

SPLC502A

132 x 65 Dot Matrix LCD Driver

Preliminary

AUG. 11, 2004

Version 0.1

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132 x 65 DOT MATRIX LCD DRIVER

1. GENERAL DESCRIPTION

The SPLC502A, a single-chip dot matrix liquid crystal display drivers, is specially designed to connect directly with a microprocessor bus. The 8-bit parallel or serial display data sent from the microprocessor is stored in the internal display data RAM.

It generates a liquid crystal drive signal independent of the

microprocessor. Since the SPLC502A contains a 65 X 132 bits of display data RAM, a 1-to-1 correspondence between the liquid crystal panel pixels and the internal RAM bits, it is able to enable displays with a high degree of flexibility. The SPLC502A contains

65 common output circuits, 132 segment output circuits and

therefore, a single chip can drive a 65 X 132 dot display (capable of displaying 8 columns X 4 rows of a 16 X 16 dot kanji font). In addition, the capacity of the display can also be extended through the use of master/slave structures between chips. The chips can save a great amount of power because no external operating clock is required for the display data RAM to read and write operations. Since each chip is equipped internally with a low-power liquid crystal driver power supply, resistors for liquid crystal driver power voltage adjustment and a display clock CR oscillator circuit, the SPLC502A can be used for creating the lowest power display system with the fewest components for high performance portable devices.

2. FEATURES

- ④ Direct display of RAM data through the display data RAM.

'1': Non-illuminated.

'0': Illuminated.

- ④ RAM capacity.

65 X 132 = 8580 bits.

- ④ Display driver circuits.

SPLC502A: 65 common outputs and 132 segment outputs.

- ④ Static drive circuit equipped internally for indicators.

(1 system, with variable flashing speed.)

- ④ These chips not designed for resistance to light or Resistance to radiation.

- ④ High-speed 8-bit MPU interface (capability to be connected directly to the both the 80 X 86 series MPUs and the 68000 series MPUs)/Serial interface are supported.

- ④ Wide range of operating temperatures.

- ④ CMOS process

- ④ CR oscillator circuit equipped internally

(External clock can also be input).

- ④ Abundant command functions

Display data Read/Write, display ON/OFF, Normal/Reverse display mode, page address set, display start line set, column address set, status read, display all points ON/OFF, LCD bias set, electronic volume, read/modify/write, segment driver direction select, power saver, static indicator, common output status select, V0 voltage regulation internal resistor ratio set. Booster ratio set

- ④ Low-power liquid crystal display power supply circuit equipped internally.

Booster circuit (with Boost ratios 2X/3X/4X/5X/6X, where the step-up voltage reference power supply can be input externally).

High-accuracy voltage adjustment circuit (Thermal gradient -0.05%/°C or external input).

V0 voltage regulator resistors equipped internally, V₄₋₁ voltage divider resistors equipped internally, electronic volume function equipped internally, voltage follower.

- ④ Driving Mode register provided for different size panel loading.

- ④ Extremely low power consumption.

Low operating power when the built-in power supply is used

- ④ Power supply

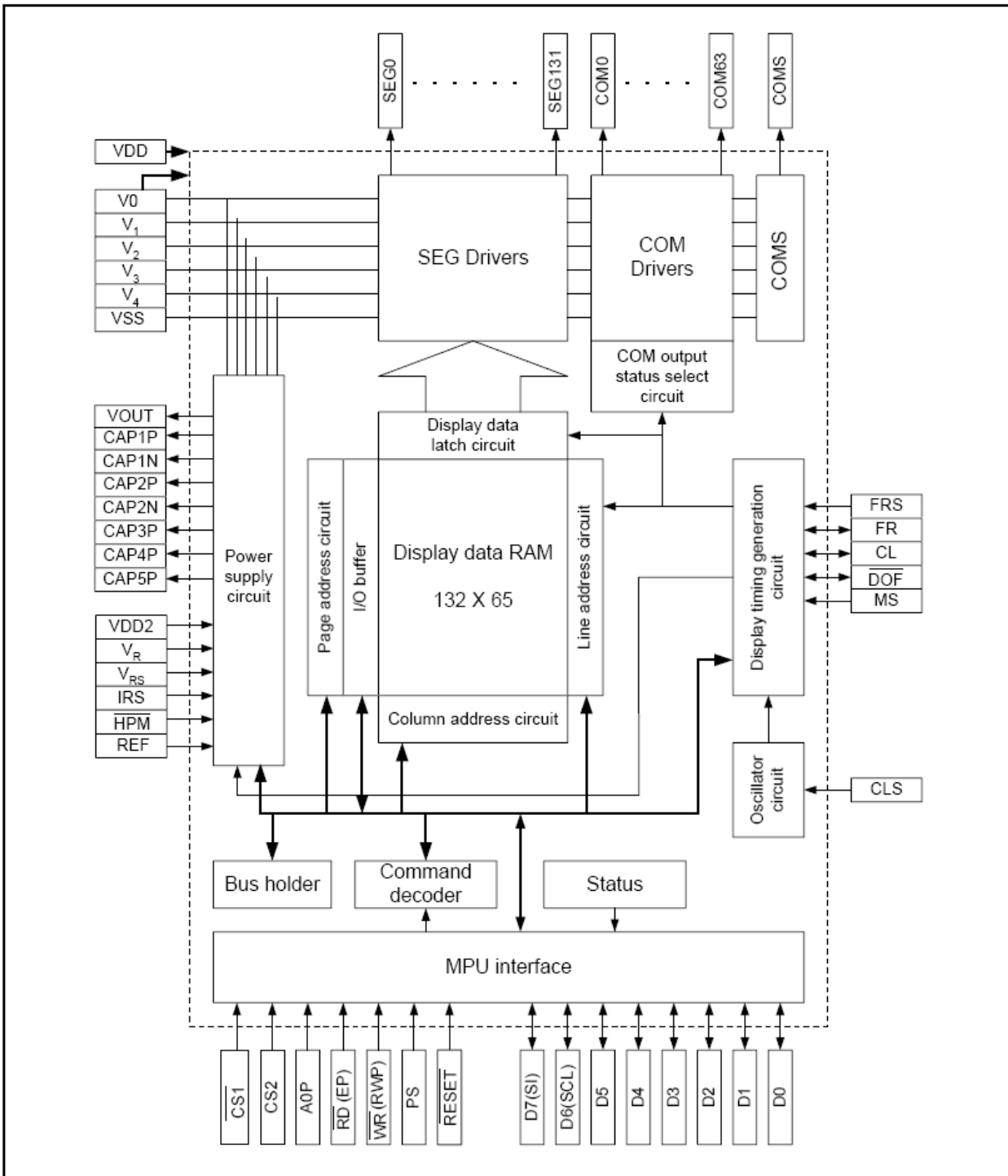
Operable on the low 1.8 voltage

Logic power supply VDD - VSS = 1.8V to 3.6V

Boost reference voltage: VDD2 - VSS = 1.8V to 3.6V

Liquid crystal drive power supply (VLCD):V0 - VSS = 4V to 12V

Product Name	Dutv	Bias	SED Dr	COM Dr	VREG Temperature Gradient	Shipping Forms
SPLC502A	1/65	1/9, 1/7	132	65	-0.05%/°C	Bare Chip with Gold Bump and TCP
	1/55	1/8, 1/6	132	55		
	1/49	1/8, 1/6	132	49		
	1/33	1/6, 1/5	132	33		

3. BLOCK DIAGRAM


4. SIGNAL DESCRIPTIONS

4.1. Power Supply Pins

Mnemonic	PIN No.	Type	Description																									
VDD	12	P	VDD Shared with MPU power supply terminal VCC																									
VSS	11	P	0V terminal connected to the system GND.																									
VDD2	4	P	A reference power supply for the step-up voltage circuit for the liquid crystal drive																									
V _{RS}	1	P	The external-input V _{REG} power supply for the LCD power supply voltage regulator. These can only be enabled for the models with the V _{REG} external input option.																									
V ₀ , V ₁ , V ₂ , V ₃ , V ₄ ,	10	P	<p>A multi-level power supply for the liquid crystal drive. The voltage applied is determined by the liquid crystal cell, and is changed through the use of a resistive voltage divider or through changing the impedance using an op. amp. Voltage levels are determined based on VDD, and must maintain the relative magnitudes shown below.</p> $V_0 \geq V_1 \geq V_2 \geq V_3 \geq V_4 \geq VSS$ <p>Master operation: When the power supply turns ON, the internal power supply circuits generate the V₁ to V₄ voltages shown below. The voltage settings are selected by the LCD bias command.</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th></th> <th>1/65 DUTY</th> <th>1/55 DUTY</th> <th>1/49 DUTY</th> <th>1/33 DUTY</th> </tr> </thead> <tbody> <tr> <td>V₁</td> <td>8/9*V₀ 6/7*V₀</td> <td>7/8*V₀ 5/6*V₀</td> <td>7/8*V₀ 5/6*V₀</td> <td>5/6*V₀ 4/5*V₀</td> </tr> <tr> <td>V₂</td> <td>7/9*V₀ 5/7*V₀</td> <td>6/8*V₀ 4/6*V₀</td> <td>6/8*V₀ 4/6*V₀</td> <td>4/6*V₀ 3/5*V₀</td> </tr> <tr> <td>V₃</td> <td>2/9*V₀ 2/7*V₀</td> <td>2/8*V₀ 2/6*V₀</td> <td>2/8*V₀ 2/6*V₀</td> <td>2/6*V₀ 2/5*V₀</td> </tr> <tr> <td>V₄</td> <td>1/9*V₀ 1/7*V₀</td> <td>1/8*V₀ 1/6*V₀</td> <td>1/8*V₀ 1/6*V₀</td> <td>1/6*V₀ 1/5*V₀</td> </tr> </tbody> </table>		1/65 DUTY	1/55 DUTY	1/49 DUTY	1/33 DUTY	V ₁	8/9*V ₀ 6/7*V ₀	7/8*V ₀ 5/6*V ₀	7/8*V ₀ 5/6*V ₀	5/6*V ₀ 4/5*V ₀	V ₂	7/9*V ₀ 5/7*V ₀	6/8*V ₀ 4/6*V ₀	6/8*V ₀ 4/6*V ₀	4/6*V ₀ 3/5*V ₀	V ₃	2/9*V ₀ 2/7*V ₀	2/8*V ₀ 2/6*V ₀	2/8*V ₀ 2/6*V ₀	2/6*V ₀ 2/5*V ₀	V ₄	1/9*V ₀ 1/7*V ₀	1/8*V ₀ 1/6*V ₀	1/8*V ₀ 1/6*V ₀	1/6*V ₀ 1/5*V ₀
	1/65 DUTY	1/55 DUTY	1/49 DUTY	1/33 DUTY																								
V ₁	8/9*V ₀ 6/7*V ₀	7/8*V ₀ 5/6*V ₀	7/8*V ₀ 5/6*V ₀	5/6*V ₀ 4/5*V ₀																								
V ₂	7/9*V ₀ 5/7*V ₀	6/8*V ₀ 4/6*V ₀	6/8*V ₀ 4/6*V ₀	4/6*V ₀ 3/5*V ₀																								
V ₃	2/9*V ₀ 2/7*V ₀	2/8*V ₀ 2/6*V ₀	2/8*V ₀ 2/6*V ₀	2/6*V ₀ 2/5*V ₀																								
V ₄	1/9*V ₀ 1/7*V ₀	1/8*V ₀ 1/6*V ₀	1/8*V ₀ 1/6*V ₀	1/6*V ₀ 1/5*V ₀																								

P: Power Supply

4.2. LCD Power Supply Circuit Terminals

Mnemonic	PIN No.	Type	Description
CAP1P	2	O	DC/DC voltage converter. A capacitor is connected between this terminal and the CAP1N
CAP1N	2	O	DC/DC voltage converter. A capacitor is connected between this terminal and the CAP1P
CAP2P	2	O	DC/DC voltage converter. A capacitor is connected between this terminal and the CAP2N
CAP2N	2	O	DC/DC voltage converter. A capacitor is connected between this terminal and the CAP2P
CAP3P	2	O	DC/DC voltage converter. A capacitor is connected between this terminal and the CAP1N
CAP4P	2	O	DC/DC voltage converter. A capacitor is connected between this terminal and the CAP2N
CAP5P	2	O	DC/DC voltage converter. A capacitor is connected between this terminal and the CAP1N
V _{OUT}	3	O	DC/DC voltage converter. A capacitor is connected between this terminal and VSS.
V _R	2	I	Output voltage regulator terminal. Provides the voltage between VDD and V ₀ through a resistive voltage divider. These are only enabled when the V ₀ voltage regulator internal resistors are not used (IRS = 'L'). These cannot be used when the V ₀ voltage regulator internal resistors are

4.3. System Bus Connection Terminals

Mnemonic	PIN No.	Type	Description															
DB7 - 0 (SI) (SCL)	8	I/O	This is an 8-bit bi-directional data bus that connects to an 8-bit or 16-bit standard MPU data bus. When the serial interface is selected (PS = 'L'), DB7 serves as the serial data input terminal (SI) and DB6 serves as the serial clock input terminal (SCL). At the same time, DB5 - 0 are set to															
AOP	1	I	This is connected to the least significant bit of the normal MPU address bus, and it determines whether the data bits are data or a command. AOP = 'H': Indicates DB7 - 0 is display data. AOP = 'L': Indicates DB7 - 0 is control data.															
RESET	1	I	When $\overline{\text{RESET}}$ is set to 'L', the settings are initialized. The $\overline{\text{RESET}}$ signal level performs the reset															
CS1 CS2	2	I	This is the chip select signal. When CS1 = 'L' and CS2 = 'H', the chip select becomes active, and data/command I/O is enabled.															
RD (EP)	1	I	When connected to an 8080 MPU, this is LOW active. This pin is connected to the RD signal of the 8080 MPU, and the SPLC502A data bus is in an output status when this signal is 'L'. When connected to a 6800 Series MPU, this is HIGH active. This is the 68000 Series MPU															
WR (RWP)	1	I	When connected to an 8080 MPU, this is LOW active. This terminal connects to the 8080 MPU $\overline{\text{WR}}$ signal. The signals on the data bus are latched at the rising edge of the $\overline{\text{WR}}$ signal. When connected to a 6800 Series MPU: This is the read/write control signal input terminal. When RWP = 'H': Read. When RWP = 'L': Write.															
C86	1	I	This is the MPU interface switch terminal. C86 = 'H': 6800 Series MPU interface. C86 = 'L': 8080 MPU interface.															
PS	1	I	This is the parallel data input/serial data input switch terminal. PS = 'H': Parallel data input. PS = 'L': Serial data input. The following applies depending on the PS status: <table border="1" style="margin: 10px auto;"> <thead> <tr> <th>PS</th> <th>Data/Command</th> <th>Data</th> <th>Read/Write</th> <th>Serial Clock</th> </tr> </thead> <tbody> <tr> <td>'H'</td> <td>AOP</td> <td>DB0 to DB7</td> <td>RD , WR Write only</td> <td>SCL (DB6)</td> </tr> <tr> <td>'L'</td> <td>AOP</td> <td>SI(DB7)</td> <td></td> <td></td> </tr> </tbody> </table> <p>When PS = 'L', DB0 to DB5 are high impedance. DB0 to DB5 may be 'H', 'L' or Open. $\overline{\text{RD}}$ (EP) and $\overline{\text{WR}}$ (RWP) are fixed to either 'H' or 'L'. With serial data input, RAM display data reading is not supported.</p>	PS	Data/Command	Data	Read/Write	Serial Clock	'H'	AOP	DB0 to DB7	RD , WR Write only	SCL (DB6)	'L'	AOP	SI(DB7)		
PS	Data/Command	Data	Read/Write	Serial Clock														
'H'	AOP	DB0 to DB7	RD , WR Write only	SCL (DB6)														
'L'	AOP	SI(DB7)																
CLS	1	I	Terminal to select whether to enable or disable the display clock internal oscillator circuit. CLS = 'H': Internal oscillator circuit is enabled. CLS = 'L': Internal oscillator circuit is disabled (requires external input). When CLS = 'L', input the display clock through the CL terminal.															
FR	1	I/O	This is the liquid crystal alternating current signal I/O terminal. MS = 'H': Output MS = 'L': Input When the SPLC502A chip is used in master/slave mode, the various FR terminals must be connected.															

Mnemonic	PIN No.	Type	Description																																								
MS	1	I	<p>This terminal selects the master/slave operation for the SPLC502A chips. Master operation outputs the timing signals that are required for the LCD display, while slave operation inputs the timing signals required for the liquid crystal display, synchronizing the liquid crystal display system.</p> <p>MS = 'H': Master operation MS = 'L': Slave operation</p> <p>The following is true depending on the MS and CLS status:</p> <table border="1"> <thead> <tr> <th>MS</th> <th>CLS</th> <th>Oscillator Circuit</th> <th>Power Supply Circuit</th> <th>CL</th> <th>FR</th> <th>FRS</th> <th>DOF</th> </tr> </thead> <tbody> <tr> <td>'H'</td> <td>'H'</td> <td>Enabled</td> <td>Enabled</td> <td>Output</td> <td>Output</td> <td>Output</td> <td>Output</td> </tr> <tr> <td></td> <td>'L'</td> <td>Disabled</td> <td>Enabled</td> <td>Input</td> <td>Output</td> <td>Output</td> <td>Output</td> </tr> <tr> <td>'L'</td> <td>'H'</td> <td>Disabled</td> <td>Disabled</td> <td>Input</td> <td>Input</td> <td>Output</td> <td>Input</td> </tr> <tr> <td></td> <td>'L'</td> <td>Disabled</td> <td>Disabled</td> <td>Input</td> <td>Input</td> <td>Output</td> <td>Input</td> </tr> </tbody> </table>	MS	CLS	Oscillator Circuit	Power Supply Circuit	CL	FR	FRS	DOF	'H'	'H'	Enabled	Enabled	Output	Output	Output	Output		'L'	Disabled	Enabled	Input	Output	Output	Output	'L'	'H'	Disabled	Disabled	Input	Input	Output	Input		'L'	Disabled	Disabled	Input	Input	Output	Input
MS	CLS	Oscillator Circuit	Power Supply Circuit	CL	FR	FRS	DOF																																				
'H'	'H'	Enabled	Enabled	Output	Output	Output	Output																																				
	'L'	Disabled	Enabled	Input	Output	Output	Output																																				
'L'	'H'	Disabled	Disabled	Input	Input	Output	Input																																				
	'L'	Disabled	Disabled	Input	Input	Output	Input																																				
CL	1	I/O	<p>This is the display clock input terminal</p> <p>The following is true depending on the MS and CLS status.</p> <table border="1"> <thead> <tr> <th>MS</th> <th>CLS</th> <th>CL</th> </tr> </thead> <tbody> <tr> <td>'H'</td> <td>'H'</td> <td>Output</td> </tr> <tr> <td></td> <td>'L'</td> <td>Input</td> </tr> <tr> <td>'L'</td> <td>'H'</td> <td>Input</td> </tr> <tr> <td></td> <td>'L'</td> <td>Input</td> </tr> </tbody> </table> <p>When the SPLC502A chips are used in master/slave mode, the various CL terminals must be connected.</p>	MS	CLS	CL	'H'	'H'	Output		'L'	Input	'L'	'H'	Input		'L'	Input																									
MS	CLS	CL																																									
'H'	'H'	Output																																									
	'L'	Input																																									
'L'	'H'	Input																																									
	'L'	Input																																									
DOF	1	I/O	<p>This is the liquid crystal display blanking control terminal.</p> <p>MS = 'H': Output MS = 'L': Input</p> <p>When the SPLC502A chip is used in master/slave mode, the various DOF terminals must be connected.</p>																																								
FRS	1	O	<p>This is the output terminal for the static drive. This terminal is only enabled when the static indicator display is ON when in master operation mode, and is used in conjunction with the FR terminal.</p>																																								
IRS	1	I	<p>This terminal selects the resistors for the V0 voltage level adjustment.</p> <p>IRS = 'H': Use the internal resistors. IRS = 'L': Do not use the internal resistors.</p> <p>The V0 voltage level is regulated by an external resistive voltage divider attached to the VR terminal. This pin is enabled only when the master operation mode is selected. It is fixed to either</p>																																								
HPM	1	I	<p>This is the power control terminal for the power supply circuit for liquid crystal drive.</p> <p>HPM = 'H': Normal mode. HPM = 'L': High power mode.</p> <p>This pin is enabled only when the master operation mode is selected. It is fixed to either 'H' or 'L' when the slave operation mode is selected.</p>																																								
REF	1	I	<p>This is the reference source select terminal for the power supply circuit for liquid crystal drive.</p> <p>REF = "H"; external reference source from VRS terminal. REF = "L"; internal reference source from SPLC502A terminal.</p> <p>This pin is enable only when the master operation mode is selected. It is fixed to either "H" or "L" when the slave operation mode is selected.</p>																																								

Mnemonic	PIN No.	Type	Description			
DSEL1-0		I	These pins can provide duty selection.			
			DSEL1	DSEL0	DUTY RATIO	BIAS
			1	1	1/65	1/9 or 1/7
			1	0	1/55	1/8 or 1/6
			0	1	1/49	1/8 or 1/6
0	0	1/33	1/6 Or 1/5			

4.4. Liquid Crystal Drive terminals

Mnemonic	PIN No.	Type	Description																										
SEG131 - 0	132	O	<p>These are the liquid crystal segment drive outputs. Through a combination of the contents of the display RAM and with the FR signal, a single level is selected from V₀, V₂, V₃, and VSS.</p> <table border="1"> <thead> <tr> <th rowspan="2">RAM DATA</th> <th rowspan="2">FR</th> <th colspan="2">Output Voltage</th> </tr> <tr> <th>Normal Display</th> <th>Reverse Display</th> </tr> </thead> <tbody> <tr> <td>H</td> <td>H</td> <td>V₀</td> <td>V₂</td> </tr> <tr> <td>H</td> <td>L</td> <td>VSS</td> <td>V₃</td> </tr> <tr> <td>L</td> <td>H</td> <td>V₂</td> <td>V₀</td> </tr> <tr> <td>L</td> <td>L</td> <td>V₃</td> <td>VSS</td> </tr> <tr> <td>Power save</td> <td>-</td> <td colspan="2">VSS</td> </tr> </tbody> </table>	RAM DATA	FR	Output Voltage		Normal Display	Reverse Display	H	H	V ₀	V ₂	H	L	VSS	V ₃	L	H	V ₂	V ₀	L	L	V ₃	VSS	Power save	-	VSS	
RAM DATA	FR	Output Voltage																											
		Normal Display	Reverse Display																										
H	H	V ₀	V ₂																										
H	L	VSS	V ₃																										
L	H	V ₂	V ₀																										
L	L	V ₃	VSS																										
Power save	-	VSS																											
COM63 - 0	64	O	<p>These are the liquid crystal common drive outputs.</p> <table border="1"> <thead> <tr> <th>Part No.</th> <th>COM</th> </tr> </thead> <tbody> <tr> <td>SPLC502</td> <td>COM63 -0</td> </tr> </tbody> </table> <p>Through a combination of the contents of the scan data and with the FR signal, a single level is selected from V₀, V₁, V₄, and Vss.</p> <table border="1"> <thead> <tr> <th>Scan Data</th> <th>FR</th> <th>Output Voltage</th> </tr> </thead> <tbody> <tr> <td>H</td> <td>H</td> <td>VSS</td> </tr> <tr> <td>H</td> <td>L</td> <td>V₀</td> </tr> <tr> <td>L</td> <td>H</td> <td>V₁</td> </tr> <tr> <td>L</td> <td>L</td> <td>V₄</td> </tr> <tr> <td>Power Save</td> <td>-</td> <td>VSS</td> </tr> </tbody> </table>	Part No.	COM	SPLC502	COM63 -0	Scan Data	FR	Output Voltage	H	H	VSS	H	L	V ₀	L	H	V ₁	L	L	V ₄	Power Save	-	VSS				
Part No.	COM																												
SPLC502	COM63 -0																												
Scan Data	FR	Output Voltage																											
H	H	VSS																											
H	L	V ₀																											
L	H	V ₁																											
L	L	V ₄																											
Power Save	-	VSS																											
COMS	2	O	<p>These are the COM output terminals for the indicator. Both terminals output the same signal. Leave these pins open if they are not used. When in master/slave mode, the same signal is output by both master and slave.</p>																										

4.5. Test Terminals

Mnemonic	PIN No.	Type	Description
TEST	1	I	This is terminal for IC chip testing only.
TEST5, TEST6	2	O	These are terminals for IC chip testing only.

5. FUNCTIONAL DESCRIPTIONS

5.1. The MPU Interface

5.1.1. Selecting the interface type

For SPLC502A, data transfers are accomplished through an 8-bit bi-directional data bus (DB7 - 0) or through a serial data input (SI). By selecting the PS terminal polarity to the 'H' or 'L', it is possible

to select either parallel data input or serial data input as shown in Table 1.

Table 1

PS	CS1	CS2	A0P	RD	WR	C86	DB7	DB6	DB5 - 0
H: Parallel Input	CS1	CS2	A0P	RD	WR	C86	DB7	DB6	DB5 - 0
L: Serial Input	CS1	CS2	A0P	-	-	-	SI	SCL	(HiZ)

'-' indicates fixed to either 'H' or to 'L'

5.1.2. The parallel interface

When the parallel interface is selected (PS = 'H'), it is possible to connect directly to either an 8080-system MPU or a 6800 Series

MPU (as shown in Table 2) by selecting the C86 terminal to either 'H' or 'L'.

Table 2

C86	CS1	CS2	A0P	RD	WR	DB7 - 0
H: 6800 Series MPU Bus	CS1	CS2	A0P	EP	RWP	DB7 - 0
L: 8080 MPU Bus	CS1	CS2	A0P	RD	WR	DB7 - 0

Data bus signals are recognized by a combination of A0P, RD (EP), WR (RWP) signals, shown in Table 3.

Table 3

Shared	6800 Series	8080 Series		Function
	WRP	RD	WR	
A0P				
1	1	0	1	Read the display data
1	0	1	0	Write the display data
0	1	0	1	Read Status
0	0	1	0	Write control data (command)

5.1.3. The serial interface

When the serial interface is selected (PS = 'L') and when the chip is in active state (CS1 = 'L' and CS2 = 'H'), the serial data input (SI) and the serial clock input (SCL) can be received. The serial data is read from the serial data input pin at the rising edge of the serial clocks DB7, DB6 through DB0 in order. The data is converted to 8-bit parallel data at the rising edge of the eighth serial clock.

The A0P input determines whether the serial data input is display data or command data; when A0P = 'H', the data is display data, and when A0P = 'L', the data is command data. The A0P input is read and used for detecting every 8th rising edge of the serial clock after the chip is active.

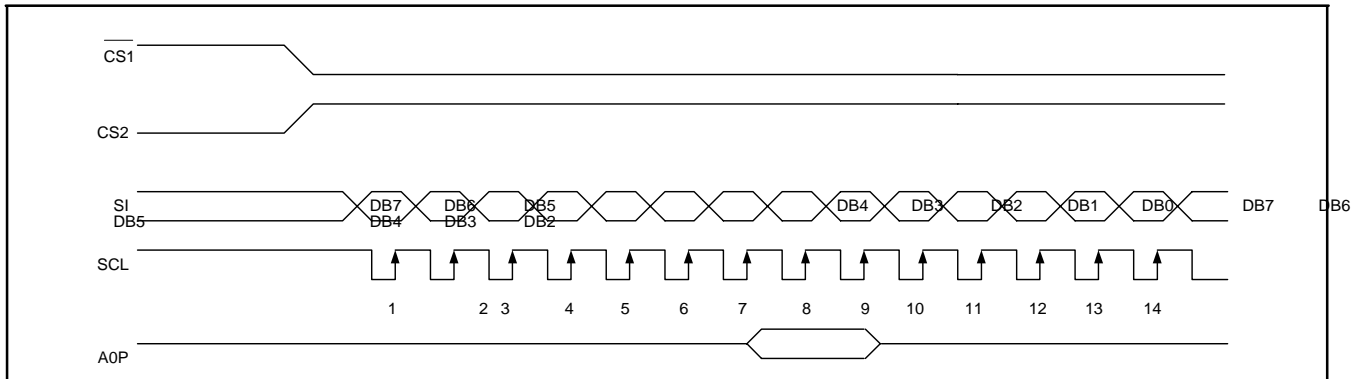


Figure 1: serial interface signal chart.

Note1: When the chip is not active, the shift registers and counter are reset to their initial states.

Note2: Reading is not acceptable in serial interface mode.

Note3: Caution is required on the SCL signal when it comes to line-end reflections and external noise. SUNPLUS recommends that operation should be rechecked on the actual equipment.

5.2. The Chip Select

The SPLC502A have two chip-select-terminals: CS1 and CS2. The MPU interface or the serial interface is enabled only when

CS1 = 'L' and CS2 = 'H'.

When the chip select is inactive, DB7 - 0 enter into a high impedance state, and the A0P, RD, and WR inputs are inactive. When the serial interface is selected, the shift register and the counter are reset.

5.3. Accessing the Display Data RAM and the Internal Registers

Data transferring at a high speed is ensured since the MPU is required to satisfy the cycle time (tcyc) requirement alone in accessing the SPLC502A. Wait time may not be considered.

Also, in SPLC502A chips, each time data is sent from MPU. A type of pipeline process between LSIs is performed through the bus holder attached to the internal data bus. For example, when

the MPU writes data to the display data RAM, once the data is stored in the bus holder, it is written to the display data RAM before the next data write cycle. Moreover, when the MPU reads the display data RAM, the first data read cycle (dummy) stores the read data in the bus holder, and then the data is read from the bus holder to the system bus at the next data read cycle. There is a certain restriction in the read sequence of the display data RAM. Note that data of the specified address is not generated by the read instruction issued immediately after the address setup. This data is generated in data read of the second time. Thus, a dummy read is required whenever the addresses setup or write cycle operation is conducted. This

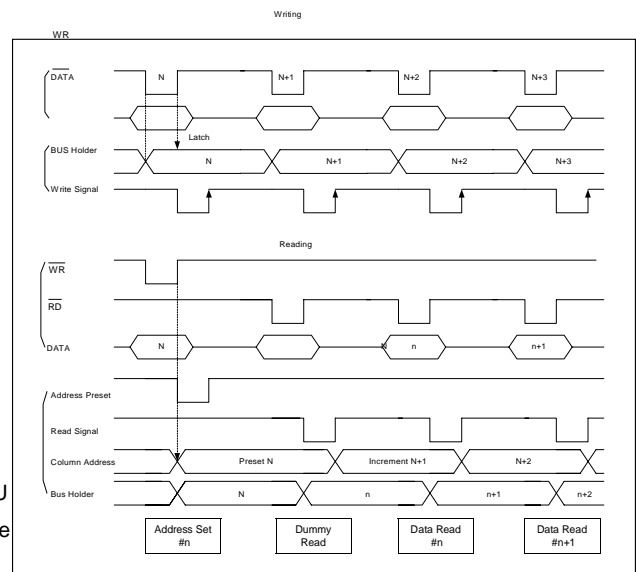


Figure2

5.4. The Busy Flag

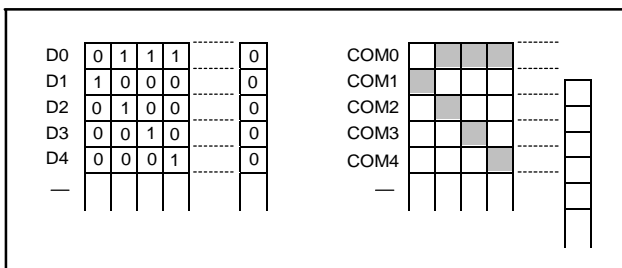
relationship is shown in Figure 2.

When the busy flag is '1', it indicates that the S PLC502A is running internal processes. At this moment, no command aside from a status read will be received. The busy flag is outputted to DB7 pin with the read instruction. If the cycle time (tcyc) is remained, it is not necessary to check for this flag before each command. This makes vast improvements in MPU processing capabilities possible.

5.5. Display Data RAM

5.5.1. Display data RAM

The display data RAM is a RAM that stores the dot data for the display. It has a 65 (8 page x 8 bit +1) x 132-bit structure. It is possible to access the desired bit by specifying the page address and the column address. Because, as is shown in Figure 3, the DB7 - 0 display data from the MPU corresponds to the liquid crystal display common direction, there are few constraints at the time of display data transfer when multiple SPLC502A chips are used. Therefore, display structures can be created easily and with a high degree of freedom.



Display data RAM

Liquid crystal display

Figure 3

Moreover, reading from and writing to the display RAM in the MPU side is performed through the I/O buffer, which is an independent operation from signal reading for the liquid crystal driver. Consequently, even if the display data RAM is accessed asynchronously during liquid crystal display, it will not cause adverse effects on the display (such as flickering).

5.5.2. The page address circuit

As shown in Figure 4, page address of the display data RAM is specified through the Page Address Set Command. The page address must be specified again when changing pages to perform access. Page address 8 (DB3, DB2, DB1, DB0 = 1, 0, 0, 0) is the page for the RAM region used only by the indicators, and only display data DB0 is used.

5.5.3. The column addresses

As is shown in Figure 4, the display data RAM column address is specified by the Column Address Set command. The specified column address is incremented (+1) with each display data read/write command. This allows the MPU display data to be accessed continuously.

Moreover, the increment of column addresses stops with 83H. Because the column address

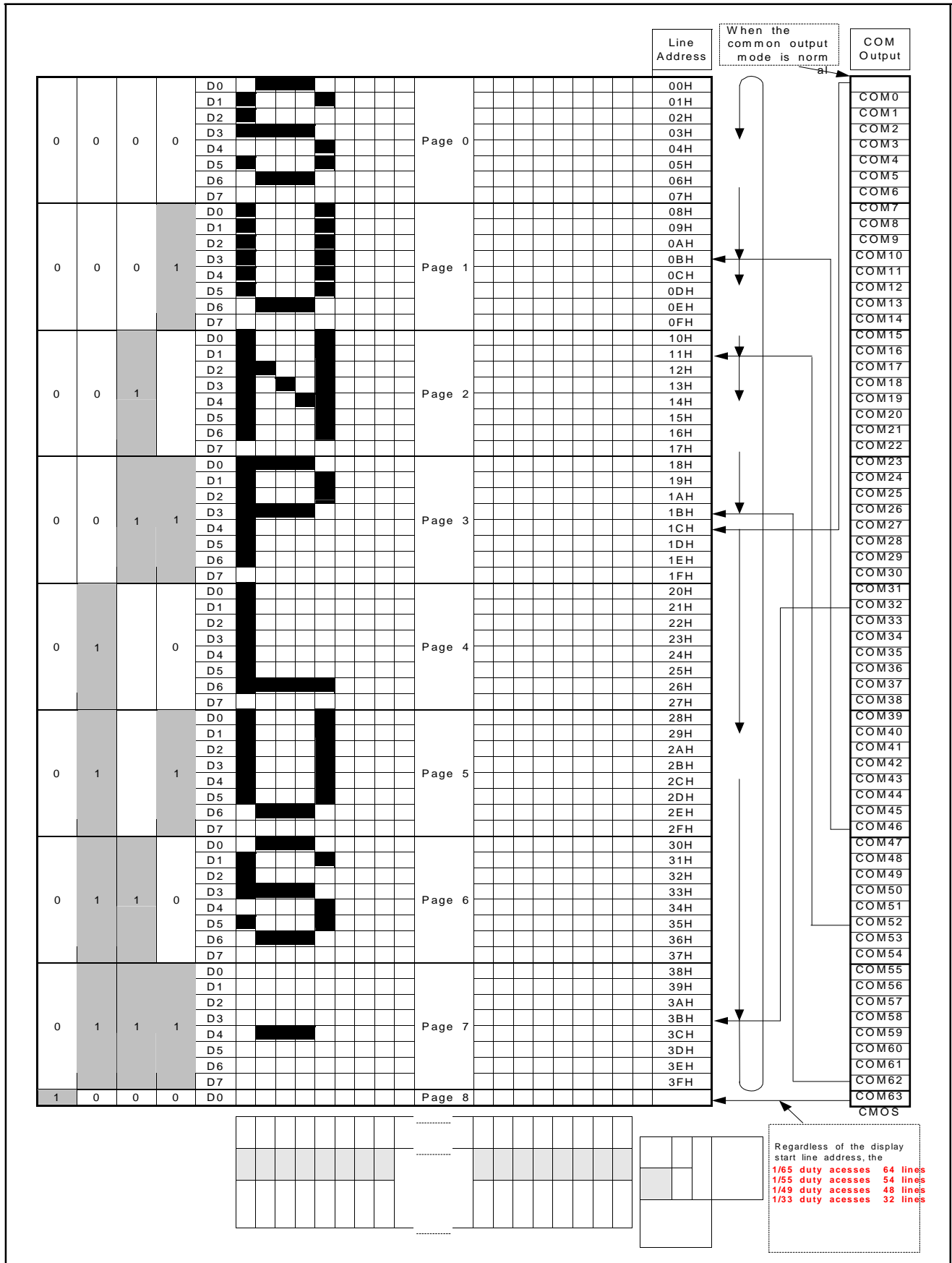
depends ON the page address, it is necessary to re-specify both the page address and the column address when moving, for example, from page 0 column 83H to page 1 column 00H. Furthermore, as is shown in Table 4, the ADC command (segment driver direction select command) can be used to reverse the relationship between the display data RAM column address and the segment output. Because of this, the constraints on the IC layout when the LCD module is assembled can be minimized.

Table 4

SEG Output	SEG0	SEG131
ADC '0'	0 (H) ↗	Column Address ↗ 83(H)
(DB0) '1'	83(H) ↘	Column Address ↘ 0(H)

5.5.4. The line address circuit

The line address circuit, as shown in Figure 4, specifies the line address relating to the COM output when the contents of the display data RAM are displayed. Using the display start line address set command, which is normally the top line of the display can be specified. This is the COM0 output when the common output mode is normal and the COM63 output for SPLC502A when the common output mode is reversed. The display area is a 65-line area for the SPLC502A from the display start line address. If the line addresses are changed dynamically using the display start line address set command, screen scrolling, page swapping ...etc. can be performed.


Figure 4

5.6. The Display Data Latch Circuit

The display data latch circuit temporarily stores the display data that is output to the liquid crystal driver circuit from the display data RAM. Because the display normal/reverse status, display ON/OFF status, and display all points ON/OFF commands control only the data within the latch, they do not change the data within the display data RAM itself.

5.7. The Oscillator Circuit

This is a CR-type oscillator that produces the display clock. The

oscillator circuit is only enabled when MS = 'H' and CLS = 'H'. When CLS = 'L', the oscillation stops, and the display clock is input through the CL terminal.

5.8. The Common Output Status Select

In the SPLC502A chips, the COM output scan direction can be selected by the common output status select command (See Table 5.). Consequently, the constraints in IC layout at the time of LCD module assembly can be minimized.

Table 5

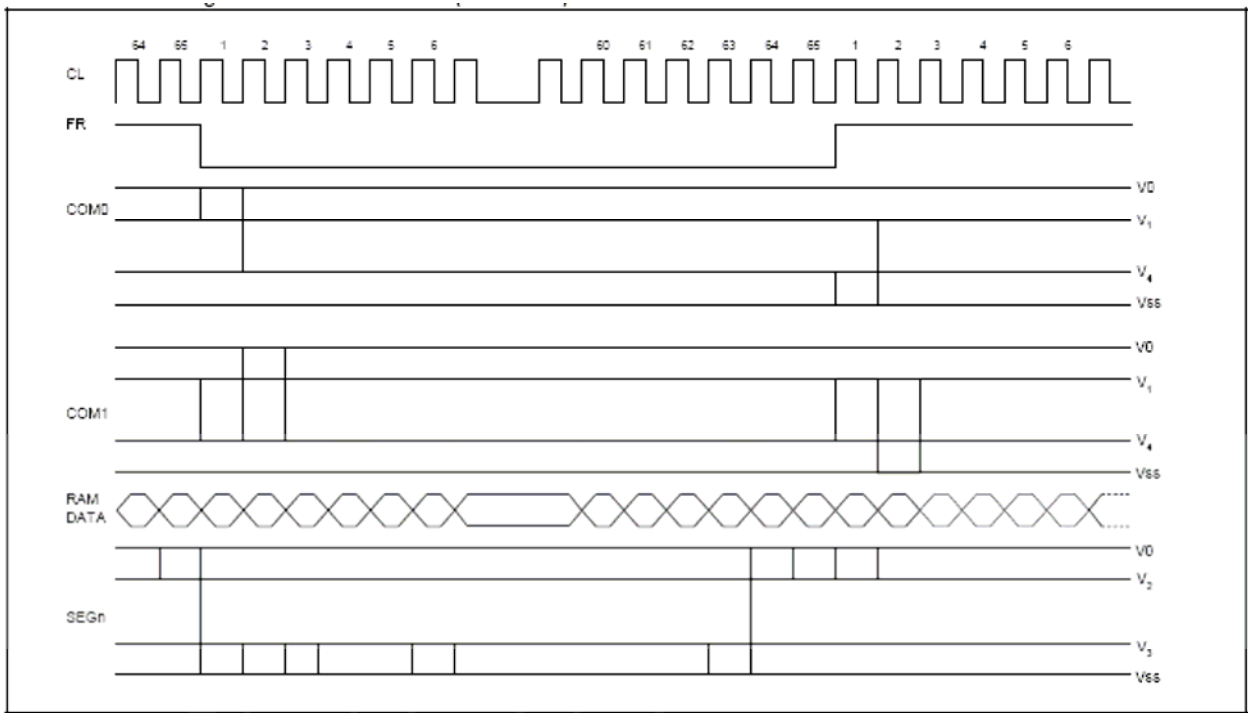
Status	COM Scan Direction			
	1/65 Duty	1/55 Duty	1/49 Duty	1/33 Duty
Normal	COM0 ↔ COM63	COM0 ↔ COM53	COM0 ↔ COM47	COM0 ↔ COM31
Reverse	COM63 ↔ COM0	COM53 ↔ COM0	COM47 ↔ COM0	COM31 ↔ COM0

Duty	Status	Common output nads							COMS
		COM [0:15]	COM [16:23]	COM [24:26]	COM [27:36]	COM [37:39]	COM [40:47]	COM [48:63]	
1/65	Normal	COM [0:63]							COMS
	Reverse	COM [63:0]							
1/55	Normal	COM [0:26]		NC	COM [27:53]				COMS
	Reverse	COM [53:27]		NC	COM [26:0]				
1/49	Normal	COM [0:23]		NC		COM [24:47]			COMS
	Reverse	COM [47:24]		NC		COM [23:0]			
1/33	Normal	COM [0:15]	NC				COM [16:31]		COMS
	Reverse	COM [31:16]	NC				COM [15:0]		

5.9. Display Timing Generator Circuit

The display timing generator circuit generates the timing signal to the line address circuit and the display data latch circuit using the display clock. The display data is latched into the display data latch circuit synchronized with the display clock, and is output to the data driver output terminal. Reading to the display data liquid crystal driver circuits is completely independent of accesses to the display data RAM by the MPU. Consequently, even if the display

data RAM is accessed asynchronously during liquid crystal display, there is absolutely no adverse effect (such as flickering) on the display. Moreover, the display timing generator circuit generates the common timing and the liquid crystal alternating current signal (FR) from the display clock. It generates a drive-wave form using a 2-frame alternating current drive method, as is shown in Figure 5, for the liquid crystal drive circuit.

Two-frame alternating current drive-wave form (SPLC502A)

Figure 5

When multiple SPLC502A chips are used, the slave chips must be supplied the display timing signals (FR, CL, DOF) from the master chip(s). Table 6 shows the status of the FR, CL, and DOF signals.

Table 6

Operating Mode	FR	CL	DOF
Master (MS = 'H'): The internal oscillator circuit is enabled (CLS = 'H')	Output	Output	Output
The internal oscillator circuit is disabled (CLS = 'L')	Output	Input	Output

Operating Mode	FR	CL	DOF
Slave (MS = 'L'): The internal oscillator circuit is enabled (CLS = 'H')	Input	Input	Input
The internal oscillator circuit is disabled (CLS = 'L')	Input	Input	Input

5.10. The Liquid Crystal Driver Circuits

These are a 197-channel (SPLC502A) that generates four voltage levels for driving the liquid crystal. The combination of the display data, the COM scan signals, and the FR signal produces the liquid

crystal drive voltage output. Figure 6 shows examples of the

SEG and COM output waveform.

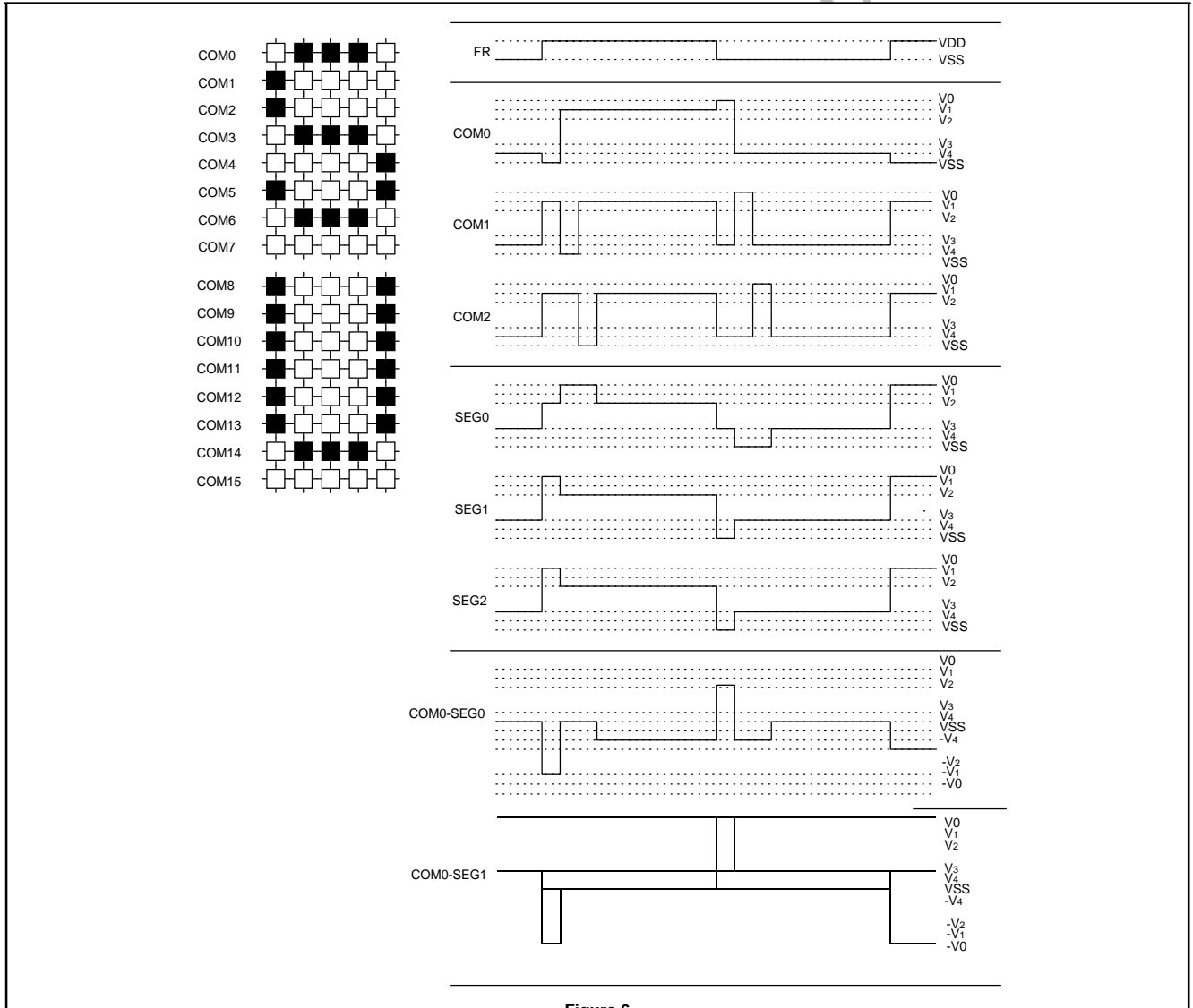


Figure 6

5.11. The Power Supply Circuits

The power supply circuits are low-power consumption power supply circuits that generate the voltage levels for the liquid crystal drivers. They comprise Booster circuits, voltage regulator circuits, and voltage follower circuits. They are only enabled in master operation. The power supply circuits can turn the Booster circuits, the voltage regulator circuits, and the voltage follower circuits ON or OFF independently through the use of the Power Control Set command. Consequently, it is possible to make an external power supply and the internal power supply function in parallel. Table 7 shows the Power Control Set Command 3-bit data control functions, and Table 8 shows reference combinations.

Table 7 The Control Details of Each Bit of the Power Control Set Command

Item	Status	
	'1'	'0'
DB2 Booster circuit control bit	ON	OFF
DB1 Voltage regulator circuit (V regulator circuit) control bit	ON	OFF
DB0 Voltage follower circuit (V/F circuit) control bit	ON	OFF

Table 8 Reference Combinations

Use Settings	DB0	DB1	DB0	Step-up circuit	V regulator circuit	V/F circuit	External voltage input	Step-up Voltage System Terminal
Only the internal power supply is used	1	1	1	O	O	O	VDD2	Used
Only the V regulator circuit and the V/F circuit are used	0	1	1	X	O	O	V _{OUT} , VDD2	Open
Only the V/F circuit is used	0	0	1	X	X	O	V ₀ , VDD2	Open
Only the external power supply is used	0	0	0	X	X	X	V ₀ to V ₄	Open

Note1: The 'step-up system terminals' refer CAP1P, CAP1N, CAP2P, CAP2N, and CAP3N.

Note2: While other combinations, not shown above, are also possible, these combinations are not recommended because they have no practical use.

5.11.1. The step-up voltage circuits

Using the step-up voltage circuits equipped within the SPLC502A chips, it is possible to product a 6 Times, 5 Times, Quad step-up, a Triple step-up, and a Double step-up of the VDD2 - VSS voltage levels.

6 Times step-up: Connect capacitor C1 between CAP1P and CAP1N, between CAP2P and CAP2N, between CAP1N and CAP3N, between CAP2N and CAP4P, between CAP1N and CAP5P, and between VOUT and VSS, to produce a voltage level in the positive direction at the VOUT terminal that is 6 times the voltage level between VDD2 and VSS.

5 Times step-up: Connect capacitor C1 between CAP1P and CAP1N, between CAP2P and CAP2N, between CAP1N and CAP3N, between CAP2N and CAP4P, between VOUT and VSS, short between CAP5P and VOUT, to produce a voltage level in the positive direction at the VOUT terminal that is 4 times the voltage level between VDD2 and VSS.

Quad step-up: Connect capacitor C1 between CAP1P and CAP1N,

between CAP2P and CAP2N, between CAP1N and CAP3N, and between VOUT and VSS, to produce a voltage level in the positive direction at the VOUT terminal that is 4 times the voltage level between VDD2 and VSS.

Triple step-up: Connect capacitor C1 between CAP1P and CAP1N, between CAP2P and CAP2N and between VOUT and VSS, and short between CAP3P and VOUT, to produce a voltage level in the positive direction at the VOUT terminal that is 3 times the voltage difference between VDD2 and VSS.

Double step-up: Connect capacitor C1 between CAP1P and

CAP1N, and between VOUT and VSS, leave CAP2N open, and short between CAP2P and VOUT, to produce a voltage in the positive direction at the VOUT terminal that is twice the voltage between VDD2 and VSS.

The step-up voltage relationships are shown in Figure 7.

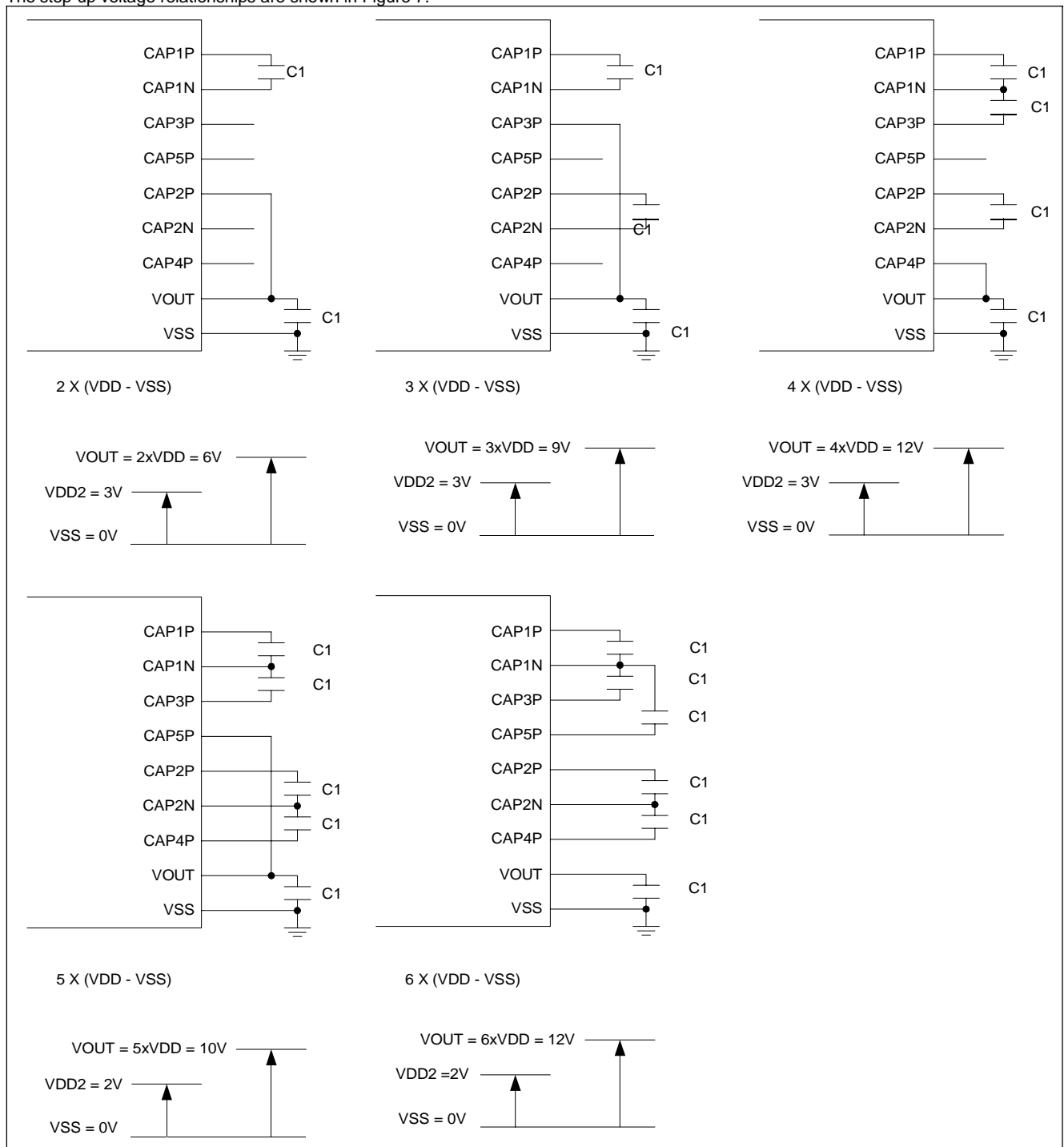


Figure 7

Note: The VDD2 voltage range must be set so that the VOUT terminal voltage does not exceed the absolute maximum rate.

5.11.2. The voltage regulator circuit

The step-up voltage generated at V_{OUT} outputs the liquid crystal driver voltage V₀ through the voltage regulator circuit. Because the SPLC502A chips have an internal high-accuracy fixed voltage power supply with a 64-level electronic volume function and internal resistors for the V₀ voltage regulator, systems can be constructed without having to include high-accuracy voltage regulator circuit components. Moreover, in the SPLC502A, two types of thermal gradients have been prepared as V_{REG} options: (1) approximately -0.05%/°C and (2) external input (supplied to the VRS terminal).

5.11.2.1. When the V₀ voltage regulator internal resistors are used

Through the use of the V₀ voltage regulator internal resistors and the electronic volume function, the liquid crystal power supply voltage, V₀, can be controlled by commands alone (without adding any external resistors), making it possible to adjust the liquid crystal display brightness. The V₀ voltage can be calculated using equation A-1 over the range where |V₀| < |V_{OUT}|.

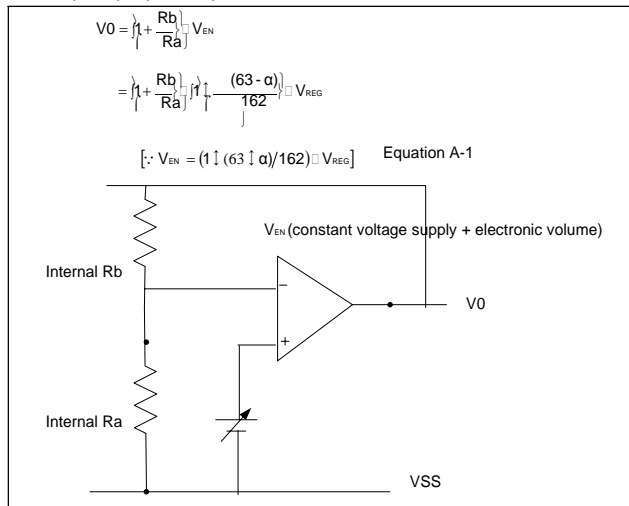


Figure 8

V_{REG} is the IC-internal fixed voltage supply, and its voltage at T_A = 25°C is as shown in Table 9.

Table 9

Equipment Type	Thermal Gradient	Units	VREG	Units
(1) Internal Power Supply	-0.05	[%/°C]	2.1	[V]
(2) External Input	-	-	VRS	[V]

⟨ is set to 1 level of 64 possible levels by the electronic volume function depending on the data set in the 6-bit electronic volume register. Table 10 shows the value for depending on the electronic volume register settings.

Table 10

DB5	DB4	DB3	DB2	DB1	DB0	⟨
0	0	0	0	0	0	0
0	0	0	0	0	1	1
0	0	0	0	1	0	2
:	:	:	:	:	:	:
1	1	1	1	0	1	61
1	1	1	1	1	0	62
1	1	1	1	1	1	63

R_b/R_a is the V₀ voltage regulator internal resistor ratio, and can be set to 8 different levels through the V₀ voltage regulator internal resistor ratio set command. The (1 + R_b/R_a) ratio assumes the values shown in Table 11 depending on the 3-bit data settings in the V₀ voltage regulator internal resistor ratio register.

V₀ voltage regulator internal resistance ratio register value and (1 + R_b/R_a) ratio (Reference value)

Table 11

Register		SPLC502A	
		Equipment Type by Thermal Gradient [Units: %/°C]	
DB2	DB1	(1) -0.05	(2) VREG External Input
0	0	3.0	1.5
0	0	3.5	2.0
0	1	4.0	2.5
0	1	4.5	3.0
1	0	5.0	3.5
1	0	5.5	4.0
1	1	6.0	4.5
1	1	6.5	5.0

**5.11.2.2. When an external resistance is used
(i.e., The V0 Voltage Regulator
Internal
Resistors are not used) (1)**

The liquid crystal power supply voltage V0 can also be set without using the V0 voltage regulator internal resistors (IRS terminal = 'L') by adding resistors Ra' and Rb' between VDD and VR, and between VR and V0, respectively. When this is done, the use of the electronic volume function makes it possible to adjust the brightness of the liquid crystal display by controlling the liquid crystal power supply voltage V0 through commands. In the range where | V0 | < | VOUT |, the V0 voltage can be calculated using equation B-1 based on the external resistance, Ra' and Rb'.

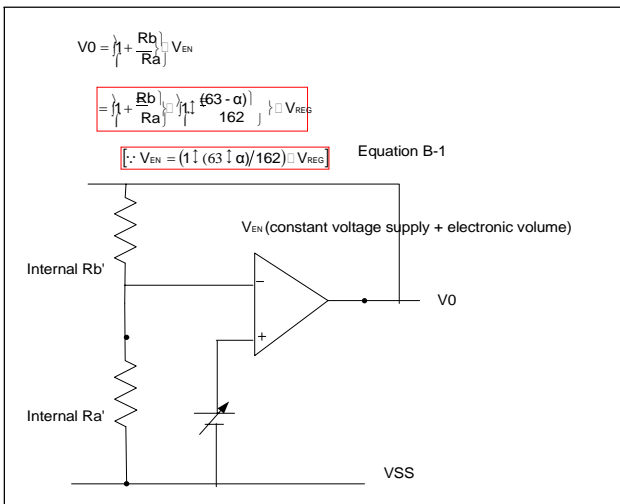


Figure 9

Setup example: When selecting $T_A = 25^\circ\text{C}$ and $V_0 = 7.0\text{V}$ for an SPLC502A model where the temperature gradient = -0.05%/°C. When the central value of the electron volume register is (DB5, DB4, DB3, DB2, DB1, DB0) = (1, 0, 0, 0, 0, 0), then $\alpha = 32$ and

$V_{REG} = 2.1\text{V}$. According to equation B-1:

$$V_0 = \left(1 + \frac{R_{b'}}{R_{a'}}\right) \cdot V_{EN}$$

$$7.0\text{V} = \left(1 + \frac{R_{b'}}{R_{a'}}\right) \cdot \left(1 + \frac{(63 - \alpha)}{162}\right) \cdot (2.1) \quad \text{Equation B-2}$$

Moreover, when the value of the current running through Ra' and Rb' is set to $5\mu\text{A}$,

$$R_{a'} + R_{b'} = 1.4\text{M}\Omega \quad \text{Equation B-3}$$

Consequently, by equations B-2 and B-3,

$$\frac{R_{b'}}{R_{a'}} = 3.12$$

$$R_{a'} = 340\text{k}\Omega$$

$$R_{b'} = 1060\text{k}\Omega$$

At this time, the V0 voltage variable range and notch width, based on the electron volume function, is as given in Table 12.

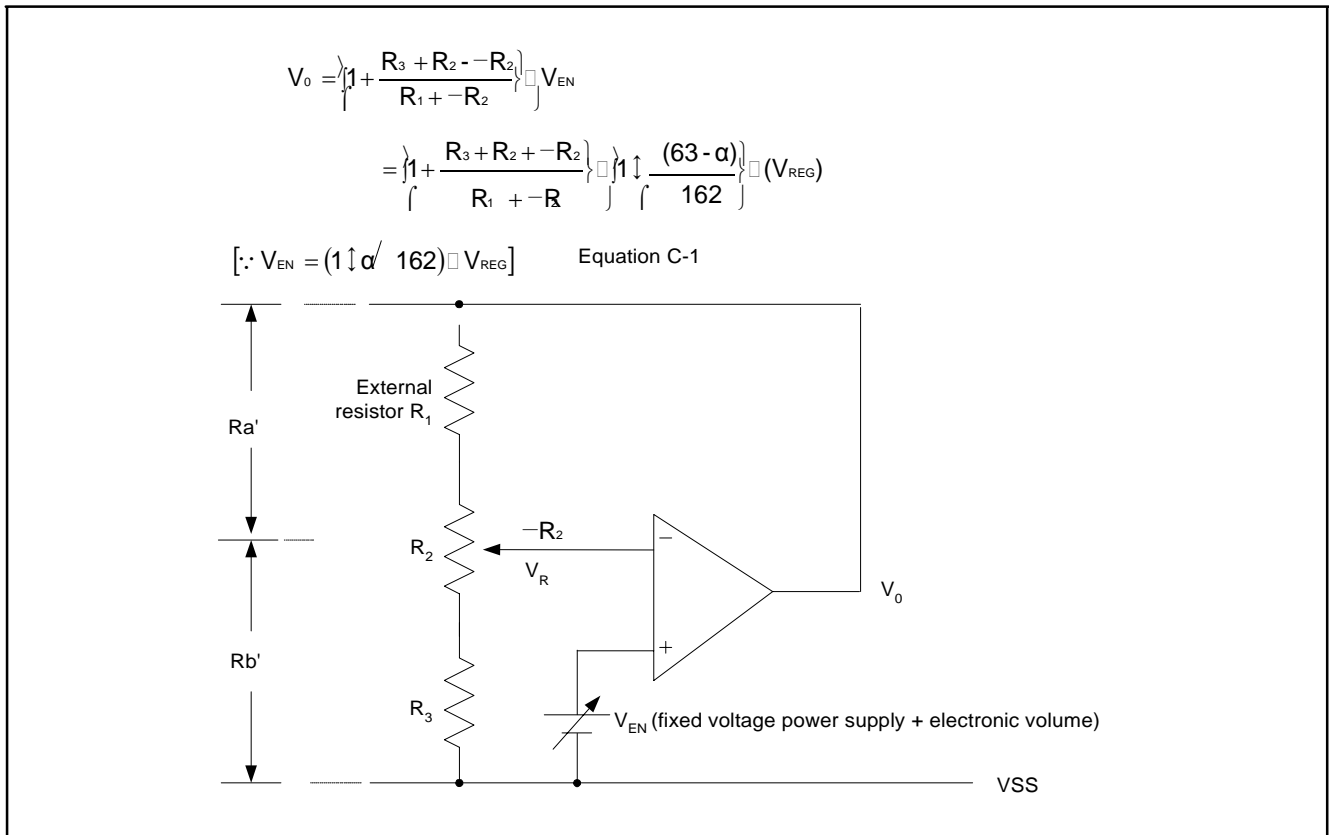
Table 12

V0	Min.	Typ.	Max.	Units
Variable Range	-8.6 (63 levels)	-7.0 (central value)	-5.3 (0 level)	[V]
Notch width	-	52	-	[mV]

**5.11.2.3. When external resistors are used
(i.e. The V0 Voltage Regulator
Internal
Resistors Are Not Used). (2)**

When the external resistor described above are used, adding a variable resistor makes it possible to perform fine adjustments on Ra' and Rb', to set the liquid crystal drive voltage V0. In this case, the use of the electronic volume function makes it possible to control the liquid crystal power supply voltage V0 by commands to adjust the liquid crystal display brightness. In the range where |

$V_0 | < | V_{OUT} |$ the V0 voltage can be calculated by equation C-1 below based on the R1 and R2 (variable resistor) and R3 settings, where R2 can be subjected to fine adjustments (ΔR_2).


Figure 10

Setup example: When selecting $T_A = 25^\circ\text{C}$ and $V_0 = -5.0\text{V}$ to

-9.0V (using R_2) for an SPLC502A model where the temperature gradient = $-0.05\%/^\circ\text{C}$.

When the central value for the electronic volume register is set at (DB5, DB4, DB3, DB2, DB1, DB0) = (1, 0, 0, 0, 0, 0),

$$\alpha = 31$$

$$V_{REG} = -2.1\text{V}$$

so, according to equation C-1, when $\Delta R_2 = 0\Omega$, in order to make $V_0 = -9.0\text{V}$,

$$-9.0\text{V} = \left\{ 1 + \frac{R_3 + R_2}{R_1} \right\} \cdot \left\{ 1 - \frac{31}{162} \right\} \cdot (-2.1) \quad \text{Equation C-2}$$

When $\Delta R_2 = R_2$, in order to make $V = -5.0\text{V}$,

$$-5.0\text{V} = \left\{ 1 + \frac{R_3}{R_1 + R_2} \right\} \cdot \left\{ 1 - \frac{31}{162} \right\} \cdot (-2.1) \quad \text{Equation C-3}$$

Moreover, when the current flowing V_{DD} and V_0 is set to $5\mu\text{A}$,

$$R_1 + R_2 + R_3 = 1.4\text{M}\Omega \quad \text{Equation C-4}$$

With this, according to equation C-2, C-3 and C-4,

$$R_1 = 264\text{k}\Omega$$

$$R_2 = 211\text{k}\Omega$$

$$R_3 = 925\text{k}\Omega$$

At this time, the V_0 voltage variable range and notch width based on the electron volume function is as shown in Table 13.

Table 13

V0	Min.	Tvp.	Max.	Units
Variable	-8.6	-7.0	-5.3	[V]
Range	(63 levels)	(central value)	(0 level)	
Notch width	-	53	-	[mV]

Note1: When the V_0 voltage regulator internal resistors or the electronic volume function is used, it is necessary to at least set the voltage

regulator circuit and the voltage follower circuit to an operating mode using the power control set commands. Moreover, it is necessary to provide a voltage from V_{OUT} when the Booster circuit is OFF.

Note2: The V_R terminal is enabled only when the V_0 voltage regulator internal resistors are not used (i.e. the IRS terminal = 'L'). When

the V_0 voltage regulator internal resistors are used (i.e. when the

IRS terminal = 'H'), the V_R terminal is left open.

Note3: Because the input impedance of the V_R terminal is high, it is necessary to take into consideration short leads, shield cables, etc. to handle noise.

5.11.3. The liquid crystal voltage generator circuit

The V₀ voltage is produced by a resistive voltage divider within the IC, and can be produced at the V₁, V₂, V₃, and V₄ voltage levels required for liquid crystal driving. Moreover, when the voltage follower changes the impedance, it provides V₁, V₂, V₃ and V₄ to the liquid crystal drive circuit. 1/9 bias or 1/7 bias for SPLC502A can be selected.

5.12. High Power Mode

The power supply circuit equipped in the SPLC502A chips has

very low power consumption (normal mode: HPM = 'H'). However, for LCDs or panels with large loads, this low-power power supply may cause display quality to degrade. When this occurs, setting the HPM terminal to 'L' (high power mode) can improve the quality of the display. We recommend that the display be checked on actual equipment to determine whether or not to use this mode. Moreover, if the improvement to the display is inadequate even

after high power mode has been set, it is necessary to add a liquid crystal drive power supply externally.

5.13. The Internal Power Supply Shutdown Command Sequence

The sequence shown in Figure 11 is recommended for shutting down the internal power supply. First place the power supply in power saver mode and then turn the power supply OFF.

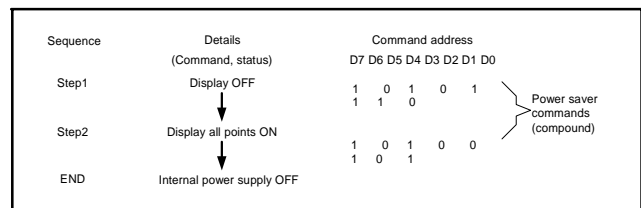


Figure 11

5.14. Reference Circuit Examples (Will be modified)

Figure 12 shows reference circuit examples.

Note: The C2 capacitor of V1, V2, V3 and V4 may not use.

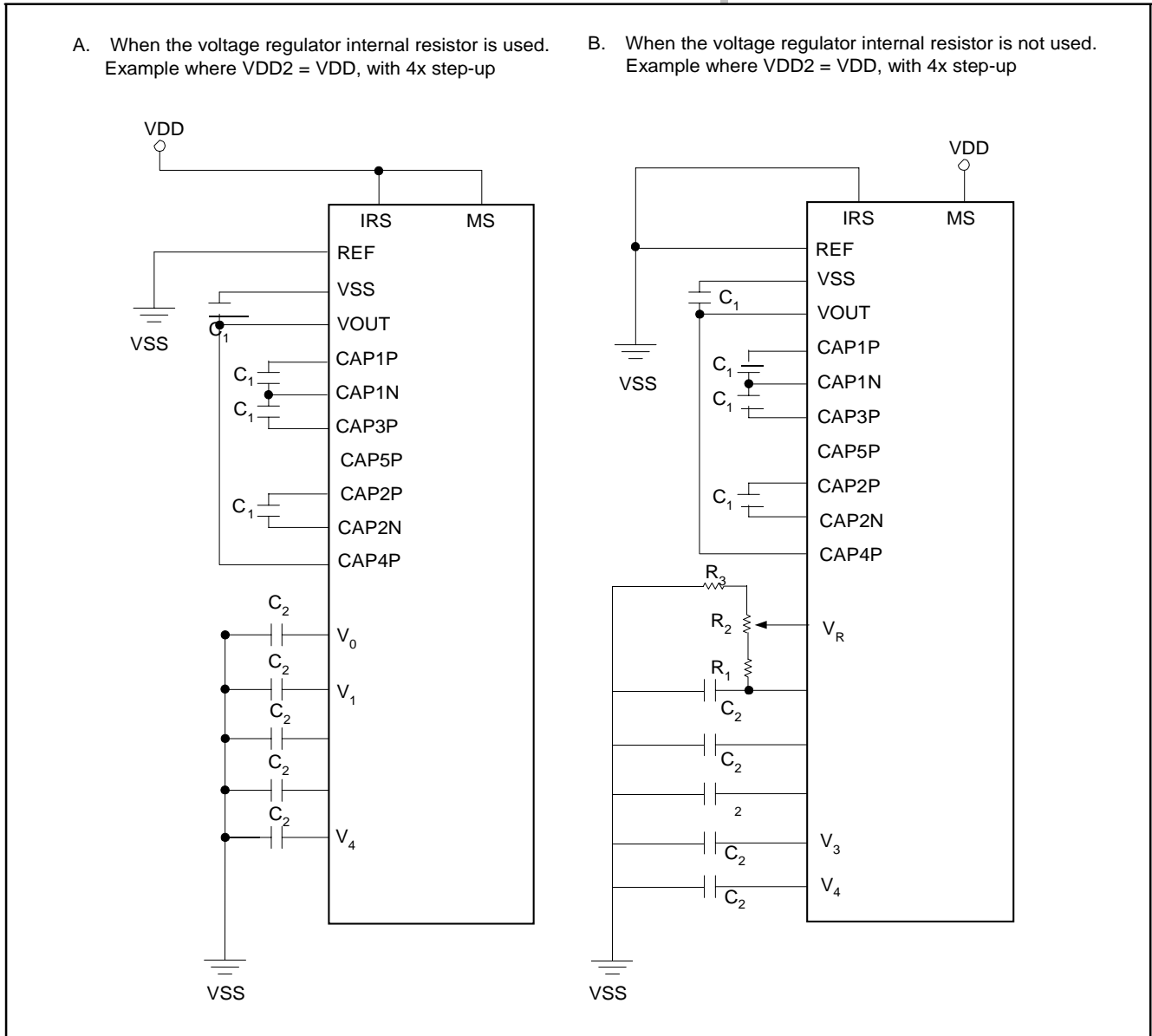
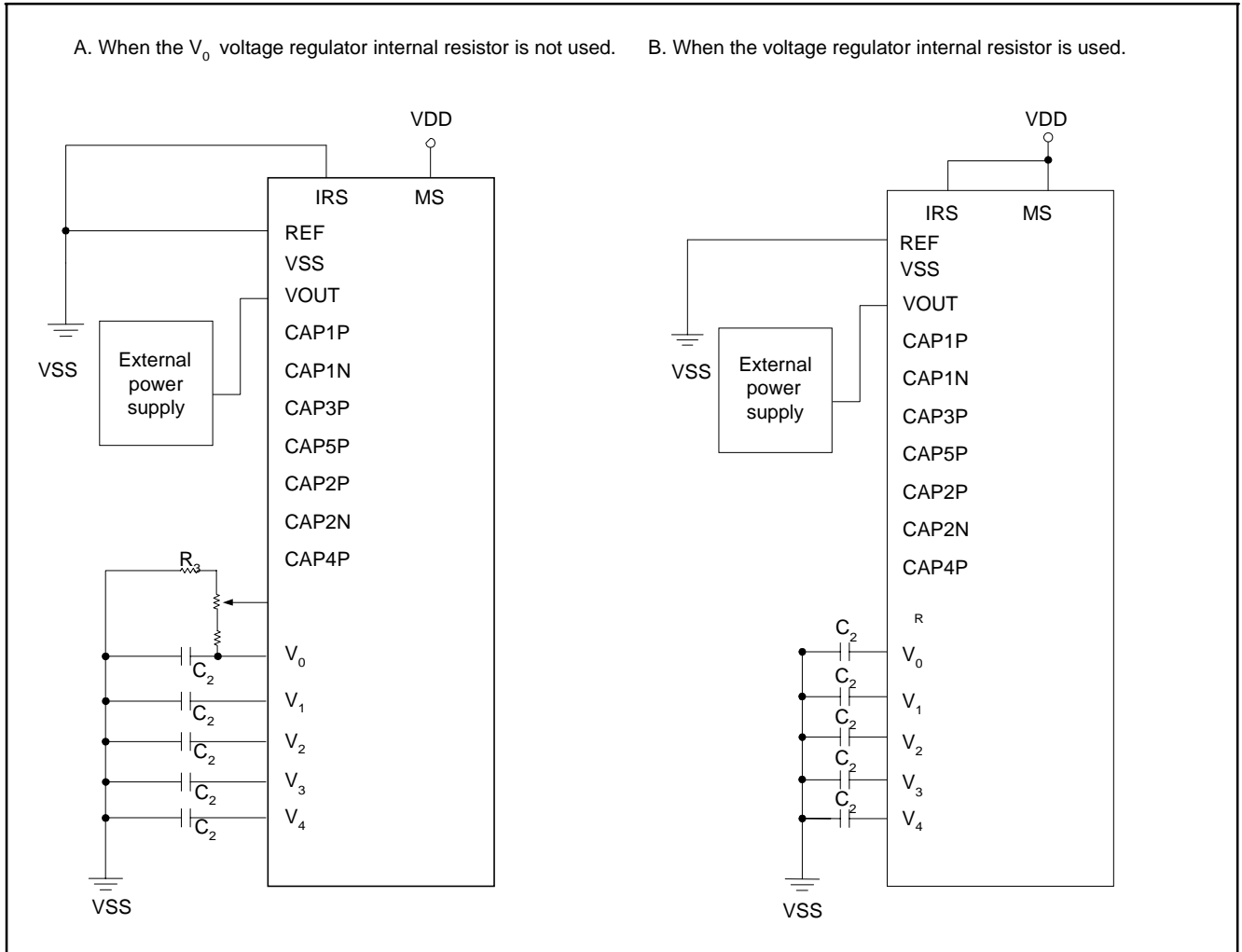
5.14.1.1. When using all of the step-up circuit, voltage regulating circuit and V/F circuit


Figure 12

5.14.1.2. When the voltage regulator circuit and V/F circuit alone are used

Figure 13

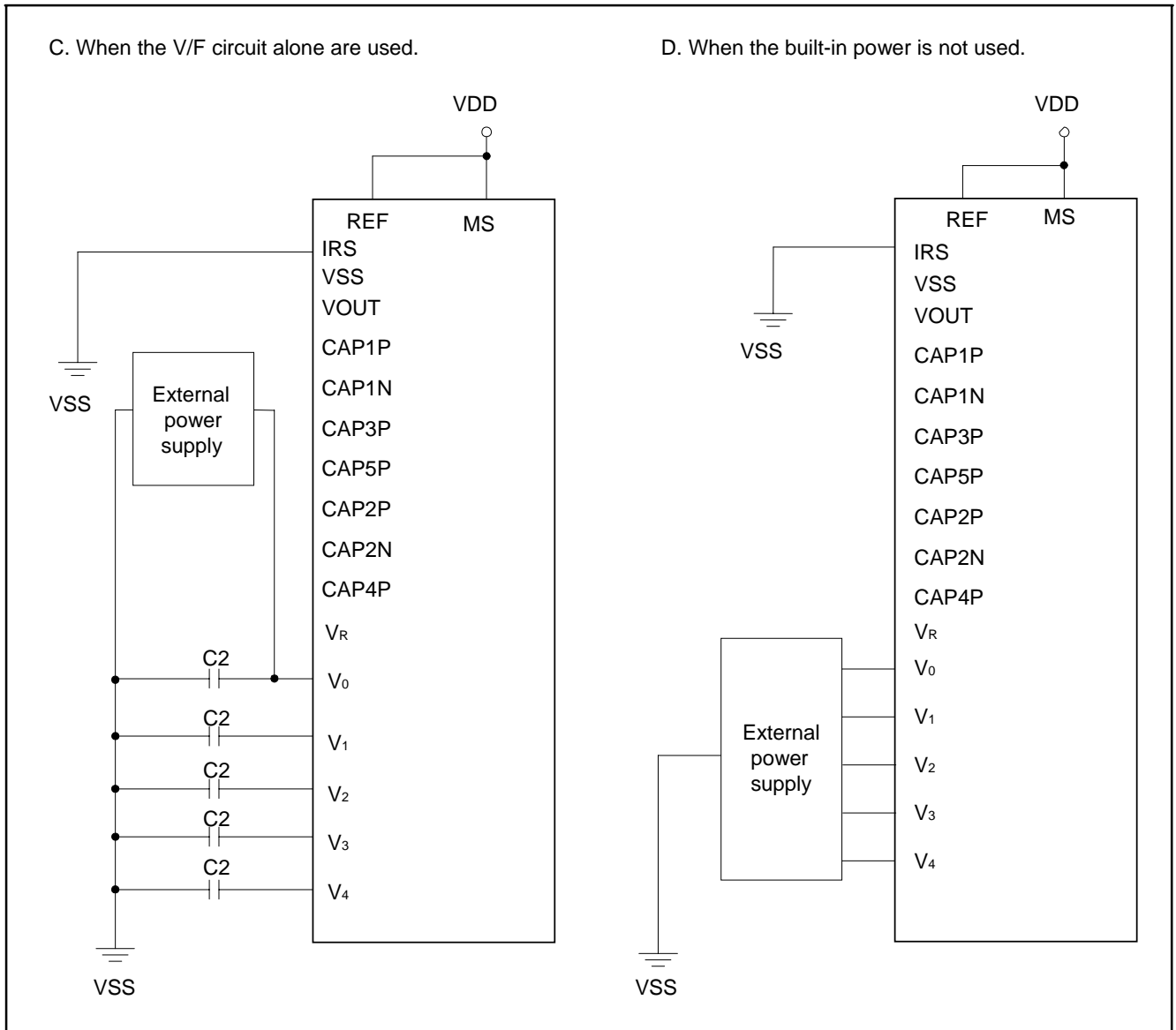


Figure 14

5.15. The Reset Circuit

When the RESET input comes to the 'L' level, these LSIs return to the default state. Their default states are as follows:

- 1). Display OFF
- 2). Normal display
- 3). ADC select: Normal (ADC command DB0 = 'L')
- 4). Power control register: (DB2, DB1, DB0) = (0, 0, 0)
- 5). Serial interface internal register data clear
- 6). LCD power supply bias rate:
SPLC502A.....1/9 bias
- 7). All-indicator lamps-on OFF (All-indicator lamps ON/OFF command DB0 = 'L')
- 8). Power saving clear
- 9). V0 voltage regulator internal resistors, Ra and Rb, are connected.
- 10). Output conditions of SEG and COM terminals
SEG: VSS, COM: VSS
- 11). Read modify write OFF
- 12). Static indicator OFF
Static indicator register: (DB1, DB2) = (0, 0)
- 13). Display start line set to first line
- 14). Column address set to Address 0
- 15). Page address set to Page 0
- 16). Common output status normal
- 17). V0 voltage regulator internal resistor ratio set mode clear
- 18). Electronic volume register set mode clear
Electronic volume register: (DB5, DB4, DB3, DB2, DB1, DB0) = (1, 0, 0, 0, 0, 0)
- 19). Test mode clear
- 20). Driving mode register: (DB7, DB6)=(1, 0)

On the other hand, when the reset command is used, only above default settings from 11 to 19 are executed. When the power is turned on, the IC internal state becomes unstable, and it is necessary to initialize it using the RESET terminal. After

the initialization, each input terminal should be controlled normally. Moreover, when the control signal from the MPU is in the high impedance, an over-current may flow to the IC. After applying a

current, it is necessary to take proper measures to prevent the input terminal from getting into the high impedance state. If the internal liquid crystal power supply circuit is not used on SPLC502A, it is necessary that RESET is 'H' when the external liquid crystal power supply is turned on. This IC has the function to discharge V0 when RESET is 'L,' and the external power

supply short-circuits to VDD when RESET is 'L'. While

RESET is 'L,' the oscillator and the display timing generator stop, and the CL, FR, FRS and DOF terminals are fixed to 'H'. The terminals DB7 - 0 are not affected. The VDD level is output

from the SEG and COM output terminals. It means that an

internal resistor is connected between VDD and V0. When the internal liquid crystal power supply circuit is not used on other models of SPLC502A, it is necessary that RESET is 'L' when the

external liquid crystal power supply is turned on. While RESET is 'L,' the oscillator works, but the display timing generator stops, and the CL, FR, FRS and DOF terminals are fixed to 'H'. The terminals DB7 - 0 are not affected.

6. COMMANDS

The SPLC502A chips identify the data bus signals by a combination of A0P, RD (EP), WR (RWP) signals. Command interpretation and execution do not depend on the external clock, but rather is performed through internal timing only, and thus the processing is fast enough that normally a busy check is not required.

In the 8080 MPU interface, commands are launched by inputting a low pulse to the RD terminal for reading, and inputting a low pulse to the WR terminal for writing. In the 6800 Series MPU interface, the interface is placed in a read mode when a 'H' signal is input to the RWP terminal. It is placed in a write mode when a 'L' signal is input to the RWP terminal. Then, the command is

launched by inputting a high pulse to the EP terminal (See '10. Timing Characteristics' regarding the timing).

Consequently, the 6800 Series MPU interface is different from the 80x86 Series MPU interface in that in the explanation of commands and the display commands the status read and display data read RD (EP) becomes '1(H)'. In the explanations below, the commands are explained using the 8080 Series MPU interface as the example. When the serial interface is selected, the data is inputted in the sequence starting from DB7.

<Explanation of Commands>

6.1. Display ON/OFF

This command turns the display ON and OFF.

AOP	EP	RWP	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	Setting
	RD	WR									
0	1	0	1	0	1	0	1	1	1	1	Display ON
										0	Display OFF

When the display OFF command is executed and when in the display all points ON mode, power saver mode is entered. See the section on the power saver for details.

6.2. Display Start Line Set

This command is used to specify the display start line address of the display data RAM shown in Figure 4. For further details, see the explanation of this function in 'The Line Address Circuit'.

AOP	EP	RWP	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	Line Address
	RD	WR									
0	1	0	0	1	0	0	0	0	0	0	0
					0	0	0	0	0	1	1
					0	0	0	0	1	0	2
								↓			↓
					1	1	1	1	1	0	62
					1	1	1	1	1	1	63

6.3. Page Address Set

This command specifies the page address corresponding to the low address when the MPU accesses the display data RAM (see Figure 4). Specifying the page address and column address enables to access a desired

Changing the page address does not accompany a change in the status display. See the page address circuit in the Function Description (page 12) for the detail.

AOP	EP	RWP	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	Page Address
	RD	WR									
0	1	0	1	0	1	1	0	0	0	0	0
							0	0	0	1	1
							0	0	1	0	2
								↓			↓
							0	1	1	1	7
							1	0	0	0	8

6.4. Column Address Set

This command specifies the column address of the display data RAM shown in Figure 4. The column address is split into two sections (the higher 4 bits and the lower 4 bits) when it is set (fundamentally, set continuously). Each time the display data RAM is accessed, the column address automatically incremented (+1),

making it possible for the MPU to continuously read from/write to the display data. The column address increment is topped at 83H. This does not change the page address continuously. See the function explanation in 'The Column Address Circuit' for details.

		EP RWP																Column Address
		DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	A7	A6	A5	A4					
High bits →	0	1	0	0	0	0	1	A7	A6	A5	A4	0	0	0	0	0	0	0
Low bits →					0	0												1
							0	A3	A2	A1	A0	0	0	0	0	0	0	2
							0		1									↓
												0	0	0		0	0	130
															1	0		↓
																		131

6.5. Status Read

A0P	EP RD	RWP WR	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	1	BUSY	ADC	ON/OFF	RESET	0	0	0	0

BUSY	When BUSY = '1', it indicates that either processing is occurring internally or a reset condition is in process. While the chip does not accept commands until BUSY = '0', if the cycle time can be satisfied, there is no need to check for BUSY condition
ADC	This shows the relationship between the column address and the segment driver. 0: Reverse (column address 131-n [^] SEG n) 1: Normal (column address n [^] SEG n) (The ADC command switches the polarity.)
ON/OFF	ON/OFF: indicates the display ON/OFF state. 0: Display ON 1: Display OFF (This display ON/OFF command switches the polarity.)
RESET	This indicates that the chip is in the process of initialization either because of a RESET signal or because of a reset command. 0: Operating state 1: Reset in progress

6.6. Display Data Write

This command writes 8-bit data to the specified display data RAM address. Since the column address is automatically incremented by one after the write, the MPU can write the display data.

A0P	EP RD	RWP WR	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
1	1	0	Write data							

6.7. Display Data Read

This command reads 8-bit data from the specified display data RAM address. Since the column address is automatically incremented by one after the read, the CPU can continuously read multiple-word data. One dummy read is required immediately after the column address being set. See the function explanation in "Display Data RAM" for the explanation of accessing the internal registers. When the serial interface is used, reading the display data becomes unavailable.

A0P	EP RD	RWP WR	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
1	0	1	Read Data							

6.8. ADC Select (Segment Driver Direction Select)

This command can reverse the correspondence between the display RAM data column address and the segment driver output. Thus, sequence of the segment driver output pins may be reversed by the command. See the column address of bits (page 12) for the detail. Increment of the column address (by '1') accompanying the reading or writing the display data is done according to the column address indicated in Figure 4.

A0P	EP RD	RWP WR	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	Setting
0	1	0	1	0	1	0	0	0	0	0	Normal
										1	Reverse

6.9. Display Normal/Reverse

This command can reverse the lit and unlit display without overwriting the contents of the display data RAM. When this is done, the display data RAM contents are maintained.

A0P	EP RD	RWP WR	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	Setting
0	1	0	1	0	1	0	0	1	1	0	RAM Data 'H' LCD ON voltage (normal)
										1	RAM Data 'L' LCD ON voltage (reverse)

6.10. Display All Points ON/OFF

This command makes it possible to force all display points ON regardless of the content of the display data RAM. The contents of the display data RAM are maintained when this is done. This command takes priority over the display normal/reverse command.

A0P	<u>EP</u> RD	<u>RWP</u> WR	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	Setting
0	1	0	1	0	1	0	0	1	0	0	Normal display mode
										1	Display all points ON

When the display is in an OFF mode, executing the display all points ON command will place the display in power save mode.

For more details, see the Power Save Section.

6.11. LCD Bias Set

This command selects the voltage bias ratio for the liquid crystal display.

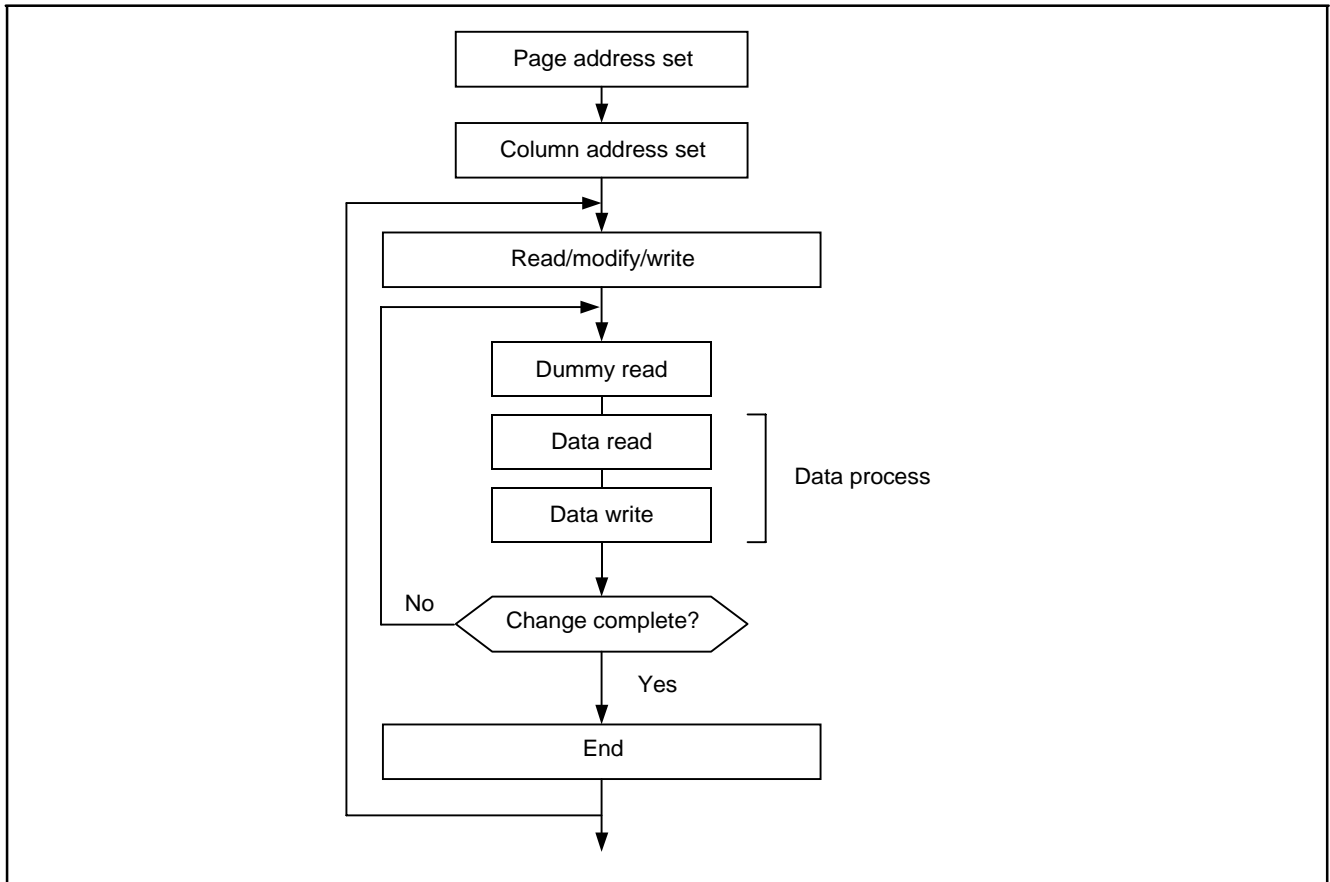
A0P	<u>EP</u> RD	<u>RWP</u> WR	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	Select Status (Duty)			
											1/65	1/55	1/49	1/33
0	1	0	1	0	1	0	0	0	1	0	1/9 bias	1/8 bias	1/8 bias	1/6 bias
										1	1/7 bias	1/6 bias	1/6 bias	1/5 bias

6.12. Read/Modify/Write

This command is used paired with the 'END' command. Once this command has been inputted, the display data read command does not change the column address, but only the display data write command increment (+1) the column address. This mode remains until the END command is inputted. When the END command is inputted, the column address returns to the address at when the read/modify/write command was entered. This function makes it possible to reduce the load on the MPU when there is repeating data changes in a specified display region, such as when there is a blanking cursor.

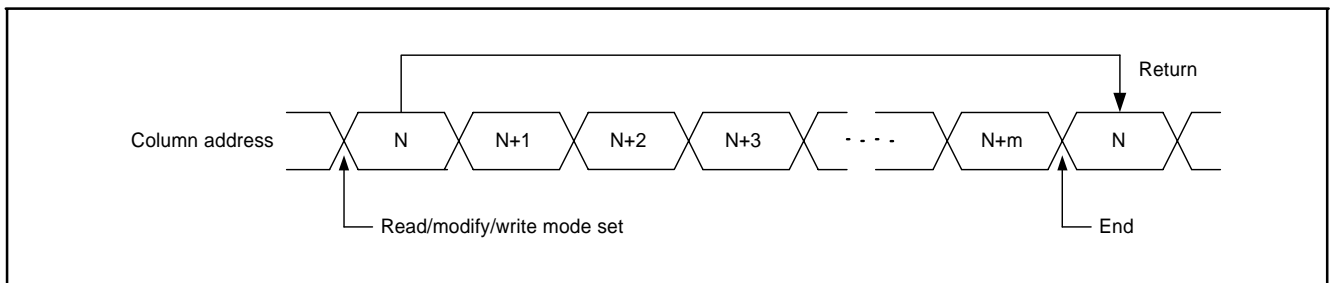
A0P	<u>EP</u> RD	<u>RWP</u> WR	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	1	0	1	1	1	0	0	0	0	0

Note: Even in read/modify/write mode, other commands aside from display data read/write commands can also be used. However, the column address set command cannot be used.

6.12.1. The sequence for cursor display

Figure 15
6.13. END

This command releases the read / modify / write mode, and returns the column address to the address at when the mode was entered.

A0P	EP RD	RWP WR	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	1	0	1	1	1	0	1	1	1	0


Figure 16

6.14. RESET

This command initializes the display start line, the column address, the page address, the common output mode, the V0 voltage regulator internal resistor ratio, the electronic volume, and the static indicator are reset, and the mode are released. There is no impact on the display data RAM. See the function explanation in "Reset" for details. The reset operation is performed after the reset command is entered.

A0P	$\overline{\text{RD}}$	$\overline{\text{WR}}$	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	1	0	1	1	1	0	0	0	1	0

The initialization must be done through applying a reset signal to the $\overline{\text{RESET}}$ terminal when the power supply is applied.

6.15. Common Output Mode Select

This command can select the scan direction of the COM output terminal. For details, see the function explanation in "Common Output Mode Select Circuit".

A0P	$\overline{\text{RD}}$	$\overline{\text{WR}}$	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	Select Status SPLC502A
0	1	0	1	1	0	0	0	*	*	*	Normal
							1				Reverse

Note: *Disabled bit

6.16. Power Controller Set

This command sets the power supply circuit functions. See the function explanation in "The Power Supply Circuit" for more details.

A0P	$\overline{\text{RD}}$	$\overline{\text{WR}}$	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	Selected Mode
0	1	0	0	0	1	0	1	0			Booster circuit: OFF Booster circuit: ON
									0		Voltage regulator circuit :OFF Voltage regulator circuit: ON
									1		
										0	Voltage follower circuit: OFF Voltage follower circuit: ON
										1	

Note: Display off command masks the power control circuits

6.17. V0 Voltage Regulator Internal Resistor Ratio Set

This command sets the V0 voltage regulator internal resistor ratio. For details, see the function explanation in “The Power Supply Circuits”.

A0P	<u>EP</u> RD	<u>RWP</u> WR	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	Setting
0	1	0	0	0	1	0	0	0	0	0	Small
								0	0	1	
								0	1	0	
									↓		
								1	1	0	
								1	1	1	Large

6.18. The Electronic Volume (Double Byte Command)

This command makes it possible to adjust the brightness of the liquid crystal display by controlling the liquid crystal drive voltage V0 through the output from the voltage regulator circuits of the internal liquid crystal power supply. This command is a two bytes command used as a pair with the electronic volume mode set command and the electronic volume register set command, and both commands must be

6.18.1. The electronic volume mode set

When this command is input, the electronic volume register set command becomes enabled. Once the electronic volume mode has been set, no other command except for the electronic volume register command can be used. Once the electronic volume register set command has been used to set data into the register, the electronic volume mode is released.

issued one after the other.

A0P	<u>EP</u> RD	<u>RWP</u> WR	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	1	0	1	0	0	0	0	0	0	1

6.18.2. Electronic volume register set

By using this command to set six bits of data to the electronic volume register, the liquid crystal driving voltage, V0, assumes one of the 64 voltage levels.

When this command is input, the electronic volume mode is released after the electronic volume register has been set.

A0P	<u>EP</u> RD	<u>RWP</u> WR	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	V0
0	1	0	*	*	0	0	0	0	0	1	Small
0	1	0	*	*	0	0	0	0	1	0	
0	1	0	*	*	0	0	0	0	1	1	
							↓				
0	1	0	*	*	1	1	1	1	1	0	
0	1	0	*	*	1	1	1	1	1	1	Large

Note: *Inactive bit

6.18.3. The electronic volume register set sequence

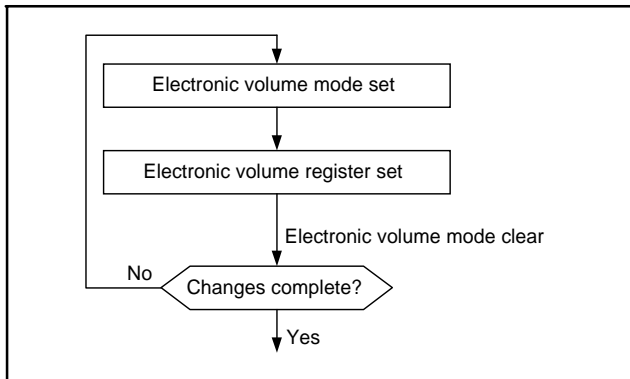


Figure 17

electrodes is connected to the FR terminal, and the other is connected to the FRS terminal. A different pattern is recommended for the static indicator electrodes than for the dynamic drive electrodes. If the pattern is too close, it can result in deterioration of the liquid crystal and of the electrodes. The static indicator ON command is a double byte command paired with the static indicator register set command, and thus one must execute one after the other. The static indicator OFF command is a single byte command.

6.19. Static Indicator (Double Byte Command)

This command controls the static drive system indicator display. The static indicator display is controlled by this command only, and is independent from other display control commands. This

6.19.1. Static indicator ON/OFF

When the static indicator ON command is entered, the static indicator register set command is enabled. Once the static indicator ON command is entered, no other command aside from the static indicator register set command can

is used when one of the static indicator liquid crystal drive be used. This mode is cleared when data is set in the register by the static indicator register set command.

A0P	EP RD	RWP WR	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	Static Indicator
0	1	0	1	0	1	0	1	1	0	0	OFF
										1	ON

6.19.2. Static indicator register set

This command sets two bits of data into the static indicator register, and is used to set the static indicator into a blinking mode.

A0P	EP RD	RWP WR	DB7	DB6	DB5	DB4	DB3	DB2	Static Indicator
0	1	0	*	*	*	*	*	0 0	OFF
			*	*	*	*	*	0 1	ON (blinking at approximately 0.5 second intervals)
			*	*	*	*	*	1 0	ON (blinking at approximately one second intervals)
			*	*	*	*	*	1 1	ON (constantly on)

Note: *Disabled bit

6.20. Page Blinking (Double Byte Command)

6.20.1. The page blinking mode set

A0P	EP RD	RWP WR	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	1	0	1	1	0	1	0	1	0	1

6.20.2. Page blinking register set

Set either bit to '1' will set corresponding PAGE0 - PAGE7 to blink.

A0P	EP		RWP		DB7	DB6	DB5	DB4	DB3	DB2	Blinking Page			
	RD	WR	RD	WR										
0	1	0			1	0	0	0	0	0	0	PAGE 7 blink		
					0	1	0	0	0	0	0	0	0	PAGE 6 blink
					0	0	1	0	0	0	0	0	0	PAGE 5 blink
								↓						
					0	0	0	0	0	0	1	PAGE 0 blink		

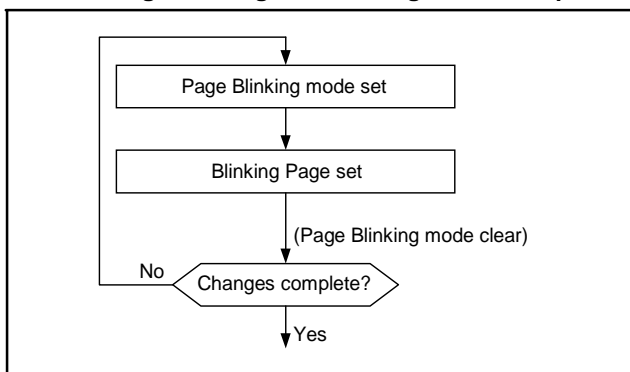
6.20.3. Page blinking indicator register set sequence


Figure 18

6.21. Set Driving Mode (Double Byte Command)

This command makes it possible to reduce the power consumption by instruction command for using different liquid crystal panel. User can select the appropriate mode for their liquid crystal panel and display pattern. The driving capability sequence is Mode1>Mode2>Mode3>Mode4, and so as the current consumption.

6.21.1. The driving mode set

A0P	EP		RWP		DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
	RD	WR	RD	WR								
0	1	0			1	1	0	1	0	0	1	0

6.21.2. Mode selection register set

A0P	EP		RWP		DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	Driving Duty Selection		
	RD	WR	RD	WR											
0	1	0			1	1	0	0	0	0	0	0	0	Mode 1	
					0	0	0	0	0	0	0	0	0	0	Mode 2
					0	1	0	0	0	0	0	0	0	0	Mode 3
					1	0	0	0	0	0	0	0	0	0	Mode 4

Note1: DB5 - DB0 6 bits must fill 0.

Note2: Mode3 (DB7, DB6)=(0,1) is default.

Note3: Driving capability Mode1>Mode2>Mode3>Mode4.

6.22. Power Save (Compound Command)

When the display all points ON is performed while the display is in the OFF mode, the power saver mode is entered and therefore, it reduces a great amount of power. The power saver mode has two different modes: the sleep mode and the standby mode. When the static indicator is OFF, the sleep mode is entered.

When the static indicator is ON, the standby mode is entered. In the sleep mode and standby mode, the display data is saved as is the operating mode that was in effect before the power saver mode was initiated, and the MPU is still able to access the display data RAM. Refer to figure 19 for power save off sequence.

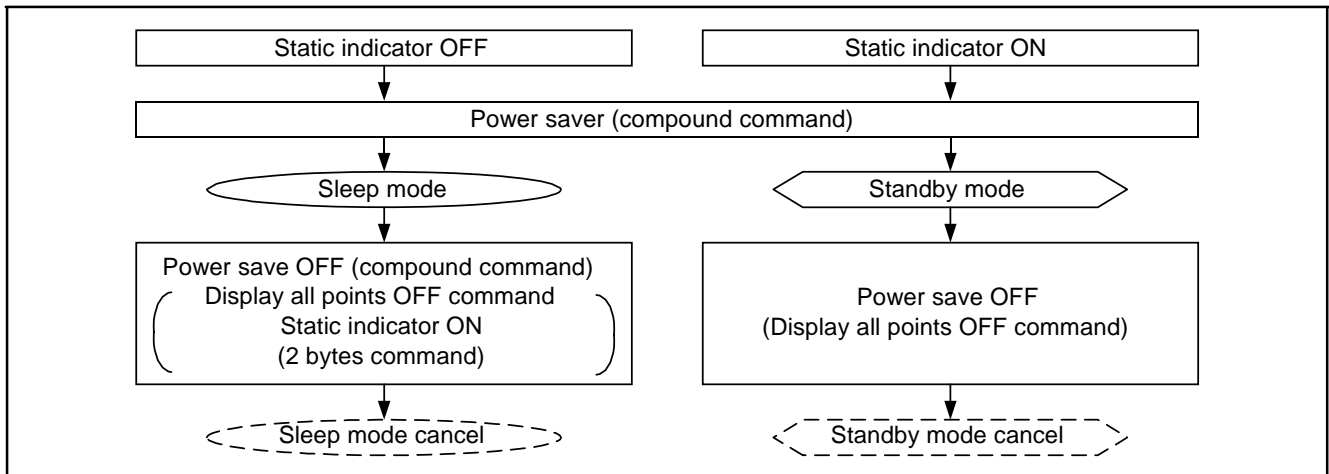


Figure 19

6.22.1. Sleep mode

This stops all operations in the LCD display system, and as long as there are no accesses from the MPU, the consumption current is reduced to a value close to the static current. The internal modes during sleep mode are as follows:

- 1). The oscillator circuit and the LCD power supply circuit are halted.
- 2). All liquid crystal drive circuits are halted, and the segment in common drive outputs output a VDD level.

6.22.2. Standby mode

The duty LCD display system operations are halted and only the static drive system for the indicator continues to operate, providing the minimum required consumption current for the static drive. The internal modes are in the following states during standby mode.

- 1). The LCD power supply circuits are halted. The oscillator circuit continues to operate.
- 2). The duty drive system liquid crystal drive circuits are halted and the segment and common driver outputs a VDD level. The static drive system does not operate.

When a reset command is performed while in standby mode, the system enters sleep mode.

Note1: When an external power supply is used, it is recommended that the functions of the external power supply circuit should be stopped when the power saver mode is started. For example, when the various levels of liquid crystal drive voltage are provided by external resistive voltage dividers, it is recommended that a circuit be added in order to cut the electrical current flowing through the resistive voltage divider circuit when the power saver mode is in effect. The SPLC502A chips have a liquid crystal display blanking control terminal DOF. This terminal enters a 'L' state when the power

saver mode is launched. Using the output of DOF, it is possible to stop the function of an external power supply circuit.

Note2: When the master is turned on, the oscillator circuit is operable immediately after the power on.

6.23. NOP

Non-Operation Command

A0P	EP	RWP	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
	RD	WR								
0	1	0	1	1	1	0	0	0	1	1

6.24. TEST

This is a command for IC chip testing. Please do not use it. applying a 'L' signal to the RESET input by the reset command or by using a NOP.

If the test command is used by accident, it can be cleared by

A0P	EP	RWP	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
	RD	WR								
0	1	0	1	1	1	1	*	*	*	*
0	1	0	1	1	0	1	0	0	1	0
0	1	0	1	1	0	1	0	1	0	0

Note: The SPLC502A chips maintain their operating modes until some conditions occurred to change them. Consequently, excessive external noise, etc., can change the internal modes of the SPLC502A chip. Thus, in the packaging and system design, it is necessary to suppress the noise or take measurement to prevent the noise from influencing the chip. Moreover, it is recommended that the operating modes be refreshed periodically to prevent the effects.

6.25. Table 13 Table of SPLC502A Commands

Command	Command Code										Function	
	A0P	RD	WR	DB7	DB6	DB5	DB4	DB3	DB2	DB1		
1). Display ON/OFF	0	1	0	1	0	1	0	1	1	0	LCD display ON/OFF 0: OFF, 1: ON	
2). Display start line set	0	1	0	0	1	Display start address					Sets the display RAM display start line address	
3). Page address set	0	1	0	1	0	1	1	Page address				Sets the display RAM page address
4). Column address set upper bit	0	1	0	0	0	0	1	Most significant column address				Sets the most significant 4 bits of the display RAM column address.
Column address set lower bit	0	1	0	0	0	0	0	Least significant column address				Set the least significant 4 bits of the display RAM column address.
5). Status read	0	0	1	Status				0	0	0	0	Reads the status data
6). Display data write	1	1	0	Write data							Writes to the display RAM	
7). Display data read	1	0	1	Read data							Reads from the display RAM	
8). ADC select	0	1	0	1	0	1	0	0	0	0	Sets the display RAM address SEG output correspondence	
9). Display normal/reverse	0	1	0	1	0	1	0	0	1	0	Sets the LCD display normal/ reverse 0: normal, 1:reverse	
10). Display all points ON/OFF	0	1	0	1	0	1	0	0	0	0	Display all points 0: normal display 1: all points ON	
11). LCD bias set	0	1	0	1	0	1	0	0	1	0	Sets the LCD driver voltage bias ratio SPLC502A.....0:1/9, 1:1/7	
12). Read/modify/write	0	1	0	1	1	1	0	0	0	0	Column address increment At write: +1 At read: 0	
13). End	0	1	0	1	1	1	0	1	Clear read/modify/write			
14). Reset	0	1	0	1	1	1	0	0	Internal reset			
15). Common output mode select	0	1	0	1	1	0	0	0	0	*	Select COM output scan direction 0: normal direction, 1: reverse direction	
16). Power control set	0	1	0	0	0	1	0	1	Operating mode			Select internal power supply operating mode
17). V0 voltage regulator internal resistor ratio set	0	1	0	0	0	1	0	0	Resistor ratio			Select internal resistor ratio (Rb/R mode)
18). Electronic volume mode set	0	1	0	1	0	0	0	0	0	1	Set the V0 output voltage electronic volume register	
Electronic volume register set	0	1	0	*	*	Electronic volume value						

Command	Command Code										Function	
	A0P	RD	WR	DB7	DB6	DB5	DB4	DB3	DB2	DB1		
19). Static indicator ON/OFF Static indicator Register set				1 1 * *	0 * *	1 * *	0 * *	1 * *	0 * *	1 0 0 1 *	0: OFF, 1: ON Set the flashing mode	
20). Page Blink Page selection	0 0	1 1	0 0	1 P7	1 P6	0 P5	1 P4	0 P3	1 P2	0 P1	1 P0	P7 - 0: 1 - blinking page 0 - no blinking, normal display
21). Driving Mode Set Mode selection	0 0	1 1	0 0	1 D1	1 D0	0 0	1 0	0 0	0 0	1 0	0 0	Set the driving mode register Driving capability (D1, D0): (1,1)>(0,0)>(0,1)>(1,0)
22). Power saver												Display OFF and display all points ON compound command
23). NOP	0	1	0	1	1	1	0	0	0	0	0	Command for non-operation
24). Test	0	1	0	1 1	1 1	1 0	1 1	* 0	* 1	* 0	* 0	Command for IC test. Do not use this command

7. COMMAND DESCRIPTION

7.1. Instruction Setup: Reference (Reference)

7.1.1. Initialization

Note: When the power is applied, LCD driving non-selective potentials V2 and V3 (SEG pin) and V1 and V4 (COM pin) are output through the LCD driving output pins SEG and COM. When electric charge is remaining in the smoothing capacitor connecting between the LCD driving voltage output pins (V0 -) and the VDD pin, the picture on the display may become totally dark instantaneously when the power is turned on. To avoid occurrence of such a failure, we recommend the following flow when turning on the power.

1). When the built-in power is being used immediately after turning on the power:

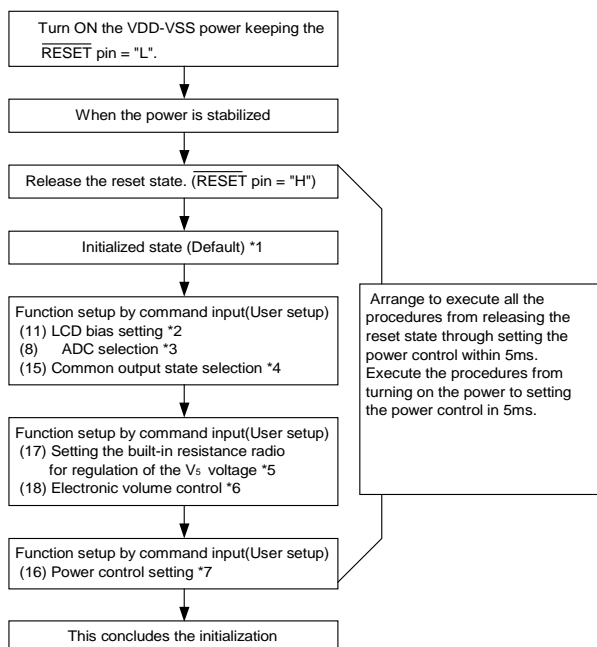


Figure 20

Note1: The target time of 5ms varied depending on the panel characteristics and the capacitance of the smoothing capacitor. Therefore, we suggest users to conduct an operation check using the actual equipment.

Note2: Refer to respective sections or paragraphs listed below.

- *1:Description of functions; Reset circuit
- *2:Command description; LCD bias setting
- *3:Command description; ADC selection
- *4:Command description; Common output state selection
- *5:Description of functions; Power circuit & Command description; Setting the built-in resistance ratio for regulation of the V0 voltage
- *6:Description of functions; Power circuit & Command description; Electronic volume control
- *7:Description of functions; Power circuit & Command description; Power control setting.

2). When the built-in power is not being used immediately after turning on the power:

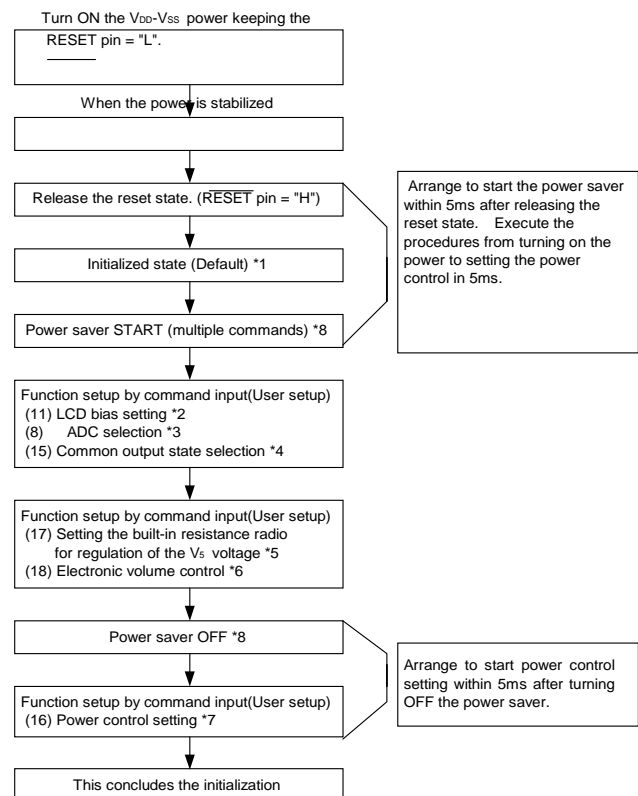
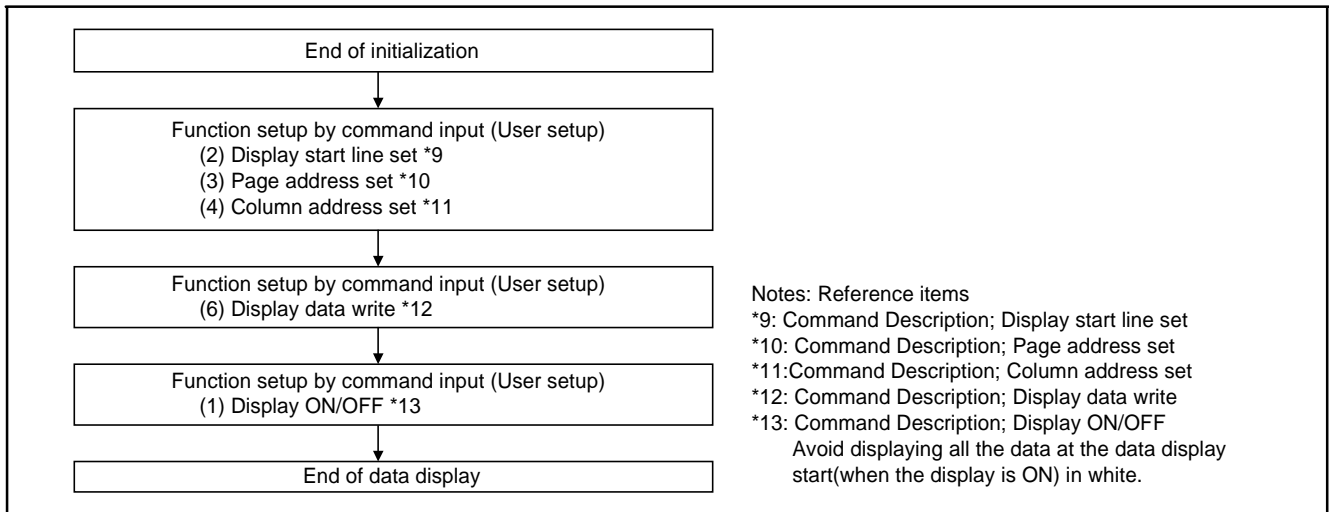
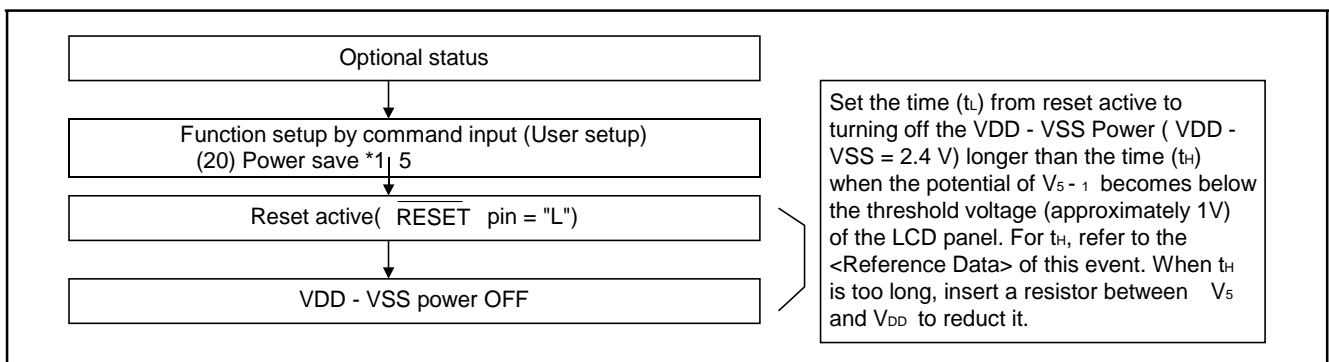


Figure 21

Note1: The target time of 5ms varied depending on the panel characteristics and the capacitance of the smoothing capacitor. Therefore, we suggest users to conduct an operation check using the actual equipment.

Note2: Refer to respective sections or paragraphs listed below.

- *1:Description of functions; Resetting circuit
- *2:Command description; LCD bias setting
- *3:Command description; ADC selection
- *4:Command description; Common output state selection
- *5:Description of functions; Power circuit & Command description; Setting the built-in resistance ratio for regulation of the V0 voltage
- *6:Description of functions; Power circuit & Command description; Electronic volume control
- *7:Description of functions; Power circuit & Command description; Power control setting
- *8:The power saver ON state can either be in sleep state or stand-by state. Command description; Power saver START (multiple commands)

7.1.2. Data display

Figure 22
7.1.3. Power OFF *14

Figure 23
Note: Reference items

*14: The logic circuit of this IC's power supply VDD - VSS controls the driver of the LCD power supply V0. Therefore, if the power supply VDD - VSS is cut off when the LCD power supply V0 has still any residual voltage, the driver (COM, SEG) may output any uncontrolled voltage. When turning off the power, observe the following basic procedures:

- After turning off the internal power supply, make sure that the potential V_{0-1} has become below the threshold voltage of the LCD panel, and then turn off this IC's power supply (VDD - VSS).

Refer to "6. Description of Function, Power Circuit" for more information.

*15: After inputting the power save command, be sure to reset the function using the RESET terminal until the power supply VDD - VSS is turned off. Refer to "7. Command Description, (20) Power Save" for more information.

8. ELECTRICAL SPECIFICATIONS

8.1. Absolute Maximum Ratings

(Unless otherwise noted, VSS = 0V)

Parameter		Symbol	Conditions	Unit
Power Supply Voltage		VDD	-0.3 to + 3.6	V
Power supply voltage (2) (VDD standard)		VDD2	3.6 to +0.3	V
	With Triple step-up		3.6 to +0.3	
	With Quad step-up		3.0 to +0.3	
Power supply voltage (3) (VDD standard)		V0, VLCD	12.0 to +0.3	V
Power supply voltage (4) (VDD standard)		V1, V2, V3, V4	V0 to +0.3	V
Input voltage		VIN	-0.3 to VDD +0.3	V
Output voltage		VO	-0.3 to VDD +0.3	V
Operating temperature		TOPR	-40 to +85	°C
Storage temperature	Bare chip	TSTR	-55 to +125	°C

Notes and Cautions:

- The VDD2, V0 to V4 and VOUT are relative to the VSS = 0V reference.
- Insure that the voltage levels of V0, V1, V2, V3, and V4 are always such that $V_0 \geq V_1 \geq V_2 \geq V_3 \geq V_4 \geq VSS(\text{GND})$
- Permanent damage to the LSI may result if the LSI is used outside of the absolute maximum ratings. Moreover, it is recommended that in normal operation the chip be used at the electrical characteristic conditions, and use of the LSI outside of these conditions may not only result in malfunctions of the LSI, but may have a negative impact on the LSI reliability as well.

8.2. DC Characteristics

(Unless otherwise specified, VSS = 0V, VDD = 3.0V±10%, TA = 25°C)

Item		Symbol	Condition		Rating			Units	Applicable PIN
					Min.	Tvp.	Max.		
Operating Voltage (1)	Recommended Voltage	VDD			1.8	-	3.6	V	VDD*1
Operating Voltage (2)	Recommended Voltage	VDD2	(Relative to VSS)		1.8	-	3.6	V	VDD2
Operating Voltage (3)	Possible Operating Voltage	V0	(Relative to VSS)		4.0	-	12.0	V	V0*2
High-level Input Voltage		V _{IHC}			0.8 x VDD	-	VDD	V	*3
Low-level Input Voltage		V _{ILC}			VSS	-	0.2 x VDD	V	*3
High-level Input Voltage		V _{OHC}	I _{OH} = -0.5mA		0.8 x VDD	-	VDD	V	*4
Low-level Input Voltage		V _{OLC}	I _{OL} = 0.5mA		VSS	-	0.2 x VDD	V	*4
Input leakage current		I _{LI}	V _{IN} = VDD or VSS		-1.0	-	1.0	αA	*5
Output leakage current		I _{LO}			-3.0	-	3.0	αA	*6
Liquid Crystal Driver ON Resistance		R _{ON}	TA = 25°C	V0 = 12V	-	2.0	3.5	K&	SEGN
			(Relative To VSS)	V0 = 8.0V	-	3.2	5.4		COMn*7
Static Consumption Current		I _{SSQ}			-	0.01	5.0	αA	VDD, VDD2
Output Leakage Current		I _{OQ}	V0 = 12V (Relative to VSS)		-	0.01	15	αA	V0
Input Terminal Capacitance		C _{IN}	TA = 25°C	f = 1.0MHz	-	5.0	8.0	pF	
Oscillator Frequency	Internal Oscillator	f _{OSC}	1/65 duty	TA = 25°C	17	20	23	KHz	*8
	External Input	f _{CL}	1/33 duty		17	20	23	KHz	CL
	Internal Oscillator	f _{OSC}	1/55 duty	TA = 25°C	28	33	38	KHz	*8
	External Input	f _{CL}	1/49 duty		28	33	38	KHz	CL

Item	Symbol	Condition		Rating			Units	Application PIN
				Min.	Tvp.	Max.		
Input Voltage	VDD2	With Triple (Relative to VSS)		1.8	-	4.0	V	VDD2
	VDD2	With Quad (Relative to VSS)		1.8	-	3.0	V	VDD2
Supply Setup-up output voltage Circuit	V _{OUT}	(Relative to VSS)		-	-	13.0	V	V _{OUT}
Voltage regulator Circuit Operating Voltage	V _{OUT}	(Relative to VSS)		4.0	-	13.0	V	V _{OUT}
Voltage Follower Circuit Operating Voltage	V _O	(Relative to VSS)		4.0	-	12.0	V	V _O *9
Base Voltage	V _{REG0}	T _A = 25°C (Relative to VSS)	-0.05%/°C	2.08	2.1	2.12	V	*10

8.3. Display Pattern OFF

 (T_A = 25°C)

Item	Symbol	Condition	Rating			Units	Notes
			Min.	Tvp.	Max.		
SPLC502A	I _{DD} (1)	VDD = 3.0V, V _O - VSS = 11V	-	TBD	TBD	αA	*11

Dynamic Consumption Current (1), During Display, with the Internal Power Supply OFF.
 Current consumed by total ICs when an external power supply is used.

8.4. Display Pattern Checker

 (T_A = 25°C)

Item	Symbol	Condition	Rating			Units	Notes
			Min.	Tvp.	Max.		
SPLC502A	I _{DD} (1)	VDD = 3.0V, V _O - VSS = 11V	-	TBD	TBD	αA	*11

Dynamic Consumption Current (1), During Display, with the Internal Power Supply OFF.
 Current consumed by total ICs when an external power supply is used.

8.5. Display Pattern Checker

 (T_A = 25°C)

Item	Symbol	Condition	Rating			Units	Notes
			Min.	Tvp.	Max.		
SPLC502A	I _{DD(2)}	VDD = 3.0V, Quad step-up voltage. V0 =	Normal Mode	-	75	TBD	αA
			High-Power Mode	-	TBD	TBD	

Dynamic Consumption Current (2), During Display, with the Internal Power Supply ON

Item	Symbol	Condition	Rating			Units	Notes
			Min.	Tvp.	Max.		
Sleep Mode SPLC502A	I _{DDs1}	-	-	0.01	5.0	αA	

Item		f _{CL}	f _{FB}
1/65 DUTY *8	When the internal oscillator circuit is used (20KHz)	f _{OSC} / 4	f _{OSC} / (4 * 65)
	When the internal oscillator circuit is not used	External input (f _{CL})	f _{CL} / 260
1/55 DUTY *8	When the internal oscillator circuit is used (33KHz)	f _{OSC} / 8	f _{OSC} / (8 * 55)
	When the internal oscillator circuit is not used	External input (f _{CL})	f _{CL} / 220
1/49 DUTY *8	When the internal oscillator circuit is used (33KHz)	f _{OSC} / 8	f _{OSC} / (8 * 49)
	When the internal oscillator circuit is not used	External input (f _{CL})	f _{CL} / 196
1/33 DUTY *8	When the internal oscillator circuit is used (20KHz)	f _{OSC} / 8	f _{OSC} / (8 * 33)
	When the internal oscillator circuit is not used	External input (f _{CL})	f _{CL} / 264

References for items market with *

*1 While a broad range of operating voltages is guaranteed, performance cannot be guaranteed if there are sudden fluctuations to the voltage while the MPU is being accessed.

*2 The operating voltage range for the VDD system and the V0 system is applied when the external power supply is being used.

*3 The A0P, DB0 to DB5, DB6 (SCL), DB7 (SI), RD (EP), WR (RWP), CS1, CS2, CLS, CL, FR, MS, C86, PS, DOF, RES, IRS, and HPM terminals.

*4 The DB0 to DB7, FR, FRS, DOF, and CL terminals.

*5 The A0P, RD (EP), WR (RWP), CS1, CS2, CLS, MS, C86, PS, RES, IRS, and HPM terminals.

*6 Applies when the DB0 to DB5, DB6 (SCL), DB7 (SI), CL, FR, and DOF terminals are in a high impedance state.*7 These are the resistance values for when a 0.1V voltage is applied between the output terminal SEGn or COMn and the various power supply terminals (V₁, V₂, V₃, and V₄). These are specified for the operating voltage (3) range.

R_{ON} = 0.1V / ΔI (Where ΔI is the current that flows when 0.1V is applied while the power supply is ON.)

*8 The relationship between the oscillator frequency and the frame rate frequency.

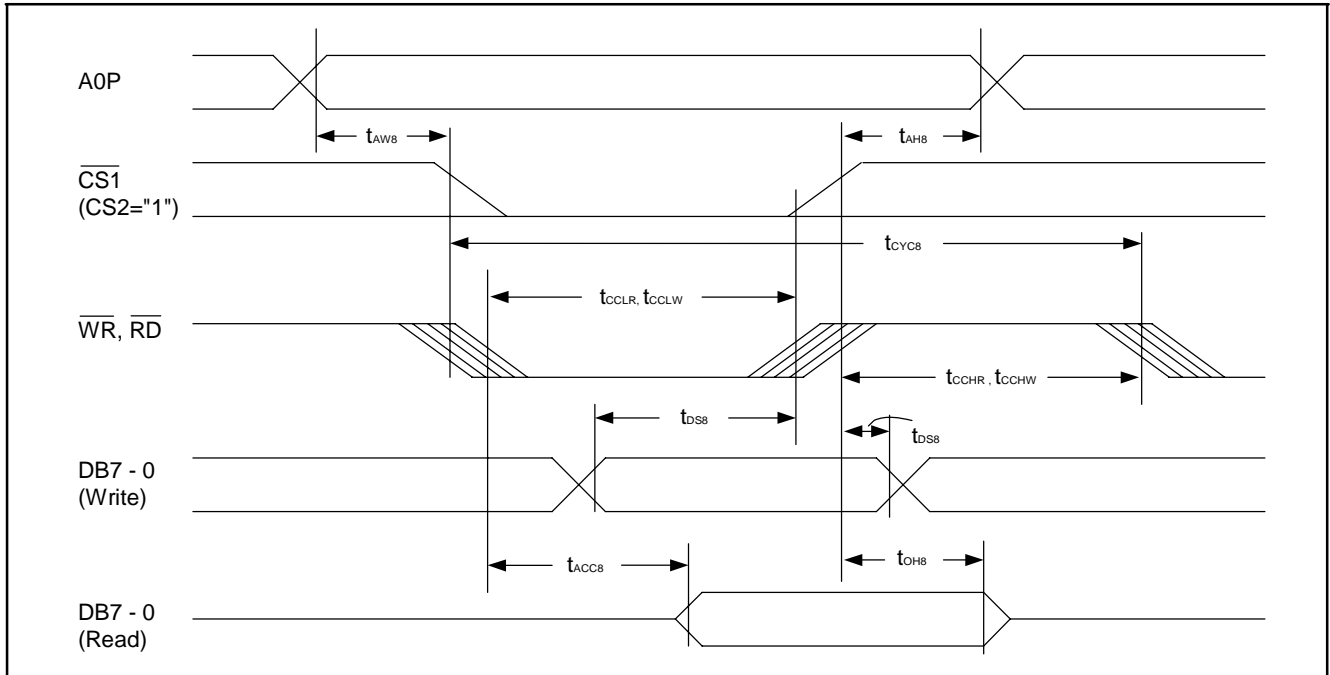
*9 The V0 voltage regulator circuit regulates within the operating voltage range of the voltage follower.

*10 This is the internal voltage reference supply for the V0 voltage regulator circuit. In the SPLC502A, the temperature range can come in three types as VREG options: (1) approximately -0.05%/C, and (2) external input.

*11, 12 It indicates the current consumed on ICs alone when the internal oscillator circuit and display are turned on.

The SPLC502A is 1/9 biased. Does not include the current due to the LCD panel capacity and wiring capacity. Applicable only when there is no access from the MPU.

*12 It is the value on a model having the V_{REG} option temperature gradient is -0.05%/C when the V0 voltage regulator internal resistor is used.

8.6. Timing Characteristics
8.6.1. System bus read/write characteristics 1 (For the 8080 Series MPU)

 (VDD = 3.3V to 3.6V, T_A = 25°C)

Item	Signal	Symbol	Condition	Rating		Units
				Min.	Max.	
Address hold time	A0P	t _{AH8}		0	-	ns
Address setup time	A0P	t _{AW8}		0	-	ns
System cycle time	A0P	t _{CYC8}		240	-	ns
Control L pulse width (<u>WR</u>)	<u>WR</u>	t _{CCLW}		80	-	ns
Control L pulse width (<u>RD</u>)	<u>RD</u>	t _{CCLR}		80	-	ns
Control H pulse width (<u>WR</u>)	<u>WR</u>	t _{CCHW}		80	-	ns
Control H pulse width (<u>RD</u>)	<u>RD</u>	t _{CCHR}		80	-	ns
Data setup time	DB7 - 0	t _{DS8}		30	-	ns
Address hold time		t _{DH8}		10	-	ns
RD access time		t _{ACC8}	C _L = 100pF	-	70	ns
Output disable time		t _{OH8}		5.0	50	ns

(VDD = 2.7V to 3.2V, T_A = 25°C)

Item	Signal	Symbol	Condition	Rating		Units
				Min.	Max.	
Address hold time	A0P	t _{AH8}		0	-	ns
Address setup time		t _{AW8}		0	-	ns
System cycle time	A0P	t _{CYCB}		400	-	ns
Control L pulse width (\overline{WR})	\overline{WR}	t _{CCLW}		100	-	ns
Control L pulse width (\overline{RD})	\overline{RD}	t _{CCLR}		100	-	ns
Control H pulse width (\overline{WR})	\overline{WR}	t _{CCHW}		100	-	ns
Control H pulse width (\overline{RD})	\overline{RD}	t _{CCHR}		100	-	ns
Data setup time	DB7 - 0	t _{DSB}		40	-	ns
Address hold time		t _{DHR}		15	-	ns
RD access time		t _{ACCB}	C _L = 100pF	-	140	ns
Output disable time		t _{OHR}		10	100	ns

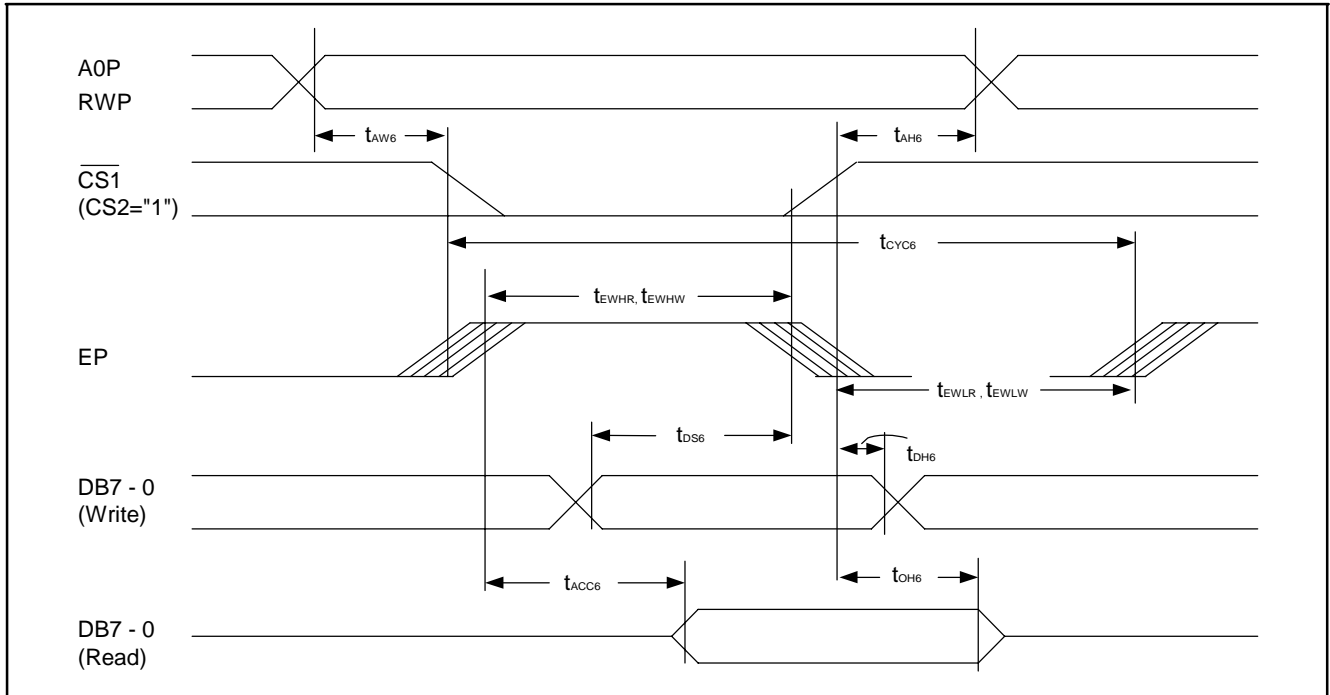
(VDD = 1.8V to 2.6V, T_A = 25°C)

Item	Signal	Symbol	Condition	Rating		Units
				Min.	Max.	
Address hold time	A0P	t _{AH8}		0	-	ns
Address setup time		t _{AW8}		0	-	ns
System cycle time	A0P	t _{CYCB}		640	-	ns
Control L pulse width (\overline{WR})	\overline{WR}	t _{CCLW}		200	-	ns
Control L pulse width (\overline{RD})	\overline{RD}	t _{CCLR}		200	-	ns
Control H pulse width (\overline{WR})	\overline{WR}	t _{CCHW}		200	-	ns
Control H pulse width (\overline{RD})	\overline{RD}	t _{CCHR}		200	-	ns
Data setup time	DB7 - 0	t _{DSB}		80	-	ns
Address hold time		t _{DHR}		30	-	ns
RD access time		t _{ACCB}	C _L = 100pF	-	280	ns
Output disable time		t _{OHR}		10	200	ns

Note1: The input signal rise time and fall time (t_r, t_f) is specified at 15 ns or less. When the system cycle time is extremely fast, (t_r + t_f) ≤ (t_{CYCB} - t_{CCLW} - t_{CCHW}) for (t_r + t_f) ≤ (t_{CYCB} - t_{CCLR} - t_{CCHR}) are specified.

Note2: All timing is specified using 20% and 80% of VDD as the reference.

Note3: t_{CCLW} and t_{CCLR} are specified as the overlap between CS1 being 'L' (CS2 = 'H') and \overline{WR} and \overline{RD} being at the 'L' level.

8.6.2. System bus read/write characteristics 2 (6800 series MPU)


(VDD = 3.3V to 3.6V, T_A = 25°C)

Item	Signal	Symbol	Condition	Rating		Units
				Min.	Max.	
Address hold time	A0P	t _{AH6}		0	-	ns
Address setup time	A0P	t _{AW6}		0	-	ns
System cycle time	A0P	t _{CYC6}		240	-	ns
Data setup time	DB7 - 0	t _{DS6}	C _L = 100pF	30	-	ns
Data hold time		t _{DH6}		10	-	ns
Access time	DB7 - 0	t _{ACC6}		-	70	ns
Output disable time		t _{OH6}		10	50	ns
Enable H pulse time	Read	EP	t _{EWHR}	80	-	ns
	Write		t _{EWHW}	80	-	ns
Enable L pulse time	Read	EP	t _{EWLR}	80	-	ns
	Write		t _{EWLW}	80	-	ns

(VDD = 2.7V to 3.2V, T_A = 25°C)

Item	Signal	Symbol	Condition	Ratio		Units
				Min.	Max.	
Address hold time	A0P	t _{AH6}		0	-	ns
Address setup time		t _{AW6}		0	-	ns
System cycle time	A0P	t _{CYC6}		400	-	ns
Data setup time	DB7 - 0	t _{DS6}	C _L = 100pF	40	-	ns
Data hold time		t _{DH6}		15	-	ns
Access time		t _{ACC6}		-	140	ns
Output disable time		t _{OH6}		10	100	ns
Enable H pulse time	Read	EP	t _{EWHR}	100	-	ns
	Write		t _{EWHW}	100	-	ns
Enable L pulse time	Read	EP	t _{EWLR}	100	-	ns
	Write		t _{EWLW}	100	-	ns

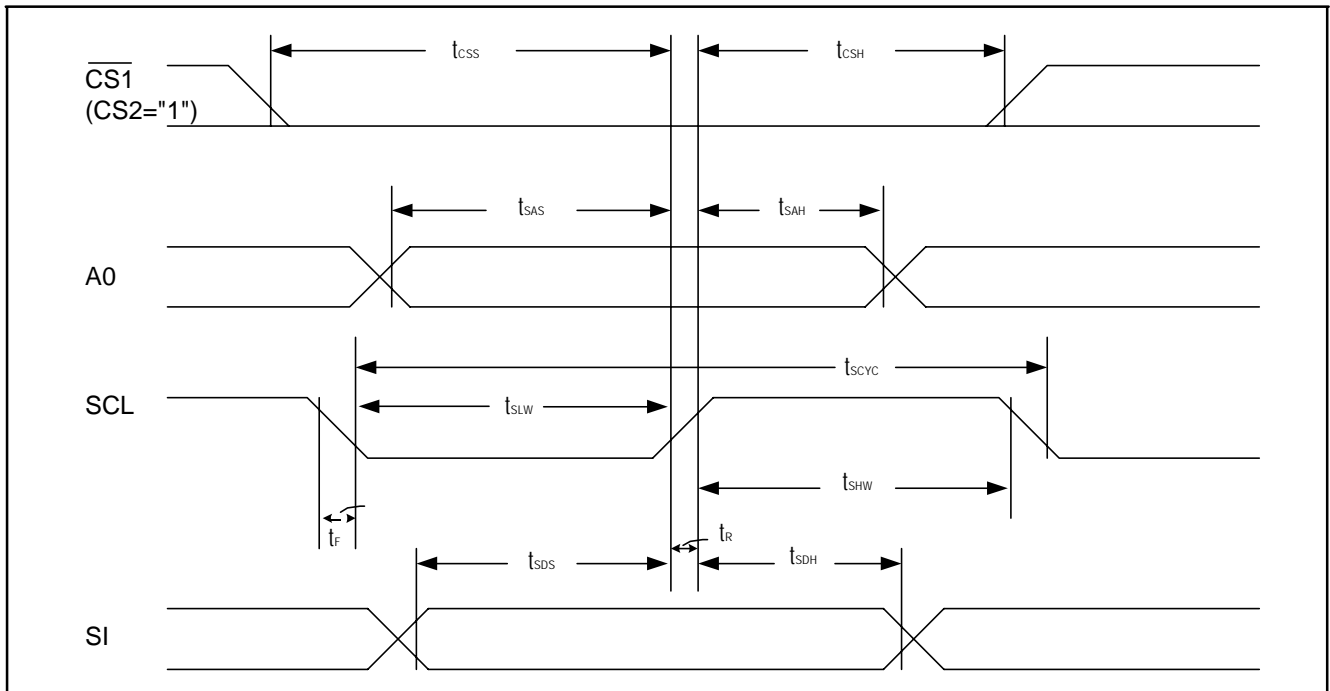
(VDD = 1.8V to 2.6V, T_A = 25°C)

Item	Signal	Symbol	Condition	Ratio		Units
				Min.	Max.	
Address hold time	A0P	t _{AH6}		0	-	ns
Address setup time		t _{AW6}		0	-	ns
System cycle time	A0P	t _{CYC6}		640	-	ns
Data setup time	DB7 - 0	t _{DS6}	C _L = 100pF	80	-	ns
Data hold time		t _{DH6}		30	-	ns
Access time		t _{ACC6}		-	280	ns
Output disable time		t _{OH6}		10	120	ns
Enable H pulse time	Read	EP	t _{EWHR}	200	-	ns
	Write		t _{EWHW}	200	-	ns
Enable L pulse time	Read	EP	t _{EWLR}	200	-	ns
	Write		t _{EWLW}	200	-	ns

Note1: The input signal rise time and fall time (t_r, t_f) is specified at 15 ns or less. When the system cycle time is extremely fast, (t_r + t_f) ≤ (t_{CYC6} - t_{EWLW} - t_{EWHW}) for (t_r + t_f) ≤ (t_{CYC6} - t_{EWLR} - t_{EWHR}) are specified.

Note2: All timing is specified using 20% and 80% of VDD as the reference.

Note3: t_{EWLW} and t_{EWLR} are specified as the overlap between CS1 being 'L' (CS2 = 'H') and EP.

8.6.3. The serial interface

(VDD = 4.5V to 5.5V, T_A = 25°C)

Item	Signal	Symbol	Condition	Ratio		Units
				Min.	Max.	
Serial Clock Period		t_{SCYC}	-	200	-	ns
SCL 'H' pulse width	SCL	t_{SHW}	-	80	-	ns
SCL 'L' pulse width		t_{SLW}	-	80	-	ns
Address setup time	A0P	t_{SAS}	-	50	-	ns
Address hold time		t_{SAH}	-	100	-	ns
Data setup time	SI	t_{SDS}	-	50	-	ns
Data hold time		t_{SDH}	-	50	-	ns
CS-SCL time	CS	t_{CSS}	-	100	-	ns
		t_{CSH}	-	100	-	ns

(VDD = 2.7V to 4.5V, T_A = 25°C)

Item	Signal	Symbol	Condition	Ratio		Units
				Min.	Max.	
Serial Clock Period		t_{SCYC}	-	250	-	ns
SCL 'H' pulse width	SCL	t_{SHW}	-	100	-	ns
SCL 'L' pulse width		t_{SLW}	-	100	-	ns
Address setup time	A0P	t_{SAS}	-	150	-	ns
Address hold time		t_{SAH}	-	150	-	ns
Data setup time	SI	t_{SDS}	-	100	-	ns
Data hold time		t_{SDH}	-	100	-	ns
CS-SCL time	CS	t_{CSS}	-	150	-	ns
		t_{CSH}	-	150	-	ns

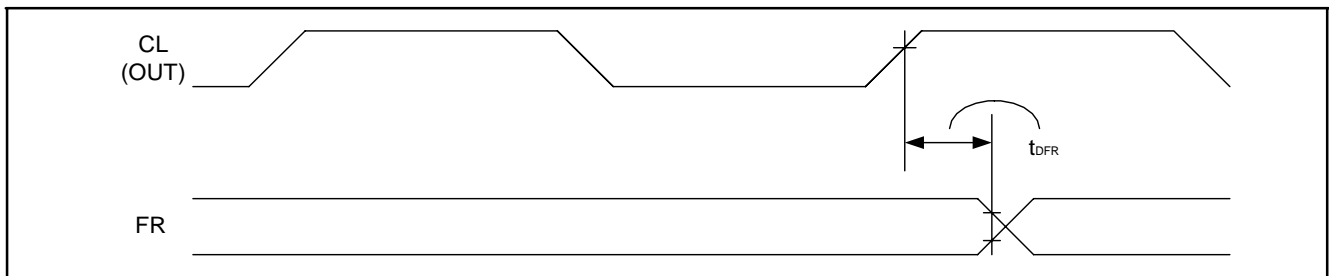
(VDD = 2.4V to 2.7V, TA = 25°C)

Item	Signal	Symbol	Condition	Rating		Units
				Min.	Max.	
Serial Clock Period		t_{SCYC}	-	350	-	ns
SCL 'H' pulse width	SCL	t_{SHW}	-	150	-	ns
SCL 'L' pulse width		t_{SLW}	-	150	-	ns
Address setup time	A0P	t_{SAS}	-	150	-	ns
Address hold time		t_{SAH}	-	150	-	ns
Data setup time	SI	t_{SDS}	-	60	-	ns
Data hold time		t_{SDH}	-	30	-	ns
CS-SCL time	CS	t_{CSS}	-	250	-	ns
		t_{CSH}	-	250	-	ns

Note1: The input signal rise and fall time (t_r , t_f) are specified at 15 ns or less.

Note2: All timing is specified using 20% and 80% of VDD as the standard.

8.6.4. Display control output timing



(VDD = 3.3V to 3.6V, TA = 25°C)

Item	Signal	Symbol	Condition	Rating			Units
				Min.	Tvp.	Max.	
FR delay time	FR	t_{DFR}	$C_L = 50\text{pF}$	-	10	40	ns

(VDD = 2.7V to 3.3V, TA = 25°C)

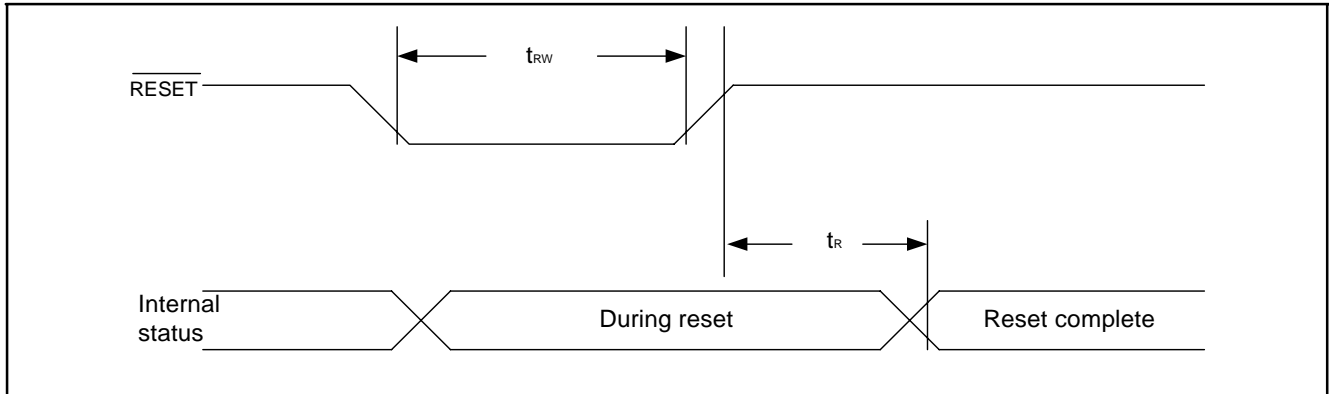
Item	Signal	Symbol	Condition	Rating			Units
				Min.	Tvp.	Max.	
FR delay time	FR	t_{DFR}	$C_L = 50\text{pF}$	-	20	80	ns

(VDD = 1.8V to 2.7V, TA = 25°C)

Item	Signal	Symbol	Condition	Rating			Units
				Min.	Tvp.	Max.	
FR delay time	FR	t_{DFR}	$C_L = 50\text{pF}$	-	50	200	ns

Note1: Valid only when the master mode is selected.

Note2: All timing is based on 20% and 80% of VDD.

8.6.5. Reset timing


(VDD = 3.3V to 3.6V, T_A = 25°C)

Item	Signal	Symbol	Condition	Rating			Units
				Min.	Typ.	Max.	
Reset time		t _R	-	-	0.5	αS	
Reset 'L' pulse width	RES	t _{DW}	-	0.5	-	αS	

(VDD = 2.7V to 3.3V, T_A = 25°C)

Item	Signal	Symbol	Condition	Rating			Units
				Min.	Typ.	Max.	
Reset time		t _R	-	-	1.0	αS	
Reset 'L' pulse width	RES	t _{DW}	-	1.0	-	αS	

(VDD = 1.8V to 2.7V, T_A = 25°C)

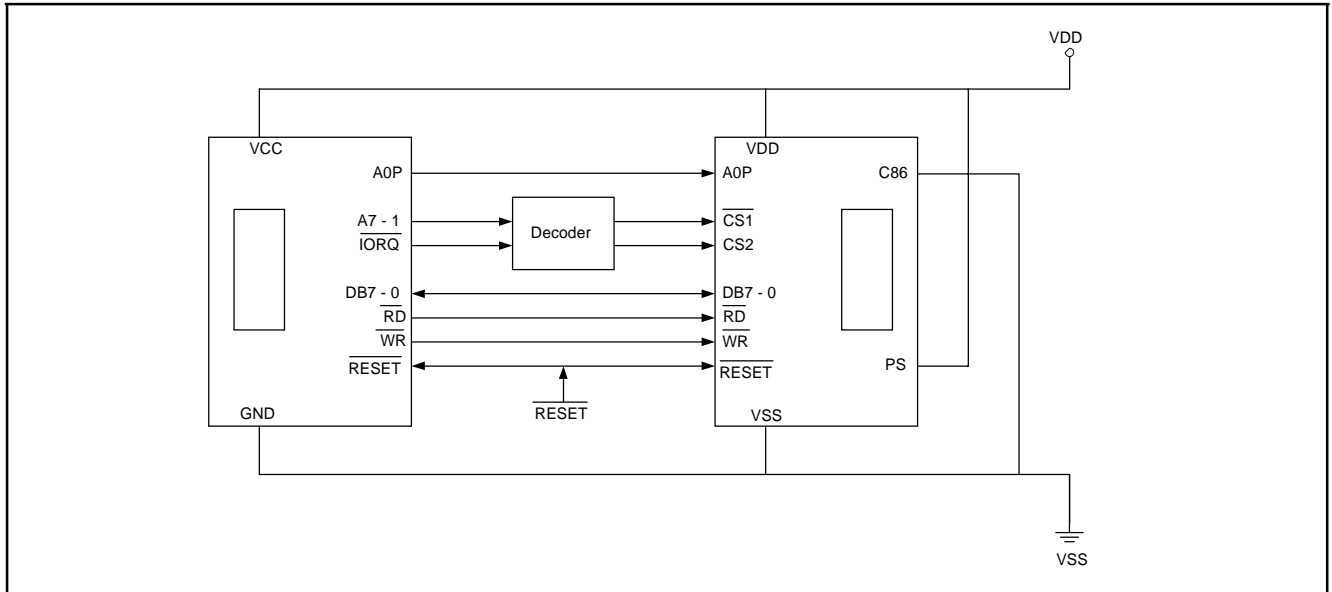
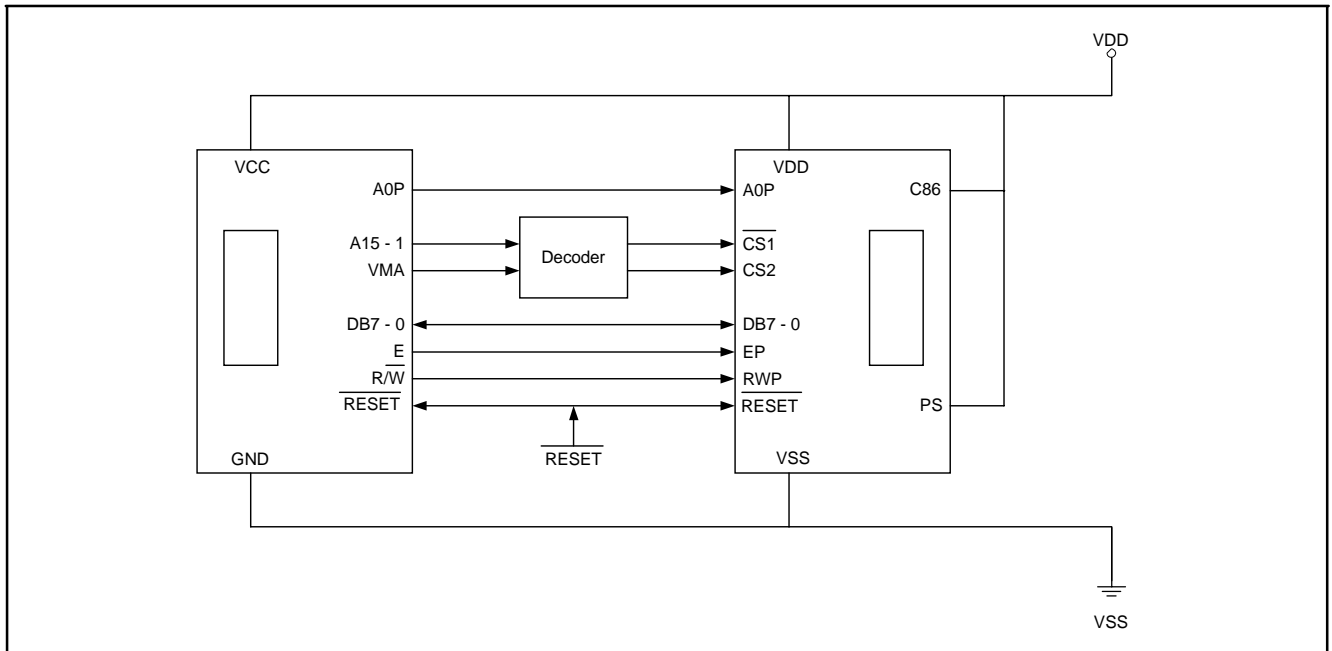
Item	Signal	Symbol	Condition	Rating			Units
				Min.	Typ.	Max.	
Reset time		t _R	-	-	1.5	αS	
Reset 'L' pulse width	RES	t	-	1.5	-	αS	

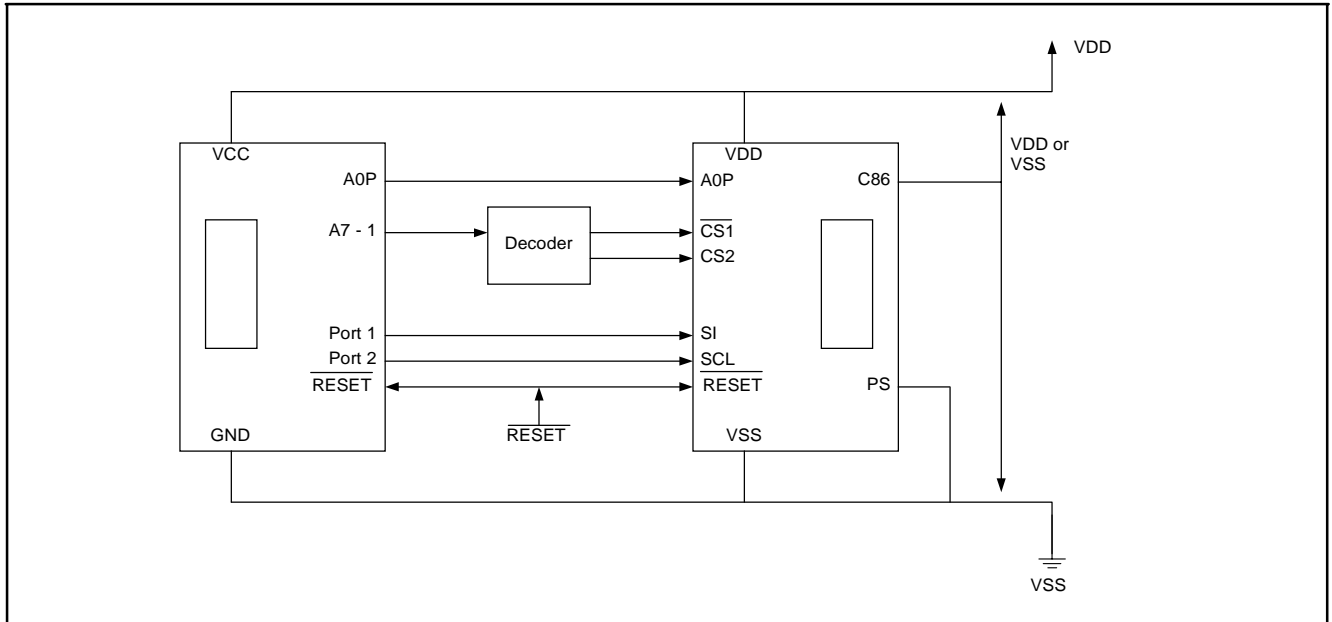
Note: All timing is specified with 20% and 80% of VDD as the standard.

8.7. The MPU Interface (Reference Examples)

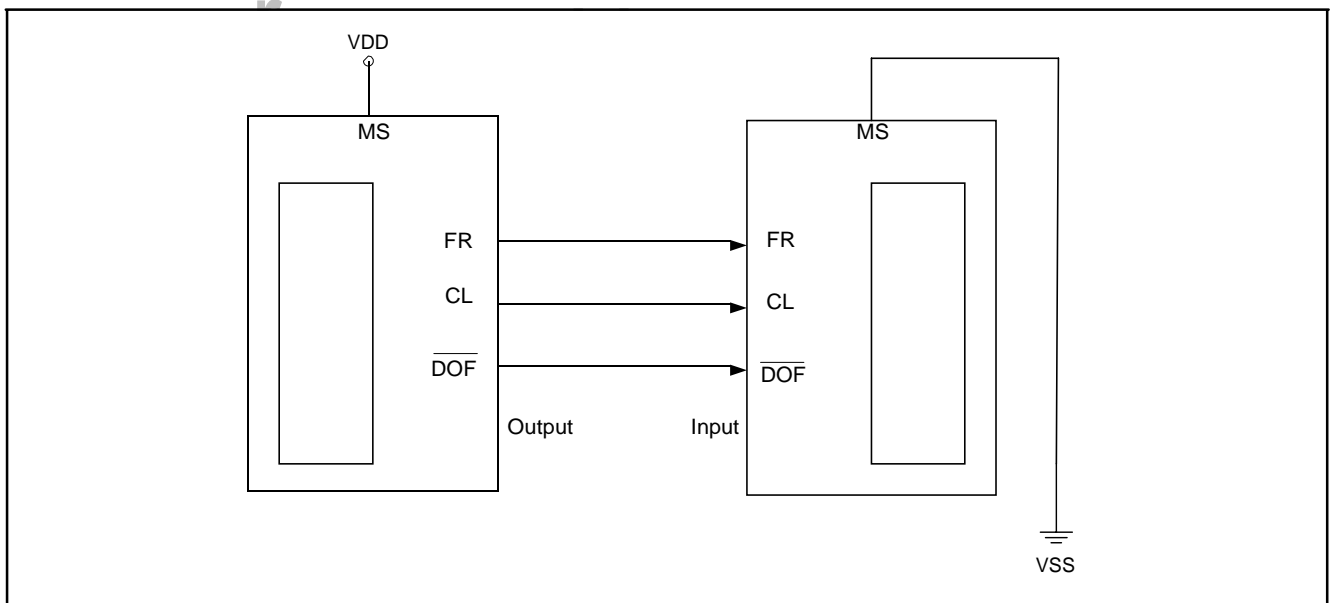
The SPLC502A can be connected to either 80 X 86 Series MPUs or to 68000 Series MPUs. Moreover, The serial interface is possible to operate the SPLC502A chips with fewer signal lines.

The display area can be enlarged by using multiple SPLC502A chips. When this is done, the chip select signal can be used to select the individual ICs to access.

8.7.1. 8080 series MPUs

Figure 26
8.7.2. 6800 series MPUs

Figure 27

8.7.3. Using the serial interface

Figure 28
8.8. Connections Between LCD Drivers (Reference Example)

The liquid crystal display area can be enlarged with ease through the use of multiple SPLC502A chips. Use a same equipment type.

8.8.1. SPLC502A (Master) <-> SPLC502A (Slave)

Figure 29

8.9. Connections Between LCD Drivers (Reference Examples)

The liquid crystal display area can be enlarged with ease through the use of multiple SPLC502A chips. Use a same equipment type, in the composition of these chips.

8.9.1. Single-chip structure

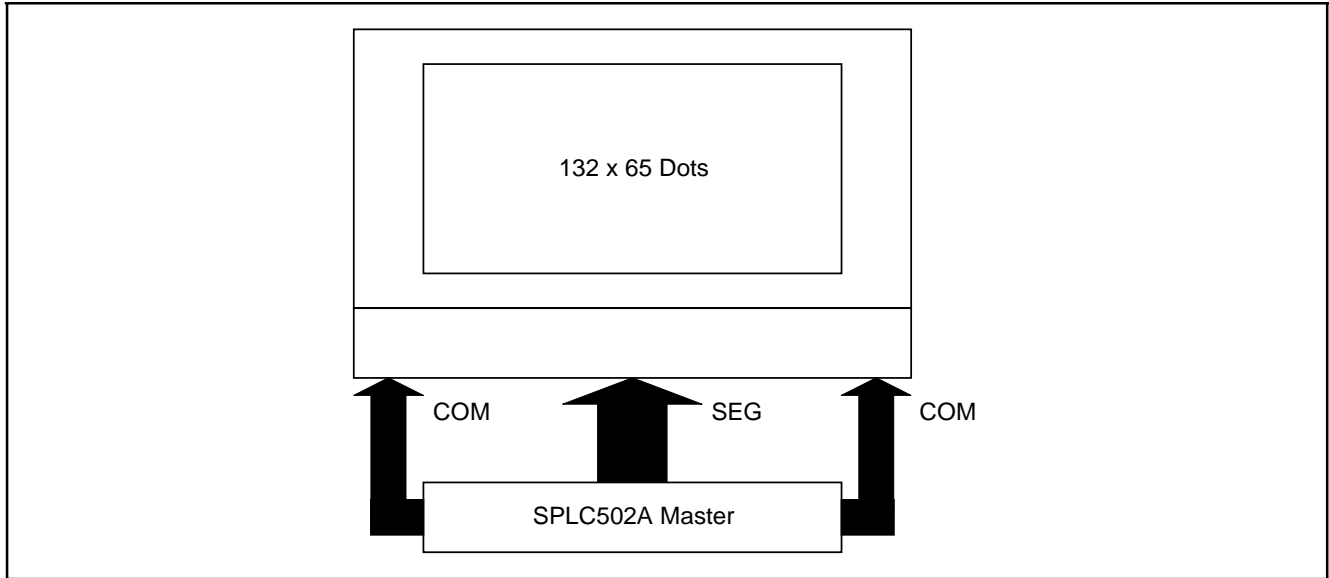
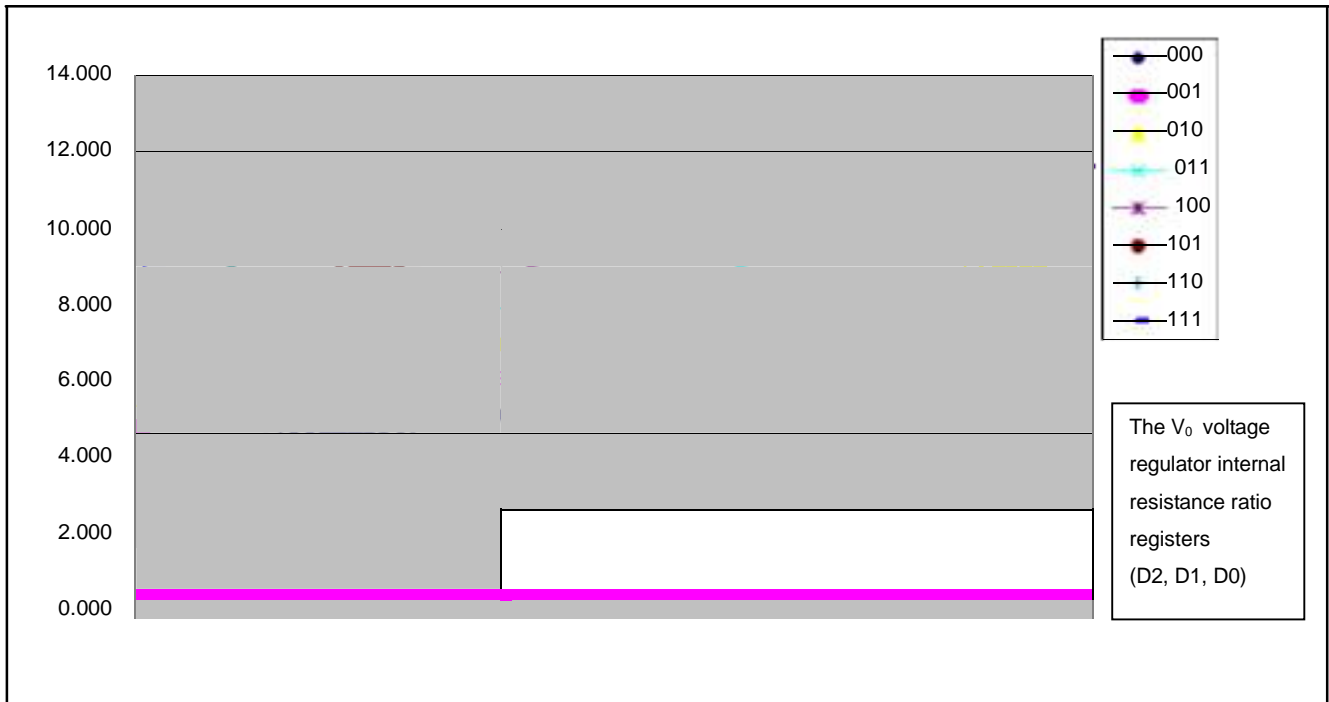


Figure 30

8.10. VLCD Voltage (Voltage between V₀ to VSS) relationship of V₀ Voltage Regulator Internal Resistor Ratio Register and Electronic Volume Control Register



Note: Use External V_{OUT} Power Supply.

9. PACKAGE/PAD LOCATIONS**9.1. Package/PAD Locations**

Please contact Sunplus sales representatives for more information.

9.2. Ordering Information

Product Number	Package Type
SPLC502A-NnnV-C	Chip form with Gold Bump

Note1: Code number is assigned for customer.

Note2: Code number (N = A - Z or 0 - 9, nn = 00 - 99); version (V = A - Z).

10. DISCLAIMER

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11. REVISION HISTORY

Date	Revision #	Description	Page
AUG. 11, 2004	0.1	Original	57