Pin	Bit	Direction	Inverted?	Signal Name
2.	D0	Data output		
3.	D1	Data output		
4.	D2	Data output		
5.	D3	Data output		
6.	D4	Data output		
7.	D5	Data output		
8.	D6	Data output		
9.	D7	Data output		
15.	D3	Control In	Yes	Error
13.	D4	Control In		Select out
12.	D5	Control In		Printer empty
10.	D6	Control In		Acknowledge
11.	D7	Control In	Yes	Printer busy
1.	D0	Control out	Yes	Data strobe
14.	D1	Control out	Yes	Auto feed
16.	D2	Control out		Initialize printer
17.	D3	Control out	Yes	Select In
18-25.	Ground			

Table 2-2: Printer port pins sorted by groups

Port Number	Data Out	Control In	Control Out
1	3BC	3BD	3BE
2	378	379	37A
3	278	279	27A

Table 2-3: PRINTER I/O address assignments (change in program if needed)

Printer Port Video Adapter 2-1

The ability to see a video picture on your computer is fast becoming a standard. Not all of us, however, have the several hundred dollars necessary to buy the needed hardware and software. Some cheaper devices have come out to do the task, but they fall far short, taking several seconds for just one frame. But you

can make an adapter yourself and do it for under $50! With a little experience in wire wrapping or printed circuit board assembly, including IC circuits, you can build yourself the printer port video adapter.

This adapter plugs into your computer's printer port. It grabs pictures at a resolution of 256 × 256 by 16 shades of gray format. The speed is one frame per one to two seconds on a 486 computer. Speed depends on computer speed and the resolution used. The only drawback is that the picture is in black and white.

Three Quick BASIC programs are included to view, save, and recall images. Both require a VGA monitor. One uses the 320 by 200 screen to allow up to 32 shades of gray. The image fills just about the whole monitor screen. The second program uses the 640 by 480 VGA screen mode. This allows separate live and recalled image areas, as well as a directory of saved images.

The third is like the second, but a whole lot slower. The speed is a trade-off for BMP compatibility.

In order to capture an image, you have to load it into some sort of memory. Then, you must be able to read that memory and show it on the screen or save it to a disk. The adapter contains its own memory of 64K by 8 bits. The adapter uses SRAM memory for high-speed operation. SRAM stands for "static random access memory." A 74LS157 multiplexer allows the adapter to select between two modes. The first is grabbing the picture into memory. The second is the computer reading the picture back out of memory. The computer then stores the picture into its memory, screen, and disk drives.

The adapter's memory is addressed by two 74LS393 counters. The first counter is the horizontal counter. It advances once for each pixel or dot from the left side to right side of the screen. The second, vertical counter advances once for each horizontal line, from the top to the bottom of the screen. The counters are also used to read data from the memory to the computer. In this case they are connected as though they are one sequential counter.

When capturing a picture, the counters are told when to count by synchronizing signals from an LM1881 sync separator. This IC takes a sample of the video input and separates the signals that tell how to synchronize the picture. Everything then lines up consistently. These signals are the horizontal and vertical sync signals.

A CA3306 high-speed video analog-to-digital converter takes the analog video pixels and converts them to digital values. These values are then stored in the SRAM memory.

A 74LS244 buffer sends the data back to the printer port of the computer 5 bits at a time. Only 4 bits are used, except in the lower resolution program. When the data gets to the computer, it has to be divided by 16 to return the bits to the correct position.

Another buffer, a 74LS14, receives control commands from the computer. It is also used as an inverter for the clock. It selects between the two memory chips and for D7 before it is sent back to the computer.

A 1N914 diode makes sure that the video level at sync time is 0 volts. This is referred to as "DC restoration." It prevents the average video level from wandering, which will happen with some VCRs.

An adjustable 5-MHz clock provides the master clock for the digital-to-analog converter. The oscillator has to be synchronized to the incoming signal. This is done by using a 4046 phase-locked loop. This PLL is synchronized so that the oscillator starts correctly with the left edge of the picture. Without this feature, vertical lines will have small steps in them. With it, every dot is synchronized with the left edge of the picture, and therefore, vertical lines are straight up and down.

The circuit can be built on a 4-1/2 × 6 inch circuit board, or on a printed circuit board. It fits into a box the same size (i.e., a little larger) by about 2 inches tall.

The printer port jack is a 25-pin male DIN type, to mate to the jack on the computer. The cable should be kept short, 4 to 6 feet maximum, to reduce noise pickup. The 220-ohm resistors, 0.001 capacitors, and 74LS14 make it possible to have that long of a cable.

Power comes from a regulated 5-volt 0.5-amp source. A 9-volt AC 500-mA adapter and an LM7805 regulator will work. The regulator will need a small heat sink.

The video input jack is a male RCA jack mounted on the box. An RCA cable then connects the input to the video output of a VCR, or to a camera. The video source must be strong or noise will be fed back into the source. A buffer could prevent this noise on weaker signals. On a VCR, this noise will appear as wavy lines through the picture of an attached TV. The noise only occurs while the video adapter is in the process of capturing a picture.

The only layout problem is with the analog parts. The CA3306 and LM1881 ICs are sensitive to and pick up digital noise. They must be kept isolated from the other circuitry and close to the input jack. A 470-ohm resistor and 500-pF capacitor at the input of the LM1881 help protect it from noise. Four or five capacitors about 0.1 µF in value from the 5-volt IC pins to their ground pins also reduce noise. Another noise reduction method is to use an 18- to 22-gauge copper wire to connect all of the grounds together. You could also use a two-layer board with one side at ground potential, as this forms a "bus" that is less prone to allow noise.

Mode selection via the 74LS157 is as follows:

```
COMPUTER IN CONTROL (D1=0)
-------------------------
HORIZONTAL COUNT = COMPUTER COUNT - D0 = 1
HORIZONTAL RESET = COMPUTER RESET - D4 = 1
VERTICAL COUNT = HORIZONTAL COUNTER BIT 7
VERTICAL RESET = COMPUTER RESET
VIDEO IN CONTROL (D1=1)
-----------------------
HORIZONTAL COUNT = 5 MHz CLOCK
HORIZONTAL RESET = HORIZONTAL SYNC.
VERTICAL COUNT = HORIZONTAL COUNTER BIT 7
VERTICAL RESET = VERTICAL SYNC.
```

The printer port pin definitions chart, Table 2-4, shows how difficult it can be to input information via the printer port. The printer port is primarily designed as an output device, but it does have five inputs to monitor the printer status. These upper 5 bits arrive at the computer with 1 bit inverted. That bit has to be inverted before it is sent to the computer. Using software correction takes too much time.

The data bits then have to be divided by 16 when they get to the computer, to return the bits to the correct positions. This math is performed in the line containing "INP(&379)/16" in the Quick BASIC programs for high-resolution and BMP operation. In the low-resolution program it is all done, in advance, when the palette is defined. There is no software division necessary and the program runs faster. The two high-resolution programs utilize only the upper 4 bits, so they don't have to manipulate the data as much.

There are some areas of the picture that you don't want to capture. This is prevented by holding the appropriate counter at reset during those undesired times.

Data Bit	Inverted Data?	Input or Output?	Plug Pin#	Signal Name
Control output port:				
D0	Yes	0	1	Strobe data
D1	Yes	0	14	Auto feed paper
D2	No	0	16	Initialize printer
D3	Yes	0	17	Select In
Control input port:				
D3	Yes	I	15	Error
D4	No	I	13	Select out
D5	No	I	12	Printer empty
D6	No	I	10	Acknowledge
D7	Yes	I	11	Printer busy

Printer control I/O assignments:

Output data	Input data	LPT port number
3BE	3BD	1
37A	379	2
27A	279	3

Table 2-4: Printer port pin definitions

Bit	Value	Definition
Bit 0	Value of "1"	Next address
Bit 1	Value of "2"	Low = read, high = write
Bit 2	Value of "4"	Reset

Table 2-5: Control output assignments for video adapter

This "back porch" area refers to signals that appear just after the synchronization signals. The LM1881 doesn't have a vertical "back porch" detection circuit, so those signals are processed and stored into SRAM. Software is used to remove them. The vertical start position, used to draw the picture on the screen, begins as a negative number. This will result in starting above the top of the visible screen, which therefore hides those signals.

Back-porch signal applications include things such as closed captioning for the hearing impaired. During the horizontal back porch, at the left side of the screen, there is a color reference signal. This is a burst of green, but it sometimes appears as a white box along the side of the picture.

The software can run faster if the aspect ratio correction is omitted. This is the "IF X=5" line in the low-resolution program. Without it, the picture is a bit tall and narrow, but with it, the program runs a little more slowly. You can experiment with it by commenting out that line.

For price and availability, 32K × 8 SRAMS were used. These are used on motherboards as "cache memory." Speed is not a critical factor. At 5 MHz there are 100 nanoseconds for the counters to settle, then another 100 nanoseconds to write data into memory. Most of these cache chips can operate in the 15- to 25-nanosecond range. Size is a factor, and the cache SRAMS are quite small.

To get 64K of storage without taking the space and time for two IC sockets, I piggy-backed two 32K chips (i.e., put one on top of the other). Pin 20 on the

Quantity	Part Number	Source	Phone Number
1	LM1881	Digi-Key	1-800-344-4539
1	CA3306	Digi-Key	1-800-344-4539
2	32K X 8 SRAM	La-Paz	1-800-[illegible]
1	74LS244	Mouser	1-800-346-6873
1	74LS158	Mouser	1-800-346-6873
2	74LS393	Mouser	1-800-346-6873
1	74HC4046	Mouser	1-800-346-6873
1	74LS14	Mouser	1-800-346-6873
1	1N914	Mouser	1-800-346-6873
1	28-pin narrow socket	Make from a wide one	
1	20-socket		
1	18-socket		
2	16-sockets		
3	14-sockets		
1	8-socket		
Misc.	resistors, capacitors, etc.	Radio Shack, Digi-Key, or Mouser	

Table 2-6: Parts sources

top chip is bent out first and connected to a short piece of wire that connects to pin 6 on the 74LS14. The two chips can then be soldered together. The run from pin 20 to ground is cut underneath the circuit board. A jumper under the circuit board connects the 74LS393 pin 3 to the 74LS14 pin 5, and to pin 20 of the SRAM socket as well.

To check out the operation of the device, first connect the 9-volt AC adapter. Then, plug in a short 25-pin to 25-pin cable to the printer port. Next, add an RCA cable to a VCR or other video output source. Make sure the VCR is on and in control, and that it has a good signal.

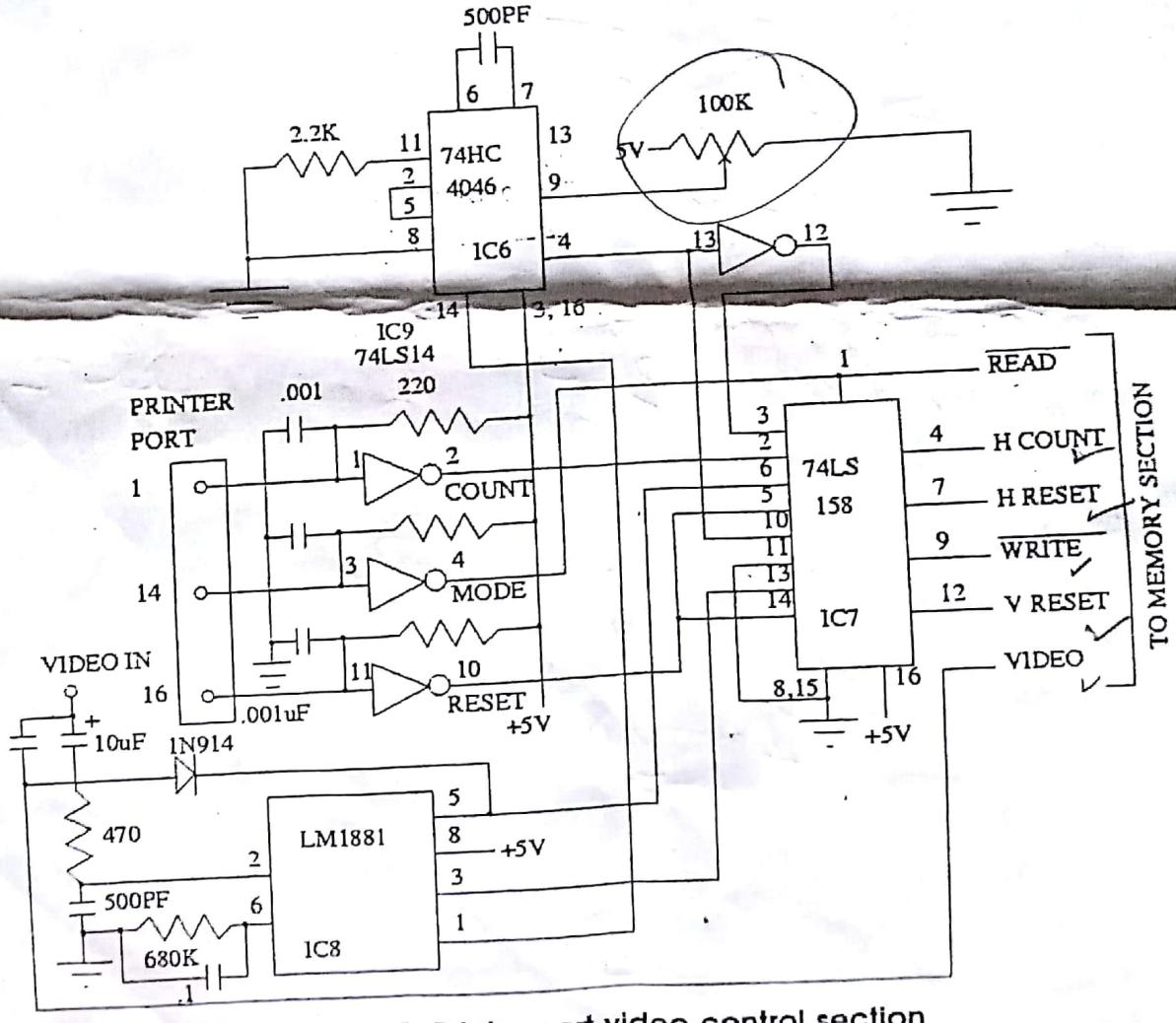


Figure 2-1: Printer port video control section

Use the software in Quick BASIC or the EXE version. When you run the software, there are three options. Pressing the letter "Q" quits the program. Pressing "S" saves the current picture from the video source. Pressing "V" lets you view a previously saved picture. It doesn't take much time to save a lot of pictures, and it's fun to be able to review them whenever you want.

There are three programs on the following pages. First there is the PPVA-FS, which is 320 × 200 with 32 shades of gray. Then there is PPVA-VGA, which is 640 × 480 with 16 shades of gray. The third is PPVA-BMP, which is 640 × 480 with BMP compatibility.

The BMP version has several lines that start with "DATA" to make a fake BMP file header. This header tells the program viewing the file the size of the picture, the size of the palette, and the actual colors to appear in the palette.

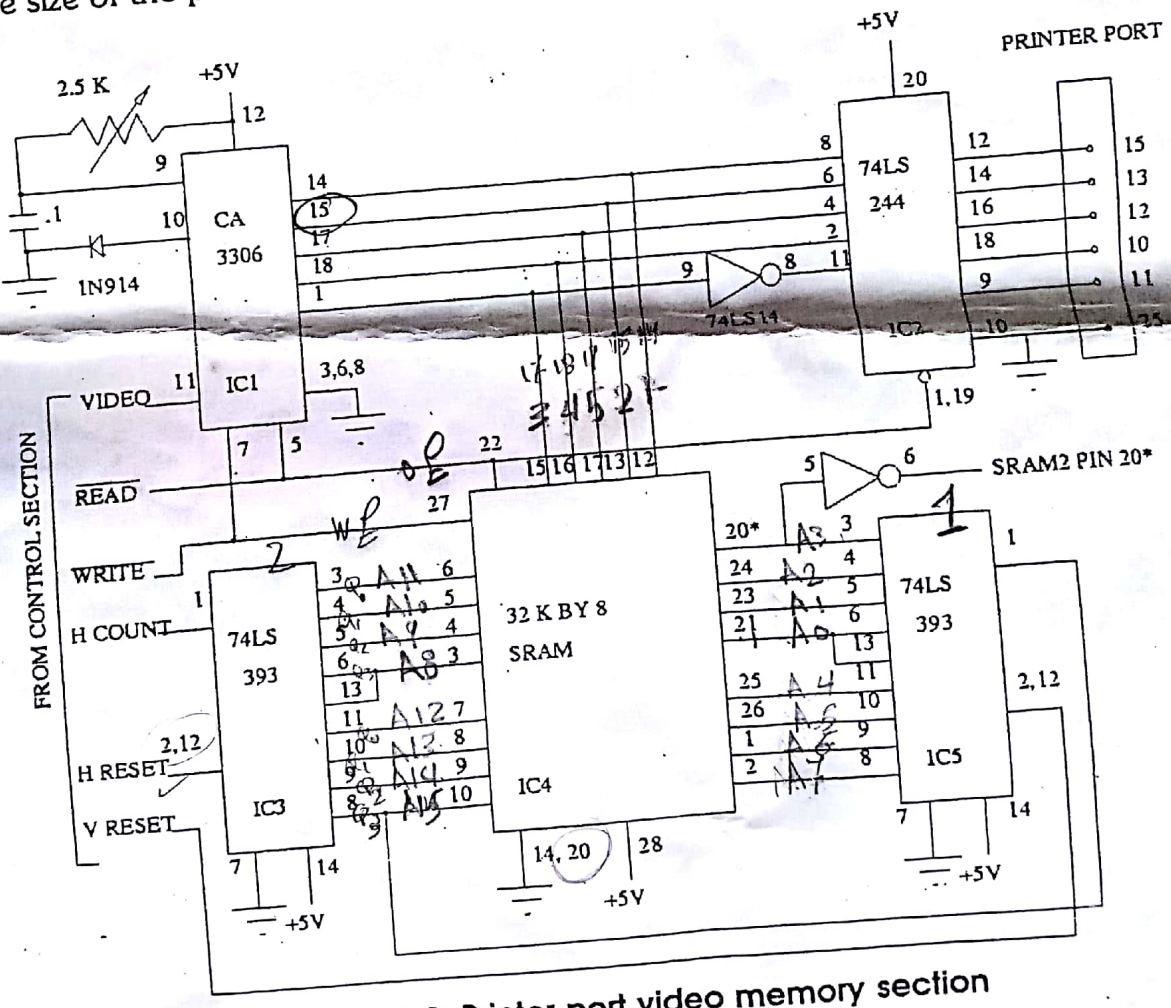
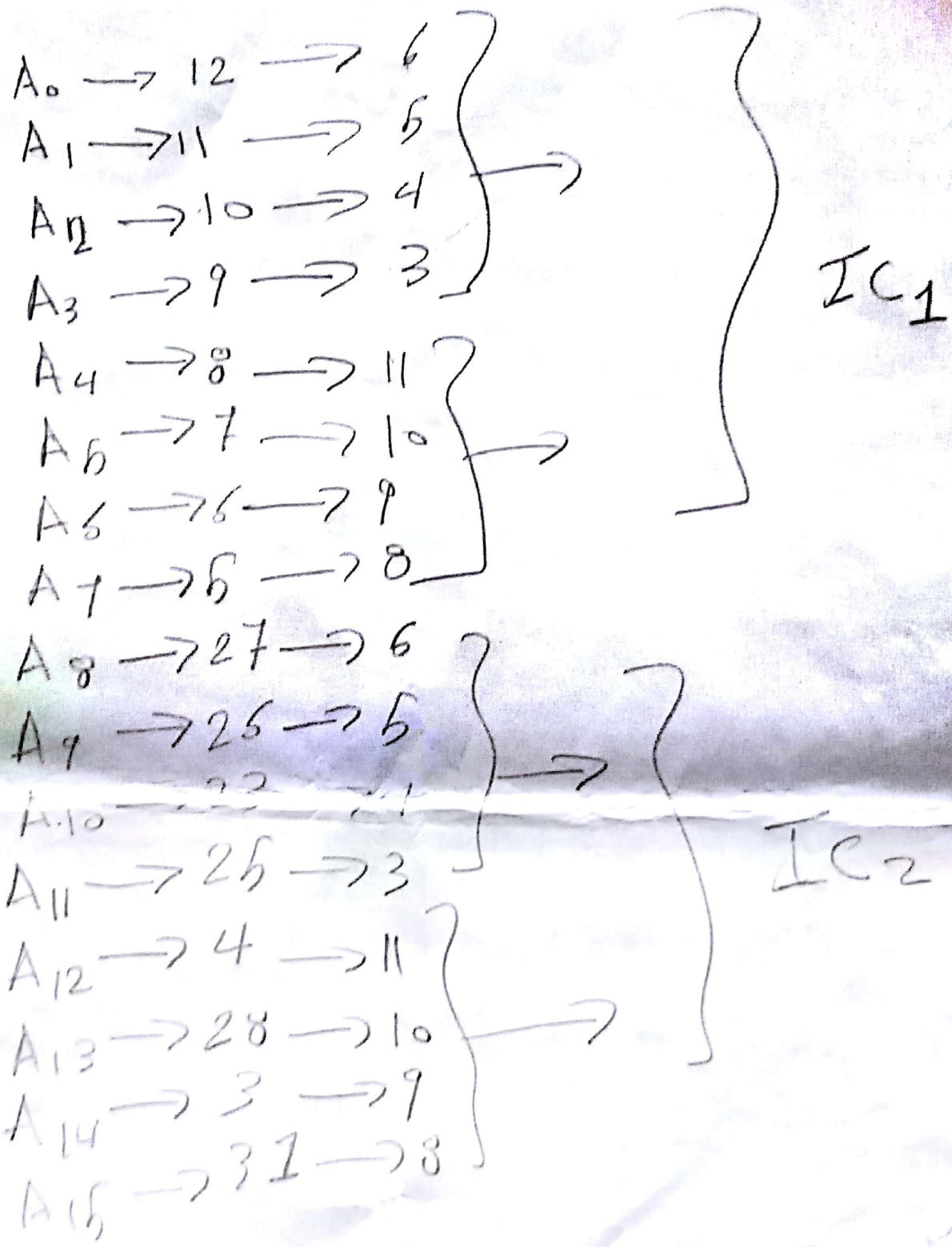


Figure 2-2: Printer port video memory section



```
'PRINTER PORT VIDEO ADAPTER - FULL SCREEN VERSION
'WRITTEN DECEMBER, 1994 BY BOB DAVIS
CLS : SCREEN 13                                    '13 = 320 X 200 x 256
FOR I& = 0 TO 63                                   'SET UP B&W PALETTE
PALETTE (I& * 4) + 7, (65536 * I& + 256 * I& + I&): NEXT I&
COLOR 127
LOCATE 1, 34: PRINT "PRINTER": LOCATE 2, 34: PRINT "PORT"
LOCATE 3, 34: PRINT "VIDEO": LOCATE 4, 34: PRINT "ADAPTER"
LOCATE 6, 34: PRINT "OPTIONS": LOCATE 7, 34: PRINT "Q=QUIT"
LOCATE 8, 34: PRINT "S=SAVE": LOCATE 9, 34: PRINT "V=VIEW"
START: OUT &H37A, 2                                'WRITE PICTURE
FOR A = 1 TO 10000: NEXT A                         'DELAY FOR V SYNC
OUT &H37A, 4                                       'READ, RESET
FOR V = -12 TO 180                                 'VERTICAL RANGE
X = X + 1: IF X = 5 THEN X = 1: V = V - 1'ASPECT RATIO FIX
PSET (0, V), 0
FOR H = 0 TO 255                                'HORIZONTAL RANGE
   OUT &H37A, 0: OUT &H37A, 1: PSET STEP(1, 0), INP(&H379)
NEXT H
NEXT V
key$ = INKEY$                                      'GET USERS RESPONSE
IF key$ = "Q" OR key$ = "q" THEN END
DIM picture%(0 TO 29000)
IF key$ = "S" OR key$ = "s" THEN
LOCATE 25, 1: INPUT "NAME"; file$
GET (0, 0)-(252, 190), picture%
DEF SEG = VARSEG(picture%(1))
BSAVE file$, VARPTR(picture%(1)), 48000
DEF SEG
END IF
IF key$ = "V" OR key$ = "v" THEN
LOCATE 25, 1: INPUT "NAME"; file$
file$ = file$ + ".bas"
GET (0, 0)-(252, 190), picture%
DEF SEG = VARSEG(picture%(1))
BLOAD file$, VARPTR(picture%(1))
DEF SEG
PUT (0, 0), picture%, PSET
FOR A = 1 TO 100000: NEXT A                     'DELAY FOR VIEWING
END IF
LOCATE 15, 34: PRINT "          ": LOCATE 16, 34: PRINT "          "
GOTO START                                         'RESTART
```

```
'PRINTER PORT VIDEO ADAPTER 640 X 480 RES
'WRITTEN, 1994 BY ROBERT DAVIS
CLS : SCREEN 12                                 '12 = 640 x 480 x 16
FOR I& = 0 TO 15                                'SET UP B&W PALETTE
PALETTE I&, (65536 * I& + 256 * I& + I&) * 4: NEXT I&
COLOR 10
LINE (1, 1)-(256, 247), , B
```

```
LINE (3, 3)-(254, 245), , B
LINE (300, 1)-(556, 247), , B
LINE (303, 3)-(554, 245), , B
LOCATE 16, 10: PRINT "LIVE VIDEO"
LOCATE 16, 48: PRINT "STORED PICTURE"
LOCATE 17, 1: PRINT "** PRINTER PORT VIDEO ADAPTER **"
LOCATE 17, 40: PRINT "OPTIONS; Q=QUIT, S=SAVE, V=VIEW"
LOCATE 18, 1: PRINT "AVAILABLE FILES;"
LOCATE 19, 1: FILES "*.MPX"
START: OUT &H37A, 2                          'WRITE PICTURE DATA TO RAM
FOR A = 1 TO 5000: NEXT A                    'DELAY FOR V SYNC
OUT &H37A, 4                                  'READ DATA, RESET
FOR V = -16 TO 240                            'VERTICAL RANGE
PSET (0, V), 0
FOR H = 0 TO 255                            'HORIZONTAL RANGE
  OUT &H37A, 0: OUT &H37A, 1: PSET STEP(1, 0), INP(&H379) / 16
NEXT H
NEXT V
key$ = INKEY$                                 'GET USERS RESPONSE
IF key$ = "Q" OR key$ = "q" THEN END
DIM PICTURE%(0 TO 29000)      ' WON'T COMPILE IF GREATER THAN 29K
IF key$ = "S" OR key$ = "s" THEN
LOCATE 18, 40: INPUT "SAVE FILE NAME? ", file$
LOCATE 18, 40: PRINT "
file$ = file$ + ".MPX"
GET (0, 0)-(255, 240), PICTURE%
DEF SEG = VARSEG(PICTURE%(1))
BSAVE file$, VARPTR(PICTURE%(1)), 32000
DEF SEG
END IF
IF key$ = "V" OR key$ = "v" THEN
LOCATE 18, 40: INPUT "VIEW FILE NAME? ", file$
LOCATE 18, 40: PRINT "
file$ = file$ + ".MPX"
GET (0, 0)-(255, 240), PICTURE%
DEF SEG = VARSEG(PICTURE%(1))
BLOAD file$, VARPTR(PICTURE%(1))
DEF SEG
PUT (300, 0), PICTURE%, PSET
END IF
LOCATE 18, 1: PRINT "AVAILABLE FILES;"
LOCATE 19, 1: FILES "*.MPX"
GOTO START                                  'RESTART FOR CONTINUOUS UPDATING
```

```
'PRINTER PORT VIDEO ADAPTER - BMP VERSION
'BMP MOD WRITTEN FEBUARY, 1996 BY BOB DAVIS
                                             '12 = 640 x 480 x 16
CLS : SCREEN 12
FOR I& = 0 TO 15:PALETTE I&, (65536 * I& + 256 * I& + I&) * 4
NEXT I&
COLOR 10
```

```
LINE (1, 1)-(256, 247), , B: LINE (3, 3)-(254, 245), , B
LINE (300, 1)-(555, 247), , B: LINE (303, 3)-(553, 245), , B
LOCATE 16, 10: PRINT "LIVE VIDEO"
LOCATE 16, 48: PRINT "STORED PICTURE"
LOCATE 17, 1: PRINT "** PRINTER PORT VIDEO ADAPTER **"
LOCATE 17, 40: PRINT "OPTIONS; Q=QUIT, S=SAVE, V=VIEW"
LOCATE 18, 1:PRINT "AVAILABLE FILES;":LOCATE 19, 1: FILES "*.BMP"
START: OUT &H37A, 2                          'WRITE PICTURE DATA TO RAM
FOR A = 1 TO 6000: NEXT A                    'DELAY FOR V SYNC
OUT &H37A, 4                                 'READ DATA, RESET
DIM BARY%(0 TO 29600): V2 = -16              'STORE REVERSE & WRITE NORMAL
FOR V = 250 TO 0 STEP -1                     'STORE IN ARRAY & ON SCREEN
 B = V * 128
 PSET (0, V2), 0: V2 = V2 + 1
 FOR H = 0 TO 127
 OUT &H37A, 0: OUT &H37A, 1: C = INP(&H379) AND &HF0: PSET STEP
  (1, 0), C / 16
 OUT &H37A, 0:OUT &H37A, 1:D = INP(&H379) \ 16:PSET STEP(1, 0), D
  IF V <= 230 THEN BARY%(B) = C + D: B = B + 1
 NEXT H
 NEXT V
key$ = INKEY$                                'GET USERS RESPONSE
IF key$ = "Q" OR key$ = "q" THEN END
IF key$ = "S" OR key$ = "s" THEN             'SAVE PICTURE TO DISK
LOCATE 18, 40: INPUT "SAVE FILE NAME? ", FILE$
LOCATE 18, 40: PRINT "
FILE$ = FILE$ + ".BMP": OPEN FILE$ FOR BINARY AS #1
DATA 66,77,246,115,0,0,0,0,0,0,118,0,0,0,40,0
DATA 0,0,255,0,0,0,230,0,0,0,1,0,4,0,0,0
DATA 0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
DATA 0,0,0,0,16,16,16,0,32,32,32,0,48,48,48,0
DATA 64,64,64,0,80,80,80,0,96,96,96,0,112,112,112,0
DATA 128,128,128,0,144,144,144,0,160,160,160,0,176,176,176,0
DATA 192,192,192,0,208,208,208,0,224,224,224,0,240,240,240,0
FOR A = 1 TO 118: READ B: C$ = CHR$(B): PUT #1, A, C$: NEXT A
FOR A = 119 TO 29559: PUT #1, (A), BARY%(A - 119): NEXT A
RESTORE: CLOSE #1
END IF
IF key$ = "V" OR key$ = "v" THEN             'GET PICTURE FROM DISK
LOCATE 18, 40: INPUT "VIEW FILE NAME? ", FILE$
LOCATE 18, 40: PRINT "
FILE$ = FILE$ + ".BMP": OPEN FILE$ FOR BINARY AS #1
B = 1
FOR V = 230 TO 1 STEP -1                     'REVERSE ORDER FOR .BPB FILE
 PSET (300, V), 0
 FOR H = 1 TO 128
```

```
  GET #1, B + 118, BARY%(B)
  PSET STEP(1, 0), (BARY%(B) AND &HF0) / 16
  PSET STEP(1, 0), BARY%(B) AND &HF
  B = B + 1
 NEXT H
NEXT V: CLOSE #1
END IF
LOCATE 18, 1: PRINT "AVAILABLE FILES;":LOCATE 19, 1:FILES "*.BMP"
                                        'RESTART FOR CONTINUOUS UPDATING
GOTO START
```

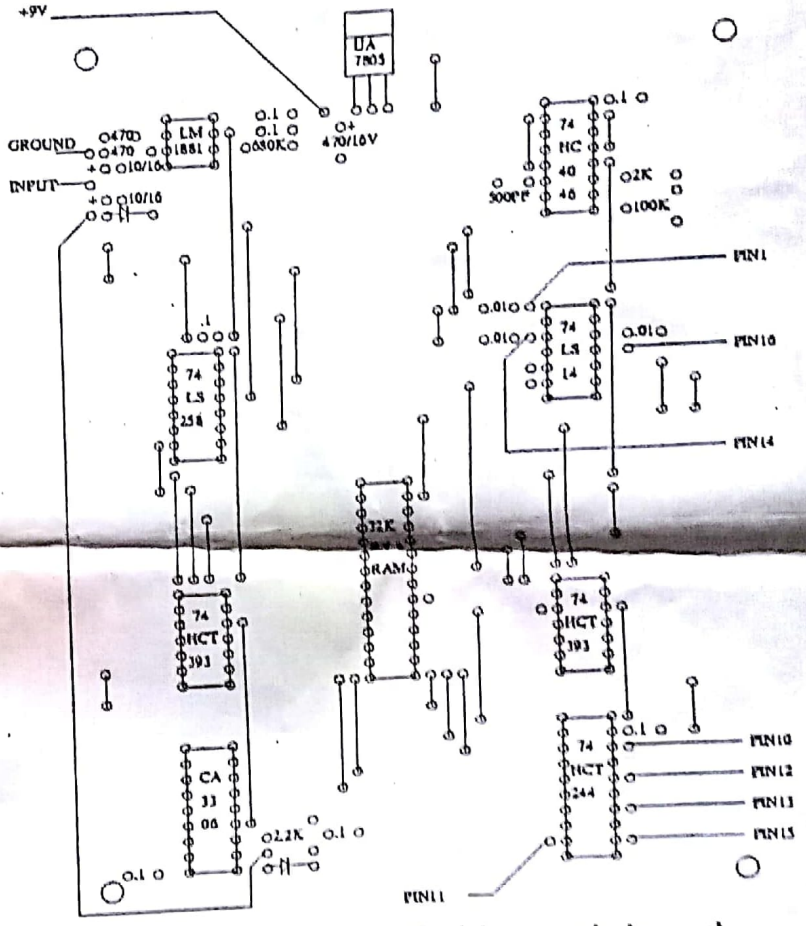


Figure 2-3: Printer port video parts layout

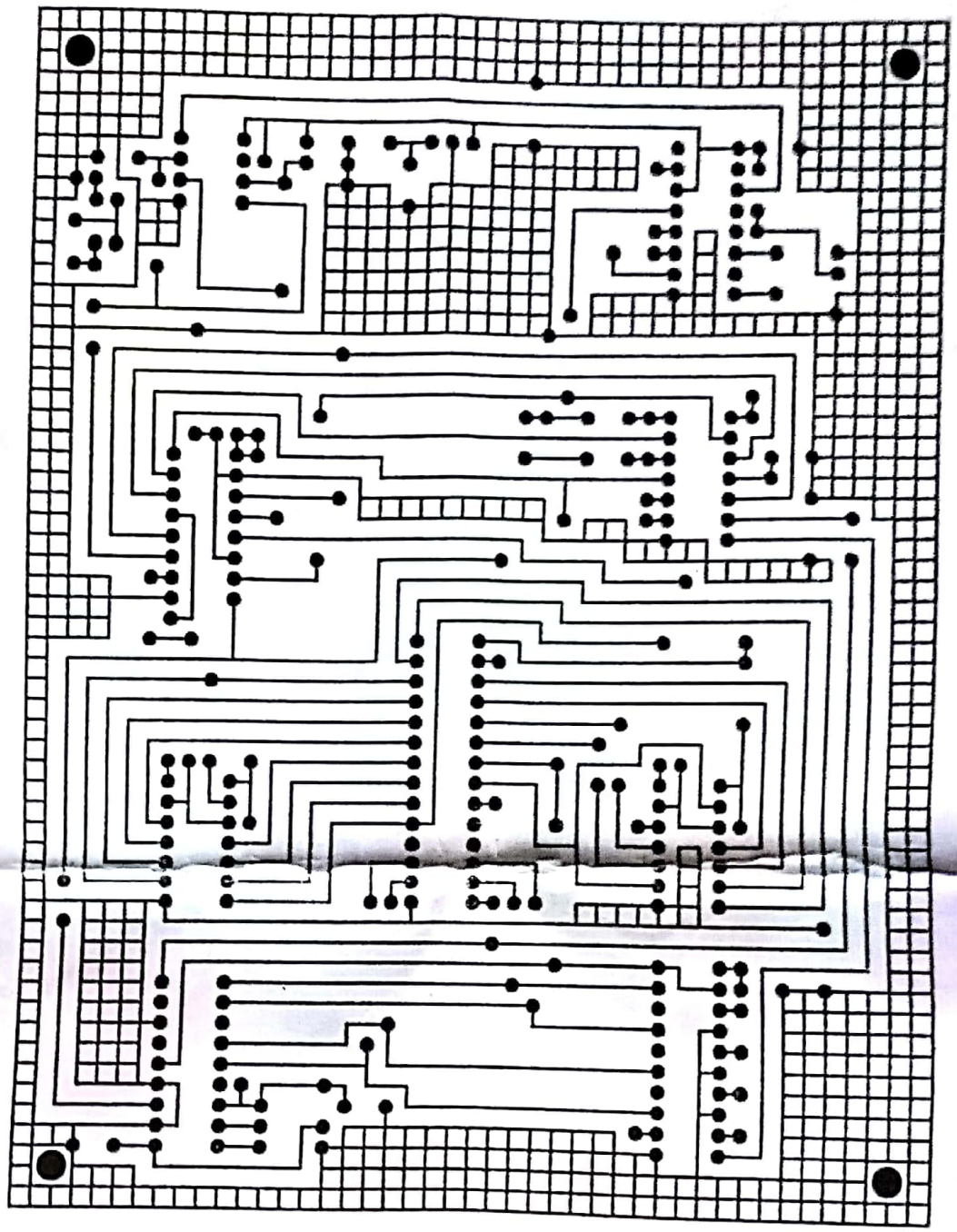


Figure 2-4: Printer port video circuit board design (top view)

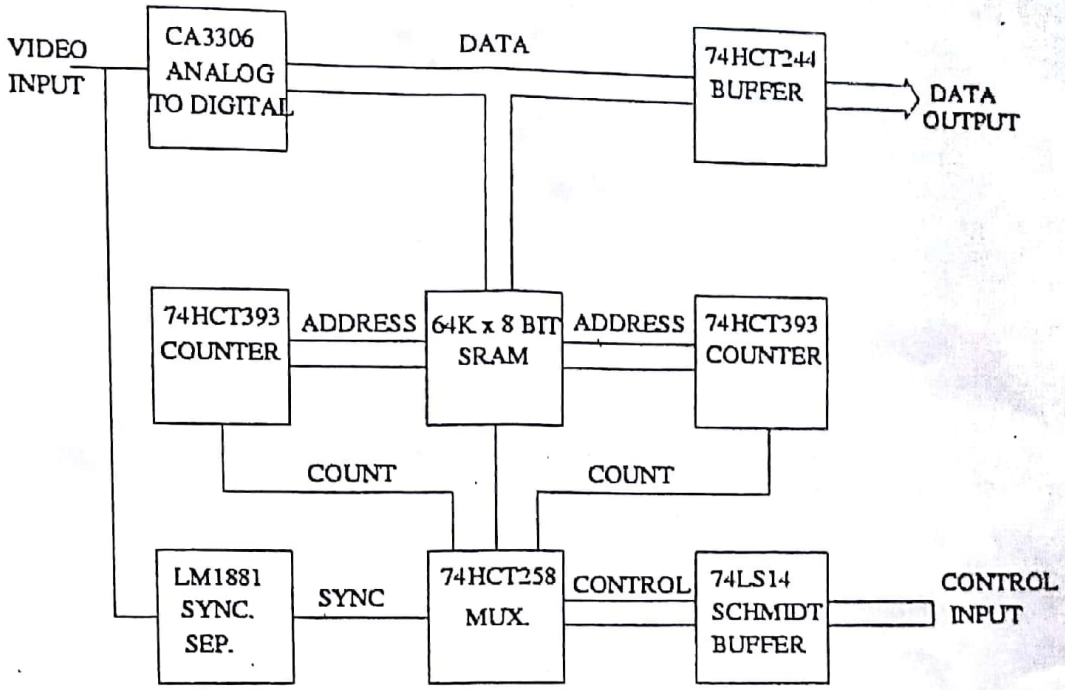


Figure 2-5: Printer port video block diagram

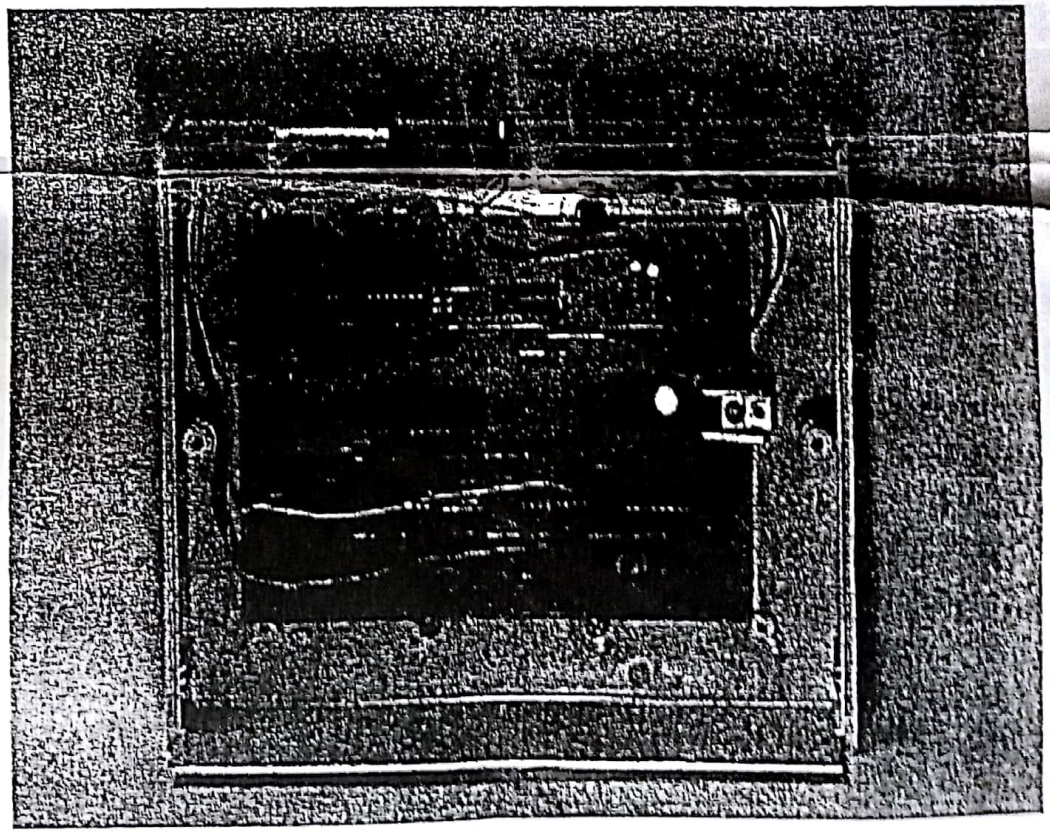


Figure 2-6: Picture of the printer port video adapter