DEFINITION OF TERMINALS

(valid for all modules except DEM 16224/40491)

PIN NO.	SYMBOL	FUNCTION
1	V_{SS}	Ground terminal of module
2	V_{DD}	Supply terminal of module +5V
3	V_O	Power supply for Liquid crystal Drive
4	RS	Register Select RS = 0 ... Instruction Register RS = 1 ... Data Register
5	R/W	Read/Write R/W = 1 ... Read R/W = 0 ... Write
6	E	Enable
7 - 14	DB0–DB7	Bi-directional Data Bus, Data Transfer is performed once, thru DB0-DB7, in the case of interface data. Length is 8-bits; and twice, thru DB4-DB7, in the case of interface data length is 4-bits. Upper four bits first then lower four bits.
15 16	L- L+	LED or EL lamp power supply terminals.

OPERATING SPECIFICATIONS

	STANDARD TEMP
Operating temperature range	0°C to +50°C
Storage temperature range	-10°C to +60°C
Operating relative humidity	90% max
	WIDE TEMP
Operating temperature range	-20°C to +70°C
Storage temperature range	-30°C to +75°C
Operating relative humidity	90% max

ELECTRICAL CHARACTERISTICS (To = +25°C)

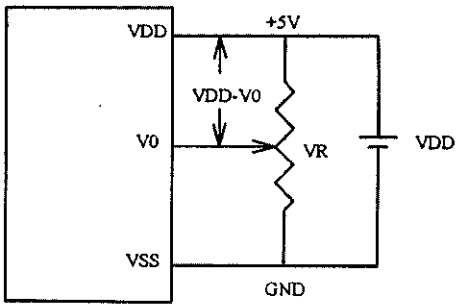
PARAMETER	SYMBOL	CONDITION	MIN	TYP	MAX	UNIT
Supply voltage	V_{DD}		4.5	5.0	5.5	V
LCD Drive Voltage Normal Temp Model (TN/STN) Wide Temp Model (STN)	V_{DD}-V_0 (V_{LCD})		 4.2 6.4	 4.5 6.8	 4.8 7.5	 V V
Supply Current [1] 1 x 16 DMM 2 x 16 DMM 1 x 20, 2 x 20 DMM 4 x 20, 2 x 40 DMM	I_{DD}	V_{DD} = 5V V_0 = 0V min	 – – – –	 1.0 1.0 1.5 2.5	 2.0 2.0 3.0 4.0	 mA mA mA mA
Input voltage [2]	V_{IL} V_{IH}		0 2.2	– –	0.6 V_{DD}	V V
Output voltage [3]	V_{OL} V_{OH}	I_{OL} = 1.6 mA I_{OH} = 0.2 mA	– 2.4	– –	0.4 –	V V
LED Lightpipe Current 1 x 8, 1 x 16, 2 x 16 DMM 2 x 20 DMM LED Lightbox Current 1 x 8, 1 x 16 DMM 2 x 16 DMM 1 x 20, 2 x 20, 4 x 20 DMM	I_{LED}	L+ – L- = 5V	 20 40 40 40 150		 60 80 100 250 300	 mA mA mA mA mA

DRIVE VOLTAGE (V_{LCD}) IS NOT IDENTICAL FOR LCD MODULES MANUFACTURES. ACCEPTABLE RESULTS CAN BE OBTAINED BY ADJUSTING V_{LCD}. IF THIS DOES NOT WORK, DISPLAY CAN MODIFY DISPLAY TO MEET CUSTOM NEEDS.

Note: 1. Applies to DB0 - DB7, E, RS and R/W
2. Applies to DB0 - DB7
3. Supply current may slightly exceed MAX. Rating if SAMSUNG controller is used without pull-up resistor for DB0 - DB7.

POWER SUPPLY REQUIREMENTS

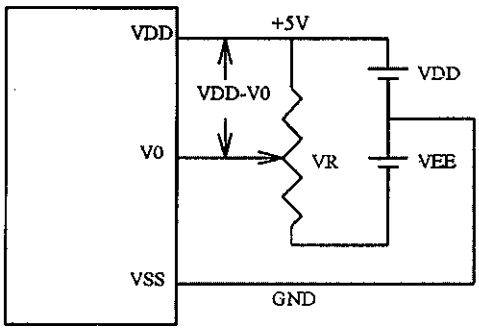
- **Standard Temperature and Wide Temperature Range**
  - Only 5 Volt (V_{DD}) - FLUID SOLUTION



VDD - Vo: LCD Driving Voltage

Vr: 10K - 20K

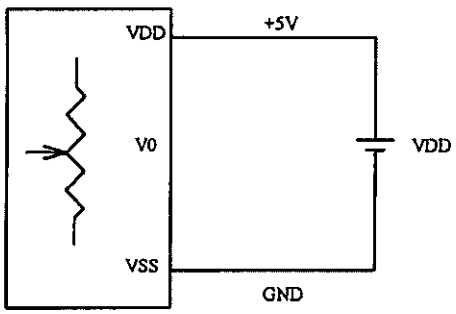
- **Wide Temperature Range Type A**
  - Requires V_{EE} (negative Voltage to V_{DD})



VDD - Vo: LCD Driving Voltage

Vr: 10K - 20K

- **Wide Temperature Range Type B**
  - Only 5 Volt Type (V_{DD}) - DC/DC SOLUTION
  - Contrast adjustment and Temp. Compensation on Board



INSTRUCTION SET

INSTRUCTION	CODE										DESCRIPTION	TYPICAL EXECUTION TIME
	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0		
Clear display	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	1	Clears display and returns the cursor to home position (Address Ø). Sets I/D = 1 of Entry Mode.	1.64 ms
Return home	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	1	●	Return the cursor to the home position (Address Ø). Also returns the display being shifted to the original position. DD RAM contents remain unchanged. Set DD RAM addresses to zero.	1.64 ms
Entry mode set	Ø	Ø	Ø	Ø	Ø	Ø	Ø	1	I/D	S	Set the cursor move direction and specifies or not to shift the display. These operations are performed during data write and read of DD RAM/CG RAM, FOR NORMAL OPERATION, SET S TO Ø	40 µs
Display ON/OFF control	Ø	Ø	Ø	Ø	Ø	Ø	1	D	C	B	Set ON/OFF all display (D), cursor ON/OFF (C), and blink of cursor postion character (B).	40 µs
Cursor or display shift	Ø	Ø	Ø	Ø	Ø	1	S/C	R/L	●	●	Moves the cursor and shifts the display without changing DD RAM contents.	40 µs
Function set	Ø	Ø	Ø	Ø	1	DL	N	F	●	●	Sets interface data length(DL), number of display lines(N) and character font (F).	40 µs
Set the CG RAM address	Ø	Ø	Ø	1	MSB	ACG				LSB	Sets the CG RAM address. CG RAM data is sent and received after this setting.	40 µs
Set the DD RAM address	Ø	Ø	1	MSB	ADD					LSB	Sets the DD RAM address. DD RAM data is sent and received after this setting.	40 µs
Read busy flag & address	Ø	1	BF	MSB	AC					LSB	Reads busy flag (BF) indicating internal operation is being performed and reads address counter contents.	40 µs
Write data to CG or DD RAM	1	Ø	MSB							LSB	Writes data into DD RAM or CG RAM.	40 µs
Read data from CG or DD RAM	1	1	MSB							LSB	Reads data from DD RAM or CG RAM	40 µs
	S = 1: Accompanies display shift when data is written, for normal operation, set to Ø I/D = 1: Increment DL = 1: 8 bits I/D = Ø: Decrement DL = Ø: 4 bits S/C = 1: Display shift N = 1: 2 (1) line S/C = Ø: Cursor move N = Ø: 1 line R/L = 1: Shift to the right F = 1: 5 x 10 dots R/L = Ø: Shift to the left F = Ø: 5 x 7 dots BF = 1: Internally operating BF = Ø: Can accept instruction										DD RAM: Display data RAM CG RAM: Character generator RAM ACG: CG RAM address ADD: DD RAM address corresponds to cursor address AC: Address counter used for both DD and CG RAM adress B: 1 = ON Ø = OFF (Blinking cursor) C: 1 = ON Ø = OFF (Cursor) D: 1 = ON Ø = OFF (Display) ● Don't Care	

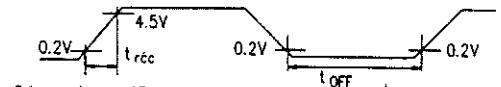
INITIALIZATION

The module automatically performed initialization when powered on (using internal reset circuit). The following instructions are executed during initialization:

1. CLEAR DISPLAY
   The Busy Flag is kept in the Busy State (BF = 1) unit initialization ends.
   The time is 15 ms.
2. FUNCTION SET ---------- DL = 1: 8-bits long interface data
   N = Ø: 1 line display
3. DISPLAY ON/OFF CONTROL ---------- D = Ø: Display OFF
   C = Ø: Cursor OFF
   B = Ø: Blink OFF
4. ENTRY MODE SET ---------- I/D = 1: +1 (INCREMENT)
   S = Ø: NO SHIFT
5. DD RAM IS SELECTED

Power O Initialization depends on rise time of the supply when it is turned on. The following time relationship must be satisfied.

ITEM	SYMBOL	STANDARD TIME			UNIT
		MIN	TYP	MAX	
Power Supply Rise Time	t_{rcc}	0.1	–	10	ms
Power Supply Off Time	t_{OFF}	1.0	–	–	ms



Power On Timing Diagram

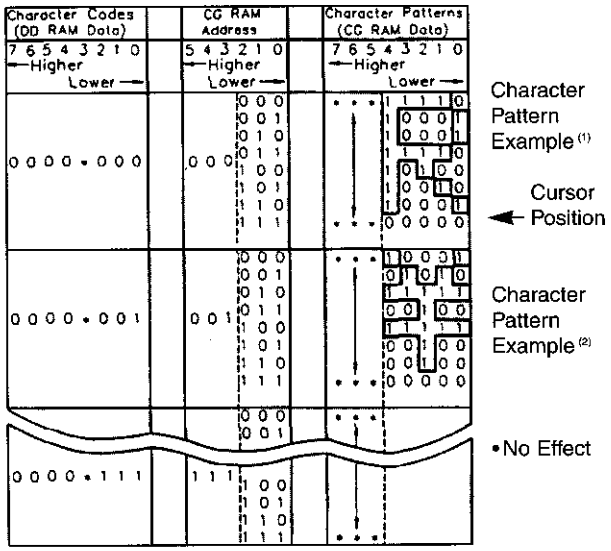
NOTE:
When the above power supply condition is not satisfied, the internal reset circuitry does not operate correctly, in this case, perform the needed initialization by sending function set instructions thrice from MPU after turning the power on, e.g., to designate a 8-bits data length, send the following instructions thrice:

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Ø	Ø	Ø	Ø	1	1	•	•	•	•
Ø	Ø	Ø	Ø	1	1	•	•	•	•
Ø	Ø	Ø	Ø	1	1	•	•	•	•

When this ends, the module enters 8-bits data length mode without fail, then enter 4-bits data length instruction for 4-bits data length interface.

DOT CHARACTER PATTERNS

For 5 x 7 Dot Character Patterns



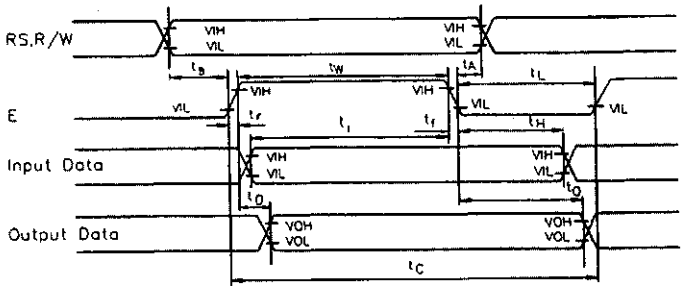
NOTE:
Character code bits 0.2
Correspond to CG RAM
address bits 3.5
(3 bits : 8 types)

TIMING CHARACTERISTICS FOR CONTROLLER CHIPS

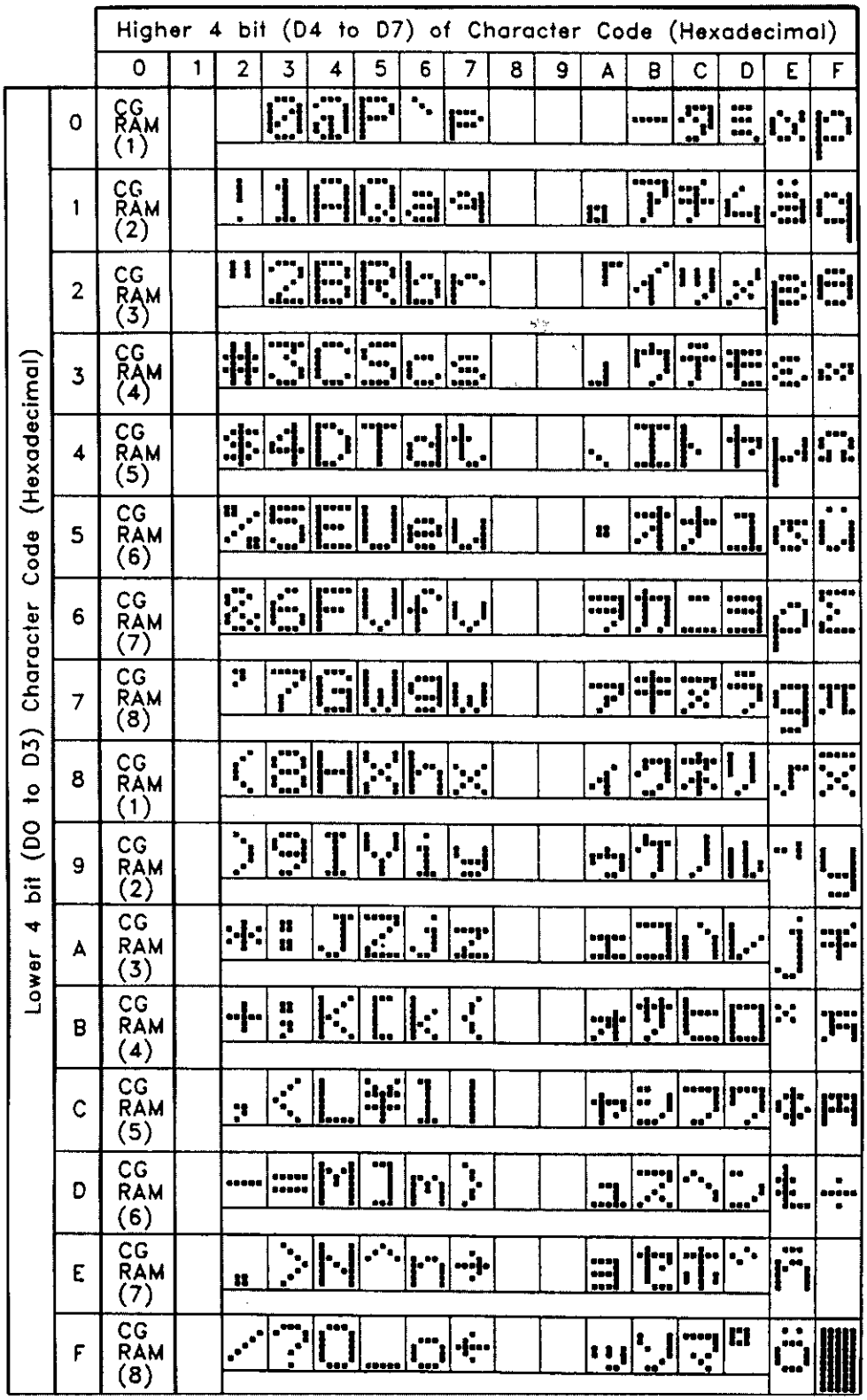
CONTROLLERS CHIPS / PARAMETERS		SAMSUNG KS0066	RECOMMENDED TIMING	UNIT
Enable Cycle Time	tC (min)	1000	1000	nS
Enable Pulse Width High Level Low Level	 tW (min) tL (min)	 450 450	 450 450	 nS nS
E. Raise Time	tr (max)	25	25	nS
E. Fall Time	tf (max)	25	25	nS
Set-up Time	tB (min)	140	140	nS
Data Set-up Time	tI (min)	195	195	nS
Data Delay Time	tD (max)	320	320	nS
Address Hold Time	tA (max)	10	10	nS
Hold Time Input Data Output Data	 tH (min) tO (min)	 10 20	 10 20	 nS nS

NOTE:
INITIALIZATION BY POWER-ON RESET INVOLVES MANY UNSTABLE FACTORS CAUSED BY POWER SUPPLY FLUCTUATIONS.
THEREFOR, INITIALISING BY INSTRUCTIONS IS STRONGLY RECOMMENDED

TIMING DIAGRAM

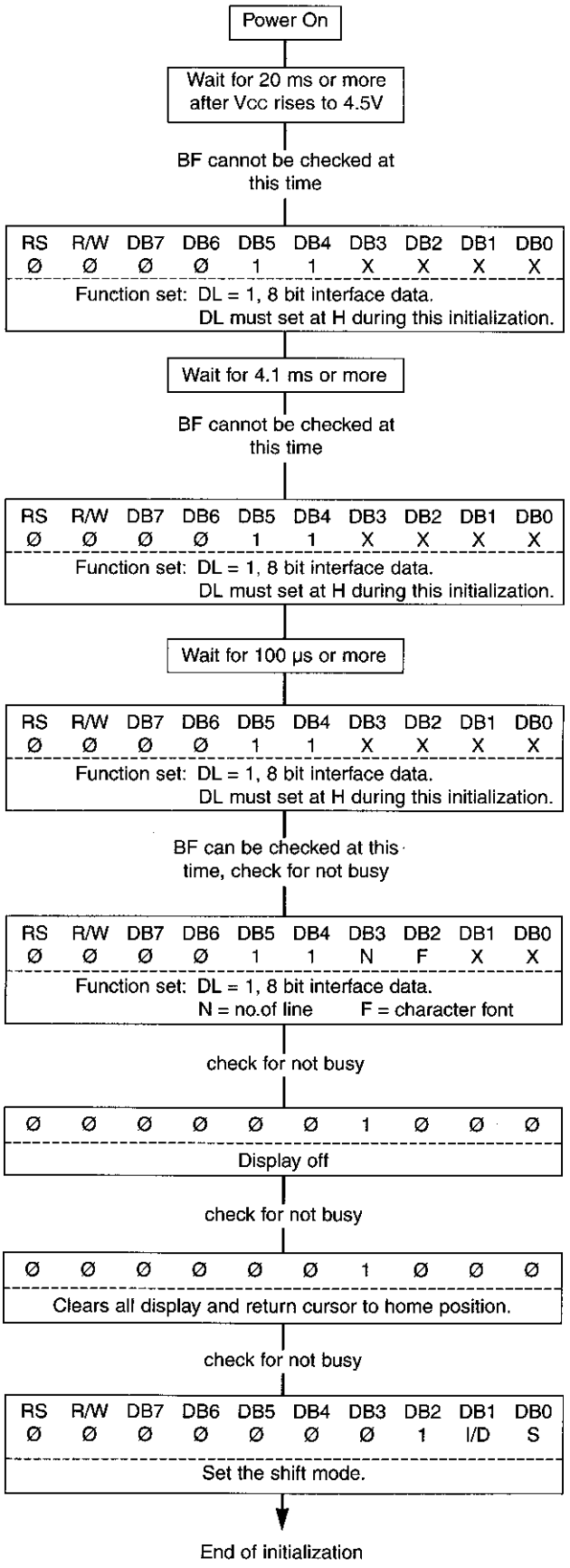


CHARACTER CODE MAP



INITIALIZATION

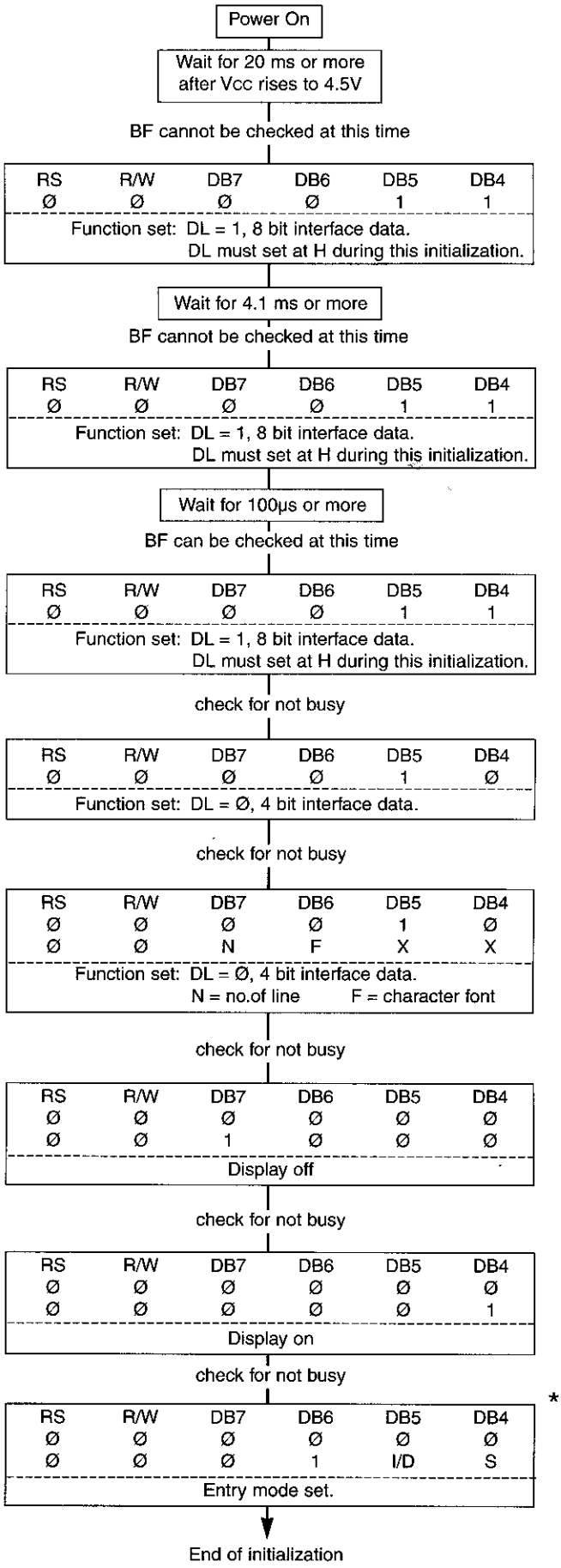
FOR 8 BIT DATA
INTERFACING



* NOTE: IN NORMAL OPERATION; SET S TO Ø

INITIALIZATION

FOR 4 BIT DATA
INTERFACING



* NOTE. IN NORMAL OPERATION, SET S TO Ø

DISPLAY CHARACTER POSITION AND DD RAM ADDRESS

1 x 8 DMM, 1/8 MUX

N = Ø: 1-LINE DISPLAY F = Ø: 5 x 7 DOTS

	1	2	3	4	5	6	7	8	
									← DISPLAY POSITION
FIRST LINE	ØØ	Ø1	Ø2	Ø3	Ø4	Ø5	Ø6	Ø7	← DD RAM ADDRESS

WHEN THE DISPLAY SHIFT OPERATION IS PERFORMED, THE DD RAM ADDRESS MOVED AS FOLLOW:

AFTER THE LEFT SHIFT INSTRUCTION

1	2	3	4	5	6	7	8	
								← DISPLAY POSITION
Ø1	Ø2	Ø3	Ø4	Ø5	Ø6	Ø7	Ø8	← DD RAM ADDRESS

AFTER THE RIGHT SHIFT INSTRUCTION

1	2	3	4	5	6	7	8	
								← DISPLAY POSITION
4F	ØØ	Ø1	Ø2	Ø3	Ø4	Ø5	Ø6	← DD RAM ADDRESS

1 x 16 DMM, 1/16 MUX

N = 1: 2-LINE DISPLAY F = Ø: 5 x 7 DOTS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
																	← DISPLAY POSITION
FIRST LINE	ØØ	Ø1	Ø2	Ø3	Ø4	Ø5	Ø6	Ø7	4Ø	41	42	43	44	45	46	47	← DD RAM ADDRESS

WHEN THE DISPLAY SHIFT OPERATION IS PERFORMED, THE DD RAM ADDRESS MOVED AS FOLLOW:

AFTER THE LEFT SHIFT INSTRUCTION

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
																← DISPLAY POSITION
Ø1	Ø2	Ø3	Ø4	Ø5	Ø6	Ø7	Ø8	41	42	43	44	45	46	47	48	← DD RAM ADDRESS

AFTER THE RIGHT SHIFT INSTRUCTION

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
																← DISPLAY POSITION
27	ØØ	Ø1	Ø2	Ø3	Ø4	Ø5	Ø6	67	4Ø	41	42	43	44	45	46	← DD RAM ADDRESS

1 x 16 DMM, 1/8 MUX

N = Ø: 1-LINE DISPLAY F = Ø: 5 x 7 DOTS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
																	← DISPLAY POSITION
FIRST LINE	ØØ	Ø1	Ø2	Ø3	Ø4	Ø5	Ø6	Ø7	Ø8	Ø9	ØA	ØB	ØC	ØD	ØE	ØF	← DD RAM ADDRESS

1 x 20 DMM, 1/8 MUX

N = Ø: 1-LINE DISPLAY F = Ø: 5 x 7 DOTS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
																					← DISPLAY POSITION
FIRST LINE	ØØ	Ø1	Ø2	Ø3	Ø4	Ø5	Ø6	Ø7	Ø8	Ø9	ØA	ØB	ØC	ØD	ØE	ØF	1Ø	11	12	13	← DD RAM ADDRESS

1 x 40 DMM, 1/11 MUX

N = Ø: 1-LINE DISPLAY F = Ø: 5 x 10 DOTS

	1	2	3	4	5	6	7	8	9	10	11	12	13		33	34	35	36	37	38	39	40	
																							← DISPLAY POSITION
FIRST LINE	ØØ	Ø1	Ø2	Ø3	Ø4	Ø5	Ø6	Ø7	Ø8	Ø9	ØA	ØB	ØC	-----	2Ø	21	22	23	24	25	26	27	← DD RAM ADDRESS

DISPLAY CHARACTER POSITION AND DD RAM ADDRESS (CONTINUE)

2 x 16 DMM, 1/16 MUX

N = 1: 2-LINE DISPLAY F = Ø: 5 x 7 DOTS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
																	← DISPLAY POSITION
FIRST LINE	ØØ	Ø1	Ø2	Ø3	Ø4	Ø5	Ø6	Ø7	Ø8	Ø9	ØA	ØB	ØC	ØD	ØE	ØF	← DD RAM ADDRESS
SECOND LINE	4Ø	41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F	

WHEN THE DISPLAY SHIFT OPERATION IS PERFORMED, THE DD RAM ADDRESS MOVED AS FOLLOW:

AFTER THE LEFT SHIFT INSTRUCTION

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
																	← DISPLAY POSITION
	Ø1	Ø2	Ø3	Ø4	Ø5	Ø6	Ø7	Ø8	Ø9	ØA	ØB	ØC	ØD	ØE	ØF	1Ø	← DD RAM ADDRESS
	41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F	5Ø	

AFTER THE RIGHT SHIFT INSTRUCTION

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
																	← DISPLAY POSITION
	27	ØØ	Ø1	Ø2	Ø3	Ø4	Ø5	Ø6	Ø7	Ø8	Ø9	ØA	ØB	ØC	ØD	ØE	← DD RAM ADDRESS
	67	4Ø	41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	

2 x 20 DMM, 1/16 MUX

N = 1: 2-LINE DISPLAY F = Ø: 5 x 7 DOTS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
																					← DISPLAY POSITION
FIRST LINE	ØØ	Ø1	Ø2	Ø3	Ø4	Ø5	Ø6	Ø7	Ø8	Ø9	ØA	ØB	ØC	ØD	ØE	ØF	1Ø	11	12	13	← DD RAM ADDRESS
SECOND LINE	4Ø	41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F	5Ø	51	52	53	

4 x 40 DMM, 1/16 MUX *
2 x 40 DMM, 1/16 MUX

N = 1: 2-LINE DISPLAY F = Ø: 5 x 7 DOTS

	1	2	3	4	5	6	7	8	9	10	11	12	13	33	34	35	36	37	38	39	40	
																						← DISPLAY POSITION
First + Third Line	ØØ	Ø1	Ø2	Ø3	Ø4	Ø5	Ø6	Ø7	Ø8	Ø9	ØA	ØB	ØC	2Ø	21	22	23	24	25	26	27	← DD RAM ADDRESS
Second + Fourth Line	4Ø	41	42	43	44	45	46	47	48	49	4A	4B	4C	6Ø	61	62	63	64	65	66	67	

* First + Second Line Control by Enable 1, Third + Fourth Line Control by Enable 2

4 x 16 DMM, 1/16 MUX

N = 1: 2-LINE DISPLAY F = Ø: 5 x 7 DOTS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
																	← DISPLAY POSITION
FIRST LINE	ØØ	Ø1	Ø2	Ø3	Ø4	Ø5	Ø6	Ø7	Ø8	Ø9	ØA	ØB	ØC	ØD	ØE	ØF	← DD RAM ADDRESS
SECOND LINE	4Ø	41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F	
THIRD LINE	10	11	12	13	14	15	16	17	18	19	1A	1B	1C	1D	1E	1F	
FOURTH LINE	50	51	52	53	54	55	56	57	58	59	5A	5B	5C	5D	5E	5F	

4 x 20 DMM, 1/16 MUX

N = 1: 2-LINE DISPLAY F = Ø: 5 x 7 DOTS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
																					← DISPLAY POSITION
FIRST LINE	ØØ	Ø1	Ø2	Ø3	Ø4	Ø5	Ø6	Ø7	Ø8	Ø9	ØA	ØB	ØC	ØD	ØE	ØF	1Ø	11	12	13	← DD RAM ADDRESS
SECOND LINE	4Ø	41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F	5Ø	51	52	53	
THIRD LINE	14	15	16	17	18	19	1A	1B	1C	1D	1E	1F	2Ø	21	22	23	24	25	26	27	
FOURTH LINE	54	55	56	57	58	59	5A	5B	5C	5D	5E	5F	6Ø	61	62	63	64	65	66	67	