

**HIGH-VOLTAGE MIXED-SIGNAL IC**

# UC1701

65x132 STN Controller-Driver

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**MP Specifications**  
**Datasheet Revision: 1.0**

**IC Version: c\_B**  
**September 29, 2014**

# ULTRACHIP

*The Coolest LCD Driver, Ever!*

Specifications and information herein are subject to change without notice.

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# UC1701

*Single-Chip, Ultra-Low Power  
65COM by 132SEG  
Passive Matrix LCD Controller-Driver*

## INTRODUCTION

UC1701c is an advanced high-voltage mixed-signal CMOS IC, especially designed for the display needs of ultra-low power hand-held devices.

In addition to low power column and row drivers, the IC 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, Smart Phones, PDA, and other battery operated palm top devices or portable Instruments

## FEATURE HIGHLIGHTS

- Single chip controller-driver supports 65x132 graphics STN LCD panels.
- Support both row ordered and column ordered display buffer RAM access.

- Support industry standard 8-bit parallel bus (8080 or 6800 mode), 4-wire serial bus (S8), and 2-wire I<sup>2</sup>C serial interfaces.
- Ultra-low power consumption under all display patterns.
- Selectable Mux Rate and Bias Ratio allow flexible power management options.
- Internal charge pump with on-chip pumping capacitor requires only 1 external capacitor to operate.
- Very low pin count (7~9-pin) allows exceptional image quality in COG format on conventional ITO glass.
- Flexible data addressing/mapping schemes to support wide ranges of software models and LCD layout placements.
- V<sub>DD</sub> range (Typ.): 2.7V ~ 3.3V  
V<sub>DD2/3</sub> range(Typ.): 2.7V ~ 3.3V  
LCD V<sub>OP</sub> range: 3.85V ~ 10.0V
- Available in gold bump dies
- COM/SEG bump information  
Bump pitch: 27 μM  
Bump gap: 12 μM ± 3 μM  
Bump surface: 1500 μM<sup>2</sup>

**ORDERING INFORMATION**

Part Number	I <sup>2</sup> C	Description
UC1701cGAB	Yes	Gold Bumped Die, Bump Height: 10uM
UC1701cGGB	Yes	Gold Bumped Die, Bump Height: 15uM

**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.

**USE OF I<sup>2</sup>C**

The implementation of I<sup>2</sup>C is already included and tested in all silicon.

**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 wafer saw/pack testing performed on individual die. Although the latest modern processes are utilized for wafer sawing and die pick-&-place into wafer 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 application 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.

**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.

**CONTENT DISCLAIMER**

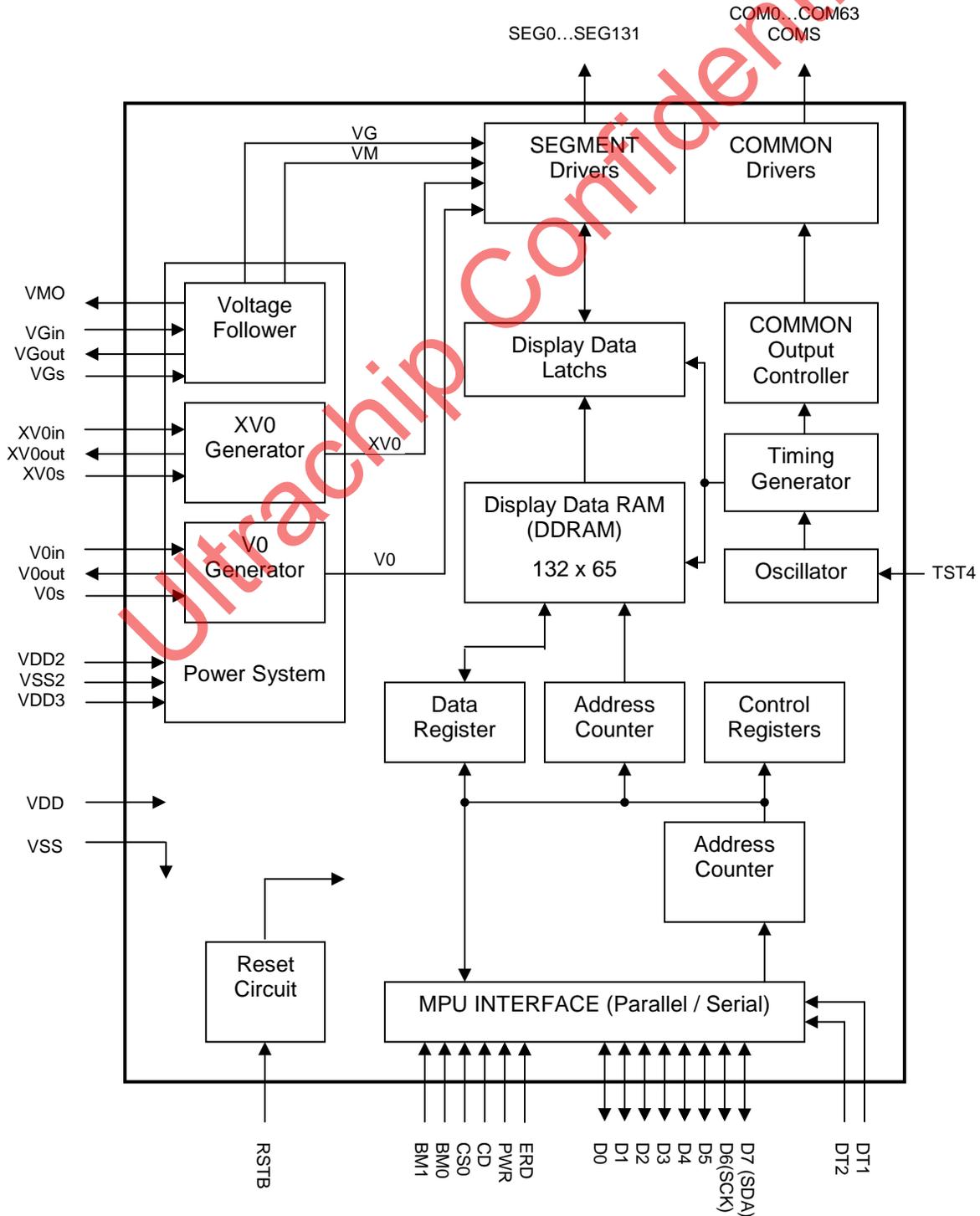
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BLOCK DIAGRAM

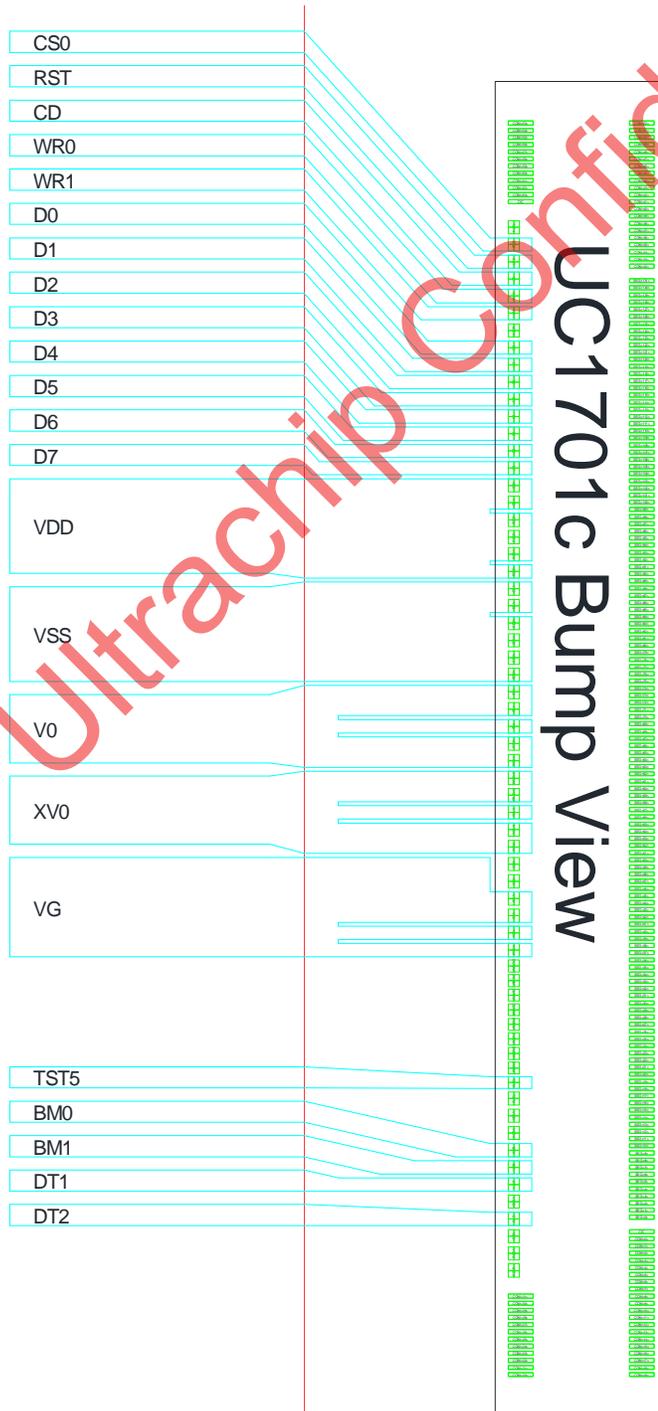


**PIN DESCRIPTION**

Pin (Pad) Name	Type	Pins	Description														
<b>MAIN POWER SUPPLY</b>																	
V <sub>DD</sub> V <sub>DD2</sub> V <sub>DD3</sub>	PWR	3 4 2	V <sub>DD</sub> supplies for Display Data RAM and digital logic, V <sub>DD2</sub> supplies for analog circuit, V <sub>DD3</sub> supplies for reference voltage circuits. V <sub>DD2</sub> /V <sub>DD3</sub> should be connected to the same power source. But V <sub>DD</sub> can be connected to a source voltage no higher than V <sub>DD2</sub> /V <sub>DD3</sub> . ITO trace resistance needs to be minimized for V <sub>DD2</sub> /V <sub>DD3</sub> .														
V <sub>SS</sub> V <sub>SS2</sub>	GND	2 4	Ground. Connect V <sub>SS</sub> and V <sub>SS2</sub> to the shared GND pin. In COG applications, minimize the ITO resistance for both V <sub>SS</sub> and V <sub>SS2</sub> .														
<b>LCD POWER SUPPLY &amp; VOLTAGE CONTROL</b>																	
V <sub>0in</sub> V <sub>0out</sub> V <sub>0s</sub>	PWR	2 2 1	V <sub>0</sub> is the LCD driving voltage for COM circuit at negative frame. V <sub>0in</sub> is the V <sub>0</sub> input of common circuits. V <sub>0out</sub> is the output of V <sub>0</sub> regulator. V <sub>0s</sub> is the feedback of V <sub>0</sub> regulator. Be sure that V <sub>0</sub> ≥ V <sub>G</sub> > V <sub>M</sub> > V <sub>SS</sub> ≥ V <sub>XV0</sub> , under operation. These pins should be separated in ITO layout; while they should be connected together in FPC layout.														
V <sub>Gin</sub> V <sub>Gout</sub> V <sub>Gs</sub>	PWR	2 1 1	V <sub>G</sub> is the LCD driving voltage for segment circuit. V <sub>Gout</sub> is the output of V <sub>G</sub> regulator. V <sub>Gs</sub> is the feedback of V <sub>G</sub> regulator. V <sub>Gin</sub> is the V <sub>G</sub> input of segment circuits. 1.6V ≤ V <sub>G</sub> < V <sub>DD2</sub> . These pins should be separated in ITO layout; while they should be connected together in FPC layout.														
XV <sub>0in</sub> XV <sub>0out</sub> XV <sub>0s</sub>	PWR	2 2 1	XV <sub>0</sub> is the LCD driving voltage for common circuit at positive frame. XV <sub>0out</sub> is the output of XV <sub>0</sub> regulator. XV <sub>0s</sub> is the feedback of XV <sub>0</sub> regulator. XV <sub>0in</sub> is the XV <sub>0</sub> input of common circuits. These pins should be separated in ITO layout; while they should be connected together in FPC layout.														
V <sub>M0</sub>	PWR	2	V <sub>M</sub> is the LCD driving voltage for common circuits. 0.8V ≤ V <sub>M</sub> < V <sub>DD2</sub> .														
<b>NOTE</b>																	
<ul style="list-style-type: none"> <li>Recommended capacitor values: C<sub>V0</sub>: Optional. 0.1uF/16V. Connect the capacitor of C<sub>V0</sub> value between XV<sub>0</sub> and V<sub>0</sub>.</li> </ul>																	
<b>HOST INTERFACE</b>																	
BM <sub>0</sub> BM <sub>1</sub> TST <sub>5</sub>	I	1 1 1	<p>Bus mode: The interface bus mode is determined by BM[1:0] and TST<sub>5</sub> by the following relationship:</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>BM[1:0]</th> <th>TST<sub>5</sub></th> <th>Mode</th> </tr> </thead> <tbody> <tr> <td>11</td> <td>Open</td> <td>6800/8-bit</td> </tr> <tr> <td>10</td> <td>Open</td> <td>8080/8-bit</td> </tr> <tr> <td rowspan="2">0x</td> <td>Open</td> <td>4-wire SPI w/ 8-bit token (S<sub>8</sub>: conventional)</td> </tr> <tr> <td>1</td> <td>2-wire serial (I<sup>2</sup>C)</td> </tr> </tbody> </table> <p>Always connect unused pins to either V<sub>SS</sub> or V<sub>DD</sub>.</p>	BM[1:0]	TST <sub>5</sub>	Mode	11	Open	6800/8-bit	10	Open	8080/8-bit	0x	Open	4-wire SPI w/ 8-bit token (S <sub>8</sub> : conventional)	1	2-wire serial (I <sup>2</sup> C)
BM[1:0]	TST <sub>5</sub>	Mode															
11	Open	6800/8-bit															
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0x	Open	4-wire SPI w/ 8-bit token (S <sub>8</sub> : conventional)															
	1	2-wire serial (I <sup>2</sup> C)															
CS <sub>0</sub>	I	1	Chip Select. Chip is selected when CS <sub>0</sub> = "L". When the chip is not selected, D[7:0] will be of high impedance.														
RST	I	1	It's necessary to set pin-reset in 3 mS after V <sub>DD/2/3</sub> stable. When RST="L", all control registers are re-initialized by their default states. An RC Filter has been included on-chip. There is no need for external RC noise filter.														

Pin (Pad) Name	Type	Pins	Description																											
CD	I	1	Select Control data or Display data for read/write operation. "L": Control data "H": Display data																											
WR0 / A3 WR1 / A2	I	1 1	WR [1:0] controls the read/write operation of the host interface. See Host Interface section for details. In parallel mode, the meaning of WR[1:0] depends on which interface it is in, 6800 or 8080 mode. In serial interface modes, these two pins are not used. Connect them to V <sub>SS</sub> or V <sub>DD</sub> . In I <sup>2</sup> C mode, these two pins specifies bits 3~2 of device address (A[3:2]).																											
DT1 DT2	I	1 1	Duty selection. <table border="1"> <thead> <tr> <th>DT2</th> <th>DT1</th> <th>Duty</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> <td>1/65</td> </tr> <tr> <td>0</td> <td>1</td> <td>1/49</td> </tr> <tr> <td>1</td> <td>0</td> <td>1/33</td> </tr> <tr> <td>1</td> <td>1</td> <td>1/55</td> </tr> </tbody> </table>	DT2	DT1	Duty	0	0	1/65	0	1	1/49	1	0	1/33	1	1	1/55												
DT2	DT1	Duty																												
0	0	1/65																												
0	1	1/49																												
1	0	1/33																												
1	1	1/55																												
D7~D0	I/O	8	Bi-directional bus for both serial and parallel host interfaces. In serial modes, connect D[7] to SDA, D[6] to SCK. <table border="1"> <thead> <tr> <th></th> <th>D7</th> <th>D6</th> <th>D5</th> <th>D4</th> <th>D3</th> <th>D2</th> <th>D1</th> <th>D0</th> </tr> </thead> <tbody> <tr> <td>Parallel (8-bit)</td> <td>DB7</td> <td>DB6</td> <td>DB5</td> <td>DB4</td> <td>DB3</td> <td>DB2</td> <td>DB1</td> <td>DB0</td> </tr> <tr> <td>Serial (S8, I<sup>2</sup>C)</td> <td>SDA</td> <td>SCK</td> <td>--</td> <td>--</td> <td>--</td> <td>--</td> <td>--</td> <td>--</td> </tr> </tbody> </table> Always connect unused pins to either V <sub>SS</sub> or V <sub>DD</sub> .		D7	D6	D5	D4	D3	D2	D1	D0	Parallel (8-bit)	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	Serial (S8, I <sup>2</sup> C)	SDA	SCK	--	--	--	--	--	--
	D7	D6	D5	D4	D3	D2	D1	D0																						
Parallel (8-bit)	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0																						
Serial (S8, I <sup>2</sup> C)	SDA	SCK	--	--	--	--	--	--																						
<b>HIGH VOLTAGE LCD DRIVER OUTPUT</b>																														
SEG0 ~ SEG131	HV	132	SEG (column) driver outputs. Support up to 132 pixels. Leave unused SEG drivers open-circuit.																											
COM0 ~ COM63	HV	64	COM (row) driver outputs. Support up to 64 rows. Leave unused COM drivers open-circuit.																											
CIC	HV	2	Icon driver outputs. Leave it open if not used.																											
<b>MISC. PINS</b>																														
V <sub>DDX</sub>		2	Auxiliary V <sub>DD</sub> . This pin is connected to the main V <sub>DD</sub> bus within the IC. It's provided to facilitate chip configurations in COG application. There's no need to connect V <sub>DDX</sub> to main V <sub>DD</sub> externally and it should <b>NOT</b> be used to provide V <sub>DD</sub> power to the chip.																											
V <sub>SSX</sub>		2	Auxiliary V <sub>SS</sub> . These pins are connected to the main V <sub>SS</sub> bus within the IC, to facilitate chip configurations in COG application. There's no need to connect V <sub>SSX</sub> to main V <sub>SS</sub> externally and they should <b>NOT</b> be used to provide V <sub>SS</sub> power to the chip.																											
TST4	I	1	Test control. There's an on-chip pull-up resistor for TST4. Leave it open during normal use.																											
TST2	I/O	1	Test I/O pins. Leave these pins open during normal use.																											
Dummy		8	Dummy pins are NOT connected inside the IC.																											

RECOMMENDED COG LAYOUT



NOTES FOR V<sub>DD</sub> WITH COG:

The operation condition, V<sub>DD</sub>=2.7V (typical), should be satisfied under all operating conditions. UC1701c's peak current (I<sub>DD</sub>) can be up to ~15mA during high speed data-write to UC1701c's on-chip SRAM. Such high pulsing current mandates very careful design of V<sub>DD</sub> and V<sub>SS</sub> ITO trances in COG modules. When V<sub>DD</sub> and V<sub>SS</sub> trace resistance is not low enough, the pulsing I<sub>DD</sub> current can cause the actual on-chip V<sub>DD</sub> to drop to below 2.6V and cause the IC to malfunction.

**CONTROL REGISTERS**

UC1701c contains registers, which control the chip operation. The following table is a summary of these control registers, a brief description and the default values. These registers can be modified by commands, which 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 hardware reset.

Name	Bits	Default	Description																									
SL	6	00H	Scroll Line. Scroll the displayed image up by SL rows. The valid SL value is between 0 (for no scrolling) and 63. Setting SL outside of this range causes undefined effects on the displayed image. This register does not affect icon output CIC.																									
CA	8	00H	Column Address of DDRAM (Display Data RAM). Value range is 0~131. (Used in Host to access DDRAM)																									
PA	4	0H	Page Address of DDRAM. Value range 0~8. (Used in Host to access DDRAM)																									
BR	1	0H	Bias Ratio. The ratio between V <sub>LCD</sub> and V <sub>BIAS</sub> varies according to Duty selected: <table border="1" style="margin-left: 20px;"> <thead> <tr> <th></th> <th>BR=0</th> <th>BR=1</th> </tr> </thead> <tbody> <tr> <td>Duty=1/65</td> <td>1/9</td> <td>1/7</td> </tr> <tr> <td>Duty=1/49</td> <td>1/8</td> <td>1/6</td> </tr> <tr> <td>Duty=1/33</td> <td>1/6</td> <td>1/5</td> </tr> <tr> <td>Duty=1/55</td> <td>1/8</td> <td>1/6</td> </tr> </tbody> </table>		BR=0	BR=1	Duty=1/65	1/9	1/7	Duty=1/49	1/8	1/6	Duty=1/33	1/6	1/5	Duty=1/55	1/8	1/6										
	BR=0	BR=1																										
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Duty=1/33	1/6	1/5																										
Duty=1/55	1/8	1/6																										
PM	6	20H	Adjust contrast of LCD panel display.																									
PC	6	20H	Power Control. PC [0]: VG pump control. (Default <b>0: Disable</b> ) PC [1]: V0 pump control. (Default <b>0: Disable</b> ) PC [2]: XV0 pump control. (Default <b>0: Disable</b> ) PC [5:3]: Resistor Ratio for V <sub>LCD</sub> . (Default <b>100b</b> ) 000b~111b : Rb/Ra ratio setting																									
CR	8	0H	Return Column Address. Useful for cursor implementation.																									
AC3	1	0H	Address Control. AC3: CUM: Cursor update mode, (Default <b>0: OFF</b> ) When CUM=1, CA increment on write only, wrap around suspended																									
DC	3	0H	Display Control: DC[0]: PXV: Pixels Inverse (bit-wise data inversion. Default <b>0: OFF</b> ) DC[1]: APO: All Pixels ON (Default <b>0: OFF</b> ) DC[2]: Display ON/OFF (Default <b>0: OFF</b> ) When DC[2] is set to 0, the IC will enter Sleep Mode																									
LC	2	0H	LCD Control: LC[0]: MX, Mirror X SEG/Column sequence inversion (Default: <b>0: OFF</b> ) LC[1]: MY, Mirror Y COM/Row sequence inversion (Default: <b>0: OFF</b> )																									
APC0 APC1	8 8	90H --	Advanced Program Control. APC0 [7] : TC, V <sub>BIAS</sub> temperature compensation coefficient (%-per-°C) 0b : TC curve definition = -0.05% / °C <b>1b : TC curve definition = -0.11% / °C</b> APC0 [6] is fixed. APC0 [5:4] : FR, Frame Rate: (Unit: Hz) <table border="1" style="margin-left: 20px;"> <thead> <tr> <th>Frame Rate</th> <th>FR[1:0]: 00b</th> <th>FR[1:0]: 01b</th> <th>FR[1:0]: 10b</th> <th>FR[1:0]: 11b</th> </tr> </thead> <tbody> <tr> <td>Duty:1/65</td> <td>58</td> <td><b>77</b></td> <td>96</td> <td>115</td> </tr> <tr> <td>Duty:1/55</td> <td>102</td> <td><b>136</b></td> <td>170</td> <td>203</td> </tr> <tr> <td>Duty:1/49</td> <td>115</td> <td><b>153</b></td> <td>191</td> <td>229</td> </tr> <tr> <td>Duty:1/33</td> <td>57</td> <td><b>76</b></td> <td>94</td> <td>113</td> </tr> </tbody> </table> APC0 [3:2] are fixed. APC0 [1:0] : WA, automatic column/row Wrap Around. WA[0] : <b>0: PA wrap around disable</b> 1: PA wrap around enable. WA[1] : <b>0: CA wrap around disable</b> 1: CA wrap around enable. APC1[7:0] : For UltraChip's use only. Do NOT use.	Frame Rate	FR[1:0]: 00b	FR[1:0]: 01b	FR[1:0]: 10b	FR[1:0]: 11b	Duty:1/65	58	<b>77</b>	96	115	Duty:1/55	102	<b>136</b>	170	203	Duty:1/49	115	<b>153</b>	191	229	Duty:1/33	57	<b>76</b>	94	113
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Name	Bits	Default	Description
<b>Status Registers</b>			
BZ,	1	0	BZ : Set to 1 when system is busy. Commands can only be accepted when BZ=0.
MX,	1		MX : Mirror X-axle (i.e. SEG or column)
DE,	1		DE : Set to 1 when display enabled.
RST	1		RST : Reset flag. RST=1 when reset is in progress.

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**COMMAND TABLE**

The following is a list of host commands supported by UC1701c

**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	BZ	MX	DE	RST	0	0	0	0	Get Status	--
4.	Set Column Address LSB	0	0	0	0	0	0	#	#	#	#	Set CA [3:0]	0
	Set Column Address MSB			0	0	0	1	#	#	#	#	Set CA [7:4]	0
5.	Set Power Control	0	0	0	0	1	0	1	#	#	#	Set PC[2:0]	000b
6.	Set Scroll Line	0	0	0	1	#	#	#	#	#	#	Set SL[5:0]	0
7.	Set Page Address	0	0	1	0	1	1	#	#	#	#	Set PA[3:0]	0
8.	Set V <sub>LCD</sub> Resistor Ratio	0	0	0	0	1	0	0	#	#	#	Set PC[5:3]	100b
9.	Set Electronic Volume (double-byte command)	0	0	1	0	0	0	0	0	0	1	Set PM[5:0]	20H
				0	0	#	#	#	#	#	#		
10.	Set All-Pixel-ON	0	0	1	0	1	0	0	1	0	#	Set DC[1]	0b
11.	Set Inverse Display	0	0	1	0	1	0	0	1	1	#	Set DC[0]	0b
12.	Set Display Enable	0	0	1	0	1	0	1	1	1	#	Set DC[2]	0b
13.	Set SEG Direction	0	0	1	0	1	0	0	0	0	#	Set LC[0]	0b
14.	Set COM Direction	0	0	1	1	0	0	#	-	-	-	Set LC[1]	0b
15.	System Reset	0	0	1	1	1	0	0	0	1	0	Software Reset	N/A
16.	NOP	0	0	1	1	1	0	0	0	1	1	No operation	N/A
17.	Set LCD Bias Ratio	0	0	1	0	1	0	0	0	1	#	Set BR	0b
18.	Set Cursor Update Mode	0	0	1	1	1	0	0	0	0	0	AC3=1, CR=CA	N/A
19.	Reset Cursor Update Mode	0	0	1	1	1	0	1	1	1	0	AC3=0, CA=CR.	N/A
21.	Set Static Indicator OFF	0	0	1	0	1	0	1	1	0	0	NOP	N/A
	Set Static Indicator ON			1	0	1	0	1	1	0	1		
22.	Set Static Indicator	0	0	-	-	-	-	-	-	-	-	NOP	N/A
				1	1	1	1	1	0	0	0		
23.	Set Booster Ratio (double-byte command)	0	0	0	0	0	0	0	0	0	#	NOP	0b
				1	1	1	1	1	0	0	0		
24.	Set Power Save (compound command)	0	0	#	#	#	#	#	#	#	#	Display OFF & All Pixel ON	N/A
				1	1	1	1	1	1	1	TT		
25.	Set Test Control (double-byte command)	0	0	-	#	#	#	#	#	#	#	For UCI only Do NOT use	N/A
				1	1	1	1	1	0	1	0		
26.	Set Adv. Program Control 0 (double-byte command)	0	0	#	0	#	#	0	0	#	#	Set TC, FR, WA	90H
				1	1	1	1	1	0	1	1		
26.	Set Adv. Program Control 1 (double-byte command)	0	0	#	#	#	#	#	#	#	#	For UCI only Set APC1	N/A
				1	1	1	1	1	0	1	1		

\* Any bit patterns other than the commands listed above, may result in NOP (No Operation).

## COMMAND DESCRIPTION

### 1. Write Data Byte to Memory

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

### 2. Read Data Byte from Memory

Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
Read data	1	1	8-bit data read from SRAM							

Write/Read Data Byte (Command 1,2) access Display Data RAM based on Page Address (PA) register and Column Address (CA) register. PA and CA can also be programmed directly by issuing *Set Page Address* and *Set Column Address* commands.

### 3. Get Status

Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
Get Status	0	1	BZ	MX	DE	RST	0	0	0	0

*BZ*: BZ=1 when busy. The system accepts commands only when BZ=0.

*MX*: Mirror X. Status of register LC[0]

*DE*: Display Enable flag. DE=1 when display is enabled.

*RST*: RST flag. RST=1 when reset is in progress.

### 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 the SRAM column address before Write/Read memory from host interface.

CA value range: 0~131

### 5. Set Power Control

Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
Set Pump Control, PC[2:0]	0	0	0	0	1	0	1	PC2	PC1	PC0

Set PC[2:0] to enable the built-in charge pump.

PC[2] : XV0 pump control. **0: Disable** (Default)

PC[1] : V0 pump control. **0: Disable** (Default)

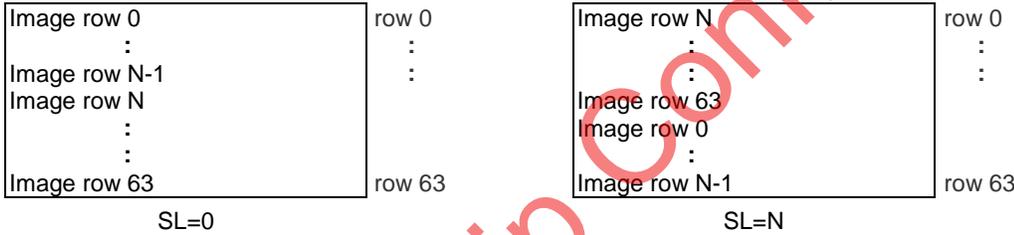
PC[0] : VG pump control. **0: Disable** (Default)

6. Set Scroll Line

Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
Set Scroll Line, SL[5:0]	0	0	0	1	SL5	SL4	SL3	SL2	SL1	SL0

Set the scroll line number. Range : 0~63

Scroll line setting will scroll the displayed image up by SL rows. Icon output CIC will not be affected by Set Scroll Line command.



7. Set Page Address

Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
Set Page Address, PA[3:0]	0	0	1	0	1	1	PA3	PA2	PA1	PA0

Set the SRAM page address before write/read memory from host interface. Each page of SRAM corresponds to 8 COM lines on LCD panel, except for the last page. The last page corresponds to the icon output CIC.

Possible value = 0~8.

8. Set V<sub>LCD</sub> Resistor Ratio

Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
Set V <sub>LCD</sub> Resistor Ratio, PC[5:3]	0	0	0	0	1	0	0	PC5	PC4	PC3

Configure PC[5:3] to set internal Resistor Ratio, R<sub>b</sub>/R<sub>a</sub>, for the V<sub>LCD</sub> Voltage regulator to adjust the contrast of the display panel:

PC[5:3] : 000b~111b – 1+R<sub>b</sub>/R<sub>a</sub> ratio. **Default : 100b.** Refer to V<sub>LCD</sub> Quick Reference for “1+R<sub>b</sub>/R<sub>a</sub>” ratio.

$$V_{LCD} = ((1 + R_b/R_a) \times V_{ev}) \times (1 + (T - 25) \times C_T \%) \quad V_{ev} = (1 - (63 - PM) / 162) \times V_{REF}$$

where R<sub>b</sub> and R<sub>a</sub> are internal resistors,  
 V<sub>REF</sub> is on-chip contrast voltage, and  
 PM is a value of electronic volume

9. Set Electronic Volume

Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
Set Electronic Volume, PM[5:0]	0	0	1	0	0	0	0	0	0	1
			0	0	PM5	PM4	PM3	PM2	PM1	PM0

Set PM[5:0] for electronic volume “PM” for VLCD voltage regulator to adjust contrast of LCD panel display

Effective range: 0~63. **Default: 32 (20h)**

**10. 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.

**Default : 0**

**11. 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.

**12. 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 1, UC1701c will first exit from sleep mode, restore the power and then turn on COM drivers and SEG drivers.

**13. Set SEG Direction**

Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
Set Segment Direction, LC[0]	0	0	1	0	1	0	0	0	0	LC0 / MX

Set LC[0] for SEG (column) mirror (MX). **Default : 0**

MX is implemented by reversing the mapping order between RAM and SEG (column) electrodes. The data stored in RAM is not affected by MX command. Yet, MX has immediate effect on the display image.

**14. Set COM Direction**

Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
Set Common Direction, LC[1]	0	0	1	1	0	0	LC1 / MY	-	-	-

Set LC[1] for COM (row) mirror (MY). **Default : 0b**

MY is implemented by reversing the mapping between RAM and COM (row) electrodes. The data stored in RAM is not affected by MY command. Yet, MY has immediate effect on the display image.

**15. System Reset (Software Reset)**

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

This command will activate the system reset.

Some control register values will be reset to their default values. Yet, data stored in RAM will not be affected. See the “Reset and Power Management” section for more details.

**16. 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”.

**17. Set LCD Bias Ratio**

Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
Set Bias Ratio, BR	0	0	1	0	1	0	0	0	1	BR

Select voltage bias ratio required for LCD. **Default : 0**

The setting of Bias ratio varies according to Duty:

DUTY	BR = 0	BR = 1
1/65	1/9	1/7
1/49	1/8	1/6
1/33	1/6	1/5
1/55	1/8	1/6

**18. Set Cursor Update Mode**

Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
Set Cursor Update Mode	0	0	1	1	1	0	0	0	0	0

This command is used for set cursor update mode function. When cursor update mode sets, UC1701c 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 commands and their feature is to support “write after read” function for cursor implementation.

**19. Reset Cursor Update Mode**

Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
Reset Cursor Update Mode	0	0	1	1	1	0	1	1	1	0

Set AC3=0 and CA=CR.

**20. Set Static Indicator OFF**

Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
Turn OFF Static Indicator	0	0	1	0	1	0	1	1	0	0

No Operation.

**21. Set Static Indicator ON**

Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
Turn ON Static Indicator	0	0	1	0	1	0	1	1	0	1
	0	0	-	-	-	-	-	-	-	-

No Operation.

**22. Set Booster Ratio**

Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
Set Booster Ratio (Double-byte command)	0	1	1	1	1	1	1	0	0	0
			0	0	0	0	0	0	0	0

This command is used for “No Operation”.

**23. Set Power Save**

Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
Power Save (Compound Command)	0	0	#	#	#	#	#	#	#	#

**24. Set Test Control**

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

This command is for UltraChip’s Test only. Do NOT use.

**25. Set Advanced Program Control 0**

Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
Set Adv. Program Control, APC0 [7:0] (Double-byte command)	0	0	1	1	1	1	1	0	1	0
			TC, APC0 [7]	0	FR1, APC0 [5]	FR0, APC0 [4]	0	0	WA1, APC0 [1]	WA0, APC0 [0]

TC : APC0 [7], V<sub>BIAS</sub> temperature compensation coefficient (%-per-degree-C)

Temperature compensation curve definition:

TC : 0b = -0.05%/°C,                      1b = -0.11%/°C

APC0 [6] is fixed.

APC0 [5:4] : FR, Frame Rate: (Unit: Hz)

FR[1:0] : Duty:1/65	00b: 58	<b>01b: 77</b>	10b: 96	11b: 115
FR[1:0] : Duty:1/55	00b: 102	<b>01b: 136</b>	10b: 170	11b: 203
FR[1:0] : Duty:1/49	00b: 115	<b>01b: 153</b>	10b: 191	11b: 229
FR[1:0] : Duty:1/33	00b: 57	<b>01b: 76</b>	10b: 94	11b: 113

APC0 [3:2] are fixed.

WA : APC0 [1:0], Automatic column/row wrap around.

WA[0] : **0: PA WA disable**                      1: PA WA enable.  
 WA[1] : **0: CA WA disable**                      1: CA WA enable.

**26. Set Advanced Program Control 1**

Action	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0
Set Adv. Program Control, APC1 [7:0] (Double-byte command)	0	0	1	1	1	1	1	0	1	1
			APC1 register parameter							

For UltraChip only. Please Do NOT use.

## LCD VOLTAGE SETTING

### MULTIPLEX RATES

Multiplex Rate is set by DT[2:1] :

DT2	DT1	Duty
0	0	1/65
0	1	1/49
1	0	1/33
1	1	1/55

### BIAS RATIO SELECTION

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

$$BR = V_{LCD} / V_{BIAS}$$

$$\text{where } V_{BIAS} = V_G - V_{MO-} = V_{MO}$$

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.

UC1701c supports four *BR* as listed below. *BR* can be selected by software program.

Duty	Bias Ratio	
	BR=0	BR=1
1/65	1/9	1/7
1/49	1/8	1/6
1/33	1/6	1/5
1/55	1/8	1/6

**Table 1:** Bias Ratios

### TEMPERATURE COMPENSATION

The temperature compensation coefficient is **-0.11% / °C (default)** or **-0.05% / °C**.

### $V_{LCD}$ GENERATION

$V_{LCD}$  is supplied by internal charge pump. The source of  $V_{LCD}$  is controlled by PC[2:0]. For good product reliability, it is recommended to keep  $V_{LCD}$  under 10.0V for all temperature conditions.

When  $V_{LCD}$  is generated internally, the voltage level of  $V_{LCD}$  is determined by three control registers: *BR* (Bias Ratio), *PM* (Potentiometer), and *PC[5:3]* ( $V_{LCD}$  Resistor Ratio) with the following relationship:

$$V_{LCD} = ((1 + R_b/R_a) \times V_{EV}) \times (1 + (T - 25) \times C_T \%)$$

$$V_{EV} = (1 - (63 - PM) / 162) \times V_{REF}$$

where

$R_a$  and  $R_b$  are two design constants, whose value depends on the setting of *BR* register, as illustrated in the table on the next page,

*PM* is value of electronic volume,

$V_{REG}$  is on-chip contrast voltage,

*T* is the ambient temperature in °C, and

$C_T$  is temperature compensation coefficient.

### $V_{LCD}$ FINE TUNING

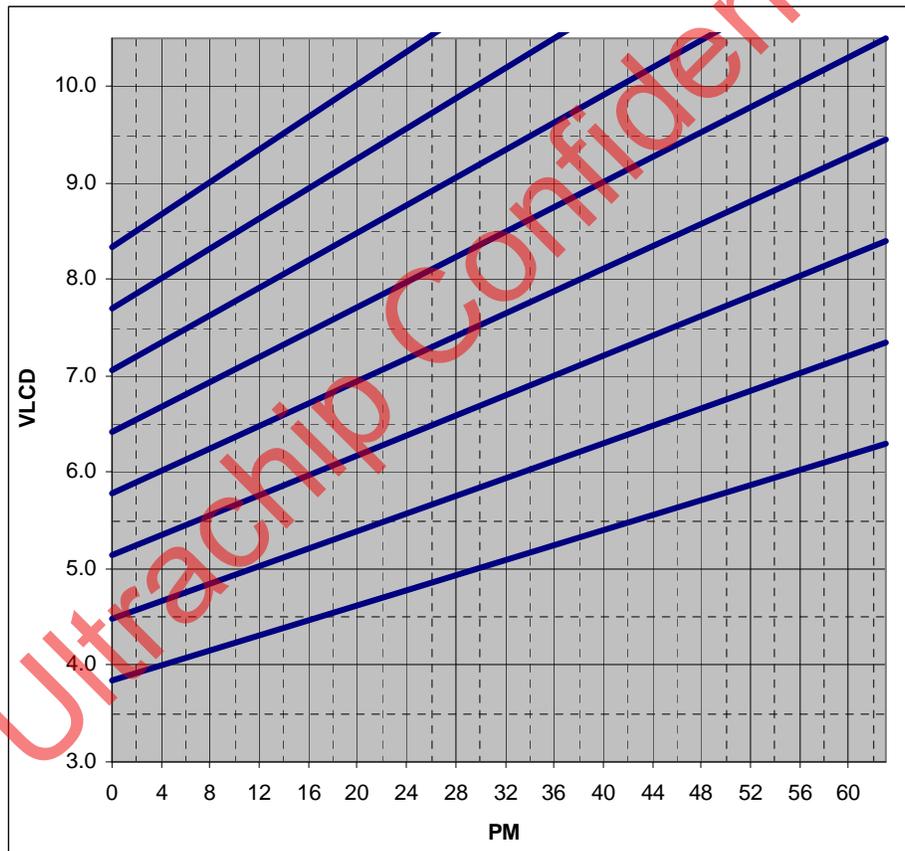
Black-and-white STN LCD is sensitive to even a 1% mismatch between IC driving voltage and the  $V_{OP}$  of LCD. However, it is difficult for LCD makers to guarantee such high precision matching of parts from different vendors. It is therefore necessary to adjust  $V_{LCD}$  to match the actual  $V_{OP}$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

For the best result, software based approach for  $V_{LCD}$  adjustment is the recommended method for  $V_{LCD}$  fine-tuning. System designers should always consider the contrast fine tuning requirement before finalizing on the LEM design

### LOAD DRIVING STRENGTH

The power supply circuit of UC1701c is designed to handle LCD panels with loading up to ~24nF using 20-Ω/Sq ITO glass with  $V_{DD2/3} \geq 2.6V$ . For larger LCD panels, use lower resistance ITO glass packaging.

V<sub>LCD</sub> QUICK REFERENCE



V<sub>LCD</sub> Programming Curve.

PC[5:3]	1+Rb/Ra	V <sub>REF</sub>	PM	V <sub>LCD</sub> Range (V)
000b	3.0	2.1	0	3.85
			63	6.30
001b	3.5	2.1	0	4.49
			63	7.35
010b	4.0	2.1	0	5.13
			63	8.40
011b	4.5	2.1	0	5.78
			63	9.45
100b	5.0	2.1	0	6.42
			56	10.05
101b	5.5	2.1	0	7.06
			42	10.05
110b	6.0	2.1	0	7.70
			30	10.03
111b	6.5	2.1	0	8.34
			20	10.03

**Note:** For good product reliability, keep V<sub>LCD</sub> under **10.0V** over all temperature.

HI-V GENERATOR AND BIAS REFERENCE CIRCUIT

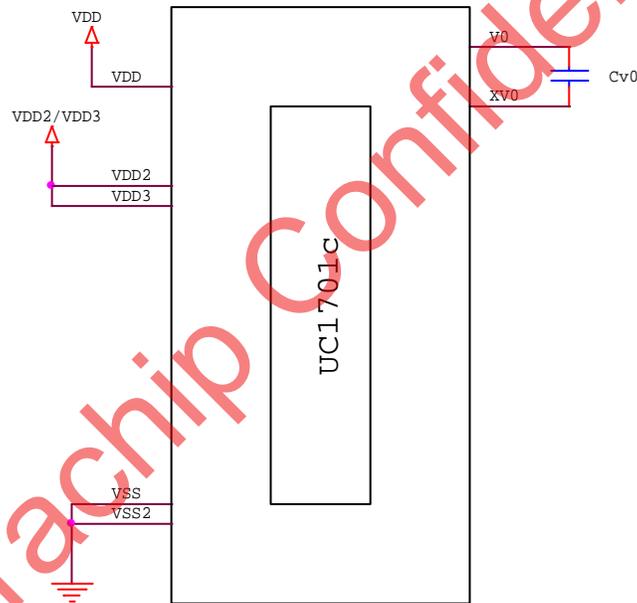


FIGURE 1: Reference circuit using internal Hi-V generator circuit

**Note**

Sample component values: (The illustrated circuit and component values are for reference only. Please optimize for specific requirements of each application.)

$C_{V0}$ : Optional. 0.1  $\mu$ F/16V Connect the capacitor of  $C_{V0}$  value between  $XV0$  and  $V0$ .

## LCD DISPLAY CONTROLS

### CLOCK & TIMING GENERATOR

UC1701c contains a built-in system clock. All required components for the clock oscillator are built-in. No external parts are required.

4 different frame rates are provided based on different Mux-Rate for system design flexibility.

### DRIVER MODES

COM and SEG drivers can be in either Idle mode or Active mode, controlled by Display Enable flag (DC[2]). When SEG and COM drivers are in idle mode, they will be connected together to ensure zero DC condition on the LCD.

### DRIVER ARRANGEMENTS

The naming conventions are: COM $x$ , where  $x = 0-63$ , refers to the row driver for the  $x$ -th row of pixels on the LCD panel.

The mapping of COM( $x$ ) to LCD pixel rows is fixed and it is not affected by SL, 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 UC1701c will put itself into Sleep Mode to conserve power.

When DC[2] is set to ON, the DE flag will become "1", and UC1701c will first exit from Sleep Mode, restore the power ( $V_{LCD}$ ,  $V_D$  etc.) and then turn ON COM and SEG drivers.

That is the display is turned ON after setting PC[2:0]=111b and DC[2]=1.

### 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 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.

**ITO LAYOUT AND LC SELECTION**

Since COM scanning pulses of UC1701c can be as short as 153µS, it is critical to control the RC delay of COM and SEG signal to minimize crosstalk and maintain good mass production consistency.

**COM TRACES**

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

Please limit the worst case of COM signals RC delay (RC<sub>MAX</sub>) as calculated below

$$(R_{ROW} / 2.7 + R_{COM}) \times C_{ROW} < 9.23\mu S$$

where

C<sub>ROW</sub>: LCD loading capacitance of one row of pixels. It can be calculated by C<sub>LCD</sub>/Mux-Rate, where C<sub>LCD</sub> is the LCD panel capacitance.

R<sub>ROW</sub>: ITO resistance over one row of pixels within the active area

R<sub>COM</sub>: COM routing resistance from IC to the active area + COM driver output impedance.

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

$$| RC_{MAX} - RC_{MIN} | < 2.76\mu S$$

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

(Use worst case values for all calculations)

**SEG TRACES**

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

For good image quality, please minimize SEG ITO trace resistance and limit the worst case of SEG signal RC delay as calculated below.

$$(R_{COL} / 2.7 + R_{SEG}) \times C_{COL} < 6.30\mu S$$

where

C<sub>COL</sub>: LCD loading capacitance of one pixel column. It can be calculated by C<sub>LCD</sub> / (# of column), where C<sub>LCD</sub> is the LCD panel capacitance.

R<sub>COL</sub>: ITO resistance over one column of pixels within the active area

R<sub>SEG</sub>: SEG routing resistance from IC to the active area + SEG driver output impedance.

(Use worst case values for all calculations)

**SELECTING LIQUID CRYSTAL**

The selection of LC material is crucial to achieve the optimum image quality of finished LCM.

When (V<sub>90</sub>-V<sub>10</sub>)/V<sub>10</sub> is too large, image contrast will deteriorate, and images will look murky and dull.

When (V<sub>90</sub>-V<sub>10</sub>)/V<sub>10</sub> is too small, image contrast will become too strong, and crosstalk will increase.

For the best result, it is recommended the LC material has the following characteristics:

$$(V_{90}-V_{10})/V_{10} = (V_{ON}-V_{OFF})/V_{OFF} \times 0.72\sim 0.80$$

where V<sub>90</sub> and V<sub>10</sub> are the LC characteristics, and V<sub>ON</sub> and V<sub>OFF</sub> are the ON and OFF V<sub>RMS</sub> voltage produced by LCD driver IC at the specific Mux-rate.

Example:

Duty	Bias	V <sub>ON</sub> /V <sub>OFF</sub> -1	x0.80	x0.72
1/65	1/9	10.6%	9.6%	7.5%

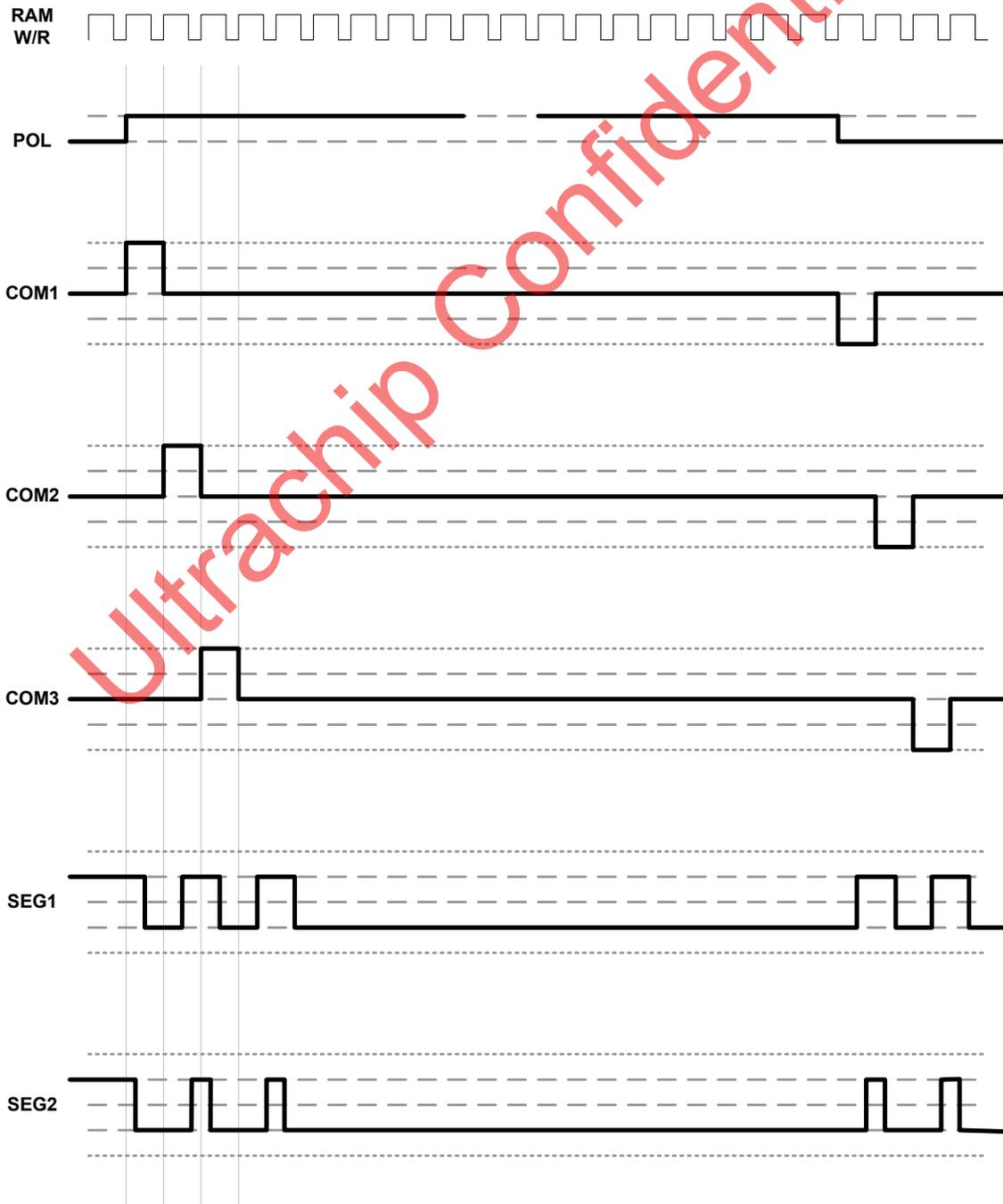


FIGURE 2: COM and SEG Electrode Driving Waveform

**THE COMMON OUTPUT STATUS SELECT CIRCUIT**

In the UC1701c chips, the COM output scan direction can be selected by the common output status select command. (See the table below for details.) Consequently, the constraints in IC layout at the time of LCD module assembly can be minimized.

Duty	Direction	COM[0:15]	COM [16:23]	COM [24:26]	COM [27:36]	COM [37:39]	COM [40:47]	COM[48:63]	CIC
1/65	0	COM [0:63]							CIC
	1	COM [63:0]							
1/49	0	COM[0:23]	NC			COM [24:47]			CIC
	1	COM[47:24]	NC			COM [23:0]			
1/33	0	COM[0:15]	NC					COM[16:31]	CIC
	1	COM[31:16]	NC					COM[15:0]	
1/55	0	COM [0:26]			NC	COM [27:53]			CIC
	1	COM [53:27]			NC	COM [26:0]			

**Table 2:** Duty Layout

**HOST INTERFACE**

As summarized in the table below, UC1701c supports 2 8-bit parallel bus protocols and 2 serial bus protocols. Designers can choose either the 8-bit parallel bus to achieve high data transfer rate, or use serial bus to create compact LCD modules and minimize connector pins.

		Bus Type			
		8080	6800	S8 (4-wire)	I <sup>2</sup> C (2-wire)
Width		8-bit	8-bit	Serial	
Access		Read / Write		Write only	
Control & Data Pins	BM[1:0]	10	11	0x	
	TST5	Open			1
	CS0	Chip select			--
	CD	Control/Data	0	-	
	WR0	$\overline{WR}$	$R/\overline{W}$	-	A3
	WR1	$\overline{RD}$	EN	-	A2
	DB[5:0]	Data		-	
	DB[7:6]	Data		DB[6]=SCK, DB[7]=SDA	

\* Connect unused control pins and data bus pins to V<sub>DD</sub> or V<sub>SS</sub>

	CS Disable Bus Interface	CS Init. Bus State	RESET Init. Bus State
8-bit	✓	-	✓
S8	✓	✓	✓
I <sup>2</sup> C	-	-	✓

- CS disable bus interface – CS can be used to disable Bus Interface Write / Read Access.
- RESET can be pin reset / soft reset.

**Table 3:** Host interfaces Summary

**PARALLEL INTERFACE**

The timing relationship between UC1701c internal control signal RD, WR and their associated bus actions are shown in the figure below.

The Display RAM read interface is implemented as a two-stage pipeline. This architecture requires that every time memory address is modified, either in parallel mode or serial mode, by either Set CA or Set PA command, a dummy read

cycle needs to be performed before the actual data can propagate through the pipeline 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.

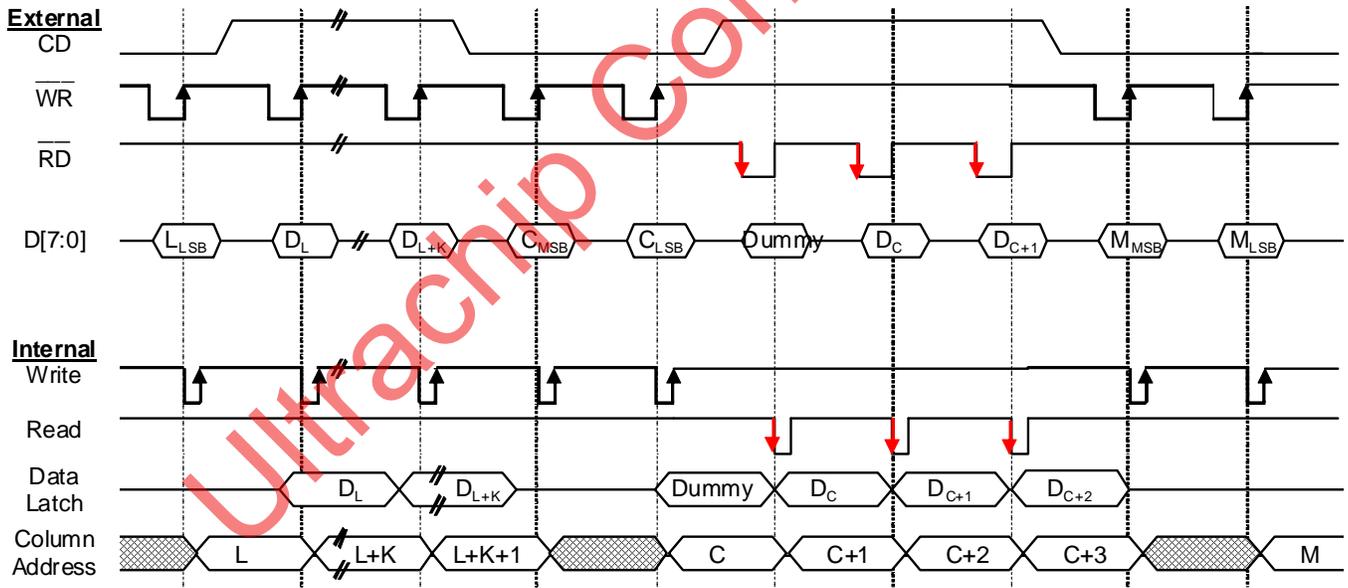


Figure 3: Parallel Interface & Related Internal Signals

**SERIAL INTERFACE**

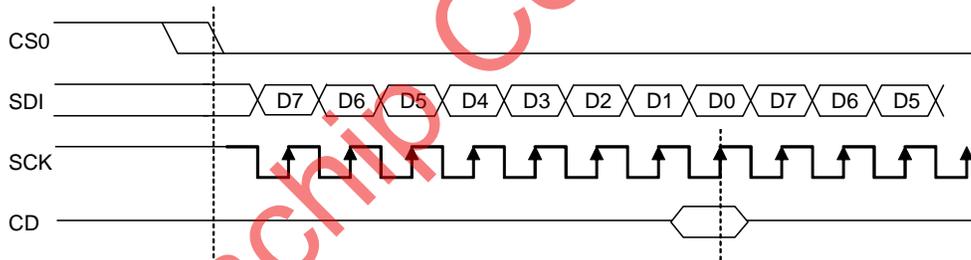
UC1701c supports 2 serial modes: 4-wire SPI mode (S8). Bus interface mode is determined by the wiring of the BM[1:0] and TST5. See table in last page for more detail.

**S8 (4-WIRE) INTERFACE**

Only write operations are supported in 4-wire serial mode. Pins WR[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 4:** 4-wire Serial Interface (S8)



HOST INTERFACE REFERENCE CIRCUIT

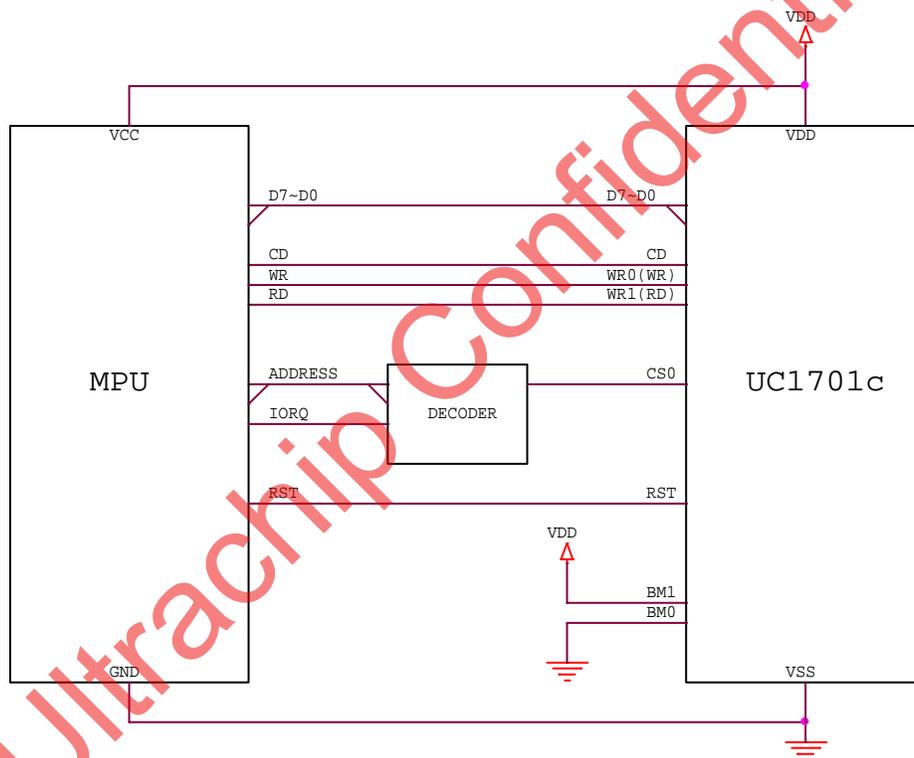


FIGURE 5: 8080/8bit parallel mode reference circuit

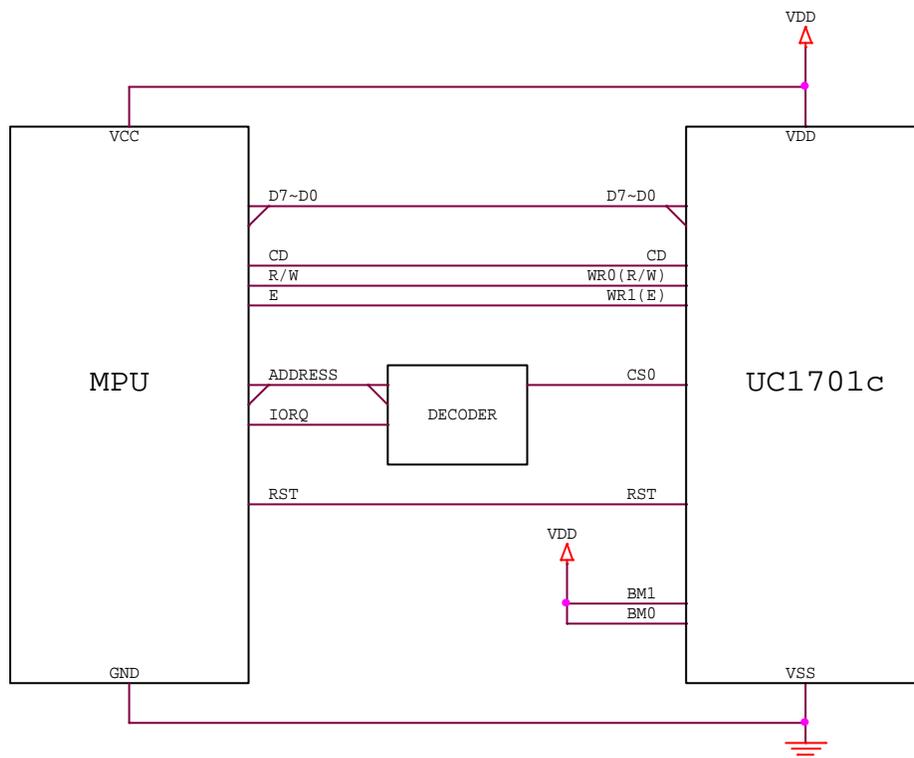


FIGURE 6: 6800/8bit parallel mode reference circuit

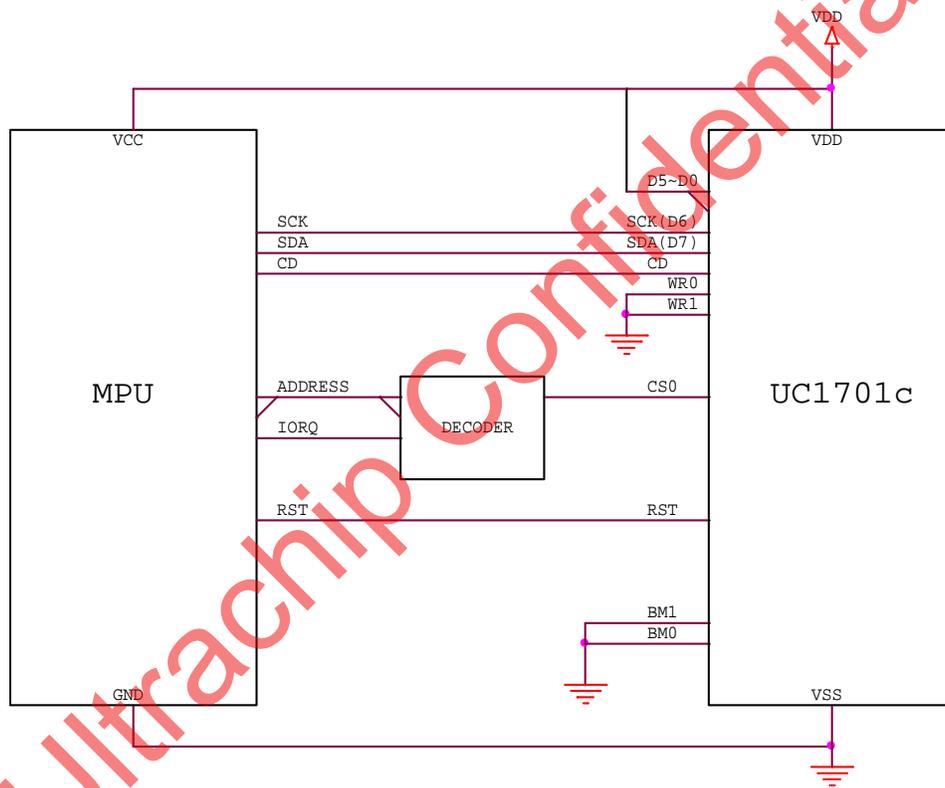


FIGURE 7: Serial-8 serial mode reference circuit

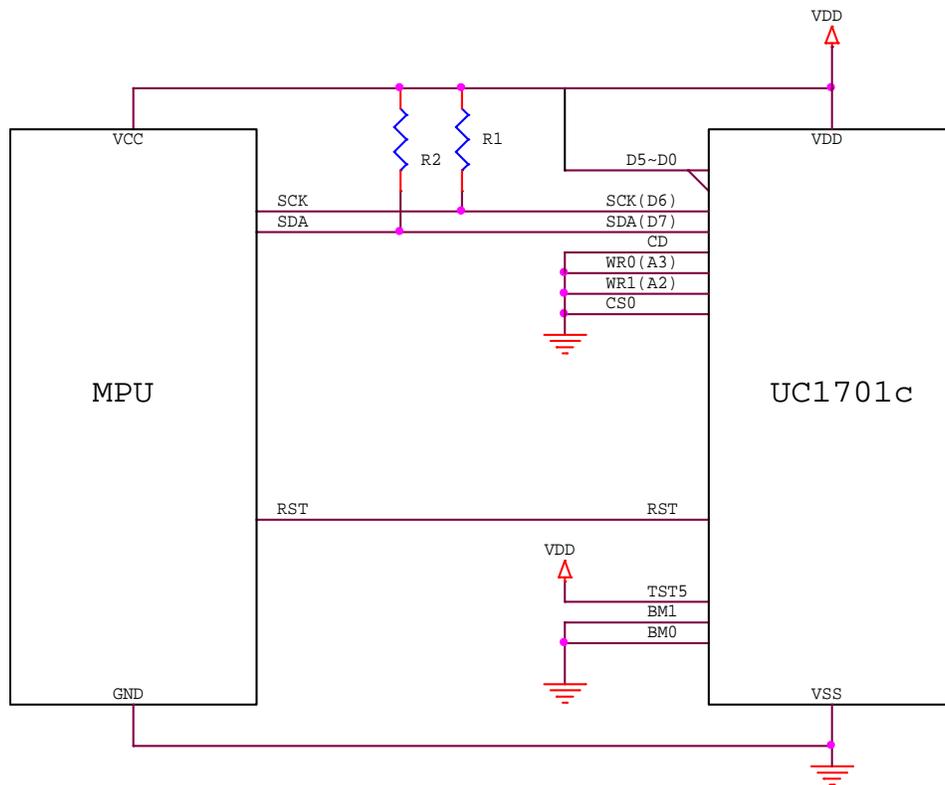


FIGURE 8: I²C serial mode reference circuit

**Note**

- The ID pins are for production control. The connection will affect the content of D[7] of the 1-st byte of the Get Status command. Connect to  $V_{DD}$  for “H” or  $V_{SS}$  for “L”.
- RST pin is optional. When the RST pin is not used, connect it to  $V_{DD}$ .
- When using I<sup>2</sup>C serial mode, WR1/0 are user configurable and affect A[3:2] of device address.
- R1, R2: 2k ~ 10k  $\Omega$ , use lower resistor for bus speed up to 3.6MHz, use higher resistor for lower power.
- When using Read function:

(8080) Set WR1=0 (6800) Set WR1=1 → data output will be enabled. (Serial) Set SCK=0
---

(8080) Set WR1=1 (6800) Set WR1=0 → data output will be disabled. (Serial) Set SCK=1
--

- It is REQUIRED to set MPU's data port to 1 before Data Read or Status Read actions.

## DISPLAY DATA RAM (DDRAM)

### DATA ORGANIZATION

The input display data is stored to a dual port static DDRAM (DDRAM, for Display Data RAM) organized as 65x132.

After setting CA and PA, the subsequent data write cycle 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, SRAM, 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 Row Address* and *Set Column Address* commands.

### MX IMPLEMENTATION

Column Mirroring (MX) is implemented by selecting either (CA) or (131-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), or Mirror Y (MY, LC[1]). 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 SRAM and the scanning electrodes can be obtained by combining the fixed Rm scanning sequence and the following RAM address generation formula.

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

$$Line = \text{Mod}(Line+1, 64)$$

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

The above Line generation formula produce the "loop around" effect as it effectively resets Line to 0 when Line+1 reaches 64.

### MY IMPLEMENTATION

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

For the 1<sup>st</sup> line period of each field

$$Line = \text{Mod}(SL + MR - 1, 64)$$

Otherwise

$$Line = \text{Mod}(Line-1, 64)$$

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



## RESET & POWER MANAGEMENT

### TYPES OF RESET

UC1701c has 2 different types of reset: Pin Reset (hardware reset) and System Reset (Software reset). Pin Reset is activated by connecting the RST pin to ground; while System

Reset is performed by software commands. After each power-up, a Pin Reset, which is in 3mS, is required. In the following discussions, reset means Pin Reset.

The differences between pin reset (hardware reset) and system reset (software reset) :

Procedure	Pin Reset (hardware reset)	System Reset (software reset)
Display OFF: DC[2]=0, all SEGs/COMs output at V <sub>SS</sub>	V	X
Normal Display: DC[0]=0, DC[1]=0	V	X
SEG Normal Direction: MX=0	V	X
Clear Serial Counter and Shift Register (if using Serial Interface)	V	X
Bias Selection: BR=0	V	X
Booster Level BL[1:0]=0	V	X
Exit Power Saving Mode	V	X
Power Control OFF: PC[2:0]=000b	V	X
Exit Cursor Update mode	V	V
Scroll Line SL[5:0]=0	V	V
Column Address CA[7:0]=0	V	V
Page Address PA[3:0]=0	V	V
COM Normal Direction: MY=0	V	V
V <sub>LCD</sub> Regulation Ratio PC[5:3]=100b	V	V
PM[5:0]=10 0000b	V	V
Exit Test Mode	V	V

### RESET STATUS

When UC1701c enters RESET sequence:

- Operation mode will be "Reset"
- All control registers are reset to default values. Refer to Control Registers for details of their default values.

### OPERATION MODES

UC1701c has three operating modes (OM): Reset, Sleep, and Normal.

For each mode, the related statuses are as below:

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**

There are 2 commands that 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 UC1701c internal clock. To ensure consistent system states, wait at least 10 $\mu$ S after *Set Display Enable* or *System Reset* command.

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

**Table 5:** OM changes

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 UC1701c consumes very little energy in Sleep mode (typically under 5 $\mu$ A).

**EXITING SLEEP MODE**

UC1701c 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 UC1701c internal voltage sources are restored to their proper values.

POWER-UP SEQUENCE

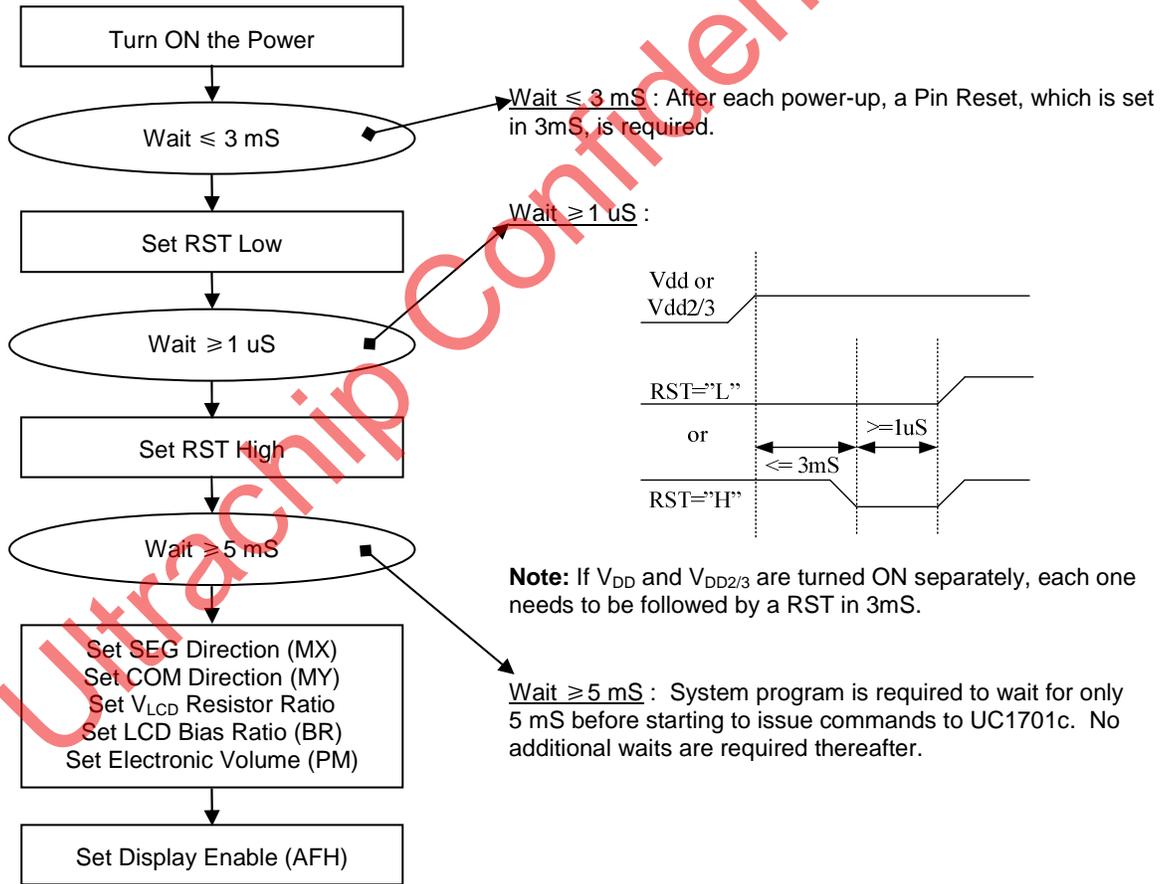


Figure 9: REFERENCE POWER-UP SEQUENCE

There's no delay needed while turning ON  $V_{DD}$  and  $V_{DD2/3}$ , and either one can be turned on first:

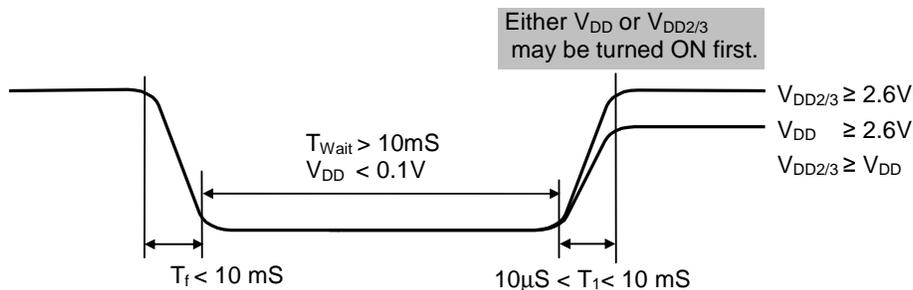
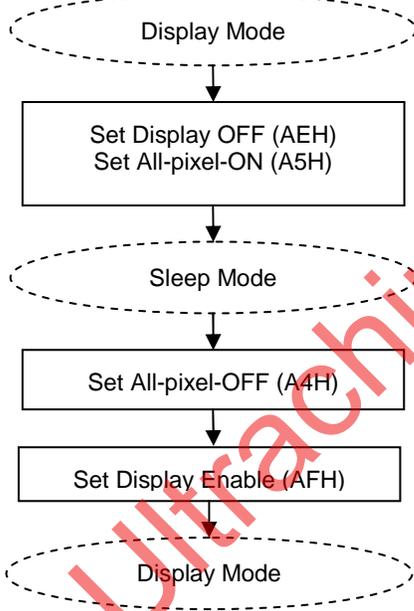


Figure 10: Power Off-On Sequence

**ENTER/EXIT SLEEP MODE SEQUENCE**

UC1701c enters Sleep mode from Display mode by issuing Set Display Disable command and setting all-pixel-ON.

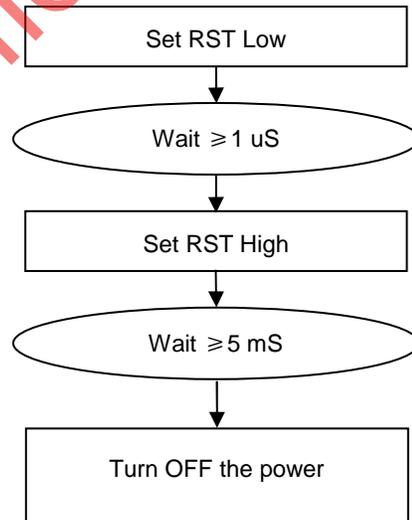
To exit Sleep mode, set All-pixel-OFF.



**FIGURE 11:** Reference Enter/Exit Sleep Mode Sequence

**Power-Down Sequence**

To prevent the charge stored in capacitor Cv0 causing abnormal residue horizontal line on display when V<sub>DD</sub> is switched off, use Reset mode to enable the built-in charge draining circuit to discharge these external capacitors.



**FIGURE 12:** Reference Power-Down Sequence

**SAMPLE COMMAND SEQUENCES FOR POWER MANAGEMENT**

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.

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

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

**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.

**POWER-UP**

Type	C/D	W/R	D7	D6	D5	D4	D3	D2	D1	D0	Chip action	Comments
R	-	-	-	-	-	-	-	-	-	-	Turn ON V <sub>DD</sub> and V <sub>DD2/3</sub>	Wait until V <sub>DD</sub> , V <sub>DD2/3</sub> are stable
R	-	-	-	-	-	-	-	-	-	-	Wait ≤ 3 mS	
R	-	-	-	-	-	-	-	-	-	-	Set RST pin Low	Wait 1 uS after RST is Low
R	-	-	-	-	-	-	-	-	-	-	Set RST pin High	Wait 5 mS after RST is High
O	0	0	1	1	1	1	1	0	1	0	Set Adv. Program Control 0	Set Wrap Around Enable
			1	0	0	1	0	0	1	1		
R	0	0	1	0	1	0	0	0	0	#	Set SEG Direction	Set up LCD format specific parameters, MX, MY, etc.
R	0	0	1	1	0	0	#	-	-	-	Set COM Direction	
R	0	0	0	0	1	0	0	#	#	#	Set V <sub>LCD</sub> Resistor Ratio	LCD specific operating voltage setting
R	0	0	1	0	1	0	0	0	1	#	Set LCD Bias Ratio	
R	0	0	1	0	0	0	0	0	0	1	Set Electronic Volume	
O	1	0	#	#	#	#	#	#	#	#	Write display RAM	Set up display image
	.	.	.	.	.	.	.	.	.	.		
	1	0	#	#	#	#	#	#	#	#		
R	0	0	0	0	1	0	1	1	1	1	Set Power Control	
R	0	0	1	0	1	0	1	1	1	1	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	System Reset	
R	-	-	-	-	-	-	-	-	-	-	Draining capacitor	Wait ~5mS before V <sub>DD</sub> 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	Set Display Disable	
C	1	0	#	#	#	#	#	#	#	#	Write display RAM	Set up display image (Image update is optional. Data in the RAM is retained through the SLEEP state.)
	.	.	.	.	.	.	.	.	.	.		
	1	0	#	#	#	#	#	#	#	#		
R	0	0	1	0	1	0	1	1	1	1	Set Display Enable	

**ABSOLUTE MAXIMUM RATINGS**

In accordance with IEC134 - notes 1, 2 and 3.

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 $V_{DD2/3}$	--	1.2	V
$V_{LCD}$	LCD Generated voltage	-0.3	+11.0	V
$V_{IN} / V_{OUT}$	Any input/output	-0.4	$V_{DD} + 0.3$	V
$T_{OPR}$	Operating temperature range	-30	+85	°C
$T_{STR}$	Storage temperature	-55	+125	°C

**Note:**

1. All voltages are based on  $V_{SS} = 0V$
2. Stress values listed above may cause permanent damages to the device.

**SPECIFICATIONS**

**DC CHARACTERISTICS**

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
V <sub>DD</sub>	Supply for digital circuit		2.6	2.7~3.3	3.6	V
V <sub>DD2/3</sub>	Supply for bias & pump		2.6	2.7~3.3	3.6	V
V <sub>LCD</sub>	Charge pump output	V <sub>DD2/3</sub> ≥ 2.6V, 25°C	3.85		10.0	V
V <sub>D</sub>	LCD data voltage	V <sub>DD2/3</sub> ≥ 2.6V, 25°C	0.80		1.32	V
V <sub>IL</sub>	Input logic LOW				0.2V <sub>DD</sub>	V
V <sub>IH</sub>	Input logic HIGH		0.8V <sub>DD</sub>			V
V <sub>OL</sub>	Output logic LOW	I <sub>OH</sub> = -0.5mA			0.2V <sub>DD</sub>	V
V <sub>OH</sub>	Output logic HIGH	I <sub>OL</sub> = 0.5mA	0.8V <sub>DD</sub>			V
I <sub>IL</sub>	Input leakage current	V <sub>IN</sub> = V <sub>DD</sub> or V <sub>SS</sub>	-50	1.5	50	uA
I <sub>SB</sub>	Standby current	V <sub>DD</sub> = V <sub>DD2/3</sub> = 3.3V, Temp = 85°C			50	uA
C <sub>IN</sub>	Input capacitance			5	10	PF
C <sub>OUT</sub>	Output capacitance			5	10	PF
R <sub>0(SEG)</sub>	SEG output impedance	V <sub>LCD</sub> = 10V		2000	3000	Ω
R <sub>0(COM)</sub>	COM output impedance	V <sub>LCD</sub> = 10V		2000	3000	Ω
F <sub>FR</sub>	Average Frame Rate	Duty=1/65	-15%	77	+20%	Hz
		Duty=1/49		153		
		Duty=1/33		76		
		Duty=1/55		136		

**POWER CONSUMPTION**

V<sub>DD</sub> = 2.7 V,  
V<sub>LCD</sub> = 8.49 V  
Mux Rate = 65,  
Temperature = 25°C

Bias Ratio = 0b,  
Frame Rate = 77Hz,  
Bus mode = 6800,

PM = 32,  
C<sub>v0</sub> = 0.1 uF,  
All outputs are open circuit.

Display Pattern	Conditions	Typical	Maximum	Unit
All-OFF	Bus = idle	203	325	μA
2-pixel checker	Bus = idle	205	328	μA
1-pixel checker	Bus = idle	218	349	μA
-	Bus = idle (standby current)	-	5	μA

AC CHARACTERISTICS

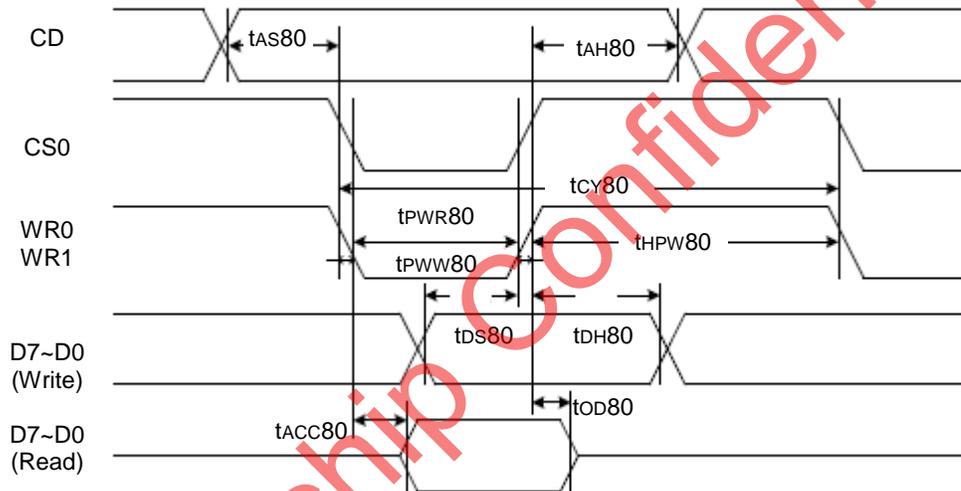


FIGURE 13: Parallel Bus Timing Characteristics (for 8080 MCU)

Symbol	Signal	Description	Condition	Min.	Max.	Unit
(2.6V ≤ V <sub>DD</sub> < 3.6V, T <sub>a</sub> = -30 to +85°C)				(Read / Write)		
t <sub>AS80</sub>	CD	Address setup time		0		nS
t <sub>AH80</sub>		Address hold time		10	–	
t <sub>CY80</sub>	WR0, WR1	Cycle time		250 / 250		nS
t <sub>PWR80</sub> , t <sub>PWW80</sub>		Low Pulse width		140 / 140	–	
t <sub>HPW80</sub>		High pulse width		80 / 80		
t <sub>DS80</sub>	D7~D0 (Write)	Data setup time		-- / 40		nS
t <sub>DH80</sub>		Data hold time		-- / 20	–	
t <sub>ACC80</sub>	D7~D0 (Read)	Read access time	CL = 16pF	-- / --	70	nS
t <sub>OD80</sub>		Output disable time		5 / --	50	

Note: tr (rising time), tf (falling time): ≤ 15nS

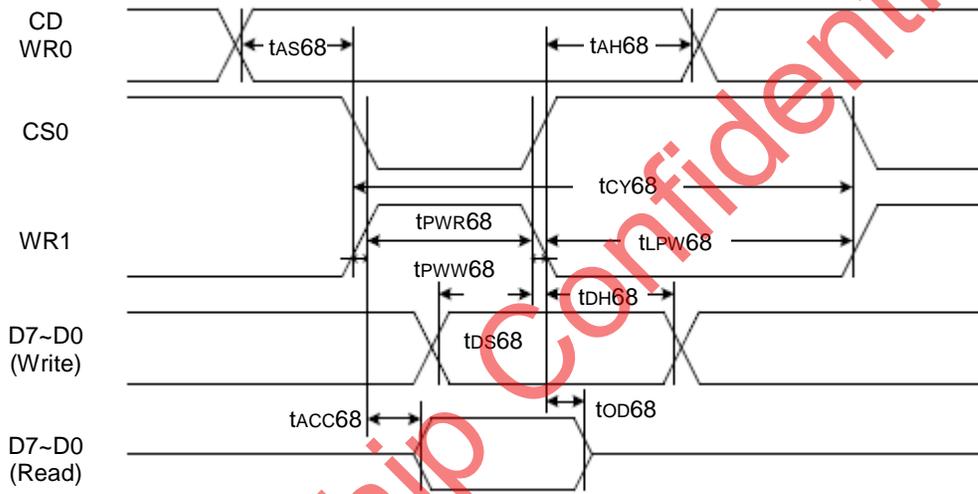


FIGURE 14: Parallel Bus Timing Characteristics (for 6800 MCU)

Symbol	Signal	Description	Condition	Min.	Max.	Unit
(2.6V ≤ V <sub>DD</sub> < 3.6V, T <sub>a</sub> = -30 to +85 °C)				(Read / Write)		
t <sub>AS68</sub> t <sub>AH68</sub>	CD	Address setup time Address hold time		0 10	-	nS
t <sub>CY68</sub>	WR1	System cycle time		250 / 250		
t <sub>PWR68</sub> , t <sub>PWW68</sub> t <sub>LPW68</sub>		High Pulse width Low pulse width		140 / 140 80 / 80	-	nS
t <sub>DS68</sub> t <sub>DH68</sub>	D7~D0 (Write)	Data setup time Data hold time		-- / 40 -- / 10	-	nS
t <sub>ACC68</sub> t <sub>OD68</sub>	D7~D0 (Read)	Read access time Output disable time	CL= 16pF	- / -- 5 / --	70 50	nS

Note: tr (rising time), tf (falling time) : ≤ 15nS

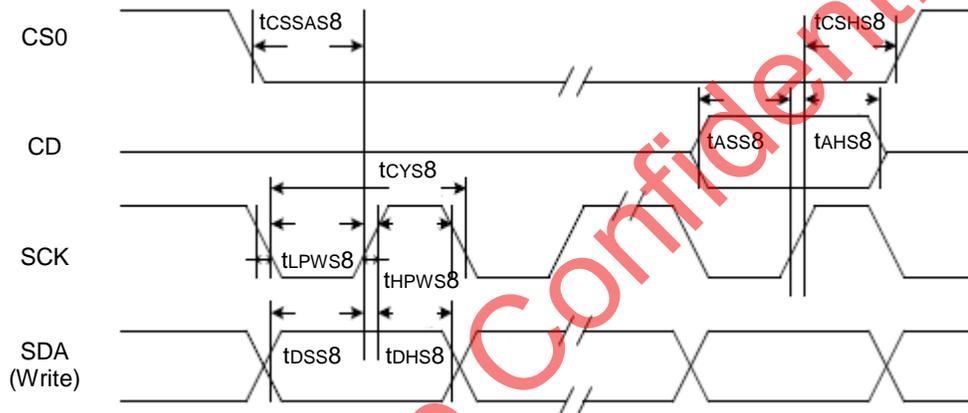


FIGURE 15: Serial Bus Timing Characteristics (for S8)

Symbol	Signal	Description	Condition	Min.	Max.	Unit
(2.6V ≤ V <sub>DD</sub> < 3.6V, T <sub>a</sub> = -30 to +85 °C)						
$t_{ASS8}$	CD	Address setup time		20	–	nS
$t_{AHS8}$		Address hold time		10		
$t_{CSSAS8}$	CS0	Chip select setup time		20	–	nS
$t_{CSHS8}$		Chip select hold time		40		
$t_{CYS8}$	SCK	Cycle time		80		nS
$t_{LPWS8}$		Low pulse width		25	–	
$t_{HPWS8}$		High pulse width		25		
$t_{DSS8}$	SDA (Write)	Data setup time		20	–	nS
$t_{DHS8}$		Data hold time		10		

Note: tr (rising time), tf (falling time) : ≤ 15nS

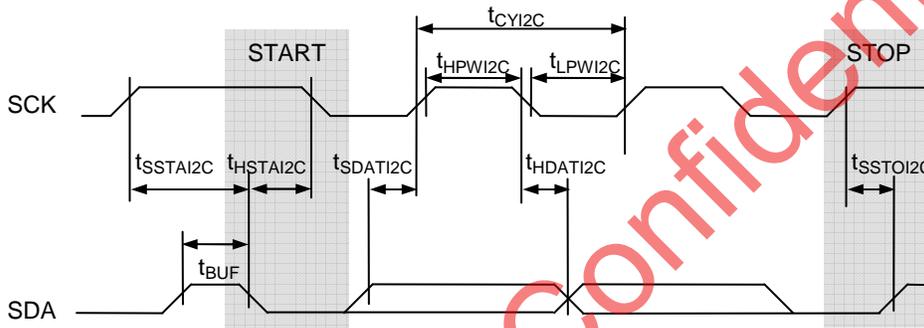


FIGURE 16: Serial bus timing characteristics (for I<sup>2</sup>C)

Symbol	Signal	Description	Condition	Min.	Max.	Unit
(2.6V ≤ V <sub>DD</sub> ≤ 3.6V, T <sub>a</sub> = -30 to +85°C)						
t <sub>CYI2C</sub>		SCK cycle time		305		
t <sub>HPWI2C</sub>	SCK	High pulse width		110	–	nS
t <sub>LPWI2C</sub>		Low pulse width		165		
t <sub>SSTAI2C</sub>		Setup time – START		28		
t <sub>HSTAI2C</sub>		Hold time – START		55		
t <sub>SDAI2C</sub>	SCK SDA	Setup time – Data		40	–	nS
t <sub>HDAI2C</sub>		Hold time – Data		11		
t <sub>SSTOI2C</sub>		Setup time – STOP		28		
t <sub>BUF</sub>	SDA	Bus Free time between STOP and START		165	–	nS

**Note:** tr (Rising time), tf (falling time): ≤ 15nS

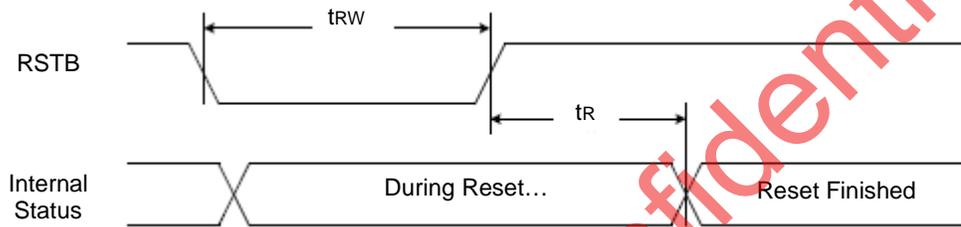


FIGURE 17: Reset Characteristics

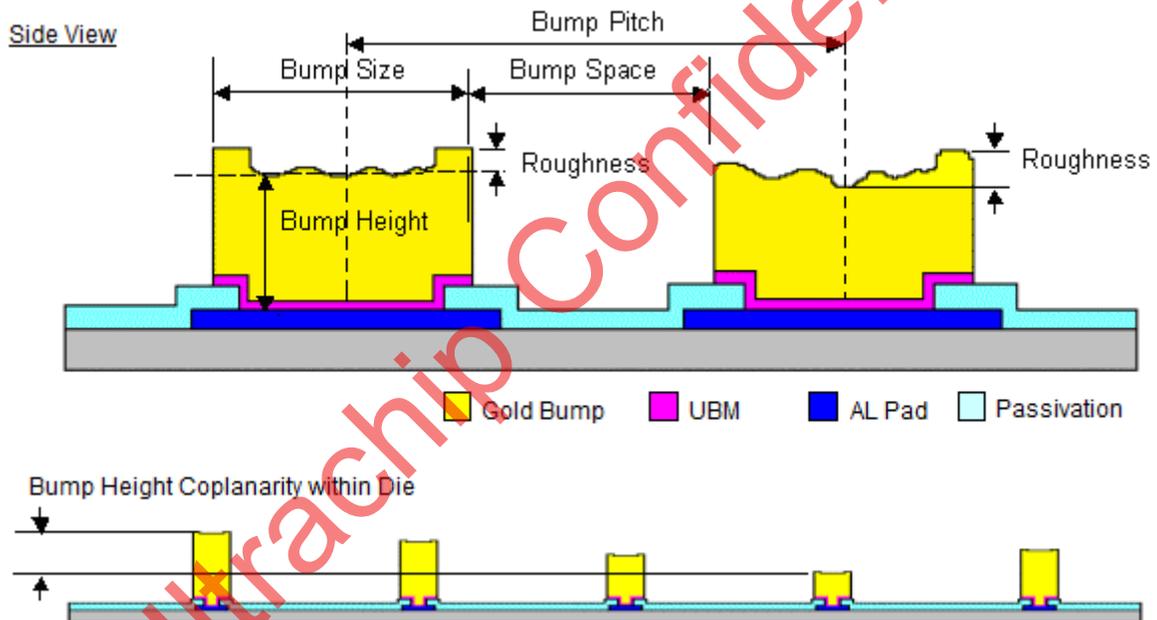
( $2.6V \leq V_{DD} < 3.6V$ ,  $T_a = -30$  to  $+85^\circ C$ )

Symbol	Signal	Description	Condition	Min.	Max.	Unit
$t_{RW}$	RST	Reset low pulse width		1	–	$\mu S$
$t_R$	RST, Internal Status	Reset to Internal Status pulse delay		--	1	mS

**Note:** For each mode, the signal's rising time ( $t_r$ ) and falling time ( $t_f$ ) are stipulated to be equal to or less than 15nS each.



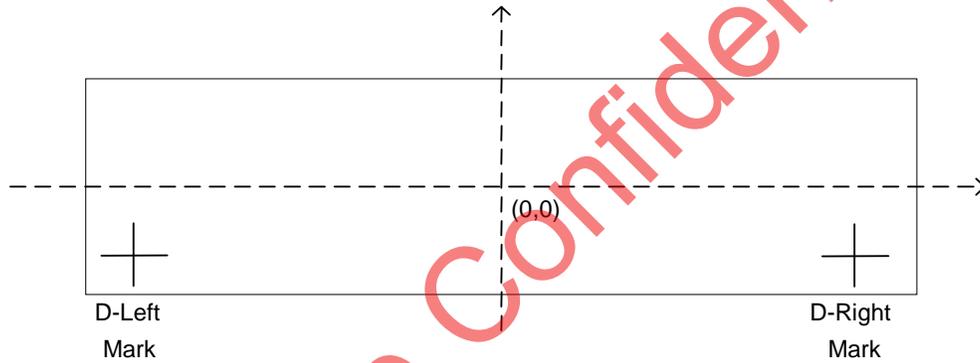
PHYSICAL DIMENSIONS



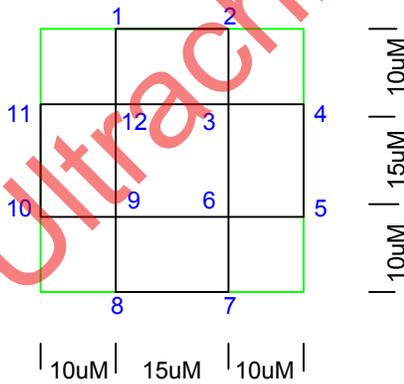
Die / Bump Information:

Die Size:	(5040 $\mu\text{M} \pm 40 \mu\text{M}$ ) x (703 $\mu\text{M} \pm 40 \mu\text{M}$ )
Die Thickness:	300 $\mu\text{M} \pm 20 \mu\text{M}$
	$D_{\text{MAX}} - D_{\text{MIN}} \leq 2 \mu\text{M}$
Bump Height:	10 $\mu\text{M} \pm 3 \mu\text{M}$ (Part Number: UC1701cGAB)
	15 $\mu\text{M} \pm 3 \mu\text{M}$ (Part Number: UC1701cGBB)
	$H_{\text{MAX}} - H_{\text{MIN}} \leq 2 \mu\text{M}$
Hardness:	90Hv $\pm 25\text{Hv}$
Bump Size:	(15 $\mu\text{M} \pm 2 \mu\text{M}$ ) x (100 $\mu\text{M} \pm 2 \mu\text{M}$ )
Bump Pitch:	27 $\mu\text{M}$
Bump Gap:	12 $\mu\text{M} \pm 3 \mu\text{M}$
Bump Area:	1500 $\mu\text{M}^2$
Coordinate origin:	Chip center
Pad reference:	Pad center

**ALIGNMENT MARK INFORMATION**



**SHAPE OF THE ALIGNMENT MARK:**



**NOTE:**

Alignment mark is on Metal3 under Passivation.  
The “+” mark is symmetric both horizontally and vertically.

**COORDINATES:**

Point	D-Left Mark		D-Right Mark	
	X	Y	X	Y
1	-1984.5	-149.5	1969.5	-149.5
2	-1969.5	-149.5	1984.5	-149.5
3	-1969.5	-159.5	1984.5	-159.5
4	-1959.5	-159.5	1994.5	-159.5
5	-1959.5	-174.5	1994.5	-174.5
6	-1969.5	-174.5	1984.5	-174.5
7	-1969.5	-184.5	1984.5	-184.5
8	-1984.5	-184.5	1969.5	-184.5
9	-1984.5	-174.5	1969.5	-174.5
10	-1994.5	-174.5	1959.5	-174.5
11	-1994.5	-159.5	1959.5	-159.5
12	-1984.5	-159.5	1969.5	-159.5

## PAD COORDINATES

#	Pad	X	Y	W	H
1	COM<53>	-2363	-247	15	100
2	COM<54>	-2336	-247	15	100
3	COM<55>	-2309	-247	15	100
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6	COM<58>	-2228	-247	15	100
7	COM<59>	-2201	-247	15	100
8	COM<60>	-2174	-247	15	100
9	COM<61>	-2147	-247	15	100
10	COM<62>	-2120	-247	15	100
11	COM<63>	-2093	-247	15	100
12	CIC	-2066	-247	15	100
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14	CS0	-1905	-274.5	50	45
15	RST	-1840	-274.5	50	45
16	CD	-1775	-274.5	50	45
17	WR0	-1710	-274.5	50	45
18	WR1	-1645	-274.5	50	45
19	VDDX	-1580	-274.5	50	45
20	D0	-1515	-274.5	50	45
21	D1	-1450	-274.5	50	45
22	D2	-1385	-274.5	50	45
23	D3	-1320	-274.5	50	45
24	D4	-1255	-274.5	50	45
25	D5	-1190	-274.5	50	45
26	D6	-1125	-274.5	50	45
27	D7	-1060	-274.5	50	45
28	VDD	-995	-274.5	50	45
29	VDD	-930	-274.5	50	45
30	VDD2	-865	-274.5	50	45
31	VDD2	-800	-274.5	50	45
32	VDD2	-735	-274.5	50	45
33	VDD3	-670	-274.5	50	45
34	VSS	-605	-274.5	50	45
35	VSS	-540	-274.5	50	45
36	VSS2	-475	-274.5	50	45
37	VSS2	-410	-274.5	50	45
38	VSS2	-345	-274.5	50	45
39	VSS2	-280	-274.5	50	45
40	V0in	-215	-274.5	50	45
41	V0in	-150	-274.5	50	45
42	V0s	-85	-274.5	50	45
43	V0out	-20	-274.5	50	45
44	V0out	45	-274.5	50	45
45	XV0out	110	-274.5	50	45
46	XV0out	175	-274.5	50	45
47	XV0s	240	-274.5	50	45
48	XV0in	305	-274.5	50	45
49	XV0in	370	-274.5	50	45
50	VMO	435	-274.5	50	45
51	VMO	500	-274.5	50	45
52	VGin	565	-274.5	50	45
53	VGin	630	-274.5	50	45
54	VGs	695	-274.5	50	45
55	VGout	760	-274.5	50	45
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57	DUMMY	875	-274.5	45	45
58	DUMMY	930	-274.5	45	45

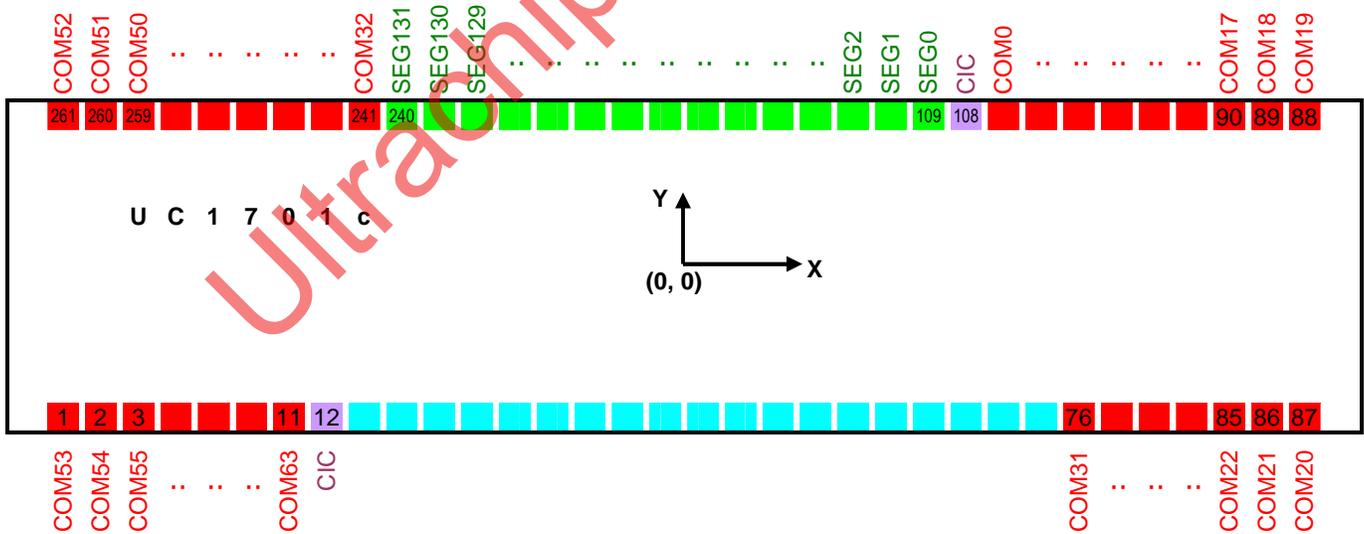
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63	DUMMY	1205	-274.5	45	45
64	TST5	1260	-274.5	45	45
65	TST2	1320	-274.5	50	45
66	VSSX	1385	-274.5	50	45
67	VDDX	1450	-274.5	50	45
68	BM0	1515	-274.5	50	45
69	BM1	1580	-274.5	50	45
70	DT1	1645	-274.5	50	45
71	VSSX	1710	-274.5	50	45
72	DT2	1775	-274.5	50	45
73	VDD	1840	-274.5	50	45
74	VDD2	1905	-274.5	50	45
75	VDD3	1970	-274.5	50	45
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92	COM<15>	2255	247	15	100
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125	SEG<16>	1336.5	247	15	100
126	SEG<17>	1309.5	247	15	100
127	SEG<18>	1282.5	247	15	100
128	SEG<19>	1255.5	247	15	100
129	SEG<20>	1228.5	247	15	100
130	SEG<21>	1201.5	247	15	100
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133	SEG<24>	1120.5	247	15	100
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136	SEG<27>	1039.5	247	15	100
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#	Pad	X	Y	W	H
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180	SEG<71>	-148.5	247	15	100
181	SEG<72>	-175.5	247	15	100
182	SEG<73>	-202.5	247	15	100
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227	SEG<118>	-1417.5	247	15	100
228	SEG<119>	-1444.5	247	15	100
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230	SEG<121>	-1498.5	247	15	100
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232	SEG<123>	-1552.5	247	15	100
233	SEG<124>	-1579.5	247	15	100
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235	SEG<126>	-1633.5	247	15	100
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#	Pad	X	Y	W	H
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243	COM<34>	-1877	247	15	100
244	COM<35>	-1904	247	15	100
245	COM<36>	-1931	247	15	100
246	COM<37>	-1958	247	15	100
247	COM<38>	-1985	247	15	100
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#	Pad	X	Y	W	H
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253	COM<44>	-2147	247	15	100
254	COM<45>	-2174	247	15	100
255	COM<46>	-2201	247	15	100
256	COM<47>	-2228	247	15	100
257	COM<48>	-2255	247	15	100
258	COM<49>	-2282	247	15	100
259	COM<50>	-2309	247	15	100
260	COM<51>	-2336	247	15	100
261	COM<52>	-2363	247	15	100



TRAY INFORMATION



**REVISION HISTORY**

Revision	Contents	Date
0.6	First Release	Jun. 17, 2014
1.0	Average Frame Rate (Min.): -10% → -15%	Sep. 29, 2014
	Average Frame Rate (Max.): +10% → +20%	
	Power Consumption data are provided.	

Ultrachip Confidential