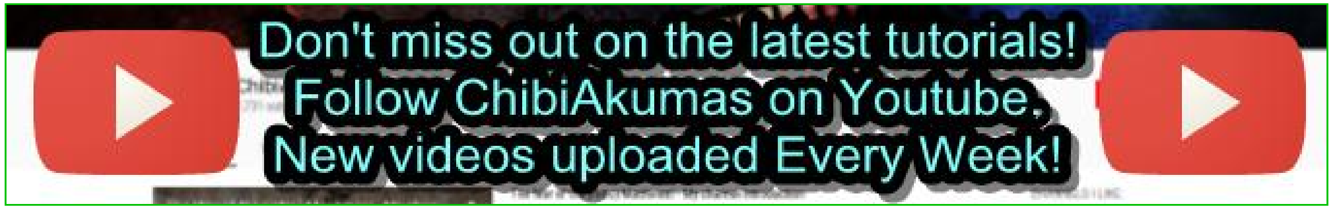
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6809 Assembly programming for the Dragon 32/64 and Tandy COCO

The Dragon is an odd beast! Using the impressive 6809 CPU, it somehow ends up being no better than it's 6502 competitors... part of the reason for this is it's clocked at less than 1mhz, and part is the limited RAM and Graphics of the system.

The Dragon 32/64 are virtually the same machine, and strangely, the Tandy COCO (TRS-80 COLOR) is also 99% compatible, for this reason we'll be covering them both here.

For simplicity, In these tutorials, we'll be looking at 32k systems, we won't cover the 4k/16k COCO

	Dragon 32	Dragon 64	Tandy COCO (TRS-80 Color Computer)
Cpu	0.89mhz	0.89mhz	0.89mhz 6809

	6809	6809	
Ram	32k	64k	4k/16k/32k/64k
Max Resolution	128x192 @ 4 color (6k) 256x192 @ 2 color (6k)	128x192 @ 4 color (6k) 256x192 @ 2 color (6k)	128x192 @ 4 color (6k) 256x192 @ 2 color (6k)

I am Dragon , hear me roar... Gao!

Z80 Platforms
Amstrad CPC
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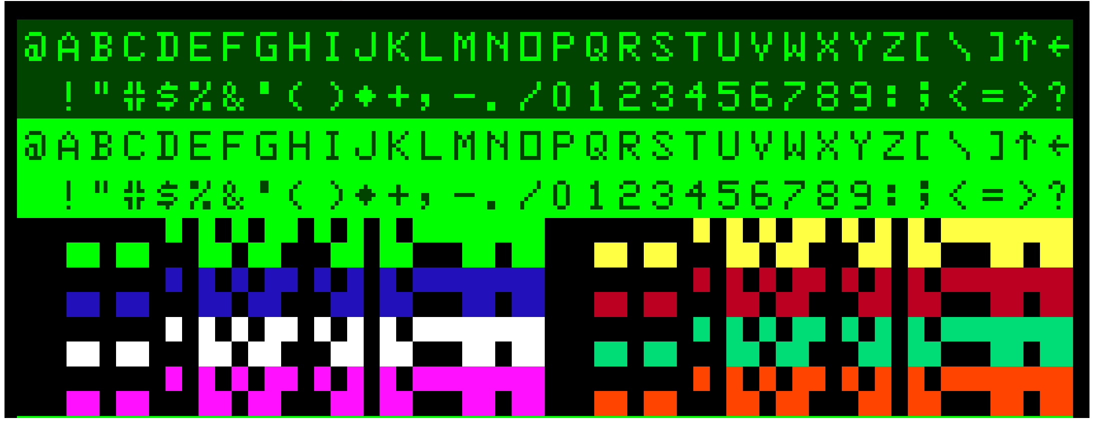
Spectrum NEXT
Camputers Lynx

Character Map

Text characters + Semigraphics


@ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]↑←
 !"#$%&'()*+,-./0123456789:;<=>?
@ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]↑←
 !"#$%&'()*+,-./0123456789:;<=>?

Screen Modes

The Dragon has a variety of possible modes... the most useful being the 'Full Graphics' modes...

Selecting a screen mode requires configuring two chips... the VDG via port $FF22, and the SAM with addresses $FFC0 to $FFC5

Screenmode selection is performed by setting the top 5 bits of $FF22 and the 3 SAM bits
Sam bits are set or cleared by writing to $FFC0-FFC5... it doesn't matter 'what' value you write... writes to Even addresses clear a bit... writes to an odd address set a bit.

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Super Nintendo (SNES)
Nintendo NES / Famicom
PC Engine (Turbografx-16)
Vic 20

68000 Content

Mode Type	G/A	GM2	GM1	INT /GM0	CSS	SAM V2	SAM V1	SAM V0	Colors	Resolution	Bytes	Screen Mode
Internal Alphanumeric	0	?	?	0	?	0	0	0	2 color	32x16	512	Default (IA)
External Alphanumeric	0	?	?	1	?	0	0	0	4 color	32x16	512	
Semigraphics 4	0	?	?	0	?	0	0	0	8 color	64 x 32	512	(IA)
Semigraphics 6	0	?	?	1	?	0	0	0	8 color	64 x 48	512	
Semigraphics 8	0	?	?	0	?	0	1	0	8 color	64 x 64	2048	
Semigraphics 12	0	?	?	0	?	1	0	0	8 color	64 x 96	3072	
Semigraphics 24	0	?	?	0	?	1	1	0	8 color	64 x 192	6144	
Full Graphics 1C	1	0	0	0	?	0	0	1	4 color	64 x 64	1024	(D)
Full Graphics 1R	1	0	0	1	?	0	0	1	2 color	128 x 64	1024	(E)
Full Graphics 2C	1	0	1	0	?	0	1	0	4 color	128 x 64	1536	(F)
Full Graphics 2R	1	0	1	1	?	0	1	1	2 color	128 x 96	1536	PMODE0
Full Graphics 3C	1	1	0	0	?	1	0	0	4 color	128 x 96	3072	PMODE1
Full Graphics 3R	1	1	0	1	?	1	0	1	2 color	128 x 192	3072	PMODE2
Full Graphics 6C	1	1	1	0	?	1	1	0	4 color	128 x 192	6144	PMODE3
Full Graphics 6R	1	1	1	1	?	1	1	0	2 color	256 x 192	6144	PMODE4
Direct Memory Access	?	?	?	?	?	1	1	1	2 color	256 x 192	6144	
Port	**$FF22 Bit 7**	**$FF22 Bit 6**	**$FF22 Bit 5**	**$FF22 Bit 4**	**$FF22 Bit 3**	**0:$FFC0 1:$FFC1**	**0:$FFC2 1:$FFC3**	**0:$FFC4 1:$FFC5**				

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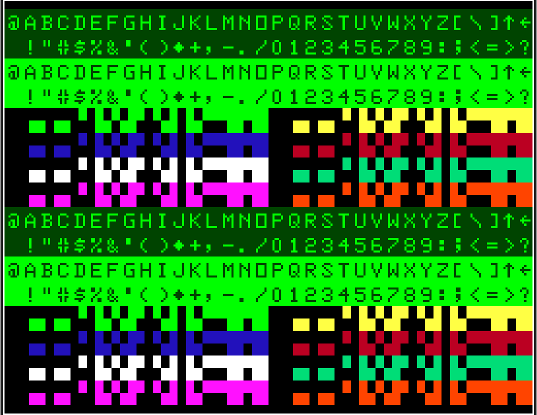
Screen Modes

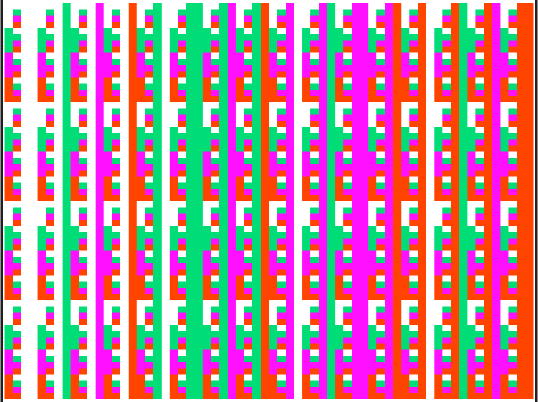
Here are all the possible screen modes... 'Unofficial' modes (not supported by basic - D/E/F) are shown with CSS=1 (alternate colors)

Text / Semigraphics (IA)

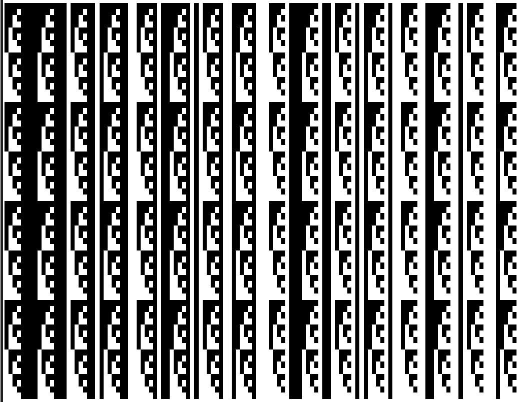


```
@ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]↑←
 !"#$%&'()*+,-./0123456789:;<=>?
@ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]↑←
 !"#$%&'()*+,-./0123456789:;<=>?
@ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]↑←
 !"#$%&'()*+,-./0123456789:;<=>?
@ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]↑←
 !"#$%&'()*+,-./0123456789:;<=>?
```

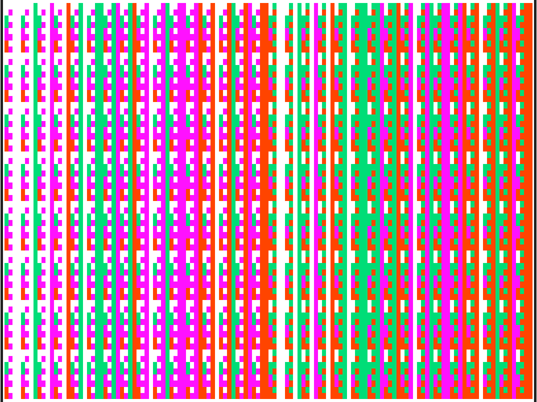
Full Graphics 1C (D)



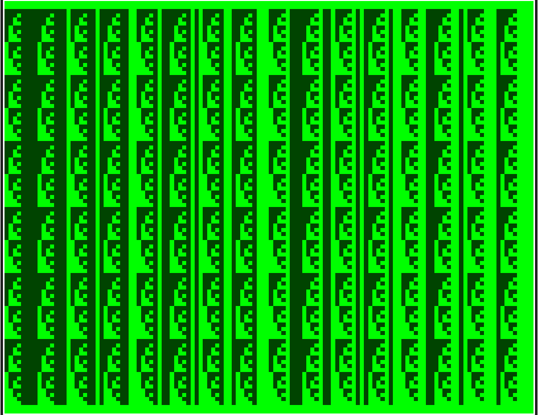
Full Graphics 1R (E)



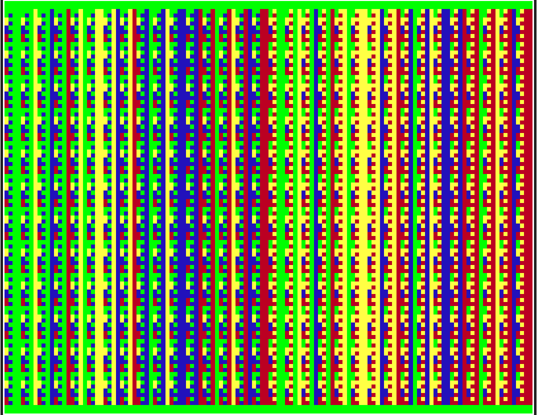
Full Graphics 2C (F)



Full Graphics 2R (PMODE 0)



Full Graphics 3C (PMODE 1)



Full Graphics 3R (PMODE 2)

Full Graphics 6C (PMODE 3)

Full Graphics 6R (PMODE 4)

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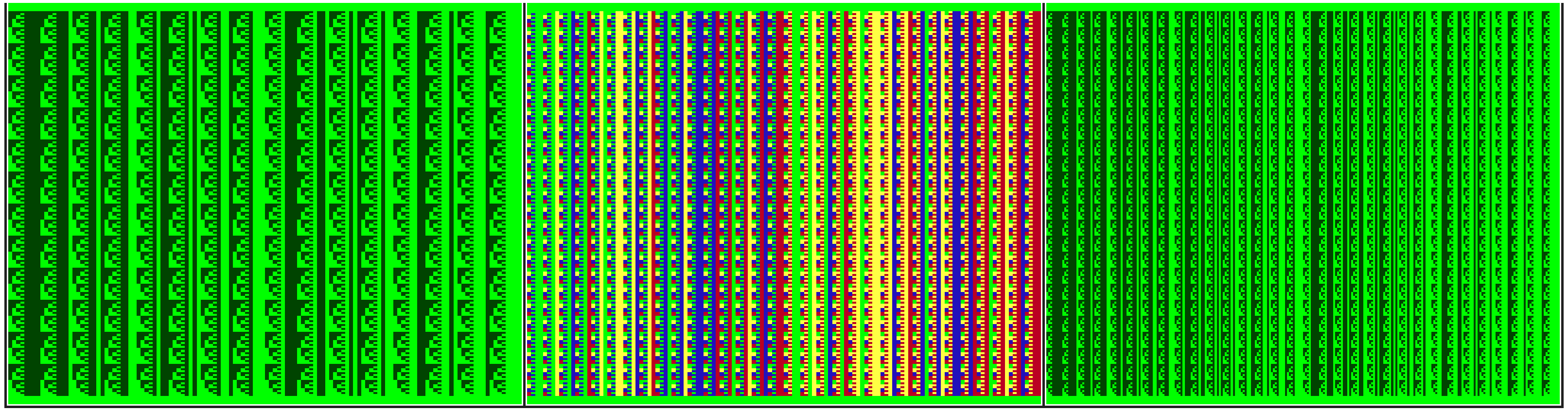

Screen Base Address

The Top 7 bits of the Screen address can be selected by writes to bits $FFC6-$FFD3... even addresses clear a bit, odd addresses set a bit.

Effectively the address of the screen base is:%DDDDDDD0 00000000.... where D is the bits we can change, and 0 is fixed bit zeros

The example code here will reset the screen base to $0400
Writes to $FFC6-D2 set all the bits to 0... Then bit 1 is set with a write to $FFC9.

```
PmodeReset:
        sta $FFC6      ;ScrBase Bit 0   $0200
        sta $FFC8      ;ScrBase Bit 1   $0400
        sta $FFCA      ;ScrBase Bit 2   $0800
        sta $FFCC      ;ScrBase Bit 3   $1000
        sta $FFCE      ;ScrBase Bit 4   $2000
        sta $FFD0      ;ScrBase Bit 5   $4000
        sta $FFD2      ;ScrBase Bit 6   $8000

        sta $FFC8+1    ;ScrBase Bit 1   $0400
```

Dragon Memory Map

Address	Dragon Purpose
$0000	Direct Page
$0100	System Vectors
$0200	Casette Buffer
$0300	Line Input Buffer
$0400	Text Screen
$0600	Memory Page 1 / Vars
$0C00	Screen Page 2 / Program

Dragon 32/Tandy Coco
Fujitsu FM7
TRS-80 Coco 3
Vectrex

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$1200	Graphics Page 3 / Basic
$1800	Normal Page 4 / Extra
$1E00	Memory Page 5 / Variables
$2400	Screen Page 6 / Program
$2A00	Graphics Page 7 / Basic
$3000	Extra Page 8 / Normal
$3600	Program / Var Storage & Stack (SP=$7F36)
$7F36	String Space
$8000	Basic Interpreter
$C000	Cartridge Memory
$FF00	PIA0 A Data direction Register / Peripheral Data Register
$FF01	PIA0 A Control Register
$FF02	PIA0 B Data direction Register / Peripheral Data Register
$FF03	PIO0 B Control Register
$FF20	PIA1 A Data direction Register / Peripheral Data Register
$FF21	PIA1 A Control Register
$FF22	PIA0 B Data direction Register / Peripheral Data Register
$FF23	PIA1 B Control Register
$FF60	Reserved
$FFC0	Clear V0
$FFC1	Set V0
$FFC2	Clear V1
$FFC3	Set V1
$FFC4	Clear V2
$FFC5	Set V2
$FFC6	Reset Screen Addr Bit 0
$FFC7	Set Screen Addr Bit 0
$FFC8	Reset Screen Addr Bit 1
$FFC9	Set Screen Addr Bit 1
$FFCA	Reset Screen Addr Bit 2
$FFCB	Set Screen Addr Bit 2
$FFCC	Reset Screen Addr Bit 3

$FFCD	Set Screen Addr Bit 3
$FFCE	Reset Screen Addr Bit 4
$FFCF	Set Screen Addr Bit 4
$FFD0	Reset Screen Addr Bit 5
$FFD1	Set Screen Addr Bit 5
$FFD2	Reset Screen Addr Bit 6
$FFD3	Set Screen Addr Bit 6
$FFE0	Reserved
$FFF2	SWi 3 Vector
$FFF4	SWI 2 Vector
$FFF6	FIRQ Vector
$FFF8	IRQ Vector
$FFFA	SWI 1 Vector
$FFFC	NMI Vector
$FFFE	Reset Vector

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Keyboard Matrix

PAx = bits read from $FF00
PBx = Write to $FF02 with byte containing zero at this point, eg PB0=%11111110

	PB0 (W)	**PB1** (W)	**PB2** (W)	**PB3** (W)	**PB4** (W)	**PB5** (W)	**PB6** (W)	**PB7** (W)
PA0 (R)	0	1	2	3	4	5	6	7
PA1 (R)	8	9	*		,	-	�	/
PA2 (R)	@	A	B	C	D	E	F	G
PA3 (R)	H	I	J	K	L	M	N	0
PA4 (R)	P	Q	R	S	T	U	V	W
PA5 (R)	X	Y	Z	Up	Down	Left	Right	Space
PA6 (R)	ENT	CLR	BRK	N/C	N/C	N/C	N/C	SHFT
PA7 (R)	JoyTest	JoyTest	JoyTest	JoyTest	JoyTest	JoyTest	JoyTest	JoyTest

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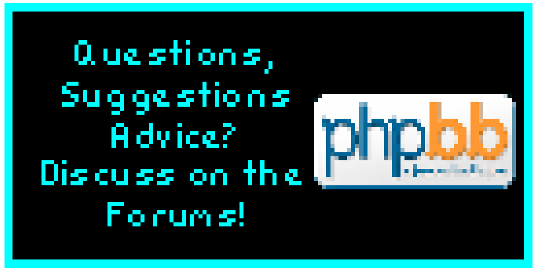
PIA0 / PIA1 - Peripheral Interface Adapters

The PIA's select and send and receive data from the graphics chip, Keyboard, Joystick, Printer (RS232) and Sound hardware

The Data ports also double up as a 'Direction Select port' (Via bit 2 of the control port)... writing a 1 bit selects Direction IN... writing a 0 selects Direction OUT



$FF00	Dir	PIA0-A Data
Bit 7	I	Joy compare (Compare to $FF20)
Bit 6	I	Key row PA6 (select with $FF02)
Bit 5	I	Key row PA5 (select with $FF02)
Bit 4	I	Key row PA4 (select with $FF02)
Bit 3	I	Key row PA3 (select with $FF02)
Bit 2	I	Key row PA2 (select with $FF02)
Bit 1	I	Key row PA1 (select with $FF02)
Bit 0	I	Key row PA0 (select with $FF02)

$FF01		PIA0-A Control
Bit 7		IRQA1: HSYNC Flag
Bit 6		IRQA2: Unused
Bit 5		1 -> CA2 in CRA3 in bit follow mode
Bit 4		1 -> CA2 in CRA3 in bit follow mode
Bit 3		CA2: Select Device (Multiplexor LSB)
Bit 2		Dir/Data: 0=$FF00 Selects Direction 1=$FF00 Access Data
Bit 1		CA1 ctrl: 0=IRQ on Hi to Low... 1=IRQ on Low to Hi
Bit 0		CA1 IRQ: 0=off 1=on

$FF02	Dir	PIA0-B Data
Bit 7	O	Key Col PB7 / Printer P7
Bit 6	O	Key Col PB6 / Printer P7
Bit 5	O	Key Col PB5 / Printer P7
Bit 4	O	Key Col PB4 / Printer P7
Bit 3	O	Key Col PB3 / Printer P7
Bit 2	O	Key Col PB2 / Printer P7
Bit 1	O	Key Col PB1 / Printer P7
Bit 0	O	Key Col PB0 / Printer P7

$FF03		PIA0-B Control
Bit 7		IRQB1: VSYNC Flag
Bit 6		IRQB2: Unused
Bit 5		1 -> CB2 in CRB3 in bit follow mode
Bit 4		1 -> CB2 in CRB3 in bit follow mode
Bit 3		CB2: Select Device (Multiplexor MSB)

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Bit 2		Dir/Data: 0=$FF02 Selects Direction 1=$FF02 Access Data
Bit 1		CB1 ctrl: 0=IRQ on Hi to Low... 1=IRQ on Low to Hi
Bit 0		CB1 IRQ: 0=off 1=on

$FF20	Dir	PIA1-A Data
Bit 7	O	DAC Bit 5 (Joy Compare / Sound)
Bit 6	O	DAC Bit 4 (Joy Compare / Sound)
Bit 5	O	DAC Bit 3 (Joy Compare / Sound)
Bit 4	O	DAC Bit 2 (Joy Compare / Sound)
Bit 3	O	DAC Bit 1 (Joy Compare / Sound)
Bit 2	O	DAC Bit 0 (Joy Compare / Sound)
Bit 1	O	RS232 Out / Printer Strobe
Bit 0	I	Casette In

$FF21		PIA1-A Control
Bit 7		IRQA1 Printer Ack Flag
Bit 6		IRQA2: Unused
Bit 5		CRA4 =1 -> CA2 in CRA3 bit follow mode
Bit 4		CRA4 =1 -> CA2 in CRA3 bit follow mode
Bit 3		CA2: Casette Motor (1=on)
Bit 2		Dir/Data: 0=$FF20 Selects Direction 1=$FF20 Access Data
Bit 1		CA1 ctrl: 0=IRQ on Hi to Low... 1=IRQ on Low to Hi
Bit 0		CA1 IRQ: 0=off 1=on

$FF22	Dir	PIA1-B Data
Bit 7	O	ScreenMode G/A
Bit 6	O	ScreenMode GM2
Bit 5	O	ScreenMode GM1
Bit 4	O	ScreenMode GM0 / INT
Bit 3	O	ScreenMode CSS
Bit 2	I	Ram Size (1=16k 0=32/64k))
Bit 1	I	Single bit sound
Bit 0	I	Rs232 In / Printer Busy

$FF23		PIA1-B Control
Bit 7		IRQB1 Cartridge Interrupt

ops and more maths!

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Bit 6	IRQB2: Unused
Bit 5	CRB4 =1 -> CB2 in CRB3 bit follow mode
Bit 4	CRB4 =1 -> CB2 in CRB3 bit follow mode
Bit 3	CB2: Sound Source Enable (1=on)
Bit 2	Dir/Data: 0=$FF22 Selects Direction 1=$FF22 Access Data
Bit 1	CB1 ctrl: 0=IRQ on Hi to Low... 1=IRQ on Low to Hi
Bit 0	CB1 IRQ: 0=off 1=on

Multiplexer Device selection

$FF23 Bit 3	$FF21 Bit 3	$FF03 Bit 3	$FF01 Bit 3	
PIA1-CB2	PIA1-CA2	PIA0-CB2	PIA0-CA2	
SoundSource	Cassette Motor	Multiplexer H	Multiplexer L	Purpose
0	?	0	0	Write JJJJJJ-- to $FF20 .... Read ($FF00) Joystick R-X O-----LR O=1 means Over written value
0	?	0	1	Write JJJJJJ-- to $FF20 .... Read ($FF00) Joystick R-Y O-----LR O=1 means Over written value
0	?	1	0	Write JJJJJJ-- to $FF20 .... Read ($FF00) Joystick L-X O-----LR O=1 means Over written value
0	?	1	1	Write JJJJJJ-- to $FF20 .... Read ($FF00) Joystick L-Y O-----LR O=1 means Over written value
1	?	0	0	Write SSSSSS-- to $FF20 .... 6 Bit DAC
1	?	0	1	Cassette
1	?	1	0	Cartridge
1	?	1	1	Unused

Basic Commands

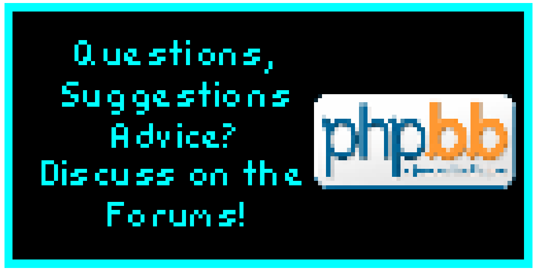
Reserved word	**Token**	**Dispatch address**
FOR	80	8448
GO(TO/SUB)	81	85B9
REM	82	8616
'	83	8616
ELSE	84	8616
IF	85	8647

DATA	86	8613
PRINT	87	903D
ON(GOTO/SUB)	88	8675
INPUT	89	872B
END	8A	8532
NEXT	8B	8829
DIM	8C	8A8B
READ	8D	8777
LET	8E	86BC
RUN	8F	85A5
RESTORE	90	8514
RETURN	91	85F3
STOP	92	8539
POKE	93	8E9D
CONT	94	8560
LIST	95	8EAA
CLEAR	96	8571
NEW	97	8415
DEF	98	9C81
CLOAD	99	B6D5
CSAVE	9A	B683
OPEN	9B	B829
CLOSE	9C	B64D
LLIST	9D	8EA4
SET	9E	B9D3
RESET	9F	BA04
CLS	A0	BA60
MOTOR	A1	B982
SOUND	A2	BA9B
AUDIO	A3	BADF
EXEC	A4	B771
SKIPF	A5	B81F
DELETE	A6	9D61
EDIT	A7	9965
TRON	A8	9AD9
TROFF	A9	9ADA

LINE	AA	A749
PCLS	AB	A8C0
PSET	AC	A6EF
PRESET	AD	A6F3
SCREEN	AE	A9FE
PCLEAR	AF	AA19
COLOR	BO	A8D4
CIRCLE	B1	B238
PAINT	B2	AC87
GET	B3	AAF0
PUT	B4	AAF3
DRAW	B5	B051
PCOPY	B6	AABE
PMODE	B7	A9AF
PLAY	B8	ADBD
DLOAD	B9	A049
RENUM	BA	9DFA

Interrupt Vectors

Address	Vector (Address)	Registers Auto-pushed onto stack
$FFF2	SWi 3 Vector ($0100)	D,X,Y,U,DP,CC
$FFF4	SWI 2 Vector ($0103)	D,X,Y,U,DP,CC
$FFF6	FIRQ Vector ($010F)	CC
$FFF8	IRQ Vector ($010C)	D,X,Y,U,DP,CC
$FFFA	SWI 1 Vector ($0106)	D,X,Y,U,DP,CC
$FFFC	NMI Vector ($0109)	D,X,Y,U,DP,CC
$FFFE	RESET Vector ($B3B4)	NA



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