

# Introduction to Electric Vehicles

## Midterm project

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**KAIST**

The KAIST logo consists of the word "KAIST" in a bold, blue, sans-serif font. Below the text is a blue horizontal oval shape that tapers at both ends, serving as a base or shadow for the text.

# Midterm project

- Using display control instructions
  - 8 bit data mode
  - Display ON/OFF control
  - Cursor ON
  - Blinking cursor
  - 2 line display mode
  - Using cursor shift
  - Read busy flag
- Writing words
  - "Hello World! >.<"
- Erase the words, one by one
- Rewrite the "Hello World! >.<"

# Midterm report

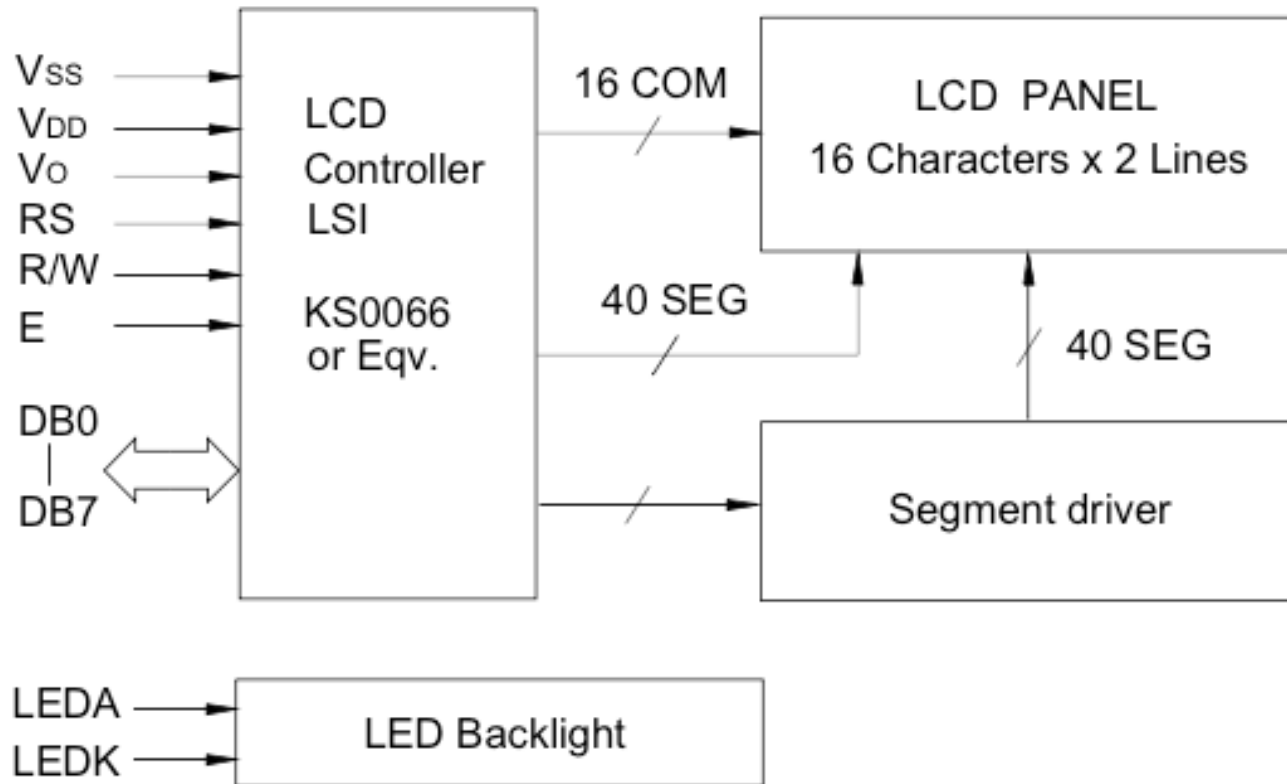
- Printed report is required
  - Until May 6th Wednesday class
  - No delayed paper accepted
- Contents should include
  - Source code
  - Detailed description of the source code
  - Answer the questions
    - 1) Explain about read/write timing
    - 2) Explain the display control instructions, which you used
    - 3) Explain about the terminal functions (e.g. RS, R/W, E, ...)
  - Photo of the operation (Hello World! >.<)

# Character display

- LC1628-BMDWH6
  - Mount LCD to your Universal board



# LCD block diagram



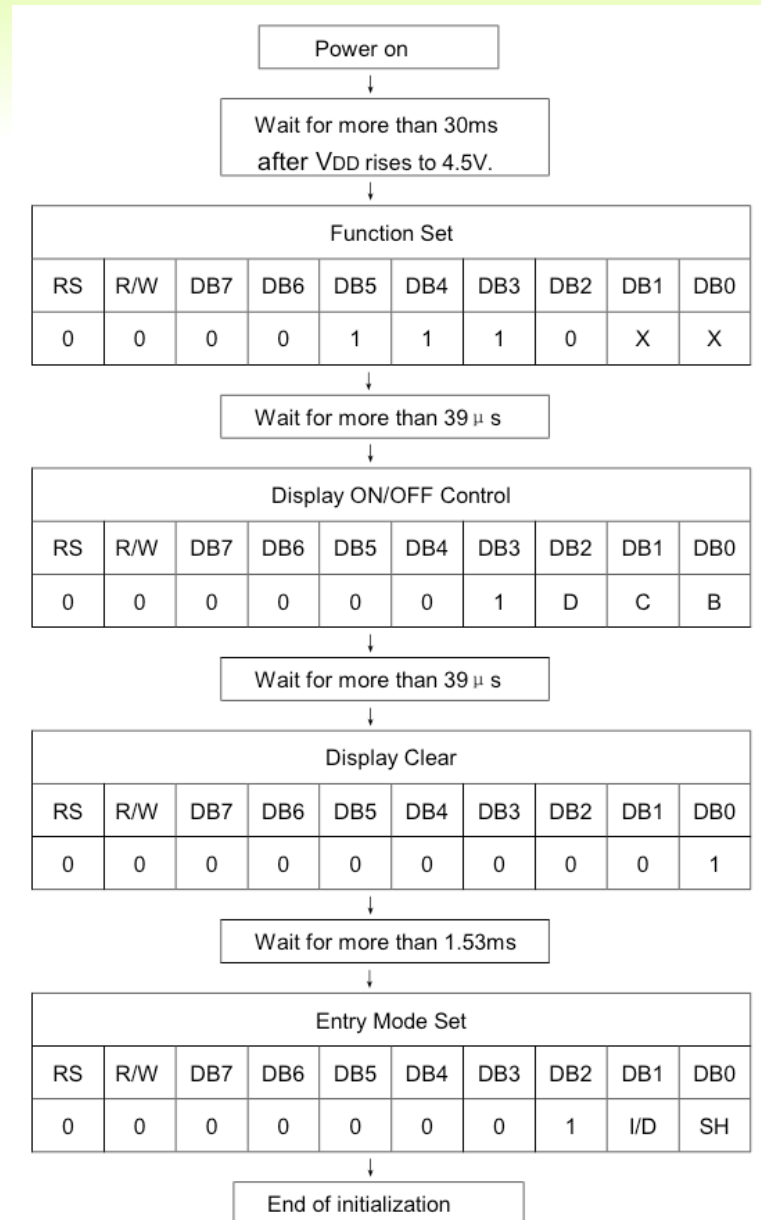
# Configurations

- UART
- Timer interrupt
  - To give some delays to the function
- GPIO
  - Data bits, LCD display configuration

# Terminal functions

Pin No.	Symbol	Level	Function
1	VSS	0V	Ground
2	VDD	+3 to 5V	Power supply for logic (refer to section 3.4)
3	VO	--	Operating voltage for LCD (contrast adjusting)
4	RS	H/L	Data or instruction selection H: Display data    L: Instruction code
5	R/W	H/L	Read or write selection H: Read operation    L: Write operation
6	E	H, H→L	Enable signal In read mode (R/W="H"), data appears at DB0 to DB7 while E is "H". In write mode (R/W="L"), data of DB0 to DB7 is latched at the falling edge of E
7	DB0	H/L	In 8-bit mode, used as low order bi-directional data bus. In 4-bit mode, open these terminals.
8	DB1	H/L	
9	DB2	H/L	
10	DB3	H/L	
11	DB4	H/L	In 8-bit mode, used as high order bi-directional data bus. In 4-bit mode, used as both high and low order data bus.
12	DB5	H/L	
13	DB6	H/L	
14	DB7	H/L	
15	LEDA	+5V	Power supply for LED backlight
16	LEDK	0V	Refer to section 3.3, 3.5

# 8 bit initialization

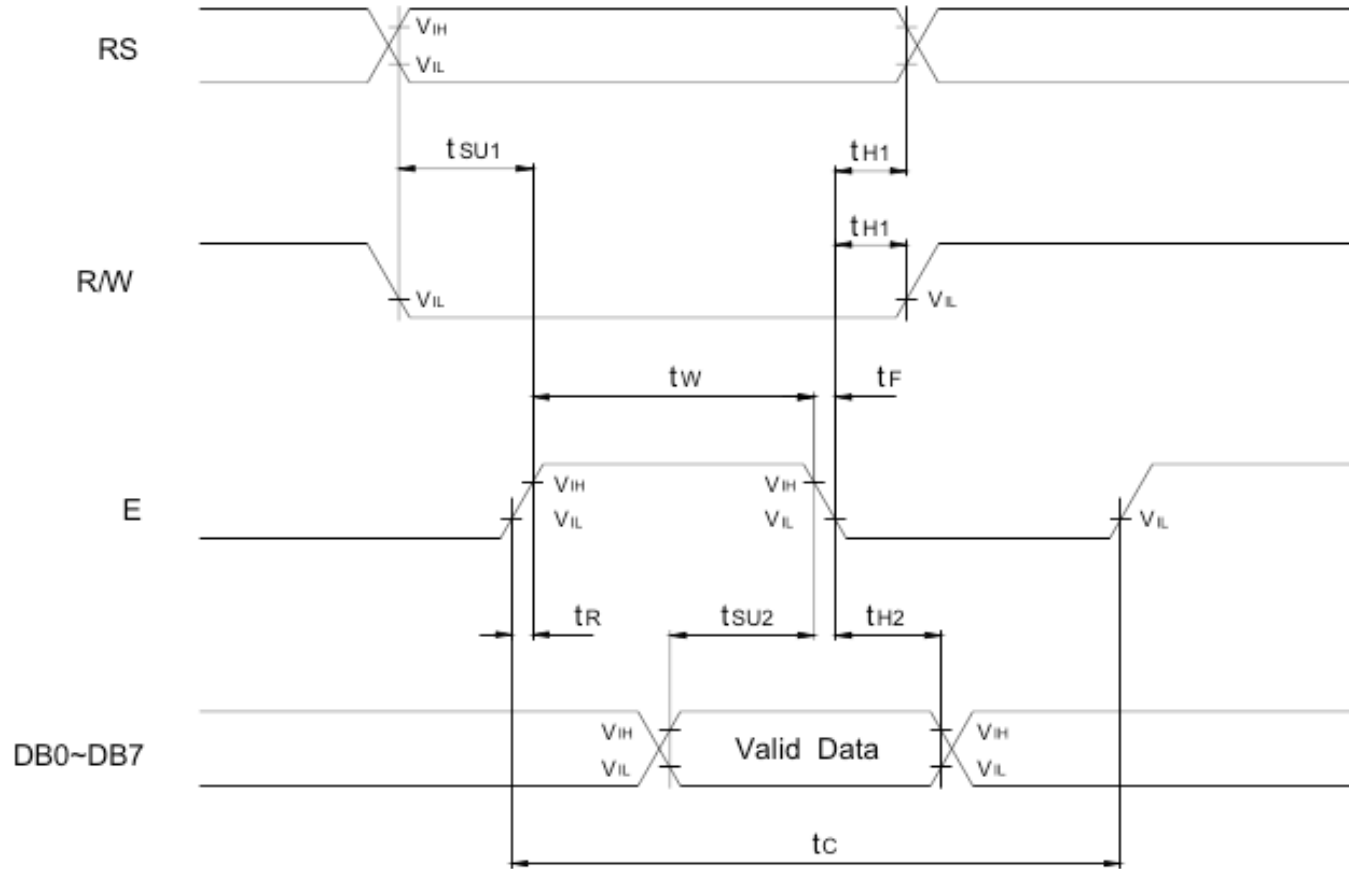




# MCU reading/writing timing

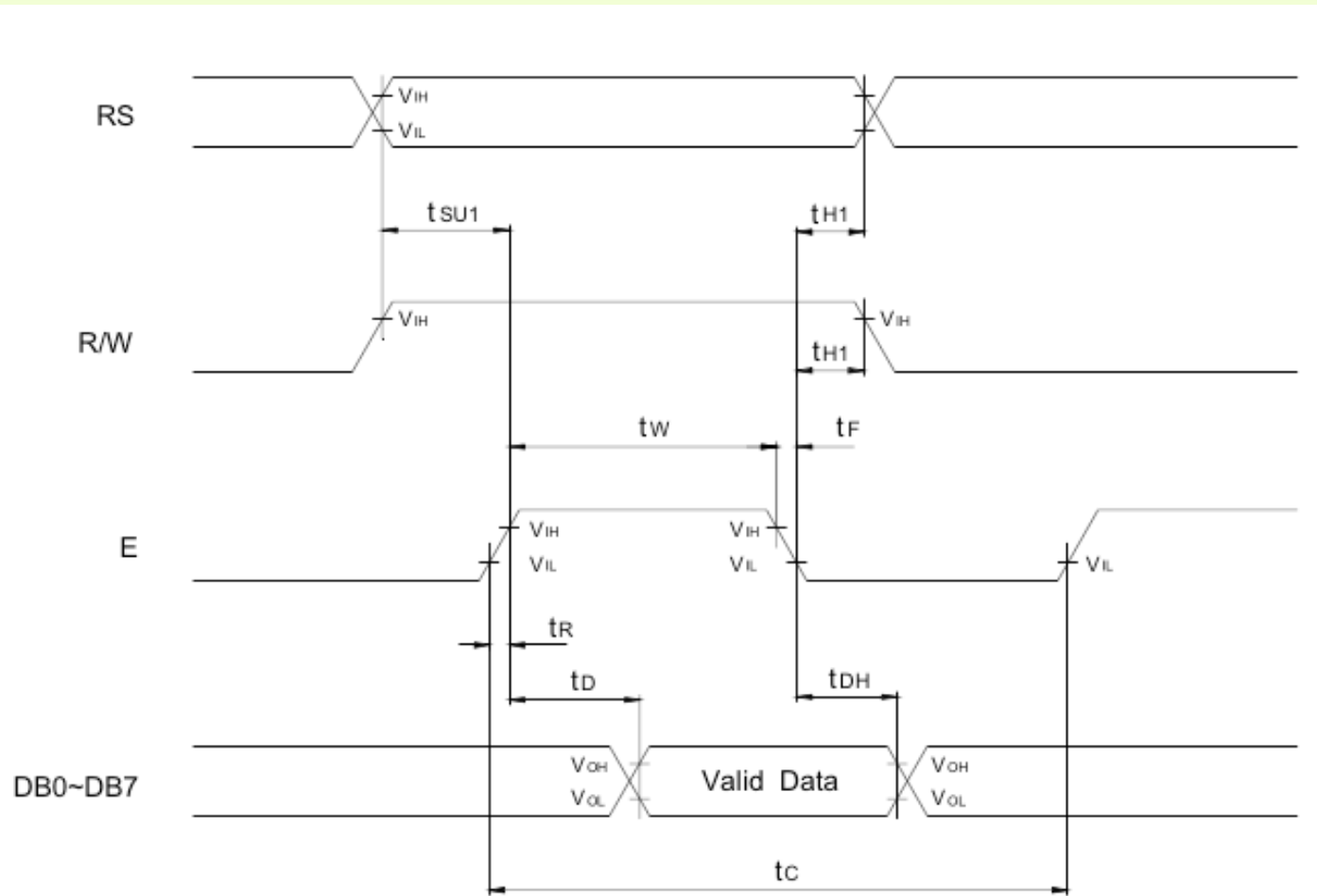
- RS
  - Data or instruction selection
- R/W
  - Read or write selection
- E
  - Enable signal
  
- Change RS, and R/W value for desired operation
- Enable signal (min 230ns)
- Data bit hold time

# MPU write timing



MPU Write Timing

# MPU read timing



MPU Read Timing

# Interface timing chart

Mode	Characteristic	Symbol	Min.	Typ.	Max.	Unit
Write Mode (Refer to MPU Write Timing)	E Cycle Time	$t_c$	500	--	--	ns
	E Rise/Fall Time	$t_R, t_F$	--	--	20	
	E Pulse Width (High,Low)	$t_w$	230	--	--	
	R/W and RS Setup Time	$t_{SU1}$	40	--	--	
	R/W and RS Hold Time	$t_{H1}$	10	--	--	
	Data Setup Time	$t_{SU2}$	80	--	--	
	Data Hold Time	$t_{H2}$	10	--	--	
Read Mode (Refer to MPU Read Timing)	E Cycle Time	$t_c$	500	--	--	ns
	E Rise/Fall Time	$t_R, t_F$	--	--	20	
	E Pulse Width (High,Low)	$t_w$	230	--	--	
	R/W and RS Setup Time	$t_{SU}$	40	--	--	
	R/W and RS Hold Time	$t_H$	10	--	--	
	Data Output Delay Time	$t_D$	--	--	120	
	Data Hold Time	$t_{DH}$	5	--	--	

# Character code table

Upper 4bit Lower 4bit	0000	0001	0010	0011	0100	0101	0110	0111	1000	1001	1010	1011	1100	1101	1110	1111
0000	CG RAM (1)		0	1	A	R	2	3				4	5	6	7	8
0001	(2)	!	2	A	R	3	4	5			6	7	8	9	0	1
0010	(3)	"	2	B	R	6	7	8			9	0	1	2	3	4
0011	(4)	#	3	C	S	6	7	8			9	0	1	2	3	4
0100	(5)	#	4	D	T	d	t				1	2	3	4	5	6
0101	(6)	%	5	E	U	e	u				1	2	3	4	5	6
0110	(7)	&	6	F	U	f	u				2	3	4	5	6	7
0111	(8)	?	7	G	U	g	u				3	4	5	6	7	8
1000	(1)	(	8	H	X	h	x				4	5	6	7	8	9
1001	(2)	)	9	I	Y	i	y				5	6	7	8	9	0
1010	(3)	#	1	J	Z	j	z				6	7	8	9	0	1
1011	(4)	#	2	K	C	k	c				7	8	9	0	1	2
1100	(5)	<	L	Y	I	l	i				8	9	0	1	2	3
1101	(6)	=	M	I	N	m	n				9	0	1	2	3	4
1110	(7)	>	N	O	N	n					0	1	2	3	4	5
1111	(8)	/	? 0	L	O	l	o				1	2	3	4	5	6

# Display control instructions

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	0	1	Clears entire display and sets DDRAM address to 00H.	1.53ms
Return Home	0	0	0	0	0	0	0	0	0	1	-	Sets DDRAM address to 00H in AC and returns shifted display to its original position. The contents of DDRAM remain unchanged.	1.53ms
Entry Mode Set	0	0	0	0	0	0	0	0	1	I/D	SH	Sets cursor move direction and enable the shift of entire display. These operations are performed during data write and read.	39 μ s
Display ON/OFF Control	0	0	0	0	0	0	0	1	D	C	B	Set ON/OFF of entire display (D), cursor ON/OFF(C), and blinking of cursor position character (B).	39 μ s
Cursor or Display Shift	0	0	0	0	0	1	S/C	R/L	-	-	-	Moves cursor and shifts display without changing DDRAM contents.	39 μ s
Function Set	0	0	0	0	1	DL	N	F	-	-	-	Sets interface data length (DL: 8-bit/4-bit), numbers of display line (N: 2-line/1-line), and display font type (F: 5x11dots/5x8dots)	39 μ s
Set CGRAM Address	0	0	0	1	AC5	AC4	AC3	AC2	AC1	AC0	-	Set CGRAM address in address counter.	39 μ s
Set DDRAM Address	0	0	1	AC6	AC5	AC4	AC3	AC2	AC1	AC0	-	Set DDRAM address in address Counter.	39 μ s
Read Busy Flag and Address	0	1	BF	AC6	AC5	AC4	AC3	AC2	AC1	AC0	-	Reads busy flag (BF) indicating internal operation is being performed and reads address counter contents.	0 μ s
Write data to CG or DD RAM	1	0	D7	D6	D5	D4	D3	D2	D1	D0	-	Write data into internal RAM (DDRAM/CGRAM).	43us
Read data from CG or DD RAM	1	1	D7	D6	D5	D4	D3	D2	D1	D0	-	Read data from internal RAM (DDRAM/CGRAM).	43us

# What you have to do

- Connect the 16 pins of LCD to the MCU with wires
- 8 bit initialization (p.7)
  - 8 bit data mode
  - Display ON/OFF control
  - Cursor ON
  - Blinking cursor
  - 2 line display mode
- Writing a character to the LCD (Refer MPU writing timing)
  - RS, R/W are set for desired operation
  - Hold RS, R/W signal
  - Enable signal is on
  - Hold Enable signal
  - Transmit data to DB (Data Bits)
  - Enable signal is off
- Instruction sets
  - Same process to writing a character