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Preliminary
Graphics Control Routines
for the
ML Foundation System

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Abstract

Preliminary PMODE 4 setup and PMODE 4 PSET Graphics Control Routines for the ML Foundation System are developed and presented to run on top of the ML Foundation Core. These Preliminary Routines will be required during the implementation of a yet-to-be-developed Fake Text (maze-like) game.

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This paper and its associated code are available online at:

<http://www.bds-soft.com/cocoPapers.php> .

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Introduction

The first thing I wanted to do with the ML Foundation System was to see if I could build a PMODE 4 (maze-like) game using it. In order to do so, I had to first build and control the PMODE 4 screens. That is the subject of this paper.

The CoCo's Extended Color BASIC ROM seems to be structured around a maximal graphics services concept; i.e. it's set up so that programmers can select and use whatever PMODE they desire at any time, changing back and forth between PMODEs in whatever sequence they choose, and the ROM would handle it all seamlessly.

Furthermore, that ROM code is also fully integrated with the BASIC Interpreter so that whatever the programmer wants to do must first be filtered through the BASIC and Extended BASIC Language system to determine what part of the ROM it should be dispatched to. For example, given a line of code, the BASIC Interpreter must first determine that it is about graphics rather than text before it can even begin to decide where it should be dispatched.

This is convenient for a beginning (or even a comparatively accomplished) BASIC programmer, but it uses a lot of memory and is quite slow.

I instead determined to pursue a minimal graphics services concept; one where only PMODE 4 would be used, and wherein the Assembly Language code could immediately dispatch control to the proper handler with a minimum of code and maximum speed.

Ultimately, separate routines will be developed for each PMODE. This will allow the programmer to determine how many (or if any) of these graphics routines are needed for the project being developed by the programmer. Keeping the PMODES separate will thus further minimize memory usage and maximize speed.

For the purposes of this paper, however, my efforts are restricted to PMODE 4 only.

In addition to restricting the game design to PMODE 4; in order to provide increased speed and simplicity, I determined to develop the game using 256 8-pixel by 12-pixel Fake Text characters as if the PMODE 4 screen were a 32x16 Text screen. The details of that are a subject for a later paper, however.

For the purposes of this present paper, that fake text concept simply served as a guideline into how complex these PMODE 4 Graphics Routines for the ML Foundation System needed to be.

To even further increase speed and simplicity, I determined to utilize only unsigned integers in the game development. Signed integer arithmetic and floating point numerical operations will also be left for future work.

A Note on Numbers: To keep everything simple to understand, and also neatly lined-up, I frequently refer to numbers as decimal bytes with three full digits, e.g., 004, 027, 229, etc. See Appendix A for conversions between the decimal and hexadecimal representations of bytes. The leading zeroes are NOT intended to indicate octal notation. Octal notation is not used anywhere in this paper.

In works of this complexity (at least for me) typos and other errors are bound to sneak in. Please let me know about any you discover so I can note and correct them.

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General Methodology

For any given PMODE (and for the Text screen as well), the CoCo's Extended BASIC ROM sets certain low-memory variables, including, but not limited to:

Hex Address -----	Abbrev. -----	Variable -----
00B2	FORCOL	Foreground Color
00B3	BAKCOL	Background Color
00B5	ALLCOL	All Pixels Color Byte
00B6	PMODE	The PMODE Value
00B7	ENDGRP	End of Current Graphic Page
00B9	HORBYT	# of Bytes/Horizontal Line
00BA	BEGGRP	Start of Current Graphic Page
00BC	GRPRAM	MSB of Start of Graphic RAM
00C1	CSSVAL	Screen's Color Set Argument
00DB	CHGFLG	Graphic Data Changed Flag

(cf. Zydhek, p. A-4).

Through some trial and error testing, I determined that by setting some of these variables and then setting-up the SAM and VDG chips appropriately, I could enter PMODE 4 quickly with a minimum of code usage.

Following that, I set-up simplified PCLS and PSET routines for PMODE 4.

More complex graphics code (e.g. LINE, BOX, FILL, etc.) are left for future work, as they were determined to not be necessary for the game I envisioned.

=====

BITWISE.BAS: Unsigned Integer Bitwise Operations in BASIC

In order to be able to check my work as I went along in the development, I decided that it would be convenient to be able to perform unsigned integer bitwise operations in BASIC, a task for which CoCo BASIC has not provided. Accordingly, I developed the following BITWISE.BAS program to perform unsigned 8-bit integer AND, OR, NOT, XOR, LSL, LSR, ROL, and ROR bitwise operations.

This is not part of the Graphics Control Routines, per se, but it is a self-contained utility which you might find useful in your own code development.

```
1000 '*****
1010 '*
1020 '* BITWISE.BAS
1030 '* MDJ 2023/03/14
1040 '*
1050 '* UNSIGNED INTEGER
1060 '* BITWISE OPERATIONS
1070 '* IN BASIC
1080 '*
1090 '*****
1100 CLS
1110 C = 0 'CARRY BIT
1120 'TEMPORARY VARIABLES
1130 ' = A8, A9, B8, B9, T
1140 '

1200 A = 0
1210 INPUT "ENTER 1ST UINT A (0-255)";A
1220 T = INT(A)
1230 IF (T < 0) THEN A = 0
1240 IF (T > 255) THEN A = 255
1250 PRINT
1260 '

1400 B = 0
1410 INPUT "ENTER 1ST UINT B (0-255)";B
1420 T = INT(B)
1430 IF (T < 0) THEN B = 0
1440 IF (T > 255) THEN B = 255
```



```

1450 PRINT
1460 GOTO 2200
1470 '

2000 A = 0
2010 C = 0 'CLEAR CARRY BIT
2020 INPUT "ENTER NEW UINT A (0-255)";A
2030 T = INT(A)
2040 IF (T < 0) THEN A = 0
2050 IF (T > 255) THEN A = 255
2060 PRINT
2070 GOTO 2200
2080 '

2100 B = 0
2110 INPUT "ENTER NEW UINT B (0-255)";B
2120 T = INT(B)
2130 IF (T < 0) THEN B = 0
2140 IF (T > 255) THEN B = 255
2150 PRINT
2160 '

2200 PRINT "SELECT OP:"
2210 PRINT "  A = INPUT NEW A"
2220 PRINT "  B = INPUT NEW B"
2230 PRINT "  Y = CHECK A"
2240 PRINT "  Z = CHECK B"
2250 PRINT "  S = SWAP:  A <--> B"
2260 PRINT "  N = NOT(A)    --> A"
2270 PRINT "  D = (A AND B) --> A"
2280 PRINT "  R = (A OR B)  --> A"
2290 PRINT "  X = (A XOR B) --> A"
2300 PRINT "  2 = GO TO SECOND MENU"
2310 PRINT "  E = EXIT ?";
2320 A$ = INKEY$
2330 IF (A$ = "") GOTO 2320
2340 PRINT
2350 IF (A$ = "A") GOTO 2000
2360 IF (A$ = "B") GOTO 2100
2370 IF (A$ = "Y") GOTO 12500
2380 IF (A$ = "Z") GOTO 13000
2390 IF (A$ = "S") GOTO 13500
2400 IF (A$ = "N") GOTO 14000
2410 IF (A$ = "D") GOTO 14500
2420 IF (A$ = "R") GOTO 15000
2430 IF (A$ = "X") GOTO 15500
2440 IF (A$ = "2") GOTO 3000

```

```
2450 IF (A$ = "E") GOTO 32767
2460 GOTO 2200
2470 '
```

```
3000 PRINT
3010 PRINT
3020 PRINT "SELECT 2ND MENU OP:"
3030 PRINT " 4 = LSL"
3040 PRINT " 5 = LSR"
3050 PRINT " 6 = ROL"
3060 PRINT " 7 = ROR"
3070 PRINT " 1 = BACK TO FIRST MENU"
3080 PRINT " E = EXIT ?";
3090 A$ = INKEY$
3100 IF (A$ = "") GOTO 3090
3110 PRINT
3120 IF (A$ = "4") GOTO 16000
3130 IF (A$ = "5") GOTO 16500
3140 IF (A$ = "6") GOTO 17000
3150 IF (A$ = "7") GOTO 17500
3160 IF (A$ = "1") GOTO 2200
3170 IF (A$ = "E") GOTO 32767
3180 GOTO 3010
3190 '
```

```
12500 'OP Y = CHECK A
12510 PRINT "UINT: A = ";A
12520 GOSUB 20000 'A: UINT-->BITS
12530 PRINT "A BITS = ";A7;A6;A5;A4;A3;A2;A1;A0;
12540 PRINT "C = CARRY BIT = ";C
12550 GOSUB 20500 'A: BITS-->UINT
12560 PRINT "CHECK: A = ";A
12570 GOTO 2200
12580 '
```

```
13000 'OP Z = CHECK B
13010 PRINT "UINT: B = ";B
13020 GOSUB 21000 'B: UINT-->BITS
13030 PRINT "B BITS = ";B7;B6;B5;B4;B3;B2;B1;B0;
13040 GOSUB 20500 'B: BITS-->UINT
13050 PRINT "CHECK: B = ";B
13060 GOTO 2200
13070 '
```

```
13500 'OP S = SWAP: A <--> B
13510 GOSUB 22000
13520 PRINT "SWAPPED, NOW:"
```

```

13530 PRINT "  UINT: A = ";A
13540 PRINT "  UINT: B = ";B
13550 GOTO 2200
13560 '

14000 'OP N = NOT(A) --> A
14010 C = 0 'CLEAR CARRY BIT
14020 GOSUB 22500
14030 PRINT "A = NOT(A) = ";A
14040 GOTO 2200
14050 '

14500 'OP D = (A AND B) --> A
14510 C = 0 'CLEAR CARRY BIT
14520 GOSUB 23000
14530 PRINT "A = (A AND B) = ";A
14540 GOTO 2200
14550 '

15000 'OP R = (A OR B) --> A
15010 C = 0 'CLEAR CARRY BIT
15020 GOSUB 23500
15030 PRINT "A = (A OR B) = ";A
15040 GOTO 2200
15050 '

15500 'OP X = (A XOR B) --> A
15510 C = 0 'CLEAR CARRY BIT
15520 GOSUB 24000
15530 PRINT "A = (A XOR B) = ";A
15540 GOTO 2200
15550 '

16000 'OP 4 = LSL(A) --> A
16010 GOSUB 24500
16020 PRINT "A = LSL(A) = ";A
16030 GOTO 2200
16040 '

16500 'OP 5 = LSR(A) --> A
16510 GOSUB 25000
16520 PRINT "A = LSR(A) = ";A
16530 GOTO 2200
16540 '

17000 'OP 6 = ROL(A) --> A
17010 GOSUB 25500

```

```

17020 PRINT "A = ROL(A) = ";A
17030 GOTO 2200
17040 '

17500 'OP 7 = ROR(A) --> A
17510 GOSUB 26000
17520 PRINT "A = ROR(A) = ";A
17530 GOTO 2200
17540 '

20000 'CONVERT AN UNSIGNED INTEGER
20010 'IN REGISTER "A" TO INDIVIDUAL BITS.
20020 'ENTER WITH A = THE UNSIGNED INTEGER.
20030 'EXIT WITH A0-A7 = THE BITS.
20040 A8 = INT(A)
20050 A9 = INT(A8/2)
20060 A0 = A8 - (A9*2)
20070 A8 = A9
20080 A9 = INT(A8/2)
20090 A1 = A8 - (A9*2)
20100 A8 = A9
20110 A9 = INT(A8/2)
20120 A2 = A8 - (A9*2)
20130 A8 = A9
20140 A9 = INT(A8/2)
20150 A3 = A8 - (A9*2)
20160 A8 = A9
20170 A9 = INT(A8/2)
20180 A4 = A8 - (A9*2)
20190 A8 = A9
20200 A9 = INT(A8/2)
20210 A5 = A8 - (A9*2)
20220 A8 = A9
20230 A9 = INT(A8/2)
20240 A6 = A8 - (A9*2)
20250 A8 = A9
20260 A9 = INT(A8/2)
20270 A7 = A8 - (A9*2)
20280 RETURN
20290 '

20500 'CONVERT INDIVIDUAL BITS IN
20510 'REGISTER "A" TO AN UNSIGNED INTEGER.
20520 'ENTER WITH A0-A7 = THE BITS.
20530 'EXIT WITH A = THE UNSIGNED INTEGER.
20540 A = A7*128 + A6*64 + A5*32 + A4*16
20550 A = A + A3*8 + A2*4 + A1*2 + A0*1

```

```

20560 RETURN
20570 '

21000 'CONVERT AN UNSIGNED INTEGER
21010 'IN REGISTER "B" TO INDIVIDUAL BITS.
21020 'ENTER WITH B = THE UNSIGNED INTEGER.
21030 'EXIT WITH B0-B7 = THE BITS.
21040 B8 = INT(B)
21050 B9 = INT(B8/2)
21060 B0 = B8 - (B9*2)
21070 B8 = B9
21080 B9 = INT(B8/2)
21090 B1 = B8 - (B9*2)
21100 B8 = B9
21110 B9 = INT(B8/2)
21120 B2 = B8 - (B9*2)
21130 B8 = B9
21140 B9 = INT(B8/2)
21150 B3 = B8 - (B9*2)
21160 B8 = B9
21170 B9 = INT(B8/2)
21180 B4 = B8 - (B9*2)
21190 B8 = B9
21200 B9 = INT(B8/2)
21210 B5 = B8 - (B9*2)
21220 B8 = B9
21230 B9 = INT(B8/2)
21240 B6 = B8 - (B9*2)
21250 B8 = B9
21260 B9 = INT(B8/2)
21270 B7 = B8 - (B9*2)
21280 RETURN
21290 '

21500 'CONVERT INDIVIDUAL BITS IN
21510 'REGISTER "B" TO AN UNSIGNED INTEGER.
21520 'ENTER WITH B0-B7 = THE BITS.
21530 'EXIT WITH B = THE UNSIGNED INTEGER.
21540 B = B7*128 + B6*64 + B5*32 + B4*16
21550 B = B + B3*8 + B2*4 + B1*2 + B0*1
21560 RETURN
21570 '

22000 'SWAP REGISTERS
22010 T = A
22020 A = B
22030 B = T

```

```

22040 RETURN
22050 '

22500 'BITWISE NOT A
22510 GOSUB 20000 'A: UINT-->BITS
22520 IF (A0 = 0) THEN A0 = 1 ELSE A0 = 0
22530 IF (A1 = 0) THEN A1 = 1 ELSE A1 = 0
22540 IF (A2 = 0) THEN A2 = 1 ELSE A2 = 0
22550 IF (A3 = 0) THEN A3 = 1 ELSE A3 = 0
22560 IF (A4 = 0) THEN A4 = 1 ELSE A4 = 0
22570 IF (A5 = 0) THEN A5 = 1 ELSE A5 = 0
22580 IF (A6 = 0) THEN A6 = 1 ELSE A6 = 0
22590 IF (A7 = 0) THEN A7 = 1 ELSE A7 = 0
22600 GOSUB 20500 'A: BITS-->UINT
22610 RETURN
22620 '

23000 'BITWISE (A AND B) --> A
23010 GOSUB 20000 'A: UINT-->BITS
23020 GOSUB 21000 'B: UINT-->BITS
23030 IF ((A0 = 1) AND (B0 = 1)) THEN A0 = 1 ELSE A0 =
0
23040 IF ((A1 = 1) AND (B1 = 1)) THEN A1 = 1 ELSE A1 =
0
23050 IF ((A2 = 1) AND (B2 = 1)) THEN A2 = 1 ELSE A2 =
0
23060 IF ((A3 = 1) AND (B3 = 1)) THEN A3 = 1 ELSE A3 =
0
23070 IF ((A4 = 1) AND (B4 = 1)) THEN A4 = 1 ELSE A4 =
0
23080 IF ((A5 = 1) AND (B5 = 1)) THEN A5 = 1 ELSE A5 =
0
23090 IF ((A6 = 1) AND (B6 = 1)) THEN A6 = 1 ELSE A6 =
0
23100 IF ((A7 = 1) AND (B7 = 1)) THEN A7 = 1 ELSE A7 =
0
23110 GOSUB 20500 'A: BITS-->UINT
23120 RETURN
23130 '

23500 'BITWISE (A OR B) --> A
23510 GOSUB 20000 'A: UINT-->BITS
23520 GOSUB 21000 'B: UINT-->BITS
23530 IF ((A0 = 1) OR (B0 = 1)) THEN A0 = 1 ELSE A0 =
0
23540 IF ((A1 = 1) OR (B1 = 1)) THEN A1 = 1 ELSE A1 =
0

```

```

23550 IF ((A2 = 1) OR (B2 = 1)) THEN A2 = 1 ELSE A2 =
0
23560 IF ((A3 = 1) OR (B3 = 1)) THEN A3 = 1 ELSE A3 =
0
23570 IF ((A4 = 1) OR (B4 = 1)) THEN A4 = 1 ELSE A4 =
0
23580 IF ((A5 = 1) OR (B5 = 1)) THEN A5 = 1 ELSE A5 =
0
23590 IF ((A6 = 1) OR (B6 = 1)) THEN A6 = 1 ELSE A6 =
0
23600 IF ((A7 = 1) OR (B7 = 1)) THEN A7 = 1 ELSE A7 =
0
23610 GOSUB 20500                'A: BITS-->UINT
23620 RETURN
23630 '

24000 'BITWISE (A XOR B) --> A
24010 GOSUB 20000                'A: UINT-->BITS
24020 GOSUB 21000                'B: UINT-->BITS
24030 IF (((A0 = 1) AND (B0 = 0)) OR ((A0 = 0) AND (B0
= 1))) THEN A0 = 1 ELSE A0 = 0
24040 IF (((A1 = 1) AND (B1 = 0)) OR ((A1 = 0) AND (B1
= 1))) THEN A1 = 1 ELSE A1 = 0
24050 IF (((A2 = 1) AND (B2 = 0)) OR ((A2 = 0) AND (B2
= 1))) THEN A2 = 1 ELSE A2 = 0
24060 IF (((A3 = 1) AND (B3 = 0)) OR ((A3 = 0) AND (B3
= 1))) THEN A3 = 1 ELSE A3 = 0
24070 IF (((A4 = 1) AND (B4 = 0)) OR ((A4 = 0) AND (B4
= 1))) THEN A4 = 1 ELSE A4 = 0
24080 IF (((A5 = 1) AND (B5 = 0)) OR ((A5 = 0) AND (B5
= 1))) THEN A5 = 1 ELSE A5 = 0
24090 IF (((A6 = 1) AND (B6 = 0)) OR ((A6 = 0) AND (B6
= 1))) THEN A6 = 1 ELSE A6 = 0
24100 IF (((A7 = 1) AND (B7 = 0)) OR ((A7 = 0) AND (B7
= 1))) THEN A7 = 1 ELSE A7 = 0
24110 GOSUB 20500                'A: BITS-->UINT
24120 RETURN
24130 '

24500 'BITWISE LOGICAL SHIFT LEFT (LSL)
24510 GOSUB 20000                'A: UINT-->BITS
24520 C = A7
24530 A7 = A6
24540 A6 = A5
24550 A5 = A4
24560 A4 = A3
24570 A3 = A2

```

```

24580 A2 = A1
24590 A1 = A0
24600 A0 = 0
24610 GOSUB 20500          'A: BITS-->UINT
24620 RETURN
24630 '

25000 'BITWISE LOGICAL SHIFT RIGHT (LSR)
25010 GOSUB 20000        'A: UINT-->BITS
25020 C = A0
25030 A0 = A1
25040 A1 = A2
25050 A2 = A3
25060 A3 = A4
25070 A4 = A5
25080 A5 = A6
25090 A6 = A7
25100 A7 = 0
25110 GOSUB 20500        'A: BITS-->UINT
25120 RETURN
25130 '

25500 'BITWISE ROTATE LEFT THRU CARRY (ROL)
25510 GOSUB 20000        'A: UINT-->BITS
25520 T = C
25530 C = A7
25540 A7 = A6
25550 A6 = A5
25560 A5 = A4
25570 A4 = A3
25580 A3 = A2
25590 A2 = A1
25600 A1 = A0
25610 A0 = T
25620 GOSUB 20500        'A: BITS-->UINT
25630 RETURN
25640 '

26000 'BITWISE ROTATE RIGHT THRU CARRY (ROR)
26010 GOSUB 20000        'A: UINT-->BITS
26020 T = C
26030 C = A0
26040 A0 = A1
26050 A1 = A2
26060 A2 = A3
26070 A3 = A4
26080 A4 = A5

```



```
26090 A5 = A6
26100 A6 = A7
26110 A7 = T
26120 GOSUB 20500           'A: BITS-->UINT
26130 RETURN
26140 '

32767 END
```

=====

Graphics Parameters

As mentioned under General Methodology above, for any given PMODE (and for the Text screen as well), the CoCo's Extended BASIC ROM sets certain low-memory variables.

To determine and record those variables' values under the various possible PMODE, Start Page, and Color Set combinations, I prepared the BASIC MLGCTST2.BAS program which appears in Appendix B.

The resulting lists of parameters are recorded in Appendix C.

For the purposes of this paper, we will be utilizing only the following three lists of parameters:

```
BASE: TEXT MODE
B2 FORCOL = 3
B3 BAKCOL = 0
B5 ALLCOL = 0
B6 PMODE = 0
B7 ENDGRP = 1400
B9 HORBYT = 10
BA BEGGRP = E00
BC GRPRAM = E
C1 CSSVAL = 0
DB CHGFLG = 0
```

```
PMODE= 4 , PAGE= 1 , COLORSET= 0
B2 FORCOL = 3
B3 BAKCOL = 0
B5 ALLCOL = 0
B6 PMODE = 4
B7 ENDGRP = 2600
B9 HORBYT = 20
BA BEGGRP = E00
BC GRPRAM = E
C1 CSSVAL = 0
DB CHGFLG = 0
```

```
MIDCALC = F0
POSTCALC = 7
ENDCALC = 6
```

PMODE= 4 , PAGE= 5 , COLORSET= 0

B2 FORCOL = 3

B3 BAKCOL = 0

B5 ALLCOL = 0

B6 PMODE = 4

B7 ENDGRP = 3E00

B9 HORBYT = 20

BA BEGGRP = 2600

BC GRPRAM = E

C1 CSSVAL = 0

DB CHGFLG = 0

MIDCALC = F0

POSTCALC = 13

ENDCALC = 6

=====

SVT: Set the SAM and VDG Registers for Text Mode

SVT is used to return to Text Mode from either of the PMODE 4 Graphics screens. This is a self-contained routine which sets the appropriate low-memory variables and also sets-up the SAM and VDG chips for Text Mode. Although SVT physically appears in memory after STSAMG (ORG \$458F vs. ORG \$4574 respectively), it appears here because it is logically prior to STSAMG in the Graphics Control System.

```

00100 *****
00110 *
00120 * SVT.ASM
00130 * MDJ 2023/03/15
00140 *
00150 * SET THE SAM AND
00160 * VDG REGISTERS FOR
00170 * TEXT MODE
00180 *
00190 * CF. EXTENDED BASIC
00200 * UNRAVELLED,
00210 * PAGE B-31
00220 *
00230 * ENTRY CONDITIONS:
00240 * NONE
00250 *
00260 * EXIT CONDITIONS:
00270 * NONE
00280 *
00290 * SEE MLGCTST2.BAS
00300 * RESULTS FOR LOW MEMORY
00310 * VARIABLE VALUES
00320 *
00330 *****
00340
00350 * LOW MEMORY
00360 * GRAPHICS
00370 * VARIABLES
COLOR      00B2      00380 FORCOL EQU      $00B2      FOREGROUND
COLOR      00B3      00390 BAKCOL EQU     $00B3      BACKGROUND

```

		00B5	00400	ALLCOL	EQU	\$00B5	PIXEL MASK
		00B6	00410	PMODE	EQU	\$00B6	PMODE (0-4)
		00B7	00420	ENDGRP	EQU	\$00B7	END OF GRAPHIC
PAGE							
		00B9	00430	HORBYT	EQU	\$00B9	# OF
BYTES/HORIZONTAL LINE							
		00BA	00440	BEGGRP	EQU	\$00BA	START OF
GRAPHIC PAGE							
		00BC	00450	GRPRAM	EQU	\$00BC	MSB OF START OF
GRAPHIC RAM							
		00C1	00460	CSSVAL	EQU	\$00C1	VDG CSS RAM
IMAGE							
		00DB	00470	CHGFLG	EQU	\$00DB	CHANGE FLAG
			00480				
			00490	* HIGH MEMORY			
			00500	* SAM AND VDG REGISTER			
			00510	* ADDRESSES			
		FF20	00520	PIA1	EQU	\$FF20	
		FFC0	00530	SAM	EQU	\$FFC0	
			00540				
458F			00550		ORG	\$458F	
			00560				
458F	34	16	00570	SVT	PSHS	A, B, X	
4591	86	0E	00580		LDA	#\$0E	
4593	97	BC	00590		STA	GRPRAM	
4595	CC	0E00	00600		LDD	#\$0E00	
4598	DD	BA	00610		STD	BEGGRP	
459A	CC	1400	00620		LDD	#\$1400	
459D	DD	B7	00630		STD	ENDGRP	
459F	86	10	00640		LDA	#\$10	
45A1	97	B9	00650		STA	HORBYT	
45A3	86	03	00660		LDA	#\$03	
45A5	97	B2	00670		STA	FORCOL	
45A7	4F		00680		CLRA		
45A8	97	B6	00690		STA	PMODE	
45AA	97	B3	00700		STA	BAKCOL	
45AC	97	B5	00710		STA	ALLCOL	
45AE	97	C1	00720		STA	CSSVAL	
45B0	97	DB	00730		STA	CHGFLG	
			00740				
45B2	8E	FFC8	00750		LDX	#\$SAM+8	POINT TO THE
MIDDLE OF THE SAM							
REGISTER							
45B5	A7	0A	00760		STA	10, X	
45B7	A7	08	00770		STA	8, X	
45B9	A7	06	00780		STA	6, X	

```

45BB A7 04 00790 STA 4,X RESET SAM
DISPLAY PAGE TO $400
45BD A7 02 00800 STA 2,X
45BF A7 01 00810 STA 1,X
45C1 A7 1E 00820 STA -2,X
45C3 A7 1C 00830 STA -4,X
45C5 A7 1A 00840 STA -6,X RESET SAM S VDG
TO TEXT MODE
45C7 A7 18 00850 STA -8,X
45C9 B6 FF22 00860 LDA PIA1+2 PORT B DATA
45CC 84 07 00870 ANDA #$07 FORCE ALL BITS
TO ZERO:
00880 * KEEP ONLY CSS
DATA
45CE B7 FF22 00890 STA PIA1+2 PUT THE VDG
INTO TEXT MODE
45D1 35 16 00900 PULS A,B,X
45D3 39 00910 RTS
00920
0000 00930 END

```

See the PCLS4 Chapter below for testing.

=====

STSAMG: Set the SAM Register for Graphics Modes

STSAMG is a subroutine called by both SVG410 and SVG450. It sets the SAM Register for either of the two PMODE 4 setups (Start Page 1 or Start Page 5). Although STSAMG physically appears in memory before SVT (ORG \$4574 vs. ORG \$458F respectively), it appears here because it is logically subsequent to SVT in the Graphics Control System.

```

00100 *****
00110 *
00120 * STSAMG.ASM
00130 * MDJ 2023/03/12
00140 *
00150 * SET THE
00160 * SAM REGISTER FOR
00170 * GRAPHICS MODES
00180 *
00190 * CF. EXTENDED BASIC
00200 * UNRAVELLED,
00210 * PAGE B-31
00220 *
00230 * ENTRY CONDITIONS:
00240 * NONE
00250 *
00260 * EXIT CONDITIONS:
00270 * NONE
00280 *
00290 *****
00300
00310 * HIGH MEMORY
00320 * SAM REGISTER
00330 * ADDRESS
          FFC0 00340 SAM      EQU      $FFC0
00350
4574      00360          ORG      $4574
00370
4574 C6   03 00380 STSAMG  LDB      #3      FIRST STSAMG
ENTRY POINT
          00390 *              3 BITS IN SAM

VDG CONTROL REGIS
TER

```

```

4576 8E  FFC0      00400      LDX      #SAM      POINT TO SAM
CONTROL REGISTER
4579 46              00410 LBL001  RORA              PUT A BIT INTO
THE CARRY FLAG
457A 24   04      00420      BCC      LBL002  GO IF BIT WAS
ZERO
457C A7   01      00430      STA      1,X      SET SAM
REGISTER BIT
457E 20   02      00440      BRA      LBL003  DO NEXT BIT
4580 A7   84      00450 LBL002  STA      ,X      CLEAR SAM
REGISTER
4582 30   02      00460 LBL003  LEAX     2,X      NEXT BIT IN
REGISTER
4584 5A              00470      DECB              HAVE WE DONE
ALL BITS?
4585 26   F2      00480      BNE      LBL001  GO IF NO
4587 39              00490      RTS
4588 C6   07      00500 STSAM2  LDB      #7      SECOND STSAMG
ENTRY POINT
                                00510 *              7 BITS IN SAM
DISPLAY PAGE REGI
STER
458A 8E  FFC6      00520      LDX      #SAM+6  POINT TO SAM
DISPLAY PAGE REGIS
TER
458D 20   EA      00530      BRA      LBL001  GO SET THE
REGISTER
                                00540
                                00550      END

```

See the PCLS4 Chapter below for testing.

=====

SVG410: Set the SAM and VDG Registers for Graphics Mode PMODE 4, Start Page 1, Color Set 0

SVG410 is used to go into PMODE 4 at Start Page 1. This routine sets the appropriate low-memory variables and also sets-up the VDG chip; it then calls STSAMG to setup the SAM chip.

```
00100 *****
00110 *
00120 * SVG410.ASM
00130 * MDJ 2023/03/15
00140 *
00150 * SET THE SAM AND
00160 * VDG REGISTERS FOR
00170 * GRAPHICS MODE
00180 *
00190 * PMODE 4
00200 * START PAGE 1
00210 * COLOR SET 0
00220 *
00230 * CF. EXTENDED BASIC
00240 * UNRAVELLED,
00250 * PAGE B-31
00260 *
00270 * ENTRY CONDITIONS:
00280 * NONE
00290 *
00300 * EXIT CONDITIONS:
00310 * NONE
00320 *
00330 * SEE MLGCTST2.BAS
00340 * RESULTS FOR LOW MEMORY
00350 * VARIABLE VALUES AND:
00360 * MIDCALC
00370 * POSTCALC
00380 * ENDCALC
00390 *
00400 *****
00410
```

			00420	*	LOW MEMORY		
			00430	*	GRAPHICS		
			00440	*	VARIABLES		
COLOR	00B2		00450	FORCOL	EQU	\$00B2	BACKGROUND
COLOR	00B3		00460	BAKCOL	EQU	\$00B3	BACKGROUND
	00B5		00470	ALLCOL	EQU	\$00B5	PIXEL MASK
	00B6		00480	PMODE	EQU	\$00B6	PMODE (0-4)
	00B7		00490	ENDGRP	EQU	\$00B7	END OF GRAPHIC
PAGE	00B9		00500	HORBYT	EQU	\$00B9	# OF
BYTES/HORIZONTAL	00BA	LINE	00510	BEGGRP	EQU	\$00BA	START OF
GRAPHIC PAGE	00BC		00520	GRPRAM	EQU	\$00BC	MSB OF START OF
GRAPHIC RAM	00C1		00530	CSSVAL	EQU	\$00C1	VDG CSS RAM
IMAGE	00DB		00540	CHGFLG	EQU	\$00DB	CHANGE FLAG
			00550				
			00560	*	SAM REGISTER CONTROL		
			00570	*	FIRST ENTRY POINT		
	4574		00580	STSAMG	EQU	\$4574	
			00590				
			00600	*	SAM REGISTER CONTROL		
			00610	*	SECOND ENTRY POINT		
	4588		00620	STSAM2	EQU	\$4588	
			00630				
			00640	*	HIGH MEMORY		
			00650	*	VDG REGISTER		
			00660	*	ADDRESS		
	FF20		00670	PIA1	EQU	\$FF20	
			00680				
45D4			00690		ORG	\$45D4	
			00700				
45D4	34	16	00710	SVG410	PSHS	A, B, X	
45D6	86	0E	00720		LDA	#\$0E	
45D8	97	BC	00730		STA	GRPRAM	
45DA	CC	0E00	00740		LDD	#\$0E00	
45DD	DD	BA	00750		STD	BEGGRP	
45DF	CC	2600	00760		LDD	#\$2600	
45E2	DD	B7	00770		STD	ENDGRP	
45E4	86	20	00780		LDA	#\$20	
45E6	97	B9	00790		STA	HORBYT	
45E8	86	04	00800		LDA	#\$04	
45EA	97	B6	00810		STA	PMODE	

45EC	86	03	00820	LDA	#\$03	
45EE	97	B2	00830	STA	FORCOL	
45F0	4F		00840	CLRA		
45F1	97	B3	00850	STA	BAKCOL	
45F3	97	B5	00860	STA	ALLCOL	
45F5	97	C1	00870	STA	CSSVAL	
45F7	97	DB	00880	STA	CHGFLG	
			00890			
45F9	86	F0	00900	LDA	#\$F0	MIDCALC
45FB	B7	FF22	00910	STA	PIA1+2	
45FE	86	07	00920	LDA	#\$07	POSTCALC
4600	BD	4588	00930	JSR	STSAM2	
4603	86	06	00940	LDA	#\$06	ENDCALC
4605	BD	4574	00950	JSR	STSAMG	
4608	35	16	00960	PULS	A, B, X	
460A	39		00970	RTS		
			00980			
		0000	00990	END		

See the PCLS4 Chapter below for testing.

=====

SVG450: Set the SAM and VDG Registers for Graphics Mode PMODE 4, Start Page 5, Color Set 0

SVG450 is used to go into PMODE 4 at Start Page 5. This routine sets the appropriate low-memory variables and also sets-up the VDG chip; it then calls STSAMG to setup the SAM chip.

```
00100 *****
00110 *
00120 * SVG450.ASM
00130 * MDJ 2023/03/15
00140 *
00150 * SET THE SAM AND
00160 * VDG REGISTERS FOR
00170 * GRAPHICS MODE
00180 *
00190 * PMODE 4
00200 * START PAGE 5
00210 * COLOR SET 0
00220 *
00230 * CF. EXTENDED BASIC
00240 * UNRAVELLED,
00250 * PAGE B-31
00260 *
00270 * ENTRY CONDITIONS:
00280 * NONE
00290 *
00300 * EXIT CONDITIONS:
00310 * NONE
00320 *
00330 * SEE MLGCTST2.BAS
00340 * RESULTS FOR LOW MEMORY
00350 * VARIABLE VALUES AND:
00360 * MIDCALC
00370 * POSTCALC
00380 * ENDCALC
00390 *
00400 *****
00410
```

			00420	*	LOW MEMORY		
			00430	*	GRAPHICS		
			00440	*	VARIABLES		
COLOR	00B2		00450	FORCOL	EQU	\$00B2	BACKGROUND
COLOR	00B3		00460	BAKCOL	EQU	\$00B3	BACKGROUND
	00B5		00470	ALLCOL	EQU	\$00B5	PIXEL MASK
	00B6		00480	PMODE	EQU	\$00B6	PMODE (0-4)
	00B7		00490	ENDGRP	EQU	\$00B7	END OF GRAPHIC
PAGE	00B9		00500	HORBYT	EQU	\$00B9	# OF
BYTES/HORIZONTAL	00BA	LINE	00510	BEGGRP	EQU	\$00BA	START OF
GRAPHIC PAGE	00BC		00520	GRPRAM	EQU	\$00BC	MSB OF START OF
GRAPHIC RAM	00C1		00530	CSSVAL	EQU	\$00C1	VDG CSS RAM
IMAGE	00DB		00540	CHGFLG	EQU	\$00DB	CHANGE FLAG
			00550				
			00560	*	SAM REGISTER CONTROL		
			00570	*	FIRST ENTRY POINT		
	4574		00580	STSAMG	EQU	\$4574	
			00590				
			00600	*	SAM REGISTER CONTROL		
			00610	*	SECOND ENTRY POINT		
	4588		00620	STSAM2	EQU	\$4588	
			00630				
			00640	*	HIGH MEMORY		
			00650	*	VDG REGISTER		
			00660	*	ADDRESS		
	FF20		00670	PIA1	EQU	\$FF20	
			00680				
460B			00690		ORG	\$460B	
			00700				
460B	34	16	00710	SVG410	PSHS	A,B,X	
460D	86	0E	00720		LDA	#\$0E	
460F	97	BC	00730		STA	GRPRAM	
4611	CC	2600	00740		LDD	#\$2600	
4614	DD	BA	00750		STD	BEGGRP	
4616	CC	3E00	00760		LDD	#\$3E00	
4619	DD	B7	00770		STD	ENDGRP	
461B	86	20	00780		LDA	#\$20	
461D	97	B9	00790		STA	HORBYT	
461F	86	04	00800		LDA	#\$04	
4621	97	B6	00810		STA	PMODE	

4623	86	03	00820	LDA	#\$03	
4625	97	B2	00830	STA	FORCOL	
4627	4F		00840	CLRA		
4628	97	B3	00850	STA	BAKCOL	
462A	97	B5	00860	STA	ALLCOL	
462C	97	C1	00870	STA	CSSVAL	
462E	97	DB	00880	STA	CHGFLG	
			00890			
4630	86	F0	00900	LDA	#\$F0	MIDCALC
4632	B7	FF22	00910	STA	PIA1+2	
4635	86	13	00920	LDA	#\$13	POSTCALC
4637	BD	4588	00930	JSR	STSAM2	
463A	86	06	00940	LDA	#\$06	ENDCALC
463C	BD	4574	00950	JSR	STSAMG	
463F	35	16	00960	PULS	A, B, X	
4641	39		00970	RTS		
			00980			
		0000	00990	END		

See the PCLS4 Chapter below for testing.

=====

PCLS4: PMODE 4 PCLS

PCLS4 clears the PMODE 4 screen to either Black or Green.

```

00100 *****
00110 *
00120 * PCLS4.ASM
00130 * MDJ 2023/03/15
00140 *
00150 * PMODE4 PCLS
00160 *
00170 * ENTRY CONDITIONS:
00180 * A = COLOR CODE
00190 *      0 = BLACK -->
00200 *          SET A = #$00
00210 *          (ALL ZEROES)
00220 *      1 = GREEN -->
00230 *          SET A = #$FF
00240 *          (ALL ONES)
00250 * DEFAULTS TO GREEN
00260 * IF ANYTHING ELSE
00270 *
00280 * EXIT CONDITIONS:
00290 * NONE
00300 *
00310 *****
00320
00330 * LOW MEMORY
00340 * GRAPHICS
00350 * VARIABLES
00B7 00360 ENDGRP EQU $00B7 END OF GRAPHIC
PAGE
00BA 00370 BEGGRP EQU $00BA START OF
GRAPHIC PAGE
00380
4642 00390 ORG $4642
00400
4642 34 14 00410 PCLS4 PSHS B,X
4644 81 00 00420 CMPA #$00 IS COLOR 0 =
BLACK?
4646 27 02 00430 BEQ LBL001 GO IF YES
4648 86 FF 00440 LDA #$FF DEFAULT TO 1 =
GREEN
464A 1F 89 00450 LBL001 TFR A,B D = A:A

```

464C	9E	BA	00460	LDX	BEGGRP	START ADDRESS
464E	ED	81	00470	LBL002	STD	,X++ SET BYTES TO
COLOR						
4650	9C	B7	00480	CMPX	ENDGRP	AT END ADDRESS?
4652	26	FA	00490	BNE	LBL002	GO IF NO
4654	35	14	00500	PULS	B,X	
4656	39		00510	RTS		
			00520			
		0000	00530	END		

The Assembly Language Test Routine:

```

00100 *****
00110 *
00120 * TEST0201.ASM
00130 * MDJ 2023/03/15
00140 *
00150 * INITIAL PMODE 4
00160 * GRAPHICS TEST
00170 *
00180 *****
00190
00200 * MLCORE ADDRESS
4142 00210 POLCAT EQU $4142
00220
00230 * GRAPHICS ROUTINES
00240 * ADDRESSES
4574 00250 STSAMG EQU $4574
4588 00260 STSAM2 EQU $4588
458F 00270 SVT EQU $458F
45D4 00280 SVG410 EQU $45D4
4608 00290 SVG450 EQU $4608
4642 00300 PCLS4 EQU $4642
00310
7000 00320 ORG $7000
00330
7000 34 02 00340 PSHS A
00350
00360 * SET PMODE 4 PAGE 1
7002 BD 45D4 00370 JSR SVG410
00380
00390 * CLEAR THE SCREEN TO GREEN
7005 86 01 00400 LDA #$01
7007 BD 4642 00410 JSR PCLS4
00420

```


			00430	* WAIT FOR A KEYPRESS	
700A	34	03	00440	PSHS	A,CC
700C	BD	4142	00450	LBL001 JSR	POLCAT
700F	27	FB	00460	BEQ	LBL001 NO KEYPRESS
7011	35	03	00470	PULS	A,CC
			00480		
			00490	* CLEAR THE SCREEN TO BLACK	
7013	86	00	00500	LDA	#\$00
7015	BD	4642	00510	JSR	PCLS4
			00520		
			00530	* WAIT FOR A KEYPRESS	
7018	34	03	00540	PSHS	A,CC
701A	BD	4142	00550	LBL002 JSR	POLCAT
701D	27	FB	00560	BEQ	LBL002 NO KEYPRESS
701F	35	03	00570	PULS	A,CC
			00580		
			00590	* SET PMODE 4 PAGE 5	
7021	BD	4608	00600	JSR	SVG450
			00610		
			00620	* CLEAR THE SCREEN TO GREEN	
7024	86	01	00630	LDA	#\$01
7026	BD	4642	00640	JSR	PCLS4
			00650		
			00660	* WAIT FOR A KEYPRESS	
7029	34	03	00670	PSHS	A,CC
702B	BD	4142	00680	LBL003 JSR	POLCAT
702E	27	FB	00690	BEQ	LBL003 NO KEYPRESS
7030	35	03	00700	PULS	A,CC
			00710		
			00720	* CLEAR THE SCREEN TO BLACK	
7032	86	00	00730	LDA	#\$00
7034	BD	4642	00740	JSR	PCLS4
			00750		
			00760	* WAIT FOR A KEYPRESS	
7037	34	03	00770	PSHS	A,CC
7039	BD	4142	00780	LBL004 JSR	POLCAT
703C	27	FB	00790	BEQ	LBL004 NO KEYPRESS
703E	35	03	00800	PULS	A,CC
			00810		
			00820	* RETURN TO TEXT MODE	
7040	BD	458F	00830	JSR	SVT
			00840		
			00850	* WAIT FOR A KEYPRESS	
7043	34	03	00860	PSHS	A,CC
7045	BD	4142	00870	LBL005 JSR	POLCAT
7048	27	FB	00880	BEQ	LBL005 NO KEYPRESS
704A	35	03	00890	PULS	A,CC

```

00900
704C 35 02 00910 PULS A
704E 39 00920 RTS
00930
0000 00940 END

```

Making the Preliminary MLFT File: This program combines the Graphics Control Routines into the single MLFT.BIN file so that the machine language Graphics Control System can be loaded as a single entity. (See the Final PSET41 Chapter below for making the Final MLFT File.)

Note that the FLSYS.BIN file specified on Line 2000 is provided by the MAKEFALS.BAS program in ([MDJ01], p.104). It is not used in these Graphics Control Routines, but is included as a check that the MLCORE, False Disk Routines and Graphics Control Routines all fit together properly without any erroneous overlaps.

```

1000 '*****
1010 '*'
1020 '* MAKEMLFT.BAS
1030 '* MDJ 2023/03/16
1040 '*'
1050 '* MAKES THE
1060 '* MLFT.BIN FILE
1070 '*'
1080 '*****
1090 '

1500 CLEAR 200, &H4000
1510 '

2000 LOADM "FLSYS.BIN"
2010 LOADM "STSAMG.BIN"
2020 LOADM "SVT.BIN"
2030 LOADM "SVG410.BIN"
2030 LOADM "SVG450.BIN"
2040 LOADM "PCLS4.BIN"
2050 '

3000 SAVEM "MLFT.BIN", &H4416, &H4656, &H4416
3010 '

32767 END

```

The BASIC Language Control Program:

```
1000 '*****
1010 '*'
1020 '* TEST0201.BAS
1030 '* MDJ 2023/03/16
1040 '*'
1050 '* INITIAL PMODE 4
1060 '* GRAPHICS TEST
1070 '*'
1080 '*****
1090 '

1100 'SETUP MEMORY
1110 CLEAR 0, &H4000
1120 PCLEAR 8
1120 '

1200 'LOAD THE
1210 'ML FOUNDATION CORE
1220 LOADM "MLCORE.BIN"
1230 '

1300 'LOAD THE MLFT FILE
1310 LOADM "MLFT.BIN"
1320 '

1400 'LOAD THE
1410 'ML TEST ROUTINE
1420 LOADM "TEST0201.BIN"
1430 '

2900 'REFERENCE THE
2910 'TRANSFER VARIABLES
2920 RA = &H400A 'REGPCH
2930 RB = &H400B 'REGPCL
2940 '

3000 'SETUP THE
3010 'RUN ADDRESS
3020 C = &H7000
3030 C1 = INT(C/256)
3040 C2 = INT(C-(C1*256))
3050 POKE RA, C1
3060 POKE RB, C2
3070 '
```

```

6000 'JUMP TO CORE
6010 'STARTUP ROUTINE
6020 EXEC &H4403
6030 '

9000 'MEMORY AND DISK
9010 'STATUS CHECK
9020 PRINT
9030 PRINT " MEM = ";MEM
9040 PRINT "FREE = ";FREE(0)
9050 '

32767 END

```

The BASIC Language Control Program, Abbreviated: The full program, as written above, bombs with a reported OM ERROR. This is intentional - The entire ML Foundation System is intended to be initialized using the absolute minimum of BASIC code; just enough to get the Machine Language system loaded and started. It is the following abbreviated BASIC code which is on disk as TEST0201.BAS.

```

1110 CLEAR0, &H4000
1120 PCLEAR8
1220 LOADM"MLCORE.BIN"
1310 LOADM"MLFT.BIN"
1420 LOADM"TEST0201.BIN"
2920 RA=&H400A
2930 RB=&H400B
3020 C=&H7000
3030 C1=INT(C/256)
3040 C2=INT(C-(C1*256))
3050 POKERA,C1
3060 POKERB,C2
6020 EXEC&H4403
9020 PRINT
9030 PRINT" MEM = ";MEM
9040 PRINT"FREE = ";FREE(0)
32767 END

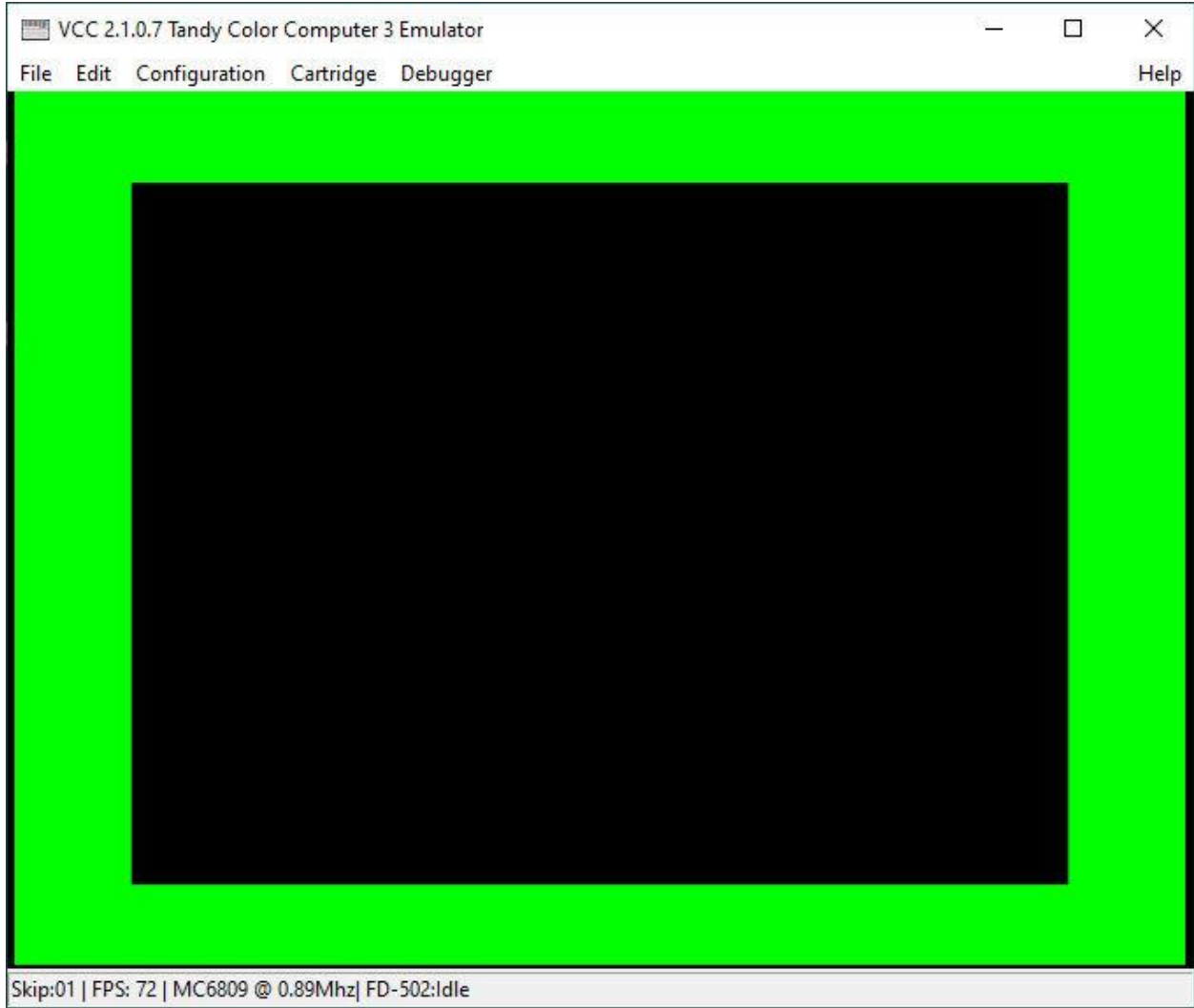
```

Results:

On Startup of TEST0201.BAS: PMODE 4. Start Page 1; cleared to Green.



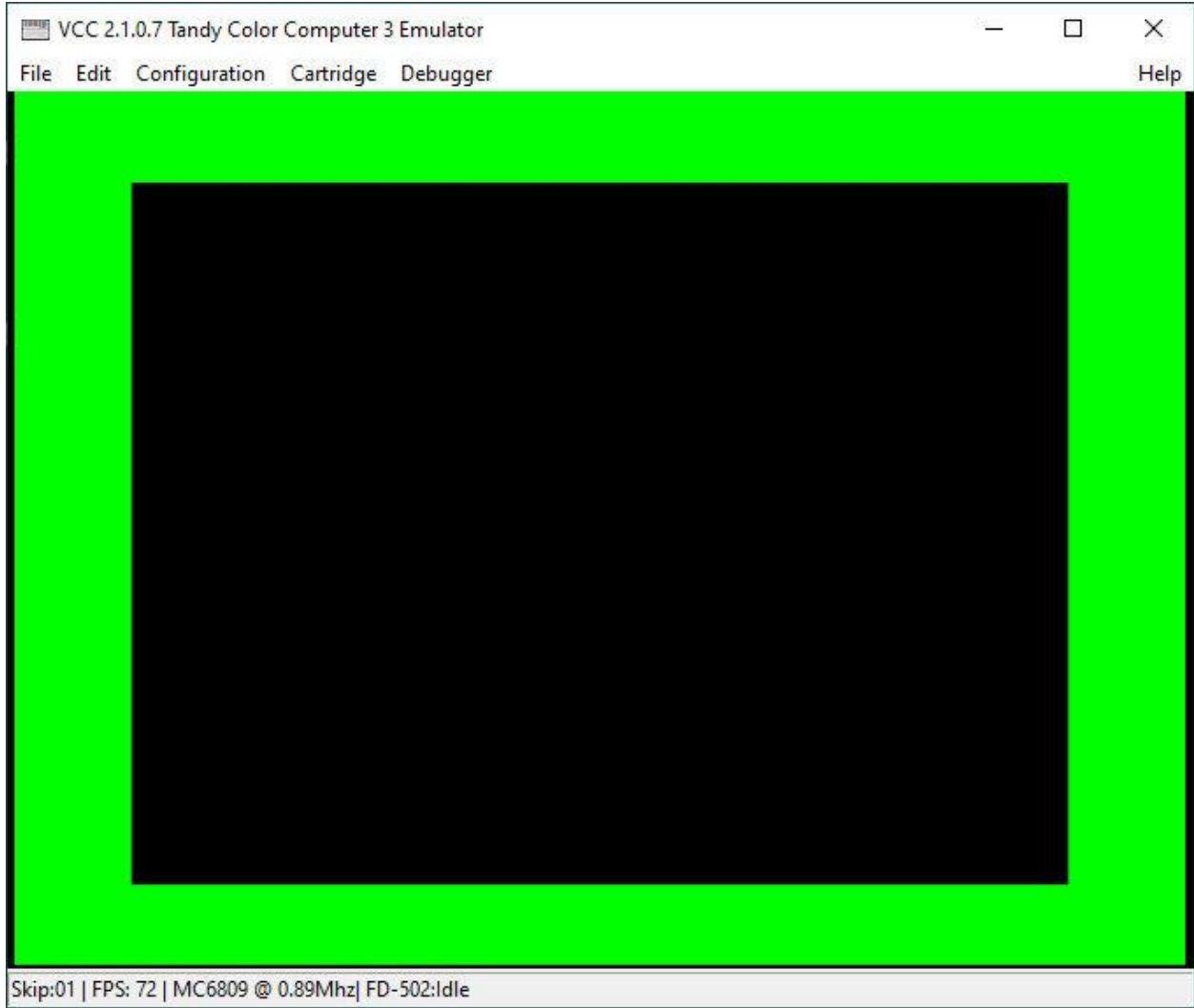
On First Keypress: PMODE 4. Start Page 1; cleared to Black.



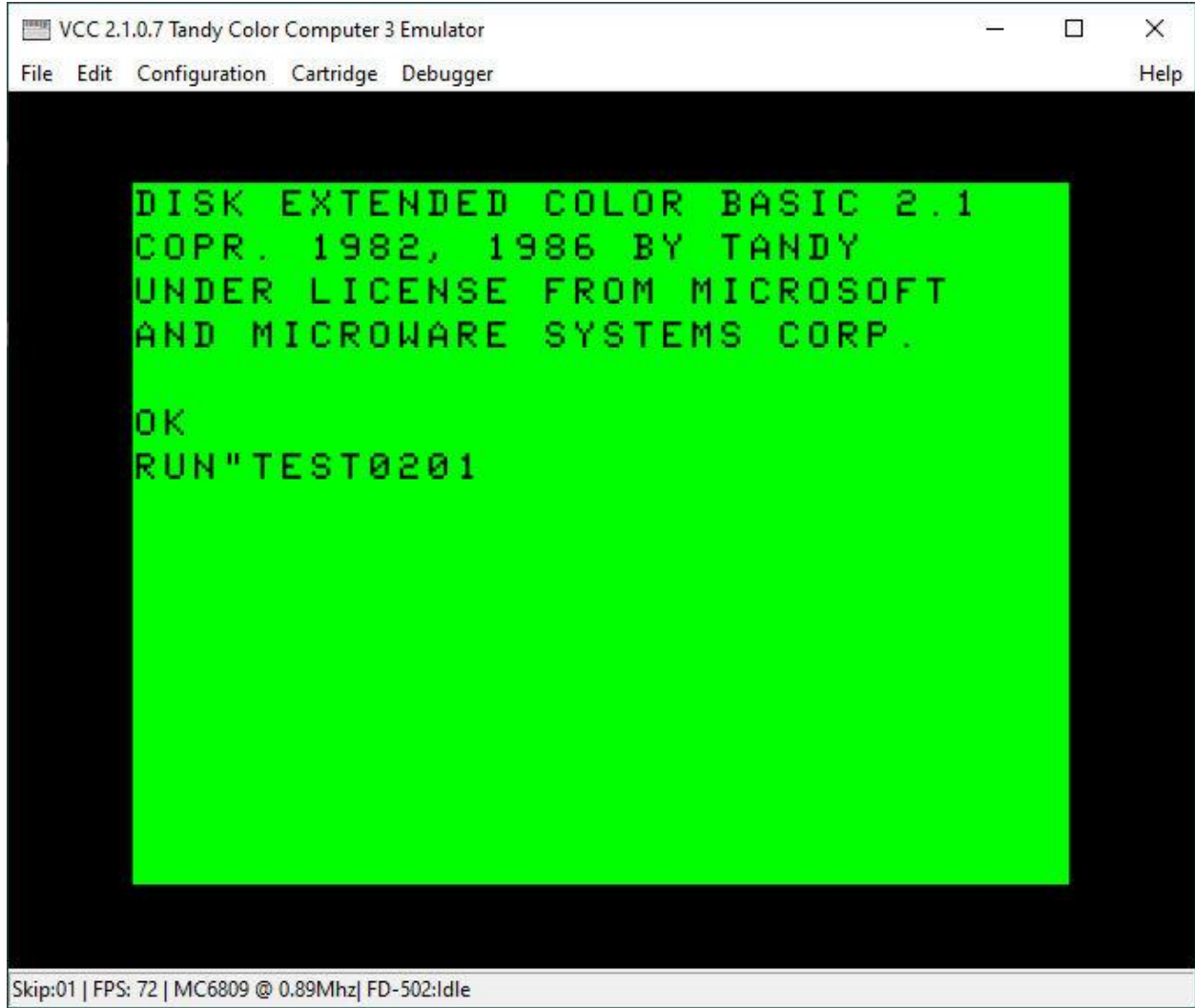
On Second Keypress: PMODE 4. Start Page 5; cleared to Green.



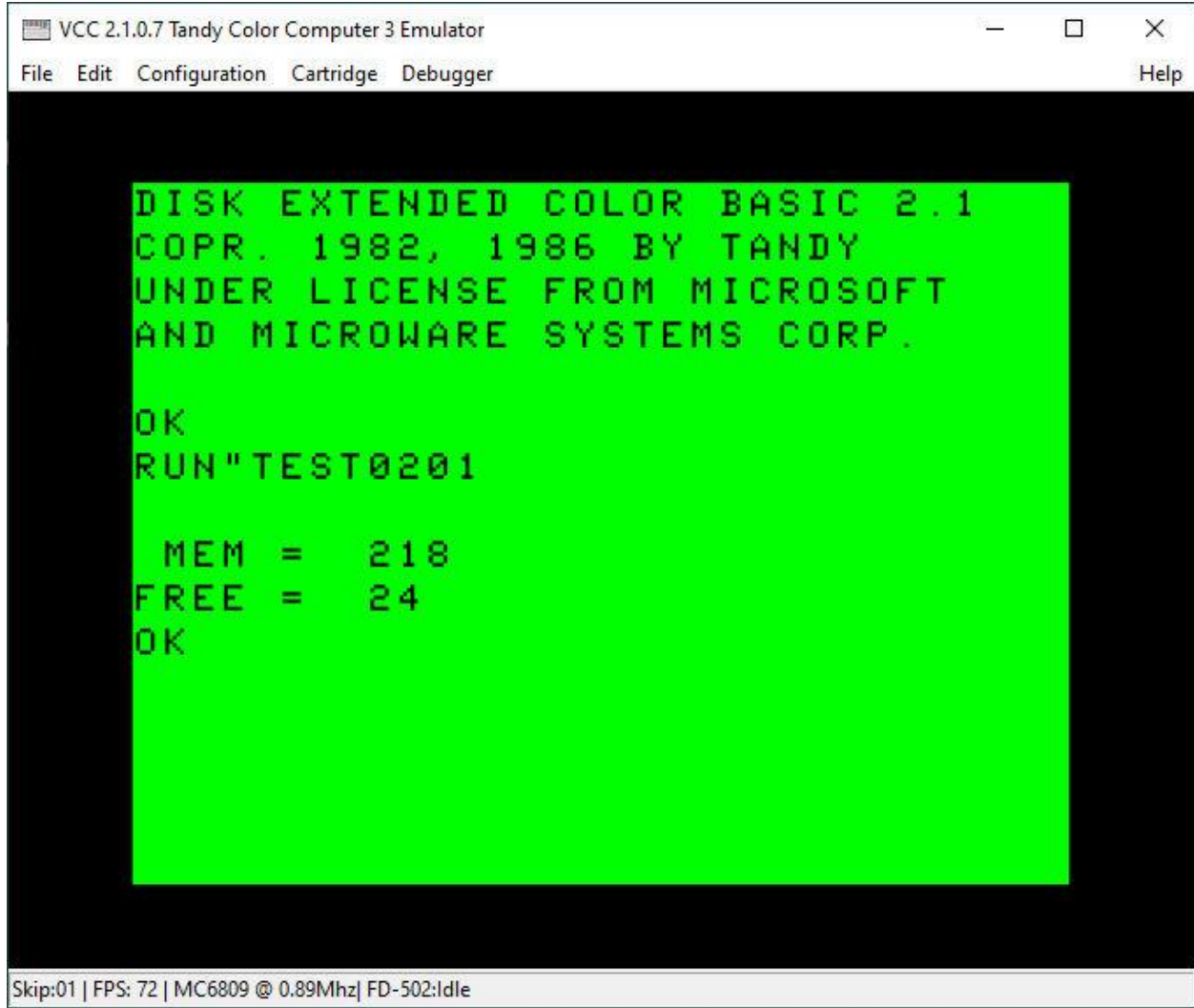
On Third Keypress: PMODE 4. Start Page 1; cleared to Black.



On Fourth Keypress: The return to Text Mode.



On Fifth Keypress: After exiting the TEST0201.BAS program.



All as expected.

=====

The ROM PSET Revisited

Since the PSET routines will eventually be the foundation of many other Graphics routines (LINE, BOX, FILL, etc.) I wanted to make sure that my PSET implementations were highly efficient; both in terms of bytes of memory occupied, and also in terms of CPU cycles consumed.

So it naturally occurred to me that the standard of comparison should be the CoCo's Extended BASIC ROM PSET routine. Regardless of its actual size and speed, the ROM PSET would be something I could measure improvements against; e.g. "This implementation is X% smaller and Y% faster than the ROM PSET."

So, I initially began to step through (Zydek)'s ROM assembly listing, unwinding the PSET and recording the number of bytes used. I intended to go back later and fill-in the CPU cycles for each instruction.

1,147 lines (of the most outrageous spaghetti code I've ever seen up close) later, I finally reached the end and had "PSET Unwound" in my hands. It was so huge, I didn't even bother to go back and record the cycles. I didn't even total up the number of bytes.

Nor did I think it worthy of adding 49 pages to this paper to include it here. If you're interested, you can find it at:

<https://www.bds-soft.com/files/coco/NewFiles/MyPapers/2023/MLGC/ROMPSETUnwound.pdf> .

PSTGB4: Get PMODE 4 Byte and Bit Position from (X,Y) Coordinates

PSTGB4 translates the selected screen's X-Coordinate and Y-Coordinate into the screen's byte address, byte contents, and the bit position within that byte. PSTGB4 is a subroutine which is called by both PSET40 and PSET41..

```

00100 *****
00110 *
00120 * PSTGB4.ASM
00130 * MDJ 2023/03/15
00140 *
00150 * GET PMODE 4 BYTE
00160 * AND BIT POSITION FROM
00170 * (X,Y) COORDINATES
00180 *
00190 * ENTRY CONDITIONS:
00200 * A = Y-COORDINATE (0-191)
00210 * B = X-COORDINATE (0-255)
00220 *
00230 * EXIT CONDITIONS
00240 * A = BIT POSITION (0-7)
00250 * B = BYTE CONTENTS
00260 * X = BYTE ADDRESS
00270 *
00280 *****
00290
00300 * LOW MEMORY
00310 * GRAPHICS
00320 * VARIABLE
00BA 00330 BEGGRP EQU $00BA START OF
GRAPHIC PAGE
4657 00340
00350 ORG $4657
00360
00370 * AT THIS POINT THE
00380 * STACK CONTAINS
00390 * 1,S RTS ADDRESS LOW BYTE
00400 * ,S RTS ADDRESS HIGH BYTE
00410
00420 * MAKE ROOM FOR

```

```

00430 * 7,S RTS ADDRESS LOW BYTE
00440 * 6,S RTS ADDRESS HIGH BYTE
00450 * 5,S PIXEL NUMBER LOW BYTE
00460 * 4,S PIXEL NUMBER HIGH BYTE
00470 * 3,S BYTE NUMBER LOW BYTE
00480 * 2,S BYTE NUMBER HIGH BYTE
00490 * 1,S TEMP VALUE LOW BYTE
00500 * ,S TEMP VALUE HIGH BYTE
4657 32 7A 00510 PSTGB4 LEAS -6,S
00520
00530 * WITH A = Y-COORDINATE
00540 * AND B = X-COORDINATE,
00550 * D = A:B = PIXEL NUMBER = PN
00560 * AND BYTE NUMBER = BN = PN/8
4659 ED 64 00570 STD 4,S SAVE PN
465B 44 00580 LSRA
465C 56 00590 RORB
465D 44 00600 LSRA
465E 56 00610 RORB
465F 44 00620 LSRA
4660 56 00630 RORB D = D/8
4661 ED 62 00640 STD 2,S SAVE BN
00650
00660 * GET BYTE ADDRESS
4663 DC BA 00670 LDD BEGGRP START OF
GRAPHIC PAGE
4665 E3 62 00680 ADDD 2,S BYTE NUMBER
4667 1F 01 00690 TFR D,X BYTE ADDRESS
00700
00710 * BIT POSITION IN BYTE = BP
00720 * = 7 - (PN - (BN*8))
4669 EC 62 00730 LDD 2,S BN = BYTE
NUMBER
466B 58 00740 LSLB
466C 49 00750 ROLA
466D 58 00760 LSLB
466E 49 00770 ROLA
466F 58 00780 LSLB
4670 49 00790 ROLA BN*8
4671 ED E4 00800 STD ,S SAVE TEMP
4673 EC 64 00810 LDD 4,S PN
4675 A3 E4 00820 SUBD ,S PN - (BN*8)
4677 ED E4 00830 STD ,S SAVE TEMP
4679 86 07 00840 LDA #7
467B A0 61 00850 SUBA 1,S LSB OF TEMP -->
BP
00860

```

```
00870 * GET BYTE CONTENTS
467D E6 84 00880 LDB ,X
00890
00900 * CLEAN THE STACK AND RETURN
467F 32 66 00910 LEAS 6,S
4681 39 00920 RTS
00930
0000 00940 END
```

See the Final PSET41 Chapter below for testing.

=====

First Attempt

PSET40: Set a PMODE 4 Point to Black = 0

This was my first attempt at writing PSET40. It calls the subroutine PSTGB4 to translate the coordinates into the screen's byte data and then puts the black pixel to the screen. As can be seen below, this first attempt was already quite efficient (certainly so as compared to the ROM PSET), consuming 80 bytes of memory and 132 CPU cycles.

```

00100 *****
00110 *
00120 * PSET40F.ASM
00130 * MDJ 2023/03/15
00140 * FIRST ATTEMPT
00150 *
00160 * SET A PMODE 4
00170 * POINT TO
00180 * BLACK = 0
00190 *
00200 * ENTRY CONDITIONS:
00210 * A = Y-COORDINATE (0-191)
00220 * B = X-COORDINATE (0-255)
00230 *
00240 * EXIT CONDITIONS:
00250 * NONE
00260 *
00270 *****
00280
00290 * BYTE DATA
00300 * ROUTINE ADDRESS
4657      00310 PSTGB4 EQU $4657
00320
4682      00330 ORG $4682
00340
4682 34 10 00350 PSET40 PSHS X
00360
00370 * AT THIS POINT THE
00380 * STACK CONTAINS
00390 * 3,S RTS ADDRESS LOW BYTE
00400 * 2,S RTS ADDRESS HIGH BYTE
00410 * 1,S REGISTER X LOW BYTE
00420 * ,S REGISTER X HIGH BYTE

```

```

00430
00440 * MAKE ROOM FOR
00450 *   5,S RTS ADDRESS LOW BYTE
00460 *   4,S RTS ADDRESS HIGH BYTE
00470 *   3,S REGISTER X LOW BYTE
00480 *   2,S REGISTER X HIGH BYTE
00490 *   1,S BYTE CONTENTS
00500 *     ,S PIXEL MASK
4684 32   7E 00510           LEAS   -2,S
00520
00530 * GO GET BYTE DATA
4686 BD   4657 00540           JSR     PSTGB4
00550
00560 * NOW:
00570 * A = BIT POSITION (0-7)
00580 * B = BYTE CONTENTS
00590 * X = BYTE ADDRESS
00600
00610 * SAVE THE BYTE CONTENTS
4689 E7   61 00620           STB     1,S
00630
00640 * ALL ONES MASK TO
00650 * SET BIT = 0 = BLACK
00660 * USING "AND"
468B 81   00 00670           CMPA   #0
468D 26   04 00680           BNE     LBL001
468F C6   FE 00690           LDB     #$FE
4691 20   32 00700           BRA     LBL008
4693 81   01 00710 LBL001  CMPA   #1
4695 26   04 00720           BNE     LBL002
4697 C6   FD 00730           LDB     #$FD
4699 20   2A 00740           BRA     LBL008
469B 81   02 00750 LBL002  CMPA   #2
469D 26   04 00760           BNE     LBL003
469F C6   FB 00770           LDB     #$FB
46A1 20   22 00780           BRA     LBL008
46A3 81   03 00790 LBL003  CMPA   #3
46A5 26   04 00800           BNE     LBL004
46A7 C6   F7 00810           LDB     #$F7
46A9 20   1A 00820           BRA     LBL008
46AB 81   04 00830 LBL004  CMPA   #4
46AD 26   04 00840           BNE     LBL005
46AF C6   EF 00850           LDB     #$EF
46B1 20   12 00860           BRA     LBL008
46B3 81   05 00870 LBL005  CMPA   #5
46B5 26   04 00880           BNE     LBL006
46B7 C6   DF 00890           LDB     #$DF

```



```

46B9 20 0A      00900      BRA      LBL008
46BB 81 06      00910 LBL006  CMPA    #6
46BD 26 04      00920      BNE      LBL007
46BF C6 BF      00930      LDB      #$BF
46C1 20 02      00940      BRA      LBL008
46C3 C6 7F      00950 LBL007  LDB      #$7F
46C5 E7 E4      00960 LBL008  STB      ,S      PIXEL MASK
00970
00980 * SET THE PIXEL TO 0 = BLACK
46C7 A6 61      00990      LDA      1,S      BYTE CONTENTS
46C9 A4 E4      01000      ANDA     ,S      PIXEL MASK
46CB A7 84      01010      STA      ,X      PUT TO SCREEN
01020
01030 * CLEAN THE STACK AND RETURN
46CD 32 62      01040      LEAS    2,S
46CF 35 10      01050      PULS    X
46D1 39          01060      RTS
01070
0000          01080      END

```

Cycles and Bytes:

```

00100 *****
00110 *
00120 * PSET40FD.ASM
00130 * MDJ 2023/03/15
00135 * FIRST ATTEMPT
00136 * CYCLES AND BYTES
00250 *
00260 *****
4657          00300 PSTGB4  EQU      $4657      CYCLES  BYTES
4682          00320          ORG      $4682      -----
4682 34 10      00340 PSET40  PSHS    X          7          2
4684 32 7E      00500          LEAS    -2,S      5          2
4686 BD 4657    00530          JSR     PSTGB4    8          3
4689 E7 61      00610          STB     1,S      5          2
468B 81 00      00660          CMPA   #0          2          2
468D 26 04      00670          BNE    LBL001    3          2
468F C6 FE      00680          LDB    #$FE     2          2
4691 20 32      00690          BRA    LBL008    3          2
4693 81 01      00700 LBL001  CMPA   #1          2          2
4695 26 04      00710          BNE    LBL002    3          2
4697 C6 FD      00720          LDB    #$FD     2          2
4699 20 2A      00730          BRA    LBL008    3          2
469B 81 02      00740 LBL002  CMPA   #2          2          2

```

469D	26	04	00750	BNE	LBL003	3	2
469F	C6	FB	00760	LDB	#\$FB	2	2
46A1	20	22	00770	BRA	LBL008	3	2
46A3	81	03	00780	LBL003	CMPA	#3	2
46A5	26	04	00790	BNE	LBL004	3	2
46A7	C6	F7	00800	LDB	#\$F7	2	2
46A9	20	1A	00810	BRA	LBL008	3	2
46AB	81	04	00820	LBL004	CMPA	#4	2
46AD	26	04	00830	BNE	LBL005	3	2
46AF	C6	EF	00840	LDB	#\$EF	2	2
46B1	20	12	00850	BRA	LBL008	3	2
46B3	81	05	00860	LBL005	CMPA	#5	2
46B5	26	04	00870	BNE	LBL006	3	2
46B7	C6	DF	00880	LDB	#\$DF	2	2
46B9	20	0A	00890	BRA	LBL008	3	2
46BB	81	06	00900	LBL006	CMPA	#6	2
46BD	26	04	00910	BNE	LBL007	3	2
46BF	C6	BF	00920	LDB	#\$BF	2	2
46C1	20	02	00930	BRA	LBL008	3	2
46C3	C6	7F	00940	LBL007	LDB	#\$7F	2
46C5	E7	E4	00950	LBL008	STB	,S	5
46C7	A6	61	00980	LDA	1,S	5	2
46C9	A4	E4	00990	ANDA	,S	4	2
46CB	A7	84	01000	STA	,X	4	2
46CD	32	62	01030	LEAS	2,S	5	2
46CF	35	10	01040	PULS	X	7	2
46D1	39		01050	RTS		5	1
		0000	01070	END		-----	-----
					TOTALS	132	80

See the Final PSET41 Chapter below for testing.

=====

First Attempt

PSET41: Set a PMODE 4 Point to Green = 1

This was my first attempt at writing PSET41. It calls the subroutine PSTGB4 to translate the coordinates into the screen's byte data and then puts the green pixel to the screen. Except for using a zeroes mask instead of a ones mask, this routine is identical to the first attempt at PSET40. Therefore, I did not do a separate cycles and bytes analysis for this routine.

```

00100 *****
00110 *
00120 * PSET41F.ASM
00130 * MDJ 2023/03/15
00140 * FIRST ATTEMPT
00150 *
00160 * SET A PMODE 4
00170 * POINT TO
00180 * GREEN = 1
00190 *
00200 * ENTRY CONDITIONS:
00210 * A = Y-COORDINATE (0-191)
00220 * B = X-COORDINATE (0-255)
00230 *
00240 * EXIT CONDITIONS:
00250 * NONE
00260 *
00270 *****
00280
00290 * BYTE DATA
00300 * ROUTINE ADDRESS
4657 00310 PSTGB4 EQU $4657
00320
46D2 00330 ORG $46D2
00340
46D2 34 10 00350 PSET41 PSHS X
00360
00370 * AT THIS POINT THE
00380 * STACK CONTAINS
00390 * 3,S RTS ADDRESS LOW BYTE
00400 * 2,S RTS ADDRESS HIGH BYTE
00410 * 1,S REGISTER X LOW BYTE
00420 * ,S REGISTER X HIGH BYTE

```

```

00430
00440 * MAKE ROOM FOR
00450 *   5,S RTS ADDRESS LOW BYTE
00460 *   4,S RTS ADDRESS HIGH BYTE
00470 *   3,S REGISTER X LOW BYTE
00480 *   2,S REGISTER X HIGH BYTE
00490 *   1,S BYTE CONTENTS
00500 *     ,S PIXEL MASK
46D4 32   7E 00510           LEAS   -2,S
00520
00530 * GO GET BYTE DATA
46D6 BD   4657 00540           JSR    PSTGB4
00550
00560 * NOW:
00570 * A = BIT POSITION (0-7)
00580 * B = BYTE CONTENTS
00590 * X = BYTE ADDRESS
00600
00610 * SAVE THE BYTE CONTENTS
46D9 E7   61 00620           STB    1,S
00630
00640 * ALL ZEROES MASK TO
00650 * SET BIT = 1 = GREEN
00660 * USING "OR"
46DB 81   00 00670 LBL000  CMPA   #0
46DD 26   04 00680           BNE    LBL001
46DF C6   01 00690           LDB    #$01
46E1 20   32 00700           BRA    LBL008
46E3 81   01 00710 LBL001  CMPA   #1
46E5 26   04 00720           BNE    LBL002
46E7 C6   02 00730           LDB    #$02
46E9 20   2A 00740           BRA    LBL008
46EB 81   02 00750 LBL002  CMPA   #2
46ED 26   04 00760           BNE    LBL003
46EF C6   04 00770           LDB    #$04
46F1 20   22 00780           BRA    LBL008
46F3 81   03 00790 LBL003  CMPA   #3
46F5 26   04 00800           BNE    LBL004
46F7 C6   08 00810           LDB    #$08
46F9 20   1A 00820           BRA    LBL008
46FB 81   04 00830 LBL004  CMPA   #4
46FD 26   04 00840           BNE    LBL005
46FF C6   10 00850           LDB    #$10
4701 20   12 00860           BRA    LBL008
4703 81   05 00870 LBL005  CMPA   #5
4705 26   04 00880           BNE    LBL006
4707 C6   20 00890           LDB    #$20

```

```

4709 20 0A      00900      BRA      LBL008
470B 81 06      00910 LBL006  CMPA    #6
470D 26 04      00920      BNE      LBL007
470F C6 40      00930      LDB      #$40
4711 20 02      00940      BRA      LBL008
4713 C6 80      00950 LBL007  LDB      #$80
4715 E7 E4      00960 LBL008  STB      ,S      PIXEL MASK
00970
00980 * SET THE PIXEL TO 0 = BLACK
4717 A6 61      00990      LDA      1,S      BYTE CONTENTS
4719 AA E4      01000      ORA      ,S      PIXEL MASK
471B A7 84      01010      STA      ,X      PUT TO SCREEN
01020
01030 * CLEAN THE STACK AND RETURN
471D 32 62      01040      LEAS    2,S
471F 35 10      01050      PULS    X
4721 39      01060      RTS
01070
0000      01080      END

```

See the Final PSET41 Chapter below for testing.

=====

Final PSET40: Set a PMODE 4 Point to Black = 0

This is the final PSET40. It calls the subroutine PSTGB4 to translate the coordinates into the screen's byte data and then puts the black pixel to the screen. As can be seen below, this final code is somewhat more efficient than the first attempt; consuming 65 bytes of memory and 126 CPU cycles, as compared to the first attempt's 80 and 132 respectively.

```
00100 *****
00110 *
00120 * PSET40.ASM
00130 * MDJ 2023/03/25
00140 * FINAL
00150 *
00160 * SET A PMODE 4
00170 * POINT TO
00180 * BLACK = 0
00190 *
00200 * ENTRY CONDITIONS:
00210 * A = Y-COORDINATE (0-191)
00220 * B = X-COORDINATE (0-255)
00230 *
00240 * EXIT CONDITIONS:
00250 * NONE
00260 *
00270 *****
00280
00290 * BYTE DATA
00300 * ROUTINE ADDRESS
4657 00310 PSTGB4 EQU $4657
00320
4682 00330 ORG $4682
00340
4682 34 30 00350 PSET40 PSHS X,Y
00360
00370 * AT THIS POINT THE
00380 * STACK CONTAINS
00390 * 3,S RTS ADDRESS LOW BYTE
00400 * 2,S RTS ADDRESS HIGH BYTE
00410 * 1,S REGISTER X LOW BYTE
00420 * ,S REGISTER X HIGH BYTE
00430
00440 * MAKE ROOM FOR
```

```

00450 * 5,S RTS ADDRESS LOW BYTE
00460 * 4,S RTS ADDRESS HIGH BYTE
00470 * 3,S REGISTER X LOW BYTE
00480 * 2,S REGISTER X HIGH BYTE
00490 * 1,S BYTE CONTENTS
00500 * ,S PIXEL MASK
4684 32 7E 00510 LEAS -2,S
00520
00530 * GO GET BYTE DATA
4686 BD 4657 00540 JSR PSTGB4
00550
00560 * NOW:
00570 * A = BIT POSITION (0-7)
00580 * B = BYTE CONTENTS
00590 * X = BYTE ADDRESS
00600
00610 * SAVE THE BYTE CONTENTS
4689 E7 61 00620 STB 1,S
00630
00640 * SAVE THE BYTE ADDRESS
468B 1F 12 00650 TFR X,Y
00660
00670 * ALL ONES MASK TO
00680 * SET BIT = 0 = BLACK
00690 * USING "AND"
468D 48 00700 LSLA A = A * 4
468E 48 00710 LSLA (4 BYTES PER
LBL)
468F 8E 4694 00720 LDX #LBL000
4692 6E 86 00730 JMP A,X
4694 C6 FE 00740 LBL000 LDB #$FE
4696 20 1A 00750 BRA LBL008
4698 C6 FD 00760 LBL001 LDB #$FD
469A 20 16 00770 BRA LBL008
469C C6 FB 00780 LBL002 LDB #$FB
469E 20 12 00790 BRA LBL008
46A0 C6 F7 00800 LBL003 LDB #$F7
46A2 20 0E 00810 BRA LBL008
46A4 C6 EF 00820 LBL004 LDB #$EF
46A6 20 0A 00830 BRA LBL008
46A8 C6 DF 00840 LBL005 LDB #$DF
46AA 20 06 00850 BRA LBL008
46AC C6 BF 00860 LBL006 LDB #$BF
46AE 20 02 00870 BRA LBL008
46B0 C6 7F 00880 LBL007 LDB #$7F
46B2 E7 E4 00890 LBL008 STB ,S PIXEL MASK
00900

```

```

00910 * SET THE PIXEL TO 0 = BLACK
46B4 1F 21 00920 TFR Y,X BYTE ADDRESS
46B6 A6 61 00930 LDA 1,S BYTE CONTENTS
46B8 A4 E4 00940 ANDA ,S PIXEL MASK
46BA A7 84 00950 STA ,X PUT TO SCREEN
00960
00970 * CLEAN THE STACK AND RETURN
46BC 32 62 00980 LEAS 2,S
46BE 35 30 00990 PULS X,Y
46C0 39 01000 RTS
01010
0000 01020 END

```

Cycles and Bytes:

```

00100 *****
00110 *
00120 * PSET40D.ASM
00130 * MDJ 2023/03/25
00135 * FINAL
00136 * CYCLES AND BYTES
00140 *
00270 *****
00280
4657 00310 PSTGB4 EQU $4657 CYCLES BYTES
4682 00330 ORG $4682 -----
4682 34 30 00350 PSET40 PSHS X,Y 9 2
4684 32 7E 00510 LEAS -2,S 5 2
4686 BD 4657 00540 JSR PSTGB4 8 3
4689 E7 61 00620 STB 1,S 5 2
468B 1F 12 00650 TFR X,Y 7 2
468D 48 00700 LSLA 2 1
468E 48 00710 LSLA 2 1
468F 8E 4694 00720 LDX #LBL000 3 3
4692 6E 86 00730 JMP A,X 4 2
4694 C6 FE 00740 LBL000 LDB # $FE 2 2
4696 20 1A 00750 BRA LBL008 3 2
4698 C6 FD 00760 LBL001 LDB # $FD 2 2
469A 20 16 00770 BRA LBL008 3 2
469C C6 FB 00780 LBL002 LDB # $FB 2 2
469E 20 12 00790 BRA LBL008 3 2
46A0 C6 F7 00800 LBL003 LDB # $F7 2 2
46A2 20 0E 00810 BRA LBL008 3 2
46A4 C6 EF 00820 LBL004 LDB # $EF 2 2
46A6 20 0A 00830 BRA LBL008 3 2

```


46A8	C6	DF	00840	LBL005	LDB	#\$DF	2	2
46AA	20	06	00850		BRA	LBL008	3	2
46AC	C6	BF	00860	LBL006	LDB	#\$BF	2	2
46AE	20	02	00870		BRA	LBL008	3	2
46B0	C6	7F	00880	LBL007	LDB	#\$7F	2	2
46B2	E7	E4	00890	LBL008	STB	,S	5	2
46B4	1F	21	00920		TFR	Y,X	7	2
46B6	A6	61	00930		LDA	1,S	5	2
46B8	A4	E4	00940		ANDA	,S	4	2
46BA	A7	84	00950		STA	,X	4	2
46BC	32	62	00980		LEAS	2,S	5	2
46BE	35	30	00990		PULS	X,Y	9	2
46C0	39		01000		RTS		5	1
		0000	01020		END		-----	-----
					TOTALS		126	65

See the Final PSET41 Chapter below for testing.

=====

Final PSET41: Set a PMODE 4 Point to Green = 1

This is the final PSET41. It calls the subroutine PSTGB4 to translate the coordinates into the screen's byte data and then puts the green pixel to the screen. Except for using a zeroes mask instead of a ones mask, this routine is identical to the final PSET40. Therefore, I did not do a separate cycles and bytes analysis for this routine.

```
00100 *****
00110 *
00120 * PSET41.ASM
00130 * MDJ 2023/03/26
00140 * FINAL
00150 *
00160 * SET A PMODE 4
00170 * POINT TO
00180 * GREEN = 1
00190 *
00200 * ENTRY CONDITIONS:
00210 * A = Y-COORDINATE (0-191)
00220 * B = X-COORDINATE (0-255)
00230 *
00240 * EXIT CONDITIONS:
00250 * NONE
00260 *
00270 *****
00280
00290 * BYTE DATA
00300 * ROUTINE ADDRESS
          4657
00310 PSTGB4 EQU $4657
00320
46C1
00330 ORG $46C1
00340
46C1 34 30
00350 PSET41 PSHS X,Y
00360
00370 * AT THIS POINT THE
00380 * STACK CONTAINS
00390 * 3,S RTS ADDRESS LOW BYTE
00400 * 2,S RTS ADDRESS HIGH BYTE
00410 * 1,S REGISTER X LOW BYTE
00420 * ,S REGISTER X HIGH BYTE
00430
00440 * MAKE ROOM FOR
```

```

00450 * 5,S RTS ADDRESS LOW BYTE
00460 * 4,S RTS ADDRESS HIGH BYTE
00470 * 3,S REGISTER X LOW BYTE
00480 * 2,S REGISTER X HIGH BYTE
00490 * 1,S BYTE CONTENTS
00500 * ,S PIXEL MASK
46C3 32 7E 00510 LEAS -2,S
00520
00530 * GO GET BYTE DATA
46C5 BD 4657 00540 JSR PSTGB4
00550
00560 * NOW:
00570 * A = BIT POSITION (0-7)
00580 * B = BYTE CONTENTS
00590 * X = BYTE ADDRESS
00600
00610 * SAVE THE BYTE CONTENTS
46C8 E7 61 00620 STB 1,S
00630
00640 * SAVE THE BYTE ADDRESS
46CA 1F 12 00650 TFR X,Y
00660
00670 * ALL ZEROES MASK TO
00680 * SET BIT = 1 = GREEN
00690 * USING "OR"
46CC 48 00700 LSLA A = A * 4
46CD 48 00710 LSLA (4 BYTES)
PER LBL)
46CE 8E 46D3 00720 LDX #LBL000
46D1 6E 86 00730 JMP A,X
46D3 C6 01 00740 LBL000 LDB #$01
46D5 20 1A 00750 BRA LBL008
46D7 C6 02 00760 LBL001 LDB #$02
46D9 20 16 00770 BRA LBL008
46DB C6 04 00780 LBL002 LDB #$04
46DD 20 12 00790 BRA LBL008
46DF C6 08 00800 LBL003 LDB #$08
46E1 20 0E 00810 BRA LBL008
46E3 C6 10 00820 LBL004 LDB #$10
46E5 20 0A 00830 BRA LBL008
46E7 C6 20 00840 LBL005 LDB #$20
46E9 20 06 00850 BRA LBL008
46EB C6 40 00860 LBL006 LDB #$40
46ED 20 02 00870 BRA LBL008
46EF C6 80 00880 LBL007 LDB #$80
46F1 E7 E4 00890 LBL008 STB ,S PIXEL MASK
00900

```

			00910	*	SET THE PIXEL TO 1 = GREEN	
46F3	1F	21	00920		TFR Y,X	BYTE
ADDRESS						
46F5	A6	61	00930		LDA 1,S	BYTE
CONTENTS						
46F7	AA	E4	00940		ORA ,S	PIXEL MASK
46F9	A7	84	00950		STA ,X	PUT TO
SCREEN						
			00960			
			00970	*	CLEAN THE STACK AND RETURN	
46FB	32	62	00980		LEAS 2,S	
46FD	35	30	00990		PULS X,Y	
46FF	39		01000		RTS	
			01010			
		0000	01020		END	

The Assembly Language Test Routine:

	00100	*****	
	00110	*	
	00120	* TEST0202.ASM	
	00130	* MDJ 2023/03/26	
	00140	*	
	00150	* SECOND PMODE 4	
	00160	* GRAPHICS TEST	
	00170	*	
	00180	*****	
	00190		
	00200	* MLCORE ADDRESS	
4142	00210	POLCAT EQU	\$4142
	00220		
	00230	* GRAPHICS ROUTINES	
	00240	* ADDRESSES	
4574	00250	STSAMG EQU	\$4574
4588	00260	STSAM2 EQU	\$4588
458F	00270	SVT EQU	\$458F
45D4	00280	SVG410 EQU	\$45D4
4608	00290	SVG450 EQU	\$4608
4642	00300	PCLS4 EQU	\$4642
4657	00310	PSTGB4 EQU	\$4657
4682	00320	PSET40 EQU	\$4682
46C1	00330	PSET41 EQU	\$46C1
	00340		
7000	00350	ORG	\$7000
	00360		

7000	34	06	00370	PSHS	A,B	
			00380			
			00390	* SET PMODE 4 PAGE 1		
7002	BD	45D4	00400	JSR	SVG410	
			00410			
			00420	* CLEAR THE SCREEN TO GREEN		
7005	86	01	00430	LDA	#\$01	
7007	BD	4642	00440	JSR	PCLS4	
			00450			
			00460	* PUT A BLACK DOT CTR OF GREEN SCREEN		
700A	86	5C	00470	LDA	#92	Y
700C	C6	80	00480	LDB	#128	X
700E	BD	4682	00490	JSR	PSET40	BLACK DOT
			00500			
			00510	* WAIT FOR A KEYPRESS		
7011	34	03	00520	PSHS	A,CC	
7013	BD	4142	00530	LBL001	JSR	POLCAT
7016	27	FB	00540	BEQ	LBL001	NO KEYPRESS
7018	35	03	00550	PULS	A,CC	
			00560			
			00570	* CLEAR THE SCREEN TO BLACK		
701A	86	00	00580	LDA	#\$00	
701C	BD	4642	00590	JSR	PCLS4	
			00600			
			00610	* PUT A GREEN DOT CTR OF BLACK SCREEN		
701F	86	5C	00620	LDA	#92	Y
7021	C6	80	00630	LDB	#128	X
7023	BD	46C1	00640	JSR	PSET41	GREEN DOT
			00650			
			00660	* WAIT FOR A KEYPRESS		
7026	34	03	00670	PSHS	A,CC	
7028	BD	4142	00680	LBL002	JSR	POLCAT
702B	27	FB	00690	BEQ	LBL002	NO KEYPRESS
702D	35	03	00700	PULS	A,CC	
			00710			
			00720	* SET PMODE 4 PAGE 5		
702F	BD	4608	00730	JSR	SVG450	
			00740			
			00750	* CLEAR THE SCREEN TO GREEN		
7032	86	01	00760	LDA	#\$01	
7034	BD	4642	00770	JSR	PCLS4	
			00780			
			00790	* PUT A BLACK DOT CTR OF GREEN SCREEN		
7037	86	5C	00800	LDA	#92	Y
7039	C6	80	00810	LDB	#128	X
703B	BD	4682	00820	JSR	PSET40	BLACK DOT
			00830			

```

00840 * WAIT FOR A KEYPRESS
703E 34 03 00850 PSHS A,CC
7040 BD 4142 00860 LBL003 JSR POLCAT
7043 27 FB 00870 BEQ LBL003 NO KEYPRESS
7045 35 03 00880 PULS A,CC
00890
00900 * CLEAR THE SCREEN TO BLACK
7047 86 00 00910 LDA #$00
7049 BD 4642 00920 JSR PCLS4
00930
00940 * PUT A GREEN DOT CTR OF BLACK SCREEN
704C 86 5C 00950 LDA #92 Y
704E C6 80 00960 LDB #128 X
7050 BD 46C1 00970 JSR PSET41 GREEN DOT
00980
00990 * WAIT FOR A KEYPRESS
7053 34 03 01000 PSHS A,CC
7055 BD 4142 01010 LBL004 JSR POLCAT
7058 27 FB 01020 BEQ LBL004 NO KEYPRESS
705A 35 03 01030 PULS A,CC
01040
01050 * RETURN TO TEXT MODE
705C BD 458F 01060 JSR SVT
01070
01080 * WAIT FOR A KEYPRESS
705F 34 03 01090 PSHS A,CC
7061 BD 4142 01100 LBL005 JSR POLCAT
7064 27 FB 01110 BEQ LBL005 NO KEYPRESS
7066 35 03 01120 PULS A,CC
01130
7068 35 06 01140 PULS A,B
706A 39 01150 RTS
01160
0000 01170 END

```

Making the Final MLFT File: This program combines all the Graphics Control Routines into the single MLFT.BIN file so that the entire machine language Graphics Control System can be loaded as a single entity.

Note that the FLSYS.BIN file specified on Line 2000 is provided by the MAKEFALS.BAS program in ([MDJ01], p.104). It is not used in these Graphics Control Routines, but is included as a check that the MLCORE, False Disk Routines and Graphics Control Routines all fit together properly without any erroneous overlaps.

```

1000 '*****
1010 '*
1020 '* MAKEMLFT.BAS
1030 '* MDJ 2023/03/26
1040 '*
1050 '* MAKES THE
1060 '* MLFT.BIN FILE
1070 '*
1080 '*****
1090 '

1500 CLEAR 200, &H4000
1510 '

2000 LOADM "FLSYS.BIN"
2010 LOADM "STSAMG.BIN"
2020 LOADM "SVT.BIN"
2030 LOADM "SVG410.BIN"
2030 LOADM "SVG450.BIN"
2040 LOADM "PCLS4.BIN"
2050 LOADM "PSTGB4.BIN"
2060 LOADM "PSET40.BIN"
2070 LOADM "PSET41.BIN"
2080 '

3000 SAVEM "MLFT.BIN", &H4416, &H46FF, &H4416
3010 '

32767 END

```

The BASIC Language Control Program:

```

1000 '*****
1010 '*
1020 '* TEST0202.BAS
1030 '* MDJ 2023/03/26
1040 '*
1050 '* SECOND PMODE 4
1060 '* GRAPHICS TEST
1070 '*
1080 '*****
1090 '

1100 'SETUP MEMORY
1110 CLEAR 0, &H4000

```

```
1120 PCLEAR 8
1120 '

1200 'LOAD THE
1210 'ML FOUNDATION CORE
1220 LOADM "MLCORE.BIN"
1230 '

1300 'LOAD THE MLFT FILE
1310 LOADM "MLFT.BIN"
1320 '

1400 'LOAD THE
1410 'ML TEST ROUTINE
1420 LOADM "TEST0202.BIN"
1430 '

2900 'REFERENCE THE
2910 'TRANSFER VARIABLES
2920 RA = &H400A 'REGPCH
2930 RB = &H400B 'REGPCL
2940 '

3000 'SETUP THE
3010 'RUN ADDRESS
3020 C = &H7000
3030 C1 = INT(C/256)
3040 C2 = INT(C-(C1*256))
3050 POKE RA, C1
3060 POKE RB, C2
3070 '

6000 'JUMP TO CORE
6010 'STARTUP ROUTINE
6020 EXEC &H4403
6030 '

9000 'MEMORY AND DISK
9010 'STATUS CHECK
9020 PRINT
9030 PRINT " MEM = ";MEM
9040 PRINT "FREE = ";FREE(0)
9050 '

32767 END
```


The BASIC Language Control Program, Abbreviated: The full program, as written above, bombs with a reported OM ERROR. This is intentional - The entire ML Foundation System is intended to be initialized using the absolute minimum of BASIC code; just enough to get the Machine Language system loaded and started. It is the following abbreviated BASIC code which is on disk as TEST0202.BAS.

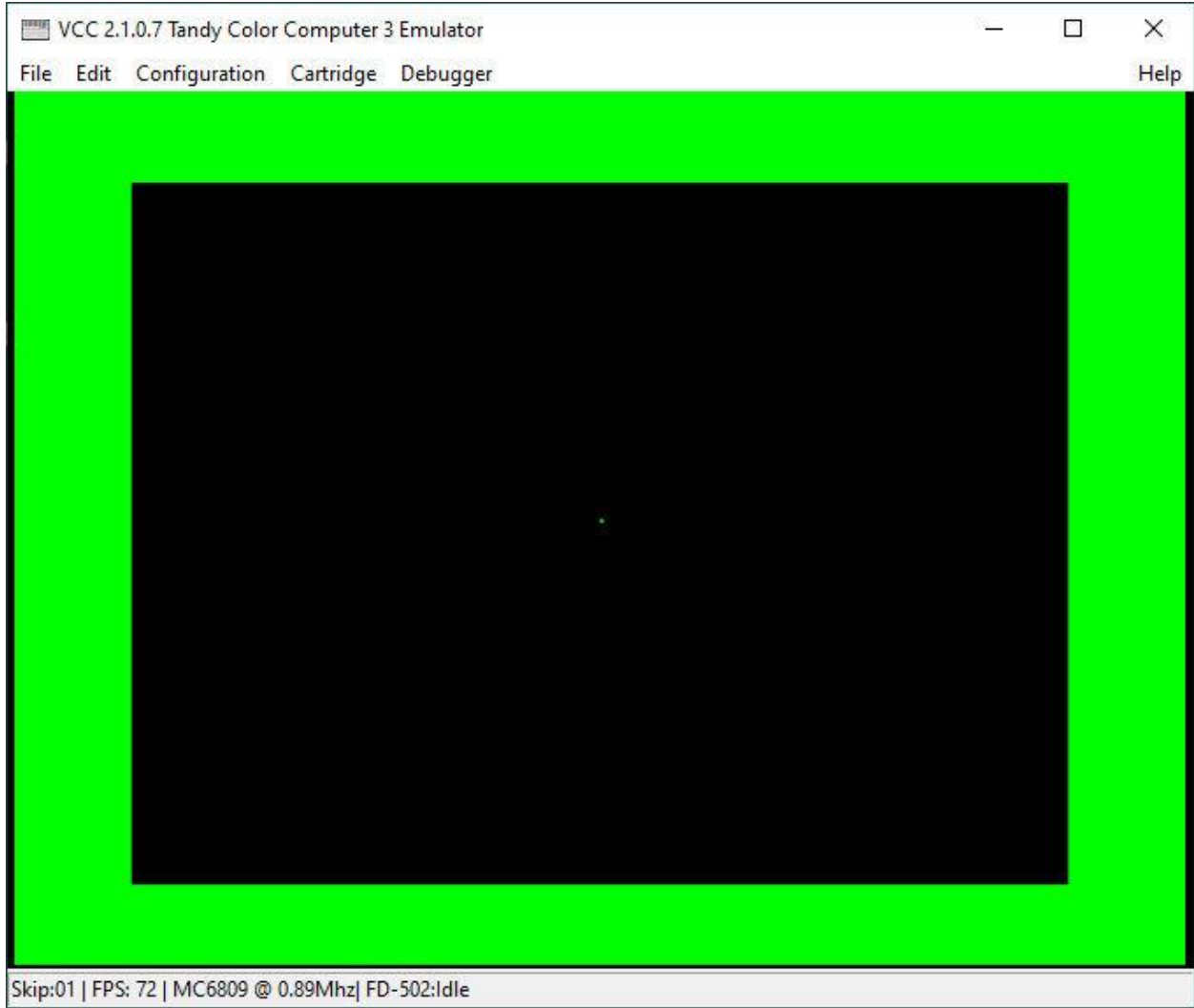
```
1110 CLEAR0 , &H4000
1120 PCLEAR8
1220 LOADM"MLCORE . BIN"
1310 LOADM"MLFT . BIN"
1420 LOADM"TEST0202 . BIN"
2920 RA=&H400A
2930 RB=&H400B
3020 C=&H7000
3030 C1=INT (C/256)
3040 C2=INT (C- (C1*256) )
3050 POKERA , C1
3060 POKERB , C2
6020 EXEC&H4403
9020 PRINT
9030 PRINT" MEM = " ;MEM
9040 PRINT"FREE = " ;FREE (0)
32767 END
```

Results:

On Startup of TEST0202.BAS: PMODE 4. Start Page 1; cleared to Green, with central Black pixel.



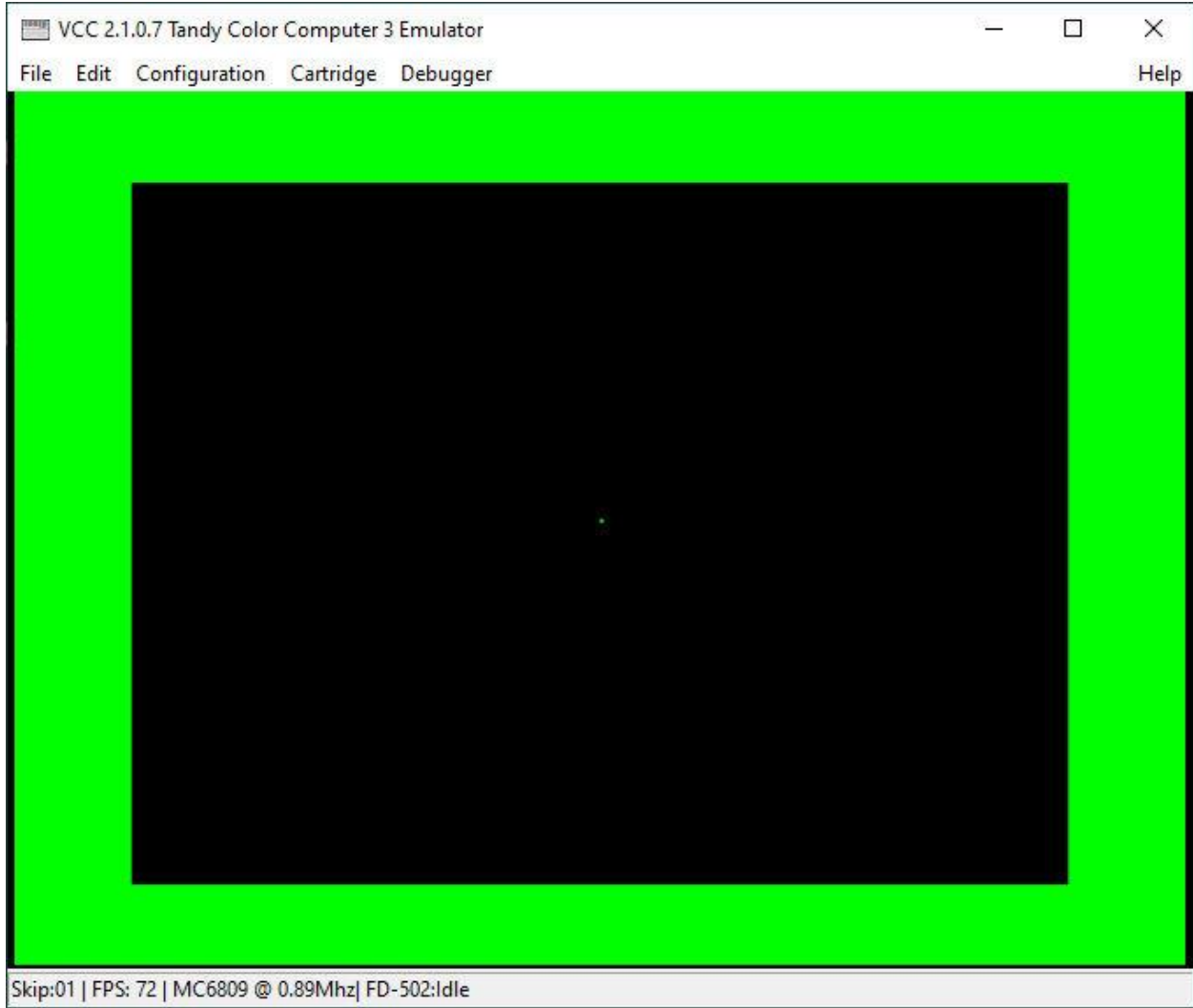
On First Keypress: PMODE 4. Start Page 1; cleared to Black, with central Green pixel.



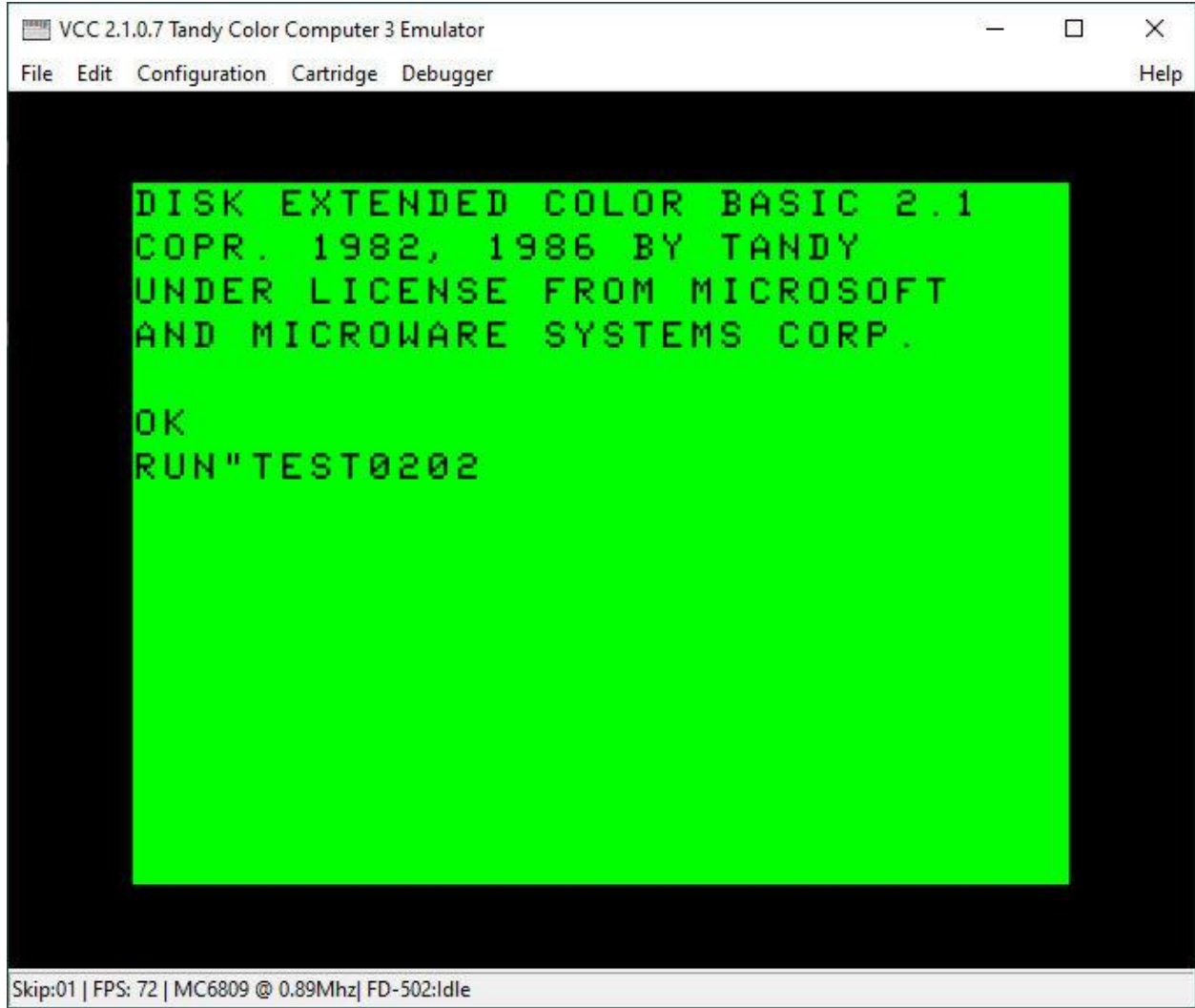
On Second Keypress: PMODE 4. Start Page 5; cleared to Green, with central Black pixel.



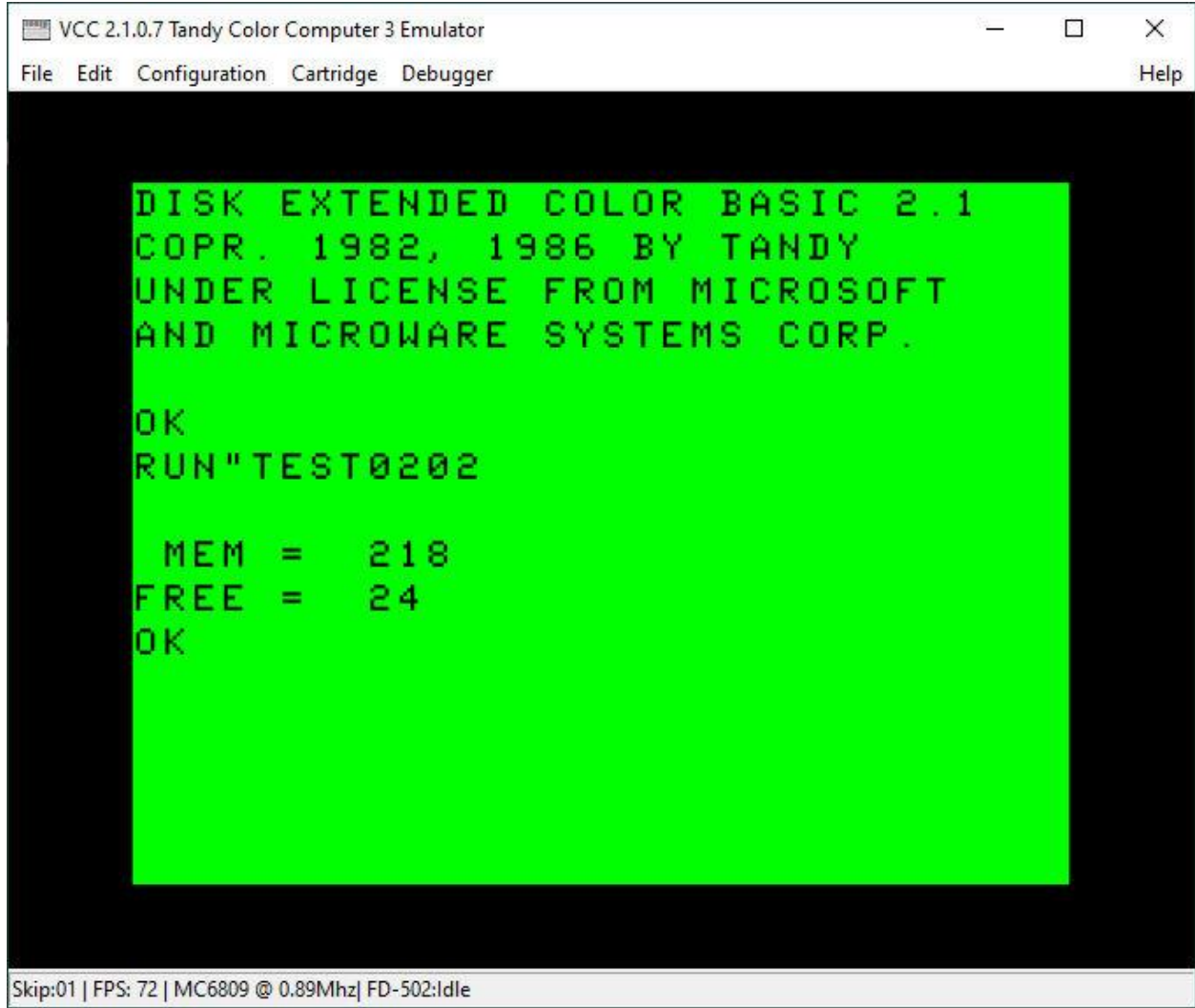
On Third Keypress: PMODE 4. Start Page 5; cleared to Black, with central Green pixel.



On Fourth Keypress: The return to Text Mode.



On Fifth Keypress: After exiting the TEST0202.BAS program.



All as expected.

=====

Results

These Graphics Control Routines, although Preliminary and for PMODE 4 only, will nevertheless serve to enable the subsequent development of the projected Fake Text PMODE 4 (maze-like) game as originally envisioned.

Finally, I present MAKEMLGC.BAS, which is identical to MAKEMLFT.BAS, except that it excludes the FLSYS.BIN file from [MDJ01]. This will allow the False Disk Routines and the Preliminary Graphics Control Routines to stand separately and on their own within the ML Foundation System.

```
1000 '*****
1010 '*
1020 '* MAKEMLGC.BAS
1030 '* MDJ 2023/04/06
1040 '*
1050 '* MAKES THE
1060 '* MLGC.BIN FILE
1070 '*
1080 '*****
1090 '

1500 CLEAR 200, &H4000
1510 '

2010 LOADM "STSAMG.BIN"
2020 LOADM "SVT.BIN"
2030 LOADM "SVG410.BIN"
2030 LOADM "SVG450.BIN"
2040 LOADM "PCLS4.BIN"
2050 LOADM "PSTGB4.BIN"
2060 LOADM "PSET40.BIN"
2070 LOADM "PSET41.BIN"
2080 '

3000 SAVEM "MLGC.BIN", &H4574, &H46FF, &H4574
3010 '

32767 END
```

=====

Conclusions and Future Work

The Preliminary Graphics Control Routines for the ML Foundation System are complete and functional (subject, of course, to the correction of any as-yet-undiscovered bugs).

They cover the setup of PMODE 4 and the PSET routines for PMODE 4.

Future work should include:

1. Setup and PSET routines for PMODES 0-3.
2. More complex graphics routines for PMODES 0-4, including, but not necessarily limited to:

DRAW
GET
LINE
PAINT
PCOPY
PPOINT
PUT

=====

Appendix A

Decimal to Hexadecimal Conversions

<u>DEC</u>	<u>HEX</u>	<u>DEC</u>	<u>HEX</u>	<u>DEC</u>	<u>HEX</u>	<u>DEC</u>	<u>HEX</u>
000	00	032	20	064	40	096	60
001	01	033	21	065	41	097	61
002	02	034	22	066	42	098	62
003	03	035	23	067	43	099	63
004	04	036	24	068	44	100	64
005	05	037	25	069	45	101	65
006	06	038	26	070	46	102	66
007	07	039	27	071	47	103	67
008	08	040	28	072	48	104	68
009	09	041	29	073	49	105	69
010	0A	042	2A	074	4A	106	6A
011	0B	043	2B	075	4B	107	6B
012	0C	044	2C	076	4C	108	6C
013	0D	045	2D	077	4D	109	6D
014	0E	046	2E	078	4E	110	6E
015	0F	047	2F	079	4F	111	6F
016	10	048	30	080	50	112	70
017	11	049	31	081	51	113	71
018	12	050	32	082	52	114	72
019	13	051	33	083	53	115	73
020	14	052	34	084	54	116	74
021	15	053	35	085	55	117	75
022	16	054	36	086	56	118	76
023	17	055	37	087	57	119	77
024	18	056	38	088	58	120	78
025	19	057	39	089	59	121	79
026	1A	058	3A	090	5A	122	7A
027	1B	059	3B	091	5B	123	7B
028	1C	060	3C	092	5C	124	7C
029	1D	061	3D	093	5D	125	7D
030	1E	062	3E	094	5E	126	7E
031	1F	063	3F	095	5F	127	7F

<u>DEC</u>	<u>HEX</u>	<u>DEC</u>	<u>HEX</u>	<u>DEC</u>	<u>HEX</u>	<u>DEC</u>	<u>HEX</u>
128	80	160	A0	192	C0	224	E0
129	81	161	A1	193	C1	225	E1
130	82	162	A2	194	C2	226	E2
131	83	163	A3	195	C3	227	E3
132	84	164	A4	196	C4	228	E4
133	85	165	A5	197	C5	229	E5
134	86	166	A6	198	C6	230	E6
135	87	167	A7	199	C7	231	E7
136	88	168	A8	200	C8	232	E8
137	89	169	A9	201	C9	233	E9
138	8A	170	AA	202	CA	234	EA
139	8B	171	AB	203	CB	235	EB
140	8C	172	AC	204	CC	236	EC
141	8D	173	AD	205	CD	237	ED
142	8E	174	AE	206	CE	238	EE
143	8F	175	AF	207	CF	239	EF
144	90	176	B0	208	D0	240	F0
145	91	177	B1	209	D1	241	F1
146	92	178	B2	210	D2	242	F2
147	93	179	B3	211	D3	243	F3
148	94	180	B4	212	D4	244	F4
149	95	181	B5	213	D5	245	F5
150	96	182	B6	214	D6	246	F6
151	97	183	B7	215	D7	247	F7
152	98	184	B8	216	D8	248	F8
153	99	185	B9	217	D9	249	F9
154	9A	186	BA	218	DA	250	FA
155	9B	187	BB	219	DB	251	FB
156	9C	188	BC	220	DC	252	FC
157	9D	189	BD	221	DD	253	FD
158	9E	190	BE	222	DE	254	FE
159	9F	191	BF	223	DF	255	FF

=====

Appendix B: MLGC Tests

Machine Language Graphics Control Parameters Lists Reporting Program:

```
1000 '*****
1010 '*
1020 '* MLGCTST2.BAS
1030 '* MDJ 2023/03/14
1040 '*
1070 '* REPORTS
1080 '* GRAPHICS
1090 '* PARAMETERS
1100 '*
1110 '* CF. EXTENDED BASIC
1120 '*     UNRAVELLED,
1130 '*     PAGE B-31
1140 '*
1150 '* RUN IMMEDIATELY AFTER
1160 '* STARTUP TO AVOID ANY
1170 '* PRECONTAMINATION OF
1180 '* THE PARAMETERS
1190 '*
1200 '* NOTE: ALL OUTPUT IS
1210 '*     TO THE PRINTER
1220 '*
1230 '*****
1240 '
1250 L = 0 'LINE COUNTER
1260 'TEMPORARY VARIABLES
1270 ' = A, A8, A9, B, I, T, X8, X9

1300 CLEAR &H200
1310 PCLEAR 8
1320 PRINT #-2, "*****"
1330 PRINT #-2, "*"
1340 PRINT #-2, "* MLGCTTST2.BAS"
1350 PRINT #-2, "* GRAPHICS PARAMETERS"
1360 PRINT #-2, "*"
1370 PRINT #-2, "*****"
1380 PRINT #-2, " "
1390 '

1400 'BASE RUN
1410 PRINT #-2, "*****"
1420 PRINT #-2, "*"
1430 PRINT #-2, "* BASE: TEXT MODE"
```

```

1440 PRINT #-2, "*"
1450 PRINT #-2, "*****"
1460 PRINT #-2, " "
1470 L = 13
1480 GOSUB 10000 'GET & REPORT GRAPHIC VARIABLES
1490 GOSUB 16000 'NEXT PAGE
1500 '

2500 'PMODE 0 RUNS
2510 P9 = 0 'PMODE
2520 FOR G9 = 1 TO 8 'PAGE
2530   FOR C9 = 0 TO 1 'COLOR SET
2540     PRINT #-2, "PMODE=";P9;" , PAGE=";G9;" , COLORSET=";C9
2550     L = L + 1
2560     PMODE P9, G9
2570     SCREEN 0, C9
2580     GOSUB 10000 'GET & REPORT GRAPHIC VARIABLES
2590     GOSUB 11000 'DO AND REPORT PRECALC
2600     GOSUB 12000 'DO AND REPORT OR WITH CSSVAL
2610     GOSUB 13000 'DO AND REPORT MIDCALC
2620     GOSUB 14000 'DO AND REPORT POSTCALC
2630     GOSUB 15000 'DO AND REPORT ENDCALC
2640     GOSUB 16000 'NEXT PAGE
2650     SCREEN 1, 0
2660   NEXT C9
2670 NEXT G9
2680 '

3500 'PMODE 1 RUNS
3510 P9 = 1 'PMODE
3520 FOR G9 = 1 TO 7 'PAGE
3530   FOR C9 = 0 TO 1 'COLOR SET
3540     PRINT #-2, "PMODE=";P9;" , PAGE=";G9;" , COLORSET=";C9
3550     L = L + 1
3560     PMODE P9, G9
3570     SCREEN 0, C9
3580     GOSUB 10000 'GET & REPORT GRAPHIC VARIABLES
3590     GOSUB 11000 'DO AND REPORT PRECALC
3600     GOSUB 12000 'DO AND REPORT OR WITH CSSVAL
3610     GOSUB 13000 'DO AND REPORT MIDCALC
3620     GOSUB 14000 'DO AND REPORT POSTCALC
3630     GOSUB 15000 'DO AND REPORT ENDCALC
3640     GOSUB 16000 'NEXT PAGE
3650     SCREEN 1, 0
3660   NEXT C9
3670 NEXT G9
3680 '

```

```

4500 'PMODE 2 RUNS
4510 P9 = 2 'PMODE
4520 FOR G9 = 1 TO 7 'PAGE
4530   FOR C9 = 0 TO 1 'COLOR SET
4540     PRINT #-2, "PMODE=";P9;", PAGE=";G9;", COLORSET=";C9
4550     L = L + 1
4560     PMODE P9, G9
4570     SCREEN 0, C9
4580     GOSUB 10000 'GET & REPORT GRAPHIC VARIABLES
4590     GOSUB 11000 'DO AND REPORT PRECALC
4600     GOSUB 12000 'DO AND REPORT OR WITH CSSVAL
4610     GOSUB 13000 'DO AND REPORT MIDCALC
4620     GOSUB 14000 'DO AND REPORT POSTCALC
4630     GOSUB 15000 'DO AND REPORT ENDCALC
4640     GOSUB 16000 'NEXT PAGE
4650     SCREEN 1, 0
4660   NEXT C9
4670 NEXT G9
4680 '

```

```

5500 'PMODE 3 RUNS
5510 P9 = 3 'PMODE
5520 FOR G9 = 1 TO 5 'PAGE
5530   FOR C9 = 0 TO 1 'COLOR SET
5540     PRINT #-2, "PMODE=";P9;", PAGE=";G9;", COLORSET=";C9
5550     L = L + 1
5560     PMODE P9, G9
5570     SCREEN 0, C9
5580     GOSUB 10000 'GET & REPORT GRAPHIC VARIABLES
5590     GOSUB 11000 'DO AND REPORT PRECALC
5600     GOSUB 12000 'DO AND REPORT OR WITH CSSVAL
5610     GOSUB 13000 'DO AND REPORT MIDCALC
5620     GOSUB 14000 'DO AND REPORT POSTCALC
5630     GOSUB 15000 'DO AND REPORT ENDCALC
5640     GOSUB 16000 'NEXT PAGE
5650     SCREEN 1, 0
5660   NEXT C9
5670 NEXT G9
5680 '

```

```

6500 'PMODE 4 RUNS
6510 P9 = 4 'PMODE
6520 FOR G9 = 1 TO 5 'PAGE
6530   FOR C9 = 0 TO 1 'COLOR SET
6540     PRINT #-2, "PMODE=";P9;", PAGE=";G9;", COLORSET=";C9
6550     L = L + 1

```

```

6560      PMODE P9, G9
6570      SCREEN 0, C9
6580      GOSUB 10000 'GET & REPORT GRAPHIC VARIABLES
6590      GOSUB 11000 'DO AND REPORT PRECALC
6600      GOSUB 12000 'DO AND REPORT OR WITH CSSVAL
6610      GOSUB 13000 'DO AND REPORT MIDCALC
6620      GOSUB 14000 'DO AND REPORT POSTCALC
6630      GOSUB 15000 'DO AND REPORT ENDCALC
6640      GOSUB 16000 'NEXT PAGE
6650      SCREEN 1, 0
6660      NEXT C9
6670      NEXT G9
6680      '

```

```

7500 PRINT #-2, " "
7510 PRINT #-2, " "
7520 PRINT #-2, "*****"
7530 PRINT #-2, "*"
7540 PRINT #-2, "* END OF RUN"
7550 PRINT #-2, "*"
7560 PRINT #-2, "*****"
7570 GOTO 32767

```

```

10000 'GET & REPORT GRAPHIC VARIABLES
10030 B2 = PEEK(&H00B2)
10040 B3 = PEEK(&H00B3)
10050 B5 = PEEK(&H00B5)
10060 B6 = PEEK(&H00B6)
10070 B7 = PEEK(&H00B7)*256+PEEK(&H00B8)
10080 B9 = PEEK(&H00B9)
10090 BA = PEEK(&H00BA)*256+PEEK(&H00BB)
10100 BC = PEEK(&H00BC)
10110 C1 = PEEK(&H00C1)
10120 DB = PEEK(&H00DB)
10130 SCREEN 1, 0
10140 PRINT #-2, "B2 FORCOL = "; HEX$(B2)
10150 PRINT #-2, "B3 BAKCOL = "; HEX$(B3)
10160 PRINT #-2, "B5 ALLCOL = "; HEX$(B5)
10170 PRINT #-2, "B6 PMODE = "; HEX$(B6)
10180 PRINT #-2, "B7 ENDGRP = "; HEX$(B7)
10190 PRINT #-2, "B9 HORBYT = "; HEX$(B9)
10200 PRINT #-2, "BA BEGGRP = "; HEX$(BA)
10210 PRINT #-2, "BC GRPRAM = "; HEX$(BC)
10220 PRINT #-2, "C1 CSSVAL = "; HEX$(C1)
10230 PRINT #-2, "DB CHGFLG = "; HEX$(DB)
10240 PRINT #-2, " "
10250 L = L + 11

```

```

10260 RETURN
10270 '

11000 'DO AND REPORT PRECALC
11005 'FOR REFERENCE ONLY
11010 A = B6 + 3      'LDA PMODE, ADDA #3
11020 A = A * 16     'LDB #10, MUL
11030 B = &H80       'DECIMAL 128
11040 GOSUB 23500    'GO DO A = (A OR B)
11050 'PRINT #-2, "PRECALC  = "; HEX$(A)
11060 'L = L + 1
11070 RETURN
11080 '

12000 'DO AND REPORT OR WITH CSSVAL
12005 'FOR REFERENCE ONLY
12010 B = C1         'CSSVAL
12020 GOSUB 23500    'GO DO A = (A OR B)
12030 'PRINT #-2, "OR CSSVAL = "; HEX$(A)
12040 'L = L + 1
12050 RETURN
12060 '

13000 'DO AND REPORT MIDCALC
13005 'TO PIA1+2
13010 T = A
13020 A = PEEK(&HFF22) 'PIA1+2 VALUE
13030 B = &H07        'DECIMAL 7
13040 GOSUB 23000    'GO DO A = (A AND B)
13050 B = T
13060 GOSUB 23500    'GO DO A = (A OR B)
13070 PRINT #-2, "MIDCALC  = "; HEX$(A)
13080 L = L + 1
13090 RETURN
13100 '

14000 'DO AND REPORT POSTCALC
14005 'LDA POSTCALC, THEN JSR STSAM2
14010 A = INT(BA/256) 'MSB OF BEGGRP
14020 A = A/2         'LSRA
14030 PRINT #-2, "POSTCALC = "; HEX$(A)
14040 L = L + 1
14050 RETURN
14060 '

15000 'DO AND REPORT ENDCALC
15005 'LDA ENDCALC, THEN JSR STSAMG

```



```

15010 A = B6 + 3      'LDA PMODE, ADDA #3
15020 'DECREMENT IF PMODE = 4
15030 IF (A = 7) THEN A = 6
15040 PRINT #-2, "ENDCALC  = "; HEX$(A)
15050 L = L + 1
15060 RETURN
15070 '

16000 'NEXT PAGE
16010 T = 57 - L
16020 FOR I = 0 TO (T-1)
16030   PRINT #-2, " "
16040 NEXT I
16050 L = 0 'RESET LINE COUNT
16060 RETURN
16070 '

20000 'CONVERT AN UNSIGNED INTEGER
20010 'IN REGISTER "A" TO INDIVIDUAL BITS.
20020 'ENTER WITH A = THE UNSIGNED INTEGER.
20030 'EXIT WITH A0-A7 = THE BITS.
20040 A8 = INT(A)
20050 A9 = INT(A8/2)
20060 A0 = A8 - (A9*2)
20070 A8 = A9
20080 A9 = INT(A8/2)
20090 A1 = A8 - (A9*2)
20100 A8 = A9
20110 A9 = INT(A8/2)
20120 A2 = A8 - (A9*2)
20130 A8 = A9
20140 A9 = INT(A8/2)
20150 A3 = A8 - (A9*2)
20160 A8 = A9
20170 A9 = INT(A8/2)
20180 A4 = A8 - (A9*2)
20190 A8 = A9
20200 A9 = INT(A8/2)
20210 A5 = A8 - (A9*2)
20220 A8 = A9
20230 A9 = INT(A8/2)
20240 A6 = A8 - (A9*2)
20250 A8 = A9
20260 A9 = INT(A8/2)
20270 A7 = A8 - (A9*2)
20280 RETURN
20290 '

```

```

20500 'CONVERT INDIVIDUAL BITS IN
20510 'REGISTER "A" TO AN UNSIGNED INTEGER.
20520 'ENTER WITH A0-A7 = THE BITS.
20530 'EXIT WITH A = THE UNSIGNED INTEGER.
20540 A = A7*128 + A6*64 + A5*32 + A4*16
20550 A = A + A3*8 + A2*4 + A1*2 + A0*1
20560 RETURN
20570 '

```

```

21000 'CONVERT AN UNSIGNED INTEGER
21010 'IN REGISTER "B" TO INDIVIDUAL BITS.
21020 'ENTER WITH B = THE UNSIGNED INTEGER.
21030 'EXIT WITH B0-B7 = THE BITS.
21040 X8 = INT(B)
21050 X9 = INT(X8/2)
21060 X0 = X8 - (X9*2)
21070 X8 = X9
21080 X9 = INT(X8/2)
21090 X1 = X8 - (X9*2)
21100 X8 = X9
21110 X9 = INT(X8/2)
21120 X2 = X8 - (X9*2)
21130 X8 = X9
21140 X9 = INT(X8/2)
21150 X3 = X8 - (X9*2)
21160 X8 = X9
21170 X9 = INT(X8/2)
21180 X4 = X8 - (X9*2)
21190 X8 = X9
21200 X9 = INT(X8/2)
21210 X5 = X8 - (X9*2)
21220 X8 = X9
21230 X9 = INT(X8/2)
21240 X6 = X8 - (X9*2)
21250 X8 = X9
21260 X9 = INT(X8/2)
21270 X7 = X8 - (X9*2)
21280 RETURN
21290 '

```

```

23000 'BITWISE (A AND B) --> A
23010 GOSUB 20000           'A: UINT-->BITS
23020 GOSUB 21000         'B: UINT-->BITS
23030 IF ((A0 = 1) AND (X0 = 1)) THEN A0 = 1 ELSE A0 = 0
23040 IF ((A1 = 1) AND (X1 = 1)) THEN A1 = 1 ELSE A1 = 0
23050 IF ((A2 = 1) AND (X2 = 1)) THEN A2 = 1 ELSE A2 = 0

```

```

23060 IF ((A3 = 1) AND (X3 = 1)) THEN A3 = 1 ELSE A3 = 0
23070 IF ((A4 = 1) AND (X4 = 1)) THEN A4 = 1 ELSE A4 = 0
23080 IF ((A5 = 1) AND (X5 = 1)) THEN A5 = 1 ELSE A5 = 0
23090 IF ((A6 = 1) AND (X6 = 1)) THEN A6 = 1 ELSE A6 = 0
23100 IF ((A7 = 1) AND (X7 = 1)) THEN A7 = 1 ELSE A7 = 0
23110 GOSUB 20500          'A: BITS-->UINT
23120 RETURN
23130 '

23500 'BITWISE (A OR B) --> A
23510 GOSUB 20000        'A: UINT-->BITS
23520 GOSUB 21000        'B: UINT-->BITS
23530 IF ((A0 = 1) OR (X0 = 1)) THEN A0 = 1 ELSE A0 = 0
23540 IF ((A1 = 1) OR (X1 = 1)) THEN A1 = 1 ELSE A1 = 0
23550 IF ((A2 = 1) OR (X2 = 1)) THEN A2 = 1 ELSE A2 = 0
23560 IF ((A3 = 1) OR (X3 = 1)) THEN A3 = 1 ELSE A3 = 0
23570 IF ((A4 = 1) OR (X4 = 1)) THEN A4 = 1 ELSE A4 = 0
23580 IF ((A5 = 1) OR (X5 = 1)) THEN A5 = 1 ELSE A5 = 0
23590 IF ((A6 = 1) OR (X6 = 1)) THEN A6 = 1 ELSE A6 = 0
23600 IF ((A7 = 1) OR (X7 = 1)) THEN A7 = 1 ELSE A7 = 0
23610 GOSUB 20500        'A: BITS-->UINT
23620 RETURN
23630 '

32767 END

```

=====

Appendix C:

Graphics PMODE Parameters

Machine Language Graphics Control Parameters Lists:

*

* MLGCTTST2A.BAS ABBREVIATED

* GRAPHICS PARAMETERS

*

*

* BASE: TEXT MODE

*

B2 FORCOL = 3
B3 BAKCOL = 0
B5 ALLCOL = 0
B6 PMODE = 0
B7 ENDGRP = 1400
B9 HORBYT = 10
BA BEGGRP = E00
BC GRPRAM = E
C1 CSSVAL = 0
DB CHGFLG = 0

PMODE= 0 , PAGE= 1 , COLORSET= 0
B2 FORCOL = 3
B3 BAKCOL = 0
B5 ALLCOL = 0
B6 PMODE = 0
B7 ENDGRP = 1400
B9 HORBYT = 10
BA BEGGRP = E00
BC GRPRAM = E
C1 CSSVAL = 0
DB CHGFLG = 0

MIDCALC = B0
POSTCALC = 7
ENDCALC = 3

PMODE= 0 , PAGE= 1 , COLORSET= 1
B2 FORCOL = 3
B3 BAKCOL = 0
B5 ALLCOL = 0
B6 PMODE = 0
B7 ENDGRP = 1400
B9 HORBYT = 10
BA BEGGRP = E00
BC GRPRAM = E
C1 CSSVAL = 8
DB CHGFLG = 0

MIDCALC = B8
POSTCALC = 7
ENDCALC = 3

PMODE= 0 , PAGE= 2 , COLORSET= 0
B2 FORCOL = 3
B3 BAKCOL = 0
B5 ALLCOL = 0
B6 PMODE = 0
B7 ENDGRP = 1A00
B9 HORBYT = 10
BA BEGGRP = 1400
BC GRPRAM = E
C1 CSSVAL = 0
DB CHGFLG = 0

MIDCALC = B0
POSTCALC = A
ENDCALC = 3

PMODE= 0 , PAGE= 2 , COLORSET= 1
B2 FORCOL = 3
B3 BAKCOL = 0
B5 ALLCOL = 0

B6 PMODE = 0
B7 ENDGRP = 1A00
B9 HORBYT = 10
BA BEGGRP = 1400
BC GRPRAM = E
C1 CSSVAL = 8
DB CHGFLG = 0

MIDCALC = B8
POSTCALC = A
ENDCALC = 3

PMODE= 0 , PAGE= 3 , COLORSET= 0
B2 FORCOL = 3
B3 BAKCOL = 0
B5 ALLCOL = 0
B6 PMODE = 0
B7 ENDGRP = 2000
B9 HORBYT = 10
BA BEGGRP = 1A00
BC GRPRAM = E
C1 CSSVAL = 0
DB CHGFLG = 0

MIDCALC = B0
POSTCALC = D
ENDCALC = 3

PMODE= 0 , PAGE= 3 , COLORSET= 1
B2 FORCOL = 3
B3 BAKCOL = 0
B5 ALLCOL = 0
B6 PMODE = 0
B7 ENDGRP = 2000
B9 HORBYT = 10
BA BEGGRP = 1A00
BC GRPRAM = E
C1 CSSVAL = 8
DB CHGFLG = 0

MIDCALC = B8
POSTCALC = D

ENDCALC = 3

PMODE= 0 , PAGE= 4 , COLORSET= 0

B2 FORCOL = 3

B3 BAKCOL = 0

B5 ALLCOL = 0

B6 PMODE = 0

B7 ENDGRP = 2600

B9 HORBYT = 10

BA BEGGRP = 2000

BC GRPRAM = E

C1 CSSVAL = 0

DB CHGFLG = 0

MIDCALC = B0

POSTCALC = 10

ENDCALC = 3

PMODE= 0 , PAGE= 4 , COLORSET= 1

B2 FORCOL = 3

B3 BAKCOL = 0

B5 ALLCOL = 0

B6 PMODE = 0

B7 ENDGRP = 2600

B9 HORBYT = 10

BA BEGGRP = 2000

BC GRPRAM = E

C1 CSSVAL = 8

DB CHGFLG = 0

MIDCALC = B8

POSTCALC = 10

ENDCALC = 3

PMODE= 0 , PAGE= 5 , COLORSET= 0

B2 FORCOL = 3

B3 BAKCOL = 0

B5 ALLCOL = 0

B6 PMODE = 0

B7 ENDGRP = 2C00

B9 HORBYT = 10
BA BEGGRP = 2600
BC GRPRAM = E
C1 CSSVAL = 0
DB CHGFLG = 0

MIDCALC = B0
POSTCALC = 13
ENDCALC = 3

PMODE= 0 , PAGE= 5 , COLORSET= 1
B2 FORCOL = 3
B3 BAKCOL = 0
B5 ALLCOL = 0
B6 PMODE = 0
B7 ENDGRP = 2C00
B9 HORBYT = 10
BA BEGGRP = 2600
BC GRPRAM = E
C1 CSSVAL = 8
DB CHGFLG = 0

MIDCALC = B8
POSTCALC = 13
ENDCALC = 3

PMODE= 0 , PAGE= 6 , COLORSET= 0
B2 FORCOL = 3
B3 BAKCOL = 0
B5 ALLCOL = 0
B6 PMODE = 0
B7 ENDGRP = 3200
B9 HORBYT = 10
BA BEGGRP = 2C00
BC GRPRAM = E
C1 CSSVAL = 0
DB CHGFLG = 0

MIDCALC = B0
POSTCALC = 16
ENDCALC = 3

PMODE= 0 , PAGE= 6 , COLORSET= 1
B2 FORCOL = 3
B3 BAKCOL = 0
B5 ALLCOL = 0
B6 PMODE = 0
B7 ENDGRP = 3200
B9 HORBYT = 10
BA BEGGRP = 2C00
BC GRPRAM = E
C1 CSSVAL = 8
DB CHGFLG = 0

MIDCALC = B8
POSTCALC = 16
ENDCALC = 3

PMODE= 0 , PAGE= 7 , COLORSET= 0
B2 FORCOL = 3
B3 BAKCOL = 0
B5 ALLCOL = 0
B6 PMODE = 0
B7 ENDGRP = 3800
B9 HORBYT = 10
BA BEGGRP = 3200
BC GRPRAM = E
C1 CSSVAL = 0
DB CHGFLG = 0

MIDCALC = B0
POSTCALC = 19
ENDCALC = 3

PMODE= 0 , PAGE= 7 , COLORSET= 1
B2 FORCOL = 3
B3 BAKCOL = 0
B5 ALLCOL = 0
B6 PMODE = 0
B7 ENDGRP = 3800
B9 HORBYT = 10
BA BEGGRP = 3200

BC GRPRAM = E
C1 CSSVAL = 8
DB CHGFLG = 0

MIDCALC = B8
POSTCALC = 19
ENDCALC = 3

PMODE= 0 , PAGE= 8 , COLORSET= 0
B2 FORCOL = 3
B3 BAKCOL = 0
B5 ALLCOL = 0
B6 PMODE = 0
B7 ENDGRP = 3E00
B9 HORBYT = 10
BA BEGGRP = 3800
BC GRPRAM = E
C1 CSSVAL = 0
DB CHGFLG = 0

MIDCALC = B0
POSTCALC = 1C
ENDCALC = 3

PMODE= 0 , PAGE= 8 , COLORSET= 1
B2 FORCOL = 3
B3 BAKCOL = 0
B5 ALLCOL = 0
B6 PMODE = 0
B7 ENDGRP = 3E00
B9 HORBYT = 10
BA BEGGRP = 3800
BC GRPRAM = E
C1 CSSVAL = 8
DB CHGFLG = 0

MIDCALC = B8
POSTCALC = 1C
ENDCALC = 3

PMODE= 1 , PAGE= 1 , COLORSET= 0
B2 FORCOL = 3
B3 BAKCOL = 0
B5 ALLCOL = 0
B6 PMODE = 1
B7 ENDGRP = 1A00
B9 HORBYT = 20
BA BEGGRP = E00
BC GRPRAM = E
C1 CSSVAL = 0
DB CHGFLG = 0

MIDCALC = C0
POSTCALC = 7
ENDCALC = 4

PMODE= 1 , PAGE= 1 , COLORSET= 1
B2 FORCOL = 3
B3 BAKCOL = 0
B5 ALLCOL = 0
B6 PMODE = 1
B7 ENDGRP = 1A00
B9 HORBYT = 20
BA BEGGRP = E00
BC GRPRAM = E
C1 CSSVAL = 8
DB CHGFLG = 0

MIDCALC = C8
POSTCALC = 7
ENDCALC = 4

PMODE= 1 , PAGE= 2 , COLORSET= 0
B2 FORCOL = 3
B3 BAKCOL = 0
B5 ALLCOL = 0
B6 PMODE = 1
B7 ENDGRP = 2000
B9 HORBYT = 20
BA BEGGRP = 1400
BC GRPRAM = E
C1 CSSVAL = 0

DB CHGFLG = 0

MIDCALC = C0

POSTCALC = A

ENDCALC = 4

PMODE= 1 , PAGE= 2 , COLORSET= 1

B2 FORCOL = 3

B3 BAKCOL = 0

B5 ALLCOL = 0

B6 PMODE = 1

B7 ENDGRP = 2000

B9 HORBYT = 20

BA BEGGRP = 1400

BC GRPRAM = E

C1 CSSVAL = 8

DB CHGFLG = 0

MIDCALC = C8

POSTCALC = A

ENDCALC = 4

PMODE= 1 , PAGE= 3 , COLORSET= 0

B2 FORCOL = 3

B3 BAKCOL = 0

B5 ALLCOL = 0

B6 PMODE = 1

B7 ENDGRP = 2600

B9 HORBYT = 20

BA BEGGRP = 1A00

BC GRPRAM = E

C1 CSSVAL = 0

DB CHGFLG = 0

MIDCALC = C0

POSTCALC = D

ENDCALC = 4

PMODE= 1 , PAGE= 3 , COLORSET= 1

B2 FORCOL = 3

B3 BAKCOL = 0
B5 ALLCOL = 0
B6 PMODE = 1
B7 ENDGRP = 2600
B9 HORBYT = 20
BA BEGGRP = 1A00
BC GRPRAM = E
C1 CSSVAL = 8
DB CHGFLG = 0

MIDCALC = C8
POSTCALC = D
ENDCALC = 4

PMODE= 1 , PAGE= 4 , COLORSET= 0
B2 FORCOL = 3
B3 BAKCOL = 0
B5 ALLCOL = 0
B6 PMODE = 1
B7 ENDGRP = 2C00
B9 HORBYT = 20
BA BEGGRP = 2000
BC GRPRAM = E
C1 CSSVAL = 0
DB CHGFLG = 0

MIDCALC = C0
POSTCALC = 10
ENDCALC = 4

PMODE= 1 , PAGE= 4 , COLORSET= 1
B2 FORCOL = 3
B3 BAKCOL = 0
B5 ALLCOL = 0
B6 PMODE = 1
B7 ENDGRP = 2C00
B9 HORBYT = 20
BA BEGGRP = 2000
BC GRPRAM = E
C1 CSSVAL = 8
DB CHGFLG = 0

MIDCALC = C8
POSTCALC = 10
ENDCALC = 4

PMODE= 1 , PAGE= 5 , COLORSET= 0
B2 FORCOL = 3
B3 BAKCOL = 0
B5 ALLCOL = 0
B6 PMODE = 1
B7 ENDGRP = 3200
B9 HORBYT = 20
BA BEGGRP = 2600
BC GRPRAM = E
C1 CSSVAL = 0
DB CHGFLG = 0

MIDCALC = C0
POSTCALC = 13
ENDCALC = 4

PMODE= 1 , PAGE= 5 , COLORSET= 1
B2 FORCOL = 3
B3 BAKCOL = 0
B5 ALLCOL = 0
B6 PMODE = 1
B7 ENDGRP = 3200
B9 HORBYT = 20
BA BEGGRP = 2600
BC GRPRAM = E
C1 CSSVAL = 8
DB CHGFLG = 0

MIDCALC = C8
POSTCALC = 13
ENDCALC = 4

PMODE= 1 , PAGE= 6 , COLORSET= 0
B2 FORCOL = 3
B3 BAKCOL = 0
B5 ALLCOL = 0

B6 PMODE = 1
B7 ENDGRP = 3800
B9 HORBYT = 20
BA BEGGRP = 2C00
BC GRPRAM = E
C1 CSSVAL = 0
DB CHGFLG = 0

MIDCALC = C0
POSTCALC = 16
ENDCALC = 4

PMODE= 1 , PAGE= 6 , COLORSET= 1
B2 FORCOL = 3
B3 BAKCOL = 0
B5 ALLCOL = 0
B6 PMODE = 1
B7 ENDGRP = 3800
B9 HORBYT = 20
BA BEGGRP = 2C00
BC GRPRAM = E
C1 CSSVAL = 8
DB CHGFLG = 0

MIDCALC = C8
POSTCALC = 16
ENDCALC = 4

PMODE= 1 , PAGE= 7 , COLORSET= 0
B2 FORCOL = 3
B3 BAKCOL = 0
B5 ALLCOL = 0
B6 PMODE = 1
B7 ENDGRP = 3E00
B9 HORBYT = 20
BA BEGGRP = 3200
BC GRPRAM = E
C1 CSSVAL = 0
DB CHGFLG = 0

MIDCALC = C0
POSTCALC = 19

ENDCALC = 4

PMODE= 1 , PAGE= 7 , COLORSET= 1

B2 FORCOL = 3

B3 BAKCOL = 0

B5 ALLCOL = 0

B6 PMODE = 1

B7 ENDGRP = 3E00

B9 HORBYT = 20

BA BEGGRP = 3200

BC GRPRAM = E

C1 CSSVAL = 8

DB CHGFLG = 0

MIDCALC = C8

POSTCALC = 19

ENDCALC = 4

PMODE= 2 , PAGE= 1 , COLORSET= 0

B2 FORCOL = 3

B3 BAKCOL = 0

B5 ALLCOL = 0

B6 PMODE = 2

B7 ENDGRP = 1A00

B9 HORBYT = 10

BA BEGGRP = E00

BC GRPRAM = E

C1 CSSVAL = 0

DB CHGFLG = 0

MIDCALC = D0

POSTCALC = 7

ENDCALC = 5

PMODE= 2 , PAGE= 1 , COLORSET= 1

B2 FORCOL = 3

B3 BAKCOL = 0

B5 ALLCOL = 0

B6 PMODE = 2

B7 ENDGRP = 1A00

B9 HORBYT = 10
BA BEGGRP = E00
BC GRPRAM = E
C1 CSSVAL = 8
DB CHGFLG = 0

MIDCALC = D8
POSTCALC = 7
ENDCALC = 5

PMODE= 2 , PAGE= 2 , COLORSET= 0
B2 FORCOL = 3
B3 BAKCOL = 0
B5 ALLCOL = 0
B6 PMODE = 2
B7 ENDGRP = 2000
B9 HORBYT = 10
BA BEGGRP = 1400
BC GRPRAM = E
C1 CSSVAL = 0
DB CHGFLG = 0

MIDCALC = D0
POSTCALC = A
ENDCALC = 5

PMODE= 2 , PAGE= 2 , COLORSET= 1
B2 FORCOL = 3
B3 BAKCOL = 0
B5 ALLCOL = 0
B6 PMODE = 2
B7 ENDGRP = 2000
B9 HORBYT = 10
BA BEGGRP = 1400
BC GRPRAM = E
C1 CSSVAL = 8
DB CHGFLG = 0

MIDCALC = D8
POSTCALC = A
ENDCALC = 5

PMODE= 2 , PAGE= 3 , COLORSET= 0
B2 FORCOL = 3
B3 BAKCOL = 0
B5 ALLCOL = 0
B6 PMODE = 2
B7 ENDGRP = 2600
B9 HORBYT = 10
BA BEGGRP = 1A00
BC GRPRAM = E
C1 CSSVAL = 0
DB CHGFLG = 0

MIDCALC = D0
POSTCALC = D
ENDCALC = 5

PMODE= 2 , PAGE= 3 , COLORSET= 1
B2 FORCOL = 3
B3 BAKCOL = 0
B5 ALLCOL = 0
B6 PMODE = 2
B7 ENDGRP = 2600
B9 HORBYT = 10
BA BEGGRP = 1A00
BC GRPRAM = E
C1 CSSVAL = 8
DB CHGFLG = 0

MIDCALC = D8
POSTCALC = D
ENDCALC = 5

PMODE= 2 , PAGE= 4 , COLORSET= 0
B2 FORCOL = 3
B3 BAKCOL = 0
B5 ALLCOL = 0
B6 PMODE = 2
B7 ENDGRP = 2C00
B9 HORBYT = 10
BA BEGGRP = 2000

BC GRPRAM = E
C1 CSSVAL = 0
DB CHGFLG = 0

MIDCALC = D0
POSTCALC = 10
ENDCALC = 5

PMODE= 2 , PAGE= 4 , COLORSET= 1
B2 FORCOL = 3
B3 BAKCOL = 0
B5 ALLCOL = 0
B6 PMODE = 2
B7 ENDGRP = 2C00
B9 HORBYT = 10
BA BEGGRP = 2000
BC GRPRAM = E
C1 CSSVAL = 8
DB CHGFLG = 0

MIDCALC = D8
POSTCALC = 10
ENDCALC = 5

PMODE= 2 , PAGE= 5 , COLORSET= 0
B2 FORCOL = 3
B3 BAKCOL = 0
B5 ALLCOL = 0
B6 PMODE = 2
B7 ENDGRP = 3200
B9 HORBYT = 10
BA BEGGRP = 2600
BC GRPRAM = E
C1 CSSVAL = 0
DB CHGFLG = 0

MIDCALC = D0
POSTCALC = 13
ENDCALC = 5

PMODE= 2 , PAGE= 5 , COLORSET= 1
B2 FORCOL = 3
B3 BAKCOL = 0
B5 ALLCOL = 0
B6 PMODE = 2
B7 ENDGRP = 3200
B9 HORBYT = 10
BA BEGGRP = 2600
BC GRPRAM = E
C1 CSSVAL = 8
DB CHGFLG = 0

MIDCALC = D8
POSTCALC = 13
ENDCALC = 5

PMODE= 2 , PAGE= 6 , COLORSET= 0
B2 FORCOL = 3
B3 BAKCOL = 0
B5 ALLCOL = 0
B6 PMODE = 2
B7 ENDGRP = 3800
B9 HORBYT = 10
BA BEGGRP = 2C00
BC GRPRAM = E
C1 CSSVAL = 0
DB CHGFLG = 0

MIDCALC = D0
POSTCALC = 16
ENDCALC = 5

PMODE= 2 , PAGE= 6 , COLORSET= 1
B2 FORCOL = 3
B3 BAKCOL = 0
B5 ALLCOL = 0
B6 PMODE = 2
B7 ENDGRP = 3800
B9 HORBYT = 10
BA BEGGRP = 2C00
BC GRPRAM = E
C1 CSSVAL = 8

DB CHGFLG = 0

MIDCALC = D8

POSTCALC = 16

ENDCALC = 5

PMODE= 2 , PAGE= 7 , COLORSET= 0

B2 FORCOL = 3

B3 BAKCOL = 0

B5 ALLCOL = 0

B6 PMODE = 2

B7 ENDGRP = 3E00

B9 HORBYT = 10

BA BEGGRP = 3200

BC GRPRAM = E

C1 CSSVAL = 0

DB CHGFLG = 0

MIDCALC = D0

POSTCALC = 19

ENDCALC = 5

PMODE= 2 , PAGE= 7 , COLORSET= 1

B2 FORCOL = 3

B3 BAKCOL = 0

B5 ALLCOL = 0

B6 PMODE = 2

B7 ENDGRP = 3E00

B9 HORBYT = 10

BA BEGGRP = 3200

BC GRPRAM = E

C1 CSSVAL = 8

DB CHGFLG = 0

MIDCALC = D8

POSTCALC = 19

ENDCALC = 5

PMODE= 3 , PAGE= 1 , COLORSET= 0

B2 FORCOL = 3

B3 BAKCOL = 0
B5 ALLCOL = 0
B6 PMODE = 3
B7 ENDGRP = 2600
B9 HORBYT = 20
BA BEGGRP = E00
BC GRPRAM = E
C1 CSSVAL = 0
DB CHGFLG = 0

MIDCALC = E0
POSTCALC = 7
ENDCALC = 6

PMODE= 3 , PAGE= 1 , COLORSET= 1

B2 FORCOL = 3
B3 BAKCOL = 0
B5 ALLCOL = 0
B6 PMODE = 3
B7 ENDGRP = 2600
B9 HORBYT = 20
BA BEGGRP = E00
BC GRPRAM = E
C1 CSSVAL = 8
DB CHGFLG = 0

MIDCALC = E8
POSTCALC = 7
ENDCALC = 6

PMODE= 3 , PAGE= 2 , COLORSET= 0

B2 FORCOL = 3
B3 BAKCOL = 0
B5 ALLCOL = 0
B6 PMODE = 3
B7 ENDGRP = 2C00
B9 HORBYT = 20
BA BEGGRP = 1400
BC GRPRAM = E
C1 CSSVAL = 0
DB CHGFLG = 0

MIDCALC = E0
POSTCALC = A
ENDCALC = 6

PMODE= 3 , PAGE= 2 , COLORSET= 1
B2 FORCOL = 3
B3 BAKCOL = 0
B5 ALLCOL = 0
B6 PMODE = 3
B7 ENDGRP = 2C00
B9 HORBYT = 20
BA BEGGRP = 1400
BC GRPRAM = E
C1 CSSVAL = 8
DB CHGFLG = 0

MIDCALC = E8
POSTCALC = A
ENDCALC = 6

PMODE= 3 , PAGE= 3 , COLORSET= 0
B2 FORCOL = 3
B3 BAKCOL = 0
B5 ALLCOL = 0
B6 PMODE = 3
B7 ENDGRP = 3200
B9 HORBYT = 20
BA BEGGRP = 1A00
BC GRPRAM = E
C1 CSSVAL = 0
DB CHGFLG = 0

MIDCALC = E0
POSTCALC = D
ENDCALC = 6

PMODE= 3 , PAGE= 3 , COLORSET= 1
B2 FORCOL = 3
B3 BAKCOL = 0
B5 ALLCOL = 0

B6 PMODE = 3
B7 ENDGRP = 3200
B9 HORBYT = 20
BA BEGGRP = 1A00
BC GRPRAM = E
C1 CSSVAL = 8
DB CHGFLG = 0

MIDCALC = E8
POSTCALC = D
ENDCALC = 6

PMODE= 3 , PAGE= 4 , COLORSET= 0
B2 FORCOL = 3
B3 BAKCOL = 0
B5 ALLCOL = 0
B6 PMODE = 3
B7 ENDGRP = 3800
B9 HORBYT = 20
BA BEGGRP = 2000
BC GRPRAM = E
C1 CSSVAL = 0
DB CHGFLG = 0

MIDCALC = E0
POSTCALC = 10
ENDCALC = 6

PMODE= 3 , PAGE= 4 , COLORSET= 1
B2 FORCOL = 3
B3 BAKCOL = 0
B5 ALLCOL = 0
B6 PMODE = 3
B7 ENDGRP = 3800
B9 HORBYT = 20
BA BEGGRP = 2000
BC GRPRAM = E
C1 CSSVAL = 8
DB CHGFLG = 0

MIDCALC = E8
POSTCALC = 10

ENDCALC = 6

PMODE= 3 , PAGE= 5 , COLORSET= 0

B2 FORCOL = 3

B3 BAKCOL = 0

B5 ALLCOL = 0

B6 PMODE = 3

B7 ENDGRP = 3E00

B9 HORBYT = 20

BA BEGGRP = 2600

BC GRPRAM = E

C1 CSSVAL = 0

DB CHGFLG = 0

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POSTCALC = 13

ENDCALC = 6

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B7 ENDGRP = 3E00

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BA BEGGRP = 2600

BC GRPRAM = E

C1 CSSVAL = 8

DB CHGFLG = 0

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POSTCALC = 13

ENDCALC = 6

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MIDCALC = F0
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MIDCALC = F8
POSTCALC = A
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C1 CSSVAL = 0
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MIDCALC = F0
POSTCALC = D
ENDCALC = 6

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B2 FORCOL = 3
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B9 HORBYT = 20
BA BEGGRP = 1A00

BC GRPRAM = E
C1 CSSVAL = 8
DB CHGFLG = 0

MIDCALC = F8
POSTCALC = D
ENDCALC = 6

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B6 PMODE = 4
B7 ENDGRP = 3800
B9 HORBYT = 20
BA BEGGRP = 2000
BC GRPRAM = E
C1 CSSVAL = 0
DB CHGFLG = 0

MIDCALC = F0
POSTCALC = 10
ENDCALC = 6

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MIDCALC = F8
POSTCALC = 10
ENDCALC = 6

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BA BEGGRP = 2600
BC GRPRAM = E
C1 CSSVAL = 0
DB CHGFLG = 0

MIDCALC = F0
POSTCALC = 13
ENDCALC = 6

PMODE= 4 , PAGE= 5 , COLORSET= 1
B2 FORCOL = 3
B3 BAKCOL = 0
B5 ALLCOL = 0
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B9 HORBYT = 20
BA BEGGRP = 2600
BC GRPRAM = E
C1 CSSVAL = 8
DB CHGFLG = 0

MIDCALC = F8
POSTCALC = 13
ENDCALC = 6

*
* END OF RUN
*

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Appendix D: My CoCo Philosophy

The CoCo community enjoys a great diversity of interests.

Some choose to concentrate on hardware innovations and modifications such as interfacing with VGA and HDMI monitors, SD Card data storage, and 104-key keyboards. This interest is at least partly born of necessity, since composite monitors, floppy diskettes, and CoCo spare parts are no longer manufactured and are in increasingly short supply.

Others concentrate on expanding the software horizons of the CoCo 3, using NitrOS-9 and other operating systems to make the multitasking CoCo behave ever closer to modern Windows, Mac, and Linux machines.

Still others are devoted to emulating the CoCo on other platforms by developing emulators such as VCC, OVCC, MAME, and XRoar.

And some just love retro gaming.

My personal interest is twofold:

1. To see VCC increasingly used as a learning tool for budding software developers.
2. To see just how much I can cram into a 64K CoCo 2.

First, VCC: Today's Grade School, Junior High, and High School students have a wealth of available learning tools. Micro-bits, Arduinos, and Raspberry Pi supermicro devices provide highly affordable entry-level introductions to computer programming and interfacing. Maker-Spaces and Innovation Centers in our schools and libraries help foster growth and experience.

But these devices do have limitations. Even these simple(?) computers can have rather steep learning curves, and their low initial cost can quickly expand as new peripherals and experimental equipment and supplies are added.

VCC is free, and can be used on any Windows computer: just download it, install it, and it runs. If you don't own a Windows computer, your school, library, or a friend probably does. The included BASIC language is easy to learn and can readily serve as a stepping-stone towards more complex programming languages. (And, no, learning structured programming does not require a language that enforces structure. In fact, I think learning to structure your programs is actually more effective when you do so on your own.)

I prefer VCC to the other emulators for these purposes because its setup is trivial: Again, just download it, install it, and it runs. OVCC, MAME, and XRoar have their advantages, but ease of setup is not one of them. Even with their available Windows binary packages, they require pre-installation of other bits and pieces of software before they can be downloaded,

installed, and run. This may not be a major problem for a reasonably adept aficionado, but it forms a significant barrier for the newbie. And, it's the newbie whom we're trying to reach, interest, and encourage here; the newbie who may not yet recognize even the tiniest awakening of interest in things computational.

But, for these purposes, VCC has one glaring weakness: its instruction manual is woefully terse. I would like to see VCC bundled with a selection of tutorials, manuals, and examples suited to guiding even the most newbie of newbies into the wonders of computing.

Second, The Stuffed CoCo: I'm simply fascinated by the challenge of seeing how much functional capability I can sandwich into the nooks and crannies of the 64K space. Whether it's working in the available RAM left by the 32K ROM and the dedicated RAM that supports that ROM, or whether it's jumping right into ALLRAM mode and just filling the entire 64K to near-overflowing; it's an investigative gauntlet which goes right to the heart of my enchantment with puzzles in general.

It's great fun!

M.D.J. 2021/08/29

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M.D.J. 2018/06/08

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