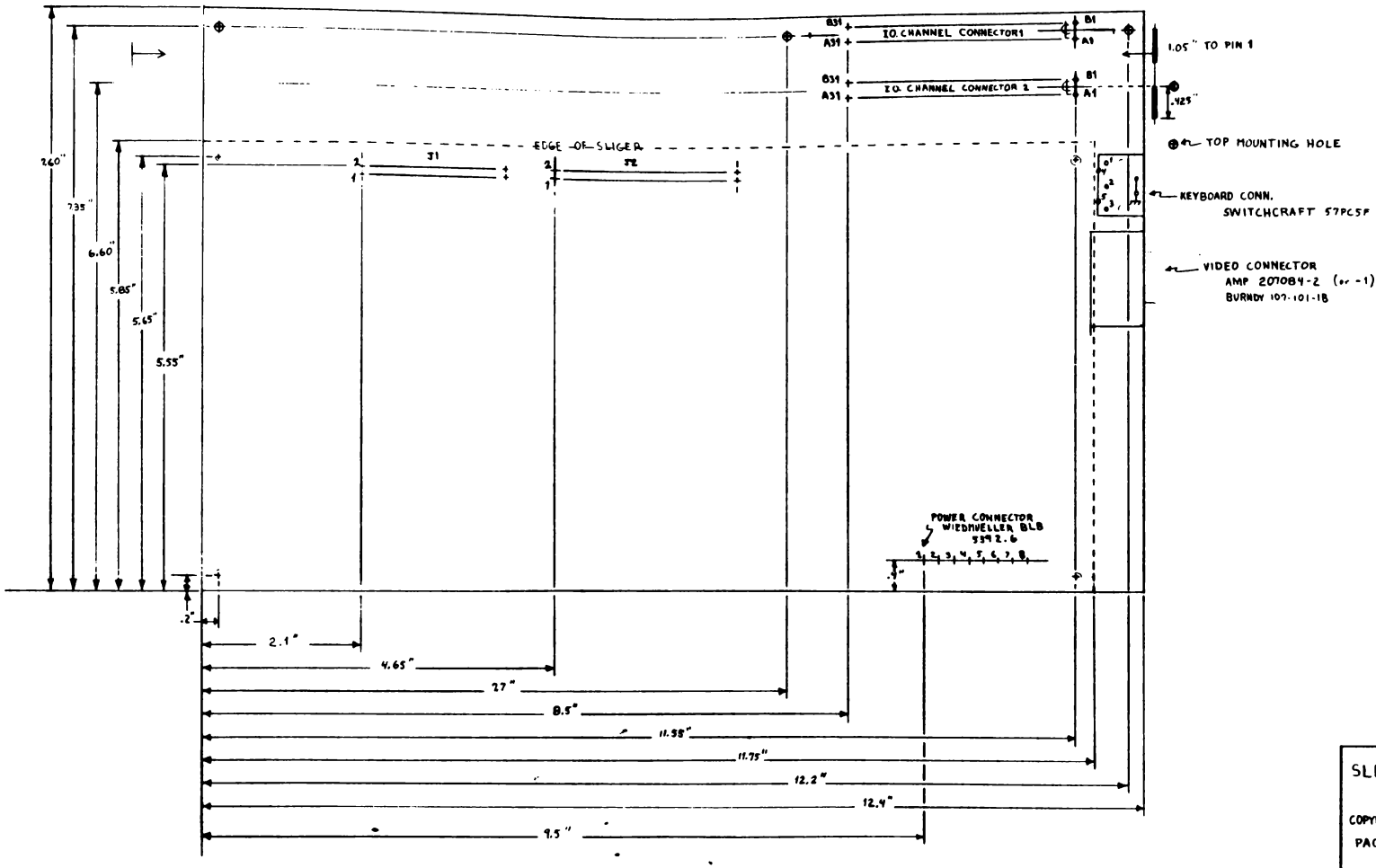

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