

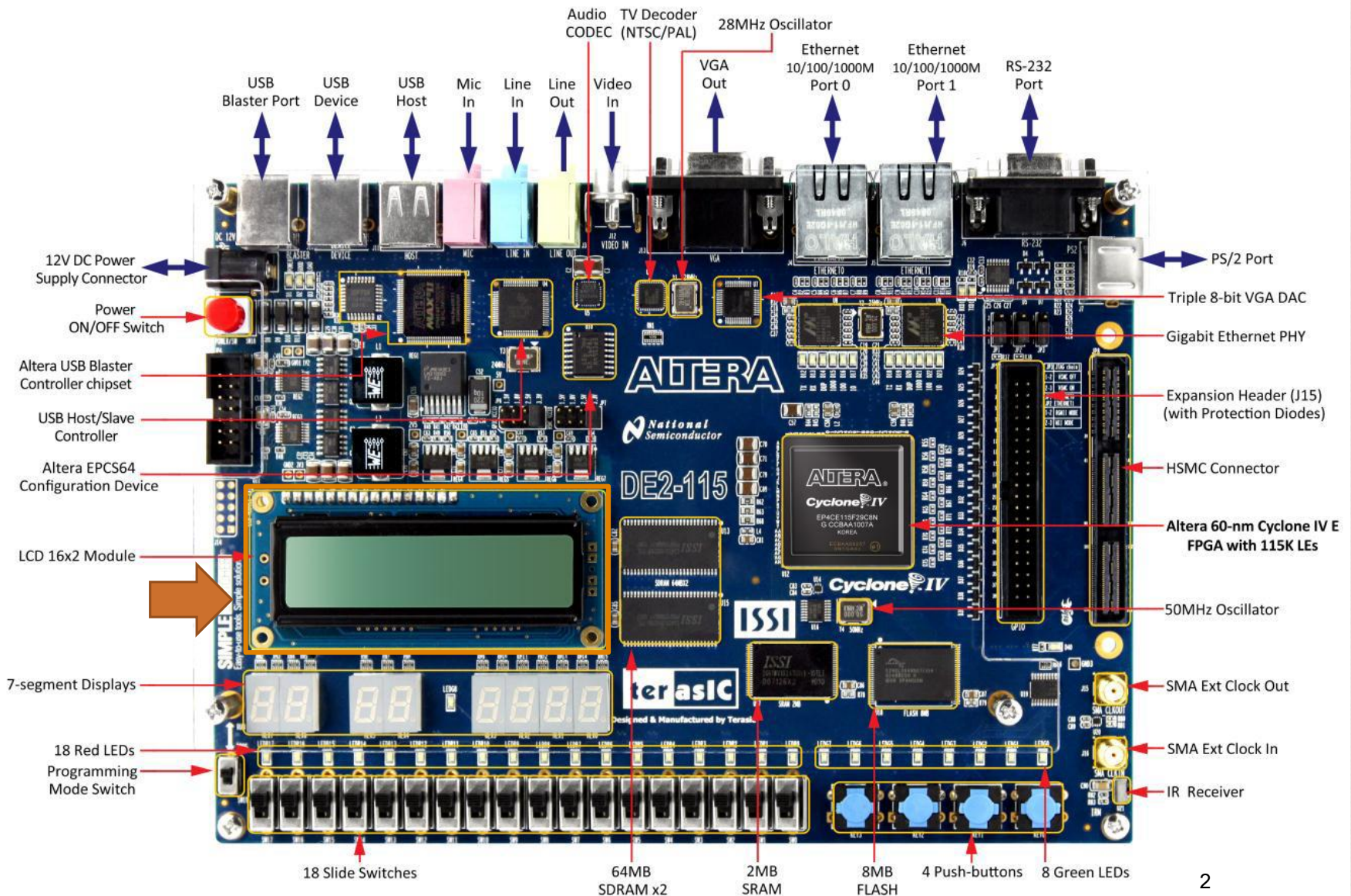
# 16x2 LCD Module on DE2-115

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數位電路實驗

Author: Trumen



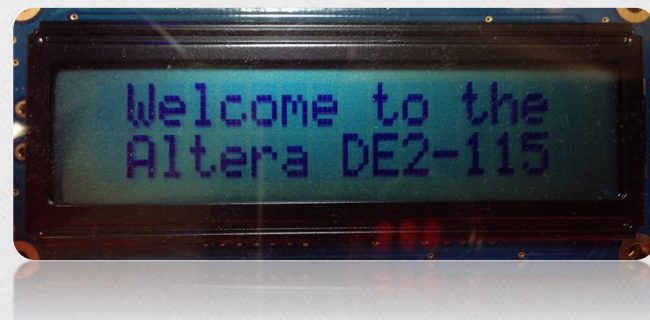




# Features

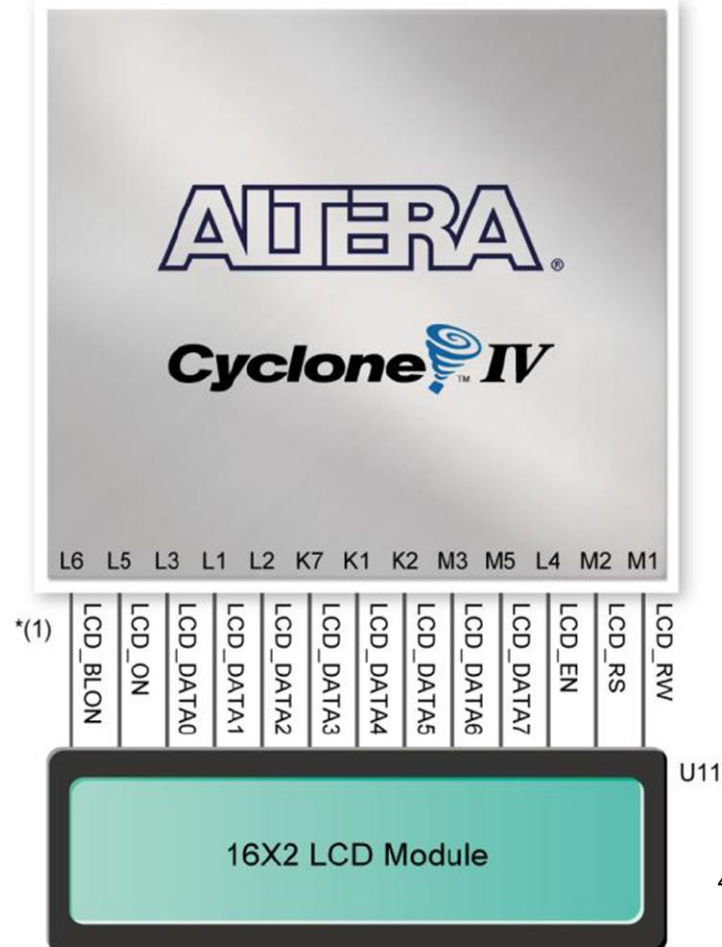
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- Display Type:
  - Character Type
- Display's logical dimensions:
  - 16 columns by 02 lines
- View direction:
  - 6 o'clock



# Schematic Diagram

\*(1): Note the current LCD modules used on DE2-115 boards do not have backlight. Therefore the **LCD\_BLON** signals should not be used in user's design project.

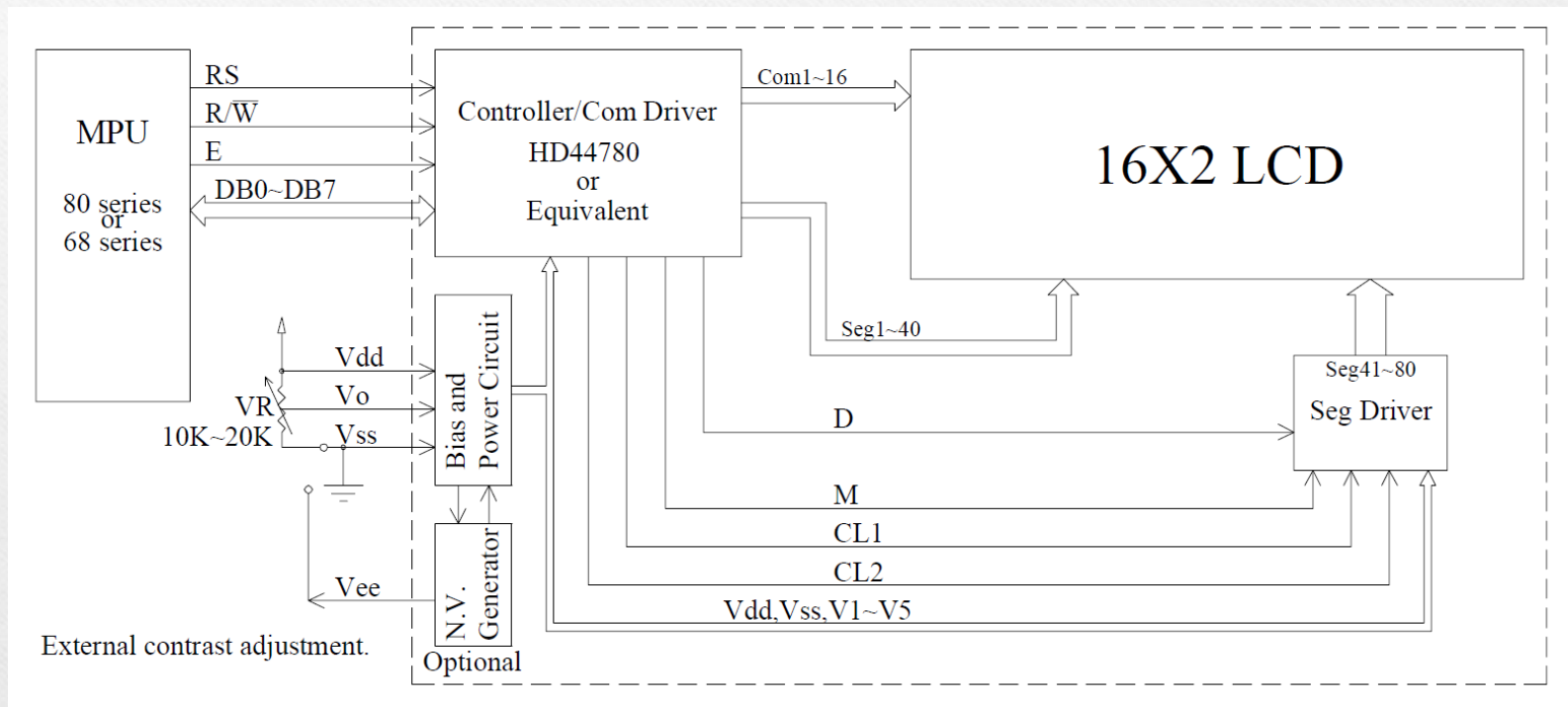




# LCD Module Pin Assignments

Signal Name	FPGA Pin No.	Description
LCD_DATA[0]~[7]	PIN_L3~M5	LCD Data[0]~[7]
LCD_EN	PIN_L4	LCD Enable <div>level sensitive: 1 edge sensitive: 1→0</div>
LCD_RW	PIN_M1	LCD Read/Write Select <div>0:write 1:read</div>
LCD_RS	PIN_M2	LCD Command Select <div>0:command 1:data</div>
LCD_ON	PIN_L5	Power ON/OFF
LCD_BLON	PIN_L6	LCD Back Light ON/OFF

# LCD Block Diagram





# Function Description (1/2)

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- The LCD display Module is built in a LSI controller.
  - The controller has two 8-bit registers, an **instruction register** (IR) and a **data register** (DR).
  - The IR stores **instruction** codes, such as display clear and cursor shift, and **address** information for display data RAM (DDRAM) and character generator (CGRAM).
  - The DR temporarily stores **data** to be written or read from DDRAM or CGRAM.

# Function Description (2/2)

0:command 1:data		0:write 1:read		
RS	R/W	Operation		
0	0	IR write as an internal operation (display clear, etc.)		
0	1	Read busy flag (DB7) and address counter (DB0 to DB6)		
1	0	Write data to DDRAM or CGRAM (DR to DDRAM or CGRAM)		
1	1	Read data from DDRAM or CGRAM (DDRAM or CGRAM to DR)		



# Busy Flag (BF)

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- When the busy flag is 1, the controller LSI is in the **internal operation mode**, and the next instruction will not be accepted.
- When  $RS=0$  and  $R/W=1$ , the busy flag is output to DB7.
- The next instruction must be written after ensuring that the busy flag is 0.

# Address Counter (AC)

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- The address counter (AC) assigns addresses to both DDRAM and CGRAM.



# Display Data RAM (DDRAM)

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- This DDRAM is used to store the display data represented in 8-bit character codes.
  - Its extended capacity is **80×8** bits or 80 characters.
  - Below figure is the relationships between DDRAM **addresses** and **positions** on the liquid crystal display.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F
40	41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F

# Character Generator ROM (CGROM)

- The CGROM generate 5×8 dot or 5×10 dot character patterns from 8-bit character codes.

Upper 4 bit Lower 4 bit	LLLL	LLLH	LLHL	LLHH	LHLL	LHLH	LHHL	LHHH	HLLL	HLLH	HLHL	HLHH	HHLL	HHLH	HHHL	HHHH
LLLL	CG RAM (1)			0	a	P	`	P					—	9	E	ap
LLLH	(2)		!	1	A	O	a	4					a	7	+	8
LLHL	(3)		"	2	B	R	b	r					r	4	v	p
LLHH	(4)		*	3	C	S	c	s					j	u	t	e
LHLL	(5)		\$	4	D	T	d	t					\	I	t	h
			.	.	.	.	.	.					.	.	.	.



# Instruction Table (1/2)

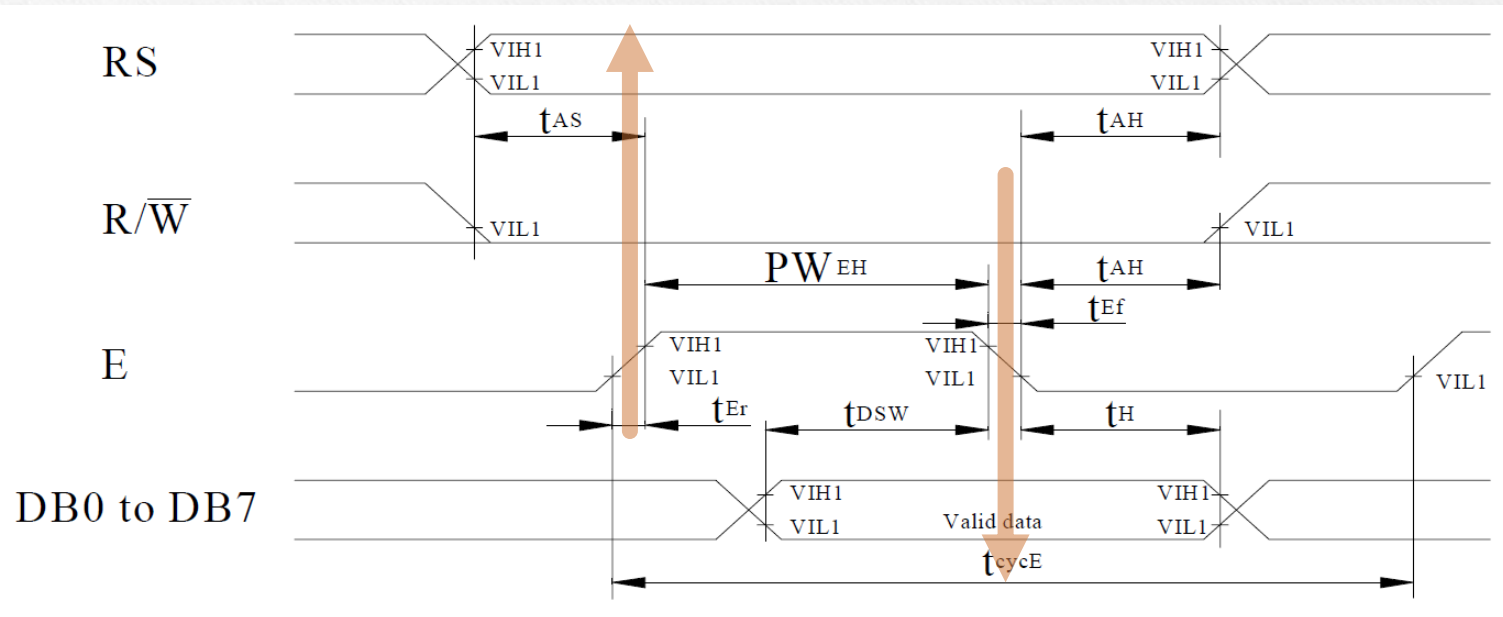
Instruction	Instruction Code										Description	Execution time (fosc=270Khz)
	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0		
Clear Display	0	0	0	0	0	0	0	0	0	1	Write "00H" to DDRAM and set DDRAM address to "00H" from AC	1.53ms
Entry Mode Set	0	0	0	0	0	0	0	1	1 I/D	0 SH	Assign cursor moving direction and enable the shift of entire display.	39 $\mu$ s
Display ON/OFF Control	0	0	0	0	0	0	1	1 D	0 C	0 B	Set display (D), cursor (C), and blinking of cursor (B) on/off control bit.	39 $\mu$ s
Function Set	0	0	0	0	1	1 DL	1 N	0 F	—	—	Set interface data length (DL:8-bit/4-bit), numbers of display line (N:2-line/1-line)and, display font type (F:5 $\times$ 11 dots/5 $\times$ 8 dots)	39 $\mu$ s

# Instruction Table (2/2)

Instruction	Instruction Code										Description	Execution time (fosc=270Khz)
	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0		
Set DDRAM Address	0	0	1	AC6	AC5	AC4	AC3	AC2	AC1	AC0	Set DDRAM address in address counter.	39 $\mu$ s
Write Data to RAM	1	0	D7	D6	D5	D4	D3	D2	D1	D0	Write data into internal RAM (DDRAM/CGRAM).	43 $\mu$ s



# Write Operation (1/2)

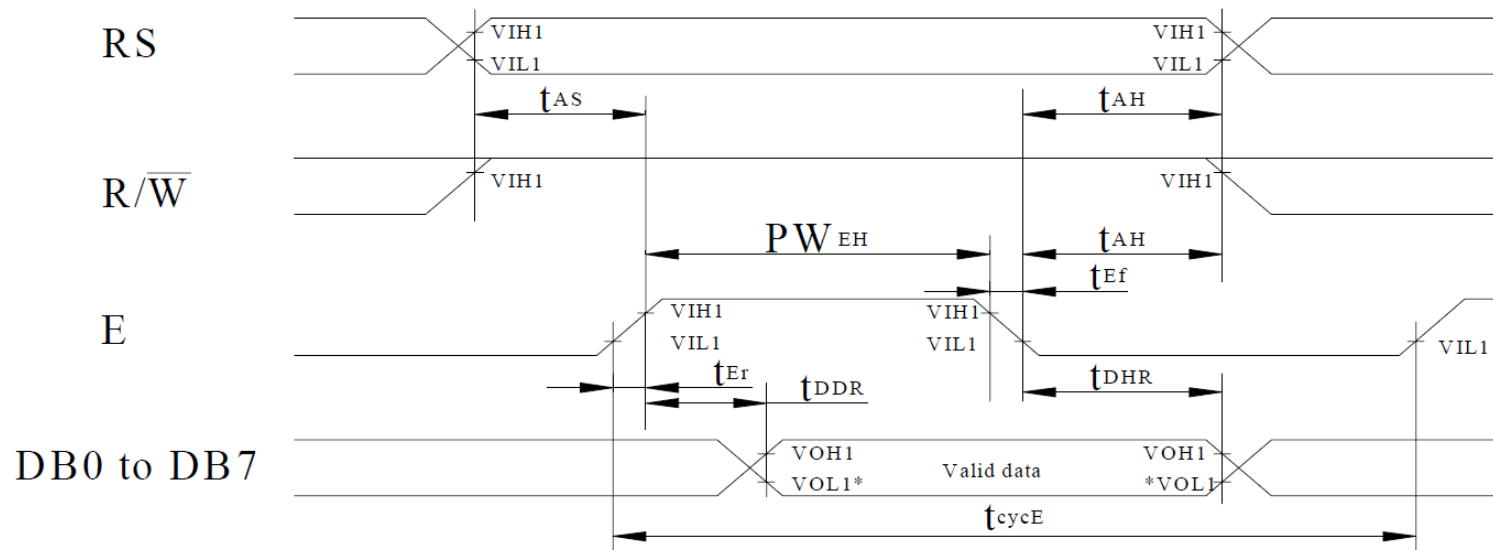


# Write Operation (2/2)

Item	Symbol	Min	Typ	Max	Unit
Enable cycle time	$t_{\text{cycE}}$	500	—	—	ns
Enable pulse width (high level)	$PW_{\text{EH}}$	230	—	—	ns
Enable rise/fall time	$t_{\text{Er}}, t_{\text{Ef}}$	—	—	20	ns
Address set-up time (RS, R/W to E)	$t_{\text{AS}}$	40	—	—	ns
Address hold time	$t_{\text{AH}}$	10	—	—	ns
Data set-up time	$t_{\text{DSW}}$	80	—	—	ns
Data hold time	$t_{\text{H}}$	10	—	—	ns



# Read Operation (1/2)

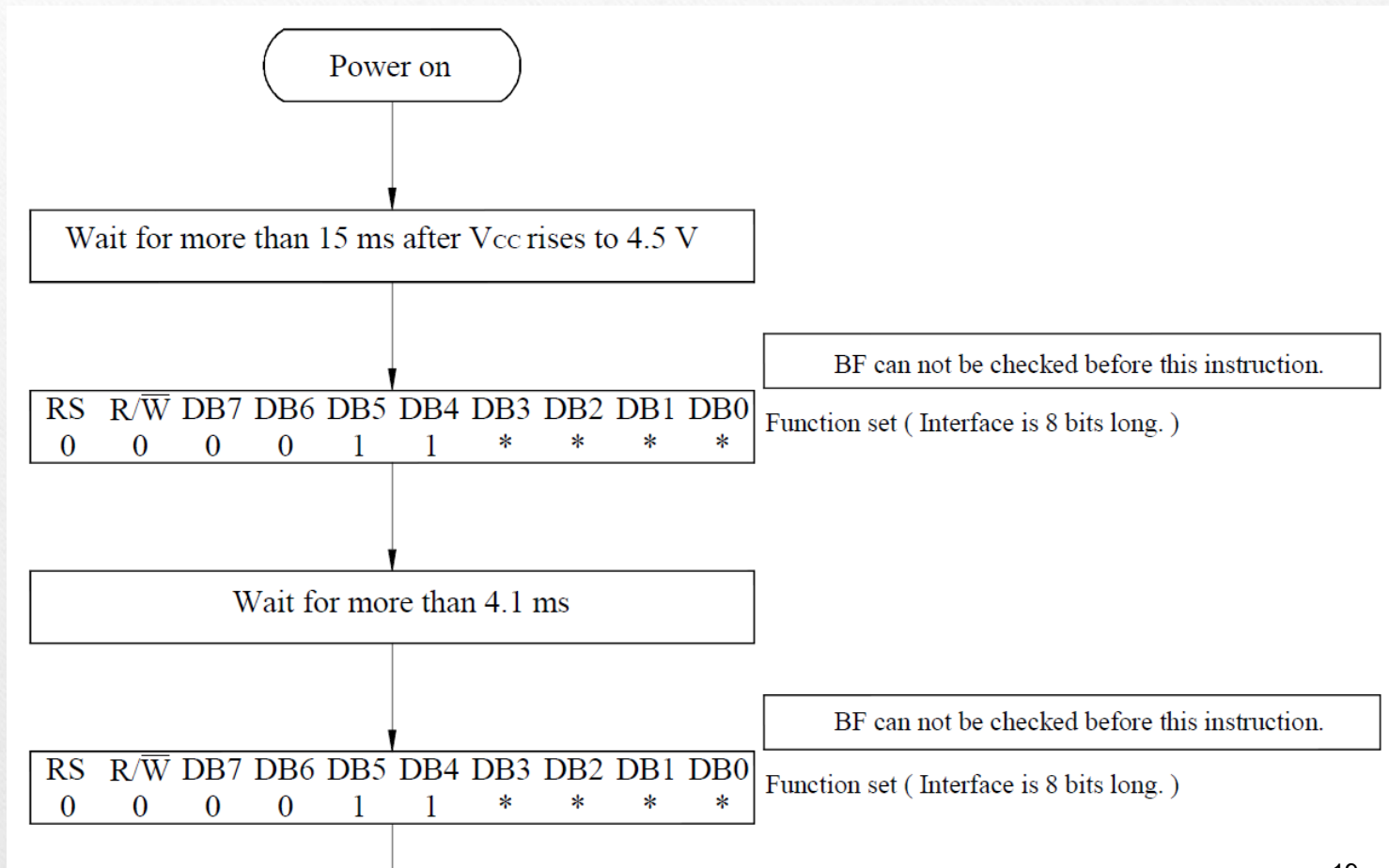


# Read Operation (2/2)

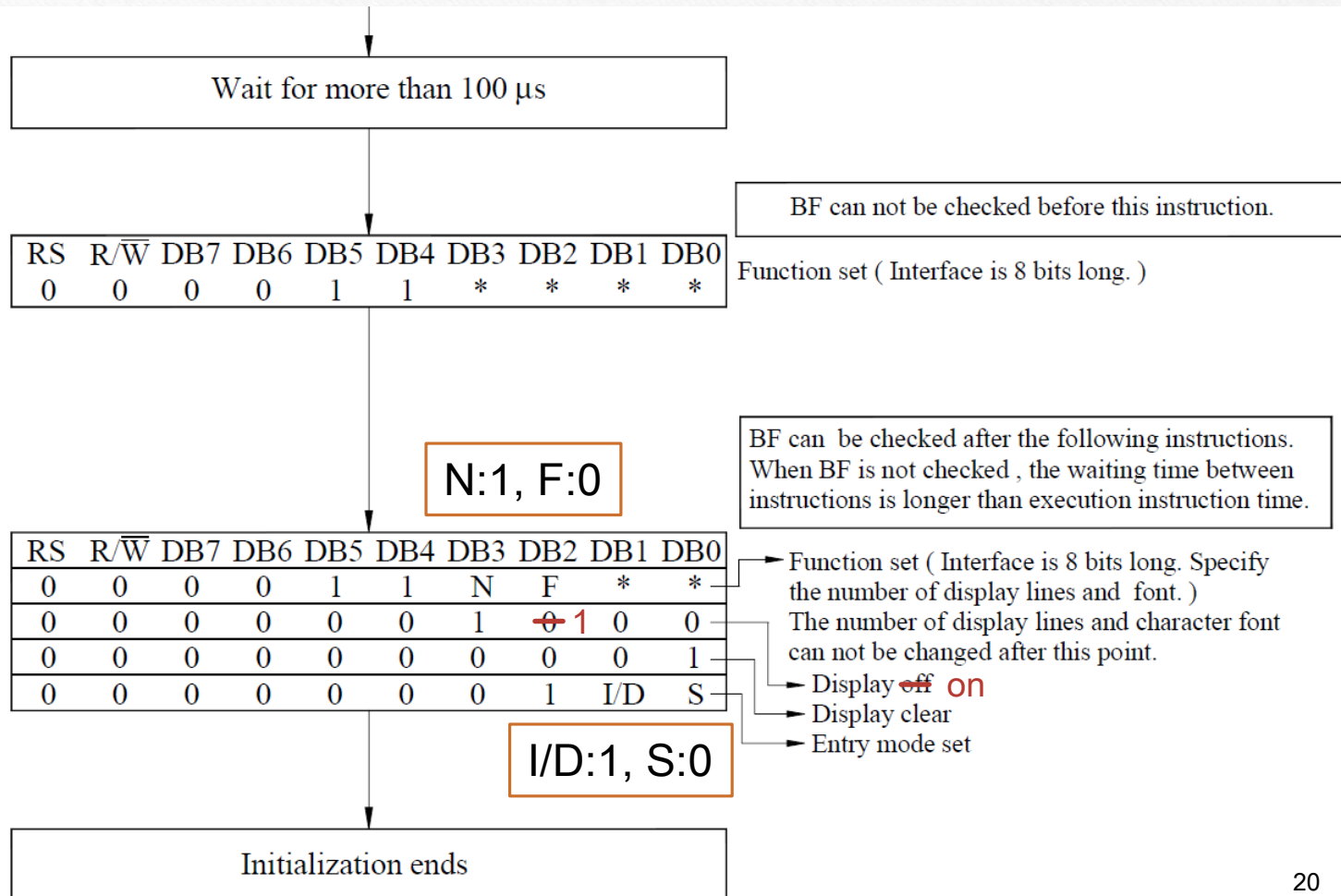
ITEM	Symbol	Min	Typ	Max	Unit
Enable cycle time	$t_{\text{cycE}}$	500	—	—	ns
Enable pulse width (high level)	$PW_{\text{EH}}$	230	—	—	ns
Enable rise/fall time	$t_{\text{Er}}, t_{\text{Ef}}$	—	—	20	ns
Address set-up time (RS, R/W to E)	$t_{\text{AS}}$	40	—	—	ns
Address hold time	$t_{\text{AH}}$	10	—	—	ns
Data delay time	$t_{\text{DDR}}$	—	—	160	ns
Data hold time	$t_{\text{DHR}}$	5	—	—	ns



# Initializing of LCM (1/2)



# Initializing of LCM (2/2)





# The End.

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Any question?

# Reference

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1. "DE2-115 User Manual" by Terasic.
2. "DE2-115\_MB.pdf" by Terasic.
3. "CFAH1602BTMCJP.pdf" by *Crystalfontz America, Inc..*