

SYSTEM 1

HARDWARE & OPERATING SYSTEM DESCRIPTION.

COMPANY CONFIDENTIAL.

DISTRIBUTION:

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SYSTEM I HARDWARE DESCRIPTION

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DATE : OCT. 31 1984
BY : SAM LY

I. Microprocessors:

- A. 68010 running @ 7.16 MHz.
- B. Program ROM:
 - 256K word max. for 256k ROM (128k word max. for 128k ROM), including 16K word on the main board.
- C. Program RAM:
 - 4K word fixed on the main board.
- D. Interrupt:
 - Sound port (from 6502) - level 6
 - Vblank - level 4.
 - IRQ level 1 & 3 available for expansion on a cartridge.
 - Analog joystick - level 2
- E. 6502 runs at 1.78 mhz
 - IRQ from timer of the YAMAHA sound chip. This is a programmable timer IRQ & IRQ acknowledge.
 - NMI from the 68010 .

F. Input/output:

1. Leta ball interface (see Leta.doc in DRA0:[general] for detail) readable by the 68010. The 8 inputs to the Leta can NOT be used to read reliably switch inputs as mentioned in the documentation LETA.DOC .
2. analog joystick:

the analog joystick is read by the 68010 through the 8 word addresses corresponding to 8 A to D channels. Each channel is controlled by a particular direction of movement (up, down, left, right) of the joystick.

Before reading any channel, a start conversion signal should be written to the A to D. Instead of separate addresses for the start conversion, reading the value of any address also automatically starts the conversion of the channel corresponding to that address.

As soon as the A to D conversion is done, a signal will be sent ('end of conversion') to the 68010 as an interrupt. This interrupt can be masked by WRITING the address F40010 to any address of any channel will automatically enable the interrupt.

G. EEPROM:

A 512 byte EEPROM is used as a nonvolatile memory for the 68010. You can read or write the EEPROM just as a RAM, however, after a write to the EEPROM, you should wait a minimum of 10 msec. before accessing (read or write) the EEPROM again (For more info, read the EEPROM data sheet & application notes.)

Before writing to the EEPROM, you should enable the write by writing (any data) to UNLOCK (@ 8C0000) . You should not read the EEPROM after you UNLOCK until you have written something somewhere (any data, any location.)



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I. Graphics.

- A. Display - 336 x 240 pixels - standard res. monitor.
- B. Playfield: - Size: 64 stamps x 64 stamps
- Visible screen: 42 stamps x 30 stamps



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- Stamp size: 8 pixels x 8 pixels
- Independent smooth scrolling horizontally & vertically (wrap-around).
- THE VERTICAL SCROLLING REGISTER SHOULD BE WRITTEN EVERY VBLANK. Ask your technician to put the vertical register mod. in the game board for game development.
- Max capacity: 2 banks of 32K stamps (assuming all graphics ROMs are playfield addressable by the graphics mapping PROM. This is the max. capacity provided by the main board. It varies depending on the cartridge used.) Each stamp in the playfield is specified by one word in the playfield RAM as follows:

D15 D14 D13 D12 D11 D10 D9 D8 D7 D6 D5 D4 D3 D2 D1 D0

| H | PIC # |

H: Horizontal flip

Note: The playfield bank select bit (addr. 840000 D2) & the upper 7 bits of the PIC# feed into 2 PROMs which map the picture code into a graphics ROM location and define bit depth/palette number.

- Variable planes playfield, up to 8 bits deep.



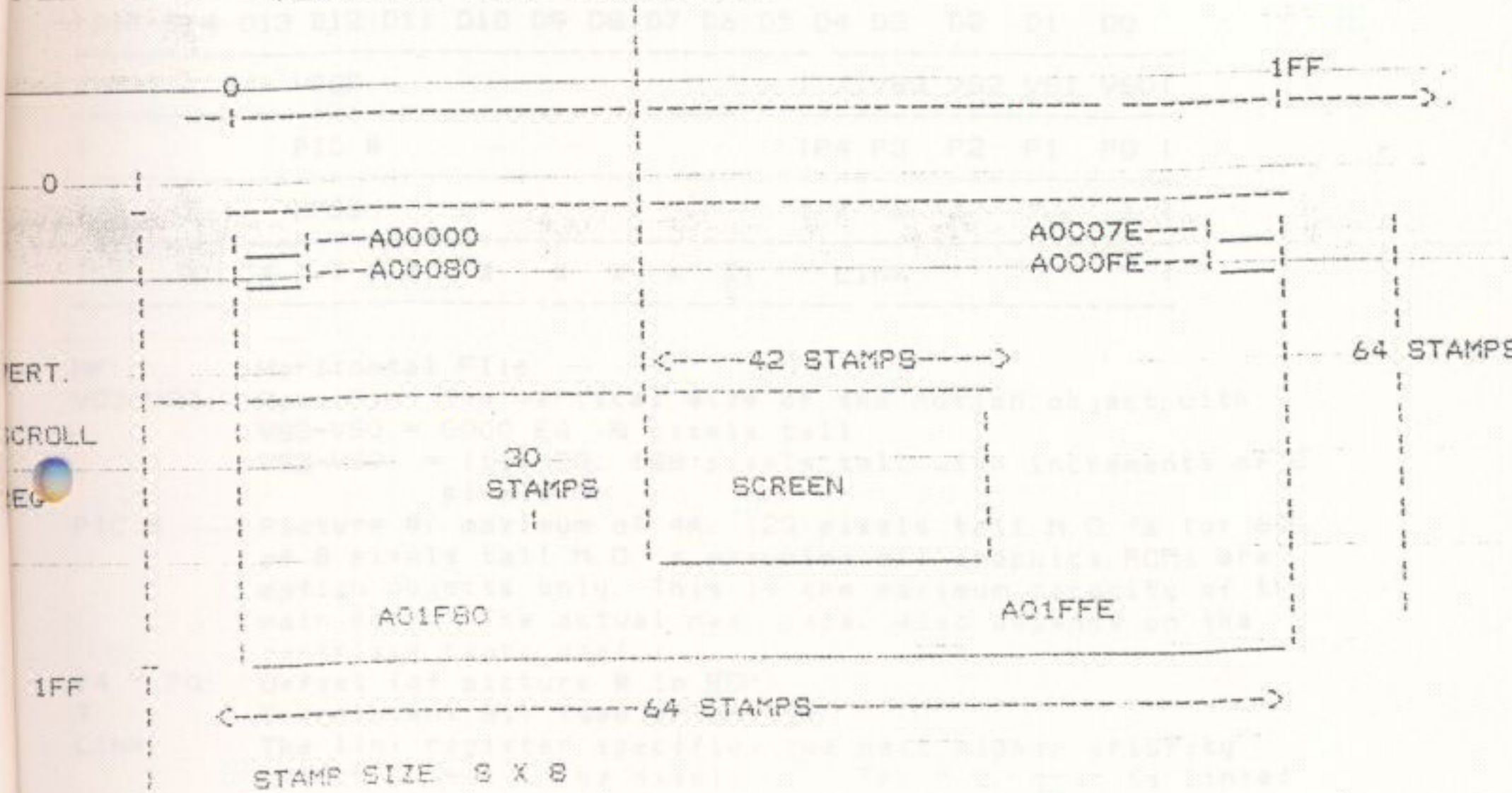
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PLAYFIELD COORDINATES:

PLAYFIELD HOR. SCROLL REG.





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- C. Motion Objects: 56 M.O.'s visible
 - "Linked" M.O.'s
 - 8 motion object parameters buffers (of 64 M.O.'s each)
 - 8 pixels wide x 8 N pixels tall up to 128
 - Variable planes/M.O.'s pixels up to 7 bits deep.

Each motion object is specified by 4 words in the motion object RAM as follows:

D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
HF	X		VPOS								X	VS3	VS2	VS1	VS0
			PIC #								P4	P3	P2	P1	P0
T	X		HPOS								X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	LINK				

- HF: Horizontal Flip
- VS3-VS0: Specifies the vertical size of the motion object with VS3-VS0 = 0000 EQ. 8 pixels tall VS3-VS0 = 1111 EQ. 128 pixels tall with increments of 8 pixels.
- PIC #: Picture #, maximum of 4K, 128 pixels tall M.O.'s (or 64K of 8 pixels tall M.O.'s assuming all graphics ROMs are motion objects only. This is the maximum capacity of the main board. The actual max. capa. also depends on the cartridge board used.)
- P4 ~ P0: Offset (of picture # in ROM)
- T: Translucent BIT (see priority)
- LINK: The link register specifies the next higher priority motion object to be displayed. The M.O. that is linked (drawn) last has the highest priority.

Note: the upper eight bits of the PIC# (D15-D8) are fed into two PROMs which map the code into graphics ROM locations and define bit depth/palette number.



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II. Alpha-Numerics:

- 2 bits per pixel, up to 8 color palettes.
- Stamp size: 8 pixels x 8 pixels
- Screen: 42 stamps x 30 stamps

Every alpha stamp is specified by one word in the alpha numeric RAM as follows:

D15 D14 D13 D12 D11 D10 D9 D8 D7 D6 D5 D4 D3 D2 D1 D0

| X | X | BG | C2 | C1 | C0 | X | SHAPE |

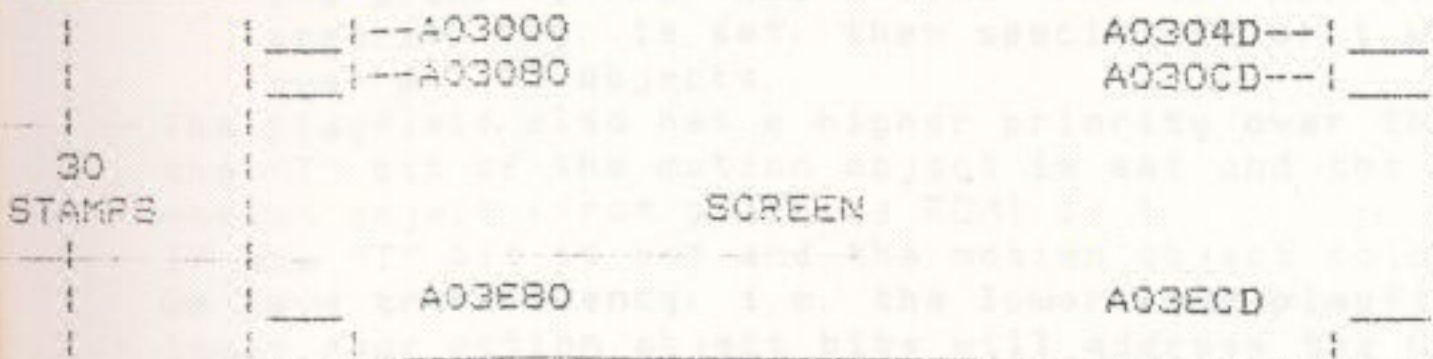
BG: The whole alpha stamp (including background) will have a higher priority than M.O.'s or PF.

C2 ~ C0: Color Palette.

alpha-numeric RAM : 27128 , contains 2 banks of 512 alpha stamps(8x8.)

ALPHA COORDINATES

<-----42 STAMPS----->



STAMP SIZE 8 X 8



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Priority:

- Alpha-numeric have the highest priority.
- If the "BG" bit in the alpha parameter is set, the background color or alpha will have priority over all other graphics.
- Playfield has the second priority if there is no motion object or if there is only motion object background (see note 3 section VI)
- There are 8 colors that the playfield can have priority over M.O.'s (color 00-07) if the corresponding bits in the priority reg. (addr 840000) are set.

These special 8 colors are:

D7	D6	D5	D4	D3	D2	D1	D0
0	0	0	0	0	X	X	X

(D0 ~ D7 are data bits from playfield graphics ROM & color mapping PROM.)

This is how the special color works:

The priority reg. has 8 bits PR7 to PR0. If bit i (PRI) of the priority reg. is set, then special color i will have priority over motion objects.

- The playfield also has a higher priority over the motion objects if the "T" bit of the motion object is set and the color of the motion object (from graphics ROM) is 1.
- If the "T" bit is set and the motion object color is >= 2, then we have translucency, i.e. the lower four playfield bits and lower four motion object bits will address the COLORAM. (see section V below.)
- Otherwise the motion objects will have a higher priority over the playfield.



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COLORAM:

The coloram gets graphics information from four sources:
ALPHA, PLAYFIELD, MOTION OBJECT & "TRANSLUCENCY"

ALPHA COLORAM ADDR = B00000 + C2-C1-C0-ABIT1-ABIT0
where C2 to C0 are the color palette bits specified
in the alpha RAM. ABIT1, ABIT0 are the bits from the
alpha ROM. hyphen "-" denotes binary concatenation

TRANSLUCENT = B00600 + P3-P2-P1-P0-M3-M2-M1-M0
where p3 to p0 and m3 to m0 are the four low playfield
ROM and motion objects ROM bits respectively.

PLAYFIELD COLORAM = B40000 + <P7:P0>
WHERE <P7:P0> are the 8 bits from the graphics ROM &/or the
color palette mapping PROM.

MOTION OBJECT COLORAM = B20000 + <M6:M0>
Where <M6:M0> are the 7 (seven) bits from the graphics
ROM and/or the color mapping PROM.

Coloram data interpretation:

<D15:D12> Intensity
<D11:D8 > Red
<D7 :D4 > Green
<D3 :D0 > Blue

In all cases, 0000=OFF
1111=highest intensity.

NOTES:

1. Graphics pixel data is low true!!!
PBCONVERT in the PPS utilities will automatically do a 1's
complement for you.
2. The current cartridge board has a max. of 1k 128 pixel tall (or 16k
8 pixel tall) motion object graphics ROM (assuming all ROM are motion
object addressable. The max playfield graphics ROM is 2 banks of 8k 8
stamps assuming all ROMs are playfield addressable.
3. If the four LSB's of a motion object color (from graphics ROM) are
all 1's, the color is considered to be background regardless of what
the upper 3 MSB's are (from color palette ROM or graphics ROM.)



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ADDRESS	R/W	DATA
Program ROM	R	D15~D0 For 128K ROM 128 kwords
	R	D15~D0 For 256K ROM 256 kwords
Program RAM	R/W	D15~D0
Playfield Hor. Scroll	W	D8~D0
Playfield Vert. Scroll	W	D8~D0
Play. Special Priority Color	W	D7~D0 Hi Enable
Sound Processor Reset	W	D7 Low Reset
Trak Ball Test (LETA chip)	W	D6 Hi Test
Motion Obj Para. Buf. Select	W	D5~D3
Playfield ROM Bank Select	W	D2
Trakball resolution & test LED (LETA chip)	W	D1 (see LETA.doc) hi ON
Alpha ROM Bank Select	W	D0
Watch Dog	W	(128 msec. timeout)
VBlank IRQ Acknowledge	W	
Unlock	W	
Cartridge External	R/W	D15~D0
Playfield RAM	R/W	D15~D0
Motion Object Vertical Pos.	R/W	D15~D0 ; M.O. parameter
Motion Object Picture	R/W	D15~D0 ; buffer 0
Motion Object Hor. Pos.	R/W	D15~D0 ; add 200 for next buffer
Motion Object Link	R/W	D15~D0
Motion Object Vertical Pos.	R/W	D15~D0 ; M.O. parameter
Motion Object Picture	R/W	D15~D0 ; buffer 1
Motion Object Hor. Pos.	R/W	D15~D0
Motion Object Link	R/W	D15~D0
Motion Object Vertical Pos.	R/W	D15~D0 ; M.O. parameter
Motion Object Picture	R/W	D15~D0 ; buffer 7
Motion Object Hor. Pos.	R/W	D15~D0 ;
Motion Object Link	R/W	D15~D0
Alpha-Numerics RAM	R/W	D15~D0
Colon Alpha	R/W	D15~D0
Colon Motion Object	R/W	D15~D0
Colon Playfield	R/W	D15~D0
Colon Trakball	R/W	D15~D0
EEPROM	R/W	D7~D0
Trak Ball	R	D7~D0
Trakball Test	R	D7~D0
Trakball IRQ enable	R	
Buffer-Buffer Full (2 FE0000)	R	D7 Hi Full
Selftest	R	D6 Low test
switch input	R	D5
VBLANK	R	D4 Hi vblank
switch input	R	D3
Switch Input	R	D2
Switch Input	R	D1
Switch-Input	R	D0
Read Sound Processor (6502)	R	D7~D0
Write Sound Processor (6502)	W	D7~D0

Note: use word mode only for VIDEO RAM (motion object, playfield, alpha) and CPU RAM. All other addresses can be accessed in byte or word mode.



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SECTION I SOFTWARE DESCRIPTION

6502 MEM-MAP	ADDRESS	R/W	DATA
Program RAM	0000~0FFF	R/W	D7~D0
Cartridge External	1000~1FFF	R/W	D7~D0
Yamaha	1800~1801	R/W	D7~D0
Read 68000 Port	1810	R	D7~D0
Write 68000 Port	1810	W	D7~D0 outbuf.
Self Test	1820	R	D7
Outbuf Full (@ 1810)		R	D4 hi full
Data avail (@ 1810)		R	D3 hi avail
Coin Aux		R	D2
Coin Left		R	D1
Coin Right		R	D0
Yamaha Reset	1820	W	D0 Low Reset
LED	1824	W	D0 Low Active
LED	1825	W	D0 Low Active
Coin Counter Right	1826	W	D0 Hi Active
Coin Counter Left	1827	W	D0 Hi Active
Pokey	1870~187F	R/W	D7~D0 see pokey.doc
Program ROM	4000~FFFF	R	D7~D0 48k bytes.

Notes: NO 6502 watchdog (see 68010)
 IRQ ACK : see SECTION I 6502 IRQ.
 NO NMI mask for the NMI coming from the 68010. NMI is automatically acknowledged when the 6502 reads the input data buffer at location 1810



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SYSTEM I SOFTWARE DESCRIPTION.

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1. Power On

System Application (Game)

Quick RAM Test
Quick ROM Test
EEPROM Checksum
RAM Cleared (Set to 00's)
Stack Set

Self Test? No-----> 10000
Yes

Full-Tests - RAM/ROM/BUS Looping

Diagnostics
Statistics

Application Tests

Alpha IF 1002A <> 0
Pf IF 10030 <> 0
Mob IF 10036 <> 0
Color Palette

2. Vector Tables/Parameter Tables

68010 Address	Function	Returns
10000	Jump to Game Reset	No
10006	Jump to Game VBlank	RTE
1000C	Jump to Game IRQ1	RTE
10012	Jump to Game IRQ3	RTE
10018	Jump to Game Analog Joystick	RTE
1001E	Jump to Game Audio	RTE
10024	Jump to Hardware Exceptions	RTE or Restart
1002A	Jump to Alpha Test (0 if none)	RTS when finished
10030	Jump to Pf Test (0 if none)	RTS when finished
10036	Jump to Mob Test (0 if none)	RTS when finished
1003C	Jump to Color Test (0 if none)	RTS when finished
10042	Jump to Control Reading Routine	RTS
10048	Jump to Game Specific Options (Screen Display)	RTS when finished
1004E	Jump to Game Specific Statistics (Screen Display)	RTS when finished
10054	Jump to EEPROM/COIN init Routine	SEIS STACK "RTS"
1005A to 1005F	Unused	
10060	Word Value of PF Blank Stamp	
10062	Word Value of PF Crosshatch Stamp	
10064	Word Value of PF Solid Color 1	
10066	Word Value of PF Solid Color 2	



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1006B Word Value of PF Solid Color 3
1006A Start Motion Object Picture #
1006C Ending Motion Object Picture #
(Used for MOB picture #'s in
Self Test. Will use start thru
end inclusive repeating until all
motion objects are displayed.)

1006E Unused
to
1007F

10080 Cartridge Configuration Block
(See [MOORE, PACKRAT]ALSSI, MEMO)

3. Support Software Available

	Programmer
-Message Routine	Mike Mahar
-Numeric Output	Mike Mahar
-Hex to Decimal Conversion	Mike Mahar
-Rad 50 Conversion	Mike Mahar
-Statistics	Mike Mahar
-Standard Self Test(s)	Mike Mahar
-EEPROM with Error Correction	Mike Albaugh
-All 6502 Code - RPM Stripped Down Coins Test Mode	Peter Lipson
-68000 Coin Handling	Mike Albaugh
-Graphics Mapping PROMs (VAX Utility)	Rich Moore

4. Application Software Required

- User Specific Statistics
Including Table of Messages, Stat Value Pointer
- User Specific Options
Including Table of Options/EEPROM Locations
- Routine to Incorporate Controls into Register D0
4 bits for Up/Down/Left/Right
D15 = Up (Low True)
D14 = Down
D13 = Left
D12 = Right
- Routines for Buttons
D1 = Button(1) (Low True)
D0 = Button(0)
- Routines for:
1) Alphanumeric Test
2) Playfield Test (Stamp Sets)
3) Motion Object Tests
4) Color Palets/Priorities Tests
- Define Tables for Vectors/Stamp Values
- Define Cart Configuration Block
<Specification Forthcoming>
- Watchdog

5. Documentation Needed/To Do



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- Specifications/Calling Parameters of All System Software
- Table Definitions:
 - 1) Configuration Block
 - 2) Statistics Table
 - 3) Option Table
- Specify Graphics Mapping PROMs

If there are any items I have left out, please let me know ASAP!
likewise, should any topic/item that has not been addressed become
pparent, please let me know so I can assure that nothing falls through
the cracks.

istribution: Chris Downend, Mike Mahar, Mike Albaugh, Ed Logg, Packrat[Peter Thompson], Doom[Peter Li
Doom (Mark Cerny, Bob Flanagan)

ACTION LINE SYSTEM SOFTWARE

21-SEP-84

updated 1-Oct-84

This is to further Update you on the Software Status of the
Action Line system:

1. As Promised, further input on the Configuration Format:
I propose the following format, please respond with other
ideas, or comments:

Starting @ 10080 block_starting_addr, block_ending_addr, device_size, ram/rom_flag
(repeat for all specific game ram/rom memory areas)
0,0 --(flags end-of memory configuration area)

All entries are 32 bits wide. Device_size specifies the Rom or Ram size
to step by when indicating RAM 0, RAM 1 ... or ROM 0, ROM 1 errors.
RAM/ROM flag indicates memory type D23=0 => RAM, D23=1 => ROM.
For Example, with the entire Program Rom area occupied by 27128's
and 16 pages of the cartridge external area decoded as RAM:

```

10080 010000, 03FFFF, 4000, 800000
1008C 900000, 900FFF, 800, 0
10098 0, 0

```

I will adjust this format with any suggestions I receive, and Release
this on the next memo.

2. Software Schedule:

Self Test	First Three Tests w/ 10000 vectoring	01-Oct-84
	First Pass/Complete	20-Sep-84
6502	RPM w/one POKEY, coin detect	05-Oct-84
EEPROM	Read/Write Routine w/Checksums	8-Oct-84

Address 100E4 (Hardware Exceptions) will be used in the case of RAM/ROM
errors on Power-On. Register D0 will indicate the reason of the
exception whenever this vector is used. It is therefore up to
the game to determine what to do with RAM/ROM errors at power-on.
RECOMMENDED: display error status on screen, pushing any button
continues into attract (or at least attempts it.)



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4. Special Graphics Proms. I forgot to cover this at our meeting, but you have to be aware of this anyway. There are two Proms on the Hardware which serve to Memory Map Picture Codes to actual Graphics Rom addresses (Prom 1) and to Select Palettes and specify Bit Plane Depth (Prom 2). I intend to write whatever Vax Utility is necessary to fill these Proms, but would very much appreciate your input as to how the User interface should be defined. In other words, speak now or get stuck with what I give you.

Some Background (perhaps old news):

- Graphics are up to 8 Bits (planes) deep.
- There are four (4) banks of Graphics Roms which serve as both Playfield & Motion Object Pictures.
- For Motion Objects, bit 8 (plane 8) serves as a Translucency Bit which implements a special color mapping, ala:

XXXX1111 = Clear (Playfield Shows through)
XXXX1110 = Cookie Cutter Clear (Playfield Shows through, underneath motion objects cut-out)

XXXX1101 to XXXX0000 combines with the Playfield low 4 bits to form the actual color (Transparency Mode)

BITS 7 6 5 4 3 2 1 0
PF _____ MO _____

- There are three (3) 256x16 Color Ram tables one for Motion objects, one for Transparency mode, and one for Playfield. Additionally there is one 16x16 table for the Alphanumerics.

MEMORY MAP PROM -

A0 - A7 determines one of 256 stamps in a block of 8x8's.
(equivalent to D0 - D7 of PIC # in MO or PF parameter field)

D8 - D14 of PF PIC # addresses this PROM
+ PF Bank Select Bit

D8 - D15 of MO PIC # addresses this PROM

P0 - P4 of MO Pic parameter indexes one of 32 stamps in a 32 stamp block (starting offset to fetch graphics regardless of the MO height. Note: graphics fetched wrap around within module 32 stamp block)

PROM is 512x8 with 48 of them addresses as MO/PF

This allows max of 256x16 (4K) PF 8x8 stamps possible
256x16 (4K) MO 8x8 stamps possible

NOTE: with a 27128 in place of a 27256 (11000 bit Mask ROM), D3 out of the ROM must be high, thus with 27128's each Bank has 8 * 256 stamps (2K), while with 27256's each Bank has 16 * 256 stamps (4K)

ADDRESS	DATA	FUNCTION
876543210	7 6 5 4 3 2 1 0	
OOO-OFF 0XXXXXXX !!!!!!!	B4 B3 B2 B1 BLOCK # -- ^ ^ ^ ^	PF Block Address



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all not true (only 1 low at a time)
B4=Bank 4, B3=Bank 3, B2=Bank 2, B1=Bank 1

D8 of PF picture #
D9 of PF picture #
D10 of PF picture #
D11 of PF picture #
D12 of PF picture #
D13 of PF picture #
D14 of PF picture #
PF Bank Select Bit (D2 of 860000 of 68000 memory map)

100-1FF 1XXXXXXX B4 B3 B2 B1 BLOCK # -- MO Block Address
 ^ ^ ^ ^

all low true (only 1 low at a time)
B4 = Bank 4, B3 = Bank 3, B2 = Bank 2, B1 = Bank 1

- ^ D8 of MO pic #
- ^ D9 of MO pic #
- ^ D10 of MO pic #
- ^ D11 of MO pic #
- ^ D12 of MO pic #
- ^ D13 of MO pic #
- ^ D14 of MO pic #
- ^ D15 of MO pic #

PALETTE SELECT -

Addressing of this PROM is identical to the Addressing of the Memory Mapping PROM above.

The Output of this Rom Determines the Presence of the top 4 bits (planes) of the graphics Roms. Thus,

- D7 low indicates no ROM Plane 7
- D6 low indicates no ROM Plane 6
- D5 low indicates no ROM Plane 5
- D4 low indicates no ROM Plane 4

NOTE: 8 planes max for Playfield, 7 planes max for Motion object.
16 palettes @ 4 bits (planes) for PF, only 7 palettes @ 4 bits for Motion objects.

Upper Nibble = Active Planes 4-7
Low Nibble = replaces respective upper bits for Depth (3 bits) (Palette select, only one of eight may be selected for MOB's/ 1 of 16 for PF (both @ 4 bits))

Palette Outputs	D7	D6	D5	D4	D3	D2	D1	D0	Function
	0	0	0	0	1	1	1	1	only 4 bits deep/palette 0
	0	1	1	1	0	1	1	1	7 bits deep/palette 1 (PF)
	0	0	0	0	1	0	1	0	4 bits deep/palette 5
	0	0	0	0	0	1	1	1	4 bits deep/palette 8 (PF only)
	0	0	0	1	1	1	0	1	5 bits deep/palette 1

NOTE: if DX is High where 7 >= X >= 4 then D(X-4) must also be High.