

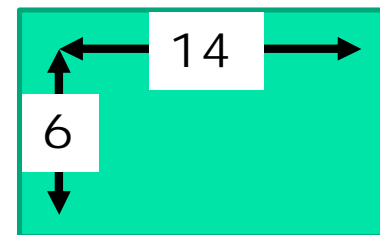
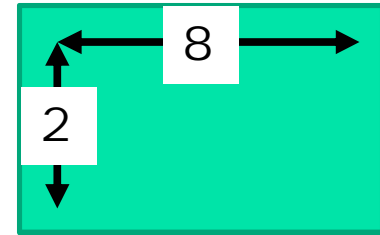
KodeKLIX for PUP

Advanced LCD Text



Overview – Advanced Text

- PUP original has a 8x2 LCD Text Display
 - By default displays text with its own internal chip fonts
- PUP *gfx* has a graphics module
 - To display text the KodeKLIX software driver sends text as font data
 - The KodeKLIX library simulates a 14x6 text display
 - Not all hardware features in this chapter apply to the PUP *gfx*





Advanced LCD Text

- The LCD Text Display has its own microcontroller and as such is capable of some specialised functions / modes
- These include:
 - Display clearing
 - User defined shapes - up to 8 of them at any one time
 - 'Scrolling' - shifting the screen line
 - 'Windowing' - showing part of a hidden line
 - 'Cursor' control – eg blinking...



Inside the LCD Text Controller

- The text LCD uses HD44780 Control Chip
 - This is a very common text chip, and lots of detail can be found on the web...
- Our summary of its structure / capabilities:
 - 224 standard characters defined in ROM
 - 8 user characters definable in RAM
 - 2 lines, each with 80 character screen RAM with a visible window of 8 characters
 - Default is write-only, can be set to read/write
 - Cursor mode and appearance controllable



LCD Character Codes

- Characters can be identified by the letter or the numerical code
 - Eg "A" or %01000001

Lower 4 Bits	Upper 4 Bits	0000	0001	0010	0011	0100	0101	0110	0111	1000	1001	1010	1011	1100	1101	1110	1111
xxxx0000	CG RAM (1)					0	a	P	`	P			-	9	3	o	p
xxxx0001	(2)	!	1	A	Q	a	q			.	7	7	4	a	q		
xxxx0010	(3)	"	2	B	R	b	r			「	イ	ツ	×	β	θ		
xxxx0011	(4)	#	3	C	S	c	s			」	ウ	テ	ε	ε	∞		
xxxx0100	(5)	\$	4	D	T	d	t			、	イ	ト	7	μ	Ω		
xxxx0101	(6)	%	5	E	U	e	u			・	オ	ナ	1	o	Ü		
xxxx0110	(7)	&	6	F	U	f	v			ヲ	カ	ニ	ヨ	ρ	Σ		

green color memory locations are belong to CGRAM area, whereas remaining locations belong to CGROM area.

Higer 4bit Lower 4bit	0000	0010	00:1	0100	0101	1110	1111	1010	1011	1130	1101	1110	1111		
xxxx0000				0	a	P	`	P			-	9	3	o	p
xxxx0001		!	1	A	Q	a	q			.	7	7	4	a	q
xxxx00:0		"	2	B	R	b	r			「	イ	ツ	×	β	θ
xxxx00:1		#	3	C	S	c	s			」	ウ	テ	ε	ε	∞
xxxx0100		\$	4	D	T	d	t			、	イ	ト	7	μ	Ω
xxxx0101		%	5	E	U	e	u			・	オ	ナ	1	o	Ü
xxxx01:0		&	6	F	U	f	v			ヲ	カ	ニ	ヨ	ρ	Σ
xxxx01:1		'	7	G	W	g	w			7	7	7	7	q	π
xxxx1000		<	8	H	X	h	x			イ	7	7	7	7	7
xxxx1001		>	9	I	Y	i	y			o	7	7	7	7	7
xxxx10:0		*	:	J	Z	j	z			ε	7	7	7	7	7
xxxx10:1		+	:	K	L	k	l			o	7	7	7	7	7
xxxx1100		,	<	L	*	l	l			o	7	7	7	7	7
xxxx1101		-	=	M	I	m	i			7	7	7	7	7	7
xxxx11:0		.	>	N	^	n	^			o	7	7	7	7	7
xxxx11:1		/	?	O	_	o	_			7	7	7	7	7	7



LCD Control Codes

- Table at right shows the control codes which the HD44780 display knows...
- RS=0 is a command!

RS	RW	D7	D6	D5	D4	D3	D2	D1	D0	Description	
0	0	0	0	0	0	0	0	0	0	No Operation	
0	0	0	0	0	0	0	0	0	1	Clear display & set address counter to zero	
0	0	0	0	0	0	0	0	1	x	Set address counter to zero, return shifted display to original position. DD RAM contents remains unchanged.	
0	0	0	0	0	0	0	1	I/D	S	Set cursor move direction (I/D) and specify automatic display shift (S).	
0	0	0	0	0	0	1	D	C	B	Turn display (D), cursor on/off (C), and cursor blinking (B).	
0	0	0	0	0	1	S/C	R/L	x	x	Shift display or move cursor (S/C) and specify direction (R/L).	
0	0	0	0	1	DL	N	F	x	x	Set interface data width (DL), number of display lines (N) and character font (F).	
0	0	0	1	CGRAM Address					Set CGRAM address. CGRAM data is sent afterwards.		
0	0	1	DDRAM Address					Set DDRAM address. DDRAM data is sent afterwards.			
0	1	BF	Address Counter					Read busy flag (BF) and address counter			
1	0	Data					Write data into DDRAM or CGRAM				
1	1	Data					Read data from DDRAM or CGRAM				
I/D	1 0	Increment Decrement					R/L	1 0	Shift to the right Shift to the left		
S	1 0	Automatic display shift					DL	1 0	8 bit interface 4 bit interface		
D	1 0	Display ON Display OFF					N	1 0	2 lines 1 line		
C	1 0	Cursor ON Cursor OFF					F	1 0	5x10 dots 5x7 dots		
B	1 0	Cursor blinking					DDRAM : Display Data RAM CGRAM : Character Generator RAM				
S/C	1 0	Display shift Cursor move									



LCD Common Controls

- The most common command codes can be summarised as shown in the table to the right...

No.	Instruction	Hex	Decimal
1	Function Set: 8-bit, 1 Line, 5x7 Dots	0x30	48
2	Function Set: 8-bit, 2 Line, 5x7 Dots	0x38	56
3	Function Set: 4-bit, 1 Line, 5x7 Dots	0x20	32
4	Function Set: 4-bit, 2 Line, 5x7 Dots	0x28	40
5	Entry Mode	0x06	6
6	Display off Cursor off (clearing display without clearing DDRAM content)	0x08	8
7	Display on Cursor on	0x0E	14
8	Display on Cursor off	0x0C	12
9	Display on Cursor blinking	0x0F	15
10	Shift entire display left	0x18	24
12	Shift entire display right	0x1C	30
13	Move cursor left by one character	0x10	16
14	Move cursor right by one character	0x14	20
15	Clear Display (also clear DDRAM content)	0x01	1
16	Set DDRAM address or cursor position on display	0x80+add	128+add

www.botskool.com



LCD Complete Controls

- The complete command set is summarised as shown in the table to the right...

Command	Code										Description	Execution Time	
	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0			
Clear Display	0	0	0	0	0	0	0	0	0	1	Clears the display and returns the cursor to the home position (address 0).	82µs-1.64ms	
Return Home	0	0	0	0	0	0	0	0	1	*	Returns the cursor to the home position (address 0). Also returns a shifted display to the home position. DD RAM contents remain unchanged.	40µs-1.64ms	
Entry Mode Set	0	0	0	0	0	0	0	1	I/D	S	Sets the cursor move direction and enables/disables the display.	40µs	
Display ON/OFF Control	0	0	0	0	0	0	1	D	C	B	Turns the display ON/OFF (D), or the cursor ON/OFF (C), and blink of the character at the cursor position (B).	40µs	
Cursor & Display Shift	0	0	0	0	0	1	S/C	R/L	*	*	Moves the cursor and shifts the display without changing the DD RAM contents.	40µs	
Function Set	0	0	0	0	1	DL	N\$	F	*	#	Sets the data width (DL), the number of lines in the display (L), and the character font (F).	40µs	
Set CG RAM Address	0	0	0	1	A _{CG}					Sets the CG RAM address. CG RAM data can be read or altered after making this setting.		40µs	
Set DD RAM Address	0	0	1	A _{DD}					Sets the DD RAM address. Data may be written or read after making this setting.		40µs		
Read Busy Flag & Address	0	1	BF		AC					Reads the BUSY flag (BF) indicating that an internal operation is being performed and reads the address counter contents.		1µs	
Write Data to CG or DD RAM	1	0	Write Data								Writes data into DD RAM or CG RAM.		46µs
Read Data from CG or DD RAM	1	1	Read Data								Reads data from DD RAM or CG RAM.		46µs
	I/D = 1: Increment I/D = 0: Decrement S = 1: Accompanies display shift. S/C = 1: Display shift S/C = 0: cursor move R/L = 1: Shift to the right. R/L = 0: Shift to the left. DL = 1: 8 bits DL = 0: 4 bits N = 1: 2 lines N = 0: 1 line F = 1: 5x10 dots F = 0: 5 x 7 dots BF = 1: Busy BF = 0: Can accept data # Set to 1 on 24x4 modules \$ With KS0072 is Address Mode.										DD RAM: Display data RAM CG RAM: Character generator RAM A _{CG} : CG RAM Address A _{DD} : DD RAM Address Corresponds to cursor address. AC: Address counter Used for both DD and CG RAM address.		Execution times are typical. If transfers are timed by software and the busy flag is not used, add 10% to the above times.



LCD Screen Line Scrolling

- Only 8 characters per row are visible
- However, each row has a 40 character display buffer
- Using SHIFT left and right commands additional data can be displayed, eg
 - Game field, track, etc

Display position	1	2	3	4	5	39	40
DDRAM address (hexadecimal)	00	01	02	03	04	26	27
	40	41	42	43	44	66	67

Display position	1	2	3	4	5	6	7	8
DDRAM address	00	01	02	03	04	05	06	07
	40	41	42	43	44	45	46	47

For shift left	01	02	03	04	05	06	07	08
	41	42	43	44	45	46	47	48

For shift right	27	00	01	02	03	04	05	06
	67	40	41	42	43	44	45	46

Cursor/Display shift	0	0	0	1	SM	RL	X	X	SM	RL	Display shift(1)/cursor move(0) Move/shift right(1)/left(0)



Tutorial: 3.5
