

512K  
TURBO RAM

*Speech Systems*  
38W255 DEERPATH ROAD  
BATAVIA, ILLINOIS 60510  
(312) 879-6880



*Introducing*

# **TURBO RAM**

**THE MEMORY TANDY LEFT OUT**

*and*

# **TURBO HARD DISK**

For the serious OS9 user, we offer Turbo Hard Disk, a half height 10 or 20 megabyte blazing fast hard disk with incredible storage capacity. Installed in an industrial quality fan cooled enclosure with oversized power supply with room and power for 4 half height drives (hard or floppy).

Turbo Hard Disk comes complete ready to run. Order OS9 Level 1 or 2 on your COCO 1, 2, or 3.

..... 10 megabytes . . . \$599.95 . . . 20 megabytes . . . \$699.95  
(C.O.D. Cash/Certified check only)

*Exclusively From Speech Systems*

**SPEECH SYSTEMS COMMITMENT TO THE COCO**

We are proud to offer TURBO RAM to our COCO 3 customers. However, rest assured we are committed to the COCO 1 and 2 as well as both the tape and disk user. We will continue to offer you the highest quality products. A few are under development that will knock your socks off. So stay tuned.



**\$35  
Free  
Extras**

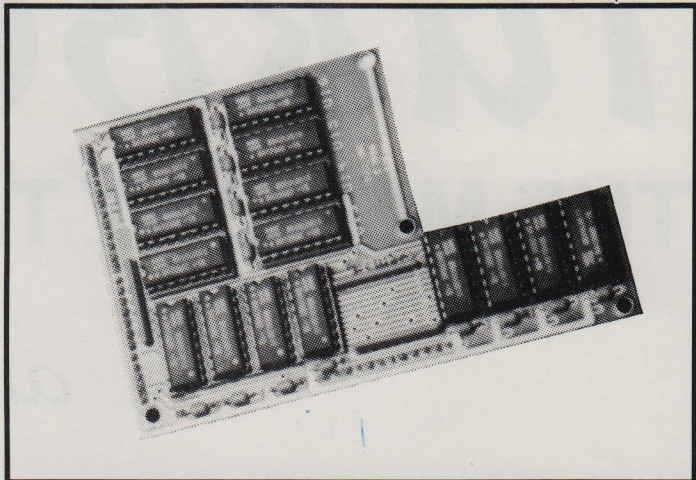
# TURBO RAM™

~~\$149.95~~  
**\$119.95**

**SAVE  
\$30  
Introductory  
Price**

## TURBO CHARGE YOUR COCO 3

- ✓ 512K Fast High Quality Memory.
- ✓ Super Easy Solderless Installation. Installs in minutes.
- ✓ Assembled, tested, and burned-in.
- ✓ Gold Connectors assure ultra high reliability.
- ✓ High Quality Double Sided, Solder Masked, Silkscreened PC Board.
- ✓ Ideal for OS9 Level II
- ✓ 2 Year Warranty.
- ✓ Free GIME Chip Technical Specs (\$10.00 without Turbo Ram).
- ✓ Free 512K Ram Test Program (\$10.00 without Turbo Ram).
- ✓ Free MUSICA RAM Disk (\$10.00 without Turbo Ram).
- ✓ \$5 OFF TURBO RAM Disk.
- ✓ Also available, TURBO RAM less memory chips. . . . . **\$69.95**



### INSTALLATION

If you know how to hold a screwdriver, we're convinced you can install Turbo Ram in minutes. However, if you like, send us your COCO 3 insured, postage paid, and we will install it, pay the return postage and guarantee it for 1 year. . . . . **\$15.00**

### SATISFACTION GUARANTEED

If for any reason you wish to return Turbo Ram, you may do so within 15 days and be charged only a 10% restocking charge. You may keep the GIME CHIP Technical Specs, 512K Ram Test program and MUSICA RAM DISK, a \$30 value.

## TURBO RAM DISK

TURBO RAM DISK adds 2 lightning fast Ram Disks to your COCO system. Imagine saving and loading programs instantaneously and having hundreds of your programs "on line" for fast access. Single disk system users can

use TURBO RAM DISK to easily make backups without continuously switching disks.

Requires 512K Turbo Charged COCO 3 . . . . . **\$24.95**  
When purchased with TURBO RAM . . . . . **\$19.95**

## COCO 3 128K

### COLOR CONNECTION IV

This is the most comprehensive modem package for the COCO 3. All standard protocols are supported including CompuServe's Protocol B, XMODEM protocol, and XON/XOFF. Full support of the auto answer/auto dial feature for both Hayes compatible and some Radio Shack modems is provided. Single key macros allow easy entry of often-used passwords and ID's with a single key stroke.

Disk . . . . . **\$49.95**

### THE MAGIC OF ZANTH

In the Land of Zanth, magic is commonplace. Dragons, Griffins, Centaurs and Demons abound. You are sent on a quest to discover the source of magic in the Land of Zanth. This intriguing adventure features over 2 dozen hi-res 16 color animated graphic screens, 4 voice music and sound effects. The 16 color, 320 x 192 graphics look great.

Disk . . . . . **\$34.95**

### COLOR SCRIBE II

This great Word Processor can take full advantage of the 80 column display of the COCO 3. Justification, Headers, Footers, and Pagination make it perfect for letters and documents as well as programming in BASIC, PASCAL, "C," and Assembly Language. Over 20 line editing commands include capabilities like character insert and delete, skip over words, breaking a line, and more!

Disk . . . . . **\$49.95**

### RETURN OF JUNIOR'S REVENGE

This is the same Junior you've seen in the Kong arcade series, but with new COCO 3 graphics. This tireless little monkey must overcome all sorts of obstacles (4 screens worth) to rescue his father, The King, from the mean zookeeper. He will traverse the jungle and swamp, climb vines, avoid chompers and birds, open locks, and more before he finally meets with his big daddy. The 16 color, 320 x 192 graphics are superb.

Disk . . . . . **\$34.95**

We accept CASH, CHECK, COD, VISA and MASTER CARD orders.  
Shipping and handling US and Canada . . . . . \$3.00  
Shipping and handling outside the US and Canada . . . . . \$5.00  
COD Charge . . . . . \$2.00  
Illinois residents add 6 1/4% sales tax.

*Speech Systems*

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DISCLAIMER=====

Speech Systems makes no other warranties or guarantees, express, statutory, or implied, of any kind whatsoever with respect to the product purchased, and any other implied warranty of merchantability or fitness for a particular purpose is hereby disclaimed by Speech Systems and excluded from any agreement made by Speech Systems. The product is sold on an "as is" basis.

Speech Systems will not be responsible for any damage of any kind not covered by the exclusive remedies set forth in this limited warranty. Speech Systems will not be responsible for any special, indirect, or consequential damage caused by its products.

Speech Systems reserves the right to make changes to any products or specifications described in this manual without notification.

WARRANTY=====

Speech Systems warrants TURBO RAM against defects in material and workmanship for a period of Ninety Days from the date of purchase to the original purchaser. The obligation of Speech Systems is limited to the repair or replacement of the product, free of all charges, which proves defective during this period. This warranty does not cover damage due to accident, negligence, abuse, or tampering.

REPAIRS=====

Call the factory for information on the repair charges should the product become defective after the warranty has expired. If it becomes defective within the warranty period, please call Speech Systems indicating that you are returning the unit and be prepared to describe the problem since it may be that the matter can be handled over the phone. Also return the invoice (or copy) along with a description of the problem.



TESTED =====

If you purchased the TURBO RAM assembled, note that it was completely tested and as a result you should find that it works perfectly in your COCO 3.

UNPACKING AND INSTALLATION=====

Carefully remove TURBO RAM from the box and inspect it for possible damage that may have occurred during shipment. If there is any damage, save all packing material and notify the carrier immediately.

TURBO RAM uses circuitry which is sensitive to static charges. Do not handle the unit more than necessary. It is imperative that it never be removed or installed while the computer is on.

SYSTEM REQUIREMENTS=====

TURBO RAM is strickly for use in the Tandy Color Computer 3.

INCLUDED WITH TURBO RAM=====

- 1 - Instruction Manual ( Your looking at it )
- 1 - MUSICA RAM DISK
- 1 - Memory Check program ( MEMCHK )
- 1 - GIME Specifications ( In this manual )

\*\*\*\*\*  
\* Follow the directions on the following \*  
\* pages very carefully. Remember you can \*  
\* permanently damage both TURBO RAM and \*  
\* your computer if you are not careful. \*  
\*\*\*\*\*



## Introduction

Thank you for your purchase of the FBJ 512cc Memory Upgrade Board for your Tandy Color Computer 3. The 512cc has been designed to bring the Color Computer 3 to its maximum memory configuration using standard 256K dynamic RAM chips and is easily installed in your computer.

The 512cc is available with or without installed memory. If you purchased the board without memory, it is your responsibility to acquire and install the necessary RAM devices yourself. Refer to the section titled "Installing RAM on Your 512cc". If you purchased the board with 512K already installed, proceed directly to the section "Installing the 512cc In Your Computer".

## Installing Ram On Your 512cc Board

If you purchased the 512cc board without any memory you will need to acquire sixteen 256K by 1 bit dynamic RAM chips. These should have an access time of 120ns or faster. Recommended vendors and part numbers are listed below:

| <u>Vendor</u>     | <u>Part Number</u> |
|-------------------|--------------------|
| Mitsubishi        | MSM4256P-12        |
| Micron Technology | 1257-12            |
| Hitachi           | HMS0256P-12        |
| NEC               | D41256C-12         |
| Texas Instruments | TMS4256-12         |

\* \* \* CAUTION \* \* \*

Dynamic RAM devices are extremely sensitive to static discharge. Permanent damage may result from improper handling of the chips and/or board.

You should begin by preparing an uncluttered, flat surfaced work area such as a table or desk. Before handling any of the RAM chips or the board itself, make sure that you discharge any static electricity you may have accumulated by touching a grounded metal object. It is a good idea to do this periodically as you work.

Refer to Fig. 1 before installing any RAM devices on the board. Note the pin 1 location of each component as indicated by the notch in the IC package. As you install each IC, make sure that it is oriented correctly as shown in Fig. 1, and that all pins are firmly seated in the socket. Once all sixteen chips have been installed, visually check the entire board once more. Be absolutely certain that no chips are installed backwards, since applying power under this condition may damage the RAM or your computer. Once you are satisfied with your work, proceed to the next section.



## Installing The 512cc In Your Computer

You will need a few small tools to install the 512cc which are readily obtainable at Radio Shack or any other retail electronic supply store. Do not begin the installation unless the following tools are available:

- o Phillips screwdriver
- o Small flat blade screwdriver
- o Small cutting pliers

Before you install your 512cc Board in the computer, you should read all the instructions and be certain that you understand all the steps before actually attempting the installation.

1. Turn the computer and all peripherals OFF, and remove the computer's AC power cord from the outlet. You should also unplug the video cable, Multipak, or any cartridge you may have connected to the ROM Port.
2. Turn the computer upside down and locate the five (5) screws holding the top and bottom cover sections together. One of the screws is covered with a warranty security label. You should note that opening the case will void the warranty on your Color Computer 3. If you do not wish to void your warranty at this time, do not proceed any further.
3. Using a Phillips screwdriver, remove the five (5) screws. Then, while holding the top and bottom cover sections together, turn the computer upright. You will now be able to lift the cover off the computer and expose the motherboard.
4. Using Fig. 2 as a reference, locate the two (2) connectors on the motherboard, a long twenty-four (24) pin connector, and a shorter twelve (12) pin connector. These will be used to mount the 512cc Board on the motherboard.
5. Before you install the 512cc Board, you must remove the four existing 64K x 4 RAM chips from the motherboard. The location of these devices is identified in Fig. 2. Use a small screwdriver to pry the chips out of their sockets.
6. Next you must disconnect or remove two capacitors labeled CAP (A) and CAP (B) in Fig. 2. You can do this by simply clipping one or both of the leads of each capacitor with a small cutting pliers.
7. You are now ready to install the 512cc Board. Align the male pins on the 512cc Board so that they mate with the two female connectors on the motherboard. Once you are sure all pins are aligned, press down firmly until the board seats properly.
8. Before you reassemble the computer, you should test the installation. Reconnect the video output to your TV or Monitor and also connect the power cord to suitable outlet.



9. Turn the TV or Monitor ON before powering-up the computer. As you turn the computer ON, you should see the familiar copyright message appear on the screen, if you do not, turn the computer off immediately and check for the following:

- a. Are the mating connectors properly seated with no bent or broken pins?
- b. Are all chips properly oriented in their sockets with no bent or broken pins?
- c. Did you remove the existing RAMS from the motherboard?
- d. Are the two capacitors disconnected from the circuit?

10. If everything is working properly, replace the cover on the computer and secure the top and bottom sections by re-installing the five (5) screws you removed earlier. Reconnect all cables and peripherals. The installation is now complete.

#### Hardware Limited Warranty

PBJ, Inc. warrants to the original purchaser of the product described herein that the hardware portion of said product shall remain free from defects in material and workmanship for a period of one year from date of purchase.

This warranty applies only to products sold as "fully assembled and tested" and excludes items supplied and installed by third parties.

If this hardware should require repair during the warranty period, it should be returned, postpaid, to PBJ, Inc. along with proof of purchase. PBJ, Inc. will, at its option, repair or replace the hardware free of charge. PBJ, Inc. reserves the right, however, to determine which items are within warranty where customer negligence, misuse, or abuse are in question, or where the hardware has been subject to unauthorized alterations, modifications and/or repairs.

Under no circumstances will PBJ, Inc. be liable for damages arising from the use of, or inability to use its products. Some states do not allow the limitation or exclusion of incidental or consequential damages, so the above limitations or exclusions may not apply to you. This warranty gives the purchaser specific legal rights which may vary from state to state.



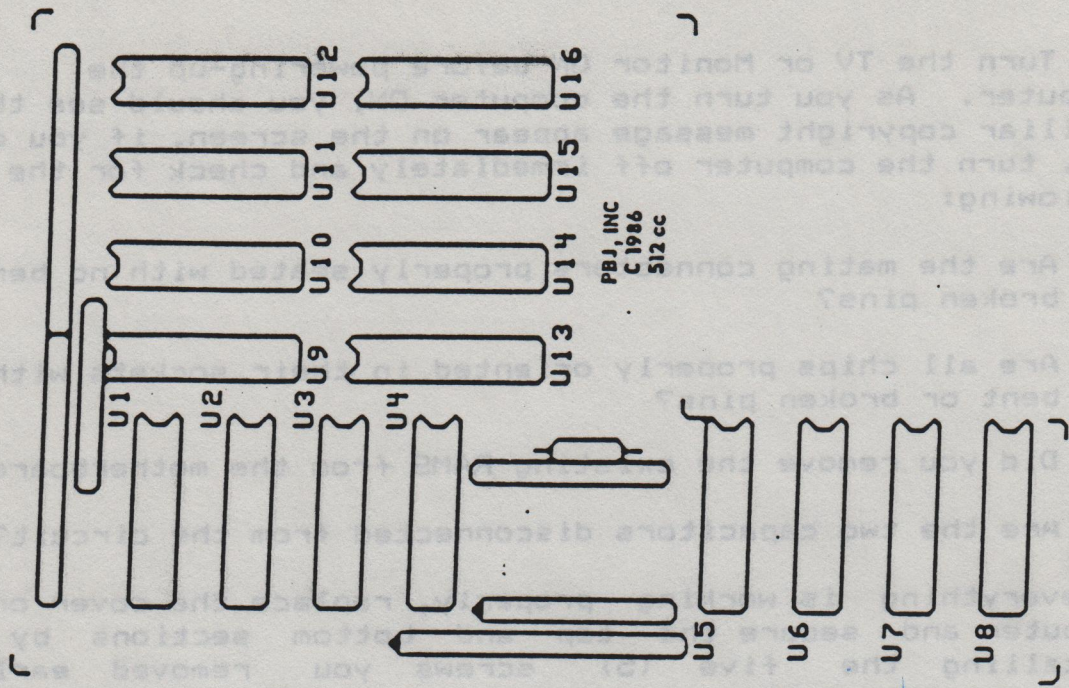
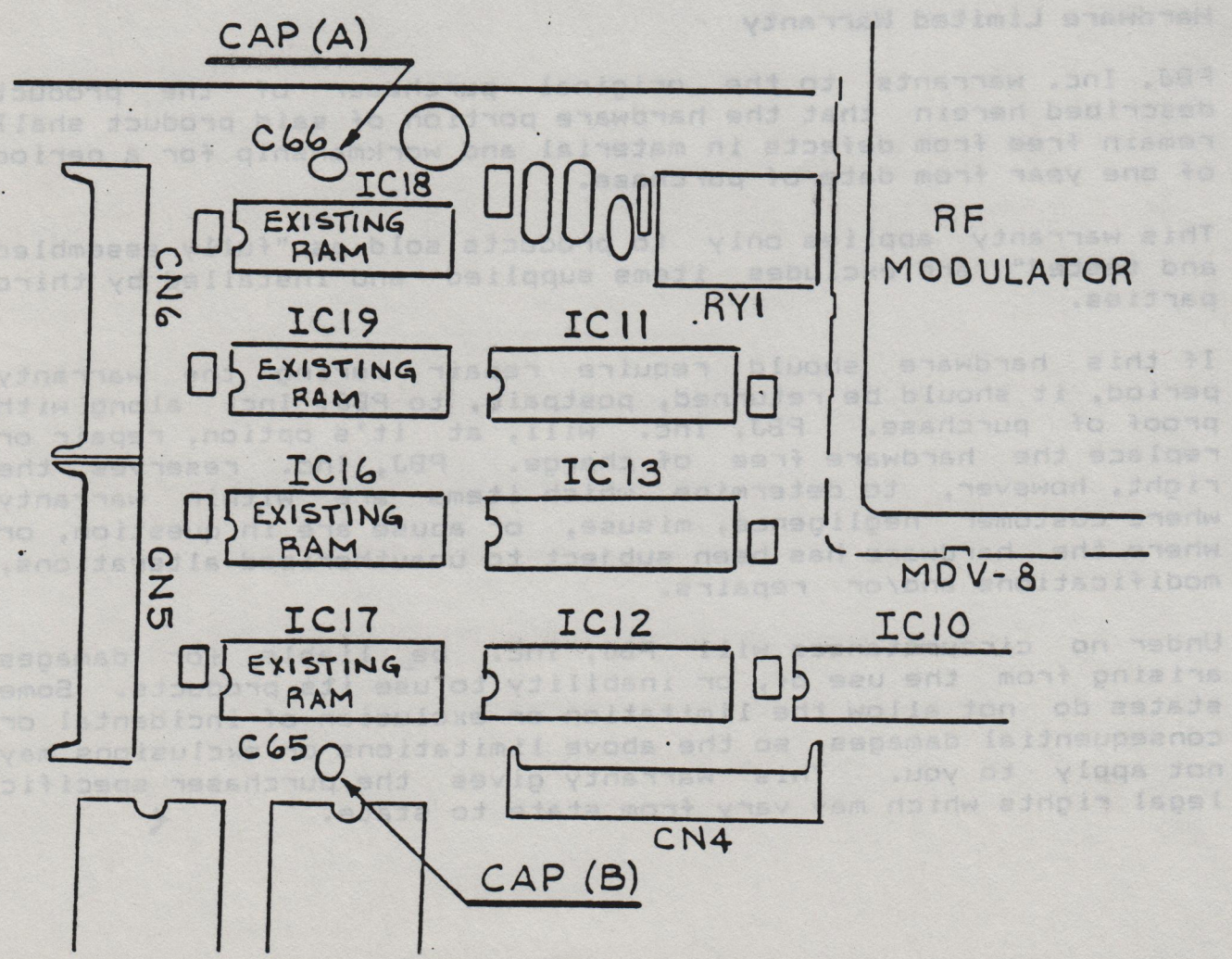


FIG. 1  
512cc Component Layout





```
*****
* The following assumes you have already *
* installed TURBO RAM *
*****
```

MEMORY CHECK=====

If you turn on your computer and it comes up "normally" showing the Copyright notice by Microsoft and Microware, you have tested much of the TURBO RAM. To test the remaining portion of the RAM, LOADM "MEMCHK" and EXEC.

The test requires only seconds. If the response is:

MEMORY CHECK COMPLETE.  
512K MEMORY PRESENT.

you can rest assured all is well. Any other response and you should turn off the computer and check your work. Should you still have problems, check the "Warranty" and "Repairs" section of this manual on details for returning the product.

IT RUNS WARM=====

You will probably find that the TURBO RAM gets rather warm. This is normal and there is no need to be concerned.

MUSICA RAM DISK=====

Supplied with TURBO RAM is a program that you hope you enjoy. The program loads many songs into the available 512K memory of the Color Computer and plays the songs in sequence from memory rather than from disk. These songs were all developed using our music composition program MUSICA 2.

To run the program just: RUN "MULTPLAY"

```
*****
* Machine Language Source Code for the *
* memory check program and the BASIC *
* MUSICA RAM DISK program are provided *
* should you wish to study them. *
*****
```



```

100 WIDTH=32:
    REM must be 32 to prevent memory conflicts!
110 CLS 1
120 CLEAR 200,&H2FFF:
    REM protect high memory from modification
130 REM LIST OF SONGS TO PLAY
132 DATA 100,200,300,400,500,600
140 DATA FOGGY,HOOKEED,INMOOD,WMTPELL,CANTINA,"RB RAG",KHAN,CHOPIN
150 POKE &HFFA2,&H3A:
    POKE &HFFA3,&H3B:
    REM put first song in "normal" RAM
160 READ D$
170 PRINT "LOADING "D$
180 LOAD M D$
190 FOR SEG = 0 TO 24 STEP 2
200     POKE &HFFA2,SEG:
        POKE &HFFA3,SEG + 1:
        REM select 2 banks of RAM
210     READ D$
220     PRINT "LOADING "D$
230     LOAD M D$
240 NEXT SEG
250 LOAD M"PLAY"
260 POKE &HFF40,0:
    REM turn off disk motor
270 CLS
272 PRINT @37,"*** MUSICA RAM DISK ***"
273 PRINT :
    PRINT "      (C) 1986 LESTER HANDS"
274 PRINT :
    PRINT "      LICENSED TO SPEECH SYSTEMS"
280 RESTORE
290 READ F$
292 PT = 224
300 PRINT @PT,"PLAYING "F$"      "
310 POKE &HFFA2,&H3A:
    POKE &HFFA3,&H3B:
    REM restore "normal" RAM
320 POKE &HFFD9,0
330 EXEC :
    REM play song
340 FOR T = 0 TO 400:
    NEXT T
350 FOR SEG = 0 TO 24 STEP 2
352     PT = PT + 16
360     POKE &HFFA2,SEG:
        POKE &HFFA3,SEG + 1:
        REM select proper RAM to play
370     READ F$
380     PRINT @PT,"PLAYING "F$"      "
390     EXEC :
        REM play music
400     FOR T = 0 TO 400:
        NEXT T
410 NEXT SEG
420 GO TO 270

```



```

0001 *****
0002 * SPEECH SYSTEMS *
0003 * COCO 3 512K memory checker *
0004 * (C) 1986 by Speech Systems *
0005 *****
0006
0E00 0007 ORG $0E00
0008
0E00 170184 0009 START LBSR CLS
0E03 1700EE 0010 LBSR ILPRINT
0E06 53 0011 FCC "SPEECH SYSTEMS MEMORY CHECKER"
0E07 5045454348
0E0C 2053595354
0E11 454D53204D
0E16 454D4F5259
0E1B 2043484543
0E20 4B4552
0E23 0D 0012 FCB 13
0E24 46 0013 FCC "FOR THE COCO 3"
0E25 4F52205448
0E2A 4520434F43
0E2F 4F2033
0E32 0D 0014 FCB 13,13
0E33 0D
0E34 43 0015 FCC "CHECKING MEMORY BLOCK &H00"
0E35 4845434B40
0E3A 4E47204D45
0E3F 4D4F525920
0E44 424C4F434B
0E49 2026483030
0E4E 00 0016 FCB 0
0E4F 5F 0017 CLRB RAM block counter
0E50 3404 0018 PSHS B
0E52 F7FFA2 0019 NXTBLK STB $FFA2 put block at $4000-$5fff
0E55 8E4000 0020 LDX #$4000
0E58 A684 0021 NB1 LDA ,X
0E5A 43 0022 COMA
0E5B A784 0023 STA ,X
0E5D A180 0024 CMPA ,X+ make sure we have really
0E5F 2703 0025 BEQ NB0 altered memory
0E61 1700A2 0026 LBSR MEMERR
0E64 8C5FFF 0027 NB0 CMPX #$5FFF done yet?
0E67 26FF 0028 BNE NB1
0E69 F74000 0029 STB $4000 save block number
0E6C 3502 0030 PULS A get block #
0E6E 4C 0031 INCA block OK, advance to next
0E6F 8126 0032 CMPA #38 done with last block?
0E71 271A 0033 BEQ NB2
0E73 3402 0034 PSHS A
0E75 1700B9 0035 LBSR HEXOUT
0E78 ED8D000A 0036 STD NB3,PCR
0E7C DC88 0037 LDD $88
0E7E 830002 0038 SURD #2 back cursor 2 spaces
0E81 DD39 0039 STD $88
0E83 17006E 0040 LBSR ILPRINT
0E86 30 0041 NB3 FCC "00"
0E87 30
0E88 00 0042 FCB 0

```



```

0E80 E6E4      0042      LDB      ,S
0E8B 20C5      0044      BRA      NXTBLK
0E8D 170064    0045 NB2    LBSR    ILPRINT
0E90 0D         0046      FCB      13
0E91 42         0047      FCC      "CROSS CHECKING EACH BLOCK..."
0E92 524F53520
0E97 434845424B
0E9C 494E472045
0EA1 4143482042
0EA6 4C4F434B2E
0EAR 2E2E
0EAD 0D         0048      FCB      13,0
0FAE 00
0EAF 5F         0049      CLRB
0EB0 F7FFA2     0050 CCB1    STR      $FFA2
0EB2 F14000     0051      CMPB    $4000      see if block # is what
0EB6 10260094  0052      LBNE    BLKERR    was stored there
0EBA 5C         0053      INCB
0EBB C126       0054      CMPB    #28      done yet?
0EBD 26F1       0055      BNE     CCB1
0EBF 170032    0056      LBSR    ILPRINT
0EC2 0D         0057      FCB      13
0EC3 4D         0058      FCC      "MEMORY CHECK COMPLETE."
0EC4 454D4F5259
0EC9 2042484542
0ECE 4B20434F4D
0ED3 504C455445
0ED8 2E
0ED9 0D         0059      FCB      13
0EDA 35         0060      FCC      "512K MEMORY PRESENT."
0EDB 31324B204D
0EE0 454D4F5259
0EE5 2050524553
0EEA 454E542E
0EEE 0D         0061      FCB      13,13,0
0EEF 0D00
0EF1 16008D    0062      LBRA    EXIT
0EF4 3412      0063
0EF4 3412      0064 ILPRINT PSHS A,X
0EF6 AE63      0065      LDX     3,S      set up pointer to text
0EF8 A680      0066 ILP1    LDA      ,X+      get text
0EFA 2706      0067      BEQ     ILP2      quit if =0
0EFC AD9FA002  0068      JSR    [$A002]   call ROM to print on screen
0F00 20F6      0069      BRA     ILP1      loop back for more
0F02 AF63      0070 ILP2    STX     3,S      change return address
0F04 3592      0071      PULS   A,X,PC
0F06 3406      0072
0F06 3406      0073 MEMERR PSHS D
0F08 1F98      0074      TFR    B,A
0F0A 8D25      0075      BSR    HEXOUT    convert block # to ASCII
0F0C ED8D001B  0076      STD    ME1,PCR
0F10 8DE2      0077      BSR    ILPRINT
0F12 0D         0078      FCB      13
0F13 44         0079      FCC      "DEFECTIVE MEMORY BLOCK #"
0F14 4546454254
0F19 495645204D
0F1E 454D4F5259
0F23 20424C4F43
0F28 4B2023

```



|      |            |      |        |      |                            |                            |
|------|------------|------|--------|------|----------------------------|----------------------------|
| 0F2B | 20         | 0080 | ME1    | FCC  | " "                        |                            |
| 0F2C | 20         |      |        |      |                            |                            |
| 0F2D | 0D         | 0081 |        | FCB  | 13,0                       |                            |
| 0F2E | 00         |      |        |      |                            |                            |
| 0F2F | 3586       | 0082 |        | PULS | D,PC                       |                            |
|      |            | 0083 |        |      |                            |                            |
| 0F31 | 3432       | 0084 | HEXOUT | PSHS | A,X,Y                      |                            |
| 0F33 | 44         | 0085 |        | LSRA |                            |                            |
| 0F34 | 44         | 0086 |        | LSRA |                            | convert byte in A to       |
| 0F35 | 44         | 0087 |        | LSRA |                            | ASCII in D                 |
| 0F36 | 44         | 0088 |        | LSRA |                            |                            |
| 0F37 | 8D0C       | 0089 |        | BSR  | H01                        |                            |
| 0F39 | 1F89       | 0090 |        | TFR  | A,B                        |                            |
| 0F3B | A6E0       | 0091 |        | LDA  | ,S+                        |                            |
| 0F3D | 840F       | 0092 |        | ANDA | #\$0F                      |                            |
| 0F3F | 8D04       | 0093 |        | BSR  | H01                        |                            |
| 0F41 | 1E89       | 0094 |        | EXG  | A,B                        |                            |
| 0F43 | 35B0       | 0095 |        | PULS | X,Y,PC                     |                            |
| 0F45 | 8109       | 0096 | H01    | CMPA | #0                         |                            |
| 0F47 | 2302       | 0097 |        | BLS  | H02                        |                            |
| 0F49 | 8B07       | 0098 |        | ADDA | #7                         |                            |
| 0F4B | 8B30       | 0099 | H02    | ADDA | #'0                        |                            |
| 0F4D | 39         | 0100 |        | RTS  |                            |                            |
|      |            | 0101 |        |      |                            |                            |
| 0F4E | 9DA4       | 0102 | BLKERR | BSR  | ILPRINT                    |                            |
| 0F50 | 0D         | 0103 |        | FCB  | 13                         |                            |
| 0F51 | 42         | 0104 |        | FCC  | "BLOCK DUPLICATION:"       |                            |
| 0F52 | 4C4F434B20 |      |        |      |                            |                            |
| 0F57 | 4455504C49 |      |        |      |                            |                            |
| 0F5C | 434154494F |      |        |      |                            |                            |
| 0F61 | 4E3A       |      |        |      |                            |                            |
| 0F63 | 0D         | 0105 |        | FCB  | 13                         |                            |
| 0F64 | 36         | 0106 |        | FCC  | "64-128K MEMORY DETECTED." |                            |
| 0F65 | 342D313238 |      |        |      |                            |                            |
| 0F6A | 4B204D454D |      |        |      |                            |                            |
| 0F6F | 4F52592044 |      |        |      |                            |                            |
| 0F74 | 4554454354 |      |        |      |                            |                            |
| 0F79 | 45442E     |      |        |      |                            |                            |
| 0F7C | 0D         | 0107 |        | FCB  | 13,13,0                    |                            |
| 0F7D | 0D00       |      |        |      |                            |                            |
| 0F7F | 2000       | 0108 |        | BRA  | EXIT                       |                            |
|      |            | 0109 |        |      |                            |                            |
| 0F81 | 863A       | 0110 | EXIT   | LDA  | #\$3A                      | put proper block of RAM    |
| 0F83 | 87FFA2     | 0111 |        | STA  | 8FFA2                      | into \$4000-\$5FFF         |
| 0F86 | 39         | 0112 |        | RTS  |                            | return to BASIC            |
|      |            | 0113 |        |      |                            |                            |
| 0F87 | 3416       | 0114 | CLS    | PSHS | D,X                        | clear the screen (low res) |
| 0F89 | 8E0400     | 0115 |        | LDY  | #\$0400                    |                            |
| 0F8C | 9F88       | 0116 |        | STX  | \$88                       | position the cursor        |
| 0F8E | CC6060     | 0117 |        | LDD  | #\$6060                    |                            |
| 0F91 | ED81       | 0118 | C1     | STD  | ,X++                       |                            |
| 0F93 | 8C0600     | 0119 |        | CMPY | #\$0600                    |                            |
| 0F96 | 26F9       | 0120 |        | BNE  | C1                         |                            |
| 0F98 | 3596       | 0121 |        | PULS | D,X,PC                     |                            |
|      |            | 0122 |        |      |                            |                            |



CUSTOM VIDEO FOR COCO  
Revised 8/1/85 jmp

MEMORY MAP:

Range: 00000 - 7FFFF (512 K Bytes)

I/O & Control: XFF00 - XFFFF (All pages)

ROM: 78000 - 7FEFF (Deselectable)  
or 78000 - 7FDFF (Deselectable)

DRAM:

128K: X0000 - XFEFF (except ROM)

AVP mode: 60000 - 7FEFF (except ROM, I/O,  
and control)  
(Duplicated at 40000 - 5FFFF, 20000 - 3FFFF, and  
00000 - 1FFFF)

512K: CoCo mode: same as 128K

AVP mode: 00000 - 7FEFF (except ROM, I/O,  
and control)

(Note: If MC3 is set, XFE00 - XFEFF is constant DRAM)

I/O: XFF00 - XFFFF

XFF00 - 03: PIA0 (same as old CoCo) SEE NOTE 1.  
XFF10 - 1F: Reserved  
XFF20 - 23: PIA1 (same as old CoCo) SEE NOTE 1.  
XFF30 - 3F: Reserved  
XFF40 - 5F: SCS. SEE NOTES 1 AND 2.  
XFF60 - 7F: Undecoded (current peripherals)  
XFF80 - 8F: Reserved  
XFF90 - 9F: Chip Control  
XFFA0 - AF: MMU  
XFFB0 - BF: Color Palette  
XFFC0 - DF: SAM Control Registers  
XFFE0 - FF: Vectors

NOTE 1: Device may respond to more addresses but only those listed should be used.

NOTE 2: If MC2 is 0, SCS is only XFF50 - 5F. 40 -4F are internal.



## CHIP CONTROL REGISTERS

### FF90: Initialization Register 0 (INIT0)

|       |   |      |                                   |
|-------|---|------|-----------------------------------|
| Bit 7 | - | COCO | 1 = Color Computer Compatible     |
| Bit 6 | - | M/P  | 1 = MMU enabled (COCO = 0)        |
| Bit 5 | - | IEN  | 1 = Chip IRQ output enabled       |
| Bit 4 | - | FEN  | 1 = Chip FIRQ output enabled      |
| Bit 3 | - | MC3  | 1 = DRAM at XFEXX is constant     |
| Bit 2 | - | MC2  | 1 = Standard SCS                  |
| Bit 1 | - | MC1  | ROM map control (see table below) |
| Bit 0 | - | MC0  | ROM map control (see table below) |

| MC1 | MC0 | ROM mapping                       |
|-----|-----|-----------------------------------|
| 0   | X   | 16K Internal, 16K External        |
| 1   | 0   | 32K Internal                      |
| 1   | 1   | 32K External (except for vectors) |

### FF91: Initialization Register 1 (INIT1)

|       |   |      |                                 |
|-------|---|------|---------------------------------|
| Bit 7 | - | --   |                                 |
| Bit 6 | - | TYPE | 0 = 64K chips, 1 = 256K chips   |
| Bit 5 | - | TINS | Timer Input Select: 0 = 70 nsec |
| Bit 4 | - | --   | 1 = 63 usec                     |
| Bit 3 | - | --   |                                 |
| Bit 2 | - | --   |                                 |
| Bit 1 | - | --   |                                 |
| Bit 0 | - | TR   | MMU Task Register Select        |

### FF92: Interrupt Request Enable Register (IRQENR)

|       |   |       |                               |
|-------|---|-------|-------------------------------|
| Bit 7 | - | --    |                               |
| Bit 6 | - | --    |                               |
| Bit 5 | - | TMR   | Interrupt from Timer enabled  |
| Bit 4 | - | HBORD | Horizontal Border IRQ enabled |
| Bit 3 | - | VBORD | Vertical Border IRQ enabled   |
| Bit 2 | - | EI2   | Serial Data IRQ enabled       |
| Bit 1 | - | EI1   | Keyboard IRQ enabled          |
| Bit 0 | - | EIO   | Cartridge IRQ enabled         |

### FF93: Fast Interrupt Request Enable Reg. (FIRQENR)

|       |   |       |                                |
|-------|---|-------|--------------------------------|
| Bit 7 | - | --    |                                |
| Bit 6 | - | --    |                                |
| Bit 5 | - | TMR   | Interrupt from Timer enabled   |
| Bit 4 | - | HBORD | Horizontal Border FIRQ enabled |
| Bit 3 | - | VBORD | Vertical Border FIRQ enabled   |
| Bit 2 | - | EI2   | Serial Data FIRQ enabled       |
| Bit 1 | - | EI1   | Keyboard FIRQ enabled          |
| Bit 0 | - | EIO   | Cartridge FIRQ enabled         |



## Chip Control (Continued)

FF94: Timer Most Significant Byte  
 FF95: Timer Least Significant Byte

**TIMER:** This is a 16 bit interval timer. When a value is loaded into the MSB, the count is automatically begun. The input clock is either 14 MHz or horizontal sync, as selected by TINS (bit 5 of FF91). As the count falls through zero, an interrupt is generated (if enabled), and the count is automatically reloaded.

FF96: Reserved  
 FF97: Reserved

**FF98: Video Mode Register**

|       |   |        |                                 |
|-------|---|--------|---------------------------------|
| Bit 7 | - | BP     | 0 = alphanumeric, 1 = bit plane |
| Bit 6 | - | --     |                                 |
| Bit 5 | - | DESCEN | 1 = extra descender enabled     |
| Bit 4 | - | MOCH   | 1 = monochrome (on composite)   |
| Bit 3 | - | H50    | 1 = 50 Hz vertical sync         |
| Bit 2 | - | LPR2   | Lines per row (see table below) |
| Bit 1 | - | LPR1   | Lines per row (see table below) |
| Bit 0 | - | LPRO   | Lines per row (see table below) |

| LPR2 | LPR1 | LPRO | Lines per character row |
|------|------|------|-------------------------|
| 0    | 0    | 0    | one                     |
| 0    | 0    | 1    | two                     |
| 0    | 1    | 0    | three                   |
| 0    | 1    | 1    | eight                   |
| 1    | 0    | 0    | nine                    |
| 1    | 0    | 1    | ten                     |
| 1    | 1    | 0    | twelve                  |
| 1    | 1    | 1    | (reserved)              |

**FF99: Video Resolution Register**

|       |   |       |   |
|-------|---|-------|---|
| Bit 7 | - | --    |   |
| Bit 6 | - | LPF1  | Lines per field (see table below)                 |
| Bit 5 | - | LPF0  | Lines per field                                   |
| Bit 4 | - | HRES2 | Horizontal resolution (see Video resolution page) |
| Bit 3 | - | HRES1 | Horizontal resolution                             |
| Bit 2 | - | HRES0 | Horizontal resolution                             |
| Bit 1 | - | CRES1 | Color resolution (see Video resolution page)      |
| Bit 0 | - | CRES0 | Color resolution                                  |

| LPF1 | LPF0 | Lines per field |
|------|------|-----------------|
| 0    | 0    | 192             |
| 0    | 1    | 200             |
| 1    | 0    | 210             |
| 1    | 1    | 225             |



Chip Control (Continued)

FF9A: Border Register (Zero all bits for CoCo compatibility)

|       |   |      |                             |
|-------|---|------|-----------------------------|
| Bit 7 | - | --   |                             |
| Bit 6 | - | --   |                             |
| Bit 5 | - | RED1 | Most significant red bit    |
| Bit 4 | - | GRN1 | Most significant green bit  |
| Bit 3 | - | BLU1 | Most significant blue bit   |
| Bit 2 | - | RED0 | Least significant red bit   |
| Bit 1 | - | GRN0 | Least significant green bit |
| Bit 0 | - | BLU0 | Least significant blue bit  |

FF9B: Reserved

FF9C: Vertical Offset 2 / Vertical Scroll Register

|       |   |      |                         |
|-------|---|------|-------------------------|
| Bit 7 | - | --   |                         |
| Bit 6 | - | Y18  | Vertical Offset address |
| Bit 5 | - | Y17  | Vertical Offset address |
| Bit 4 | - | Y16  | Vertical Offset address |
| Bit 3 | - | VSC3 | Vertical Scroll bit     |
| Bit 2 | - | VSC2 | Vertical Scroll bit     |
| Bit 1 | - | VSC1 | Vertical Scroll bit     |
| Bit 0 | - | VSC0 | Vertical Scroll bit     |

FF9D: Vertical Offset 1 Register

|       |   |     |                         |
|-------|---|-----|-------------------------|
| Bit 7 | - | Y15 | Vertical Offset address |
| Bit 6 | - | Y14 | Vertical Offset address |
| Bit 5 | - | Y13 | Vertical Offset address |
| Bit 4 | - | Y12 | Vertical Offset address |
| Bit 3 | - | Y11 | Vertical Offset address |
| Bit 2 | - | Y10 | Vertical Offset address |
| Bit 1 | - | Y9  | Vertical Offset address |
| Bit 0 | - | Y8  | Vertical Offset address |

FF9E: Vertical Offset 0 Register

|       |   |    |                         |
|-------|---|----|-------------------------|
| Bit 7 | - | Y7 | Vertical Offset address |
| Bit 6 | - | Y6 | Vertical Offset address |
| Bit 5 | - | Y5 | Vertical Offset address |
| Bit 4 | - | Y4 | Vertical Offset address |
| Bit 3 | - | Y3 | Vertical Offset address |
| Bit 2 | - | Y2 | Vertical Offset address |
| Bit 1 | - | -- |                         |
| Bit 0 | - | -- |                         |

NOTE: In CoCo mode, Y15 - Y9 are not effective, and are controlled by SAM bits F6 - F0. Also, in CoCo mode, Y18 - Y16 should be one, all others zero.



FF9F: Horizontal Offset 0 Register

|       |   |      |                           |
|-------|---|------|---------------------------|
| Bit 7 | - | HVEN | Horizontal Virtual Enable |
| Bit 6 | - | X6   | Horizontal Offset address |
| Bit 5 | - | X5   | Horizontal Offset address |
| Bit 4 | - | X4   | Horizontal Offset address |
| Bit 3 | - | X3   | Horizontal Offset address |
| Bit 2 | - | X2   | Horizontal Offset address |
| Bit 1 | - | X1   | Horizontal Offset address |
| Bit 0 | - | X0   | Horizontal Offset address |

NOTE: HVEN enables a horizontal screen width of 128 bytes regardless of the HRES bits and CRES bits selected. This will allow a "virtual" screen somewhat larger than the displayed screen. The user can move the "window" (the displayed screen) by means of the horizontal offset bits. In character mode, the screen width is 128 characters regardless of attribute (or 64, if double-wide is selected).

SAM CONTROL REGISTERS: (FFC0 - FFDF)

|      |     |   |      |                           |
|------|-----|---|------|---------------------------|
| FFC0 | - 1 | - | V0   | CoCo graphics mode select |
| FFC2 | - 3 | - | V1   | CoCo graphics mode select |
| FFC4 | - 5 | - | V2   | CoCo graphics mode select |
| FFC6 | - 7 | - | F0   | CoCo vertical offset      |
| FFC8 | - 9 | - | F1   | CoCo vertical offset      |
| FFCA | - B | - | F2   | CoCo vertical offset      |
| FFCC | - D | - | F3   | CoCo vertical offset      |
| FFCE | - F | - | F4   | CoCo vertical offset      |
| FFD0 | - 1 | - | F5   | CoCo vertical offset      |
| FFD2 | - 3 | - | F6   | CoCo vertical offset      |
| FFD8 | - 9 | - | R1   | MPU Speed                 |
| FFDE | - F | - | MAPA | ROM disable               |

NOTE: These bits work like the ones in the Motorola SAM chip, (MC6883), in that by writing to the upper address of each two address group (data is don't care), the bit is set and by writing to the lower address the bit is cleared. The graphics modes and vertical offset bits are valid only in the CoCo mode, but the other two bits are valid anytime. Note that the only semigraphics mode supported is Semi Four.



MEMORY MANAGEMENT UNIT

WR: XFFA0 - XFFAF, 6 bits

|     |     |     |     |     |     |
|-----|-----|-----|-----|-----|-----|
| D5  | D4  | D3  | D2  | D1  | D0  |
| --- | --- | --- | --- | --- | --- |
| A18 | A17 | A16 | A15 | A14 | A13 |

When the CPU accesses any memory outside the I/O and control range, (XFF00 - XFFFF), CPU address lines A13 - A15, in conjunction with the TR (task register) bit of FFA1, determine the MMU address location accessed. The data from the MMU is then used as the most significant addresses for memory access, according to the following ranges:

| TR  | A15 | A14 | A13 | (Address range) | MMU location addressed |
|-----|-----|-----|-----|-----------------|------------------------|
| --- | --- | --- | --- | -----           | -----                  |
| 0   | 0   | 0   | 0   | X0000 - X1FFF   | FFA0                   |
| 0   | 0   | 0   | 1   | X2000 - X3FFF   | FFA1                   |
| 0   | 0   | 1   | 0   | X4000 - X5FFF   | FFA2                   |
| 0   | 0   | 1   | 1   | X6000 - X7FFF   | FFA3                   |
| 0   | 1   | 0   | 0   | X8000 - X9FFF   | FFA4                   |
| 0   | 1   | 0   | 1   | XA000 - XBFFF   | FFA5                   |
| 0   | 1   | 1   | 0   | XC000 - XDFFF   | FFA6                   |
| 0   | 1   | 1   | 1   | XE000 - XFFFF   | FFA7                   |
| 1   | 0   | 0   | 0   | X0000 - X1FFF   | FFA8                   |
| 1   | 0   | 0   | 1   | X2000 - X3FFF   | FFA9                   |
| 1   | 0   | 1   | 0   | X4000 - X5FFF   | FFAA                   |
| 1   | 0   | 1   | 1   | X6000 - X7FFF   | FFAB                   |
| 1   | 1   | 0   | 0   | X8000 - X9FFF   | FFAC                   |
| 1   | 1   | 0   | 1   | XA000 - XBFFF   | FFAD                   |
| 1   | 1   | 1   | 0   | XC000 - XDFFF   | FFAE                   |
| 1   | 1   | 1   | 1   | XE000 - XFFFF   | FFAF                   |

It is important to note that in order for the MMU to function, the CoCo bit must be cleared, and the MMU enabled. Prior to doing this, the desired addresses for each segment must be loaded. For example, if a standard 64K map is desired when task register 0 is selected, the following values must be preloaded into the MMU registers:

|      |   |    |
|------|---|----|
| FFA0 | - | 38 |
| FFA1 | - | 39 |
| FFA2 | - | 3A |
| FFA3 | - | 3B |
| FFA4 | - | 3C |
| FFA5 | - | 3D |
| FFA6 | - | 3E |
| FFA7 | - | 3F |



## COLOR PALLETTE

FFB0 - FFBF: 16 addresses, 6 bits each

For the RGB outputs, the bits are defined as follows:

|    |    |    |    |    |    |
|----|----|----|----|----|----|
| D5 | D4 | D3 | D2 | D1 | D0 |
| R1 | G1 | B1 | R0 | G0 | B0 |

For the Composite output, the bits are defined as follows, where I is intensity level and P is phase:

|    |    |    |    |    |    |
|----|----|----|----|----|----|
| D5 | D4 | D3 | D2 | D1 | D0 |
| I1 | I0 | P3 | P2 | P1 | P0 |

Some Color Examples:

|                | RGB    |      | Composite |      |
|----------------|--------|------|-----------|------|
|                | Binary | Hex  | Binary    | Hex  |
| White          | 111111 | (3F) | 110000    | (30) |
| Black          | 000000 | (00) | 000000    | (00) |
| Bright Green   | 010010 | (12) | 100010    | (22) |
| Medium Green   | 010000 | (10) | 010010    | (12) |
| Dark Green     | 000010 | (02) | 000010    | (02) |
| Medium Magenta | 101000 | (28) | 010101    | (15) |

For CoCo Compatibility, the following values should be loaded upon initialization. (Note: Internal logic adjusts both pallettes to be the same in the CoCo mode, as long as the following values are loaded.)

|        |         |      |
|--------|---------|------|
| FFB0 - | Green   | (12) |
| FFB1 - | Yellow  | (36) |
| FFB2 - | Blue    | (09) |
| FFB3 - | Red     | (24) |
| FFB4 - | Buff    | (3F) |
| FFB5 - | Cyan    | (1B) |
| FFB6 - | Magenta | (2D) |
| FFB7 - | Orange  | (34) |
| FFB8 - | Black   | (00) |
| FFB9 - | Green   | (12) |
| FFBA - | Black   | (00) |
| FFBB - | Buff    | (3F) |
| FFBC - | Black   | (00) |
| FFBD - | Green   | (12) |
| FFBE - | Black   | (00) |
| FFBF - | Orange  | (34) |



. COLOR TABLE

| Palette Data |     | RGB Color Produced  | Composite Color      |
|--------------|-----|---------------------|----------------------|
| -----        |     | -----               | -----                |
| 000000       | 00H | Black               | Black                |
| 000001       | 01H | Dark Blue           | Dark Blue            |
| 000010       | 02H | Medium Blue         | Dark Green           |
| 000011       | 03H | Bright Blue         | Dark Cyan            |
| 000100       | 04H | Dark Green          | Dark Red             |
| 000101       | 05H | Dark Cyan           | Dark Magenta         |
| 000110       | 06H | Light Blue/Cyan     | Brown                |
| 000111       | 07H | Light Blue          | Dark Green/Blue      |
| 001000       | 08H | Medium Green        | Dark Sky Blue        |
| 001001       | 09H | Medium Green/Cyan   | Medium Peacock       |
| 001010       | 0AH | Medium Cyan         | Medium Green/Cyan    |
| 001011       | 0BH | Peacock             | Dark Red/Magenta     |
| 001100       | 0CH | Bright Green        | Dark Red/Orange      |
| 001101       | 0DH | Bright Green/Cyan   | Dark Orange          |
| 001110       | 0EH | Light Green/Cyan    | Medium Yellow/Green  |
| 001111       | 0FH | Bright Cyan         | Medium Blue/Purple   |
| 010000       | 10H | Dark Red            | Dark Grey            |
| 010001       | 11H | Dark Magenta        | Medium Blue          |
| 010010       | 12H | Indigo              | Medium Green         |
| 010011       | 13H | Medium Blu/Purple   | Medium Cyan          |
| 010100       | 14H | Brown               | Medium Red           |
| 010101       | 15H | Dark Grey           | Medium Blue/Magenta  |
| 010110       | 16H | Medium Sky Blue     | Yellow/Brown         |
| 010111       | 17H | Medium Peacock      | Medium Green/Blue    |
| 011000       | 18H | Medium Yellow/Green | Medium Sky Blue      |
| 011001       | 19H | Light Green/Cyan    | Bright Peacock       |
| 011010       | 1AH | Light Peacock       | Bright Green/Cyan    |
| 011011       | 1BH | Pale Peacock        | Medium Red/Magenta   |
| 011100       | 1CH | Bright Yellow/Green | Medium Red/Orange    |
| 011101       | 1DH | Light Green         | Medium Orange        |
| 011110       | 1EH | Pale Green/Cyan     | Bright Yellow/Green  |
| 011111       | 1FH | Light Cyan          | Bright Purple        |
| 100000       | 20H | Medium Red          | Light Grey           |
| 100001       | 21H | Medium Red/Magenta  | Bright Blue          |
| 100010       | 22H | Medium Blue/Magenta | Bright Green         |
| 100011       | 23H | Blue/Purple         | Bright Cyan          |
| 100100       | 24H | Yellow/Orange       | Bright Red           |
| 100101       | 25H | Light Red           | Bright Magenta       |
| 100110       | 26H | Light Magenta       | Medium Yellow        |
| 100111       | 27H | Purple              | Bright Green/Blue    |
| 101000       | 28H | Medium Yellow       | Bright Sky Blue      |
| 101001       | 29H | Light Yellow        | Light Peacock        |
| 101010       | 2AH | Light Grey          | Light Green/Cyan     |
| 101011       | 2BH | Pale Blue           | Bright Red/Magenta   |
| 101100       | 2CH | Light Yellow/Green  | Bright Orange        |
| 101101       | 2DH | Pale Yellow/Green   | Bright Yellow/Orange |
| 101110       | 2EH | Pale Cyan           | Light Yellow/Green   |
| 101111       | 2FH | Pale Blue/Cyan      | Light Purple         |



COLOR TABLE (Continued)

|        |     |                     |                     |
|--------|-----|---------------------|---------------------|
| 110000 | 30H | Bright Red          | White               |
| 110001 | 31H | Light Red/Magenta   | Light Blue          |
| 110010 | 32H | Light Purple        | Light Green         |
| 110011 | 33H | Bright Magenta      | Light Cyan          |
| 110100 | 34H | Orange              | Light Red           |
| 110101 | 35H | Pale Red/Magenta    | Light Blue/Magenta  |
| 110110 | 36H | Pale Blue/Magenta   | Light Yellow        |
| 110111 | 37H | Pale Purple         | Light Green/Blue    |
| 111000 | 38H | Light Yellow/Orange | Light Sky Blue      |
| 111001 | 39H | Medium Yellow       | Pale Peacock        |
| 111010 | 3AH | Pale Red            | Pale Green/Cyan     |
| 111011 | 3BH | Pale Magenta        | Light Red/Magenta   |
| 111100 | 3CH | Bright Yellow       | Light Orange        |
| 111101 | 3DH | Pale Yellow         | Light Yellow/Orange |
| 111110 | 3EH | Very Pale Yellow    | Pale Yellow/Green   |
| 111111 | 3FH | White               | Pale Purple         |



## VIDEO RESOLUTION

The combination of HRES and CRES bits determine the resolution of the screen. The following resolutions are supported:

Alphanumerics (BP = 0, CoCo = 0)

|              | HR2 | HR1 | HR0 | CR1 | CR0 |
|--------------|-----|-----|-----|-----|-----|
| 32 character | 0   | --  | 0   | --  | --  |
| 40 character | 0   | --  | 1   | --  | --  |
| 64 character | 1   | --  | 0   | --  | --  |
| 80 character | 1   | --  | 1   | --  | --  |

*MUST: 1*  
*HR.*

Graphics (BP = 1, CoCo = 0)

|                       | HR2 | HR1 | HR0 | CR1 | CR0 |
|-----------------------|-----|-----|-----|-----|-----|
| 640 Pixels, 4 Colors  | 1   | 1   | 1   | 0   | 1   |
| 640 Pixels, 2 Colors  | 1   | 0   | 1   | 0   | 0   |
| 512 Pixels, 4 Colors  | 1   | 1   | 0   | 0   | 1   |
| 512 Pixels, 2 Colors  | 1   | 0   | 0   | 0   | 0   |
| 320 Pixels, 16 Colors | 1   | 1   | 1   | 1   | 0   |
| 320 Pixels, 4 Colors  | 1   | 0   | 1   | 0   | 1   |
| 320 Pixels, 2 Colors  | 0   | 1   | 1   | 0   | 0   |
| 256 Pixels, 16 Colors | 1   | 1   | 0   | 1   | 0   |
| 256 Pixels, 4 Colors  | 1   | 0   | 0   | 0   | 1   |
| 256 Pixels, 2 Colors  | 0   | 1   | 0   | 0   | 0   |
| 160 Pixels, 16 Colors | 1   | 0   | 1   | 1   | 0   |

In addition to the above modes, the previous CoCo modes are available. These result when the CoCo bit is set, and in this case, the HRES and CRES bits do not change the modes. If any combinations of the HRES and CRES bits not listed above are used, the results are not guaranteed, and whatever the resulting mode is WILL NOT BE SUPPORTED IN FUTURE VERSIONS.



# ALPHANUMERIC MODES

## Even Byte (Character byte)

---

|       |   |                 |
|-------|---|-----------------|
| Bit 7 | - | --              |
| Bit 6 | - | Character bit 6 |
| Bit 5 | - | Character bit 5 |
| Bit 4 | - | Character bit 4 |
| Bit 3 | - | Character bit 3 |
| Bit 2 | - | Character bit 2 |
| Bit 1 | - | Character bit 1 |
| Bit 0 | - | Character bit 0 |

## Odd Byte (Attribute byte)

---

|       |   |       |                                      |
|-------|---|-------|--------------------------------------|
| Bit 7 | - | BLINK | Characters blink at 1/2 sec. rate    |
| Bit 6 | - | UNDLN | Characters are underlined            |
| Bit 5 | - | FGND2 | Foreground color bit (palette addr.) |
| Bit 4 | - | FGND1 | Foreground color bit (palette addr.) |
| Bit 3 | - | FGND0 | Foreground color bit (palette addr.) |
| Bit 2 | - | BGND2 | Background color bit (palette addr.) |
| Bit 1 | - | BGND1 | Background color bit (palette addr.) |
| Bit 0 | - | BGND0 | Background color bit (palette addr.) |

NOTE: Attributes are not available when CoCo = 1.



## GRAPHICS MODES

16 Color Modes: (CRES1 = 1, CRES0 = 0)

Byte from DRAM

|       |   |                   |
|-------|---|-------------------|
| Bit 7 | - | PA3, First Pixel  |
| Bit 6 | - | PA2, First Pixel  |
| Bit 5 | - | PA1, First Pixel  |
| Bit 4 | - | PA0, First Pixel  |
| Bit 3 | - | PA3, Second Pixel |
| Bit 2 | - | PA2, Second Pixel |
| Bit 1 | - | PA1, Second Pixel |
| Bit 0 | - | PA0, Second Pixel |

4 Color Modes: (CRES1 = 0, CRES0 = 1)

Byte from DRAM

|       |   |                   |
|-------|---|-------------------|
| Bit 7 | - | PA1, First Pixel  |
| Bit 6 | - | PA0, First Pixel  |
| Bit 5 | - | PA1, Second Pixel |
| Bit 4 | - | PA0, Second Pixel |
| Bit 3 | - | PA1, Third Pixel  |
| Bit 2 | - | PA0, Third Pixel  |
| Bit 1 | - | PA1, Fourth Pixel |
| Bit 0 | - | PA0, Fourth Pixel |

2 Color Modes: (CRES1 = 0, CRES0 = 0)

Byte from DRAM

|       |   |                    |
|-------|---|--------------------|
| Bit 7 | - | PA0, First Pixel   |
| Bit 6 | - | PA0, Second Pixel  |
| Bit 5 | - | PA0, Third Pixel   |
| Bit 4 | - | PA0, Fourth Pixel  |
| Bit 3 | - | PA0, Fifth Pixel   |
| Bit 2 | - | PA0, Sixth Pixel   |
| Bit 1 | - | PA0, Seventh Pixel |
| Bit 0 | - | PA0, Eighth Pixel  |

### Palette Addresses

| PA3 | PA2 | PA1 | PA0 | Address of Contents Displayed |
|-----|-----|-----|-----|-------------------------------|
| 0   | 0   | 0   | 0   | FFB0                          |
| 0   | 0   | 0   | 1   | FFB1                          |
| 0   | 0   | 1   | 0   | FFB2                          |
| 0   | 0   | 1   | 1   | FFB3                          |
| 0   | 1   | 0   | 0   | FFB4                          |
| 0   | 1   | 0   | 1   | FFB5                          |
| 0   | 1   | 1   | 0   | FFB6                          |
| 0   | 1   | 1   | 1   | FFB7                          |
| 1   | 0   | 0   | 0   | FFB8                          |
| 1   | 0   | 0   | 1   | FFB9                          |
| 1   | 0   | 1   | 0   | FFBA                          |
| 1   | 0   | 1   | 1   | FFBB                          |
| 1   | 1   | 0   | 0   | FFBC                          |
| 1   | 1   | 0   | 1   | FFBD                          |
| 1   | 1   | 1   | 0   | FFBE                          |
| 1   | 1   | 1   | 1   | FFBF                          |