HIGH-VOLTAGE MIXED-SIGNAL IC

UC1610

128 x 160 4S STN LCD Controller-Driver

MP Specifications
Datasheet Revision: 1.36

IC Version: i_B
August 19, 2011

ULTRACHIP

The Coolest LCD Driver, Ever!!

TABLE OF CONTENT

UC1610

Single-Chip, Ultra-Low Power
128COM x 160SEG Matrix
Passive LCD Controller-Driver

INTRODUCTION

UC1610i is an advanced high-voltage mixed-signal CMOS IC, especially designed for the display needs of ultra-low power hand-held devices.

This chip employs UltraChip's unique DCC (Direct Capacitor Coupling) driver architecture to achieve near crosstalk free images, with well balanced gray shades.

In addition to low power COM and SEG drivers, UC1610i contains all necessary circuits for high-V LCD power supply, bias voltage generation, timing generation and graphics data memory.

Advanced circuit design techniques are employed to minimize external component counts and reduce connector size while achieving extremely low power consumption.

MAIN APPLICATIONS

- Cellular Phones and other battery operated palm top devices or portable Instruments

FEATURE HIGHLIGHTS

- Single chip controller-driver for 128x160 matrix STN LCD with 4 gray shades.
- One software readable ID pin to support configurable vender identification.
- Partial scroll function and programmable data update window to support flexible manipulation of screen data.
- Support both row ordered and column ordered display buffer RAM access
- Support industry standard 2-wire, 3-wire, 4-wire serial bus (I^2C, S9, S8, S8uc) and 8-bit/4-bit parallel bus (8080 or 6800).
- Special driver structure and gray shade modulation scheme. Consistent low power consumption under all display patterns.
- Fully programmable Mux Rate, partial display window, Bias Ratio and Line Rate allow many flexible power management options.
- Four software programmable frame rates up to 130Hz. Support the use of fast Liquid Crystal material for speedy LCD response.
- Software programmable 4 temperature compensation coefficients.
- On-chip Power-ON Reset and Software RESET command, make RST pin optional.
- Self-configuring 8x charge pump with on-chip pumping capacitors. Only 3 external capacitors are required to operate.
- Flexible data addressing/mapping schemes to support wide ranges of software models and LCD layout placements.
- Very low pin count (9~10 pins with S9 or I^2C) allows exceptional image quality in COG format on conventional ITO glass.
- Many on-chip and I/O pad layout features to support optimized COG applications.
- V_{DD} (digital) range: 1.8V ~ 3.3V (Typical)
  V_{DD} (analog) range: 2.6V ~ 3.3V (Typical)
  LCD V_{OP} range: 5.0V ~ 15V
- Available in gold bump dies
  Bump pitch: 50μM
  Bump gap: 17μM or 12uM.
  Bump surface: >3,000μM^2

ORDERING INFORMATION

Part Number	Versions	I^2C	Description
UC1610iGAB	Gold Bumped Die	Yes	Bare die with gold bumps with I^2C interface
UC1610iGAB-2	Gold Bumped Die	Yes	Bare die with gold bumps with I^2C interface, Bump Height 12uM

General Notes

APPLICATION INFORMATION

For improved readability, the specification contains many application data points. When application information is given, it is advisory and does not form part of the specification for the device.

BARE DIE DISCLAIMER

All die are tested and are guaranteed to comply with all data sheet limits up to the point of wafer sawing. There is no post waffle saw/pack testing performed on individual die. Although the latest processes are utilized for wafer sawing and die pick-&-place into waffle pack carriers, UltraChip has no control of third party procedures in the handling, packing or assembly of the die. Accordingly, it is the responsibility of the customer to test and qualify their applications in which the die is to be used. UltraChip assumes no liability for device functionality or performance of the die or systems after handling, packing or assembly of the die.

USE OF I^2C

The implementation of I^2C is already included and tested in all silicon.

LIFE SUPPORT APPLICATIONS

These devices are not designed for use in life support appliances, or systems where malfunction of these products can reasonably be expected to result in personal injuries. Customer using or selling these products for use in such applications do so at their own risk.

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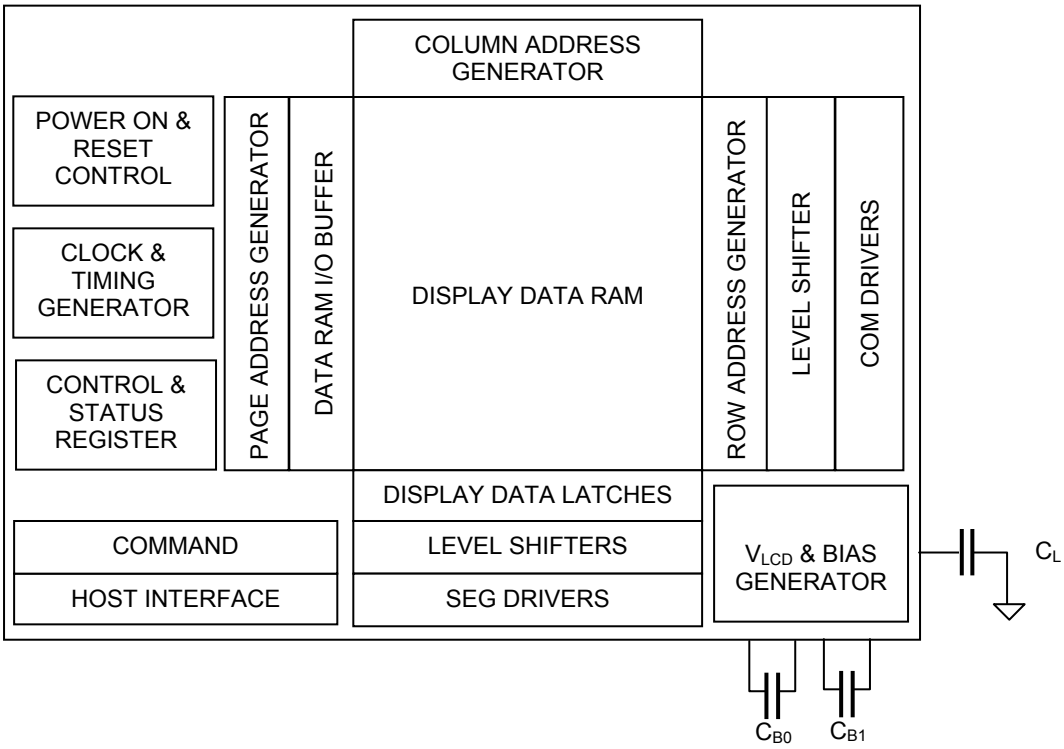
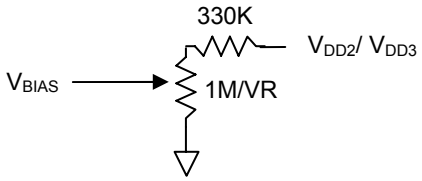
BLOCK DIAGRAM



PIN DESCRIPTION

Name	Type	Pins	Description
			MAIN POWER SUPPLY
V_{DD} V_{DD2} V_{DD3}	PWR	5 3 3	V_{DD2}/V_{DD3} is the analog power supply and it should be connected to the same power source. V_{DD} is the digital power supply and it should be connected to a voltage source that is no higher than V_{DD2}/V_{DD3}. Please maintain the following relationship: $V_{DD}+1.3V \geq V_{DD2/3} \geq V_{DD}$ Minimize the trace resistance for V_{DD} and V_{DD2}/V_{DD3}.
V_{SS} V_{SS2}	GND	6 5	Ground. Connect V_{SS} and V_{SS2} to the shared GND pin. Minimize the trace resistance for this node.
			LCD POWER SUPPLY & VOLTAGE CONTROL
V_{BIAS}	I	1	This is the reference voltage to generate the actual SEG driving voltage. V_{BIAS} can be used to fine tune V_{LCD} by external variable resistors. Internal resistor network has been provided to simplify external trimming circuit. The following network is sufficient for most applications.  An internal RC filter is provided to filter noise on the V_{BIAS} pin. When not use, it is OK to leave V_{BIAS} open circuit. If noise starts to cause problem, connect a small bypass capacitor between V_{BIAS} and V_{SS}.
V_{B0+} V_{B0-} V_{B1+} V_{B1-}	PWR	9, 9 9, 9	LCD Bias Voltages. These are the voltage sources to provide SEG driving currents. These voltages are generated internally. Connect capacitors of C_{BX} value between V_{BX+} and V_{BX-}. The resistance of these traces directly affects the driving strength of SEG electrodes and impacts the image of the LCD module. Minimize the trace resistance is critical in achieving high quality image.
V_{LCDIN} V_{LCDOUT}	PWR	2 2	High voltage LCD Power Supply. Connect these pins together. By-pass capacitor C_L is optional. It can be connected between V_{LCD} and V_{SS}. When C_L is used, keep the trace resistance under 300 Ω.

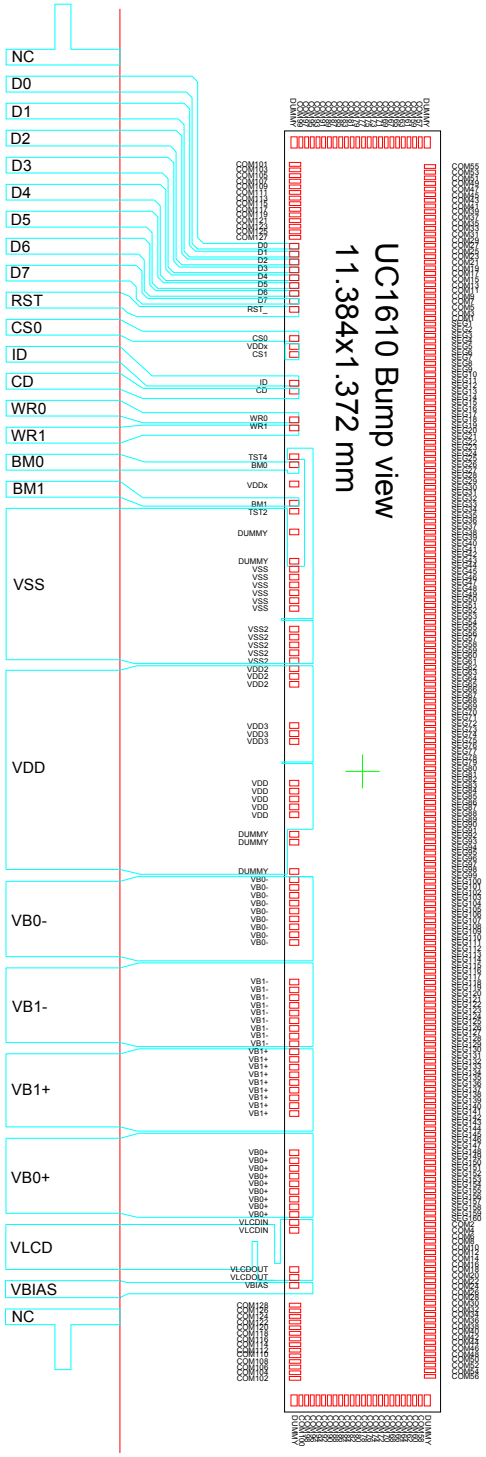
NOTE

- Recommended capacitor values:
  C_B: 150~250x LCD load capacitance or 2μF (2V), whichever is higher.
  C_L: 0.06μF~0.3μF (25V) is appropriate for most applications.

<table>
<tr><th>Name</th><th>Type</th><th>Pins</th><th>Description</th></tr>
<tr><td colspan="4">HOST INTERFACE</td></tr>
<tr><td>BM0
BM1</td><td>I</td><td>1
1</td><td>Bus mode: The interface bus mode is determined by BM[1:0] and D[7:6] by the following relationship:
<table>
<tr><th colspan="2">Mode</th><th>BM[1:0]</th><th>D[7:6]</th></tr>
<tr><td>8080</td><td rowspan="2">8-bit</td><td>10</td><td>Data</td></tr>
<tr><td>6800</td><td>11</td><td>Data</td></tr>
<tr><td>8080</td><td rowspan="2">4-bit</td><td>00</td><td>00</td></tr>
<tr><td>6800</td><td>01</td><td>00</td></tr>
<tr><td colspan="2">4-wire SPI w/ 8-bit token (S8: conventional)</td><td>00</td><td>10</td></tr>
<tr><td colspan="2">3-wire SPI w/ 8-bit token (S8uc: Ultra-Compact)</td><td>00</td><td>11</td></tr>
<tr><td colspan="2">3-wire SPI w/ 9-bit token (S9: conventional)</td><td>01</td><td>10</td></tr>
<tr><td colspan="2">2-wire I^2C</td><td>01</td><td>11</td></tr>
</table></td></tr>
<tr><td>CS1/A3
CS0/A2</td><td>I</td><td>1
1</td><td>Chip Select. Chip is selected when CS1=”H” and CS0 = “L”. When the chip is not selected, D[7:0] will be high impedance.
In I^2C mode, these two pins indicate the I^2C bus address’ bit 2 and bit 3.</td></tr>
<tr><td>RST</td><td>I</td><td>1</td><td>When RST=”L”, all control registers are re-initialized by their default states. Since UC1610i has built-in Power-ON Reset and Software Reset command, RST pin is not required for proper chip operation.
An RC Filter has been included on-chip. There is no need for external RC noise filter. When RST is not used, connect the pin to V_{DD}.</td></tr>
<tr><td>CD</td><td>I</td><td>1</td><td>Select Control data or Display data for read/write operation.
”L”: Control data ”H”: Display data
In S9 and I^2C modes, CD pin is not used. Connect CD to V_{SS} when not used.</td></tr>
<tr><td>ID</td><td>I</td><td>1</td><td>ID pin is for production control. The connection will affect the content of D[7] when using Get Status command. Connect to V_{DD} for “H” or V_{SS} for “L”.</td></tr>
<tr><td>WR0
WR1</td><td>I</td><td>1
1</td><td>WR[1:0] controls the read/write operation of the host interface.
<table>
<tr><th colspan="2">Mode</th><th>WR[1:0]</th></tr>
<tr><td rowspan="2">Parallel</td><td>8080</td><td>$\overline{RD}$, $\overline{WR}$</td></tr>
<tr><td>6800</td><td>EN, R/$\overline{W}$</td></tr>
<tr><td rowspan="4">Serial</td><td>S8</td><td>11</td></tr>
<tr><td>S8uc</td><td>11</td></tr>
<tr><td>S9</td><td>00</td></tr>
<tr><td>I^2C</td><td>11</td></tr>
</table></td></tr>
</table>

<table>
<tr><th>Name</th><th>Type</th><th>Pins</th><th>Description</th></tr>
<tr><td>D0~D7</td><td>I/O</td><td>8</td><td>Bi-directional bus for both serial and parallel host interfaces.
In serial modes, connect D[0] to SCK, D[3] to SDA,
<table>
<tr><th></th><th>8-bit (BM=1x)</th><th>4-bit (BM=0x)</th><th>S8/S8uc (BM=00)</th><th>S9/I^{2}C (BM=01)</th></tr>
<tr><td>D0</td><td>D0</td><td>D0/D4</td><td>SCK</td><td>SCK</td></tr>
<tr><td>D1</td><td>D1</td><td>D1/D5</td><td>–</td><td>–</td></tr>
<tr><td>D2</td><td>D2</td><td>D2/D6</td><td>–</td><td>–</td></tr>
<tr><td>D3</td><td>D3</td><td>D3/D7</td><td>SDA</td><td>SDA</td></tr>
<tr><td>D4</td><td>D4</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>D5</td><td>D5</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>D6</td><td>D6</td><td>–</td><td>S8 / S8uc</td><td>S9 / I^{2}C</td></tr>
<tr><td>D7</td><td>D7</td><td>0</td><td>1</td><td>1</td></tr>
</table>
Connect unused pins to V_{SS}.</td></tr>
<tr><th colspan="4">HIGH VOLTAGE LCD DRIVER OUTPUT</th></tr>
<tr><td>SEG1 ~ SEG160</td><td>HV</td><td>160</td><td>SEG (column) driver outputs. Support up to 160 pixels.
Leave unused drivers open-circuit.</td></tr>
<tr><td>COM1 ~ COM128</td><td>HV</td><td>128</td><td>COM (row) driver outputs. Support up to 128 rows. Leave unused COM drivers open-circuit.</td></tr>
<tr><th colspan="4">MISC. PINS</th></tr>
<tr><td>V_{DDX}</td><td></td><td>2</td><td>Auxiliary V_{DD}. These pins are connected to the main V_{DD} bus on chip. They are provided to facilitate chip configurations in COG application.
These pins should not be used to provide V_{DD} power to the chip. It is not necessary to connect V_{DDX} to main V_{DD} externally.</td></tr>
<tr><td>TST4</td><td>I</td><td>1</td><td>Test control. Connect TST4 to V_{SS} during normal use.</td></tr>
<tr><td>TST2</td><td>I/O</td><td>1</td><td>Test I/O pin. Leave these pins open during normal use.</td></tr>
<tr><td>Dummy</td><td></td><td>9</td><td>Dummy pins are NOT connected inside the IC.</td></tr>
<tr><td colspan="4">Note:
Several control registers will specify “0 based index” for COM and SEG electrodes. In those situations, COMX or SEGX will correspond to index X-1, and the value ranges for those index registers will be 0~127 for COM and 0~159 for SEG.</td></tr>
</table>

RECOMMENDED COG LAYOUT



NOTES FOR V_{DD} WITH COG:

The typical operation condition of UC1610i, V_{DD}=1.75V, should be met under all operating conditions. Unless V_{DD} and $V_{DD2/3}$ ITO trances can each be controlled to be 5Ω or lower; otherwise V_{DD}-$V_{DD2/3}$ separation can cause the actual on-chip V_{DD} to drop below V_{DD}=1.75V during high speed data write condition. Therefore, for COG, V_{DD}-$V_{DD2/3}$ separation requires very careful ITO layout and very stringent testing before MP.

CONTROL REGISTERS

Registers control the chip operation. These registers can be modified by commands. The following table is a summary of the control registers, their meanings and their default values. Commands supported by UC1610i will be described in the next two sections, “Command Table” and “Command Description”.

Name: The Symbolic reference of the register.
Note that, some symbol name refers to bits (flags) within another register.

Default: Numbers shown in **Bold** font are default values after Power-Up-Reset and System-Reset.

Name	Bits	Default	Description
SL	7	0H	Scroll Line. Scroll the displayed image up by SL rows. The valid SL value is between 0 (for no scrolling) and (127– 2xFL). Setting SL outside of this range causes undefined effect on the displayed image.
FL	4	0H	Fixed Lines. The first FLx2 lines of each frame are fixed and are not affected by scrolling (SL). When FL is non-zero, the screen is effectively separated into two regions: one scrollable, one non-scrollable. When partial display mode is activated, the display of these 2xFL lines are also controlled by LC[0].
CR	8	0H	Return Column Address. Useful for cursor implementation.
CA	8	0H	Display Data RAM Column Address (Used in Host to Display Data RAM access)
PA	5	0H	Display Data RAM Page Address (Used in Host to Display Data RAM access)
BR	2	2H	Bias Ratio. The ratio between V_{LCD} and V_{BIAS}. 00b: 5 01b: 10 **10b: 11** 11b: 12
TC	2	0H	Temperature Compensation (per ^{o}C) **00b: -0.05%** 01b: -0.10% 10b: -0.15% 11b: -0.20%
PM	8	B2H	Electronic Potentiometer to fine tune V_{BIAS} and V_{LCD}
OM	2	–	Operating Modes (Read only) 00b: Reset 01b: (Not used) 10b: Sleep 11b: Normal
ID	1	PIN	Access the connected status of ID pin.
RS	1		Reset in progress. Host Interface not ready
PC	4	DH	Power Control. PC[1:0]: 00b: LCD: ≤ 16nF **01b: LCD: 16~21nF** 10b: LCD: 21~28nF 11b: LCD: 28~38nF PC[3:2]: 00b: External V_{LCD} 01b: Internal V_{LCD} (6X pump, low V_{LCD}, only used when BR=5) 10b: Internal V_{LCD} (7X pump) **11b: Internal V_{LCD} (8X pump, standard)**
DC	3	00H	Display Control: DC[0]: PXV: Pixels Inverse. Bit-wise data inversion. (Default **0: OFF**) DC[1]: APO: All Pixels ON (Default **0: OFF**) DC[2]: Display ON/OFF (Default **0: OFF**)

Name	Bits	Default	Description
AC	5	01H	Address Control: AC[0]: WA: Automatic column/page Wrap Around (Default **1: ON**) AC[1]: Auto-Increment order **0: Column (CA) first** 1: Row (PA) first AC[2]: PID: PA (Page Address) auto increment direction (**L:+1** H:-1) AC[3]: CUM: Cursor update mode, (Default **0: OFF**) when CUM=1, CA increment on write only, wrap around suspended AC[4] : Window Program Enable **0 : Disable** 1 : Enable
WPC0	8	00H	Window program starting column address. Value range: 0 ~159.
WPP0	5	00H	Window program starting Page Address. Value range: 0~31.
WPC1	8	9FH	Window program ending column address. Value range: 0~159.
WPP1	5	1FH	Window program ending Page Address. Value range: 0~31.
CEN DST DEN	7 7 7	7FH 00H 7FH	COM scanning end (last COM with full line cycle, 0 based index) Display start (first COM with active scan pulse, 0 based index) Display end (last COM with active scan pulse, 0 based index) Please maintain the following relationship: CEN = the actual number of pixel rows on the LCD - 1 CEN ≥ DEN ≥ DST+ 9
LC	9	008H	LCD Control: LC[0]: Enable the first FLx2 lines in partial display mode (Default **OFF**). LC[1]: MX, Mirror X. SEG/Column sequence inversion (Default: **OFF**) LC[2]: MY, Mirror Y. COM/Row sequence inversion (Default: **OFF**) LC[4:3]: Line Rate (Klps: Kilo-Line-per-second) **00b: 12.1 Klps (95fps)** 01b: 13.4 Klps (105fps) 10b: 14.7 Klps (115fps) 11b: 16.6 Klps (130fps) (Frame-Rate = Line-Rate / Mux-Rate, Frame rate at 128 is listed) LC[6:5] : Gray-Shade control. Control the difference of percentage between data “01” and “10” **00b: 24%** 01b: 29% 10b: 36% 11b: 40% LC[8:7] : Partial Display Control **00b: Disable** Mux-Rate = CEN+1 (DST, DEN not used) 10b: Enable Mux-Rate = CEN+1 11b: Enabled Mux-Rate = DEN-DST+1
APC0 APC1	8 8	-- --	Advanced Product Configuration. For UltraChip only. Do *NOT* use.

COMMAND SUMMARY

The following is a list of host commands supported by UC1610i:

C/D: 0: Control, 1: Data W/R: 0: Write Cycle, 1: Read Cycle D7-D0: # Useful Data bits, – Don't Care

	Command	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0	Action	Default
1	Write Data Byte	1	0	#	#	#	#	#	#	#	#	Write 1 byte	N/A
2	Read Data Byte	1	1	#	#	#	#	#	#	#	#	Read 1 byte	N/A
3	Get Status	0	1	ID	MX	MY	WA	DE	PM7	PM6	1	Get Status	N/A
4	Set Column Address LSB	0	0	0	0	0	0	#	#	#	#	Set CA[3:0]	0
	Set Column Address MSB	0	0	0	0	0	1	#	#	#	#	Set CA[7:4]	0
5	Set Temp. Compensation	0	0	0	0	1	0	0	1	#	#	Set TC[1:0]	0
6	Set Panel Loading	0	0	0	0	1	0	1	0	#	#	Set PC[1:0]	1
7	Set Pump Control	0	0	0	0	1	0	1	1	#	#	Set PC[3:2]	11b
8	Set Adv. Program Control (double byte command)	0	0	0	0	1	1	0	0	0	R	Set APC[R][7:0], R = 0, or 1	N/A
		0	0	#	#	#	#	#	#	#	#		
9	Set Scroll Line LSB	0	0	0	1	0	0	#	#	#	#	Set SL[3:0]	0
	Set Scroll Line MSB	0	0	0	1	0	1	-	#	#	#	Set SL[6:4]	0
10	Set Page Address	0	0	0	1	1	#	#	#	#	#	Set PA[4:0]	0
11	Set V_{BIAS} Potentiometer (double-byte command)	0	0	1	0	0	0	0	0	0	1	Set PM[7:0]	B2H
		0	0	#	#	#	#	#	#	#	#		
12	Set Partial Display Control	0	0	1	0	0	0	0	1	#	#	Set LC[8:7]	00b: Disable
13	Set RAM Address Control	0	0	1	0	0	0	1	#	#	#	Set AC[2:0]	001b
14	Set Fixed Lines	0	0	1	0	0	1	#	#	#	#	Set FL[3:0]	0
15	Set Line Rate	0	0	1	0	1	0	0	0	#	#	Set LC[4:3]	00b
16	Set All-Pixel-ON	0	0	1	0	1	0	0	1	0	#	Set DC[1]	0
17	Set Inverse Display	0	0	1	0	1	0	0	1	1	#	Set DC[0]	0
18	Set Display Enable	0	0	1	0	1	0	1	1	1	#	Set DC[2]	0b
19	Set LCD Mapping Control	0	0	1	1	0	0	0	#	#	#	Set LC[2:0]	000b
20	Set LCD Gray Shade	0	0	1	1	0	1	0	0	#	#	Set LC[6:5]	00b
21	System Reset	0	0	1	1	1	0	0	0	1	0	System Reset	N/A
22	NOP	0	0	1	1	1	0	0	0	1	1	No operation	N/A
23	Set Test Control (double byte command)	0	0	1	1	1	0	0	1	TT		For testing only. Do not use.	N/A
		0	0	#	#	#	#	#	#	#	#		
24	Set LCD Bias Ratio	0	0	1	1	1	0	1	0	#	#	Set BR[1:0]	10b: 11
25	Reset Cursor Update Mode	0	0	1	1	1	0	1	1	1	0	AC[3]=0, CA=CR	AC[3]=0
26	Set Cursor Update Mode	0	0	1	1	1	0	1	1	1	1	AC[3]=1, CR=CA	AC[3]=1
27	Set COM End	0	0	1	1	1	1	0	0	0	1	Set CEN[6:0]	127
		0	0	-	#	#	#	#	#	#	#		
28	Set Partial Display Start	0	0	1	1	1	1	0	0	1	0	Set DST[6:0]	0
		0	0	-	#	#	#	#	#	#	#		
29	Set Partial Display End	0	0	1	1	1	1	0	0	1	1	Set DEN[6:0]	127
		0	0	-	#	#	#	#	#	#	#		
30	Set Window Program Starting Column Address	0	0	1	1	1	1	0	1	0	0	Set WPC0[7:0]	0
		0	0	#	#	#	#	#	#	#	#		
31	Set Window Programming Starting Page Address	0	0	1	1	1	1	0	1	0	1	Set WPP0[4:0]	0
		0	0	-	-	-	#	#	#	#	#		
32	Set Window Programming Ending Column Address	0	0	1	1	1	1	0	1	1	0	Set WPC1[7:0]	159
		0	0	#	#	#	#	#	#	#	#		
33	Set Window Programming Ending Page Address	0	0	1	1	1	1	0	1	1	1	Set WPP1[4:0]	31
		0	0	-	-	-	#	#	#	#	#		
34	Enable window program	0	0	1	1	1	1	1	0	0	#	Set AC[4]	0: Disable

* Any other bit patterns other than the commands listed above may result in undefined behavior.

COMMAND DESCRIPTION

(1) WRITE DATA TO DISPLAY MEMORY

Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
Write data	1	0	8bits data write to DDRAM							

(2) READ DATA FROM DISPLAY MEMORY

Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
Read data	1	1	8bits data from DDRAM							

Write/Read Data Byte (command 1, 2) operation use internal Page Address register (PA) and Column Address register (CA). Four rows of LCD pixel image are defined as one page in DDRAM. Each column of pixel corresponds to one column of DDRAM data. PA and CA registers can be programmed by issuing *Set Page Address* and *Set Column Address* commands. If wrap-around (WA, AC[0]) is OFF (0), CA will stop incrementing after reaching the CA boundary, and system programmers need to set the values of PA and CA explicitly. If WA is ON (1), when CA reaches end of column address, CA will be reset to 0 and PA will be incremented or decremented, depending on the setting of Row Increment Direction (PID, AC[2]). When PA reaches the boundary of RAM (i.e. PA = 0 or 31), PA will be wrapped around to the other end of RAM and continue.

(3) GET STATUS

Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
Get Status	0	1	ID	MX	MY	WA	DE	PM7	PM6	1

Status flag definitions:

ID: Provide access to ID pin connection status.
MX: Status of register LC[1], mirror X.
MY: Status of register LC[2], mirror Y.
WA: Status of register AC[0]. Automatic column/page wrap around.
DE: Display enable flag. DE=1 when display is enabled

(4) SET COLUMN ADDRESS

Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
Set Column Address LSB CA[3:0]	0	0	**0**	**0**	**0**	**0**	CA3	CA2	CA1	CA0
Set Column Address MSB CA[7:4]	0	0	**0**	**0**	**0**	**1**	CA7	CA6	CA5	CA4

Set DDRAM column address for read/write access. Each CA corresponds to one individual SEG electrode.

CA value range: **0**~159

(5) SET TEMPERATURE COMPENSATION

Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
Set Temperature Comp TC[1:0]	0	0	**0**	**0**	**1**	**0**	**0**	**1**	TC1	TC0

Set V_{BIAS} temperature compensation coefficient (%-per-degree-C)

Temperature compensation curve definition:
00b= -0.05%/°C 01b= -0.10%/°C 10b= -0.15%/°C 11b= -0.20%/°C

(6) SET PANEL LOADING

Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
Set Panel Loading PC[1:0]	0	0	**0**	**0**	**1**	**0**	**1**	**0**	PC1	PC0

Set PC[1:0] according to the capacitance loading of LCD panel.

Panel loading definition: 00b≤16nF **01b=16~21nF** 10b=21~28nF 11b=28~38nF

(7) SET PUMP CONTROL

Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
Set Pump Control PC[3:2]	0	0	**0**	**0**	**1**	**0**	**1**	**1**	PC3	PC2

Set PC[3:2] to program the build-in charge pump stages.

Pump control definition:

00b=External V_{LCD} 01b= Internal V_{LCD} (6X pump, for BR=5)
01b= Internal V_{LCD} (7X pump) **11b= Internal V_{LCD}** (8X pump, standard)

(8) SET ADVANCED PROGRAM CONTROL

Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
Set APC[R]	0	0	**0**	**0**	**1**	**1**	**0**	**0**	**0**	R
(Double byte command)	0	0	APC register parameter							

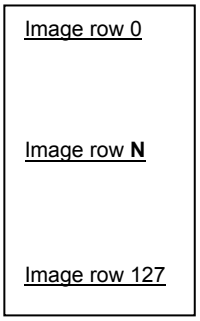
For UltraChip only. Please do NOT use.

(9) SET SCROLL LINE

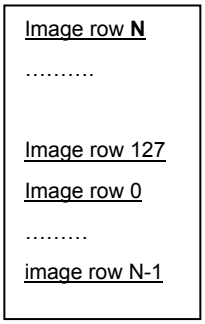
Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
Set Scroll Line LSB SL[3:0]	0	0	**0**	**1**	**0**	**0**	SL3	SL2	SL1	SL0
Set Scroll Line MSB SL[6:4]	0	0	**0**	**1**	**0**	**1**	-	SL6	SL5	SL4

Set the scroll line number.

Scroll line setting will scroll the displayed image up by SL rows. The valid value for SL is between 0 (no scrolling) and (127-2xFL). FL is the register value programmed by *Set Fixed Lines* command.



SL=0



SL=N

(10) SET PAGE ADDRESS

Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
Set Page Address PA [4:0]	0	0	**0**	**1**	**1**	PA4	PA3	PA2	PA1	PA0

Set DDRAM Page Address for read/write access.

Possible value = **0**~31

(11) SET VBIAS POTENTIOMETER

Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
Set V_{BIAS} Potentiometer PM [7:0]	0	0	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**1**
(Double-byte command)	0	0	PM7	PM6	PM5	PM4	PM3	PM2	PM1	PM0

Program V_{BIAS} Potentiometer (PM[7:0]). See section LCD VOLTAGE SETTING for more detail.

Effective range: **0 ~ 255**

(12) SET PARTIAL DISPLAY CONTROL

Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
Set Partial Display Enable LC [8:7]	0	0	**1**	**0**	**0**	**0**	**0**	**1**	LC8	LC7

This command is used to enable partial display function.

LC[8:7] : **00b: Disable Partial Display**, Mux-Rate = CEN+1 (DST, DEN not used.)
10b: Enable Partial Display, Mux-Rate = CEN+1
11b: Enable Partial Display, Mux-Rate = DEN-DST+1

(13) SET RAM ADDRESS CONTROL

Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
Set AC [2:0]	0	0	**1**	**0**	**0**	**0**	**1**	AC2	AC1	AC0

Program registers AC[2:0] for RAM address control.

AC[0]: WA, Automatic column/page wrap around.
0: CA or PA (depends on AC[1]= 0 or 1) will stop incrementing after reaching boundary
1: CA or PA (depends on AC[1]= 0 or 1) will restart, and PA or CA will increment by one step.

AC[1]: Auto-Increment order
0 : column (CA) increment (+1) first until CA reaches CA boundary, then PA will increment by (+/-1).
1 : row (PA) increment (+/-1) first until PA reach PA boundary, then CA will increment by (+1) .

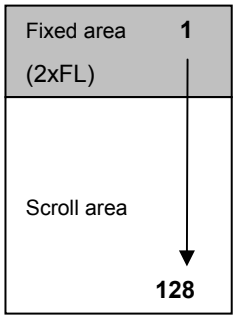
AC[2]: PID, Page Address (PA) auto increment direction (0/1 = +/- 1)
When WA=1 and CA reaches CA boundary, PID controls whether Page Address will be adjusted by +1 or -1.

AC[2:0] controls the auto-increment behavior of CA and PA. When Window Program is enabled (AC[4]=ON), see command description (32) ~ (36) for more details. When Window Program is disabled (AC[4]=OFF), the behavior of CA, PA auto-increment is the same as WPC[1:0] and WPP[1:0] values are the default values and AC[4]=ON.

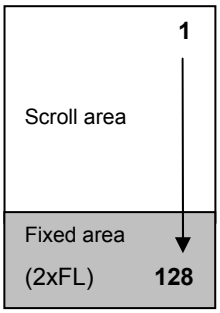
(14) SET FIXED LINES

Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
Set Fixed Lines FL [3:0]	0	0	**1**	**0**	**0**	**1**	FL3	FL2	FL1	FL0

The fixed line function is used to implement the partial scroll function by dividing the screen into scroll and fixed area. Set Fixed Lines command will define the fixed area, which will not be affected by the SL scroll function. The fixed area covers the top 2xFL rows for mirror Y (MY) is 0 and bottom 2xFL rows for MY=1. One example of the visual effect on LCD is illustrated in the figure below.



MY = 0



MY = 1

(15) SET LINE RATE

Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
Set Line Rate LC [4:3]	0	0	**1**	**0**	**1**	**0**	**0**	**0**	LC4	LC3

Program LC [4:3] for line rate setting (Frame-Rate = Line-Rate / Mux-Rate). The line rate is automatically scaled down by 1/2 and 1/4 at Mux-Rate = 56 and 24.

The following are line rates at Mux Rate = 57~128.

LC[4:3]: **00b: 12.1 Klps** 01b: 13.4 Klps 10b: 14.7 Klps 11b: 16.6 Klps
(Klps: Kilo-Line-per-second)

(16) SET ALL PIXEL ON

Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
Set All Pixel ON DC [1]	0	0	**1**	**0**	**1**	**0**	**0**	**1**	**0**	DC1

Set DC[1] to force all SEG drivers to output ON signals. This function has no effect on the existing data stored in display RAM.

(17) SET INVERSE DISPLAY

Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
Set Inverse Display DC [0]	0	0	**1**	**0**	**1**	**0**	**0**	**1**	**1**	DC0

Set DC[0] to force all SEG drivers to output the inverse of the data (bit-wise) stored in display RAM. This function has no effect on the existing data stored in display RAM.

(18) SET DISPLAY ENABLE

Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
Set Display Enable DC [2]	0	0	**1**	**0**	**1**	**0**	**1**	**1**	**1**	DC2

This command is for programming register DC[2].

When DC[2] is set to 0, the IC will put itself into Sleep mode. All drivers, voltage generation circuit and timing circuit will be halted to conserve power. When any of the DC[2] bits is set to 1, UC1610i will first exit from Sleep Mode, restore the power and then turn on COM drivers and SEG drivers. There is no other explicit user action or timing sequence required to enter or exit the Sleep mode.

(19) SET LCD MAPPING CONTROL

Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
Set LCD Mapping Control LC [2:0]	0	0	**1**	**1**	**0**	**0**	**0**	MY	MX	LC0

This command is used for program LC[2:0] for COM (row) mirror (MY), SEG (column) mirror (MX).

LC2 controls Mirror Y (MY): MY is implemented by reversing the mapping order between RAM and COM electrodes. The data stored in RAM is not affected by MY command. MY will have immediate effect on the display image.

LC1 controls Mirror X (MX): MX is implemented by selecting the CA or 127-CA as write/read (from host interface) display RAM column address so this function will only take effect after rewriting the RAM data.

LC0 controls whether the soft icon section (0~ 2xFL) is display or not during partial display mode.

(20) SET LCD GRAY SHADE

Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
Set LCD Gray Shade LC[6:5]	0	0	**1**	**1**	**0**	**1**	**0**	**0**	LC6	LC5

Program gray scale register (LC[6:5]). This register controls the voltage RMS separation between the two gray shade levels (data “01” and data “10”)

00b=24% 01b=29% 10b=36% 11b=40%

(21) SYSTEM RESET

Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
System Reset	0	0	**1**	**1**	**1**	**0**	**0**	**0**	**1**	**0**

This command will activate the system reset. Control register values will be reset to their default values. Data stored in RAM will not be affected.

(22) NOP

Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
No Operation	0	0	**1**	**1**	**1**	**0**	**0**	**0**	**1**	**1**

This command is used for “no operation”.

(23) SET TEST CONTROL

Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
Set TT	0	0	**1**	**1**	**1**	**0**	**0**	**1**	**TT**	
(Double byte command)	0	0	Testing parameter							

This command is used for UltraChip production testing. Please do not use.

(24) SET LCD BIAS RATIO

Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
Set Bias Ratio BR [1:0]	0	0	**1**	**1**	**1**	**0**	**1**	**0**	BR1	BR0

Bias ratio definition:

00b = 5 01b = 10 **10b = 11** 11b = 12

(25) RESET CURSOR UPDATE MODE

Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
Set AC[3]=0 CA=CR	0	0	**1**	**1**	**1**	**0**	**1**	**1**	**1**	AC3

This command is used to reset cursor update mode function.

(26) SET CURSOR UPDATE MODE

Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
Set AC[3]=1 CR=CA	0	0	**1**	**1**	**1**	**0**	**1**	**1**	**1**	AC3

This command is used for set cursor update mode function. When cursor update mode sets, UC1610i will update register CR with the value of register CA. The column address CA will increment with write RAM data operation but the address wraps around will be suspended no matter what WA setting is. However, the column address will not increment in read RAM data operation.

The set cursor update mode can be used to implement “write after read RAM” function. The column address (CA) will be restored to the value, which is before the set cursor update mode command, when reset cursor update mode.

The purpose of this pair of commands and their features is to support “write after read” function for cursor implementation.

(27) SET COM END

Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
Set CEN	0	0	**1**	**1**	**1**	**1**	**0**	**0**	**0**	**1**
(Double-byte command)	0	0	*CEN* register parameter							

This command programs the ending COM electrode. CEN defines the number of used COM electrodes, and it should correspond to the number of pixel-rows in the LCD.

(28) SET PARTIAL DISPLAY START

Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
Set DST	0	0	**1**	**1**	**1**	**1**	**0**	**0**	**1**	**0**
(Double-byte command)	0	0	*DST* register parameter							

This command programs the starting COM electrode, which has been assigned a full scanning period, and which will output an active COM scanning pulse.

(29) SET PARTIAL DISPLAY END

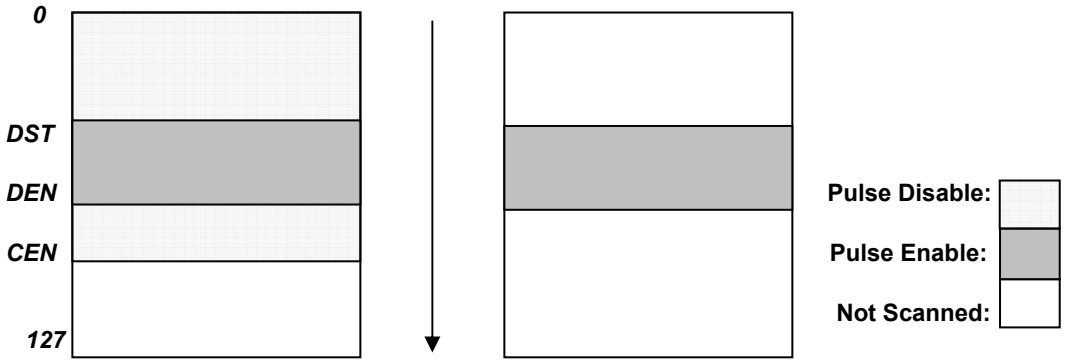
Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
Set DEN	0	0	**1**	**1**	**1**	**1**	**0**	**0**	**1**	**1**
(Double-byte command)	0	0	*DEN* register parameter							

This command programs the ending COM electrode, which has been assigned a full scanning period, and which will output an active COM scanning pulse.

CEN, DST DEN are 0-based index of COM electrodes. They control only the COM electrode activity, and do not affect the mapping of display RAM to each COM electrodes. The image displayed by each pixel row is therefore not affected by the setting of these three registers.

When LC[8]=1, two partial display modes are possible with UC1610i:
LC[7]=1: ON-OFF only, ultra-low-power mode (if Mux-Rate ≤ 32, set BR=5, PC[3:2]=01b).
LC[7]=0: Full gray shade low power mode (BR and PM stays the same)

When LC[8:7]=11b, the Mux-Rate is narrowed down to just the range between DST and DEN. When Mux-Rate is under 32, set BR=5, PC[3:2]=01b, and adjust PM to reduce V_{LCD} and achieve the lowest power consumption. When LC[8:7]=10b, the Mux-Rate is still CEN+1. This is achieved by suppressing only the scanning pulses, but not the scanning time slots, for COM electrodes that is outside of DST~DEN. Under this mode, the gray-scale quality of the display is preserved, while the power can be reduced significantly. In either case, DST/DEN defines a small subsection of the display which will remain active while shutting down all the rest of the display to conserve energy.



(30) SET WINDOW PROGRAM STARTING COLUMN ADDRESS

Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
Set WPC0 (Double-byte command)	0	0	**1**	**1**	**1**	**1**	**0**	**1**	**0**	**0**
	0	0	*WPC0[7:0]* register parameter							

This command is to program the starting column address of RAM program window.

(31) SET WINDOW PROGRAM STARTING PAGE ADDRESS

Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
Set WPP0 (Double-byte command)	0	0	**1**	**1**	**1**	**1**	**0**	**1**	**0**	**1**
	0	0	**-**	**-**	**-**	*WPP0[4:0]* register parameter				

This command is to program the starting Page Address of RAM program window.

(32) SET WINDOW PROGRAM ENDING COLUMN ADDRESS

Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
Set WPC1 (Double-byte command)	0	0	**1**	**1**	**1**	**1**	**0**	**1**	**1**	**0**
	0	0	*WPC1[7:0]* register parameter							

This command is to program the ending column address of RAM program window.

(33) SET WINDOW PROGRAM ENDING PAGE ADDRESS

Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
Set WPP1 (Double-byte command)	0	0	**1**	**1**	**1**	**1**	**0**	**1**	**1**	**1**
	0	0	**-**	**-**	**-**	*WPP1[4:0]* register parameter				

This command is to program the ending Page Address of RAM program window.

(34) SET WINDOW PROGRAM ENABLE

Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
Set Window Program Enable AC[4]	0	0	**1**	**1**	**1**	**1**	**1**	**0**	**0**	AC4

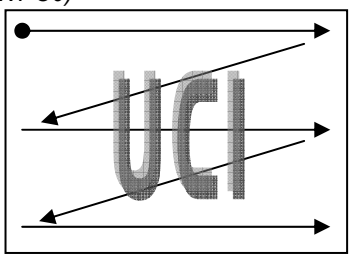
This command is to enable the Window Program Function. Window Program Enable should always be reset when changing the window program boundary and then set right before starting the new boundary program.

Window Program Function can be used to refresh the RAM data in a specified window of DDRAM address. When window programming is enabled, the CA and PA increment and wrap around will be automatically adjusted, and therefore allow effective data update within the window.

The direction of Window Program will depend on the WA (AC[0]) , PID (AC[2]), auto-increment order (AC[1]) and MX (LC[1]) register setting. WA decides whether the program RAM address advances to next row / column after reaching the specified window column / row boundary. PID controls the RAM address incrementing from WPP0 toward WPP1 (PID=0) or reverse the direction (PID=1). Auto-increment order directs the RAM address increment vertically (AC[1]=1) or horizontally (AC[1]=0). MX results the RAM column address incrementing from 127-WPC0 to 127-WPC1 (MX=1) or WPC0 to WPC1 (MX=0).

Auto-increment order = 0 MX=0 RID = 0

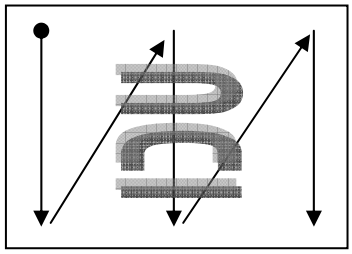
(WPP0,WPC0)



(WPP1,WPC1)

Auto-increment order = 1 MX=0 RID = 0

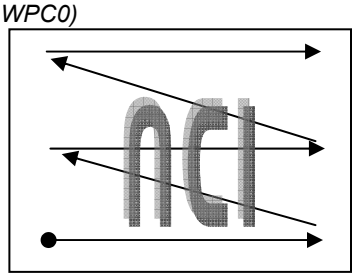
(WPP0,WPC0)



(WPP1,WPC1)

Auto-increment order = 0 MX=0 RID = 1

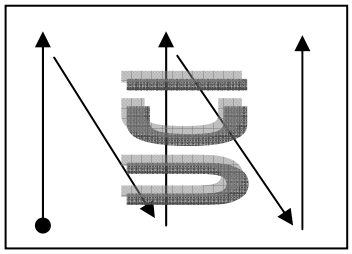
(WPP0,WPC0)



(WPP1,WPC1)

Auto-increment order = 1 MX=0 RID = 1

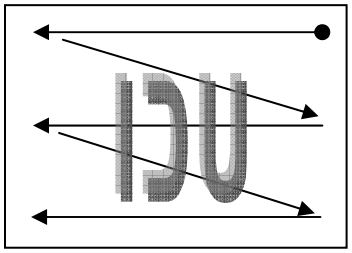
(WPP0,WPC0)



(WPP1,WPC1)

Auto-increment order = 0 MX=1 RID = 0

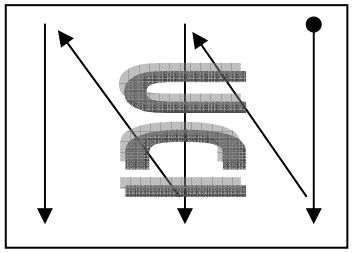
(WPP0,SEG-WPC0-1)



(WPP1,SEG-WPC1-1)

Auto-increment order = 1 MX=1 RID = 0

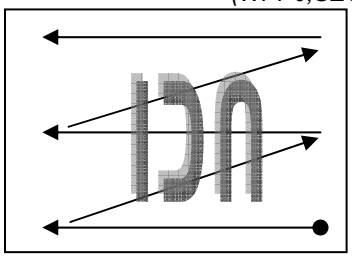
(WPP0,SEG-WPC0-1)



(WPP1,SEG-WPC1-1)

Auto-increment order = 0 MX=1 RID = 1

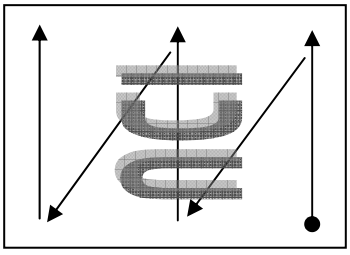
(WPP0,SEG-WPC0-1)



(WPP1,SEG-WPC1-1)

Auto-increment order = 1 MX=1 RID = 1

(WPP0,SEG-WPC0-1)



(WPP1,SEG-WPC1-1)

LCD VOLTAGE SETTING

MULTIPLEX RATES

Multiplex Rate is completely software programmable in UC1610i via registers CEN, DST, DEN, and partial display control LC[8:7].

Combined with low power partial display mode and a low bias ratio of 5, UC1610i can support wide variety of display control options. For example, when a system goes into stand-by mode, a large portion of LCD screen can be turned off to conserve power.

BIAS RATIO SELECTION

Bias Ratio (*BR*) is defined as the ratio between V_{LCD} and V_{BIAS}, i.e.

BR = V_{LCD}/V_{BIAS},
where $V_{BIAS} = V_{B1+} - V_{B1-} = V_{B0+} - V_{B0-}$.

The theoretical optimum *Bias Ratio* can be estimated by $\sqrt{Mux}+1$. *BR* of value 15~20% lower/higher than the optimum value calculated above will not cause significant visible change in image quality.

Due to the nature of STN operation, an LCD designed for good gray-shade performance at high Mux Rate (e.g. MR=128), can generally perform very well as a black and white display, at lower Mux Rate. However, it is also true that such technique generally cannot maintain LCD's quality of gray shade performance, since the contrast of the LCD will increase as the Mux Rate decreases, and the shades near the two ends of the spectrum will start to loose visibility.

UC1610i supports four *BR* as listed below. BR can be selected by software program.

BR	0	1	2	3
Bias Ratio	5	10	11	12

Table 1: Bias Ratios

TEMPERATURE COMPENSATION

Four (4) different temperature compensation coefficients can be selected via software. The four coefficients are given below:

TC	0	1	2	3
% per ^{o}C	-0.05	-0.10	-0.15	-0.20

Table 2: Temperature Compensation

V_{LCD} GENERATION

V_{LCD} may be supplied either by internal charge pump or by external power supply. The source of V_{LCD} is controlled by PC[3:2]. For good product reliability, it is recommended to keep V_{LCD} under 15V over the entire operating range.

When V_{LCD} is generated internally, the voltage level of V_{LCD} is determined by three control registers: *BR* (Bias Ratio), *PM* (Potentiometer), and TC (Temperature Compensation), with the following relationship:

$$V_{LCD} = (C_{V0} + C_{PM} \times PM) \times (1 + (T - 25) \times C_T\,\%)$$

where

C_{V0} and C_{PM} are two constants, whose value depends on the setting of BR register, as illustrated in the table on the next page,

PM is the numerical value of PM register,

T is the ambient temperature in ^{O}C, and

C_T is the temperature compensation coefficient as selected by TC register.

V_{LCD} FINE TUNING

Gray shade and STN LCD is sensitive to even a 1% mismatch between IC driving voltage and the V_{OP} of LCD. However, it is difficult for LCD makers to guarantee such high precision matching of parts from different venders. It is therefore necessary to adjust V_{LCD} to match the actual V_{OP} of the LCD.

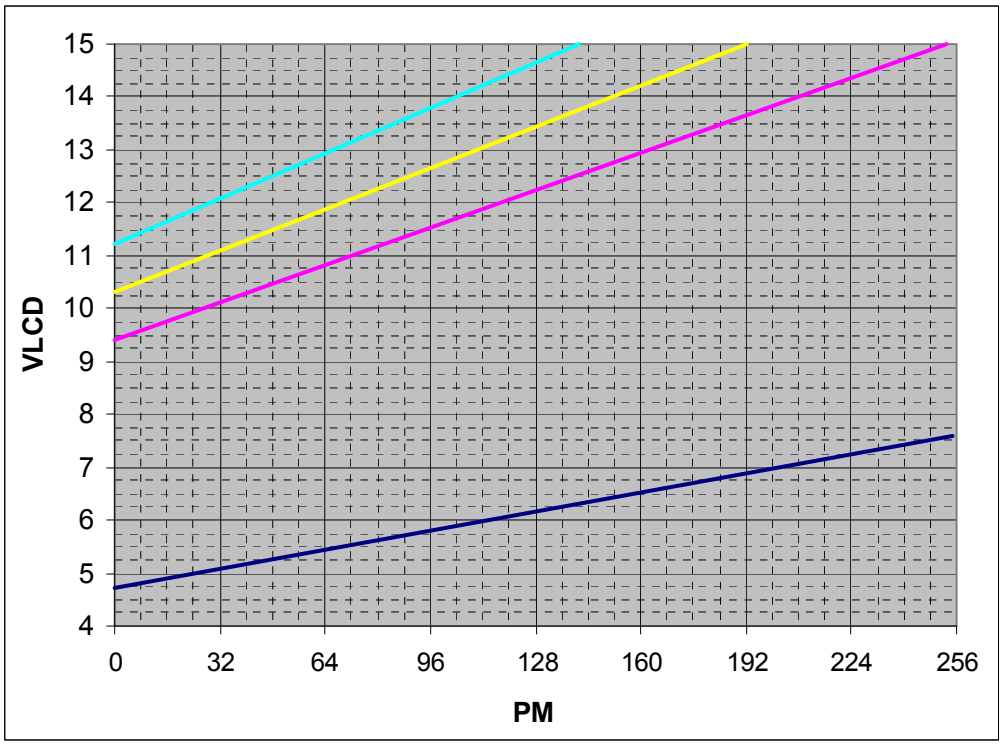
For the best result, software based approach for V_{LCD} adjustment is the recommended method for V_{LCD} fine tuning.

For applications where mechanical manual fine tuning of V_{LCD} becomes necessary, then V_{BIAS} pin may be used with an external trim pot to fine tune the V_{LCD}. Please refer to Application Notes for more detailed discussion on this subject.

LOAD DRIVING STRENGTH

The power supply circuit of UC1610i is designed to handle LCD panels with load capacitance up to ~30nF when V_{DD2} = 2.7V. 30nF is also the recommended limit for LCD panel size for COG applications. For larger LCD panels, use higher V_{DD}.

V_{LCD} QUICK REFERENCE



V_{LCD} Relationship to BR and PM at 25 °C

BR	C_{V0} (V)	C_{PM} (mV)	PM	V_{LCD} (V)
5	4.728	11.234	0	4.728
			255	7.592
10	9.390	22.235	0	9.390
			253	15.015
11	10.308	24.529	0	10.308
			192	15.018
12	11.228	26.844	0	11.228
			141	15.013

Note: For best reliability, keep V_{LCD} under **15V** over all temperature.

HI-V GENERATOR AND BIAS REFERENCE CIRCUIT

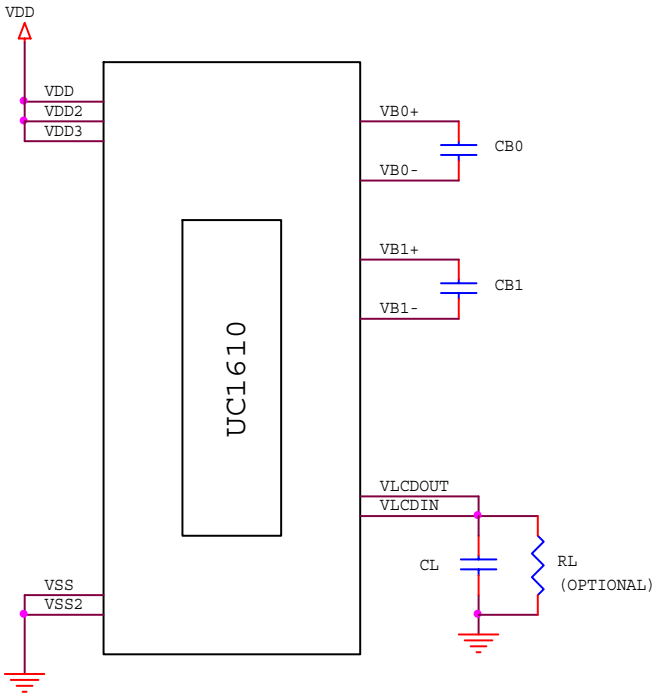


FIGURE 1: Reference circuit using internal Hi-V generator circuit

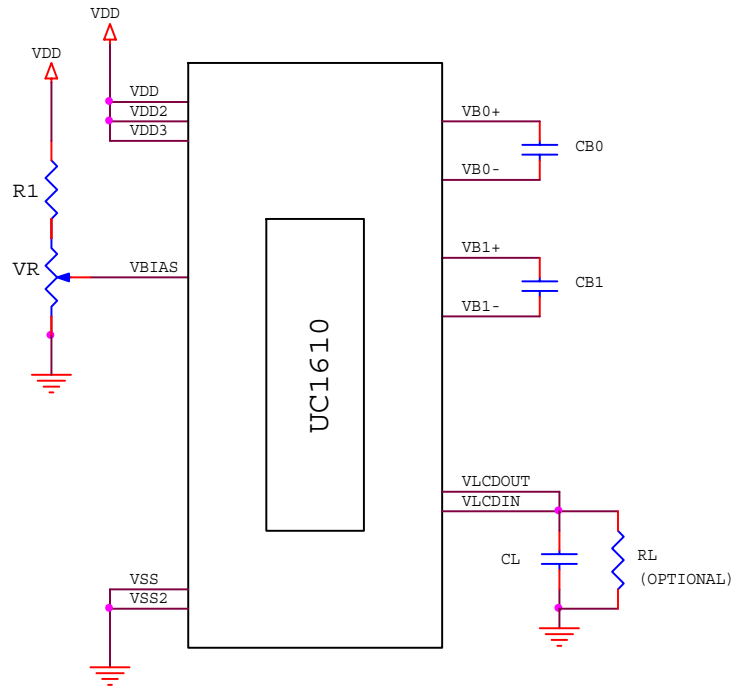


FIGURE 2: Reference circuit using external Bias source

Note

- Sample component values: (The illustrated circuit and component values are for reference only. Please optimize for specific requirements of each application.)
  C_B: 150 ~ 250x LCD load capacitance or 2µF (2V), whichever is higher.
  C_L: 0.06 µF ~ 0.3µF (16V) is appropriate for most applications.
  R_L: 10MΩ. Acts as a draining circuit when the power is abnormally shut down.
  V_R: 1MΩ
  R_1: 330kΩ

LCD DISPLAY CONTROLS

CLOCK & TIMING GENERATOR

UC1610i contains a built-in system clock. All required components for the clock oscillator are built-in. No external parts are required.

Four different line rates are provided for system design flexibility. The line rate is controlled by register LC[4:3]. When Mux-Rate is above 56, frame rate is calculated as:

Frame Rate = Line-Rate / Mux-Rate.

When Mux-Rate is lowered to 56 (and 24), line rate will be scaled down by 2 (and 4) times automatically to reduce power consumption.

Flicker-free frame rate is dependent on LC material and gray-shade modulation scheme. Choose lower frame rate for lower power, and choose higher frame rate to improve LCD contrast and minimize flicker.

When fast LC material with ($t_r + t_f$) < 160mS is used, faster line rate may be required under 4-shade mode to maintain good contrast ratio at operating temperature >50^{o}C.

DRIVER MODES

COM and SEG drivers can be in either Idle mode or Active mode, controlled by Display Enable flag (DC[2]). When COM drivers are in idle mode, their outputs are high-impedance (open circuit). When SEG drivers are in idle mode, their outputs are shorted to V_{SS}.

DRIVER ARRANGEMENTS

The naming conventions are: COM(x), where x=1~128, refers to the COM driver for the x-th row of pixels on the LCD panel.

The mapping of COM(x) to LCD pixel rows fixed and it is not affected by SL, CST, CEN, DST, DEN, MX or MY settings.

DISPLAY CONTROLS

There are three groups of display control flags in the control register DC: Driver Enable (DE), All-Pixel-ON (APO) and Inverse (PXV). DE has the overriding effect over PXV and APO.

DRIVER ENABLE (DE)

Driver Enable is controlled by the value of DC[2] via *Set Display Enable* command. When DC[2] is set to OFF (logic "0"), both COM and SEG drivers will become idle and UC1610i will put itself into Sleep Mode to conserve power.

When DC[2] is set to ON, the DE flag will become "1", and UC1610i will first exit from Sleep Mode, restore the power (V_{LCD}, V_D etc.) and then turn on COM and SEG drivers.

ALL PIXELS ON (APO)

When set, this flag will force all SEG drivers to output ON signals, disregarding the data stored in the display buffer.

This flag has no effect when Display Enable is OFF and it has no effect on data stored in RAM.

INVERSE (PXV)

When this flag is set to ON, SEG drivers will output the inverse of the value it received from the display buffer RAM (bit-wise inversion). This flag has no impact on data stored in RAM.

PARTIAL SCROLL

Control register FL specifies a region of rows which are not affected by the SL register. Since SL register can be used to implement scroll function. The FL register can be used to implement fixed region when the other part of the display is scrolled by SL.

PARTIAL DISPLAY

UC1610i provides flexible control of Mux Rate and active display area. Please refer to command description (27) ~ (29) for more detail.

GRAY-SHADE MODULATION

UC1610i uses a proprietary frame rate modulation scheme to generate 4 levels of gray shade. The relative levels of the gray shades can be programmed by setting register bit LC[6:5]. It controls the relative position of the light gray and dark gray shades. For detailed value, please refer to the register definition table.

ITO LAYOUT CONSIDERATIONS

Since the COM scanning pulses of UC1610i can be as short as 44µS, it is critical to control the RC delay of COM and SEG signal to minimize crosstalk and maintain good mass production consistency.

For COG applications, low resistance ITO glass will help reduce SEG signal RC decay, minimize V_{DD}, V_{SS} noise, and ensure sufficient V_{DD2}, V_{SS2} supply for on-chip DC-DC converter.

ITO TRACES FOR COM SIGNALS

Excessive COM scanning pulse RC decay can cause fluctuation of contrast and increase of COM direction crosstalk.

Please limit the worst case of COM signals RC delay (RC_{MAX}) as calculated below

$$(R_{ROW} / 2.7 + R_{COM}) \times C_{ROW} < 2.6\mu S$$

where

C_{ROW}: LCD loading capacitance of one row of pixels. It can be calculated by C_{LCD}/Mux-Rate, where C_{LCD} is the LCD panel capacitance.

R_{ROW}: ITO resistance over one row of pixels within the active area

R_{COM}: COM routing resistance from IC to the active area + COM driver output impedance.

(Use worst case values for all calculations)

In addition, please limit the min-max spread of RC decay to be:

$$| RC_{MAX} - RC_{MIN} | < 1\mu S$$

so that the COM distortions on the top of the screen to the bottom of the screen are uniform.

ITO TRACES FOR SEG SIGNALS

Excessive SEG signal RC decay can cause image dependent changes of medium gray shades and sharply increase of SEG direction crosstalk.

To minimize crosstalk, please limit the worst case of SEG signal RC delay as calculated below.

$$(R_{COL} / 2.7 + R_{SEG}) \times C_{COL} < 0.35\mu S$$

where

C_{COL}: LCD loading capacitance of one pixel column. It can be calculated by C_{LCD}/#_column, where C_{LCD} is the LCD panel capacitance.

R_{COL}: ITO resistance over one column of pixels within the active area

R_{SEG}: SEG routing resistance from IC to the active area + SEG driver output impedance.

(Use worst case values for all calculations)

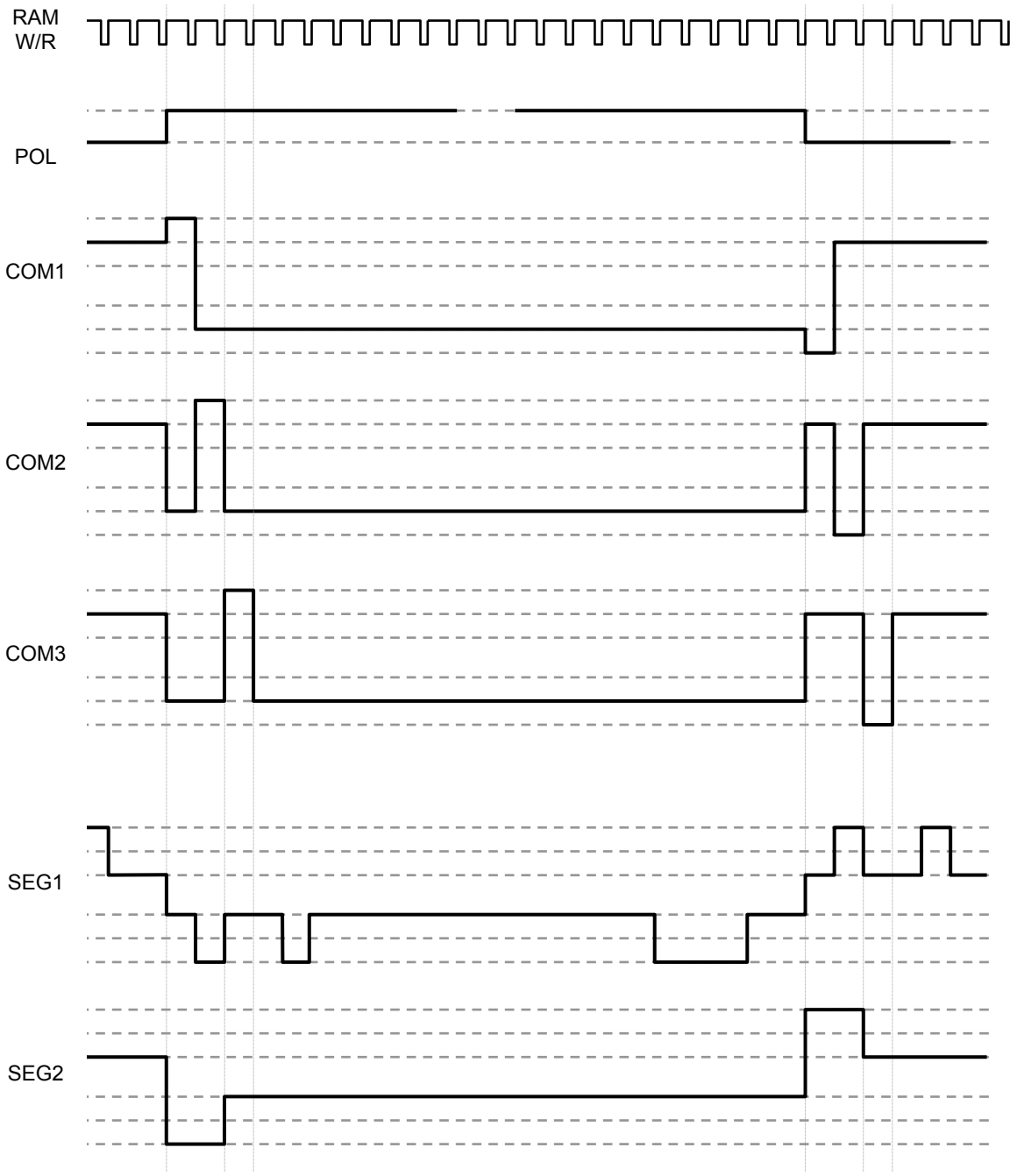


FIGURE 3: COM and SEG Driving Waveform

HOST INTERFACE

As summarized in the table below, UC1610i supports two parallel bus protocols, in either 8-bit or 4-bit bus width, and four serial bus protocols.

Designers can either use parallel bus to achieve high data transfer rate, or use serial bus to create compact LCD modules.

Bus Type		**Parallel**				Serial			
		8080		**6800**		**S8 (4-wire)**	**S8uc (3-, 4-wr)**	**S9 (3-wire)**	**I²C (2-wire)**
Width		8-bit	4-bit	8-bit	4-bit	--			
Access		Read/Write				Write Only			R/W
Control & Data Pins	BM[1:0]	10	00	11	01	00		01	
	D[7:6]	Data	00	Data	00	10	11	10	11
	CS[1:0]	Chip Select							A[3:2]
	CD	Control/Data						--	
	WR0	$\overline{WR}$		R/$\overline{W}$		1	1	0	1
	WR1	$\overline{RD}$		EN		1	1	0	1
	D[5:4]	Data	--	Data	--	--			
	D[3:0]	Data	Data	Data	Data	D0=SCK, D3=SDA			

* Connect unused control pins and data bus pins to V_{SS}.

Table 3: Host interfaces Choices

PARALLEL INTERFACE

The timing relationship between UC1610i internal control signals, RD and WR, and their associated bus actions are shown in the figure below.

The Display RAM read interface is implemented as a two-stage pipe-line. This architecture requires that, every time memory address is modified, either in 8-bit mode or 4-bit mode, by either *Set CA,* or *Set PA* command, a dummy read cycle need to be performed before the actual data can propagate through the pipe-line and be read from data port D[7:0].

There is no pipeline in write interface of Display RAM. Data is transferred directly from bus buffer to internal RAM on the rising edges of write pulses.

8-BIT & 4-BIT BUS OPERATION

UC1610i supports both 8-bit and 4-bit bus width. The bus width is determined by pin BM[1].

4-bit bus operation exactly doubles the clock cycles of 8-bit bus operation, MSB followed by LSB, including the dummy read, which also requires two clock cycles. The bus cycle of 4-bit mode is reset each time Chip-Select or CD pin changes state.

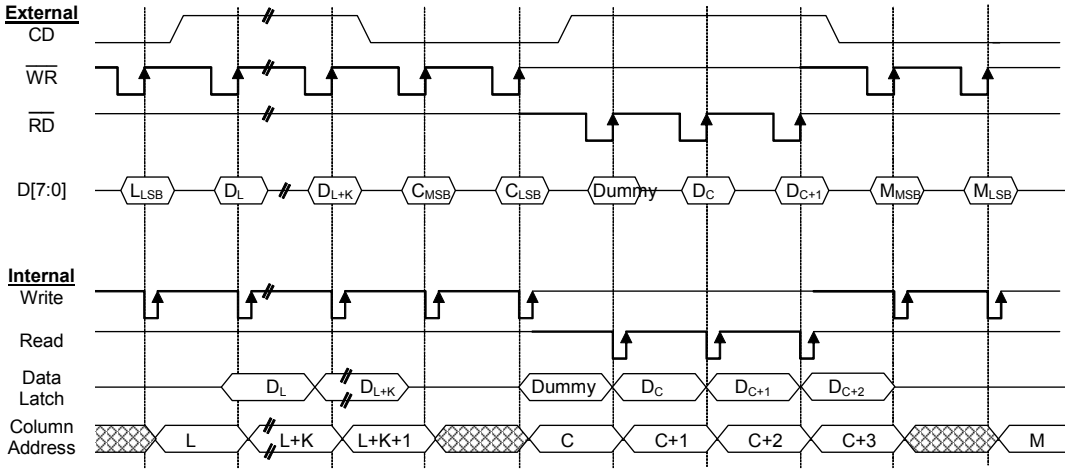


FIGURE 4: 8 bit Parallel Interface & Related Internal Signals

SERIAL INTERFACE

UC1610i supports 4 serial modes, a 4-wire SPI mode (S8), a compact 3-/4-wire mode (S8uc), a 3-wire SPI mode (S9) and a 2-wire mode (I^2C). Bus interface mode is determined by the wiring of the BM[1:0] and D[7:6]. See table in the Host Interface page (the page before last) for more detail.

S8 (4-WIRE) INTERFACE

Only write operations are supported in 4-wire serial mode. Pin CS[1:0] are used for chip select and bus cycle reset. Pin CD is used to determine the content of the data been transferred. During each write cycle, 8 bits of data, MSB first, are latched on eight rising SCK edges into an 8-bit data holder.

If CD=0, the data byte will be decoded as command. If CD=1, this 8-bit will be treated as data and transferred to proper address in the Display Data RAM on the rising edge of the last SCK pulse. Pin CD is examined when SCK is pulled low for the LSB (D0) of each token.

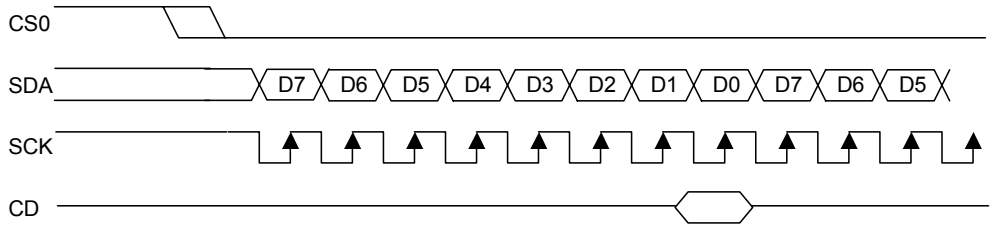


FIGURE 5.a: 4-wire Serial Interface (S8)

S8UC (3/4-WIRE) INTERFACE

Only write operations are supported in this 3/4-wire serial mode. The data format is identical as S8. However, in addition to CS pins, CD pin transitions will also reset the bus cycle in this mode. So, if CS pins are hardwired to enable chip-select, the bus can work properly with only three signal pins.

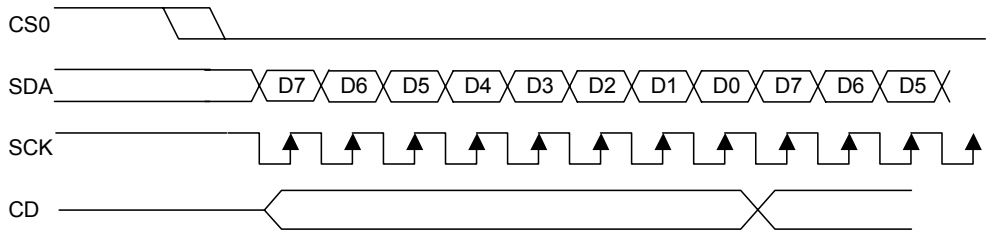


FIGURE 5.b: 3/4-wire Serial Interface (S8uc)

S9 (3-WIRE) INTERFACE

Only write operations are supported in this 3-wire serial mode. Pin CS[1-0] are used for chip select and bus cycle reset. On each write cycle, the first bit is CD, which determines the content of the following 8 bits of data, MSB first. These 8 command or data bits are latched on rising SCK edges into an 8-bit data holder. If CD=0, the data byte will be decoded as command. If CD=1, this 8-bit will be treated as data and transferred to proper address in the Display Data RAM at the rising edge of the last SCK pulse.

By sending CD information explicitly in the bit stream, control pin CD is not used. Connected to V_{SS}. The toggle of CS0 or CS1 for each byte of data/command is recommended but optional.

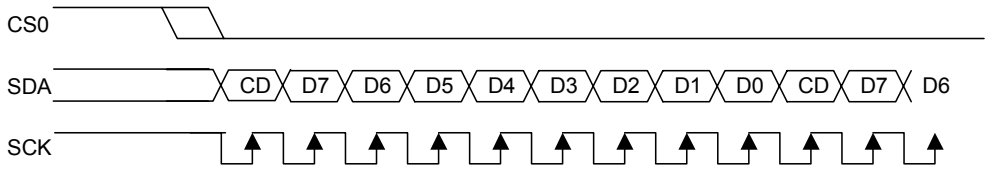
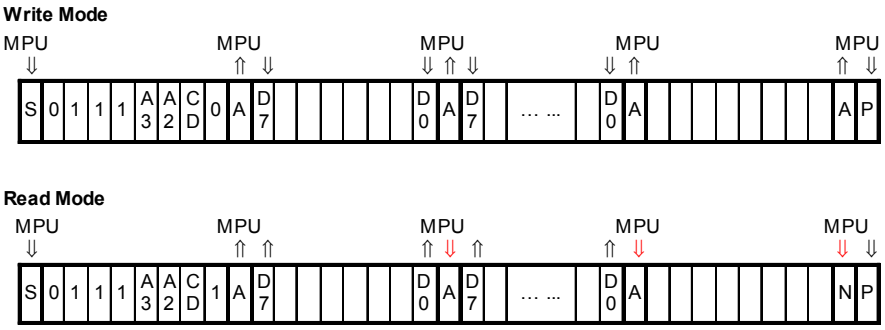


FIGURE 5.c: 3-wire Serial Interface (S9)

2-WIRE SERIAL INTERFACE (I^2C)



When BM[1:0] is set to "LH" and D[7:6] is set to "HH", UC1610i is configured as an I^2C bus signaling protocol compliant slave device. Please refer to I^2C standard for details of the bus signaling protocol, and AC Characteristic section for timing parameters of UltraChip implementation.

In this mode, pins CS[1:0] become A[3:2] and is used to configure UC1610i's device address. Proper wiring to V_{DD} or V_{SS} is required for the IC to operate properly for I^2C mode.

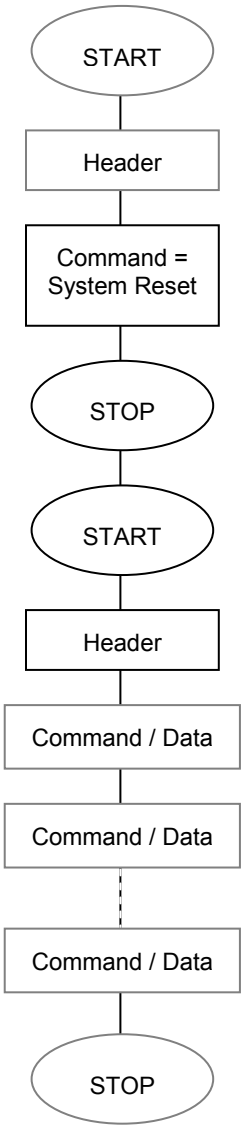
Each UC1610i I^2C interface sequence starts with a START condition (S) from the bus master, followed by a sequence header, containing a device address, the mode of transfer (CD, 0:Control, 1:Data), and the direction of the transfer (RW, 0:Write, 1:Read).

Since both WR and CD are expressed explicitly in the header byte, the control pins WR[1:0] and CD are not used in I^2C mode. Connect WR[1:0] to V_{DD}, and CD to Vss. The direction (read or write) and content type (command or data) of the data bytes following each header byte are fixed for the sequence. To change the direction (R⇔W) or the content type (C⇔D), start a new sequence with a START (S) flag, followed by a new header.

After receiving the header, the UC1610i will send out an acknowledge signal (A). Then, depends on the setting of the header, the transmitting device (either the bus master or UC1610i) will start placing data bits on SDA, MSB to LSB, and the sequence will repeat until a STOP signal (P, in WRITE), or a Not Acknowledge (N, in READ mode) is sent by the bus master.

When using I^2C serial mode, if the command of System Reset is to be written, the writing sequence must be finished (STOP) before succeeding data or commands start. The flow chart on the right shows a writing sequence with a "System Reset" command.

Note that, for data read (CD=1), the first byte of data transmitted will be dummy.



HOST INTERFACE REFERENCE CIRCUIT

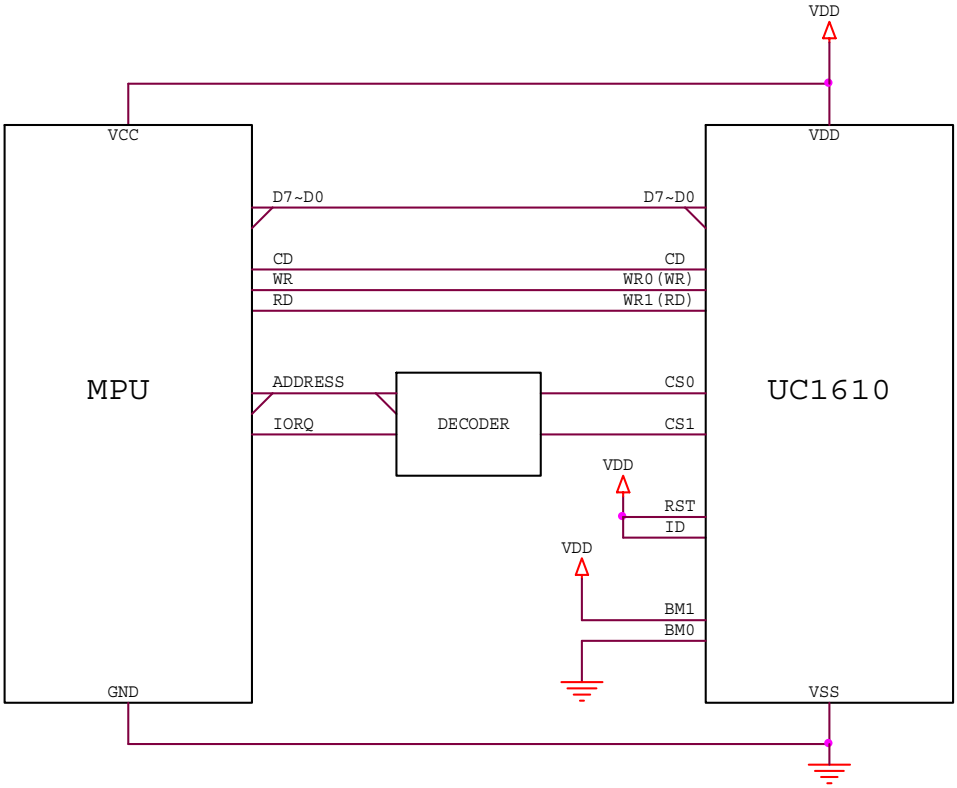


FIGURE 6: 8080/8bit parallel mode reference circuit

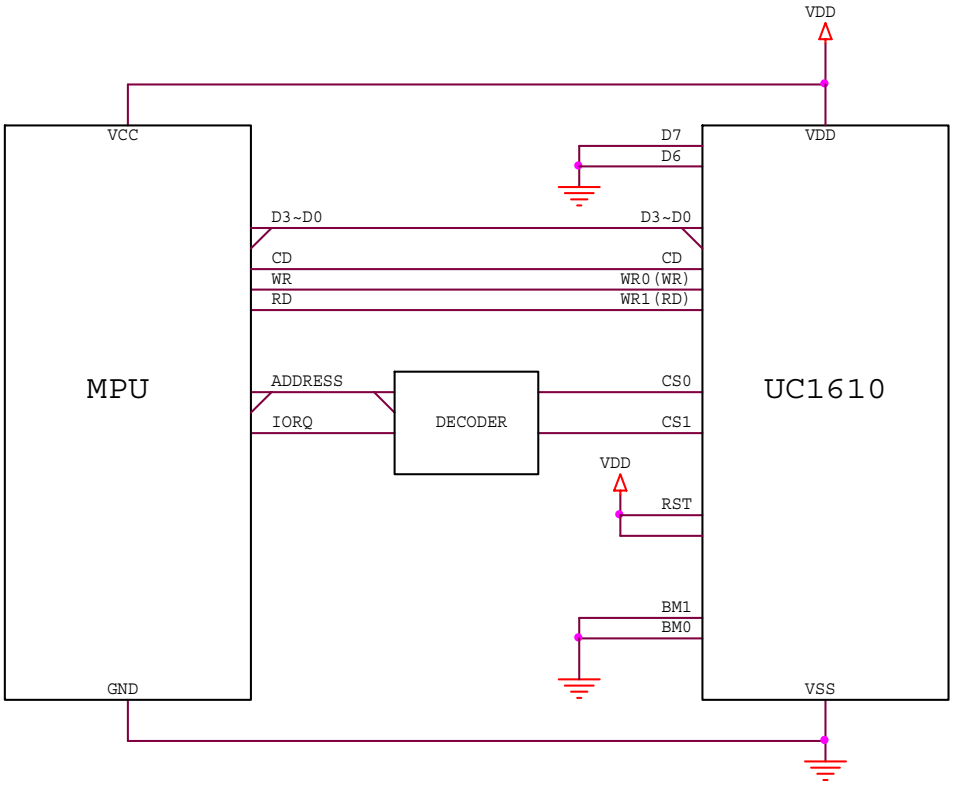


FIGURE 7: 8080/4bit parallel mode reference circuit

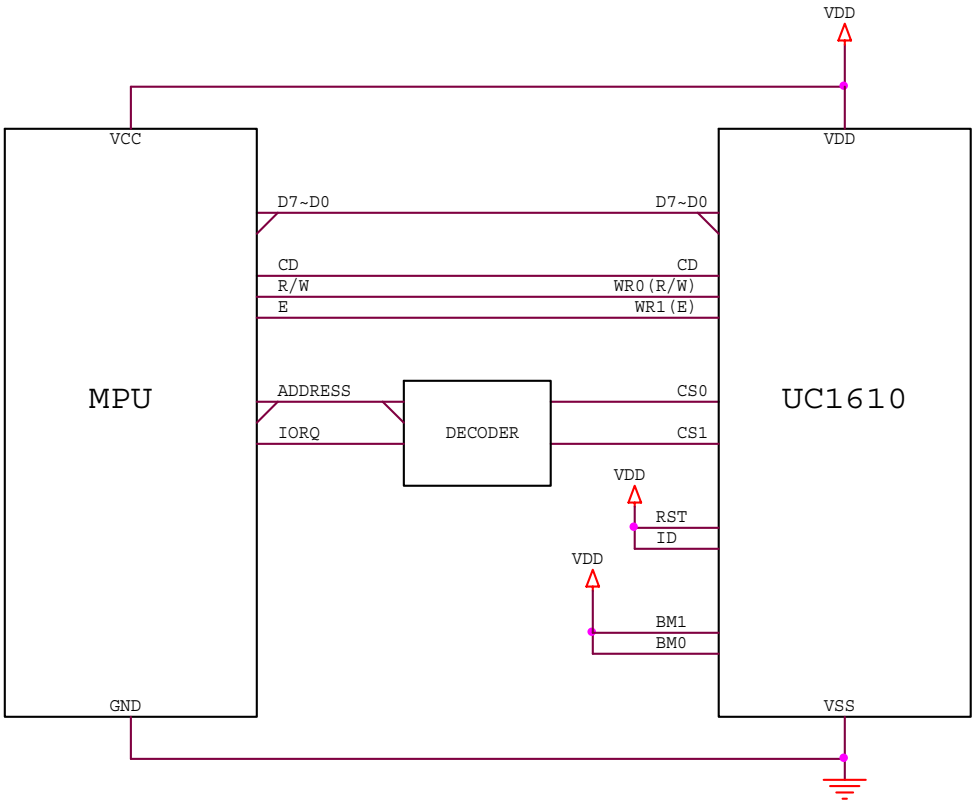


FIGURE 8: 6800/8bit parallel mode reference circuit

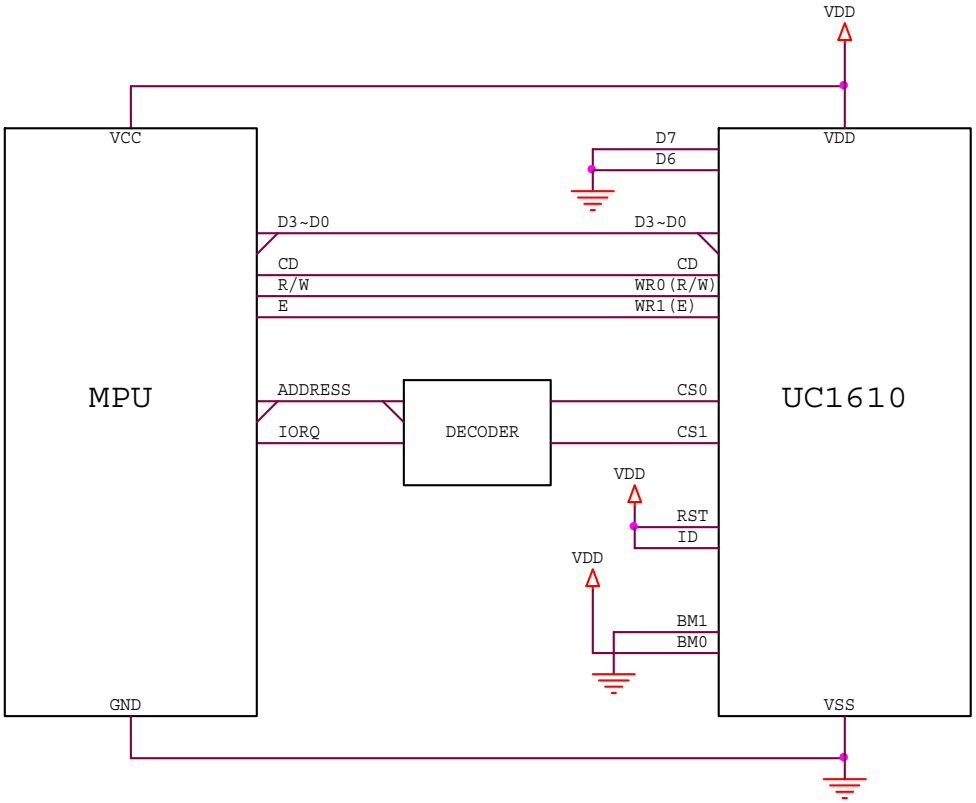


FIGURE 9: 6800/4bit parallel mode reference circuit

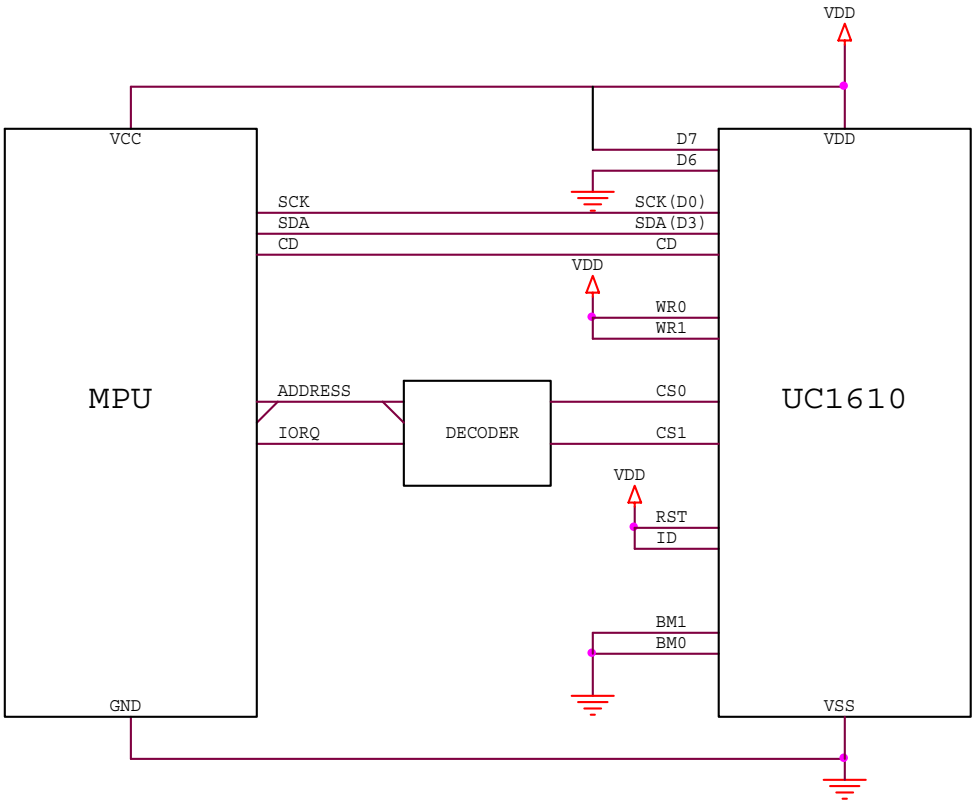


FIGURE 10: 4-Wires SPI (S8) serial mode reference circuit

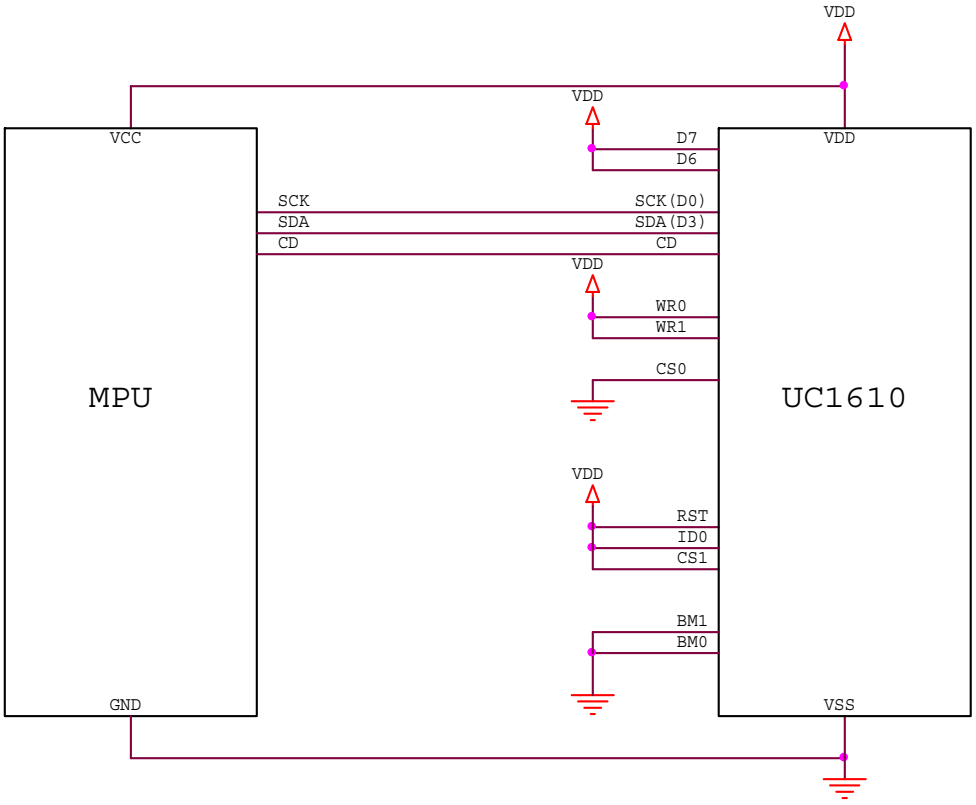


FIGURE 11: 3/4-Wires SPI (S8uc) serial mode reference circuit

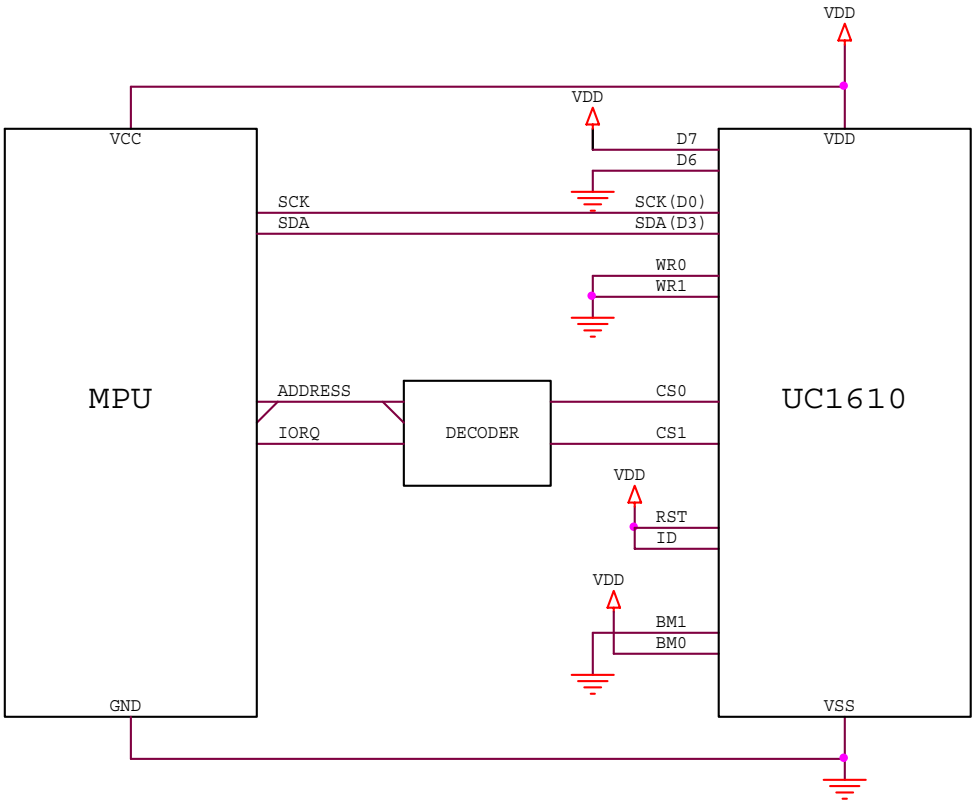


FIGURE 12: 3-Wires SPI (S9) serial mode reference circuit

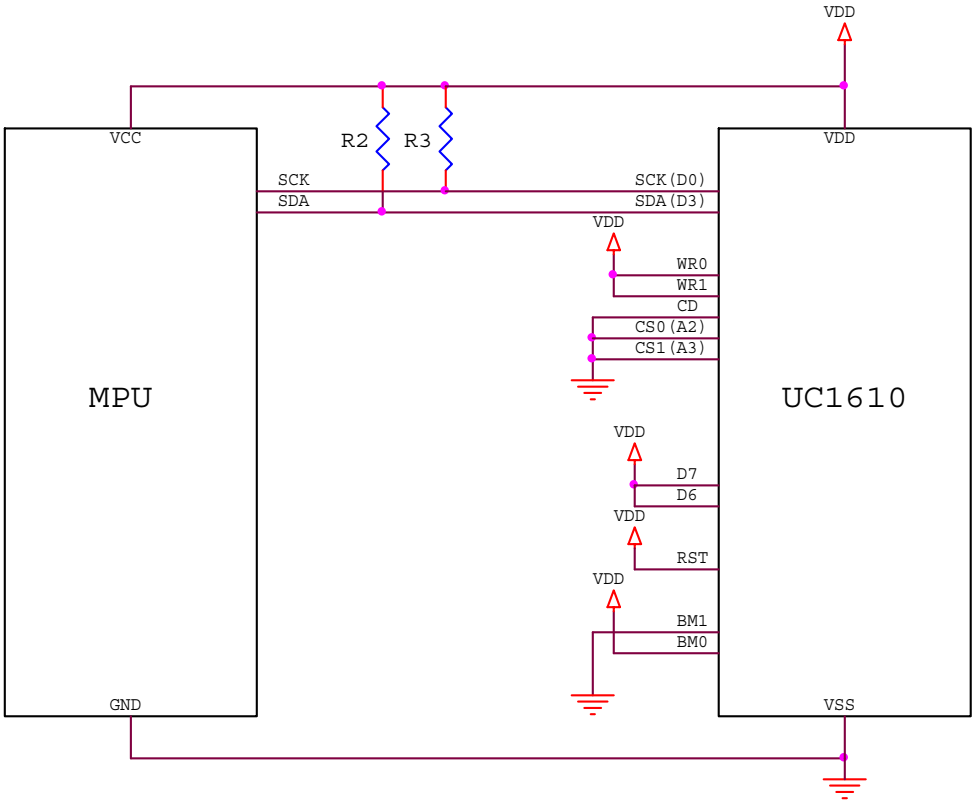


FIGURE 13: I^2C serial mode reference circuit

Note

- ID pin is for production control. The connection will affect the content of D[7] when using the *Get Status* command. Connect to V_{DD} for "H" or V_{SS} for "L".
- RST pin is optional. When RST pin is not used, connect the pin to V_{DD}.
- When using I^2C serial mode, CS0/1 are user configurable and affect A[3:2] of device address.
- R_2, R_3: 2 kΩ ~ 10 kΩ, use lower resistor for bus speed up to 4MHz, use higher resistor for lower power.

DISPLAY DATA RAM

DATA ORGANIZATION

The input display data is stored to a dual port static RAM (RAM, for Display Data RAM) organized as 128x160x2.

After setting CA and PA, the subsequent data write cycles will store the data for the specified pixel to the proper memory location.

Please refer to the map in the following page between the relation of COM, SEG, DDRAM, and various memory control registers.

DISPLAY DATA RAM ACCESS

The Display RAM is a special purpose dual port RAM which allows asynchronous access to both its column and row data. Thus, RAM can be independently accessed both for Host Interface and for display operations.

DISPLAY DATA RAM ADDRESSING

A Host Interface (HI) memory access operation starts with specifying Page Address (PA) and Column Address (CA) by issuing *Set Page Address* and *Set Column Address* commands.

If wrap-around (WA, AC[0]) is OFF (0), CA will stop incrementing after reaching the end of row (127), and system programmers need to set the values of PA and CA explicitly.

If WA is ON (1), when CA reaches end of page, CA will be reset to 0 and PA will increment or decrement, depending on the setting of row Increment Direction (PID, AC[2]). When PA reaches the boundary of RAM (i.e. PA = 0 or 31), PA will be wrapped around to the other end of RAM and continue.

MX IMPLEMENTATION

Column Mirroring (MX) is implemented by selecting either (CA) or (159–CA) as the RAM column address. Changing MX affects the data written to the RAM.

Since MX has no effect of the data already stored in RAM, changing MX does not have immediate effect on the displayed pattern. To refresh the display, refresh the data stored in RAM after setting MX.

ROW MAPPING

COM electrode scanning orders are not affected by Start Line (SL), Fixed Line (FL) or Mirror Y (MY, LC[3]). Visually, register SL having a non-zero value is equivalent to scrolling the LCD display up or down (depends on MY) by *SL* rows.

RAM ADDRESS GENERATION

The mapping of the data stored in the display DDRAM and the scanning COM electrodes can be obtained by combining the fixed COM scanning sequence and the following RAM address generation formula.

When FL=0, during the display operation, the RAM line address generation can be mathematically represented as following:

For the 1st line period of each field
Line = *SL*

Otherwise
Line = Mod (*Line*+1, 128)

Where Mod is the modular operator, and *Line* is the bit slice line address of RAM to be outputted to SEG drivers. Line 0 corresponds to the first bit-slice of data in RAM.

The above *Line* generation formula produces the “loop around” effect as it effectively resets *Line* to 0 when *Line+1* reaches *128*. Effects such as page scrolling, page swapping can be emulated by changing SL dynamically.

MY IMPLEMENTATION

Row Mirroring (MY) is implemented by reversing the mapping order between COM electrodes and RAM, i.e. the mathematical address generation formula becomes:

For the 1st line period of each field
Line = Mod (*SL* + *MUX-1*, *128*)
where MUX = CEN + 1

Otherwise
Line = Mod (*Line-1* , *128*)

Visually, the effect of MY is equivalent to flipping the display upside down. The data stored in display RAM is not affected by MY.

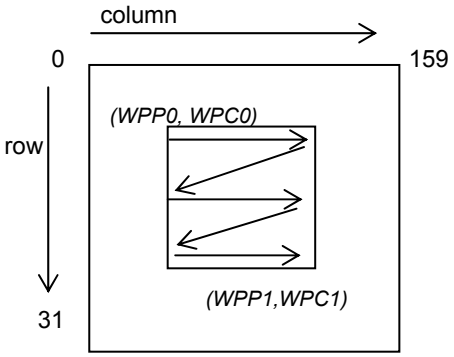
WINDOW PROGRAM

Window program is designed for data write in a specified window range of DDRAM address. The procedure should start with window boundary registers setting (*WPP0*, *WPP1*, *WPC0* and *WPC1*) and then enable AC[4]. After AC[4] sets, data can be written to DDRAM within the window address range which is specified by (*WPP0, WPC0*) and (*WPP1, WPC1*). AC[4] should be cleared after any modification of window boundary registers and then set again in order to initialize another window program.

The data write direction will be determined by AC[2:0] and MX settings. When AC[0]=1, the data write can be consecutive within the range of the specified window. AC[1] will control the data write in either column or row direction. AC[2] will result the data write starting either from row *WPP0* or WPP1. MX is for the initial column address either from *WPC0* to *WPC1* or from (*MC-WPC0* to *MC-WPC1*). MC stands for Maximum Column.

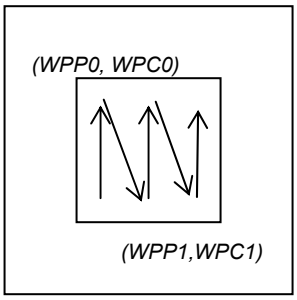
Example1:

AC[2:0] = 001 MX=0



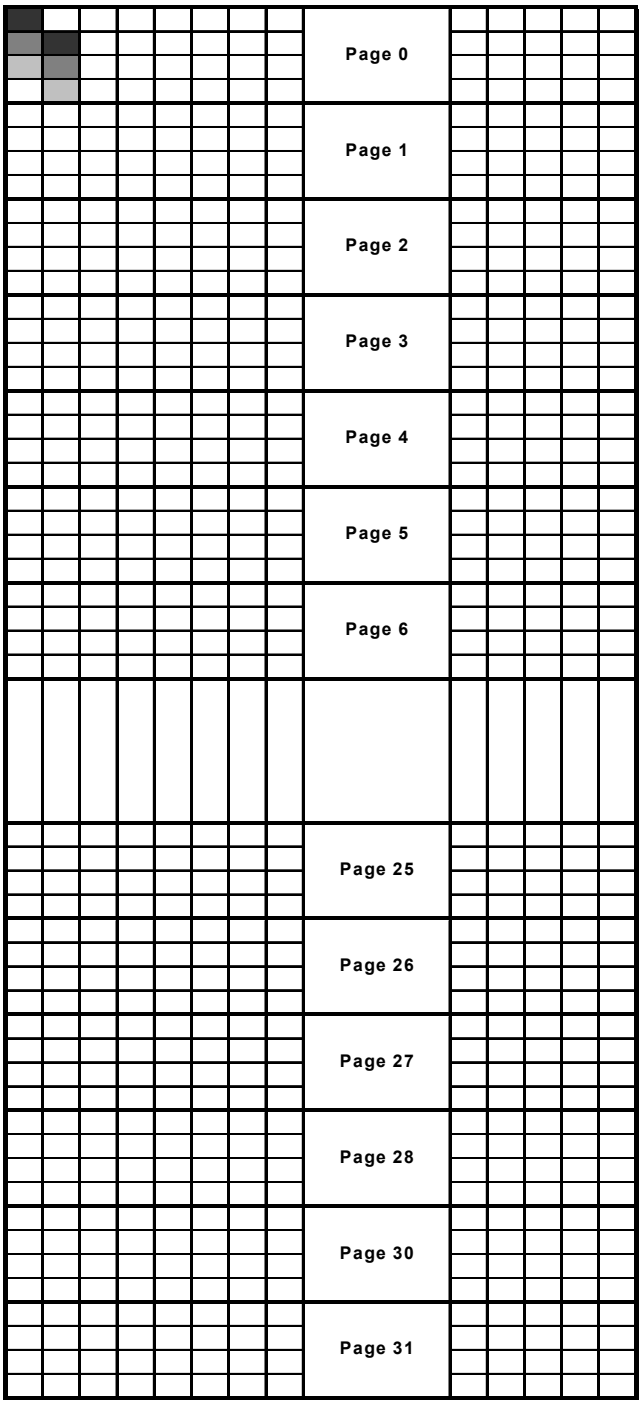
Example 2:

AC[2:0] = 111 MX = 0



Data	Line Adderss
D1/0	00H
D3/2	01H
D5/4	02H
D7/6	03H
D1/0	04H
D3/2	05H
D5/4	06H
D7/6	07H
D1/0	08H
D3/2	09H
D5/4	0AH
D7/6	0BH
D1/0	0CH
D3/2	0DH
D5/4	0EH
D7/6	0FH
D1/0	10H
D3/2	11H
D5/4	12H
D7/6	13H
D1/0	14H
D3/2	15H
D5/4	16H
D7/6	17H
D1/0	18H
D3/2	19H
D5/4	1AH
D7/6	1BH
D1/0	68H
D3/2	69H
D5/4	6AH
D7/6	6BH
D1/0	6CH
D3/2	6DH
D5/4	6EH
D7/6	6FH
D1/0	70H
D3/2	71H
D5/4	72H
D7/6	73H
D1/0	74H
D3/2	75H
D5/4	76H
D7/6	77H
D1/0	78H
D3/2	79H
D5/4	7AH
D7/6	7BH
D1/0	7CH
D3/2	7DH
D5/4	7EH
D7/6	7FH

RAM



MX															
0	C1	C2	C3	C4	C5	C6	C7	C8		C156	C157	C158	C159	C160
1	C160	C159	C158	C157	C156	C155	C154	C153		C5	C4	C3	C2	C1

MY=0 SL=0	MY=0 SL=16	MY=1 SL=0	MY=1 SL=16
R1	R113	R128	R16
R2	R114	R127	R15
R3	R115	R126	R14
R4	R116	R125	R13
R5	R117	R124	R12
R6	R118	R123	R11
R7	R19	R122	R10
R8	R120	R121	R9
R9	R121	R120	R8
R10	R122	R119	R7
R11	R123	R118	R6
R12	R124	R117	R5
R13	R125	R116	R4
R14	R126	R115	R3
R15	R127	R114	R2
R16	R128	R113	R1
R17	R1	R112	R128
R18	R2	R111	R127
R19	R3	R110	R126
R20	R4	R109	R125
R21	R5	R108	R124
R22	R6	R107	R123
R23	R7	R106	R122
R24	R8	R105	R121
R25	R9	R104	R120
R26	R10	R103	R119
R27	R11	R102	R118
R28	R12	R101	R117
R105	R89	R24	R40
R106	R90	R23	R39
R107	R91	R22	R38
R108	R93	R21	R37
R109	R93	R20	R36
R110	R94	R19	R35
R111	R95	R18	R34
R112	R96	R17	R33
R113	R97	R16	R32
R114	R98	R15	R31
R115	R99	R14	R30
R116	R100	R13	R29
R117	R101	R12	R28
R118	R102	R11	R27
R19	R103	R10	R26
R120	R104	R9	R25
R121	R105	R8	R24
R122	R106	R7	R23
R123	R107	R6	R22
R124	R108	R5	R21
R125	R109	R4	R20
R126	R110	R3	R19
R127	R111	R2	R18
R128	R112	R1	R17
		128	128
		MUX	

Example: when MX=0, MY=0, SL=0, the corresponding data in DDRAM as the pixels shown is:

Page 0 Seg 1 ⇨ 00011011

Page 0 Seg 2 ⇨ 01101100

RESET & POWER MANAGEMENT

TYPES OF RESET

UC1610i has two different types of Reset:
Power-ON-Reset and *System-Reset*.

Power-ON-Reset is performed right after V_{DD} is connected to power. *Power-On-Reset* will first wait for about ~5mS, depending on the time required for V_{DD} to stabilize, and then trigger the *System Reset*.

System Reset can also be activated by software command or by connecting RST pin to ground.

In the following discussions, Reset means *System Reset*.

RESET STATUS

When UC1610i enters RESET sequence:

- Operation mode will be "Reset"
- System Status bits RS and BZ will stay as "1" until the Reset process is completed. When RS=1, the IC will only respond to *Read Status* command. All other commands are ignored.
- All control registers are reset to default values. Refer to Control Registers for details of their default values.

OPERATION MODES

UC1610i has three operating modes (OM):
Reset, Normal, Sleep.

Mode	Reset	Sleep	Normal
OM	00	10	11
Host Interface	Active	Active	Active
Clock	OFF	OFF	ON
LCD Drivers	OFF	OFF	ON
Charge Pump	OFF	OFF	ON
Draining Circuit	ON	ON	OFF

Table 4: Operating Modes

CHANGING OPERATION MODE

In addition to Power-ON-Reset, two commands will initiate OM transitions:

Set Display Enable, and *System Reset*.

When DC[2] is modified by *Set Display Enable*, OM will be updated automatically. There is no other action required to enter Sleep Mode.

OM changes are synchronized with the edges of UC1610i internal clock. To ensure consistent system states, wait at least 10µS after *Set Display Enable or System Reset* command.

Action	Mode	OM
Reset command RST_ pin pulled "L" Power ON reset	Reset	00
Set Driver Enable to "0"	Sleep	10
Set Driver Enable to "1"	Normal	11

Table 5: OM changes

Both Reset mode and Sleep mode drain the charges stored in the external capacitors C_{B0}, C_{B1}, and C_L. When entering Reset mode or Sleep mode, the display drivers will be disabled.

The difference between Sleep mode and Reset mode is that, Reset mode clears all control registers and restores them to default values, while Sleep mode retains all the control registers values set by the user.

It is recommended to use Sleep Mode for Display OFF operations as UC1610i consumes very little energy in Sleep mode (typically under 2µA).

EXITING SLEEP MODE

UC1610i contains internal logic to check whether V_{LCD} and V_{BIAS} are ready before releasing COM and SEG drivers from their idle states. When exiting Sleep or Reset mode, COM and SEG drivers will not be activated until UC1610i internal voltage sources are restored to their proper values.

POWER-UP SEQUENCE

UC1610i power-up sequence is simplified by built-in "Power Ready" flags and the automatic invocation of *System-Reset* command after *Power-ON-Reset*.

System programmers are only required to wait 5~ 10 mS before the CPU starting to issue commands to UC1610i. No additional time sequences are required between enabling the charge pump, turning on the display drivers, writing to RAM or any other commands. However, while turning on V_{DD}, $V_{DD2/3}$ should be started not later than V_{DD}.

Delay allowance between V_{DD} and $V_{DD2/3}$ is illustrated as Figure 16.

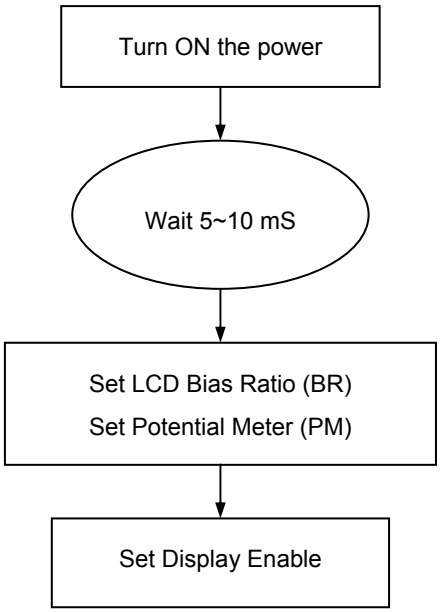


Figure 14: Reference Power-Up Sequence

POWER-DOWN SEQUENCE

To prevent the charge stored in capacitors C_{BX+}, C_{BX-}, and C_L from damaging the LCD, when V_{DD} is switched off, use Reset mode to enable the built-in draining circuit and discharge these capacitors.

The draining resistor is 1K Ohm for both V_{LCD} and V_{B+}. It is recommended to wait *3* x *RC* for V_{LCD} and *1.5 x RC* for V_{B+}. For example, if C_L is 10nF, then the draining time required for V_{LCD} is 0.5~1mS.

When internal V_{LCD} is not used, UC1610i will *NOT* drain V_{LCD} during RESET. System designers need to make sure external V_{LCD} source is properly drained off before turning off V_{DD}.

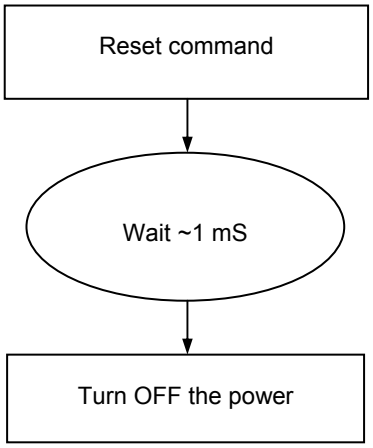


Figure 15: Reference Power-Down Sequence

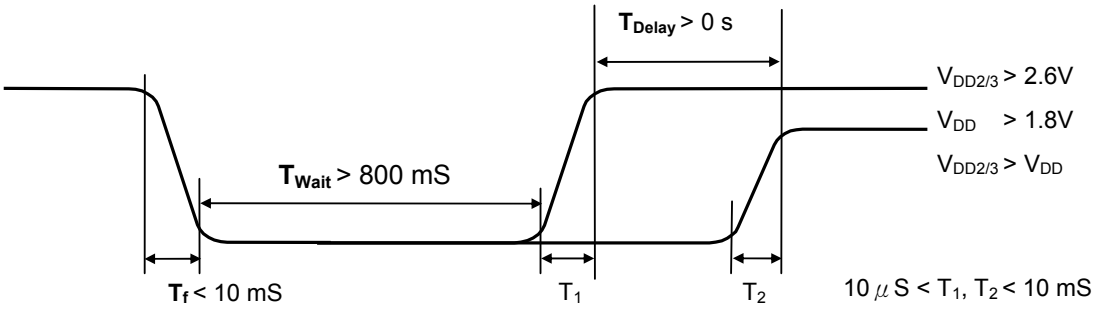


Figure 16: Delay allowance between V_{DD} and V_{DD23}

SAMPLE POWER MANAGEMENT COMMAND SEQUENCES

The following tables are examples of command sequence for power-up, power-down and display ON/OFF operations. These are only to demonstrate some "*typical, generic*" scenarios. Designers are encouraged to study related sections of the datasheet and find out what the best parameters and control sequences are for their specific design needs.

Type — Required: These items are required
Customized: These items are not necessary if customer parameters are the same as default
Advanced: We recommend new users to skip these commands and use default values.
Optional: These commands depend on what users want to do.

C/D — The type of the interface cycle. It can be either Command (0) or Data (1)

W/R — The direction of dataflow of the cycle. It can be either Write (0) or Read (1).

POWER-UP

Type	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0	Chip action	Comments
R	–	–	–	–	–	–	–	–	–	–	Automatic Power-ON Reset.	Wait 5~10mS after V_{DD} is ON
C	0	0	0	0	1	0	0	1	#	#	(5) Set Temp. Compensation	Set up LCD format specific parameters, MX, MY, etc.
C	0	0	1	1	0	0	0	#	#	#	(19) Set LCD Mapping	
A	0	0	1	0	1	0	0	0	#	#	(15) Set Line Rate	Fine tune for power, flicker, contrast, and shading.
C	0	0	1	1	0	1	0	0	#	#	(20) Set Gray Shade	
C	0	0	1	1	1	0	1	0	#	#	(24) Set Bias Ratio	LCD specific operating voltage setting
R	0 0	0 0	1 #	0 #	0 #	0 #	0 #	0 #	0 #	1 #	(11) Set V_{BIAS} Potentiometer	
O	1 . . 1	0 . . 0	# . . #	# . . #	# . . #	# . . #	# . . #	# . . #	# . . #	# . . #	Write display RAM	Set up display image
R	0	0	1	0	1	0	1	1	1	1	(18) Set Display Enable	

POWER-DOWN

Type	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0	Chip action	Comments
R	0	0	1	1	1	0	0	0	1	0	(21) System Reset	
R	–	–	–	–	–	–	–	–	–	–	Draining capacitor	Wait ~1mS before V_{DD} OFF

DISPLAY-OFF

Type	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0	Chip action	Comments
R	0	0	1	0	1	0	1	1	1	0	(18) Set Display Disable	
C	1 . . 1	0 . . 0	# . . #	# . . #	# . . #	# . . #	# . . #	# . . #	# . . #	# . . #	Write display RAM	Set up display image (Image update is optional. Data in the RAM is retained through the SLEEP state.)
R	0	0	1	0	1	0	1	1	1	1	(18) Set Display Enable	

ESD CONSIDERATION

1. UC1600 series products are usually provided in bare die format to customers. This makes the product particularly sensitive to ESD damage during handling and manufacturing process. It is therefore highly recommended that LCM makers strictly follow the "JESD 625-A Requirements for Handling Electrostatic-Discharge-Sensitive (ESDS) Devices" when manufacturing LCM.

   In particular, the following pins in UC1610i require special "ESD Sensitivity" consideration, please refer to Table below.

Test Mode / Pin Name	Machine Mode		Human Body Mode	
	V_{DD}	V_{SS}	V_{DD}	V_{SS}
V_{LCDIN}	Pass 150V	Pass 150V	Pass 1000V	Pass 1500V
V_{LCDOUT}	Pass 150V	Pass 150V	Pass 1500V	Pass 1500V
C_B	Pass 100V	Pass 150V	Pass 1500V	Pass 1500V

   According to UltraChip's Mass Production experiences, the ESD tolerance conditions are believed to be very stable and can produce high yield in multiple customer sites. However, special care is still required during handling and manufacturing process to avoid unnecessary yield loss due to ESD damages.

2. LCM design suggestions: To minimize potential ESD damages to the finished LCD modules, please consider placing external components (C_{B0} and C_{B1}) in such a way that they will not be exposed to Machine Mode ESD zap path. For example, place C_B capacitors on the internal side after folding FPC.

ABSOLUTE MAXIMUM RATINGS

In accordance with IEC134, note 1 and 2

Symbol	Parameter	Min.	Max.	Unit
V_{DD}	Logic Supply voltage	-0.3	+4.0	V
V_{DD2}	LCD Generator Supply voltage	-0.3	+4.0	V
V_{DD3}	Analog Circuit Supply voltage	-0.3	+4.0	V
$V_{DD2/3}$-V_{DD}	Voltage difference between V_{DD} and $V_{DD2/3}$	--	1.6	V
V_{LCD}	LCD Generated voltage (-30^{O}C ~ +80^{O}C)	-0.3	+18.0	V
V_{IN}	Digital input signal	-0.4	V_{DD} + 0.5	V
T_{OPR}	Operating temperature range	-30	+85	^{o}C
T_{STR}	Storage temperature	-55	+125	^{o}C

Notes

1. V_{DD} is based on V_{SS} = 0V
2. Stress beyond ranges listed above may cause permanent damages to the device.

SPECIFICATIONS

DC CHARACTERISTICS

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
V_{DD}	Supply for digital circuit		1.8	1.8~3.3	3.465	V
$V_{DD2/3}$	Supply for bias & pump		2.6	2.6~3.3	3.465	V
V_{LCD}	Charge pump output	$V_{DD2/3} \geq 2.6V$, $25^{O}C$		13.5	15	V
V_D	LCD data voltage	$V_{DD2/3} \geq 2.6V$, $25^{O}C$	0.9		1.5	V
V_{IL}	Input logic LOW				$0.2V_{DD}$	V
V_{IL}(Serial)	Input logic LOW in serial Mode				$0.15V_{DD}$	
V_{IH}	Input logic HIGH		$0.8V_{DD}$			V
V_{IH}(Serial)	Input logic HIGH in serial Mode		$0.85V_{DD}$			
V_{OL}	Output logic LOW				$0.2V_{DD}$	V
V_{OH}	Output logic HIGH		$0.8V_{DD}$			V
I_{IL}	Input leakage current				1.5	µA
C_{IN}	Input capacitance			5	10	pF
C_{OUT}	Output capacitance			5	10	pF
$R_{ON(SEG)}$	SEG output impedance	V_{LCD} = 14.7V		1.2	2.5	kΩ
$R_{ON(COM)}$	COM output impedance	V_{LCD} = 14.7V		2.0	4.0	kΩ
f_{LINE}	Average Line rate	LC[4:3] = 11b	11.1	12.1	-	kHz

POWER CONSUMPTION

V_{DD} =2.7, Bias Ratio =10b, PM = 178, Line Rate = 00b, P_L =16~21nF,
MR = 128, Bus mode = 6800, C_L = 0.3µF, C_B = 2µF, C_{BIAS} = 0.1µF.
All outputs are open circuit.

Display Pattern	Conditions	Typical	Maximum	Unit
All-OFF	Bus = idle	617	925	µA
2-pixel checker	Bus = idle	725	1087	µA
-	Bus = idle (standby current)	-	5	µA

AC CHARACTERISTICS

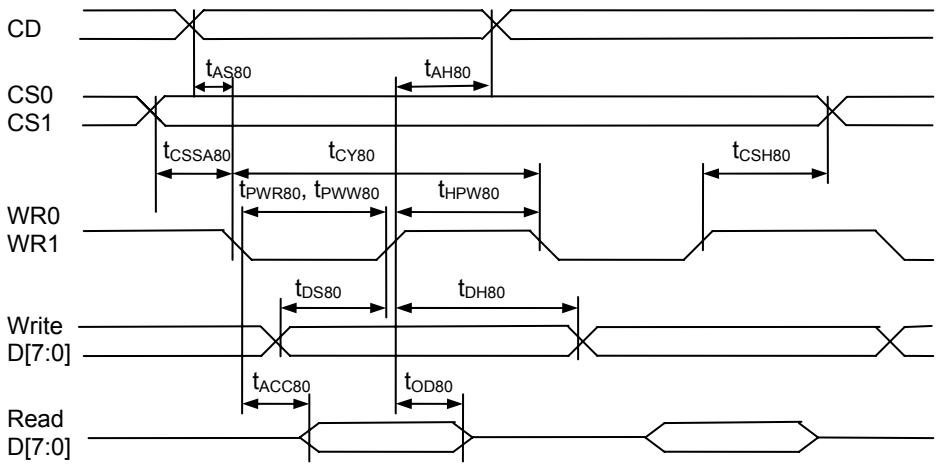


FIGURE 17: Parallel Bus Timing Characteristics (for 8080 MCU)

Symbol	Signal	Description	Condition	Min.	Max.	Unit
(2.5V ≤ V_{DD} < 3.465V, Ta= –30 to +85°C)				(Read / Write)		
t_{AS80} t_{AH80}	CD	Address setup time Address hold time		5 15	–	nS
t_{CSSA80} t_{CSH80}	CS1/CS0	Chip select setup time		5 5	–	nS
t_{CY80}	WR1 / WR0	System cycle time	(8-bit bus) (4-bit bus)	170 / 110 170 / 110	–	nS
t_{PWR80} / t_{PWW80}		Pulse width	(8-bit bus) (4-bit bus)	70 / 40 70 / 40		
t_{HPW80}		High pulse width	(8-bit bus) (4-bit bus)	70 / 40 70 / 40		
t_{DS80} t_{DH80}	D7~D0 (Write)	Data setup time Data hold time		30 15	–	nS
t_{ACC80} t_{OD80}	D7~D0 (Read)	Read access time Output disable time	C_L = 100pF	– 25	60	nS
(1.8V ≤ V_{DD} < 2.5V, Ta= –30 to +85°C)				(Read / Write)		
t_{AS80} t_{AH80}	CD	Address setup time Address hold time		10 30	–	nS
t_{CSSA80} t_{CSH80}	CS1/CS0	Chip select setup time		10 10	–	nS
t_{CY80}	WR1 / WR0	System cycle time	(8-bit bus) (4-bit bus)	310 / 190 310 / 190	–	nS
t_{PWR80} / t_{PWW80}		Pulse width	(8-bit bus) (4-bit bus)	140 / 80 140 / 80		
t_{HPW80}		High pulse width	(8-bit bus) (4-bit bus)	140 / 80 140 / 80		
t_{DS80} t_{DH80}	D7~D0 (Write)	Data setup time Data hold time		60 30	–	nS
t_{ACC80} t_{OD80}	D7~D0 (Read)	Read access time Output disable time	C_L = 100pF	– 50	–	nS

Note: The rising time (tr) and the falling time (tf) are stipulated to be equal to or less than 15nS each.

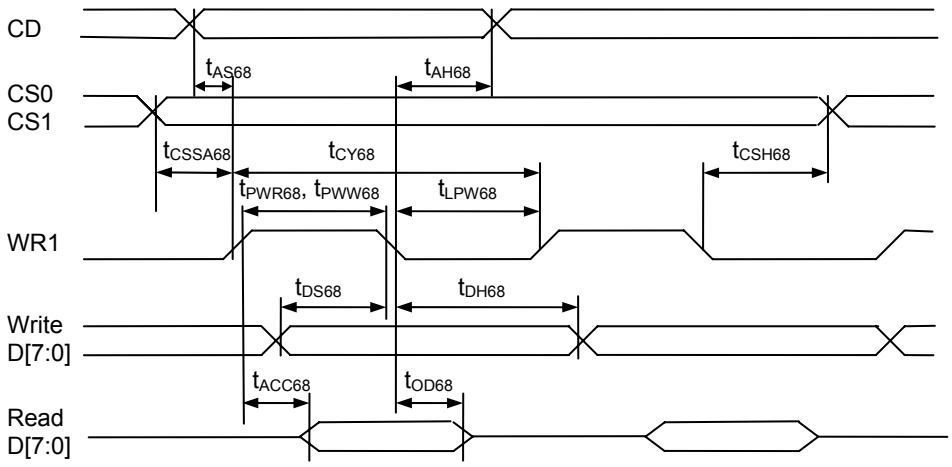


FIGURE 18: Parallel Bus Timing Characteristics (for 6800 MCU)

Symbol	Signal	Description	Condition	Min.	Max.	Unit
(2.5V ≤ V_{DD} < 3.465V, Ta= –30 to +85°C)				(Read / Write)		
t_{AS68} t_{AH68}	CD	Address setup time Address hold time		5 15	–	nS
t_{CSSA68} t_{CSH68}	CS1/CS0	Chip select setup time		5 5		nS
t_{CY68}	WR1	System cycle time	(8-bit bus) (4-bit bus)	170 / 110 170 / 110	–	nS
t_{PWR68} / t_{PWW68}		Pulse width	(8-bit bus) (4-bit bus)	70 / 40 70 / 40		
t_{LPW68}		Low pulse width	(8-bit bus) (4-bit bus)	70 / 40 70 / 40		
t_{DS68} t_{DH68}	D7~D0 (Write)	Data setup time Data hold time		30 15	–	nS
t_{ACC68} t_{OD68}	D7~D0 (Read)	Read access time Output disable time	C_L = 100pF	– 25	60	nS
(1.8V ≤ V_{DD} < 2.5V, Ta= –30 to +85°C)				(Read / Write)		
t_{AS68} t_{AH68}	CD	Address setup time Address hold time		10 30	–	nS
t_{CSSA68} t_{CSH68}	CS1/CS0	Chip select setup time		10 10		nS
t_{CY68}	WR1	System cycle time	(8-bit bus) (4-bit bus)	310 / 190 310 / 190	–	nS
t_{PWR68} / t_{PWW68}		Pulse width	(8-bit bus) (4-bit bus)	140 / 80 140 / 80		
t_{LPW68}		Low pulse width	(8-bit bus) (4-bit bus)	140 / 80 140 / 80		
t_{DS68} t_{DH68}	D7~D0 (Write)	Data setup time Data hold time		60 30	–	nS
t_{ACC68} t_{OD68}	D7~D0 (Read)	Read access time Output disable time	C_L = 100pF	– 50		nS

Note: The rising time (tr) and the falling time (tf) are stipulated to be equal to or less than 15nS each.

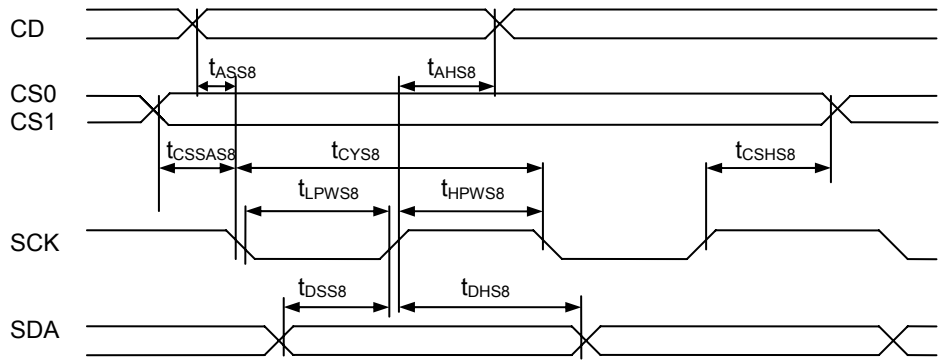


FIGURE 19: Serial Bus Timing Characteristics (for S8 / S8uc)

Symbol	Signal	Description	Condition	Min.	Max.	Unit
(2.5V ≤ V_{DD} < 3.465V, Ta= –30 to +85°C)				(Read / Write)		
t_{ASS8}	CD	Address setup time		5	–	nS
t_{AHS8}		Address hold time		20		
t_{CSSAS8}	CS1/CS0	Chip select setup time		5	–	nS
t_{CSHS8}				15		
t_{CYS8}	SCK	System cycle time	tr, tf ≤ 15	155	–	nS
t_{LPWS8}		Low pulse width		63		
t_{HPWS8}		High pulse width		62		
t_{DSS8}	SDA	Data setup time		30	–	nS
t_{DHS8}		Data hold time		20		
(1.8V ≤ V_{DD} < 2.5V, Ta= –30 to +85°C)				(Read / Write)		
t_{ASS8}	CD	Address setup time		10	–	nS
t_{AHS8}		Address hold time		45		
t_{CSSAS8}	CS1/CS0	Chip select setup time		10	–	nS
t_{CSHS8}				30		
t_{CYS8}	SCK	System cycle time	tr, tf ≤ 15	280	–	nS
t_{LPWS8}		Low pulse width		125		
t_{HPWS8}		High pulse width		125		
t_{DSS8}	SDA	Data setup time		60	–	nS
t_{DHS8}		Data hold time		40		

Note: The rising time (tr) and the falling time (tf) are stipulated to be equal to or less than 15nS each.

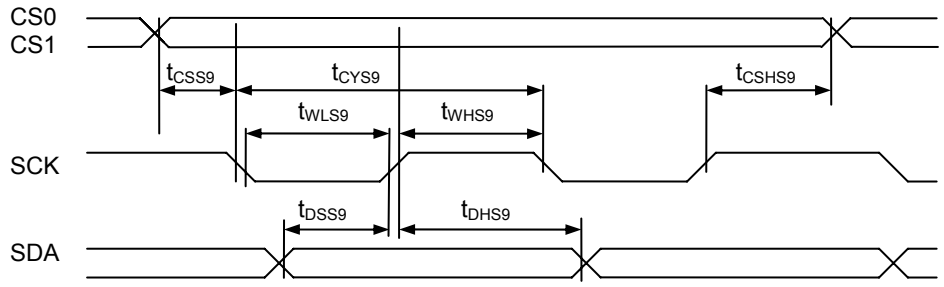


FIGURE 20: Serial Bus Timing Characteristics (for S9)

Symbol	Signal	Description	Condition	Min.	Max.	Unit
(2.5V ≤ V_{DD} < 3.465V, Ta= –30 to +85°C)				(Read / Write)		
t_{CSSAS9} t_{CSHS9}	CS1/CS0	Chip select setup time		5 5	–	nS
t_{CYS9} t_{LPWS9} t_{HPWS9}	SCK	System cycle time Low pulse width High pulse width	tr, tf ≤ 15	110 40 40	–	nS
t_{DSS9} t_{DHS9}	SDA	Data setup time Data hold time		30 20	–	nS
(1.8V ≤ V_{DD} < 2.5V, Ta= –30 to +85°C)				(Read / Write)		
t_{CSSAS9} t_{CSHS9}	CS1/CS0	Chip select setup time		10 10	–	nS
t_{CYS9} t_{LPWS9} t_{HPWS9}	SCK	System cycle time Low pulse width High pulse width	tr, tf ≤ 15	190 80 80	–	nS
t_{DSS9} t_{DHS9}	SDA	Data setup time Data hold time		60 40	–	nS

Note: The rising time (tr) and the falling time (tf) are stipulated to be equal to or less than 15nS each.

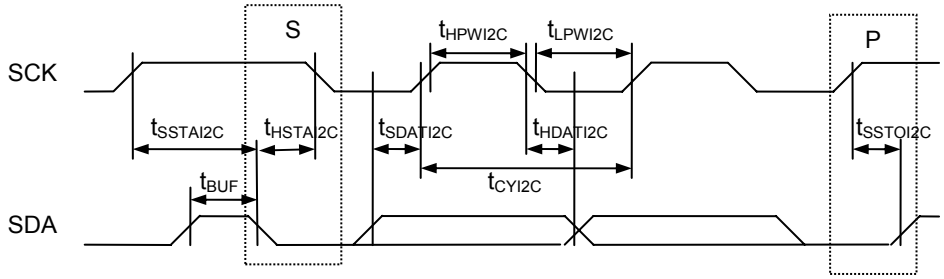


FIGURE 21: Serial bus timing characteristics (for I^2C)

Symbol	Signal	Description	Condition	Min.	Max.	Unit
(2.5V ≤ V_{DD} < 3.465V, Ta= –30 to +85°C)				(Read / Write)		
t_{CYI2C}	SCK	SCK cycle time	tr, tf ≤ 15	280	–	nS
t_{LPWI2C}		Low pulse width		125	–	nS
t_{HPWI2C}		High pulse width		125	–	nS
tr, tf	SCK SDA	Rise time and fall time		–	–	nS
$t_{SSDAI2C}$		Data setup time		25	–	nS
t_{HDAI2C}		Data hold time		10	–	nS
$t_{SSTAI2C}$		START Setup time		25	–	nS
$t_{HSTAI2C}$		STAR Hold time		20	–	nS
$t_{SSTOI2C}$		STOP setup time		25	–	nS
(1.8V ≤ V_{DD} < 2.5V, Ta= –30 to +85°C)				(Read / Write)		
t_{CYI2C}	SCK	SCK cycle time	tr, tf ≤ 15	330	–	nS
t_{LPWI2C}		Low pulse width		150	–	nS
t_{HPWI2C}		High pulse width		150	–	nS
tr, tf	SCK SDA	Rise time and fall time		–	–	nS
$t_{SSDAI2C}$		Data setup time		40	–	nS
t_{HDAI2C}		Data hold time		10	–	nS
$t_{SSTAI2C}$		START Setup time		25	–	nS
$t_{HSTAI2C}$		STAR Hold time		35	–	nS
$t_{SSTOI2C}$		STOP setup time		25	–	nS

Note: The rising time (tr) and the falling time (tf) are stipulated to be equal to or less than 15nS each.

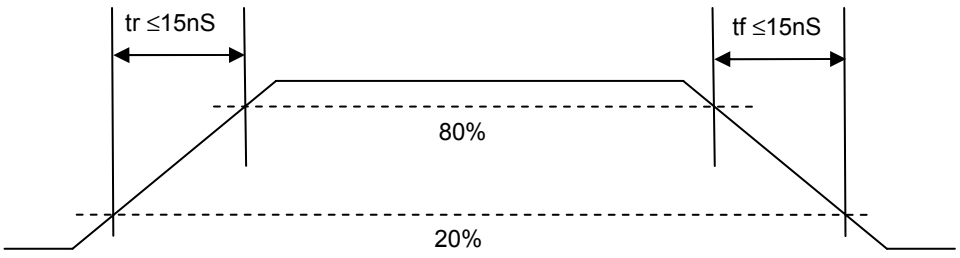
FIGURE 22: Reset Characteristics

($1.8V \leq V_{DD} < 3.465V$, Ta= –30 to +85°C)

Symbol	Signal	Description	Condition	Min.	Max.	Unit
t_{RW}	RST	Reset low pulse width		1	–	µS

Note:

For each mode, the signal's rising time and falling time (tf, tr) are stipulated to be equal to or less than 15nS each.



PHYSICAL DIMENSIONS

DIE SIZE:
1.372mm x 11.384mm

DIE THICKNESS:
0.5mm

BUMP HEIGHT:
17 ± 3µM

(12 ± 3µM also available)

H_{Max}-H_{Min} (within die) < 2µM

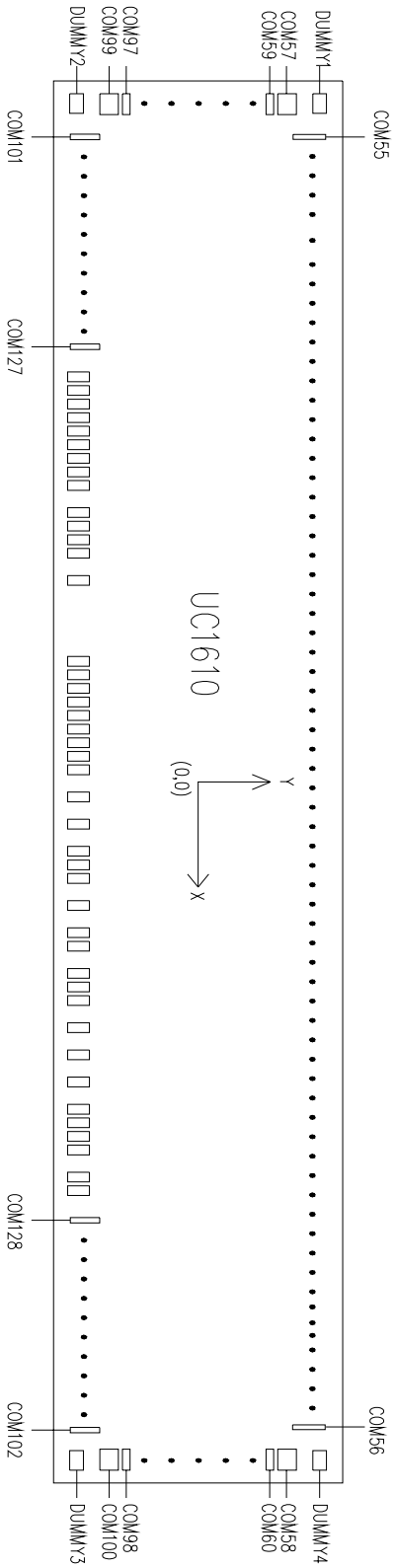
MINIMUM BUMP PITCH:
SEG: 50µM
COM: 50µM

MINIMUM BUMP GAP:
17µM

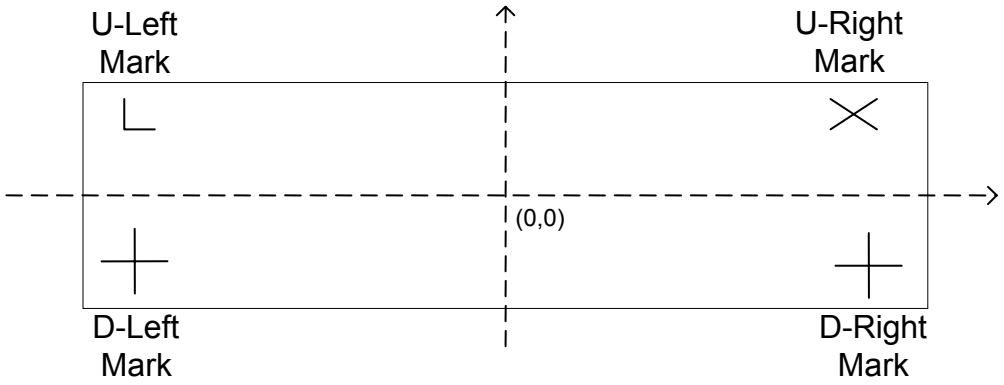
COORDINATE ORIGIN:
Chip center

PAD REFERENCE:
Pad center

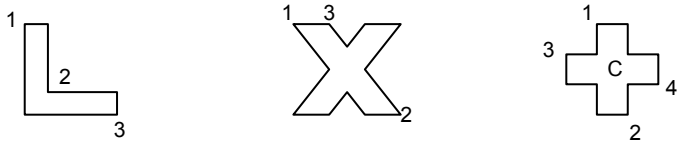
(Drawing and coordinates are for the Circuit/Bump view.)



ALIGNMENT MARK INFORMATION



SHAPE OF THE ALIGNMENT MARK:



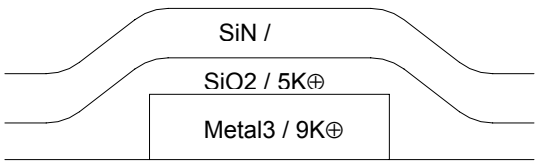
COORDINATES:

	U-Left Mark		U-Right Mark	
	X	Y	X	Y
1	-5496.3	623.8	5430.4	625.9
2	-5480.7	591.9	5497.8	578.6
3	-5449.5	576.4	5452.1	625.9

	D-Left Mark		D-Right Mark	
	X	Y	X	Y
1	-5474.3	-591.0	5467.9	-591.0
2	-5463.3	-646.0	5478.9	-646.0
3	-5496.3	-613.0	5445.9	-613.0
4	-5441.3	-624.0	5501.0	-624.0
C	-5468.8	-618.5	5473.4	-618.5

(The values of the x-coordinate and the y-coordinate in the table are after rounded.)

TOP METAL AND PASSIVATION:



FOR NON-OTP PROCESS CROSS-SECTION

PAD COORDINATES

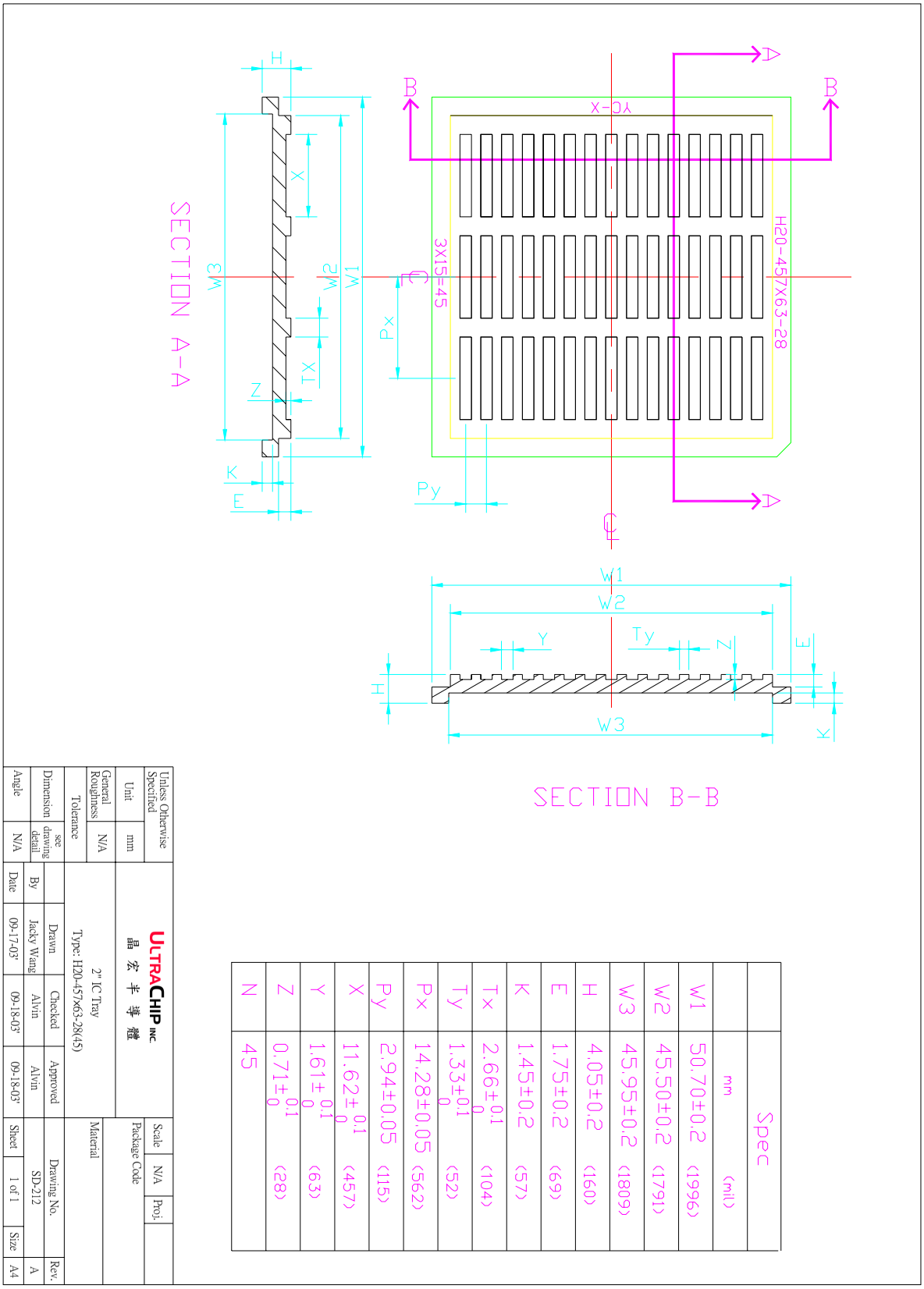
#	Pad	X	Y	W	H
1	DUMMY	-5588.915	568.575	99	53
2	COM57	-5588.915	508.450	99	33
3	COM59	-5588.915	458.450	99	33
4	COM61	-5588.915	408.450	99	33
5	COM63	-5588.915	358.450	99	33
6	COM65	-5588.915	308.450	99	33
7	COM67	-5588.915	258.450	99	33
8	COM69	-5588.915	208.450	99	33
9	COM71	-5588.915	158.450	99	33
10	COM73	-5588.915	108.450	99	33
11	COM75	-5588.915	58.450	99	33
12	COM77	-5588.915	8.450	99	33
13	COM79	-5588.915	-41.550	99	33
14	COM81	-5588.915	-91.550	99	33
15	COM83	-5588.915	-141.550	99	33
16	COM85	-5588.915	-191.550	99	33
17	COM87	-5588.915	-241.550	99	33
18	COM89	-5588.915	-291.550	99	33
19	COM91	-5588.915	-341.550	99	33
20	COM93	-5588.915	-391.550	99	33
21	COM95	-5588.915	-441.550	99	33
22	COM97	-5588.915	-491.550	99	33
23	COM99	-5588.915	-541.550	99	33
24	DUMMY	-5588.915	-601.425	99	53
25	COM101	-5395.015	-593.025	33	99
26	COM103	-5345.015	-593.025	33	99
27	COM105	-5295.015	-593.025	33	99
28	COM107	-5245.015	-593.025	33	99
29	COM109	-5195.015	-593.025	33	99
30	COM111	-5145.015	-593.025	33	99
31	COM113	-5095.015	-593.025	33	99
32	COM115	-5045.015	-593.025	33	99
33	COM117	-4995.015	-593.025	33	99
34	COM119	-4945.015	-593.025	33	99
35	COM121	-4895.015	-593.025	33	99
36	COM123	-4845.015	-593.025	33	99
37	COM125	-4795.015	-593.025	33	99
38	COM127	-4745.015	-593.025	33	99
39	D0	-4667.515	-600.025	50	80
40	D1	-4597.515	-600.025	50	80
41	D2	-4527.515	-600.025	50	80
42	D3	-4457.515	-600.025	50	80
43	D4	-4387.515	-600.025	50	80
44	D5	-4317.515	-600.025	50	80
45	D6	-4247.515	-600.025	50	80
46	D7	-4177.515	-600.025	50	80
47	RST_	-4105.915	-600.025	50	80
48	CS0	-3846.790	-600.025	50	80
49	VDDX	-3775.865	-600.025	50	80
50	CS1	-3705.190	-600.025	50	80
51	ID	-3450.190	-600.025	50	80
52	CD	-3378.590	-600.025	50	80
53	WR0	-3123.590	-600.025	50	80
54	WR1	-3051.990	-600.025	50	80
55	TST4	-2796.990	-600.025	50	80
56	BM0	-2725.390	-600.025	50	80
57	VDDX	-2554.390	-600.025	50	80
58	BM1	-2383.390	-600.025	50	80
59	TST2	-2312.465	-600.025	50	80
60	DUMMY	-2128.390	-600.025	50	80
61	DUMMY	-1867.990	-600.025	50	80
62	VSS	-1797.740	-600.025	50	80
63	VSS	-1727.740	-600.025	50	80
64	VSS	-1657.740	-600.025	50	80
65	VSS	-1587.740	-600.025	50	80
66	VSS	-1517.740	-600.025	50	80
67	VSS	-1447.740	-600.025	50	80
68	VSS2	-1264.315	-600.025	50	80
69	VSS2	-1194.315	-600.025	50	80
70	VSS2	-1124.315	-600.025	50	80
71	VSS2	-1054.315	-600.025	50	80
72	VSS2	-984.315	-600.025	50	80
73	VDD2	-914.315	-600.025	50	80
74	VDD2	-844.315	-600.025	50	80
75	VDD2	-774.315	-600.025	50	80
76	VDD3	-407.615	-600.025	50	80
77	VDD3	-336.365	-600.025	50	80
78	VDD3	-266.365	-600.025	50	80
79	VDD	104.685	-600.025	50	80
80	VDD	174.935	-600.025	50	80
81	VDD	244.935	-600.025	50	80
82	VDD	314.935	-600.025	50	80
83	VDD	384.935	-600.025	50	80
84	DUMMY	558.635	-600.025	50	80
85	DUMMY	628.885	-600.025	50	80
86	DUMMY	889.285	-600.025	50	80
87	VB0-	960.460	-600.025	50	80
88	VB0-	1030.460	-600.025	50	80
89	VB0-	1100.460	-600.025	50	80
90	VB0-	1170.460	-600.025	50	80
91	VB0-	1240.460	-600.025	50	80
92	VB0-	1310.460	-600.025	50	80
93	VB0-	1380.460	-600.025	50	80
94	VB0-	1450.460	-600.025	50	80
95	VB0-	1520.460	-600.025	50	80
96	VB1-	1871.460	-600.025	50	80
97	VB1-	1941.710	-600.025	50	80
98	VB1-	2010.110	-600.025	50	80
99	VB1-	2078.510	-600.025	50	80
100	VB1-	2146.910	-600.025	50	80
101	VB1-	2215.310	-600.025	50	80
102	VB1-	2283.710	-600.025	50	80
103	VB1-	2352.110	-600.025	50	80
104	VB1-	2420.510	-600.025	50	80
105	VB1+	2490.510	-600.025	50	80
106	VB1+	2558.910	-600.025	50	80
107	VB1+	2627.310	-600.025	50	80
108	VB1+	2695.710	-600.025	50	80
109	VB1+	2764.110	-600.025	50	80
110	VB1+	2832.510	-600.025	50	80
111	VB1+	2900.910	-600.025	50	80
112	VB1+	2969.310	-600.025	50	80
113	VB1+	3039.310	-600.025	50	80
114	VB0+	3388.310	-600.025	50	80
115	VB0+	3458.560	-600.025	50	80
116	VB0+	3526.960	-600.025	50	80
117	VB0+	3595.360	-600.025	50	80
118	VB0+	3663.760	-600.025	50	80
119	VB0+	3732.160	-600.025	50	80
120	VB0+	3800.560	-600.025	50	80
121	VB0+	3868.960	-600.025	50	80
122	VB0+	3937.360	-600.025	50	80
123	VLCDIN	4007.360	-600.025	50	80
124	VLCDIN	4077.360	-600.025	50	80
125	VLCDOUT	4426.360	-600.025	50	80
126	VLCDOUT	4496.610	-600.025	50	80
127	VBIAS	4566.610	-600.025	50	80
128	COM128	4742.660	-593.025	33	99
129	COM126	4792.660	-593.025	33	99
130	COM124	4842.660	-593.025	33	99

#	Pad	X	Y	W	H
131	COM122	4892.660	-593.025	33	99
132	COM120	4942.660	-593.025	33	99
133	COM118	4992.660	-593.025	33	99
134	COM116	5042.660	-593.025	33	99
135	COM114	5092.660	-593.025	33	99
136	COM112	5142.660	-593.025	33	99
137	COM110	5192.660	-593.025	33	99
138	COM108	5242.660	-593.025	33	99
139	COM106	5292.660	-593.025	33	99
140	COM104	5342.660	-593.025	33	99
141	COM102	5392.660	-593.025	33	99
142	DUMMY	5588.910	-601.425	99	53
143	COM100	5588.910	-541.550	99	33
144	COM98	5588.910	-491.550	99	33
145	COM96	5588.910	-441.550	99	33
146	COM94	5588.910	-391.550	99	33
147	COM92	5588.910	-341.550	99	33
148	COM90	5588.910	-291.550	99	33
149	COM88	5588.910	-241.550	99	33
150	COM86	5588.910	-191.550	99	33
151	COM84	5588.910	-141.550	99	33
152	COM82	5588.910	-91.550	99	33
153	COM80	5588.910	-41.550	99	33
154	COM78	5588.910	8.450	99	33
155	COM76	5588.910	58.450	99	33
156	COM74	5588.910	108.450	99	33
157	COM72	5588.910	158.450	99	33
158	COM70	5588.910	208.450	99	33
159	COM68	5588.910	258.450	99	33
160	COM66	5588.910	308.450	99	33
161	COM64	5588.910	358.450	99	33
162	COM62	5588.910	408.450	99	33
163	COM60	5588.910	458.450	99	33
164	COM58	5588.910	508.450	99	33
165	DUMMY	5588.910	568.575	99	53
166	COM56	5375.010	593.025	33	99
167	COM54	5325.010	593.025	33	99
168	COM52	5275.010	593.025	33	99
169	COM50	5225.010	593.025	33	99
170	COM48	5175.010	593.025	33	99
171	COM46	5125.010	593.025	33	99
172	COM44	5075.010	593.025	33	99
173	COM42	5025.010	593.025	33	99
174	COM40	4975.010	593.025	33	99
175	COM38	4925.010	593.025	33	99
176	COM36	4875.010	593.025	33	99
177	COM34	4825.010	593.025	33	99
178	COM32	4775.010	593.025	33	99
179	COM30	4725.010	593.025	33	99
180	COM28	4675.010	593.025	33	99
181	COM26	4625.010	593.025	33	99
182	COM24	4575.010	593.025	33	99
183	COM22	4525.010	593.025	33	99
184	COM20	4475.010	593.025	33	99
185	COM18	4425.010	593.025	33	99
186	COM16	4375.010	593.025	33	99
187	COM14	4325.010	593.025	33	99
188	COM12	4275.010	593.025	33	99
189	COM10	4225.010	593.025	33	99
190	COM8	4175.010	593.025	33	99
191	COM6	4125.010	593.025	33	99
192	COM4	4075.010	593.025	33	99
193	COM2	4025.010	593.025	33	99
194	SEG160	3975.010	593.025	33	99
195	SEG159	3925.010	593.025	33	99
196	SEG158	3875.010	593.025	33	99
197	SEG157	3825.010	593.025	33	99

#	Pad	X	Y	W	H
198	SEG156	3775.010	593.025	33	99
199	SEG155	3725.010	593.025	33	99
200	SEG154	3675.010	593.025	33	99
201	SEG153	3625.010	593.025	33	99
202	SEG152	3575.010	593.025	33	99
203	SEG151	3525.010	593.025	33	99
204	SEG150	3475.010	593.025	33	99
205	SEG149	3425.010	593.025	33	99
206	SEG148	3375.010	593.025	33	99
207	SEG147	3325.010	593.025	33	99
208	SEG146	3275.010	593.025	33	99
209	SEG145	3225.010	593.025	33	99
210	SEG144	3175.010	593.025	33	99
211	SEG143	3125.010	593.025	33	99
212	SEG142	3075.010	593.025	33	99
213	SEG141	3025.010	593.025	33	99
214	SEG140	2975.010	593.025	33	99
215	SEG139	2925.010	593.025	33	99
216	SEG138	2875.010	593.025	33	99
217	SEG137	2825.010	593.025	33	99
218	SEG136	2775.010	593.025	33	99
219	SEG135	2725.010	593.025	33	99
220	SEG134	2675.010	593.025	33	99
221	SEG133	2625.010	593.025	33	99
222	SEG132	2575.010	593.025	33	99
223	SEG131	2525.010	593.025	33	99
224	SEG130	2475.010	593.025	33	99
225	SEG129	2425.010	593.025	33	99
226	SEG128	2375.010	593.025	33	99
227	SEG127	2325.010	593.025	33	99
228	SEG126	2275.010	593.025	33	99
229	SEG125	2225.010	593.025	33	99
230	SEG124	2175.010	593.025	33	99
231	SEG123	2125.010	593.025	33	99
232	SEG122	2075.010	593.025	33	99
233	SEG121	2025.010	593.025	33	99
234	SEG120	1975.010	593.025	33	99
235	SEG119	1925.010	593.025	33	99
236	SEG118	1875.010	593.025	33	99
237	SEG117	1825.010	593.025	33	99
238	SEG116	1775.010	593.025	33	99
239	SEG115	1725.010	593.025	33	99
240	SEG114	1675.010	593.025	33	99
241	SEG113	1625.010	593.025	33	99
242	SEG112	1575.010	593.025	33	99
243	SEG111	1525.010	593.025	33	99
244	SEG110	1475.010	593.025	33	99
245	SEG109	1425.010	593.025	33	99
246	SEG108	1375.010	593.025	33	99
247	SEG107	1325.010	593.025	33	99
248	SEG106	1275.010	593.025	33	99
249	SEG105	1225.010	593.025	33	99
250	SEG104	1175.010	593.025	33	99
251	SEG103	1125.010	593.025	33	99
252	SEG102	1075.010	593.025	33	99
253	SEG101	1025.010	593.025	33	99
254	SEG100	975.010	593.025	33	99
255	SEG99	925.010	593.025	33	99
256	SEG98	875.010	593.025	33	99
257	SEG97	825.010	593.025	33	99
258	SEG96	775.010	593.025	33	99
259	SEG95	725.010	593.025	33	99
260	SEG94	675.010	593.025	33	99
261	SEG93	625.010	593.025	33	99
262	SEG92	575.010	593.025	33	99
263	SEG91	525.010	593.025	33	99
264	SEG90	475.010	593.025	33	99

#	Pad	X	Y	W	H
265	SEG89	425.010	593.025	33	99
266	SEG88	375.010	593.025	33	99
267	SEG87	325.010	593.025	33	99
268	SEG86	275.010	593.025	33	99
269	SEG85	225.010	593.025	33	99
270	SEG84	175.010	593.025	33	99
271	SEG83	125.010	593.025	33	99
272	SEG82	75.010	593.025	33	99
273	SEG81	25.010	593.025	33	99
274	SEG80	-24.990	593.025	33	99
275	SEG79	-74.990	593.025	33	99
276	SEG78	-124.990	593.025	33	99
277	SEG77	-174.990	593.025	33	99
278	SEG76	-224.990	593.025	33	99
279	SEG75	-274.990	593.025	33	99
280	SEG74	-324.990	593.025	33	99
281	SEG73	-374.990	593.025	33	99
282	SEG72	-424.990	593.025	33	99
283	SEG71	-474.990	593.025	33	99
284	SEG70	-524.990	593.025	33	99
285	SEG69	-574.990	593.025	33	99
286	SEG68	-624.990	593.025	33	99
287	SEG67	-674.990	593.025	33	99
288	SEG66	-724.990	593.025	33	99
289	SEG65	-774.990	593.025	33	99
290	SEG64	-824.990	593.025	33	99
291	SEG63	-874.990	593.025	33	99
292	SEG62	-924.990	593.025	33	99
293	SEG61	-974.990	593.025	33	99
294	SEG60	-1024.990	593.025	33	99
295	SEG59	-1074.990	593.025	33	99
296	SEG58	-1124.990	593.025	33	99
297	SEG57	-1174.990	593.025	33	99
298	SEG56	-1224.990	593.025	33	99
299	SEG55	-1274.990	593.025	33	99
300	SEG54	-1324.990	593.025	33	99
301	SEG53	-1374.990	593.025	33	99
302	SEG52	-1424.990	593.025	33	99
303	SEG51	-1474.990	593.025	33	99
304	SEG50	-1524.990	593.025	33	99
305	SEG49	-1574.990	593.025	33	99
306	SEG48	-1624.990	593.025	33	99
307	SEG47	-1674.990	593.025	33	99
308	SEG46	-1724.990	593.025	33	99
309	SEG45	-1774.990	593.025	33	99
310	SEG44	-1824.990	593.025	33	99
311	SEG43	-1874.990	593.025	33	99
312	SEG42	-1924.990	593.025	33	99
313	SEG41	-1974.990	593.025	33	99
314	SEG40	-2024.990	593.025	33	99
315	SEG39	-2074.990	593.025	33	99
316	SEG38	-2124.990	593.025	33	99
317	SEG37	-2174.990	593.025	33	99
318	SEG36	-2224.990	593.025	33	99
319	SEG35	-2274.990	593.025	33	99
320	SEG34	-2324.990	593.025	33	99
321	SEG33	-2374.990	593.025	33	99
322	SEG32	-2424.990	593.025	33	99
323	SEG31	-2474.990	593.025	33	99
324	SEG30	-2524.990	593.025	33	99
325	SEG29	-2574.990	593.025	33	99
326	SEG28	-2624.990	593.025	33	99
327	SEG27	-2674.990	593.025	33	99
328	SEG26	-2724.990	593.025	33	99
329	SEG25	-2774.990	593.025	33	99
330	SEG24	-2824.990	593.025	33	99
331	SEG23	-2874.990	593.025	33	99
332	SEG22	-2924.990	593.025	33	99
333	SEG21	-2974.990	593.025	33	99
334	SEG20	-3024.990	593.025	33	99
335	SEG19	-3074.990	593.025	33	99
336	SEG18	-3124.990	593.025	33	99
337	SEG17	-3174.990	593.025	33	99
338	SEG16	-3224.990	593.025	33	99
339	SEG15	-3274.990	593.025	33	99
340	SEG14	-3324.990	593.025	33	99
341	SEG13	-3374.990	593.025	33	99
342	SEG12	-3424.990	593.025	33	99
343	SEG11	-3474.990	593.025	33	99
344	SEG10	-3524.990	593.025	33	99
345	SEG9	-3574.990	593.025	33	99
346	SEG8	-3624.990	593.025	33	99
347	SEG7	-3674.990	593.025	33	99
348	SEG6	-3724.990	593.025	33	99
349	SEG5	-3774.990	593.025	33	99
350	SEG4	-3824.990	593.025	33	99
351	SEG3	-3874.990	593.025	33	99
352	SEG2	-3924.990	593.025	33	99
353	SEG1	-3974.990	593.025	33	99
354	COM1	-4024.990	593.025	33	99
355	COM3	-4074.990	593.025	33	99
356	COM5	-4124.990	593.025	33	99
357	COM7	-4174.990	593.025	33	99
358	COM9	-4224.990	593.025	33	99
359	COM11	-4274.990	593.025	33	99
360	COM13	-4324.990	593.025	33	99
361	COM15	-4374.990	593.025	33	99
362	COM17	-4424.990	593.025	33	99
363	COM19	-4474.990	593.025	33	99
364	COM21	-4524.990	593.025	33	99
365	COM23	-4574.990	593.025	33	99
366	COM25	-4624.990	593.025	33	99
367	COM27	-4674.990	593.025	33	99
368	COM29	-4724.990	593.025	33	99
369	COM31	-4774.990	593.025	33	99
370	COM33	-4824.990	593.025	33	99
371	COM35	-4874.990	593.025	33	99
372	COM37	-4924.990	593.025	33	99
373	COM39	-4974.990	593.025	33	99
374	COM41	-5024.990	593.025	33	99
375	COM43	-5074.990	593.025	33	99
376	COM45	-5124.990	593.025	33	99
377	COM47	-5174.990	593.025	33	99
378	COM49	-5224.990	593.025	33	99
379	COM51	-5274.990	593.025	33	99
380	COM53	-5324.990	593.025	33	99
381	COM55	-5374.990	593.025	33	99

TRAY INFORMATION



	Spec
	mm (mil)
W1	50.70±0.2 (1996)
W2	45.50±0.2 (1791)
W3	45.95±0.2 (1809)
H	4.05±0.2 (160)
E	1.75±0.2 (69)
K	1.45±0.2 (57)
Tx	$2.66\pm^{0.1}_{0}$ (104)
Ty	$1.33\pm^{0.1}_{0}$ (52)
Px	14.28±0.05 (562)
Py	2.94±0.05 (115)
X	$11.62\pm^{0.1}_{0}$ (457)
Y	$1.61\pm^{0.1}_{0}$ (63)
Z	$0.71\pm^{0.1}_{0}$ (28)
N	45

Unless Otherwise Specified		ULTRACHIP INC 晶宏半導體				Scale	N/A	Proj.	
Unit	mm					Package Code			
General Roughness	N/A	2" IC Tray Type: H20-457x63-28(45)				Material			
Tolerance	see drawing detail								
Dimension			Drawn	Checked	Approved		Drawing No.		Rev.
Angle	N/A	By	Jacky Wang	Alvin	Alvin		SD-212		A
		Date	09-17-03'	09-18-03'	09-18-03'	Sheet	1 of 1	Size	A4

REVISION HISTORY

Revision	Contents	Date
0.6	Golden release	Aug. 12, 2004
0.61	(1) The table is updated. (Section "ESD Consideration", page 41)	Aug. 16, 2004
0.7	(1) COG section presents. (Section "Recommended COG Layout", page 7) (2) Gray-shade control percentages are updated. LC[6:5] : 20%, 24%, 28%, 32% → 24%, 29%, 36%, 40% (Section "Control Register", page 9; "Command Description", page 15) (3) The condition on V_{DD2} is adjusted: 2.5V → 2.7V (Section "LCD Voltage Setting" – Load Driving Strength, page 21) (4) Pad coordination information is updated. (Section "Pad Coordinates", Pp 55 ~ 58)	Nov. 5, 2004
0.71	(1) In the "Operating Mode" table, the status of "Draining Circuit" in Sleep mode is corrected: "OFF" → "ON" (2) Most contents of subsection "Changing Operation Mode" are re-written. (Section "Reset & Power Management", page 38) (3) Subsection "Extended Display OFF" is removed. (4) Subsection "Brief Display OFF" is renamed as "Display OFF". (Section "Reset & Power Management", page 40) (5) COF drawings are removed. (Section "COF Information", Pp 59 ~ 60)	Nov. 9, 2004
0.8	(1) The V_{LCD} Formula is updated. (Section "V_{LCD} Quick Reference", page 22) (2) A typo error is corrected: "8-shade" → "4-shade" (Section "LCD Display Controls" - Clock & Timing Generator, page 24) (3) In the I^2C figure (Read Mode), the direction of some acknowledge signals (A) is modified from upward to downward. (Section "Host Interface" – 2-wire Serial Interface (I^2C), page 30) (4) SEG output impedance, $R_{ON\ (SEG)}$, COM output impedance, $R_{ON\ (COM)}$, and Average Line rate, f_{LINE}, are adjusted. (Section "Specification" – DC Characteristics, page 44) (5) Experiment data are corrected. (Section "Specification" – Power Consumption, page 44) (6) For 8080, 6800, S8/S8uc, and S9 modes, Chip Select Setup Time t_{CSSD80}, t_{CSSD68}, t_{CSSDS8}, t_{CSSDS9} are removed. (7) Some AC timing data are adjusted. (Section "AC Characteristics", Pp 45 ~ 51)	Nov. 30, 2004
1.0	(1) "COF" related contents are removed. (Overall) (2) V_{DD} for COG application is adjusted: 17V → 17.5V (Section "Recommended COG Layout", page 7) (3) The default of APC0~1 is erased. (Section "Control Register", page 9) (4) The content of 2nd byte is corrected. (Section "Command Description" – (31) and (33), page 18) (5) The contents of WR0 and WR1 for serial mode are modified. (Section "Host Interface", page 27)	Feb. 16, 2005

Revision	Contents	Date
1.0	(6) The RAM table is corrected. (Section "Display Data RAM", page 38)	Feb. 16, 2005
	(7) Point 2 is updated. (Section "ESD Consideration", page 42)	
	(8) Some AC timings are updated. (Section "AC Characteristics", page 49)	
	(9) The presentation of Bump Height is modified. (Section "Physical Dimension", page 53)	
1.01	(1) Figures 14 and 15, for Power Up/Down Sequence, are fixed. (Section "Reset and Power Management", page 40)	Feb. 18, 2005
1.1	(1) Some description for absolute maximum ratings is revised (Section "Absolute Maximum Ratings", page 43)	Mar. 25, 2005
	(2) VIL and VIH of Serial Mode are adjusted: $0.2V_{DD}$/ $0.8V_{DD}$ → $0.15V_{DD}$/$0.85V_{DD}$ (Section "Specifications", page 44)	
	(3) Max Output Disable Time is deleted (Section "AC Characteristics", Pp 45 and 47)	
1.11	(1) Remove the "non-I^2C" option. (Section "Ordering Information" – Part Number, page 2)	Apr. 13, 2005
1.2	(1) CS0/A3 → CS0/A2 CS1/A2 → CS1/A3 (Section "Pin Description", page 5)	Jul. 31, 2006
	(2) The reference circuit drawings are corrected. (Section "Host interface reference circuit", Pp 33~34)	
1.21	(1) Some legacy words are stroked out. (Section "Introduction", pages 3; "LCD Voltage Setting", page 22)	Jun. 26, 2007
	(2) In the "Power Up" table, a typo is corrected: 1101 01## → 1101 00## (for command (20) Set Gray Shade) (Section "Sample Power Management Command Sequences", page 43)	
1.3	(1) The 7th character of the product name is shown: "UC1610" → "UC1610i" (Overall)	Dec. 2, 2008
	(2) "Typical" is added to the V_{DD} feature. (Section "Feature Highlights", page 3)	
	(3) The note on I^2C is stroked out. (Section "General Notes", page 4)	
	(4) V_{DD}(Max) and $V_{DD2/3}$ (Max) are adjusted : 3.3V → 3.465V (Section "Specifications" – DC Characteristics, page 46; "AC Characteristics, Pp 47~54)	
1.31	(1) The remark "Typical" is removed from LCD Vop range. (Section "Feature Highlights", page 3)	Jan. 8, 2009
	(2) The description of WR0/WR1 is updated. (Section "Pin Description" – WR0/WR1, page 7; "Host Interface" – I^2C, page 31)	
1.32	(1) The description on unused CD is updated. (Section "Host Interface" – S9, I^2C, Pp 30~31)	Jan. 21, 2009
1.33	Bump height is corrected : 17±1μM → 17±3μM. (Section "Physical Dimension", page 53)	Mar. 19, 2009
1.34	Rising time (tr) and falling time (tf), 15nS each, are added into System Cycle Time. (Pp 46~51)	Nov. 25, 2009
1.35	Pad coordinates are re-provided without rounded off. (Pp 53~55)	Sep. 21, 2010
1.36	Provide one more Part Number for products of Bump Height 12uM.	Aug. 19, 2011