

# Real world Interfacing

In recent years the LCD is finding widespread use replacing LEDs. This is due to the following reasons

- Declining price of the LCD
- The ability to display numbers ,characters, graphics in contrast to LED.
- Ease of programming .

# LCD Background

Frequently, an Microcontroller program must interact with the outside world using input and output devices that communicate directly with a human being. One of the most common devices attached to an AVR is an LCD display. Some of the most common LCDs connected to the AVR are 16x2 and 20x2 displays. This means 16 characters per line by 2 lines and 20 characters per line by 2 lines, respectively.

Fortunately, a very popular standard exists which allows us to communicate with the vast majority of LCDs regardless of their manufacturer. The standard is referred to as HD44780U, which refers to the controller chip which receives data from an external source and communicates directly with the LCD.

# 44780 BACKGROUND

- The 44780 standard requires 3 control lines as well as either 4 or 8 I/O lines for the data bus
- The user may select whether the LCD is to operate with a 4-bit data bus or an 8-bit data bus
- If a 4-bit data bus is used the LCD will require a total of 7 data lines (3 control lines plus the 4 lines for the data bus)
- If an 8-bit data bus is used the LCD will require a total of 11 data lines (3 control lines plus the 8 lines for the data bus).

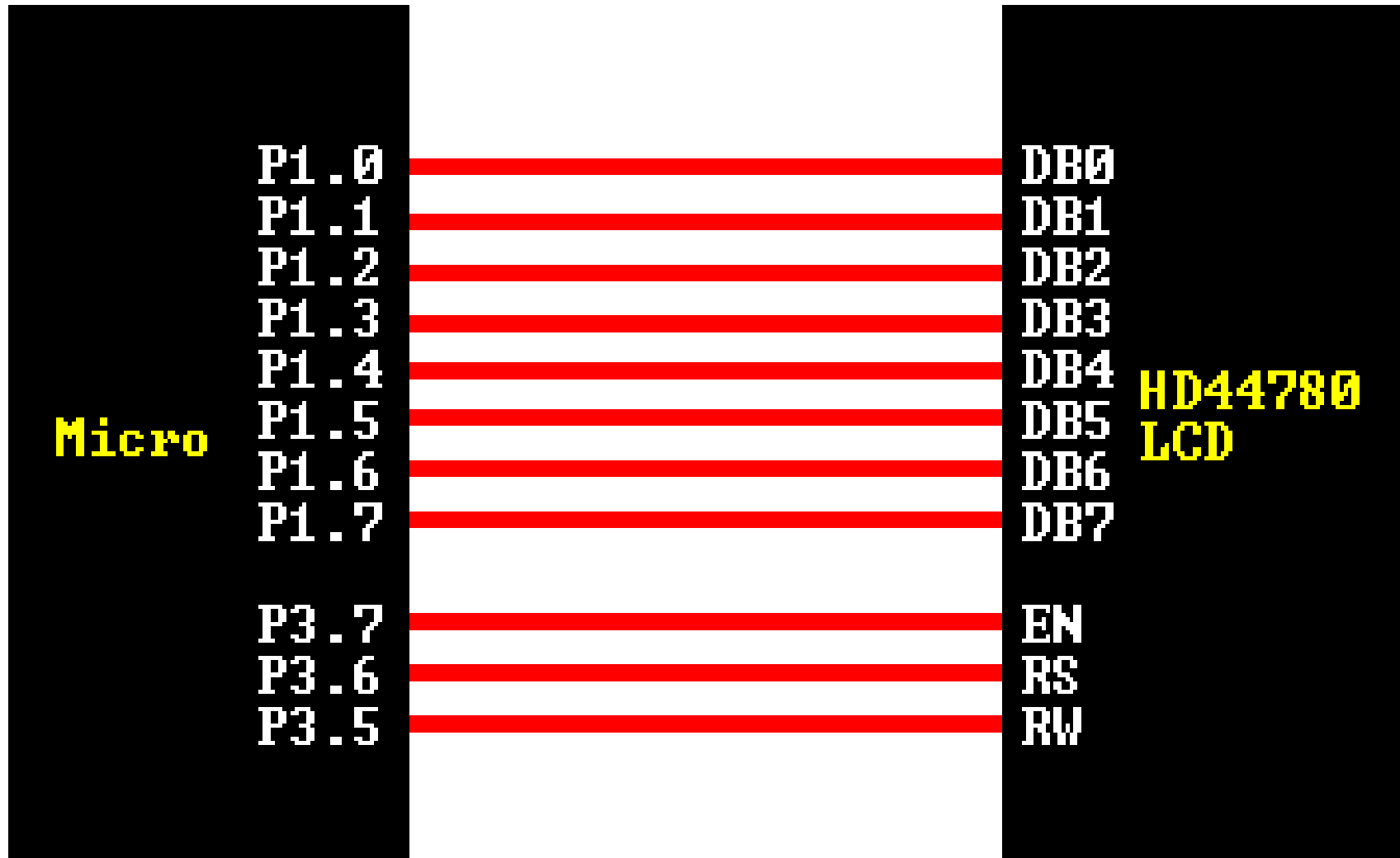
# contd.....

- The three control lines are referred to as EN, RS, and RW
- The EN line is called "Enable." This control line is used to tell the LCD that you are sending it data. To send data to the LCD, your program should make sure this line is low (0) and then set the other two control lines and/or put data on the data bus. When the other lines are completely ready, bring EN high (1) and wait for the minimum amount of time required by the LCD datasheet (this varies from LCD to LCD), and end by bringing it low (0) again.

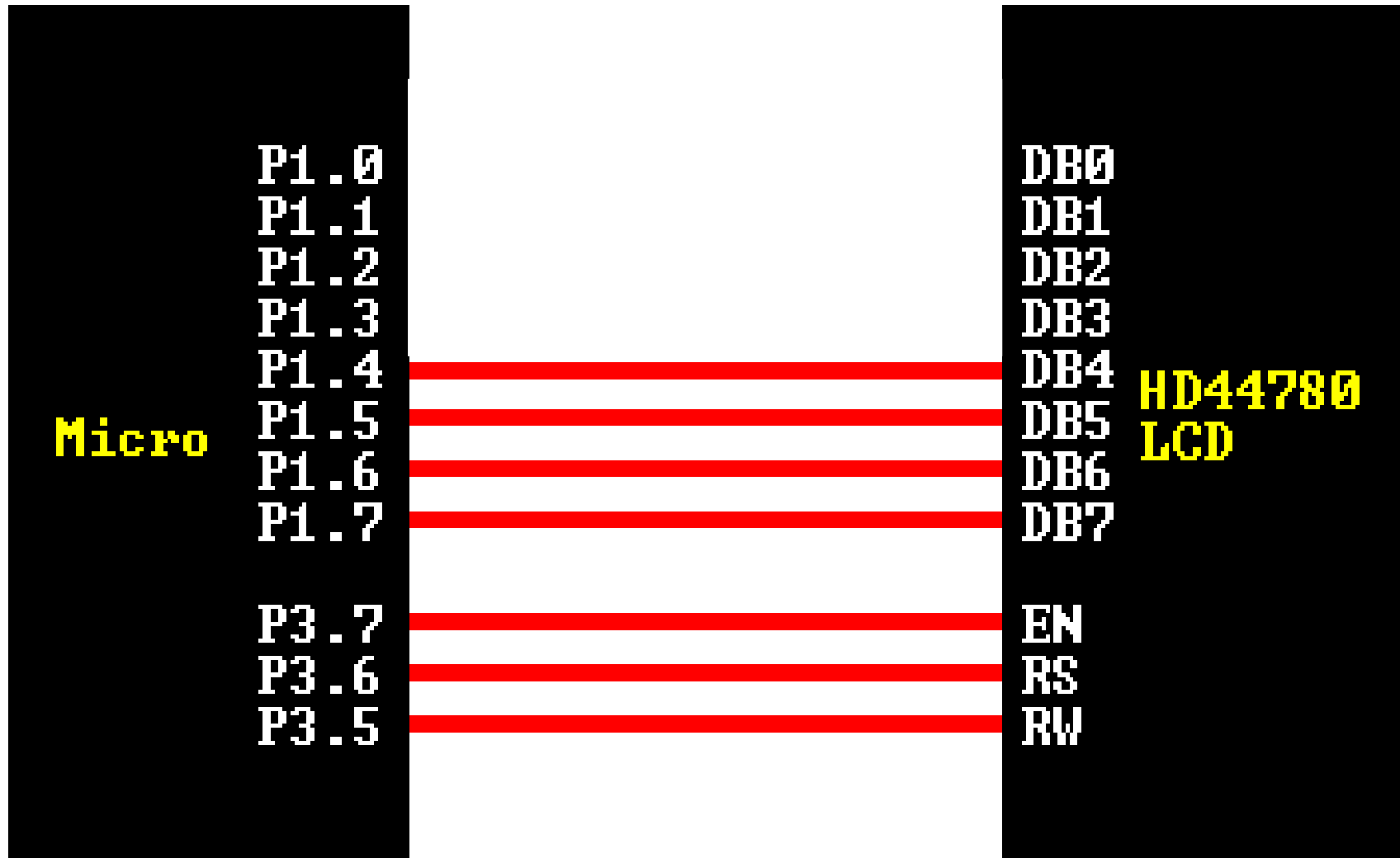
## contd...

- The **RS** line is the "**Register Select**" line. When RS is low (0), the data is to be treated as a command or special instruction (such as clear screen, position cursor, etc.). When RS is high (1), the data being sent is text data which could be displayed on the screen. For example, to display the letter "T" on the screen you would set RS high.
- The **RW** line is the "**Read/Write**" control line. When RW is low (0), the information on the data bus is being written to the LCD. When RW is high (1), the program is effectively querying (or reading) the LCD. Only one instruction ("Get LCD status") is a read command. All others are write commands--so RW will almost always be low.
- Finally, the data bus consists of 4 or 8 lines (depending on the mode of operation selected by the user). In the case of an 8-bit data bus, the lines are referred to as DB0, DB1, DB2, DB3, DB4, DB5, DB6, and DB7.

# AN EXAMPLE HARDWARE CONFIGURATION



# AN EXAMPLE HARDWARE CONFIGURATION IN 4 Bit Mode



### Programming Tip:

The LCD interprets and executes our command at the instant the EN line is brought low. If you never bring EN low, your instruction will never be executed. Additionally, when you bring EN low and the LCD executes your instruction, it requires a certain amount of time to execute the command. The time it requires to execute an instruction depends on the instruction and the speed of the crystal which is attached to the 44780's oscillator input.



# Sending command to LCD

set RS to "control" =0

set R/W to "write" = 0

set "E" line

set data I/O lines to output (8bit)

output data, 8bits

DELAY

clear "E" line

DELAY

## Sending data to LCD

- set RS to "data" = 1
- set R/W to "write" =0
- set "E" line
- set data I/O lines to output (8bit)
- output data, 8bits
- DELAY
- clear "E" line
- DELAY

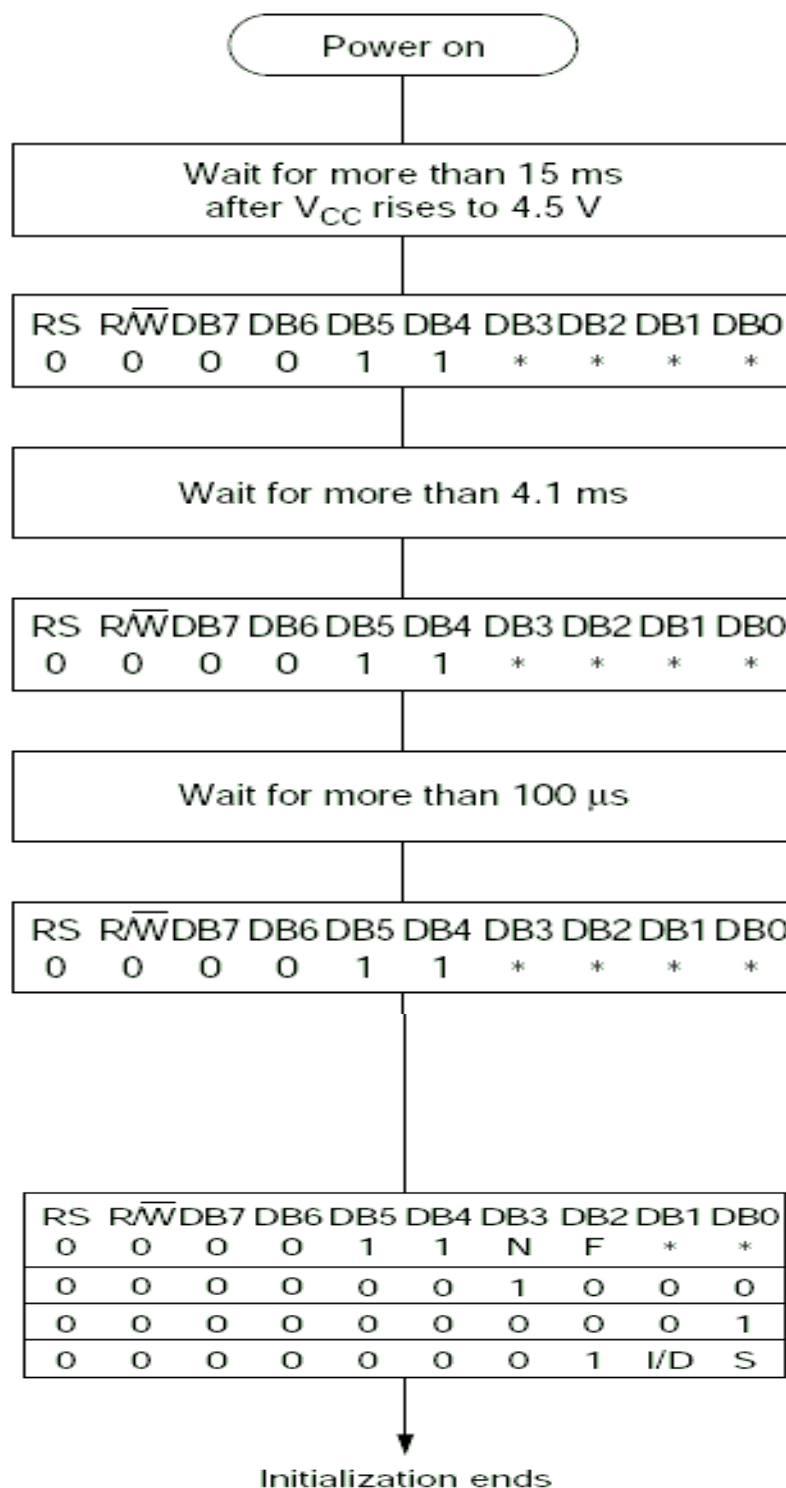
# LCD COMMAND CODES

0x1	clear screen
0x02	Return Home
0x04	Decrement cursor (shift to left)
0x06	Increment cursor
0x05	Shift display right
0x80	Force cursor to the beginning of first line
0xC0	Force cursor to the beginning of 2 <sup>nd</sup> line
0x38	2 lines and 5X7 matrix

Instruction	Code										Description	Execution Time (max) (when $t_{cp}$ or $t_{osc}$ is 270 kHz)
	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0		
Clear display	0	0	0	0	0	0	0	0	0	1	Clears entire display and sets DDRAM address 0 in address counter.	
Return home	0	0	0	0	0	0	0	0	1	—	Sets DDRAM address 0 in address counter. Also returns display from being shifted to original position. DDRAM contents remain unchanged.	1.52 ms
Entry mode set	0	0	0	0	0	0	0	1	I/D	S	Sets cursor move direction and specifies display shift. These operations are performed during data write and read.	37 $\mu$ s
Display on/off control	0	0	0	0	0	0	1	D	C	B	Sets entire display (D) on/off, cursor on/off (C), and blinking of cursor position character (B).	37 $\mu$ s
Cursor or display shift	0	0	0	0	0	1	S/C	R/L	—	—	Moves cursor and shifts display without changing DDRAM contents.	37 $\mu$ s
Function set	0	0	0	0	1	DL	N	F	—	—	Sets interface data length (DL), number of display lines (N), and character font (F).	37 $\mu$ s
Set CGRAM address	0	0	0	1	ACG	ACG	ACG	ACG	ACG	ACG	Sets CGRAM address. CGRAM data is sent and received after this setting.	37 $\mu$ s
Set DDRAM address	0	0	1	ADD	ADD	ADD	ADD	ADD	ADD	ADD	Sets DDRAM address. DDRAM data is sent and received after this setting.	37 $\mu$ s
Read busy flag & address	0	1	BF	AC	AC	AC	AC	AC	AC	AC	Reads busy flag (BF) indicating internal operation is being performed and reads address counter contents.	0 $\mu$ s

Instruction	Code										Description	Execution Time (max) (when $f_{cp}$ or $f_{osc}$ is 270 kHz)
	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0		
Write data to CG or DDRAM	1	0	Write data								Writes data into DDRAM or CGRAM.	37 $\mu$ s $t_{ADD} = 4 \mu$ s*
Read data from CG or DDRAM	1	1	Read data								Reads data from DDRAM or CGRAM.	37 $\mu$ s $t_{ADD} = 4 \mu$ s*
<div>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: 5 <math>\times</math> 10 dots, F = 0: 5 <math>\times</math> 8 dots BF = 1: Internally operating BF = 0: Instructions acceptable</div>											<div>DDRAM: Display data RAM CGRAM: Character generator RAM ACG: CGRAM address ADD: DDRAM address (corresponds to cursor address) AC: Address counter used for both DD and CGRAM addresses</div>	<div>Execution time changes when frequency changes Example: When <math>f_{cp}</math> or <math>f_{osc}</math> is 250 kHz, <math>37 \mu</math>s <math>\times \frac{270}{250} = 40 \mu</math>s</div>

## 8-Bit Interface



( Wait for more than 40 ms  
after  $V_{CC}$  rises to 2.7 V )

BF cannot be checked before this instruction.

Function set (Interface is 8 bits long.)

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BF can be checked after the following instructions.  
When BF is not checked, the waiting time between  
instructions is longer than the execution instruction  
time. (See Table 6.)

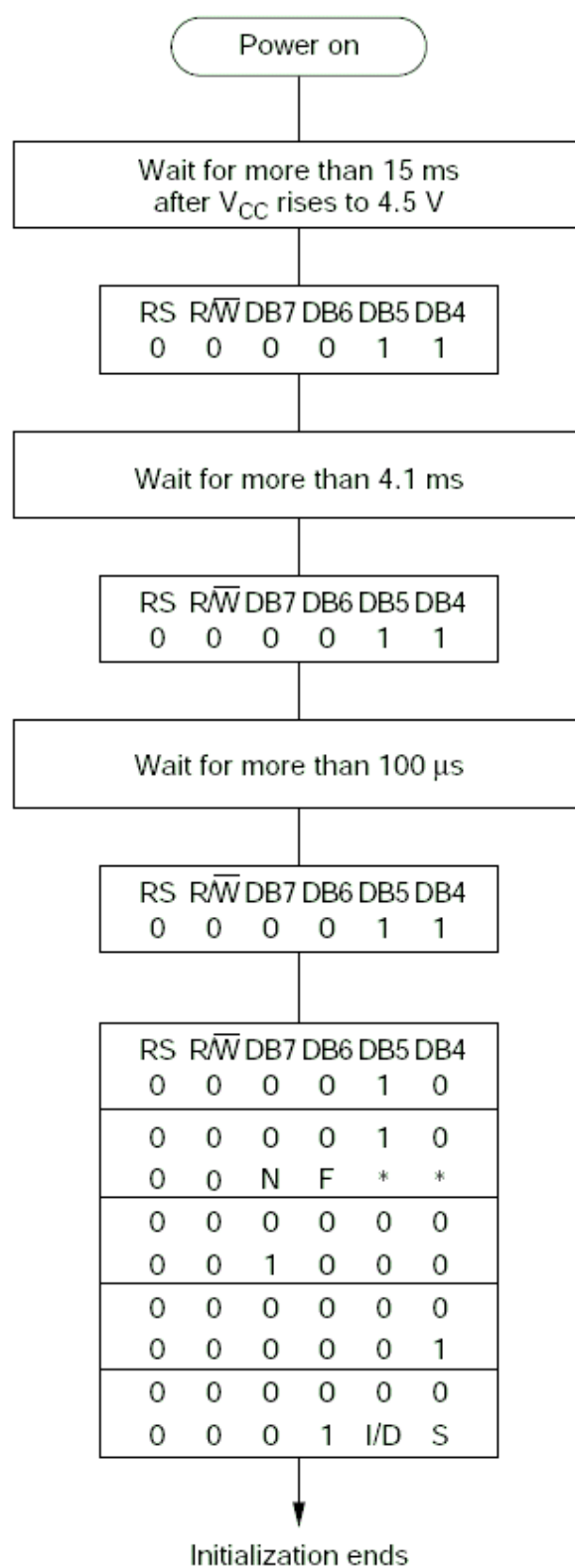
Function set (Interface is 8 bits long. Specify the  
number of display lines and character font.)  
The number of display lines and character font  
cannot be changed after this point.

Display off

Display clear

Entry mode set

## 4-Bit Interface



(Wait for more than 40 ms  
after  $V_{CC}$  rises to 2.7 V)

BF cannot be checked before this instruction.  
Function set (Interface is 8 bits long.)

BF cannot be checked before this instruction.  
Function set (Interface is 8 bits long.)

BF cannot be checked before this instruction.  
Function set (Interface is 8 bits long.)

BF can be checked after the following instructions.  
When BF is not checked, the waiting time between  
instructions is longer than the execution instruction  
time. (See Table 6.)

Function set (Set interface to be 4 bits long.)  
Interface is 8 bits in length.

Function set (Interface is 4 bits long. Specify the  
number of display lines and character font.)  
The number of display lines and character font  
cannot be changed after this point.

Display off

Display clear

Entry mode set

# Character set for lcd

Char. code										
	0	0	0	0	0	0	1	1	1	1
	0	0	0	1	1	1	0	0	1	1
	0	1	1	0	0	1	1	0	0	1
	0	0	1	0	1	0	1	0	1	0
xxxxx0000			0	0	P	`	F		一	夕
xxxxx0001		!	1	A	Q	a	4	。	ア	チ
xxxxx0010		"	2	B	R	b	r	「	イ	ツ
xxxxx0011		#	3	C	S	c	s	」	ウ	テ
xxxxx0100		\$	4	D	T	d	t	、	エ	ト
xxxxx0101		%	5	E	U	e	u	・	オ	ナ
xxxxx0110		&	6	F	V	f	v	ヲ	カ	ニ
xxxxx0111		'	7	G	W	g	w	ア	キ	ヌ
xxxxx1000		(	8	H	X	h	x	ィ	ク	ネ
xxxxx1001		)	9	I	Y	i	y	ウ	ケ	ル
xxxxx1010		*	:	J	Z	j	z	エ	コ	ハ
xxxxx1011		+	;	K	[	k	[	オ	サ	ヒ
xxxxx1100		,	<	L	¥	1		ハ	シ	フ
xxxxx1101		-	=	M	]	m	}	ユ	ス	ヘ
xxxxx1110		.	>	N	^	n	→	ヨ	セ	ホ
xxxxx1111		/	?	O	_	o	←	ッ	ソ	マ



