06/25/91

INTEGRATED CIRCUIT SPECIFICATION

for the

LISA

DISPLAY CONTROLLER

Commodore P/N XXXXXX-XX

PRELIMINARY

06/29/91:	added sheet behind cover which addresses changes to the current revision.
06/13/91:	corrected 3.4.12-15(SCLK),3.4.20(WIDE),3.4.28(video)
06/07/91:	removed functional definition already included in AA spec, corrected desription of ECSENA
06/03/91:	SCLK,MLD_,WIDE now all spec'd for 2TTL/50pF
05/08/91:	modified MLD_,WIDE parametric specs.
05/03/91:	cleaned up parametric specs,clarified ECSENA
04/30/91:	revised description of LISAID
11/14/90:	moved FMODE to 1FC, added scan-doubling
08/29/90:	PINS 24 & 25 REVERSED IN PINOUT

List of changes to R1:

1.) FMODE now resides at $1FC not $076 as before.
2.) Data bus drivers now disabled on D(15:0)
3.) internal data bus configuration logic changes state 1/2 bus cycle later(should be transparent to ATE)
4.) RDRAM bit moved to BPLCON2 from BPLCON3 (may have already been done to R0A ???)
5.) Sprite scan-double mod: FMODE(15) (SSCAN2) when high causes SH10 bit compare of sprite position to be disabled, in other words a "don't care".
6.) BRDRBLNK logic fixed: BLANK=OLDCBD+BRDRBLNK*DSPN-
7.) Newtek fix - hardwired end of blanking occurs 140nS earlier, at $05D.
8.) OSPRMx bits are now used whenever attached sprites are active. Before choice between OSPRMx and ESPRMx depended on attached sprite data content.

1.1 GENERAL DESCRIPTION

This Specification describes the requirements for Lisa, a Display Controller Integrated Circuit (I.C.). offering considerable advantages to our Amiga product line, both new features and higher performance.

The basic function of Lisa is to accept bitplane data and sprite data from chip ram, and serialize and prioritize them to provide a set of signals suitable for input to a video DAC. Lisa also provides mouse/joystick circuitry and genlock support.

New features for Lisa (as compared to ECS Denise):

- 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 16,777,220 colors is available in all resolutions.

- 28Mhz clock input allows for cleaner definition of HIRES and SHRES pixels. ALICE's clock generator 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.

- 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 scroll bits 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. Both HAM modes are available in all resolutions (not just LORES as before).

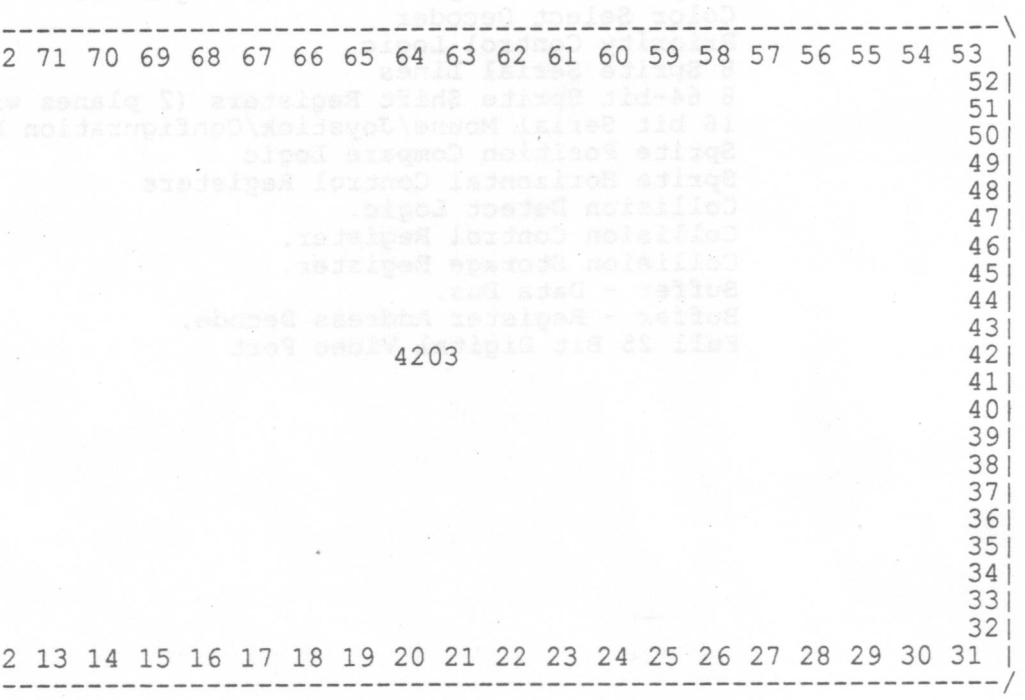
- A RST_ input pin has been added, which resets all the bits contained in registers that were new for ECS or LISA: BPLCON3,BPLCON4,CLXCON2,DIWHIGH,FMODE.

- Hardware Scan Doubling support has been added(modified SPRxPOS SH10 bit definition).

LISA Chip Elements:

256 Color Registers
8 64-bit Bitplane Shift Registers
Bitplane Priority and Control Registers
Color Select Decoder
Priority Control Logic
8 Sprite Serial Lines
8 64-bit Sprite Shift Registers (2 planes wide)
16 bit Serial Mouse/Joystick/Configuration Port
Sprite Position Compare Logic
Sprite Horizontal Control Registers
Collision Detect Logic.
Collision Control Register.
Collision Storage Register.
Buffer - Data Bus.
Buffer - Register Address Decode.
Full 25 Bit Digital Video Port

1.2 PIN CONFIGURATION



PIN	NAME	TYPE	PIN	NAME	TYPE	PIN	NAME	TYPE	PIN	NAME	TYPE
1	VSS	G	22	SCLK	VO	43	C28OUT	VO	64	D26	IO
2	D6	IO	23	C14O	VO	44	G4	VO	65	D25	IO
3	D5	IO	24	RST_	I	45	G5	VO	66	D24	IO
4	D4	IO	25	C28M	I	46	G6	VO	67	D23	IO
5	D3	IO	26	SOG	VO	47	G7	VO	68	D22	IO
6	D2	IO	27	BLANK	VO	48	R0	VO	69	D21	IO
7	D1	IO	28	ZD	VO	49	R1	VO	70	D20	IO
8	D0	IO	29	B0	VO	50	R2	VO	71	D19	IO
9	CAS_	I	30	VDD	P	51	R3	VO	72	D18	IO
10	CCK	I	31	B1	VO	52	R4	VO	73	D17	IO
11	WIDE	DO	32	B2	VO	53	VSS	G	74	D16	IO
12	RGA8	I	33	VSS	G	54	R5	VO	75	D15	IO
13	RGA7	I	34	B3	VO	55	R6	VO	76	D14	IO
14	RGA6	I	35	B4	VO	56	VDD	P	77	D13	IO
15	RGA5	I	36	B5	VO	57	R7	VO	78	D12	IO
16	RGA4	I	37	B6	VO	58	BRST_	VO	79	D11	IO
17	RGA3	I	38	B7	VO	59	D31	IO	80	D10	IO
18	RGA2	I	39	G0	VO	60	D30	IO	81	D9	IO
19	RGA1	I	40	G1	VO	61	D29	IO	82	D8	IO
20	MDAT	I	41	G2	VO	62	D28	IO	83	VDD	P
21	MLD_	DO	42	G3	VO	63	D27	IO	84	D7	IO

ZDCLKEN= ZD pin outputs a 14MHZ clock whose falling edge coincides with high-res(7MHZ) video data. This bit when set disables all other ZD pin functions.
BRDRSPRT= enables sprites outside the display window.
EXTBLKEN= causes Blank output to be programmable instead of reflecting internal fixed decodes.
BPLAMx= 8 bit field is XOR'd with the 8 bit bitplane color address, thereby altering the color address sent to the color table.
ESPRMx= 4 bit field provides the 4 high order color table address bits for even sprites(SPR0,SPR2,SPR4,SPR6) (default=0001)
OSPRMx= 4 bit field provides the 4 high order color table address bits for odd sprites(SPR1,SPR3,SPR5,SPR7) (default=0001)

CLXCON 098 W 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 OR-ing them with their corresponding even numbered sprite.

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 Sprite 2)
12	ENSP1	ENable Sprite 1 (ORed with Sprite 0)
11	ENBP6	ENable Bit Plane 6 (Match required for collision)
10	ENBP5	ENable Bit Plane 5 (Match required for collision)
09	ENBP4	ENable Bit Plane 4 (Match required for collision)
08	ENBP3	ENable Bit Plane 3 (Match required for collision)
07	ENBP2	ENable Bit Plane 2 (Match required for collision)
06	ENBP1	ENable Bit Plane 1 (Match required for collision)
05	MVBP6	Match Value for Bit Plane 6 collision
04	MVBP5	Match Value for Bit Plane 5 collision
03	MVBP4	Match Value for Bit Plane 4 collision
02	MVBP3	Match Value for Bit Plane 3 collision
01	MVBP2	Match Value for Bit Plane 2 collision
00	MVBP1	Match Value for Bit Plane 1 collision

CLXCON2 10E W Extended Collision Control. This register controls when bitplanes 7&8 are included in collision detection, and their required state if included.
**** BITS INITIALIZED BY RESET ****

BIT#	FUNCTION	DESCRIPTION
15-08	-	unused
07	ENBP8	ENable Bit Plane 8 (Match req'd for collision)
06	ENBP7	ENable Bit Plane 7 (Match req'd for collision)
05-02	-	unused
01	MVBP8	Match Value for Bit Plane 8 collision
00	MVBP7	Match Value for Bit Plane 7 collision

NOTE: Disabled Bit Planes cannot prevent collisions. Therefore if all Bit Planes are disabled,

collisions will be continuous, regardless of the match values.

CLXDAT 00E R Collision Data Register (Read and Clear)

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

NOTE: Playfield 1 includes all odd numbered enabled bitplanes(BP1,BP3,BP5,BP7)
Playfield 2 includes all even numbered enabled bitplanes(BP2,BP4,BP6,BP8)

BIT #	COLLISIONS REGISTERED
15	unused
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 1 to Playfield 2

COLORxx 180-1BE W COLOR table xx

There are thirty-two (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 2 sets of color registers, selection of which is controlled by the LOCT register bit. When LOCT=0, the 4 MSB of RED,GREEEN, and BLUE video data are selected along with the ZD bit for Genlocks. The low-order set of registers is also selected simultaneously, so that the 4 bit 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 independent 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 of COLOR00 thru COLOR31 sets ZD pin HI when color is selected in all video modes.

DIWHIGH 1E4 W Display Window upper bits - start/stop

This is an added register for the ECS chips, allowing larger display window start & stop ranges.
DIWSTART/DIWSTOP set bit#13, while bits #12,11,5,4,3

are reset. If DIWHIGH is written subsequent to DIWSTART and DIWSTOP then these horrizontal bit values are overridden.

Bit#	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
Use	x	x	H10	H1	H0	y	y	y	x	x	H10	H1	H0	y	y	y
			(stop)								(start)					

Don't care bits (x) should always be set to 0 to maintain upwards compatibility. ALICE bits (y) are defined in a separate document. H1 values define a 70nS increment and H0 values define a 35nS increment.

DIWSTOP	090	W	Display Window Stop horiz. bits
DIWSTRT	08E	W	Display Window Start horiz. bits

These registers control the Display Window size & position, by locating the beginning & end of the horizontal display line.

Bit#	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
Use	y	y	y	y	y	y	y	y	H9	H8	H7	H6	H5	H4	H3	H2

Don't care bits (x) should always be set to 0 to maintain upwards compatibility. ALICE bits (y) are defined in a separate document. In all 3 display window registers, horizontal bit positions have been renamed to reflect HIRES pixel increments, eg. what used to be called H0 is now referred to as H2.

FMODE 1FC W Fetch Mode

This register controls the fetch mechanism for sprites and bitplanes:

BIT#	FUNCTION	DESCRIPTION
15	SSCAN2	global enable for sprite scan-doubling
14	BSCAN2	enables use of 2nd P/F modulus on an alternate line basis to support bitplane scan doubling.
13-04	x	(unused)
03	SPAGEM	Sprite Page Mode (double CAS)
02	SPR32	Sprite 32 Bit Wide Mode
01	BPAGEM	Bitplane Page Mode (double CAS)
00	BPL32	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

HBSTOP	1C6	W	Horizontal STOP position
HBSTRT	1C4	W	Horizontal STaRT position

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

BIT#	FUNCTION	DESCRIPTION
15-11	x	(unused)
10	H2	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

JOY0DAT 00A R JOYstick/mouse 0 DATa
JOY1DAT 00C R JOYstick-mouse 1 DATa

These addresses each read a pair of 8 bit mouse counters. 0=left controller pair, 1=right controller pair (4 counters total). Each counter is clocked by 2 of 8 signals from the MDAT serial stream. Bits 0 and 1 of each counter reflect the state of the 2 associated mouse controller port pins,allowing these pins to double as joystick switch inputs. These 8 signals are the first 8 signals shifted into LISA, preceding the optional LISAID configuration bits.

Mouse counter usage:

Bit #	15 14 13 12 11 10 09 08	07 06 05 04 03 02 01 00
0DAT	Y7,Y6,Y5,Y4,Y3,Y2,Y1,Y0	X7,X6,X5,X4,X3,X2,X1,X0
1DAT	Y7,Y6,Y5,Y4,Y3,Y2,Y1,Y0	X7,X6,X5,X4,X3,X2,X1,X0

The following Table shows the Mouse/Joystick port pin usage. The pins (and their functions) are sampled once every 16 bus cycles, and shifted into the LISA chip during the clock times shown in the Table. This Table is for reference only, and should not be needed by the programmer. NOTE: The joystick functions are all "active low" at the port pins.

CONN PIN	JOYSTICK FUNCTION	MOUSE FUNCTION	PIN NAME	SERIAL POSITION	SAMPLE ON
L1	FORWARD*	Y	M0V	15	CCK hi
L3	LEFT*	YQ	M0V	14	CCK lo
L2	BACK*	X	M0H	13	CCK hi
L4	RIGHT*	XQ	M0H	12	CCK lo
R1	FORWARD*	Y	M1V	11	CCK hi
R3	LEFT*	YQ	M1V	10	CCK lo
R2	BACK*	X	M1H	9	CCK hi
R4	RIGHT*	XQ	M1H	8	CCK lo

NOTE: serial positions listed are MSB first

These signals are paired in quadrature to clock the

Mouse Counters. The LEFT and RIGHT joystick functions (active high) are directly available on the Y1 and X1 bits of each counter. In order to recreate the FORWARD and BACK joystick functions; however, it is necessary to (exclusive OR) the lower two bits of each counter. This is illustrated in the following table.

To Detect	Read these Counter Bits
Forward	Y1 xor Y0 (BIT#09 xor BIT#08)
Left	Y1
Back	X1 xor X0 (BIT#01 xor BIT#00)
Right	X1

JOYTEST 036 W 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
0DAT	Y7,Y6,Y5,Y4,Y3,Y2,xx xx	X7,X6,X5,X4,X3,X2,xx,xx
1DAT	Y7,Y6,Y5,Y4,Y3,Y2,xx xx	X7,X6,X5,X4,X3,X2,xx xx

LISAID 07C R Lisa/Denise revision level(formerly DENISEID)

The 8 LSB of this register identify the chip revision. The early Denise revision levels do not have this register, so whatever was previously written to the data bus on the previous access will still be there during this read cycle. ECS DENISE(8373Rx) returns hex(FC) while prototype 8369Rx returned hex(FE). LISA returns hex(F8).

The 8 low-order bits 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

The 8 MSB are loaded by the 8 MSB shifted into the mouse serial port. These are intended for configuration jumpers on the mother board.

SPRxPOS 140 W Sprite x Vert-Horiz start position data.
148
150
158
160
168
170
178

BIT #	SYM	FUNCTION
15-08	y	
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.

SPRxCTL 142 W Sprite x Vert stop position and control data.
14A These two (2) registers work together as
152 position, size and feature Sprite control
15A registers. They are usually loaded by the
162 Sprite DMA channel, during horizontal blanking,
16A however they may be loaded by either processor
172 at any time (writing this address disables
17A Sprite horizontal comparator circuit).

BIT #	SYM	FUNCTION
15-08	y	
07	ATT	Sprite attach control bit (odd Sprites only)
06-05	y	
04	SH1	Start horiz. value, 70nS sprite position bit
03	SH0	Start horiz. value, 35nS sprite position bit
02-01	y	
00	SH2	Start horiz. value, 140nS sprite position bit.

SPRxDATA 144 W Sprite x image data register A.
14C
154
15C
164
16C
174
17C

SPRxDATB 146 W Sprite x image data register B.
14E These 2 registers buffer the Sprite image
156 data. They are usually loaded by either
15E processor at any time. When horizontal
166 coincidence occurs the buffers are dumped
16E into shift registers and serially
176 output to the display, MSB is the first pixel
17E output. NOTE: Writing to the DATA buffer
enables (arms) the sprite. Writing to
the SPRxCTL register disables the Sprite.
If enabled, data in the DATA and DATB
buffers will be output whenever the beam
counter equals the Sprite horizontal
position value in the SPRxPOS register.

STREQU 038 S Strobe for horiz. reset with VB and EQU.
STRVBL 03A S Strobe for horiz. reset with VB
STRHOR 03C S Strobe for horiz. reset
STRLONG 03E S Strobe for long horiz. line(228 CC)

One of the first 3 strobe addresses above is
placed on the RGA bus during the first refresh
time slot. The STRLONG is used during the
second refresh time slot of every other
line, to identify lines with long counts
(228). There are 4 refresh time slots,
and any not used for strobes will leave a
null (FF) address on the RGA bus.

VHPOSW 02C W Write vert./horiz. beam position

Bit #	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
USE	y	y	y	y	y	y	Y	y	H10	H9	H8	H7	H6	H5	H4	H3

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.

PF2Hx= Playfield 2 horizontal scroll code, x= 7-0

PF1Hx= Playfield 1 horizontal scroll code, x= 7-0
where PFxH0=LSB=35nS= 1 SHRES pixel(bits have been renamed, old PFxH0 now PFxH1,etc.). Note that scroll range has been quadrupled to allow for wider (64 bits) bitplanes.

ZDBPSELx= 3 bit field which selects which bitplane is to be used for ZD when ZDBPEN is set;000 selects BP1,111 selects BP8,etc.

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.

ZDCTEN= causes ZD pin to mirror bit #15 of the active entry in the high color table.

KILLEHB= disables ExtraHalfBrite mode. If BPU=0110,HAM=0, DPF=0, and KILLEHB=0 then ExtraHalfBrite mode is defined; this dictates that whenever BP6=1 the color selected by the other 5 bitplanes is halved in intensity.

RDRAM= causes Color Table accesses to be a read instead of a write.

SOGEN= causes SOG (sync on green) output pin to go high

PF2PRI= gives Playfield 2 priority over Playfield 1.

PF2Px= Playfield 2 priority code (with resp. to sprites)

PF1Px= Playfield 1 priority code (with resp. to sprites)
A priority of 0 places the playfield in front of all the sprites; a priority of 4 places it behind them all.

BANKx= selects 1 of 8 Color Palette banks, x= 0-2

PF2OF2,1,0= determines playfield color table offset when Playfield 2 has priority in dual playfield mode:

PF2OF			AFFECTED PLAYFIELD ADDRESS BIT								OFFSET
2	1	0	8	7	6	5	4	3	2	1	(dec.)
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

LOCT= dictates that subsequent color palette values will be written to a second 12-bit color palette,constituting the RGB low-order bits. Writes to the normal high-order color palette write to the low-order color palette as well.

SPRES1,0= determines resolution of all 8 sprites. ECS defaults are 140nS,140nS,70nS for LORES,HIRES,and SHRES playfields, respectively.

SPRES1	SPRES0	SPRITE RESOLUTION
0	0	ECS defaults
0	1	LORES(140nS)
1	0	HIRES(70nS)
1	1	SHRES(35nS)

BRDRBLNK= "border area" is blackened instead of displaying color(0).

BRDNTRAN= "border area" is non-transparent (ZD pin is low when border is displayed)

2.1 REGISTER MAP

register	addr	R/W	function
BPL1DAT	110	W	Bit plane data parallel to serial conversion(16/32 bits). These registers receive the DMA data fetched from RAM by the bitplane address pointers. They may also be written by either the copper or the CPU. They act as a 8 word parallel to serial buffer for up to 8 bitplanes. The parallel to serial conversion is triggered whenever BP1 is written, indicating the transmission of all bitplanes for the next 16/32/64 pixels. The MSB is output first and is therefore always on the left.
BPL2DAT	112		
BPL3DAT	114		
BPL4DAT	116		
BPL5DAT	118		
BPL6DAT	11A		
BPL7DAT	11C		
BPL8DAT	11E		
BPLCON0	100	W	Bitplane control reg.(misc. bits)
BPLCON1	102	W	Bitplane control reg.(horiz scroll)
BPLCON2	104	W	Bitplane control reg.(video priority)
BPLCON3	106	W	Bitplane control reg.(new features)
BPLCON4	10C	W	Bitplane control reg.(mask bits)

These 5 registers control the operation of the bitplanes and various aspects of the display as explained below:

BIT#	BPLCON0	BPLCON1	BPLCON2	BPLCON3	BPLCON4
15	HIRES	PF2H7	x	BANK2=0	BPLAM7=0
14	BPU2	PF2H6	ZDBPSEL2	BANK1=0	BPLAM6=0
13	BPU1	PF2H1	ZDBPSEL1	BANK0=0	BPLAM5=0
12	BPU0	PF2H0	ZDBPSEL0	PF2OF2=0	BPLAM4=0
11	HAM	PF1H7	ZDBPEN	PF2OF1=1	BPLAM3=0
10	DPF	PF1H6	ZDCTEN	PF2OF0=1	BPLAM2=0
09	COLOR	PF1H1	KILLEHB	LOCT=0	BPLAM1=0
08	GAUD	PF1H0	RDRAM=0	x	BPLAM0=0
07	y	PF2H5	SOGEN=0	SPRES1=0	ESPRM7=0
06	SHRES	PF2H4	PF2PRI	SPRES0=0	ESPRM6=0
05	BYPASS=0	PF2H3	PF2P2	BRDRBLNK=0	ESPRM5=0
04	BPU3=0	PF2H2	PF2P1	BRDNTRAN=0	ESPRM4=1
03	y	PF1H5	PF2P0	x	OSPRM7=0
02	y	PF1H4	PF1P2	ZDCLKEN=0	OSPRM6=0
01	y	PF1H3	PF1P1	BRDSPRT=0	OSPRM5=0
00	ECSENA=0	PF1H2	PF1P0	EXTBLKEN=0	OSPRM4=1

x= don't care; but drive to 0 for upward compatibility!
y= register bits contained in ALICE, not defined here.
=0/=1 bit values initialized by RST_ pin going low

HIRES=High resolution mode (70nS pixel width)
BPUx=Bit plane use code 0000-1000 (NONE thru 8 inclusive)
HAM=Hold and Modify mode, now using either 6 or 8 bitplanes. New mode is automatically invoked when BPU=1000.
DPF=Double playfield (PF1=odd bitplanes PF2=even bitplanes), now available in all resolutions.
COLOR=enables Color Burst output signal
GAUD=Genlock audio enable. This level appears on the ZD pin on Lisa during all blanking intervals,unless ZDCLK is set.
SHRES= Super-hi-res mode (35nS pixel width)
BYPASS=bitplanes are scrolled and prioritized normally, but bypass color table and 8 bit wide data appear on R(7:0).
ECSENA= When low(default), the following bits in BPLCON3 are

H10 thru H3 allow the programmer to move the horizontal beam position in 280ns increments. This is primarily used for test purposes.

2.2 PIN DESCRIPTION

PIN NAME	PIN NUMBER	PIN TYPE	SIGNAL DESCRIPTION
D0 - D31	59-82 84 2-8	IO	DATA BUS (0:31) - 32 bit bidirectional system databus.If BPWIDE and SPWIDE register bits are low, only D31-D16 are used.
RGA1 - RGA8	12-19	I	RGA Address inputs - sampled on falling edge of CCK.
WIDE	11	O	Goes HI when 32 bit bus is required.
MDAT	20	I	Mouse data input - 16 bits of serial data is accepted here from an external shift register running at 3.57MHz. Data transitions should occur at rising edge of CCK.
MLD_	21	O	Mouse data shift/load_ - signals external shift register to reload. Signal is low during low half of CCK every 16 cycles. MLD_ and MDAT signals are compatible with use of a 'LS166.
SCLK	22	O	ALICE clock synchonization pulse - falling edge of this signal causes ALICE CCK (C1) to be synchronized with LISA's internal CCK. This allows jitter-free timing between ALICE's HSYNC/VSYNC and LISA's analog video.
C14O	23	CO	14MHz clock output - sent to ALICE to generate her internal clock phases (C1,C2,C3,C4), as well as C7M,CDAC_, and CCK
C28M	24	CI	Master clock for LISA. All internal video timebases as well as external video timing are derived from this clock. ALICE is synchronized to this clock as well (via C14O).
RST_	25	I	System Reset - when low,bits in all registers new for ECS or LISA are cleared: BPLCON3, BPLCON4,FMODE,CLXCON2,DIWHIGH. Also LISA's clock generator is reset to a known state.
SOG	26	O	Sync-On-Green - goes high when SOG bit in BPLCON3 is set. For proper operation, ALICE should send a positive composite sync signal to KELLY chip.

3.1 ABSOLUTE MAXIMUM RATINGS

Stresses above those listed may cause permanent damage to the circuit. Functional operation of the device at these or any conditions other than those indicated in the operating conditions of this specification is not implied. Exposure to the maximum ratings for extended periods may adversely affect device reliability.

	characteristic	min	max	units
3.1.1	ambient temperature under bias	-25	+125	deg. c.
3.1.2	storage temperature	-65	+150	deg. c.
3.1.3	applied supply voltage	-0.5	+7.0	volts
3.1.4	applied output voltage	-0.5	+5.5	volts
3.1.5	applied input voltage	-2.0	+7.0	volts
3.1.6	power dissipation	-	1.5	watt
3.1.7	output current(1 pin at a time)	-100	+100	mA

3.2 OPERATING CONDITIONS

All electrical characteristics are specified over the entire range of the operating conditions unless specifically noted. All voltages are referenced to Vss = 0.0V.

	Condition	Min	Max	Units
3.2.1	Supply voltage (Vcc)	4.75	5.25	volts
3.2.2	Free air temperature	0	70	Deg. C.

3.3 INTERFACE CHARACTERISTICS

	Characteristic	Symbol	Min	Max	units	Conditions	Note
3.3.1	Input high level	Vih	2.0	Vcc+0.3	volts		(I,IO)
3.3.2	Input low level	Vil	-0.3	0.8	volts		(I,IO)
3.3.3	Data Out high level	Voh	.7*Vcc	-	volts	Ioh = -40uA	(IO,DO)
3.3.4	Data Out low level	Vol	-	0.4	volts	Iol = +800uA	(IO,DO)
3.3.5	Video Out high level	Voh	.7*Vcc	-	volts	Ioh = -20uA	(VO)
3.3.6	Video Out low level	Vol	-	0.4	volts	Iol = +400uA	(VO)
3.3.5	Input leakage	Iin	-10	10 uA		0.0v<Vin<Vcc	(I)
3.3.6	Tristate Out lkg	Ilkg	-10	10 uA		0.4v<Vout<2.4v (Deselected)	(IO)
3.3.7	Supply current	Icc	-	400 mA		Outputs open (Vcc = 5.25V)	(P)

(I) input pins CAS_,CCK,RGAx,MDAT,RST_,C28M
(IO) I/O pins Dx
(DO) output pins WIDE,MLD_,SCLK
(VO) output pins SOG,BLANK,ZD,Rx,Gx,Bx,C28OUT,BRST_,C14O
(P) supply pins VDD

3.4 SWITCHING CHARACTERISTICS

Switching characteristics are specified for input waveforms switching between 0.4V low level and 2.4V high level with 10%-90% rise and fall times of 5ns. Time measurements of transitions into high impedance are referenced to Vol+0.2V and Voh-0.2V levels.

	Characteristic	Symbol	Min	Typ	Max	Unit	Notes	Load
3.4.1	C28M period	tpC28M	30	35	10K	nSec		
3.4.2	C28M width lo/hi	twC28M	15	17.5	-	nSec		
3.4.3	C28M rise/fall	trC28M	-	-	5	nSec		

3.4.4	C14O period	tpC14O	65	70	-	nSec		1
3.4.5	C14O width lo/hi	twC14O	30	35	-	nSec		1
3.4.6	C14O rise/fall	trC14O	-	-	5	nSec		1
3.4.7	C14O prop. delay	tdC14O	0	-	20	nSec		1
3.4.8	CCK period	tpCCK	240	280	10K	nSec	(tpC28M)*8	
3.4.9	CCK rise/fall	trCCK	-	-	10	nSec		
3.4.10	CAS_ period	tpCAS_	240	280	10K	nSec		
3.4.11	CAS_ rise/fall	trCAS_	-	-	10	nSec		
3.4.12	SCLK period	tpSCLK	260	280	-	nSec		3
3.4.13	SCLK width hi	twSCLK	65	70	-	nSec		3
3.4.14	SCLK rise/fall	trSCLK	-	-	5	nSec		3
3.4.15	SCLK prop. delay (reference: C14O rise)	tdSCLK	0	-	20	nSec		3
3.4.12	MLD_ period	tpMLD_	260	280	-	nSec		3
3.4.13	MLD_ width hi	twMLD_	65	70	-	nSec		3
3.4.14	MLD_ rise/fall	trMLD_	-	-	5	nSec		3
3.4.15	MLD_ prop. delay (reference: SCLK rise)	tdMLD_	0	-	25	nSec		3
3.4.16	MDAT setup time (reference: SCLK rise)	tsMDAT	15	-	-	nSec		
3.4.17	MDAT hold time (reference: SCLK rise)	thMDAT	15	-	-	nSec		
3.4.18	RGA setup (reference: CCK fall)	tsRGAx	30	-	-	nSec		
	RGA hold (reference: CCK fall)	thRGAx	30	-	-	nSec		
3.4.20	WIDE prop. delay (reference: RGA valid)	tdWIDE	0	-	30	nSec		3
3.4.21	Dx out dly (reference: CCK fall)	tdDxo	0	-	90	nSec		2
3.4.22	Dx out hold (reference: CCK rise)	thDxo	10	-	-	nSec		2
3.4.23	Dx inp setup (reference: CCK rise)	tsDxi	-	-	-	nSec	"Classic"	
3.4.24	Dx inp hold (reference: CCK rise)	thDxi	-	-	-	nSec	"Classic"	
3.4.25	Dx inp setup (reference: CAS_ rise)	tsDxi	-	-	-	nSec	"New"	
3.4.26	Dx inp hold (reference: CAS_ rise)	thDxi	-	-	-	nSec	"New"	
3.4.27	RST_ pulse width	twRST_	70	-	-	nSec	tpC28M=35nS	
3.4.28	video out skew (reference: C28O fall)	tdVID	-10	0	+10	nSec		1
3.4.29	SOG prop. delay (reference: CCK rise)	tdSOG	-	-	280	nSec		1

Loading: 1. 30pF + 1 LS TTL (1 x 400uA source)
2. 100pF + 2 LS TTL (2 x 400uA source)
3. 50pF + 2 LS TTL (2 x 400uA source)

BURST, PIXELS, ~~2~~ 20

4.1 Marking

Parts shall be marked with Commodore part number, manufacturers identification and EIA data code. Pin 1 shall be identified.

4.2 PACKAGING

The circuit shall be packaged in a standard plastic or ceramic 84 pin leaded chip carrier.