AGA

COLLABORATORS

	TITLE : AGA		
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REVISION HISTORY

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Chapter 1

AGA

1.1 Pandora Chipset Documentation

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Specification for the
Advanced Amiga (AA) Chip Set

TYPED BY FIREFLASH/C18,SPONGE/C18
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3. List of Registers ordered by address
4. List of Registers ordered alphabetically
5. New LISA Display & Sprite Modes

1.2 summary

1. Summary of new features for AA
----

32 bit wide data bus supports input of 32-bit wide bitplane data and allows doubling of memory bandwidth. Additional doubling of bandwidth can be achieved by using FAST page mode Ram. The same bandwidth enhancements are available for sprites. Also the maximum number of bitplanes useable in all modes was increased to eight (8).

The color Palette has been expanded to 256 colors deep and 25 bits wide (8 RED,8 GREEN,8 BLUE,1 GENLOCK). This permits display of 256 simultaneous colors in all resolutions. A palette of 16,777,216 colors are available in all resolutions.

28Mhz clock input allows for cleaner definition of HIRES and SHRES pixels ALICE‘S clock genarator is synchronized by means of LISA‘s 14MHz and SCLK outputs, Genlock XCLK and XCLKEN pins have been eliminated (external MUX is now required).

A new register bit allows sprites to appear in the screen border regions (BRDRSPRT - See BPLCON3).

A bitplane mask field of 8 bits allows an address offset into the color palette.
Two 4-bit mask fields do the same for odd and even sprites.

In Dual Playfield modes,2 4-bitplane playfields are now possible in all resolutions.

Two Extra high-order playfield scrollbits allow seamless scrolling of up to 64 bit wide bitplanes in all resolutions. Resolution of bitplane scroll, display window,and horizontal sprite position has been improved to 35ns in all resolutions.

A new 8-bitplane HAM mode has been created, 6 for colors and 2 for control bits. All HAM modes are available in all resolutions (not just LORES as before).

A RST_input pin has been added, which resets all the bits contained in registers that were new for ECS or LISA:
BPLCON3, BPLCON4 , CLXCON2 , DIWHIGH, FMODE .

Sprite resolution can be set to LORES,HIRES,SHRES,independant of bitplane resolution.

Attached Sprites are now available in all resolutions.

Hardware Scan Doubling support has been added for bitplanes and sprites. This is intended to allow 15KHz screens to be intelligently displayed on a 31KHz monitor and share the display with 31KHz screens.

1.3 explanation

2. Explanation of new features

Bitplanes

There are now 8 bitplanes instead of 6. In single playfield modes they can address 256 colors instead of 64. As long as the memory architecture can support the bandwidth, all 8 bitplanes are available in all 3 resolutions In the same vein, 4+4 bitplane dualplayfield is available in all 3 resolutions, unless bitplane scan-doubling is enabled, in which case both playfields share the same bitplane modulus register. Bits 15 thru 8 of

BPLCON4
comprise an 8 bit mask for the 8 bitplane address, XOR‘ing the individual bits. This allows the copper to exchange color maps with a single instruction.

BPLCON1
now contains an 8 bit scroll value for each of the playfields. Granularity of scroll now extends down to 35nSec.(1 SHRES pixel), and scroll can delay playfield thru 32 bus cycles. Bits BPAGEM and BPL32 in new register
FMODE
control size of bitplane data in
BPL1DAT
thru
BPL8DAT
.

The old 6 bitplane HAM mode, unlike before, works in HIRES and SHRES resolutions.

As before bitplanes 5 and 6 control it‘s function as follows:

BP6	BP5	RED	GREEN	BLUE
0	0	select new base register (1 of 16)		
0	1	hold	hold	modify
1	0	modify	hold	hold
1	1	hold	modify	hold

There is a new 8 bitplane HAM (Hold and Modify) mode. This mode is invoked when BPU field in
BPLCON0
is set to 8 , and HAMEN is set. Bitplanes 1 and 2 are used as control bits analagous to the function of bitplanes 5 and 6 in 6 bitplane HAM mode:

BP2	BP1	RED	GREEN	BLUE
0	1	select new base register (1 of 64)		

```
+-----+-----+--------+--------+------------------+
| 0   | 1   |  hold  |  hold  | modify           |
+-----+-----+--------+--------+------------------+
| 1   | 0   | modify |  hold  |  hold            |
+-----+-----+--------+--------+------------------+
| 1   | 1   |  hold  | modify |  hold            |
+-----+-----+--------+--------+------------------+
```

Since only 6 bitplanes are available for modify data, the data is placed in 6 MSB. The 2 LSB are left unmodified, which allows creation of all 16,777,216 colors simultaneously, assuming one had a large enough screen and picked one's base registers judiciously. This HAM mode also works in HIRES and SHRES modes.

For compatibility reasons EHB mode remains intact. Its existence is rather moot in that we have more than enough colors in the color table to replace its functionality. As before, EHB is invoked whenever SHRES = HIRES = HAMEN= DPF = 0 and BPU = 6. Please note that starting with ECS DENISE there is a bit in
BPLCON2
which disables this mode (KILLEHB).

Bits PF2OF2,1,0 in
BPLCON3
determine second playfield's offset into the color table. This is now necessary since playfields in DPF mode can have up to 4 bitplanes. Offset value are as defined in register map.

BSCAN2 bit in
FMODE
enables bitplane scan-doubling. When V0 bit of
DIWSTRT
matches V0 of vertical beam counter, BPL1MOD contains the modulus ↩
for the
display line, else BPL2MOD is used. When scan-doubled both odd and even bitplanes use the same modulus on a given line, whereas in normal mode odd bitplanes used BPL1MOD and even bitplanes used BPL2MOD. As a result Dual Playfields screens will probably not display correctly when scan-doubled.

Sprites

Bits SPAGEM and SPR32 in
FMODE
whether size of sprite load datain

SPR0DATA(B)
thru
SPR7DATA(B)
is 16,32, or 64 bits, analagous to bitplanes.

BPLCON3
contains several bits relating to sprite behavior. SPRES1 and SPRES0 control sprite resolution, whether they conform to theECS standard or override tp LORES,HIRES,or SHRES. BRDRSPRT, when high,allows sprites to be visible in border areas. ESPRM7 thru ESPRM4 allow relocation of the even sprite color map. OSPRM7 thru OSPRN4 allow relocation of the odd sprite

color map. In the case of attached sprites OSPRM bits are used.

SSCAN2 bit in
FMODE
enables sprite scan-doubling. When enabled, individual
SH10 bits in SPRxPOS registers control whether or not a given sprite is to
be scan-doubled. When V0 bit of
SPRxPOS
register matches V0 bit of vertical
beam counter, the given sprite's DMA is allowed to proceed as before. If
the don't match, then sprite DMA is disabled and LISA reuses the sprite
data
from the previous line. When sprites are scan-doubled, only the position
and control registers need be modified by the programmer; the data
registers need no modification.

NOTE: Sprite vertical start and stop positions must be of the same parity,
i.e. both odd or even.

Compatibility

RST_pin resets all bits in all registers new to AA. These registers include:

BPLCON3
,
BPLCON4
,
CLXCON2
,
DIWHIGH
,
FMODE
.

ECSENA bit (formerly ENBPLCN3) is used to disable those register bits in
BPLCON3 that are never accessed by old copper lists, and in addition are
required by old style copper lists to be in their default
settings.Specifically ECSENA forces the following bits to their default low
settings: BRDRBLNK, BRDNTRAN, ZDCLKEN, EXTBLKEN, and BRDRSPRT.

CLXCON2 is reset by a write to CLXCON, so that old game programs will be
able to correctly detect collisions.

DIWHIGH
is reset by writes to
DIWSTRT
or
DIWSTOP
. This is interlock is
inhertied from ECS Denise.

Genlock

Lots of new genlock features were added to ECS DENISE and arecarried over to LISA. ZDBPEN in BPLCON2 allows any bitplane, selected by ZDBPSEL2,1,0,to be used as a transparency mask (ZD pin mirrors contents of selected bitplane). ZDCTEN disables the old COLOR00 is transparent mode, and allows the bit31 position of each color in the color table to control transparency.ZDCLKEN generates a 14MHz clock synchronized with the video data that can be used by video post-processors. Finally, BRDNTRAN in

BPLCON3 generates an opaque border region which can be used to frame live video.

Color Lookup Table

The color table has grown from 32 13-bit registers to 256 25-bit registers. Several new register bits have been added to BPLCON3 to facilitate loading the table with only 32 register addresses. LOCT, selects either the 16 MSB or LSB for loading. Loading the MSB always loads the LSB as well for compatibility, so when 24 bit colors are desired load LSB after MSB. BANK2,1,0 of 8 32 address banks for loading as follows:

BANK2	BANK1	BANK0	COLOR ADDRESS RANGE
0	0	0	COLOR00 - COLOR1F
0	0	1	COLOR20 - COLOR3F
0	1	0	COLOR40 - COLOR5F
0	1	1	COLOR60 - COLOR7F
1	0	0	COLOR80 - COLOR9F
1	0	1	COLORA0 - COLORBF
1	1	0	COLORC0 - COLORDF
1	1	1	COLORE0 - COLORFF

RDRAM bit in BPLCON2 causes LISA to interpret all color table accesses as reads.

Note: There is no longer any need to "scramble" SHRES color table entries. This artifice is no longer required and pepole who bypass ECS graphics library calls to do their own 28MHz graphics are to be pointed at and publicly humiliated.

Collision

A new register CLXCON2 contains 4 new bits. ENBP7 and ENBP6 are the enable

bits for bitplanes 7 and 8, respectively. Similarly, MVBP7 and MPBP8 are
their match value bits.
CLXDAT
is unchanged.

Horizontal Comparators

All programmable comparators with the exception of VHPOSW have 35nSec
resolution.:
DIWHIGH
,
HBSTOP
, SPRCTL,
BPLCON1
. BPLCON1 has additional
high-order bits as well. Note that horizontal bit position representing
140nSec resolution has been changed to 3rd least significant bit,where
before it used to be a field‘s LSB, For example, bit 00 in BPLCON1 used to
be named PF1H0 and now it‘s called PF1H2.

Coercion of 15KHz to 31KHz:

We have added new hardware features to LISA to aid in properly displaying
15KHz and 31KHz viewports together on the same 31KHz display. LISA can
globally set sprite resolution to LORES, HIRES, or SHRES.
LISA will ignore SH10 compare bits in
SPRxPOS
when scan-doubling, thereby
allowing ALICE to use these bits individually set scan-doubling.

1.4 registersindex

3. List of registers ordered by address

Symbols Used:

& = Register used by DMA channel only.
% = Register used by DMA channel usually, processors sometimes.
+ = Address register pair. Low word uses DB1-DB15, High word DB0-DB4.
~ = Address not writable by the coprocessor unless
COPCON
bit 1 is set true
h = new for HiRes chip set.
p = new for IAA chip set.
A = Agnus/Alice chip set.
D = Denise/Lisa chip set.
P = Paula chip.
W = Write.
R = Read.
ER= Early read. This is a DMA transfer to RAM, from either the disk or from
the blitter. Ram timing requires data to be on the bus earlier than
microprocessor read cycles. These transfers are therefore initiated by

```
    Agnus timing, rather than a read address on the register address bus
    (RGA).
S = Strobe (Write address with no register bits).
PTL,PTH = 20 bit pointer that addresses DMA data. Must be reloaded by a
    processor before use (Vertical blank for bit plane and sprite pointers.
    and prior to starting the blitter for blitter pointers). (old chips -
    18 bits).
LCL,LCH = 20 bit location (starting address) of DMAdata. Used to
    automatically restart pointers. such as the Coprocessor program counter
    (during vertical blank), and the audio sample counter (whenever the
    audio lentgh count is finished), (Old chips - 18 bits).
MOD = 15 bit Modulo. A number that is automatically added to the memory
    address at the end of each line to generate the address for the
    beginning of the next line. This allows the blitter (or the display
    window) to operate on (or display) a window of data that is smaller
    than the actual picture in memory. (memory map) Uses 15 bits, plus
    sign extended.


NAME        ADDR   R/W CHIP(s)   FUNCTION
---------------------------------------------------------------------------

                BLTDDAT
                   & ~000   ER  A         Blitter dest. early read (dummy address)

                DMACONR
                     ~002   R   A     P   Dma control (and blitter status) read

                VPOSR
                       ~004   R   A         Read vert most sig. bits (and frame ↩
                          flop

                VHPOSR
                      ~006   R   A         Read vert and horiz position of beam

                DSKDATR
                   & ~008   ER        P   Disk data early read (dummy address)

                JOY0DAT
                     ~00A   R      D      Joystick-mouse 0 data (vert,horiz)

                JOT1DAT
                     ~00C   R      D      Joystick-mouse 1 data (vert,horiz)

                CLXDAT
                      ~00E   R      D      Collision data reg. (read and clear)

                ADKCONR
                     ~010   R         P   Audio,disk control register read

                POT0DAT
                     ~012   R         P   Pot counter pair 0 data (vert,horiz)

                POT1DAT
                     ~014   R         P   Pot counter pair 1 data (vert,horiz)

                POTINP
```

```
      ~016   R         P   Pot pin data read

SERDATR
     ~018   R         P   Serial port data and status read

DSKBYTR
     ~01A   R         P   Disk data byte and status read

INTENAR
     ~01C   R         P   Interrupt enable bits read

INTREQR
     ~01E   R         P   Interrupt request bits read

DSKPTH
    + ~020   W   A         Disk pointer (high 5 bits)

DSKPTL
    + ~022   W   A         Disk pointer (low 15 bits)

DSKLEN
      ~024   W         P   Disk lentgh

DSKDAT
    & ~026   W         P   Disk DMA data write

REFPTR
    & ~028   W   A         Refresh pointer

VPOSW
       ~02A   W   A         Write vert most sig. bits(and frame ↩
          flop)

VHPOSW
      ~02C   W   A  D      Write vert and horiz pos of beam

COPCON
      ~-2E   W   A         Coprocessor control reg (CDANG)

SERDAT
      ~030   W         P   Serial port data and stop bits write

SERPER
      ~032   W         P   Serial port period and control

POTGO
       ~034   W         P   Pot count start,pot pin drive enable ↩
          data

JOYTEST
     ~036   W      D      Write to all 4 joystick-mouse counters ↩
        at
                 once

STREQU
    & ~038   S      D      Strobe for horiz sync with VB and EQU
```

```
STRVBL
    & ~03A   S      D      Strobe for horiz sync with VB (vert  ←
       blank)

STRHOR
    & ~03C   S      D  P   Strobe for horiz sync

STRLONG
   & ~03E   S      D      Strobe for identification of long horiz
                 line

BLTCON0
     ~040   W  A          Blitter control reg 0

BLTCON1
     ~042   W  A          Blitter control reg 1

BLTAFWM
     ~044   W  A          Blitter first word mask for source A

BLTALWM
     ~046   W  A          Blitter last word mask for source A

BLTCPTH
   + ~048   W  A          Blitter pointer to source C (high 5 bits ←
      )

BLTCPTL
   + ~04A   W  A          Blitter pointer to source C (low 15 bits ←
      )

BLTBPTH
   + ~04C   W  A          Blitter pointer to source B (high 5 bits ←
      )

BLTBPTL
   + ~04E   W  A          Blitter pointer to source B (low 15 bits ←
      )

BLTAPTH
   + ~050   W  A          Blitter pointer to source A (high 5 bits ←
      )

BLTAPTL
   + ~052   W  A          Blitter pointer to source A (low 15 bits ←
      )
BPTDPTH   + ~054   W  A          Blitter pointer to destn  D (high 5 bits)

BLTDPTL
   + ~056   W  A          Blitter pointer to destn  D (low 15 bits ←
      )

BLTSIZE
     ~058   W  A          Blitter start and size (win/width,height ←
        )

BLTCON0L
```

```
                h ~05A   W  A         Blitter control 0 lower 8 bits (minterms)

              BLTSIZV
                 h ~05C   W  A         Blitter V size (for 15 bit vert size)

              BLTSIZH
                 h ~05E   W  A         Blitter H size & start (for 11 bit H  ↩
                    size)

              BLTCMOD
                   ~060   W  A         Blitter modulo for source C

              BLTBMOD
                   ~062   W  A         Blitter modulo for source B

              BLTAMOD
                   ~064   W  A         Blitter modulo for source A

              BLTDMOD
                   ~066   W  A         Blitter modulo for destn  D
          ~068
          ~06a
          ~06c
          ~06e
BLTCDAT   & ~070   W  A          Blitter source C data reg
BLTBDAT   & ~072   W  A          Blitter source B data reg
BLTADAT   & ~074   W  A          Blitter source A data reg
          ~076

              SPRHDAT
                 &h 078   W  A         Ext logic UHRES sprite pointer and data
                                 identifier

              (BPLHDAT)
                 ~07A   ????          ?????

              LISAID
                  h ~07C   R     D       Chip revision level for Denise/Lisa

              DSKSYNC
                   ~07E   W        P   Disk sync pattern reg for disk read

              COP1LCH
                 +  080   W  A         Coprocessor first location reg
                                 (high 5 bits)

              COP1LCL
                 +  082   W  A         Coprocessor first location reg
                                 (low 15 bits)

              COP2LCH
                 +  084   W  A         Coprocessor second reg
                                 (high 5 bits)

              COP2LCL
                 +  086   W  A         Coprocessor second reg
                                 (low 15 bits)
```

```
COPJMP1
      088   S  A          Coprocessor restart at first location

COPJMP2
      08A   S  A          Coprocessor restart at second location

COPINS
       08C   W  A          Coprocessor inst fetch identify

DIWSTRT
      08E   W  A  D       Display window start
                 (upper left vert-hor pos)

DIWSTOP
      090   W  A  D       Display window stop
                 (lower right vert-hor pos)

DDFSTRT
      092   W  A          Display bit plane data fetch start.hor  ←
         pos

DDFSTOP
      094   W  A          Display bit plane data fetch stop.hor  ←
         pos

DMACON
       096   W  A      P   DMA control write (clear or set)

CLXCON
       098   W     D       Collision control

INTENA
       09A   W         P   Interrupt enable bits (clear or set  ←
          bits)

INTREQ
       09C   W         P   Interrupt request bits (clear or set  ←
          bits)

ADKCON
       09E   W         P   Audio,disk,UART,control

AUD0LCH
   +  0A0   W  A          Audio channel 0 location (high 5 bits)

AUD0LCL
   +  0A2   W  A          Audio channel 0 location (low 15 bits)

AUD0LEN
      0A4   W         P   Audio channel 0 lentgh

AUD0PER
      0A6   W         P   Audio channel 0 period

AUD0VOL
      0A8   W         P   Audio channel 0 volume
```

```
   AUD0DAT
      &  0AA   W         P   Audio channel 0 data
0AC
0AE

   AUD1LCH
      +  0B0   W  A          Audio channel 1 location (high 5 bits)

   AUD1LCL
      +  0B2   W  A          Audio channel 1 location (low 15 bits)

   AUD1LEN
         0B4   W         P   Audio channel 1 lentgh

   AUD1PER
         0B6   W         P   Audio channel 1 period

   AUD1VOL
         0B8   W         P   Audio channel 1 volume

   AUD1DAT
      &  0BA   W         P   Audio channel 1 data
0BC
0BE

   AUD2LCH
      +  0C0   W  A          Audio channel 2 location (high 5 bits)

   AUD2LCL
      +  0C2   W  A          Audio channel 2 location (low 15 bits)

   AUD2LEN
         0C4   W         P   Audio channel 2 lentgh

   AUD2PER
         0C6   W         P   Audio channel 2 period

   AUD2VOL
         0C8   W         P   Audio channel 2 volume

   AUD2DAT
      &  0CA   W         P   Audio channel 2 data
0CC
0CE

   AUD3LCH
      +  0D0   W  A          Audio channel 3 location (high 5 bits)

   AUD3LCL
      +  0D2   W  A          Audio channel 3 location (low 15 bits)

   AUD3LEN
         0D4   W         P   Audio channel 3 lentgh

   AUD3PER
         0D6   W         P   Audio channel 3 period
```

```
     AUD3VOL
          0D8   W         P   Audio channel 3 volume

     AUD3DAT
        & 0DA   W         P   Audio channel 3 data
   0DC
   0DE

     BPL1PTH
        + 0E0   W  A          Bit plane pointer 1 (high 5 bits)

     BPL1PTL
        + 0E2   W  A          Bit plane pointer 1 (low 15 bits)

     BPL2PTH
        + 0E4   W  A          Bit plane pointer 2 (high 5 bits)

     BPL2PTL
        + 0E6   W  A          Bit plane pointer 2 (low 15 bits)

     BPL3PTH
        + 0E8   W  A          Bit plane pointer 3 (high 5 bits)

     BPL3PTL
        + 0EA   W  A          Bit plane pointer 3 (low 15 bits)

     BPL4PTH
        + 0EC   W  A          Bit plane pointer 4 (high 5 bits)

     BPL4PTL
        + 0EE   W  A          Bit plane pointer 4 (low 15 bits)

     BPL5PTH
        + 0F0   W  A          Bit plane pointer 5 (high 5 bits)

     BPL5PTL
        + 0F2   W  A          Bit plane pointer 5 (low 15 bits)

     BPL6PTH
        + 0F4   W  A          Bit plane pointer 6 (high 5 bits)

     BPL6PTL
        + 0F6   W  A          Bit plane pointer 6 (low 15 bits)

     BPL7PTH
        + 0F8   W  A          Bit plane pointer 7 (high 5 bits)

     BPL7PTL
        + 0FA   W  A          Bit plane pointer 7 (low 15 bits)

     BPL8PTH
        + 0FC   W  A          Bit plane pointer 8 (high 5 bits)

     BPL8PTL
        + 0FE   W  A          Bit plane pointer 8 (low 15 bits)
```

```
BPLCON0
      100   W  A  D       Bit plane control reg (misc control bits ←
         )

BPLCON1
      102   W     D       Bit plane control reg (scroll val PF1, ←
         PF2)

BPLCON2
      104   W     D       Bit plane control reg (priority control)

BPLCON3
      106   W     D       Bit plane control reg (enhanced features ←
         )

BPL1MOD
      108   W  A          Bit plane modulo (odd planes,or active-
                 fetch lines if bitplane scan-doubling is
                 enabled

BPL2MOD
      10A   W  A          Bit plane modulo (even planes or  ←
         inactive-
                 fetch lines if bitplane scan-doubling is
                 enabled

BPLCON4
   p  10C   W     D       Bit plane control reg (bitplane and  ←
      sprite
                 masks)

CLXCON2
   p  10e   W     D       Extended collision control reg

BPL1DAT
   &  110   W     D       Bit plane 1 data (parallel to serial con ←
      -
                 vert)

BPL2DAT
   &  112   W     D       Bit plane 2 data (parallel to serial con ←
      -
                 vert)

BPL3DAT
   &  114   W     D       Bit plane 3 data (parallel to serial con ←
      -
                 vert)

BPL4DAT
   &  116   W     D       Bit plane 4 data (parallel to serial con ←
      -
                 vert)

BPL5DAT
   &  118   W     D       Bit plane 5 data (parallel to serial con ←
      -
```

```
                 vert)

BPL6DAT
   &  11a   W     D       Bit plane 6 data (parallel to serial con ↩
      -
                 vert)

BPL7DAT
   &p 11c   W     D       Bit plane 7 data (parallel to serial con ↩
      -
                 vert)

BPL8DAT
   &p 11e   W     D       Bit plane 8 data (parallel to serial con ↩
      -
                 vert)

SPR0PTH
   +  120   W  A          Sprite 0 pointer (high 5 bits)

SPR0PTL
   +  122   W  A          Sprite 0 pointer (low 15 bits)

SPR1PTH
   +  124   W  A          Sprite 1 pointer (high 5 bits)

SPR1PTL
   +  126   W  A          Sprite 1 pointer (low 15 bits)

SPR2PTH
   +  128   W  A          Sprite 2 pointer (high 5 bits)

SPR2PTL
   +  12A   W  A          Sprite 2 pointer (low 15 bits)

SPR3PTH
   +  12C   W  A          Sprite 3 pointer (high 5 bits)

SPR3PTL
   +  12E   W  A          Sprite 3 pointer (low 15 bits)

SPR4PTH
   +  130   W  A          Sprite 4 pointer (high 5 bits)

SPR4PTL
   +  132   W  A          Sprite 4 pointer (low 15 bits)

SPR5PTH
   +  134   W  A          Sprite 5 pointer (high 5 bits)

SPR5PTL
   +  136   W  A          Sprite 5 pointer (low 15 bits)

SPR6PTH
   +  138   W  A          Sprite 6 pointer (high 5 bits)

SPR6PTL
```

```
   +  13A   W  A          Sprite 6 pointer (low 15 bits)

SPR7PTH
   +  13C   W  A          Sprite 7 pointer (high 5 bits)

SPR7PTL
   +  13E   W  A          Sprite 7 pointer (low 15 bits)

SPR0POS
   %  140   W  A  D       Sprite 0 vert-horiz start pos data

SPR0CTL
   %  142   W  A  D       Sprite 0 position and control data

SPR0DATA
  %  144   W     D       Sprite 0 image data register A

SPR0DATB
  %  146   W     D       Sprite 0 image data register B

SPR1POS
   %  148   W  A  D       Sprite 1 vert-horiz start pos data

SPR1CTL
   %  14A   W  A  D       Sprite 1 position and control data

SPR1DATA
  %  14C   W     D       Sprite 1 image data register A

SPR1DATB
  %  14E   W     D       Sprite 1 image data register B

SPR2POS
   %  150   W  A  D       Sprite 2 vert-horiz start pos data

SPR2CTL
   %  152   W  A  D       Sprite 2 position and control data

SPR2DATA
  %  154   W     D       Sprite 2 image data register A

SPR2DATB
  %  156   W     D       Sprite 2 image data register B

SPR3POS
   %  158   W  A  D       Sprite 3 vert-horiz start pos data

SPR3CTL
   %  15A   W  A  D       Sprite 3 position and control data

SPR3DATA
  %  15C   W     D       Sprite 3 image data register A

SPR3DATB
  %  15E   W     D       Sprite 3 image data register B

SPR4POS
```

```
   % 160   W  A  D       Sprite 4 vert-horiz start pos data

SPR4CTL
   % 162   W  A  D       Sprite 4 position and control data

SPR4DATA
  % 164   W     D       Sprite 4 image data register A

SPR4DATB
  % 166   W     D       Sprite 4 image data register B

SPR5POS
   % 168   W  A  D       Sprite 5 vert-horiz start pos data

SPR5CTL
   % 16A   W  A  D       Sprite 5 position and control data

SPR5DATA
  % 16C   W     D       Sprite 5 image data register A

SPR5DATB
  % 16E   W     D       Sprite 5 image data register B

SPR6POS
   % 170   W  A  D       Sprite 6 vert-horiz start pos data

SPR6CTL
   % 172   W  A  D       Sprite 6 position and control data

SPR6DATA
  % 174   W     D       Sprite 6 image data register A

SPR6DATB
  % 176   W     D       Sprite 6 image data register B

SPR7POS
   % 178   W  A  D       Sprite 7 vert-horiz start pos data

SPR7CTL
   % 17A   W  A  D       Sprite 7 position and control data

SPR7DATA
  % 17C   W     D       Sprite 7 image data register A

SPR7DATB
  % 17E   W     D       Sprite 7 image data register B

COLOR00
     180   W     D       Color table 00

COLOR01
     182   W     D       Color table 01

COLOR02
     184   W     D       Color table 02

COLOR03
```

```
      186   W     D       Color table 03

COLOR04
      188   W     D       Color table 04

COLOR05
      18A   W     D       Color table 05

COLOR06
      18C   W     D       Color table 06

COLOR07
      18E   W     D       Color table 07

COLOR08
      190   W     D       Color table 08

COLOR09
      192   W     D       Color table 09

COLOR10
      194   W     D       Color table 10

COLOR11
      196   W     D       Color table 11

COLOR12
      198   W     D       Color table 12

COLOR13
      19A   W     D       Color table 13

COLOR14
      19C   W     D       Color table 14

COLOR15
      19E   W     D       Color table 15

COLOR16
      1A0   W     D       Color table 16

COLOR17
      1A2   W     D       Color table 17

COLOR18
      1A4   W     D       Color table 18

COLOR19
      1A6   W     D       Color table 19

COLOR20
      1A8   W     D       Color table 20

COLOR21
      1AA   W     D       Color table 21

COLOR22
```

```
                1AC   W     D       Color table 22

          COLOR23
                1AE   W     D       Color table 23

          COLOR24
                1B0   W     D       Color table 24

          COLOR25
                1B2   W     D       Color table 25

          COLOR26
                1B4   W     D       Color table 26

          COLOR27
                1B6   W     D       Color table 27

          COLOR28
                1B8   W     D       Color table 28

          COLOR29
                1BA   W     D       Color table 29

          COLOR30
                1BC   W     D       Color table 30

          COLOR31
                1BE   W     D       Color table 31

          HTOTAL
              h  1C0   W  A          Highest number count in horiz line
                             (VARBEAMEN = 1)

          HSSTOP
              h  1C2   W  A          Horiz line pos for HSYNC stop

          HBSTRT
              h  1C4   W  A  D       Horiz line pos for HBLANK start

          HBSTOP
              h  1C6   W  A  D       Horiz line pos for HBLANK stop

          VTOTAL
              h  1C8   W  A          Highest numbered vertical line
                             (VARBEAMEN = 1)

          VSSTOP
              h  1CA   W  A          Vert line for VBLANK start

          VBSTRT
              h  1CC   W  A          Vert line for VBLANK start

          VBSTOP
              h  1CE   W  A          Vert line for VBLANK stop
SPRHSTRT  h  1D0   W  A          UHRES sprite vertical start

          SPRHSTOP
```

```
                  h   1D2    W   A          UHRES sprite vertical stop

                BPLHSTRT
                  h   1D4    W   A          UHRES bit plane vertical stop

                BPLHSTOP
                  h   1D6    W   A          UHRES bit plane vertical stop

                HHPOSW
                    h   1D8    W   A          DUAL mode hires H beam counter write

                HHPOSR
                    h   1DA    R   A          DUAL mode hires H beam counter read

                BEAMCON0
                  h   1DC    W   A          Beam counter control register
                                 (SHRES,UHRES,PAL)

                HSSTRT
                    h   1DE    W   A          Horizontal sync start (VARHSY)

                VSSTRT
                    h   1E0    W   A          Vertical sync start (VARVSY)

                HCENTER
                   h   1E2    W   A          Horizontal pos for vsync on interlace

                DIWHIGH
                   h   1E4    W   A   D       Display window upper bits for start/stop

                BPLHMOD
                   h   1E6    W   A          UHRES bit plane modulo

                SPRHPTH
                  +h   1E8    W   A          UHRES sprite pointer (high 5 bits)

                SPRHPTL
                  +h   1EA    W   A          UHRES sprite pointer (low 15 bits)

                BPLHPTH
                  +h   1EC    W   A          VRam (UHRES) bitplane pointer (hi 5 bits ←
                     )

                BPLHPTL
                  +h   1EE    W   A          VRam (UHRES) bitplane pointer (lo 15  ←
                     bits)
RESERVED     1F0 - 1FA

                FMODE
                     p   1FC    W   A   D       Fetch mode register
NO-OP(NULL)  1FE                  Can also indicate last 2 or 3 refresh
                                  cycles or the restart of the COPPER after
                                  lockup.
```

1.5 Some Notes to Start Width

```
4. List of Registers Ordered Alphabetically
-------------------------------------------

P  =  New register in Pandora chip set
p  =  Stuff added or changed in hires chips
H  =  New register in hires chips
h  =  stuff added or changed in hires chips

A  =  Agnus/Alice chip
D  =  Denise/Lisa chip
P  =  Paula chip

W  =  Write
R  =  Read
ER =  Early read. This is a DMA data transfer to RAM, from either the disk
      or from the blitter, Ram timing requires data to be on the bus
      earlier than microprocessor read cycles. These transfers are
      therefore initiated by Agnus timing, rather than a read address on
      the register address bus (RGA).
```

1.6 ADKCON

```
                NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
ADKCON      09E   W   P    Audio,Disk,Uart,Control write
ADKCONR     010   R   P    Audio,Disk,Uart,Control read

         +-------+-------------+-----------------------------------------+
         | BITS  | USE         | DESCRIPTION                             |
         +-------+-------------+-----------------------------------------+
         | 15    | SET/CLEAR   | Set/clear control bit.determines if bits  |
         |       |             | written with a 1 get set or cleared.bits  |
         |       |             | written with a zero are always unchanged. |
         |       |             |                                         |
         |       |             | +------+---------------+                |
         | 14-13 | PRECOMP 1-0 | | CODE | PRECOMP VALUE |                |
         |       |             | +------+---------------+                |
         |       |             | | 00   | none          |                |
         |       |             | | 01   | 140 ns        |                |
         |       |             | | 10   | 280 ns        |                |
         |       |             | | 11   | 560 ns        |                |
         |       |             | +------+---------------+                |
         |       |             |                                         |
         | 12    | MFMPREC     | (1 = MFM precomp / 0 = GCR precomp)     |
         | 11    | UARTBRK     | Forces a UART break (clears TXD) if true  |
         | 10    | WORDSYNC    | Enables disk read synchronizing on a word |
         |       |             | equal to DISK SYNC CODE, Located in      |
         |       |             | address
                DSKSYNC
                 (7E).                     |
         | 09    | MSBSYNC     | Enables disk read synchrinizing on the    |
         |       |             | MSB (most signif bit) appl type GCR       |
```

```
| 08    | FAST        | Disk data clock rate control 1=fast(2us)  |
|       |             | 0=slow(4us)                               |
|       |             | (Fast for MFM or 2us,slow for 4us GCR)    |
| 07    | USE3PN      | Use audio channel 3 to modulate nothing   |
| 06    | USE2P3      | Use audio channel 2 to modulate period    |
|       |             | of channel 3                              |
| 05    | USE1P2      | Use audio channel 1 to modulate period    |
|       |             | of channel 2                              |
| 04    | USE0P1      | Use audio channel 0 to modulate period    |
|       |             | of channel 1                              |
| 03    | USE3VN      | Use audio channel 3 to modulate nothing   |
|       |             |                                           |
| 02    | USE2V3      | Use audio channel 2 to modulate volume    |
|       |             | of channel 3                              |
| 01    | USE1V2      | Use audio channel 1 to modulate volume    |
|       |             | of channel 2                              |
| 00    | USE0V1      | Use audio channel 0 to modulate volume    |
|       |             | of channel 1                              |
+-------+-------------+-------------------------------------------+
```

```
   Note: If both period and volume aremodulated on the same channel,
         the period and volume will be alternated. First
                AUDxDAT
                 word
         is used for V6-V0 of
                AUDxVOL
                . Second AUDxDAT word is used for
         P15-P0 of
                AUDxPER
                . This alternating sequence is repeated.
```

1.7 AUDxLCH

```
NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
AUDxLCH h 0A0    W   A    Audio channel x location (high 5 bits)
                          (old-3 bits)
```

1.8 AUDxLCL

```
NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
AUDxLCL   0A2    W   A    Audio channel x location (low 15 bits)

         This pair of registers contains the 20 bit starting
         address(location) of audio channel x (x=0,1,2,3)DMA
         data. This is not a pointer reg and therfore only
         needs to be reloaded if a diffrent memory location
         is to be outputted.
```

1.9 AUDxLEN

```
NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
AUDxLEN   0A4    W   P    Audio channel x length

         This reg contains the lentgh (number of words) of
         audio channel x DMA data.
```

1.10 AUDxPER

```
NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
AUDxPER h 0A6    W   P    Audio channel x period

         This reg contains the period (rate) of audio channel
         x DMA data transfer.
         The minimum period is 124 clocks. This means that
         the smallest number that should be placed in this
         reg is 124.
```

1.11 AUDxVOL

```
NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
AUDxVOL   0A8    W   P    Audio channel x volume

         This reg contains the volume setting for audio channel x.
         Bits 6,5,4,3,2,1,0 specify 65 linear volume levels as shown below.

         +--------+---------------------------------------------------+
         | BITS   | USE                                               |
         +--------+---------------------------------------------------+
         | -15-07 | Not used                                          |
         |  06    | Forces volume to max (64 ones,no zeros)           |
         | 05-00  | Sets one of the 64 levels (000000 = no output,    |
         |        | 111111 = 63 ones, one zero)                       |
         +--------+---------------------------------------------------+
```

1.12 AUDxDAT

```
NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
AUDxDAT   0AA    W   P    Audio channel x data

         This reg is the audio channel x (x=0,1,2,3) DMA
         data buffer. It contains 2 bytes of data (each
         byte is a twos complement signed integer) that
         are outputed sequentially (with digital to analog
```

```
conversion)to the audio output pins. With maximum
volume, each byte can drive the audio outputs
with 0.8 volts(peak to peak,typ). The audio DMA
channel controller automatically transfers data
to this reg from RAM. The processor can also
write directly to this reg. When the DMA data is
finished (words outputted=lentgh)and the data in
this reg has been used, an audio channel interrupt
request is set.
```

1.13 BEAMCON0

```
                NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
BEAMCON0 h 1DC  W    A            Beam counter control bits

          +-------+---------------------------+
          | BIT#  | FUNCTION                  |
          +-------+---------------------------+
          | 15    | (unused)                  |
          | 14    | HARDDIS                   |
          | 13    | LPENDIS                   |
          | 12    | VARVBEN                   |
          | 11    | LOLDIS                    |
          | 10    | CSCBEN                    |
          | 9     | VARVSYEN                  |
          | 8     | VARHSYEN                  |
          | 7     | VARBEAMEN                 |
          | 6     | DUAL                      |
          | 5     | PAL                       |
          | 4     | VARCSYEN                  |
          | 3     | (unused, formerly BLANKEN) |
          | 2     | CSYTRUE                   |
          | 1     | VSYTRUE                   |
          | 0     | HSYTRUE                   |
          +-------+---------------------------+

HARDDIS = This bit is used to disable the hardwire vertical horizontal
          window limits. It is cleared upon reset.

LPENDIS = When this bit is a low and LPE (
                BPLCON0
                ,BIT 3) is enabled, the
          light-pen latched value(beam hit position) will be read by

                VHPOSR
                ,
                VPOSR
                 and
                HHPOSR
                . When
          the bit is a high the light-pen latched value is ignored and
          the actual beam counter position is read by VHPOSR, VPOSR, and
          HHPOSR.
```

```
VARVBEN = Use the comparator generated vertical blank (from
                VBSTRT
                ,
                VBSTOP
                )
          to run the internal chip stuff-sending RGA signals to Denise,
          starting sprites,resetting light pen. It also disables the hard
          stop on the vertical display window.

LOLDIS  = Disable long line/short toggle. This is useful for DUAL mode
          where even multiples are wanted, or in any single display
          where this toggling is not desired.

CSCBEN  = The variable composite sync comes out on the HSY pin, and the
          variable conosite blank comes out on the VSY pin. The idea is
          to allow all the information to come out of the chip for a
          DUAL mode display. The normal monitor uses the normal composite
          sync, and the variable composite sync &blank come out the HSY &
          VSY pins. The bits VARVSTEN & VARHSYEN (below) have priority over
          this control bit.

VARVSYEN= Comparator VSY -> VSY pin. The variable VSY is set vertically on

                VSSTRT
                , reset vertically on
                VSSTOP
                , with the horizontal position
          for set set & reset
                HSSTRT
                 on short fields (all fields are short
          if LACE = 0) and
                HCENTER
                 on long fields (every other field if
          LACE = 1).

VARHSYEN= Comparator HSY -> HSY pin. Set on HSSTRT value, reset on
                HSSTOP
                          value.

VARBEAMEN=Enables the variable beam counter comparators to operate
          (allowing diffrent beam counter total values) on the main horiz
          counter. It also disables hard display stops on both horizontal
          and vertical.

DUAL    = Run the horizontal comparators with the alternate horizontal beam
          counter, and starts the UHRES pointer chain with the reset of
          this counter rather than the normal one. This allows the UHRES
          pointers to come out more than once in a horizontal line,
          assuming there is some memory bandwidth left (it doesn't work in
          640*400*4 interlace mode) also, to keep the two displays synced,
          the horizontal line lentghs should be multiples of each other.
          If you are amazingly clever, you might not need to do this.

PAL     = Set appropriate decodes (in normal mode) for PAL. In variable
          beam counter mode this bit disables the long line/short line
          toggle- ends up short line.
```

```
VARCSYEN= Enables CSY from the variable decoders to come out the CSY
          (VARCSY is set on
                HSSTRT
                 match always, and also on
                HCENTER
                          match when in vertical sync. It is reset on
                HSSTOP
                 match when VSY
          and on both
                HBSTRT
                 &
                HBSTOP
                 matches during VSY. A reasonable
          composite can be generated by setting HCENTER half a horiz line
          from
                HSSTRT
                , and HBSTOP at (HSSTOP-HSSTRT) before HCENTER, with
          HBSTRT at (HSSTOP-HSSTRT) before HSSTRT.
          HSYTRUE, VSYTRUE, CSYTRUE = These change the polarity of the
          HSY*, VSY*, & CSY* pins to HSY, VSY, & CSY respectively for
          input & output.
```

1.14 BLTxPTH

```
                NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
BLTxPTH  h 050  W    A    Blitter Point to x (High 5 bits)

See also:
                BLTxPTL
```

1.15 BLTxPTL

```
                NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
BLTxPTL  h 052  W    A    Blitter Pointer to x (Low 15 bits)

         This pair of registers (see also:
                BLTxPTH
                )
         contains the 20 bit address of Blitter source (X=A,B,C) or dest.
         (x=D) DMA data. This pointer must be preloaded with the
         starting address of the data to be processed by the blitter. After
         the Blitter is finished it will contain the last data address
         (plus increment and modulo).
```

1.16 BLTxMOD

```
NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
BLTxMOD    064  W    A    Blitter Modulo x

         This register contains the Modulo for Blitter source (x=A,B,C)
         or Dest (X=D). A Modulo is a number that is automatically
         added to the address at the end of each line, in order that
         the address then points to the start of the next line. Each
         source or destination has it's own Modulo, allowing each
         to be a different size, while an identical area of each is
         used in the Blitter operation.
```

1.17 BLTAFWM

```
                NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
BLTAFWM     044 W    A    Blitter first word mask for source A

See also:
                BLTALWM
```

1.18 BLTALWM

```
                NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
BLTALWM    046  W    A    Blitter last word mask for source A

         The patterns in these two registers (see also:
                BLTAFWM
                )
         are "anded" with the first and last words of each line of data
         from Source A into the Blitter. A zero in any bit overrides
         data from Source A. These registers should be set to all
         "ones" for fill mode or for line drawing mode.
```

1.19 BLTxDAT

```
NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
BLTxDAT    074  W    A    Blitter source x data reg.

         This register holds Source x (x=A,B,C) data for use by the Blitter.
         It is normally loaded by the Blitter DMA channel, however it
         may also be preloaded by the microprocessor.
```

1.20 BLTDDAT

```
NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
BLTDDAT    000  W    A    Blitter destination data register

         This register holds the data resulting from each word of
         Blitter operation until it is sent to a RAM destination.
         This is a dummy address and cannot be read by the micro.
         The transfer is automatic during Blitter operation.
```

1.21 BLTSIZE

```
NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
BLTSIZE      058   W    A Blitter start and size (win/width, height)

         This register contains the width and height of the blitter operation
         (in line mode width must = 2, height = line length). Writing
         to this register will start the Blitter, and should be done last,
         after all pointers and control registers have been initialized.

         BIT# 15,14,13,12,11,10,09,08,07,06,05,04,03,02,01,00
              H9 H8 H7 H6 H5 H4 H3 H2 H1 H0 W5 W4 W3 W2 W1 W0

         H=Height=Vertical lines (10 bits=1024 lines max)
         W=Width=Horiz pixels (6 bits=64 words=1024 pixels max)
```

1.22 BLTCON0

```
NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
BLTCON0    040  W    A    Blitter control register 0
BLTCON0L H 05A  W    A    Blitter control register 0 (lower 8 bits)
                          This is to speed up software - the upper bits are
                          often the same.
BLTCON1  h 042  W    A    Blitter control register 1

         These two control registers are used together to control blitter
         operations. There are 2 basic modes, are and line, which are
         selected by bit 0 of BLTCON1, as show below.

         +--------------------------+--------------------------+
         | AREA MODE ("normal")     | LINE MODE (line draw)    |
         +------+---------+---------+------+---------+---------+
         | BIT# | BLTCON0 | BLTCON1 | BIT# | BLTCON0 | BLTCON1  |
         +------+---------+---------+------+---------+---------+
         | 15   | ASH3    | BSH3    | 15   | ASH3    | BSH3     |
         | 14   | ASH2    | BSH2    | 14   | ASH2    | BSH2     |
         | 13   | ASH1    | BSH1    | 13   | ASH1    | BSH1     |
         | 12   | ASA0    | BSH0    | 12   | ASH0    | BSH0     |
         | 11   | USEA    | 0       | 11   | 1       | 0        |
         | 10   | USEB    | 0       | 10   | 0       | 0        |
```

```
| 09   | USEC     | 0        | 09   | 1        | 0         |
| 08   | USED     | 0        | 08   | 1        | 0         |
| 07   | LF7      | DOFF     | 07   | LF7      | DPFF      |
| 06   | LF6      | 0        | 06   | LF6      | SIGN      |
| 05   | LF5      | 0        | 05   | LF5      | OVF       |
| 04   | LF4      | EFE      | 04   | LF4      | SUD       |
| 03   | LF3      | IFE      | 03   | LF3      | SUL       |
| 02   | LF2      | FCI      | 02   | LF2      | AUL       |
| 01   | LF1      | DESC     | 01   | LF1      | SING      |
| 00   | LF0      | LINE(=0)| 00   | LF0      | LINE(=1) |
+------+---------+---------+------+---------+----------+

ASH3-0    Shift value of A source
BSH3-0    Shift value of B source and line texture
USEA      Mode control bit to use source A
USEB      Mode control bit to use source B
USEC      Mode control bit to use source C
USED      Mode control bit to use destination D
LF7-0     Logic function minterm select lines
EFE       Exclusive fill enable
IFE       Inclusive fill enable
FCI       Fill carry input
DESC      Descending (dec address)control bit
LINE      Line mode control bit
SIGN      Line draw sign flag
OVF       Line/draw r/l word overflow flag
SUD       Line draw, Sometimes up or down (=AUD)
SUL       Line draw, Sometimes up or left
AUL       Line draw, Always up or left
SING      line draw, Single bit per horiz line
DOFF      Disables the D output- for external ALUs
          The cycle occurs normally, but the data
          bus is tristate (hires chips only)
```

1.23 BLTSIZH

```
                NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
BLTSIZH  h 05E  W    A    Blitter H size & start (11 bit width)

         BIT# 15 14 13 12 11 10  09 08 07 06 05 04 03 02 01 00
               x  x  x  x  x w10 w9 w8 w7 w6 w5 w4 w3 w2 w1 w0

         See also:
                BLTSIZV
```

1.24 BLTSIZV

```
                NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
BLTSIZV  h 05C  W    A    Blitter V size (15 bit height)
```

```
BIT# 15  14  13  12  11  10  09 08 07 06 05 04 03 02 01 00
      x  h14 h13 h12 h11 h10 h9 h8 h7 h6 h5 h4 h3 h2 h1 h0
```

These are the blitter size regs for blits larger than the earlier chips could accept. The original commands are retained for compatibility. BLTSIZV should be written first, followed by
BLTSIZH
,
which starts the blitter. BLTSIZV need not be rewritten for subsequent bits if the vertical size is the same. Max size of blit 32k pixels * 32k lines, x's should be written to 0 for upward compatibility.

1.25 BPLHDAT

```
NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
BPLHDAT  h 07A  W         Ext logic UHRES bit plane identifier
```

This is the number (sign extended) that is added to the UHRES bitplane pointer (BPLHPTL,H) every line, and then another 2 is added, just like the other modulos.

1.26 BPLHMOD

```
NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
BPLHMOD  h 1E6  W    A    Uhres bit plane modulo
```

This is the number (sign extended) that is added to the UHRES bitplane pointer (BPLHPTL,H) every line, and then another 2 is added, just like the other modulos.

1.27 BPLHPTH

```
                NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
BPLHPTH  h 1EC  W    A    UHRES (VRAM) bit plane pntr (high 5 bits)
```

When UHRES is enabled, this pointer comes out on the 2nd 'free' cycle after the start of each horizontal line. It‘s modulo is added every time it comes out. 'free' means priority above the copper and below the fixed stuff (audio,sprites....).

BPLHDAT
comes out as an identifier on the RGA lines when the pointer address is valid so that external detectors can use this to do the special cycle for the VRAMs, The SHRHDAT gets the first and third free cycles.

1.28 BPLHPTL

```
                NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
BPLHPTL  h 1EE  W    A    UHRES (VRAM) bit plane pntr (low 15 bits)

         When UHRES is enabled, this pointer comes out on the 2nd 'free' cycle
         after the start of each horizontal line. It`s modulo is added every
         time it comes out. 'free' means priority above the copper and below
         the fixed stuff (audio,sprites....).

                BPLHDAT
                 comes out as an identifier on the RGA lines when the pointer
         address is valid so that external detectors can use this to do the
         special cycle for the VRAMs, The SHRHDAT gets the first and third
         free cycles.
```

1.29 bplhstop

```
                NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
BPLHSTOP p 1D6  W    A    UHRES bit plane vertical stop

         +-------+---------+
         | BIT#  | Name    |
         +-------+---------+
         | 15    | BPLHWRM |
         | 14-11 | Unused  |
         | 10-0  | V10-V0  |
         +-------+---------+

         BPLHWRM = Swaps the polarity of ARW* when the
                BPLHDAT
                 comes out so
         that external devices can detect the RGA and put things into memory
         (ECS and later versions).
```

1.30 BPLHSTRT

```
                NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
BPLHSTRT h 1D4  W   A           UHRES bit plane vertical stop

         This controls the line when the data fetch starts for
         the
                BPLHPTH
                , L pointers. V10-V0 on DB10-0.
```

1.31 BPLxPTH

```
NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
BPLxPTH   0E0   W    A    Bit plane x pointer (high 5 bits)

          0E8            x=1,2,3,4,5,6,7,8
          0EC
          0F0
          0F4
        p 0F8
        p 0FC
```

1.32 BPLxPTL

```
NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
BPLxPTL    0E2  W    A    Bit plane pointer (low 15 bits)

           0EA        Address of bit plane x  (x=1,2,3,4,5,6,7,8) DMA data.
           0EE        This pointer must be reinitialized by the processor or
           0F2        coprocessor to point to the beginning of bit plane data
           0F6        every vertical blank time.
         p 0FA
         p 0FE
```

1.33 BPLxDAT

```
NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
BPLxDAT   110  W    A          Bit plane x data (parallel to serial convert)

          112          These regs recieve the DMA data fetched from RAM by the
          114          bit plane address pointers described above.
          116          They may also be rewritten by either micro.
          118          they act as a 8 word parallel to serial buffer for up
          11A          to 8 memory 'bit planes'. x=1-8 the parallel to serial
        p 11C          conversion id triggered whenever bit plane #1 is
        p 11E          written, indicing the completion of all bit planes for
                       that word (16/32/64 pixels). The MSB is output first,
                       and is therefore always on the left.
```

1.34 BPLxMOD

```
                NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
BPL1MOD    108  W    A    Bit plane modulo (odd planes)
BPL2MOD    10A  W    A    Bit plane modulo (even planes)

         These registers contain the modulos for the odd and
         even bit planes. A modulo is a number that is automa-
```

itcally added to the address at the end of each line, in order that the address then points to the start of the next line. Since they have seperate modulos, the odd and even bit planes may have sizes that are different from each other, as well as different from the display window size.
If scan-doubling is enabled, BPL1MOD serves as the primary bitplane modulos and BPL2MOD serves as the alternate. Lines whose LSBs of beam counter and
DIWSTRT
match are designated primary, whereas lines whose LSBs don‘t match are designated alternate.

1.35 BPLCON0

```
               NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
BPLCON0 p  100  W    D    Bit plane control reg. (misc, control bits)
```

BIT#	BPLCON0	DESCRIPTION
15	HIRES	HIRES = High resoloution (640*200/640*400 interlace) mode
14	BPU2	Bit plane use code 0000-1000 (NODE thru 8 inclusive)
13	BPU1	
12	BPU0	
11	HAM	Hold and modify mode, now using either 6 or 8 bit planes.
10	DPF	Double playfield (PFI=odd FP2= even bit planes) now available in all resoloutions. (If BPU=6 and HAM=0 and DPF=0 a special mode is defined that allows bitplane 6 to cause an intensity reduction of the other 5 bitplanes. The color register output selected by 5 bitplanes is shifted to half intensity by the 6th bit plane. This is called EXTRA-HALFBRITE Mode.
09	COLOR	Enables color burst output signal
08	GAUD	Genlock audio enable. This level appears on the ZD pin on denise during all blanking periods, unless ZDCLK bit is set.
07	UHRES	Ultrahi res enables the UHRES pointers (for 1k*1k) (also needs bits in DMACON (hires chips only). Disables hard stops for vert, horiz display windows.
06	SHRES	Super hi-res mode (35ns pixel width)
05	BYPASS=0	Bitplanes are scrolled and prioritized normally, but bypass color table and 8 bit wide data appear on R(7:0).
04	BPU3=0	See above (BPU0/1/2)
03	LPEN	Light pen enable (reset on power up)
02	LACE	Interlace enable (reset on power up)
01	ERSY	External resync (HSYNC, VSYNC pads become inputs) (reset on power up)
00	ECSENA=0	When low (default), the following bits in

BPLCON3
are |

		disabled: BRDRBLNK,BRDNTRAN,ZDCLKEN,BRDSPRT, and EXTBLKEN. These 5 bits can always be set by writing to BPLCON3, however there effects are inhibited until ECSENA goes high. This allows rapid context switching between pre-ECS viewports and new ones.

1.36 BPLCON1

NAME	rev	ADDR	type	chip	Description
BPLCON1	p	102	W	D	Bit plane control reg. (horiz, scroll counter)

BIT#	BPLCON1	DESCRIPTION
15	PF2H7=0	(PF2Hx =) Playfield 2 horizontal scroll code, x=0-7
14	PF2H6=0	
13	PF2H1=0	
12	PF2H0=0	
11	PF1H7=0	(PF1Hx =) Playfield 1 horizontal scroll code, x=0-7
10	PF1H6=0	where PFyH0=LSB=35ns SHRES pixel (bits have been
09	PF1H1=0	renamed, old PFyH0 now PFyH2, ect). Now that the scroll
08	PF1H0=0	range has been quadrupled to allow for wider (32 or
		64 bits) bitplanes.
07	PF2H5	
06	PF2H4	
05	PF2H3	
04	PF2H2	
03	PF1H5	
02	PF1H4	
01	PF1H3	
00	PF1H2	

1.37 BPLCON2

NAME	rev	ADDR	type	chip	Description
BPLCON2	p	104	W	D	Bit plane control reg. (new control bits)

BIT#	BPLCON2	DESCRIPTION
15	X	don't care- but drive to 0 for upward compatibility!
14	ZDBPSEL2	3 bit field which selects which bitplane is to be used for ZD when ZDBBPEN is set- 000 selects BB1 and 111 selects BP8.
13	ZDBPSEL1	
12	ZDBPSEL0	
11	ZDBPEN	Causes ZD pin to mirror bitplane selected by ZDBPSELx

```
 |      |          | bits. This does not disable the ZD mode defined by     |
 |      |          | ZDCTEN, but rather is "ored" with it.                  |
 | 10   | ZDCTEN   | Causes ZD pin to mirror bit #15 of the active entry in |
 |      |          | high color table. When ZDCTEN is reset ZD reverts to   |
 |      |          | mirroring color (0).                                   |
 | 09   | KILLEHB  | Disables extra half brite mode.                        |
 | 08   | RDRAM=0  | Causes color table address to read the color table     |
 |      |          | instead of writing to it.                              |
 | 07   | SOGEN=0  | When set causes SOG output pin to go high              |
 | 06   | PF2PRI   | Gives playfield 2 priority over playfield 1.           |
 | 05   | PF2P2    | Playfield 2 priority code (with resp. to sprites).     |
 | 04   | PF2P1    |                                                        |
 | 03   | PF2P0    |                                                        |
 | 02   | PF1P2    | Playfield 1 priority code (with resp. to sprites).     |
 | 01   | PF1P1    |                                                        |
 | 00   | PF1P0    |                                                        |
 +------+----------+--------------------------------------------------------+
```

1.38 BPLTCON3

```
NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
BPLCON3 p 106  W       D        Bit plane control reg. (enhanced features)

 +------+------------+-------------------------------------------------------+
 | BIT# | BPLCON3    | DESCRIPTION                                           |
 +------+------------+-------------------------------------------------------+
 |      |            |                                                       |
 | 15   | BANK2=0    | BANKx = Selects one of eight color banks, x=0-2.      |
 | 14   | BANK1=0    |                                                       |
 | 13   | BANK0=0    |                                                       |
 | 12   | PF2OF2=0   | Determine bit plane color table offset when playfield 2|
 |      |            | has priority in dual playfield mode:                  |
 |      |            +-----------+--------------------------------+------------+
 |      |            | PF20F     | AFFECTED BITPLANE              | OFFSET     |
 |      |            +---+---+---+--------------------------------+------------+
 |      |            | 2 | 1 | 0 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | (decimal)  |
 |      |            +---+---+---+--------------------------------+------------+
 |      |            | 0 | 0 | 0 | - | - | - | - | - | - | - | - | none       |
 |      |            | 0 | 0 | 1 | - | - | - | - | - | - | 1 | - | 2          |
 |      |            | 0 | 1 | 0 | - | - | - | - | - | 1 | - | - | 4          |
 |      |            | 0 | 1 | 1 | - | - | - | - | - | 1 | - | - | 8 (default)|
 |      |            | 1 | 0 | 0 | - | - | - | 1 | - | - | - | - | 16         |
        |            | 1 | 0 | 1 | - | - | 1 | - | - | - | - | - | 32         |
 |      |            | 1 | 1 | 0 | - | 1 | - | - | - | - | - | - | 64         |
 |      |            | 1 | 1 | 1 | 1 | - | - | - | - | - | - | - | 128        |
 |      |            +---+---+---+---+---+---+---+---+---+---+---+------------+
 |      |            |                                                       |
 | 11   | PF2OF1=1   |                                                       |
 | 10   | PF2OF0=1   |                                                       |
 | 09   | LOCT=0     | Dictates that subsequent color palette values will be |
 |      |            | written to a second 12- bit color palette, constituting|
 |      |            | the RGB low minus order bits. Writes to the normal hi |
 |      |            | monus order color palette automattically copied to the |
 |      |            | low order for backwards compatibility.                |
```

```
| 08    | X           |  don‘t care- but drive to 0 for upward compatibility!  |
| 07    | SPRES1=0    | Determine resolution of all 8 sprites (x=0,1):         |
|       |                                                                      |
|       |      +-------+--------+-----------------------------------------+
|       |      |SPRES1 | SPRES0 | SPRITE RESOLUTION                       |
|       |      +-------+--------+-----------------------------------------+
|       |      |0      | 0      | ECS defaults (LORES,HIRES=140ns,SHRES=70ns) |
|       |      |0      | 1      | LORES (140ns)                           |
|       |      |1      | 0      | HIRES (70ns)                            |
|       |      |1      | 1      | SHRES (35ns)                            |
|       |      +-------+--------+-----------------------------------------+
|       |                                                                      |
| 06    | SPRES0=0    |                                                        |
| 05    | BRDRBLNK=0 | "Border area" is blanked instead of color (0).         |
|       |             | Disabled when ECSENA low.                              |
| 04    | BRDNTRAN=0 | "Border area" is non minus transparant (ZD pin is low  |
|       |             | when border is displayed). Disabled when ECSENA low.   |
| 03    | X           | don‘t care- but drive to 0 for upward compatibility!   |
| 02    | ZDCLKEN=0   | ZD pin outputs a 14MHz clock whose falling edge        |
|       |             | coincides with hires (7MHz) video data. this bit when  |
|       |             | set disables all other ZD functions.                   |
|       |             | Disabled when ESCENA low.                              |
| 01    | BRDSPRT=0   | Enables sprites outside the display window.            |
|       |             | disabled when ESCENA low.                              |
| 00    | EXTBLKEN=0 | Causes BLANK output to be programmable instead of      |
|       |             | reflecting internal fixed decodes.                     |
|       |             | Disabled when ESCENA low.                              |
+------+------------+---------------------------------------------------------+
```

1.39 BPLCON4

```
NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
BPLCON4 p 10c  W       D  Bit plane control reg. (display masks)
```

```
+------+----------+-----------------------------------------------------------+
| BIT# | BPLCON4  | DESCRIPTION                                               |
+------+----------+-----------------------------------------------------------+
| 15   | BPLAM7=0 | This 8 bit field is XOR‘ed with the 8 bit plane color     |
|      |          | address, thereby altering the color address sent to the   |
|      |          | color table (x=1-8)                                       |
| 14   | BPLAM6=0 |                                                           |
| 13   | BPLAM5=0 |                                                           |
| 12   | BPLAM4=0 |                                                           |
| 11   | BPLAM3=0 |                                                           |
| 10   | BPLAM2=0 |                                                           |
| 09   | BPLAM1=0 |                                                           |
| 08   | BPLAM0=0 |                                                           |
| 07   | ESPRM7=0 | 4 Bit field provides the 4 high order color table address|
|      |          | bits for even sprites: SPR0,SPR2,SPR4,SPR6. Default value|
|      |          | is 0001 binary. (x=7-4)                                   |
| 06   | ESPRM6=0 |                                                           |
| 05   | ESPRM5=0 |                                                           |
| 04   | ESPRM4=1 |                                                           |
| 03   | OSPRM7=0 | 4 Bit field provides the 4 high order color table address|
```

```
 |      |          | bits for odd sprites: SPR1,SPR3,SPR5,SPR7. Default value |
 |      |          | is 0001 binary. (x=7-4)                                  |
 | 02   | OSPRM6=0 |                                                          |
 | 01   | OSPRM5=0 |                                                          |
 | 00   | OSPRM4=1 |                                                          |
 +------+----------+----------------------------------------------------------+
```

1.40 CLXCON

```
                NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
CLXCON    098   W   A     Collision control

         This register controls which bitplanes are included (enabled) in
         collision detection, and their required state if included. It also
         controls the individual inclusion of odd numbered sprites in the
         collision detection, by logically ORing them with their correspond-
         ing even numbered sprite. Writing to this register resets the bits
         in
                CLXCON2
                .

         +------+----------+---------------------------------------------+
         | BIT# | FUNCTION | DESCRIPTION                                 |
         +------+----------+---------------------------------------------+
         | 15   | ENSP7    | Enable Sprite 7 (ORed with Sprite 6)        |
         | 14   | ENSP5    | Enable Sprite 5 (ORed with Sprite 4)        |
         | 13   | ENSP3    | Enable Sprite 3 (ORed with Sprite2)         |
         | 12   | ENSP1    | Enable Sprite 1 (ORed with Sprite 0)        |
         | 11   | ENSP6    | Enable bit plane 6 (match reqd. for collision |
         | 10   | ENSP5    | Enable bit plane 5 (match reqd. for collision |
         | 09   | ENSP4    | Enable bit plane 4 (match reqd. for collision |
         | 08   | ENSP3    | Enable bit plane 3 (match reqd. for collision |
         | 07   | ENSP2    | Enable bit plane 2 (match reqd. for collision |
         | 06   | ENSP1    | Enable bit plane 1 (match reqd. for collision |
         | 05   | ENSP6    | Match value for bit plane 6 collision       |
         | 04   | ENSP5    | Match value for bit plane 5 collision       |
         | 03   | ENSP4    | Match value for bit plane 4 collision       |
         | 02   | ENSP3    | Match value for bit plane 3 collision       |
         | 01   | ENSP2    | Match value for bit plane 2 collision       |
         | 00   | ENSP1    | Match value for bit plane 1 collision       |
         +------+----------+---------------------------------------------+
```

1.41 CLXCON2

```
                NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
CLXCON2 P  10C  W    D    Extended collision control

         This reg controls when bit planes 7 and 8 are included in collision
         detection, and there required state if included. Contents of this
         register are reset by a write to
```

CLXCON
.

BITS INITIALIZED BY RESET

BIT#	FUNCTION	DESCRIPTION
15-08		unused
07	ENBP8	Enable bit plane 8 (match reqd. for collision)
06	ENBP7	Enable bit plane 7 (match reqd. for collision)
05-02		unused
01	MVBP8	Match value for bit plane 8 collision
00	MVBP7	Match value for bit plane 7 collision

Note: Disable bit planes cannot prevent collisions. Therefore if all bitplanes are disabled, collision will be continuous, regardless of the match values.

1.42 CLXDAT

```
NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
CLXDAT   00E  R     D     Collision data reg. (read and clear)
```

This address reads (and clears) the collision detection reg. The bit assignments are below

Note: Playfield 1 is all odd numbered enabled bit planes.
Playfield 2 is all even numbred enabled bit planes.

BIT#	COLLISIONS REGISTERED
15	not used
14	Sprite 4 (or 5) to Sprite 6 (or 7)
13	Sprite 2 (or 3) to Sprite 6 (or 7)
12	Sprite 2 (or 3) to Sprite 4 (or 5)
11	Sprite 0 (or 1) to Sprite 6 (or 7)
10	Sprite 0 (or 1) to Sprite 4 (or 5)
09	Sprite 0 (or 1) to Sprite 2 (or 3)
08	Playfield 2 to Sprite 6 (or 7)
07	Playfield 2 to Sprite 4 (or 5)
06	Playfield 2 to Sprite 2 (or 3)
05	Playfield 2 to Sprite 0 (or 1)
04	Playfield 1 to Sprite 6 (or 7)
03	Playfield 1 to Sprite 4 (or 5)
02	Playfield 1 to Sprite 2 (or 3)
01	Playfield 1 to Sprite 0 (or 1)
00	Playfield 2 to Playfield 2

1.43 COLORx

```
NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
COLORxx  180-1BE  W       COLOR table xx
```

There 32 of these registers (xx=00-31) and together with the banking bits they address the 256 locations in the color palette. There are actually two sets of color regs, selection of which is controlled by the LOCT reg bit. When LOCT = 0 the 4 MSB of red, green and blue video data are selected along with the T bit for genlocks the low order set of registers is also selected as well, so that the 4 bits-values are automatically extended to 8 bits.This provides compatibility with old software. If the full range of palette values are desired, then LOCT can be set high and independant values for the 4 LSB of red, green and blue can be written. The low order color registers do not contain a transparency (T) bit.

The table below shows the color register bit usage.

BIT#	15,14,13,12	11,10,09,08	07,06,05,04	03,02,01,00
LOCT=0	T X X X	R7 R6 R5 R4	G7 G6 G5 G4	B7 B6 B5 B4
LOCT=1	X X X X	R3 R2 R1 R0	G3 G2 G1 G0	B3 B2 B1 B0

T = TRANSPARENCY, R = RED, G = GREEN, B = BLUE, X = UNUSED

T bit of COLOR00 thru COLOR31 sets ZD_pin HI, When that color is selected in all video modes.

1.44 COPCON

```
                NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
COPCON h  02E  W     A    Coproccessor control register
```

This is a-1 bit register that when set true, allows the coprocessor to access the blitter hardware. This bit is cleared power on reset, so that the coprocessor cannot access the blitter hardware.

BIT#	NAME	FUNCTION
01	CDANG	Coprocessor danger mode. Allows coprocessor access to all RGA registers if true. (if 0, access to RGA>7E) (On old chips access to only RGA>3E if CDANG=1) (see VPOSR)

1.45 COPJMP1

```
                NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
COPJMP1   088  S    A     Coprocessor restart at first location
```

See:

COPJMP2

1.46 COPJMP2

```
NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
COPJMP2   08A  S    A     Coprocessor restart at second location

         These address are strobe address, that when written to cause the
         coprocessor to jump indirect useing the address contained in the
         first or second location regs described below. The coprocessor itself
         can write to these address, causeing it‘s own jump indirect.
```

1.47 COP1LCH

```
                NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
COP1LCH h 080  W    A         A Coprocessor first location reg
                                (high 5 bits) (old-3 bits)
COP1LCL   082  W    A         A Coprocessor first location reg
                                (low 15 bits)
COP2LCH h 084  W    A         A Coprocessor second location reg
                                (high 5 bits) (old-3 bits)
COP2LCL   086  W    A         A Coprocessor second location reg
                                (low 15 bits)

         These regs contain the jump addresses described in
```

COPINS

1.48 COPINS

```
                NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
COPINS    08C  W   A      Coprocessor inst. fetch identify

         This is a dummy address that is generated by the coprocessor whenever
         it is loading instructions into its own instruction register.
         This actually occurs every coprocessor cycle except for the second
         (IR2) cycle of the MOVE instruction. The three types of instructions
         are shown below.

         MOVE: Move immediate to dest
```

```
WAIT: Wait until beam counter is equal to, or greater than.
      (Keeps coprocessor off of bus until beam position has
      been reached)

SKIP: Skip if beam counter is equal to, or greater than.
      (Skips following MOVE inst. unless beam position has been
      reached)
```

	MOVE		WAIT UNTIL		SKIP IF	
BIT#	IR1	IR2	IR1	IR2	IR1	IR2
15	x	RD15	VP7	BFD	VP7	BFD
14	x	RD14	VP6	VE6	VP6	VE6
13	x	RD13	VP5	VE5	VP5	VE5
12	x	RD12	VP4	VE4	VP4	VE4
11	x	RD11	VP3	VE3	VP3	VE3
10	x	RD10	VP2	VE2	VP2	VE2
09	x	RD09	VP1	VE1	VP1	VE1
08	DA8	RD08	VP0	VE0	VP0	VE0
07	DA7	RD07	HP8	HE8	HP8	HE8
06	DA6	RD06	HP7	HE7	HP7	HE7
05	DA5	RD05	HP6	HE6	HP6	HE6
04	DA4	RD04	HP5	HE5	HP5	HE5
03	DA3	RD03	HP4	HE4	HP4	HE4
02	DA2	RD02	HP3	HE3	HP3	HE3
01	DA1	RD01	HP2	HE2	HP2	HE2
00	0	RD00	1	0	1	1

```
IR1=First instruction register
IR2=Second insturction register
DA =Destination address for MOVE instruction.Fetched during
    IR1 time,used during IR2 time on RGA bus.
RD =RAM Data moved by MOVE instruction at IR2 time
    directly from RAM to the address given by the DA field.
VP =Vertical beam position comparison bit.
HP =Horizontal beam position comparison bit.
VE =Enable comparison (mask bit)
HE =Enable comparison (mask bit)

* Note: BFD = Blitter finished disable. When this bit is true, the blitter
              finished flag will have no effect on the coprocessor. When this
              bit is zero the blitter finished flag must be true (in addition
              to the rest of the bit comparisons) before the coprocessor can
              exit from it`s wait state, or skip over an instruction. Note
              that the V7 comparison cannot be masked.

The coprocessor is basically a 2 cycle machine that requests
the bus only during odd memory cycles. (4 memory cycles per in)

It has priority over the blitter and micro.

There are only three types of instructions, MOVE immediate,
WAIT until ,and SKIP if. All instructions require 2 bus cycles
```

```
(and two instruction words).Since only the odd bus cycles are
requested, 4 memory cycle times are required per instruction.
(memory cycles are 280 ns)

There are two indirect jump registers
       COP1LC
        and
       COP2LC
       .
These are 20 bit pointer registers whose contents are used to modify
program counter for initalization or jumps.

They are transfered to the program counter whenever strobe address

       COPJMP1
        or
       COPJMP2
        are written.In addition COP1LC is automatically
used at the beginning of each vertical blank time.

It is important that one of the jump registers be initalized and it`s
jump strobe address hit, after power up but before coprocessor DMA is
initalized.T his insures a determined startup address, and state.
```

1.49 DDFSTRT

```
NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
DDFSTRT  092  W  A  Display data fetch start(horiz. position)
DDFSTOP  094  W  A  Display data fetch stop (horiz. position)
  These registers control the horizontal timing of the beginning
  and end of the bit plane DMA timing display data fetch.
  The vertical bit plane DMA timing is identical to the display
  windows described above.
  The bit plane Modulos are dependent on the bit plane
  horizontal size, and on this data fetch window size.

  Register bit assignment
  -----------------------

  BIT# 15  14  13  12  11  10  09  08  07  06  05  04  03  02  01  00
  USE  XX   X   X   X   X   X   X  H8  H7  H6  H5  H4  H3  H2   X
    (X bits should always be driven with 0 to maintain upward
     compatability)

  The tables below show the start and stop timing for
  different register contents

         DDFSTRT (Left edge of display data fetch)
         +------------------+----+----+----+----+----+
         | PURPOSE          | H8 | H7 | H6 | H5 | H4 |
         +------------------+----+----+----+----+----+
         | Extra wide (max) | 0  | 0  | 1  | 0  | 1  |
         |                  |    |    |    |    |    |
         | wide             | 0  | 0  | 1  | 1  | 0  |
```

```
|                  |    |    |    |    |    |
| normal           | 0  | 0  | 1  | 1  | 1  |
|                  |    |    |    |    |    |
| narrow           | 0  | 1  | 0  | 0  | 0  |
+------------------+----+----+----+----+----+

DDFSTOP (Right edge of display data fetch)
+------------------+----+----+----+----+----+
| PURPOSE          | H8 | H7 | H6 | H5 | H4 |
+------------------+----+----+----+----+----+
| narrow           | 1  | 1  | 0  | 0  | 1  |
|                  |    |    |    |    |    |
| normal           | 1  | 1  | 0  | 1  | 0  |
|                  |    |    |    |    |    |
| wide (max)       | 1  | 1  | 0  | 1  | 1  |
+------------------+----+----+----+----+----+

Note that these numbers will vary with variable beam counter
mode set: (The maxes and mins, that is)
```

1.50 DIWSTRT

```
                NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
DIWSTRT 08E  W  A D   Display window start (upper left vert-hor pos)
DIWSTOP 090  W  A D   Display window stop (lower right vert-hor pos)
  These registers control the display window size and position,
  by locating the upper left and lower right corners.

  BIT# 15  14  13  12  11  10  09  08  07  06  05  04  03  02  01  00
  USE  V7  V6  V5  V4  V3  V2  V1  V0  H9  H8  H7  H6  H5  H4  H3  H2

  DIWSTRT is vertically restricted to the upper 2/3
  of the display (v8=0),and horizontally restricted to the
  left 3/4 of the display (H8=0).*
  * Poof.. (see
                DIWHIGH
                 for exceptions)
```

1.51 DIWHIGH

```
                NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
DIWHIGH  p 1E4  W  A D Display window upper bits for start, stop
  This is an added register for Hires chips, and allows
  larger start & stop ranges. If it is not written, the above
  (
                DIWSTRT
                ,STOP) description holds. If this register is written,
  direct start & stop positions anywhere on the screen.
  It doesn`t affect the UHRES pointers.
```

```
BIT# 15  14  13  12  11  10  09  08  07  06  05  04  03  02  01  00
      X   X  H10 H1  H0  V10 V9  V8   X   X  H10 H1  H0  V10 V9  V8
                   (stop)                |          (start)
```

Take care (X) bits should always be written to 0 to maintain upwards compatibility. H1 and H0 values define 70ns amd 35ns increments respectively, and new LISA bits.

Note: In all 3 display window registers, horizontal bit positions have been renamed to reflect HIRES pixel increments, e.g. what used to be called H0 is now referred to as H2.

1.52 DMACON

```
NAME    rev ADDR type chip Description
---------------------------------------------------------------------------
DMACON  096  W  A D P DMA control write (clear or set)
DMACONR 002  R  A   P DMA control (and blitter status) read
```

This register controls all of the DMA channels, and contains blitter DMA status bits.

BIT#	FUNCTION	DESCRIPTION
15	SET/CLR	Set/Clear control bit. Determines if bits written wit a 1 get set or cleared. Bits written witn a zero are unchanged.
14	BBUSY	Blitter busy status bit (read only)
13	BZERO	Blitter logic zero status bit. (read only)
12	X	
11	X	
10	BLTPRI	Blitter DMA prioiry (over CPU micro) (also called "blitter nasty") (disables /BLS pin, preventing micro from stealing any bus cycles while blitter DMA is running)
09	DMAEN	Enable all DMA below (also UHRES DMA)
08	BPLEN	Bit plane DMA enable
07	COPEN	Coprocessor DMA enable
06	BLTEN	Blitter DMA enable
05	SPREN	Sprite DMA enable
04	DSKEN	Disk DMA enable
03	AUD3EN	Audio chanel 3 DMA enable
02	AUD2EN	Audio chanel 2 DMA enable
01	AUD1EN	Audio chanel 1 DMA enable
00	AUD0EN	Audio chanel 0 DMA enable

1.53 dskpth

```
NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
DSKPTH h 020 W  A Disk pointer (high 5 bits) (old-3 bits)
DSKPTL   022 W  A Disk pointer (low 15 bits)

    This pair of registers contains the 20 bit address
    of disk DMA data. These address registers must be
    initalized by the processor or coprocessor
    before disk DMA is enabled.
```

1.54 DSKLEN

```
NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
DSKLEN  024 W   P    Disk length

   This register contains the length (number of words) of
   disk DMA data. It also contains 2 control bits. These
   are a DMA enable bit, and a DMA direction (read/write) bit.

         +------+----------+------------------------------------+
         | BIT# | FUNCTION | DESCRIPTION                        |
         +------+----------+------------------------------------+
         | 15   | DMAEN    | Disk DMA enable                    |
         | 14   | WRITE    | Disk write (RAM or disk) if 1      |
         | 13-0 | LENGTH   | Length (# of words) of DMA data.   |
         +------+----------+------------------------------------+
```

1.55 DSKDAT

```
NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
DSKDAT  026 W  P  Disk DMA data write
```

1.56 DSKDATR

```
NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
DSKDATR 008 ER   P  Disk DMA  data read (early read dummy address)

  This register is the disk-DMA data buffer.It contains 2
  bytes of data that are either sent to (write) or received
  from (read) the disk. The DMA controller automatically
  transfers data to or from this register and RAM, and when
  the DMA data is finished (length=0) it causes a disk
  block interrupt. See interrupts below.
```

1.57 DSKBYTR

```
                NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
DSKBYTR 01A  R  p Disk data byte and status read

  This register is the Disk-Microrocessor data buffer.
  Data from the disk (in read mode) is leaded into this
  register one byte at a time, and bit 15 (DSKBYT) is set true.

        +-------+----------+---------------------------------------------------+
        | BIT#  | FUNCTION | DESCRIPTION                                       |
        +-------+----------+---------------------------------------------------+
        | 15    | DSKBYT   | Disk byte ready (reset on read)                   |
        | 14    | DMAON    | DMAEN (DSKLEN) & DMAEN (DMACON) & DSKEN (DMACON) |
        | 13    | DISKWRITE| Mirror of bit 14 (WRITE) in DSKLEN                |
        | 12    | WORDEQUAL| This bit true only while
                DSKSYNC
                 register        |
        |       |          | equals the data from disk                         |
        | 11-08 | 0        | Not used                                          |
        | 07-00 | DATA     | Disk byte data                                    |
        +-------+----------+---------------------------------------------------+
```

1.58 DSKSYNC

```
                NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
DSKSYNC  07E W    P Disk sync register,the match code for disk
              read synchronization. See
                ADKCON
                 bit 10
```

1.59 FMODE

```
NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
FMODE P  1FC W      Memory Fetch Mode
    This register controls the fetch mechanism for different
    types of Chip RAM accesses:

         +-------+----------+--------------------------------------------+
         | BIT#  | FUNCTION | DESCRIPTION                                |
         +-------+----------+--------------------------------------------+
         | 15    | SSCAN2   | Global enable for sprite scan-doubling.    |
         | 14    | BSCAN2   | Enables the use of 2nd P/F modulus on an   |
         |       |          | alternate line basis to support bitplane   |
         |       |          | scan-doubling.                             |
         | 13-04 | Unused   |                                            |
         | 03    | SPAGEM   | Sprite page mode (double CAS)              |
         | 02    | SPR32    | Sprite 32 bit wide mode                    |
         | 01    | BPAGEM   | Bitplane Page Mode (double CAS)            |
```

```
| 00     | BLP32     | Bitplane 32 bit wide mode                    |
+--------+----------+---------------------------------------------+

+------+-----+---------------+-----------+--------------+---------+
|BPAGEM|BPL32| Bitplane Fetch|Increment   | Memory Cycle |Bus Width|
+------+-----+---------------+-----------+--------------+---------+
| 0    |  0  | By 2 bytes    |(as before)|normal CAS    |16       |
| 0    |  1  | By 4 bytes    |           |normal CAS    |32       |
| 1    |  0  | By 4 bytes    |           |double CAS    |16       |
| 1    |  1  | By 8 bytes    |           |double CAS    |32       |
+------+-----+---------------+-----------+--------------+---------+

+------+-----+------------+-----------+-------------+---------+
|SPAGEM|SPR32|Sprite Fetch|Increment  |Memory Cycle |Bus Width|
+------+-----+------------+-----------+-------------+---------+
|  0   |  0  | By 2 bytes |(as before)| normal CAS  |   16    |
|  0   |  1  | By 4 bytes |           | normal CAS  |   32    |
|  1   |  0  | By 4 bytes |           | double CAS  |   16    |
|  1   |  1  | By 8 bytes |           | double CAS  |   32    |
+------+-----+------------+-----------+-------------+---------+
```

1.60 HBSTOP

```
NAME   rev ADDR type chip Description
-----------------------------------------------------------------------------
HBSTOP 1C6 W   D    Horizontal STOP position
HBSTRT 1C4 W   D    Horizontal START position

   Bits 7-0 contain the stop and start positions,
   respectively, for programed horizontal blanking in
   280nS increments.Bits 10-8 provide a fine position
   control in 35nS increments.


         +-------+----------+--------------+
         | BIT#  | FUNCTION | DESCRIPTION  |
         +-------+----------+--------------+
         | 15-11 |  x       | (unused)     |
         | 10    |  H1      | 140nS        |
         | 09    |  H1      | 70nS         |
         | 08    |  H0      | 35nS         |
         | 07    |  H10     | 35840nS      |
         | 06    |  H9      | 17920nS      |
         | 05    |  H8      | 8960nS       |
         | 04    |  H7      | 4480nS       |
         | 03    |  H6      | 2240nS       |
         | 02    |  H5      | 1120nS       |
         | 01    |  H4      | 560nS        |
         | 00    |  H3      | 280nS        |
         +-------+----------+--------------+
```

1.61 HCENTER

```
                NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
HCENTER H 1E2  W  A  Horizontal position (CCKs) of VSYNC on long field
```

this is necessary for interlace mode with variable beam counters. See BEAMCON0 for when it affects chip outputs. See HTOTAL for bits.

1.62 HHPOSR

```
                NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
HHPOSR  H 1DA  R  A  DUAL mode hires Hbeam counter read
HHPOSW  H 1D8  W  A  DUAL mode hires Hbeam counter write
```

This the secondary beam counter for the faster mode, triggering the UHRES pointers & doing the comparisons for HBSTRT , STOP, HTOTAL, HSSRT, HSSTOP (See HTOTAL for bits)

1.63 HSSTOP

```
                NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
HSSTOP H  1C2  W  A   Horiz line position for SYNC stop
```

Sets # of colour clocks for sync stop (HTOTAL for bits)

1.64 HSSTRT

```
                NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
HSSTRT H  1DE  W  A  Horiz line position for HSYNC stop
```

Sets # of colour clocks for sync start (HTOTAL for bits) See

```
                BEAMCON0
                 for details of when these 2 are active.
```

1.65 HTOTAL

```
NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
HTOTAL H  1C0  W  A    Highest colour clock count in horiz line


  BIT#  15  14  13  12  11  10  09  08  07  06  05  04  03  02  01  00
         x   x   x   x   x   x   x   x  h8  h7  h6  h5  h4  h3  h2  h1

   (x's should be driven to 0 for upward compatibility)
  Horiz line has theis many + 1 280nS increments. If the
  pal bit & LOLDIS are not high, long line/skort line toggle
  will occur, and there will be this many +2 every other line.
  Active if VARBEAMEN=1 or DUAL+1.
```

1.66 INTREQ

```
NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
INTREQ   09C  W          P Interrupt request bits (clear or set)
INTREQR  01E  R          P Interrupt request bits (read)

  This register contains interrupt request bits (or flags).
  These bits may be polled by the processor, and if enabled
  by the bits listed in the next register, they may cause
  processor interrupts. Both a set and clear operation
  are required to load arbitary data into this register.
  The bit assignments are identical to the enable register
  below.
```

1.67 INTENA

```
                NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
INTENA   09A  W       P Interrupt enable bits (clear or set bits)
INTENAR  01C  R         P Interrupt enable bits (read)

  This register contains interrupt enable bits. The bit
  assignment for both the request, and enable registers
  is given below.

 +------+----------+-------+-------------------------------------------+
 | BIT# | FUNCTION | LEVEL | DESCRIPTION                               |
 +------+----------+-------+-------------------------------------------+
 | 15   |  SET/CLR |       | Set/clear control bit. Determines if bits  |
 |      |          |       | written with a 1 get set or cleared. Bits  |
```

```
|      |          |       | written with a zero are always unchanged.  |
| 14   |  INTEN   |       | Master interrupt (enable only, no request) |
| 13   |  EXTER   |   6   | External interrupt                         |
| 12   |  DSKSYN  |   5   | Disk sync register (
                DSKSYNC
                ) matches disk  |
| 11   |  RBF     |   5   | Serial port receive buffer full            |
| 10   |  AUD3    |   4   | Audio channel 3 block finished             |
| 09   |  AUD2    |   4   | Audio channel 2 block finished             |
| 08   |  AUD1    |   4   | Audio channel 1 block finished             |
| 07   |  AUD0    |   4   | Audio channel 0 block finished             |
| 06   |  BLIT    |   3   | Blitter has finished                       |
| 05   |  VERTB   |   3   | Start of vertical blank                    |
| 04   |  COPER   |   3   | Coprocessor                                |
| 03   |  PORTS   |   2   | I/O Ports and timers                       |
| 02   |  SOFT    |   1   | Reserved for software initated interrupt.  |
| 01   |  DSKBLK  |   1   | Disk block finished                        |
| 00   |  TBE     |   1   | Serial port transmit buffer empty          |
+------+----------+-------+--------------------------------------------+
```

1.68 JOYxDAT

```
                NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
JOY0DAT  00A R     D   Joystick-mouse 0 data (left vert, horiz)
JOY1DAT  00C R     D   Joystick-mouse 1 data (right vert,horiz)

  These addresses each read a 16 bit register. These in turn
  are loaded from the MDAT serial stream and are clocked in on
  the rising edge of SCLK. MLD output is used to parallel load
  the external parallel-to-serial converter.This in turn is
  loaded with the 4 quadrature inputs from each of two game
  controller ports (8 total) plus 8 miscellaneous control bits
  which are new for LISA and can be read in upper 8 bits of

                LISAID
                .
  Register bits are as follows:
  Mouse counter usage (pins  1,3 =Yclock, pins 2,4 =Xclock)

    BIT#  15  14  13  12  11  10  09  08      07  06  05  04  03  02  01  00
JOY0DAT   Y7  Y6  Y5  Y4  Y3  Y2  Y1  Y0      X7  X6  X5  X4  X3  X2  X1  X0
JOY1DAT   Y7  Y6  Y5  Y4  Y3  Y2  Y1  Y0      X7  X6  X5  X4  X3  X2  X1  X0


  0=LEFT CONTROLLER PAIR, 1=RIGHT CONTROLLER PAIR.
  (4 counters total).The bit usage for both left and right
  addresses is shown below. Each 6 bit counter (Y7-Y2,X7-X2) is
  clocked by 2 of the signals input from the mouse serial
  stream. Starting with first bit recived:

         +--------------------+-----------------------------------------+
         | Serial | Bit Name | Description                              |
         +--------+----------+------------------------------------------+
         |   0    | M0H      | JOY0DAT Horizontal Clock                 |
```

```
|    1    | M0HQ     | JOY0DAT Horizontal Clock (quadrature)   |
|    2    | M0V      | JOY0DAT Vertical Clock                  |
|    3    | M0VQ     | JOY0DAT Vertical Clock  (quadrature)    |
|    4    | M1V      | JOY1DAT Horizontall Clock               |
|    5    | M1VQ     | JOY1DAT Horizontall Clock (quadrature)  |
|    6    | M1V      | JOY1DAT Vertical Clock                  |
|    7    | M1VQ     | JOY1DAT Vertical Clock (quadrature)     |
+--------+----------+------------------------------------------+

Bits 1 and 0 of each counter (Y1-Y0,X1-X0) may be
read to determine the state of the related input signal pair.
This allows these pins to double as joystick switch inputs.
Joystick switch closures can be deciphered as follows:

+------------+------+--------------------------------+
| Directions | Pin# | Counter bits                   |
+------------+------+--------------------------------+
| Forward    |  1   | Y1 xor Y0 (BIT#09 xor BIT#08)  |
| Left       |  3   | Y1                             |
| Back       |  2   | X1 xor X0 (BIT#01 xor BIT#00)  |
| Right      |  4   | X1                             |
+------------+------+--------------------------------+
```

1.69 JOYTEST

```
                NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
JOYTEST  036 W   D     Write to all 4  joystick-mouse counters at once.

      Mouse counter write test data:
     BIT#  15  14  13  12  11  10  09  08     07  06  05  04  03  02  01  00

                JOY0DAT
                  Y7  Y6  Y5  Y4  Y3  Y2  xx  xx     X7  X6  X5  X4  X3  X2  xx  ↩
                     xx

                JOY1DAT
                  Y7  Y6  Y5  Y4  Y3  Y2  xx  xx     X7  X6  X5  X4  X3  X2  xx  ↩
                     xx
```

1.70 LISAID

```
NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
LISAID  H  07C  R   D    Denise/Lisa (video out chip) revision level

  The original Denise (8362) does not have this register, so
  whatever value is left over on the bus from the last cycle
  will be there. ECS Denise (8373) returns hex (fc) in the lower
  8 bits.Lisa returns hex (f8). The upper 8 bits of this
  Register are loaded from the serial mouse bus, and are
  reserved for future hardware implentation.
```

```
  The 8 low-order bits are encoded as follows:

         +------+-----------------------------------------------------+
         | BIT# | Description                                         |
         +------+-----------------------------------------------------+
         | 7-4  | Lisa/Denise/ECS Denise Revision level(decrement to  |
         |      | bump revision level, hex F represents 0th rev. level). |
         |   3  | Maintain as a 1 for future generation               |
         |   2  | When low indicates AA feature set (LISA)            |
         |   1  | When low indicates ECS feature set (LISA or ECS DENISE) |
         |   0  | Maintain as a 1 for future generation               |
         +------+-----------------------------------------------------+
```

1.71 POTxDAT

```
NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
POT0DAT h  012  R       P  Pot counter data left pair (vert, horiz)
POT1DAT h  014  R       P  Pot counter data right pair (vert,horiz)

  These addresses each read a pair of 8 bit pot counters.
  (4 counters total). The bit assignment for both
  addresses is shown below. The counters are stopped by signals
  from 2 controller connectors (left-right) with 2 pins each.

  BIT#  15  14  13  12  11  10  09  08     07  06  05  04  03  02  01  00
 RIGHT  Y7  Y6  Y5  Y4  Y3  Y2  Y1  Y0     X7  X6  X5  X4  X3  X2  X1  X0
  LEFT  Y7  Y6  Y5  Y4  Y3  Y2  Y1  Y0     X7  X6  X5  X4  X3  X2  X1  X0

         +--------------------------+-------+
         | CONNECTORS               | PAULA |
         +-------+------+-----+-----+-------+
         | Loc.  | Dir. | Sym | pin | pin   |
         +-------+------+-----+-----+-------+
         | RIGHT | Y    | RX  | 9   | 33    |
         | RIGHT | X    | RX  | 5   | 32    |
         | LEFT  | Y    | LY  | 9   | 36    |
         | LEFT  | X    | LX  | 5   | 35    |
         +-------+------+-----+-----+-------+

         With normal (NTSC or PAL) horiz. line rate, the pots will
         give a full scale (FF) reading with about 500kohms in one
         frame time. With proportionally faster horiz line times,
         the counters will count proportionally faster.
         This should be noted when doing variable beam displays.
```

1.72 POTGO

```
NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
POTGO  034 W      P   Pot port (4 bit) bi-direction and data,
```

```
                      and pot counter start.
```

1.73 POTINP

```
NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
POTINP 016 R      P Pot pin data read

  This register controls a 4 bit bi-direction I/O port
  that shares the same 4 pins as the 4 pot counters above.

         +-------+----------+------------------------------------------+
         | BIT#  | FUNCTION | DESCRIPTION                              |
         +-------+----------+------------------------------------------+
         | 15    | OUTRY    | Output enable for Paula pin 33           |
         | 14    | DATRY    | I/O data Paula pin 33                    |
         | 13    | OUTRX    | Output enable for Paula pin 32           |
         | 12    | DATRX    | I/O data Paula pin 32                    |
         | 11    | OUTLY    | Out put enable for Paula pin 36          |
         | 10    | DATLY    | I/O data Paula pin 36                    |
         | 09    | OUTLX    | Output enable for Paula pin 35           |
         | 08    | DATLX    | I/O data  Paula pin 35                   |
         | 07-01 |   X      | Not used                                 |
         | 00    | START    | Start pots (dump capacitors,start counters) |
         +-------+----------+------------------------------------------+
```

1.74 REFPTR

```
NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
REFPTR   028  W   A     Refresh pointer

  This register is used as a dynamic RAM refresh address
  generator. It is writeable for test purposes only,and
  should never be written by the microprocesor.
```

1.75 SERDAT

```
NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
SERDAT  030  W      P   Serial port data and stop bits write.

  This address writes data to a transmit data buffer.
  Data from this buffer is moved into a serial shift register
  for output transmission whenever it is empty.This sets the
  interrupt request TBE  (transmit buffer empty). A stop bit
  must be provided as part of the data word. The length
  of the data word is set by the position of the stop bit.
```

```
BIT#  15  14  13  12  11  10  09  08     07  06  05  04  03  02  01  00
USE    0   0   0   0   0   0   S  D8     D7  D6  D5  D4  D3  D2  D1  D0

Note :  S= Stop bit =1, D= data bits
```

1.76 SERDATR

```
NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
SERDATR  018  R      P  Serial port data and status read.

  This address reads data from a recive data buffer.
  Data in this buffer is loaded from a receiving shift
  register whenever it is full. Several interrupt request
  bits are also read at this address, along with the data as
  shown below.

         +------+----------+------------------------------------------+
         | BIT# | FUNCTION | DESCRIPTION                              |
         +------+----------+------------------------------------------+
         | 15   | OVRUN    | Serial port receiver overun              |
         | 14   | RBF      | Serial port receive buffer full (mirror) |
         | 13   | TBE      | Serial port transmit buffer empty (mirror) |
         | 12   | TSRE     | Serial port transmit shift reg. empty    |
         | 11   | RXD      | RXD pin receives UART serial data for    |
         |      |          | direct bit test by the micro.            |
         | 10   | X        | Not used.                                |
         | 09   | STP      | Stop bit                                 |
         | 08   | STP-DB8  | Stop bit if LONG, data bit if not.       |
         | 07   | DB7      | Data bit.                                |
         | 06   | DB6      | Data bit.                                |
         | 05   | DB5      | Data bit.                                |
         | 04   | DB4      | Data bit.                                |
         | 03   | DB3      | Data bit.                                |
         | 02   | DB2      | Data bit.                                |
         | 01   | DB1      | Data bit.                                |
         | 00   | DB0      | Data bit.                                |
         +------+----------+------------------------------------------+
```

1.77 SERPER

```
NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
SERPER  032  W        P    Serial port period and control.

   This register contains the control bit LONG reffered to
   above, and a 15 bit number defining the serial port
   Baud rate.If this number is N,then the baud rate is
   1 bit every (N+1)*.2794 microseconds.

         +-------+----------+------------------------------------------+
         | BIT#  | FUNCTION | DESCRIPTION                              |
```

```
+-------+----------+---------------------------------------------+
| 15    | LONG     | Defines serial receive as 9 bit word.       |
| 14-00 | RATE     | Defines baud rate=1/((N+1)*.2794 microseconds) |
+-------+----------+---------------------------------------------+
```

1.78 SPRHDAT

```
NAME   rev ADDR type chip Description
----------------------------------------------------------------------------
SPRHDAT  H 078   W  exe logic UHRES sprite identifier and data

  This identifies the cycle when this pointer address is on
  the bus accessing the memory.
```

1.79 SPRHPTH

```
NAME   rev ADDR type chip Description
----------------------------------------------------------------------------
SPRHPTH  H  1E8  W   A    UHRES sprite pointer (high 5 bits)
SPRHPTL  H  1EA  W   A    UHRES sprite pointer (low 15 bits)

  This pointer is activated in the 1st and 3rd `free` cycles
  (see BPLHPTH,L) after horiz line start.It increments
  for the next line.
```

1.80 SPRHSTOP

```
                NAME   rev ADDR type chip Description
----------------------------------------------------------------------------
SPRHSTOP H 1D2  W    A    UHRES sprite vertical display stop

    BIT#  15  14  13  12  11  10  09  08      07  06  05  04  03  02  01  00
SPRHWRM   x   x   x   x   x  v10  v9  v8      v7  v6  v5  v4  v3  v2  v1  v0

  SPRHWRM = Swaps the polarity of ARW* when the
                SPRHDAT
                 comes
  out so that external devices can detect the RGA and put
  things into memory.(ECS and later chips only)
```

1.81 SPRHSTRT

```
NAME   rev ADDR type chip Description
----------------------------------------------------------------------------
SPRHSTRT H 1D0  W   A     UHRES sprite vertical display start

 BIT#  15  14  13  12  11  10  09  08      07  06  05  04  03  02  01  00
        x   x   x   x   x  v10 v9  v8      v7  v6  v5  v4  v3  v2  v1  v0
```

1.82 SPRxPTH

```
NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
SPRxPTH    120  W    A      Sprite x pointer (High 5 bits)
SPRxPTL    122  W    A      Sprite x pointer (low 15 bits)

  This pair of registers contains the 20 bit address
  of sprite x (x=0,1,2,3,4,5,6,7) DMA data.These address
  registers must be initalized by the processor or coprocessor
  every vertical blank time.
```

1.83 sprxpos

```
                NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
SPRxPOS   140   W    A  D   Sprite x vert-horiz start position data.

         +-------+----------+----------------------------------------------+
         | BIT#  | SYM      | FUNCTION                                     |
         +-------+----------+----------------------------------------------+
         | 15-08 | SV7-SV0  | Start vertical value.High bit (SV8) is       |
         |       |          | in SPRxCTL register below.                   |
         | 07-00 | SH10-SH3 | Sprite horizontal start value. Low order     |
         |       |          | 3 bits are in
                SPRxCTL
                 register below. If       |
         |       |          | SSCAN2 bit in
                FMODE
                 is set, then disable       |
         |       |          | SH10 horizontal coincidence detect.This bit    |
         |       |          | is then free to be used by ALICE as an       |
         |       |          | individual scan double enable.               |
         +-------+----------+----------------------------------------------+
```

1.84 sprxctl

```
NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
SPRxCTL p 142 W     A  D   Sprite position and control data

         +-------+----------+----------------------------------------------+
         | BIT#  | SYM      | FUNCTION                                     |
         +-------+----------+----------------------------------------------+
         | 15-08 | EV7-EV0  | End (stop) vert. value. Low 8 bits           |
         | 07    | ATT      | Sprite attach control bit (odd sprites only)  |
         | 06    | SV9      | Start vert value 10th bit.                   |
         | 05    | EV9      | End (stop) vert. value 10th bit              |
         | 04    | SH1=0    | Start horiz. value, 70nS increment           |
         | 03    | SH0=0    | Start horiz. value 35nS increment            |
         | 02    | SV8      | Start vert. value 9th bit                    |
         | 01    | EV8      | End (stop) vert. value 9th bit               |
```

```
| 00    | SH2      | Start horiz.value,140nS increment              |
+-------+----------+------------------------------------------------+
```

These 2 registers work together as position, size and feature sprite control registers.They are usually loaded by the sprite DMA channel, during horizontal blank, however they may be loaded by either processor any time. Writing to SPRxCTL disables the corresponding sprite.

1.85 SPRxDAT

```
NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
SPRxDATA  144  W      D    Sprite x image data register A
SPRxDATB  146  W      D    Sprite x image data register B
```

These registers buffer the sprite image data.They are usually loaded by the sprite DMA channel but may be loaded by either processor at any time. When a horizontal coincidence occurs the buffers are dumped into shift registers and serially outputed to the display, MSB first on the left.
NOTE: Writing to the A buffer enables (arms) the sprite. Writing to the SPRxCTL registers disables the sprite. If enabled, data in the A and B buffers will be output whenever the beam counter equals the sprite horizontal position value in the SPRxPOS register. In lowres mode, 1 sprite pixel is 1 bitplane pixel wide.In HRES and SHRES mode, 1 sprite pixel is 2 bitplane pixels. The DATB bits are the 2SBs (worth 2) for the color registers, and MSB for SHRES. DATA bits are LSBs of the pixels.

1.86 STREQU

```
                NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
STREQU    038   S    D    Strobe for horiz sync with VB (vert blank) and EQU
STRVBL    038   S    D    Strobe for horiz sync with VB
STRHOR    03C   S    D P  Strobe for horiz sync
STRLONG h 03E   S    D    Strobe for identification of long horiz line (228CC)
```

One of the first 3 strobe addresses above, it is placed on the RGA bus during the first refresh time slot of every other line, to identify lines with long counts (228- NTSC,
HTOTAL
+2- VARBEAMEN=1
hires chips only).There are 4 refresh time slots and any not used for strobes will leave a null (1FE) address on the RGA bus.

1.87 vbstop

```
                NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
VBSTOP H 1CE   W    A    Vertical line for VBLANK stop
VBSRTR H 1CC   W    A    Vertical line for VBLANK start
    (V10-0 <- D10-0) Affects CSY pin if BLAKEN=1 and VSY pin
    if CSCBEN=1 (see
                BEAMCON0
                )
```

1.88 VPOSR

```
                NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
VPOSR  p 004   R    A   Read vert most sig. bits (and frame flop)
VPOSW    02A   W    A   Write most sig. bits (and frame flop)


 BIT#  15  14  13  12  11  10  09  08     07  06  05  04  03  02  01  00
 USE LOF   I6  I5  I4  I3  I2  I1  I0 LOL --  --  --  --  --  V10 V9  V8

         LOF = Long frame(auto toggle control bit in
                BPLCON0
                )

         I0-I6 Chip identitication:

         8361 (Regular) or 8370 (Fat) (Agnus-ntsc) = 10
         8367 (Pal) or 8371 (Fat-Pal) (Agnus-pal)  = 00
         8372 (Fat-hr) (agnushr),thru rev4         = 20 Pal, 30 NTSC
         8372 (Fat-hr) (agnushr),rev 5             = 22 Pal, 31 NTSC
         8374 (Alice) thru rev 2                   = 22 Pal, 32 NTSC
         8374 (Alice) rev 3 thru rev 4             = 23 Pal, 33 NTSC

         LOL = Long line bit. When low, it indicates short raster line.
         v9,10 -- hires chips only (20,30 identifiers)
```

1.89 VHPOSR

```
NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
VHPOSR     006  R   A    Read vert and horiz position of beam, or lightpen
VHPOSW     02C  W   A    Write vert horiz position of beam, or lightpen
 BIT#  15  14  13  12  11  10  09  08     07  06  05  04  03  02  01  00
 USE   V7  V6  V5  V4  V3  V2  V1  V0     H8  H7  H6  H5  H4  H3  H2  H1

    RESOLUTION = 1/160 of SCREEN WITH ( 280 nS)
```

1.90 VSSTOP

```
                NAME   rev ADDR type chip Description
---------------------------------------------------------------------------
VSSTOP H   1CA W   A   Vert position for VSYNC start
VTOTAL H   1C8 W   A   Highest numbered vertival line (VARBEAMEN = 1)

  It‘s the line number to reset the counter,
  so there‘s this many + 1 in a field. The exception is
  if the LACE bit is set (
                BPLCON0
                ), in which case every
  other field is this many + 2 and the short field is this
  many + 1.
```

1.91 lisamodes

```
                5. New LISA Display Modes

        We now have a palette of 2~24 colours.

        LORES  (320x200)
        ----------------

        6 Bitplane (non HAM, non EHB)   64 colours      !
        7 Bitplane                      128 colours                     !
        8 Bitplane                      256 colours                     !
        8 Bitplane HAM                  Any 2^24 colours                !

        Dual playfield, Max 4 bitplane per playfield. 16 colours        !
        per playfield. The bank of 16 colours in the 256 colour palette
        is selectable per playfield.

        HIRES  (640x200)
        ----------------

        5 Bitplanes             32 colours        @
        6 Bitplanes             64 colours                              @
        7 Bitplanes             128 colours                             @
        8 Bitplanes             256 colours                             @
        6 Bitplanes EHB         32 * 2 colours                          @
        6 Bitplanes HAM         4096 colours                            @
        8 Bitplanes HAM         any of 2^24 colours                     @

        Dual playfield, max 4 bitplane per playfield 16 colours per     ! or @
        playfield. The bank of 16 colours in the 256 colour palette
        is selectable per playfield.

        SUPERHIRES (1280X200)
        ---------------------

        1 or 2 bitplanes, as ECS, but no colour fudging     !
        3 Bitplanes   8 colours       @
        4 Bitplanes   16 colours        @
```

```
5 Bitplanes   32 colours        $
6 Bitplanes   64 colours        $
7 Bitplanes   128 colours       $
8 Bitplanes   256 colours       $
6 Bitplanes EHB         32 * 2 colours        $
6 Bitplanes HAM   4O96 colours       $
8 Bitplanes HAM         any of 2~24 colours     $

Dual Playfield, max 4 bitplanes per playfield     @ or $
16 colours per playfield. The bank of 16 of colours
in the 256 colours palette is selectable per playfield.

VGA  (640X480 non-interlaced)
-----------------------------


1 or 2 bitplanes, as ECS, but no colour fudging     !
3 Bitplanes   8 colours       @
4 Bitplanes   16 colours        @
5 Bitplanes   32 colours        $
6 Bitplanes   64 colours        $
7 Bitplanes   128 colours       $
8 Bitplanes   256 colours       $
6 Bitplanes EHB         32 * 2 colours        $
6 Bitplanes HAM   4O96 colours       $
8 Bitplanes HAM         any of 2~24 colours     $

Dual playfield,Max 4 bitplanes per playfield           @ or $
16 colours per playfield . The bank of 16 colours
in the 256 colour palette is selectable per playfield


Super 72 (848x614 interlaced, 70 Hz frame rate)
-----------------------------------------------


1 or 2 bitplanes, as ECS, but no colour fudging          1X
3 Bitplanes                     8 colours                2X
4 Bitplanes                     16 colours               2X
5 Bitplanes                     32 colours               4X
6 Bitplanes                     64 colours               4X
7 Bitplanes                     128 colours              4X
8 Bitplanes                     256 colours              4X
6 Bitplanes EHB                 32 * 2 colours           4X
6 Bitplanes HAM                 4O96 colours             4X
8 Bitplanes HAM                 any of 2~24 colours      4X

Dual playfield,Max 4 bitplanes per playfield             2X or 4X
16 colours per playfield . The bank of 16 colours
in the 256 colour palette is selectable per playfield


All playfield scrolling is now in 35ns increments.
Pre AA scrolling was in 140ns increments.

Scroll Range as Programmed in
BPLCON1
```

1X Modes	LORES Pixels	SHRES Pixels
LORES	0-15	0-63
HIRES	0-7	0-31
SHRES	0-3	0-15

2X Modes	LORES Pixels	SHRES Pixels
LORES	0-31	0-127
HIRES	0-15	0-63
SHRES	0-7	0-31

4X Modes	LORES Pixels	SHRES Pixels
LORES	0-63	0-255
HIRES	0-31	0-127
SHRES	0-15	0-63

Sprites

All sprites can now be displayed in either:

1) ECS default mode
2) 140 ns (this is not ECS mode!)
3) 70 ns
4) 35 ns

on display resolution. eg 35 ns sprites on a lores screen, or 140 ns sprites on a superhires screen.

Sprites are either 16, 32, or 64 bits wide.

Sprites can be attatched in any mode (formerly could not attach sprites in the ECS SHRES 35ns resolution mode).

Can use any bank of 16 colours from the 256 colour palette for the sprite colours.

Key:

! needs 1x Bandwidth (old modes)
@ needs 2x Bandwidth (normal CAS 32bit bus with or double CAS 16 bit bus width)
$ needs 4x Bandwidth (double CAS 32bit bus width)