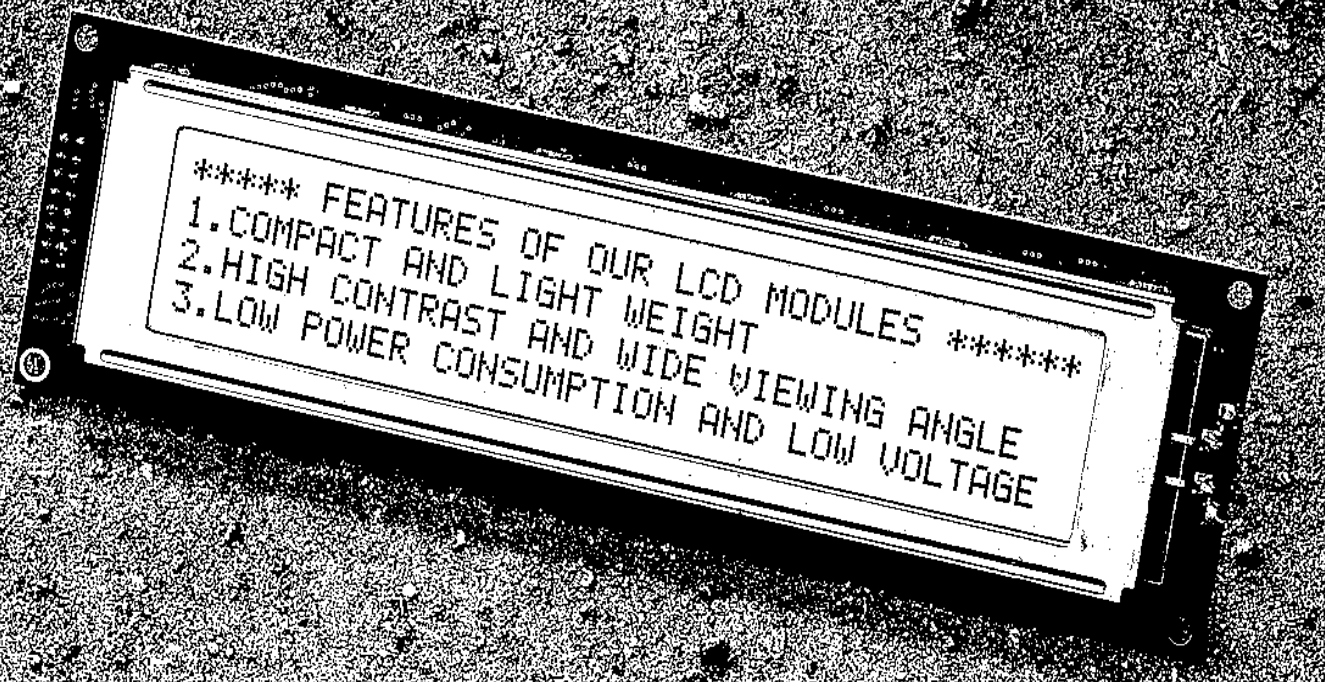
Liquid Crystal Displays

Standard Character Modules

Application Notes



Seiko Instruments GmbH

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Product Selection Guide

Dot Matrix Liquid Crystal Display Module

Character Type

■ FEATURES

- Slim, light-weight and low power consumption
- High contrast and wide viewing angle
- Built-in controller for easy interface
- Available EL and LED backlight type
- Available in wide temperature type

The table below shows a quick reference guide of the character LCD modules. You can see the standard specifications and other optical specifications on the reference page of each model shown in the table below.

Character Format (character x line)		16 x 1	16 x 2	16 x 2	16 x 2	16 x 4	20 x 2
Model		M1641	M1632	L1642	L1652	L1614	L2012
Reflective		M16410AS	M16320AS	L164200J000S	L165200J200S	L161400J000S	L201200J000S
EL backlight		M16419DWS	M16329DWS	L164221J000S	L165221J200S	L161421J000S	L201221J000S
LED backlight		M16417DYS	M16327DYS	L1642B1J000S	L1652B1J200S	L1614B1J000S	L2012B1J000S
Reflective (wide temp)		M16410CS	M16320CS	L164200L000S	L165200L200S	L161400L000S	L201200L000S
LED backlight (wide temp)		M16417JYS	M16327JYS	L1642B1L000S	L1652B1L200S	L1614B1L000S	L2012B1L000S
Character font		5x7 dots + cursor	5x7 dots + cursor	5x7 dots + cursor	5x7 dots + cursor	5x7 dots + cursor	5x7 dots + cursor
Module size (HxVxT) mm	Reflective	80,0 x 36,0 x 11,3	85,0 x 30,0 x 10,1	80,0 x 36,0 x 11,3	122,0 x 44,0 x 11,3	87,0 x 60,0 x 11,6	116,0 x 37,0 x 11,3
	EL backlight	80,0 x 36,0 x 11,3	85,0 x 30,0 x 10,1	80,0 x 36,0 x 11,3	122,0 x 44,0 x 11,3	87,0 x 60,0 x 11,6	116,0 x 37,0 x 11,3
	LED backlight	80,0 x 36,0 x 15,8	80,0 x 30,0 x 15,8	80,0 x 36,0 x 15,8	122,0 x 44,0 x 15,8	87,0 x 60,0 x 15,8	116,0 x 37,0 x 15,8
Viewing area (HxV) mm		64,5 x 13,8	62,0 x 16,0	64,5 x 13,8	99,0 x 24,0	61,8 x 25,2	83,0 x 18,6
Character size (HxV) mm		3,07 x 5,73	2,78 x 4,27	2,95 x 3,80	4,84 x 8,06	2,95 x 4,15	3,20 x 4,85
Dot size (HxV) mm		0,55 x 0,75	0,50 x 0,55	0,50 x 0,55	0,92 x 1,10	0,55 x 0,55	0,60 x 0,65
Power supply voltage (VDD-VSS)		+ 5 V	+ 5 V	+ 5 V	+ 5 V	+ 5 V	+ 5 V
Current consumption (mA,typ)	IDD	1,5	2,0	1,6	2,0	2,7	2,0
	ILC	0,2	0,2	0,3	0,4	1,1	0,4
Driving method (duty)		1/16	1/16	1/16	1/16	1/16	1/16
Built-in LSI		KS0066 or equivalent	KS0066 MSM5839 or equivalent	KS0066 MSM5839 or equivalent	KS0066 MSM5839 or equivalent	KS0066 KS0063 or equivalent	KS0066 KS0063 or equivalent
Operating temperature (°C)	normal temp.	0 to + 50	0 to + 50	0 to + 50	0 to + 50	0 to + 50	0 to + 50
	wide temp.	- 20 to + 70	- 20 to + 70	- 20 to + 70	- 20 to + 70	- 20 to + 70	- 20 to + 70
Storage temperature (°C)	normal temp.	- 20 to + 60	- 20 to + 60	- 20 to + 60	- 20 to + 60	- 20 to + 60	- 20 to + 60
	wide temp.	- 30 to + 80	- 30 to + 80	- 30 to + 80	- 30 to + 80	- 30 to + 80	- 30 to + 80
Weight (g, typ.)	Reflective	25	25	25	50	50	40
	EL backlight	30	30	30	55	55	45
	LED backlight	35	40	35	65	65	60
Inverters for EL	Model	5S	5S	5S	5C	5A	5A
	Power supply (V)	+ 5.0	+ 5,0	+ 5.0	+ 5.0	+ 5.0	+ 5.0
	current consumption (mA	10	10	10	35	45	45
LED backlight	Forward current consumption (mA)	100	112	100	240	200	154
	Forward input voltage (V,typ.)	+ 4,1	+ 4,1	+ 4,1	+ 4,1	+ 4,1	+ 4,1
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Product Selection Guide

Dot Matrix Liquid Crystal Display Module

Character Type

■ FEATURES

- Slim, light-weight and low power consumption
- High contrast and wide viewing angle
- Built-in controller for easy interface
- Available EL and LED backlight type
- Available in wide temperature type

The table below shows a quick reference guide of the character LCD modules. You can see the standard specifications and other optical specifications on the reference page of each model shown in the table below.

Character Format (character x line)		20 x 2	20 x 4	24 x 2	40 x 2	40 x 4
Model		L2022	L2014	L2432	L4042	M4024
Reflective		-	L201400J000S	L243200J000S	L404200J000S	M40240AS
EL backlight		-	L201421J000S	L243221J000S	L404221J000S	M40249DWS
LED backlight		-	L2014B1J000S	L2432B1J000S	L4042B1J000S	M40247DYS
Reflective (wide temp)		L202200P000S	L201400L000S	L243200L000S	L404200L000S	M40240CS
LED backlight (wide temp)		L2022B1P000S	L2014B1L000S	L2432B1L000S	L4042B1L000S	M40247JYS
Character font		5x7 dots + cursor	5x7 dots + cursor	5x7 dots + cursor	5x7 dots + cursor	5x7 dots + cursor
Module size (HxVxT) mm	Reflective	180,0 x 40,0 x 10,5	98,0 x 60,0 x 11,6	118,0 x 36,0 x 11,3	182,0 x 33,5 x 11,3	190,0 x 54,0 x 10,1
	EL backlight	180,0 x 40,0 x 10,5	98,0 x 60,0 x 11,6	118,0 x 36,0 x 11,3	182,0 x 33,5 x 11,3	190,0 x 54,0 x 10,1
	LED backlight	180,0 x 40,0 x 14,8	98,0 x 60,0 x 15,8	118,0 x 36,0 x 15,8	182,0 x 33,5 x 16,3	190,0 x 54,0 x 16,3
Viewing area (HxV) mm		149,0 x 23,0	76,0 x 25,2	94,5 x 17,8	154,4 x 15,8	147,0 x 29,5
Character size (HxV) mm		6,00 x 9,66	2,95 x 4,15	3,20 x 4,85	3,20 x 4,85	2,78 x 4,27
Dot size (HxV) mm		1,12 x 1,12	0,55 x 0,55	0,60 x 0,65	0,60 x 0,65	0,50 x 0,55
Power supply voltage (VDD-VSS)		+ 5 V	+ 5 V	+ 5 V	+ 5 V	+ 5 V
Current consumption (mA,typ)	IDD	4,2	2,9	2,5	3,0	8,0
	ILC	2,6	1,2	0,5	1,0	3,0
Driving method (duty)		1/16	1/16	1/16	1/16	1/16
Built-in LSI		KS0066 KS0063 or equivalent	KS0066 MSM5839 or equivalent	KS0066 KS0063 or equivalent	KS0066 KS0063 or equivalent	KS0066 MSM5839 or equivalent
Operating temperature (ºC)	normal temp.	-	0 to + 50	0 to + 50	0 to + 50	0 to + 50
	wide temp.	- 20 to + 70	- 20 to + 70	- 20 to + 70	- 20 to + 70	- 20 to + 70
Storage temperature (ºC)	normal temp.	-	- 20 to + 60	- 20 to + 60	- 20 to + 60	- 20 to + 60
	wide temp.	- 30 to + 80	- 30 to + 80	- 30 to + 80	- 30 to + 80	- 30 to + 80
Weight (g, typ.)	Reflective	80	55	40	70	90
	EL backlight	-	60	45	75	105
	LED backlight	110	70	60	95	140
Inverters for EL	Model	-	5A	5A	5C	5D
	Power supply (V)	+ 5.0	+ 5.0	+ 5.0	+ 5.0	+ 5.0
	current consumption (mA)	-	45	45	25	80
LED backlight	Forward current consumption (mA)	320	240	150	260	480
	Forward input voltage (V,typ.)	+ 4,1	+ 4,1	+ 4,1	+ 4,1	+ 4,1
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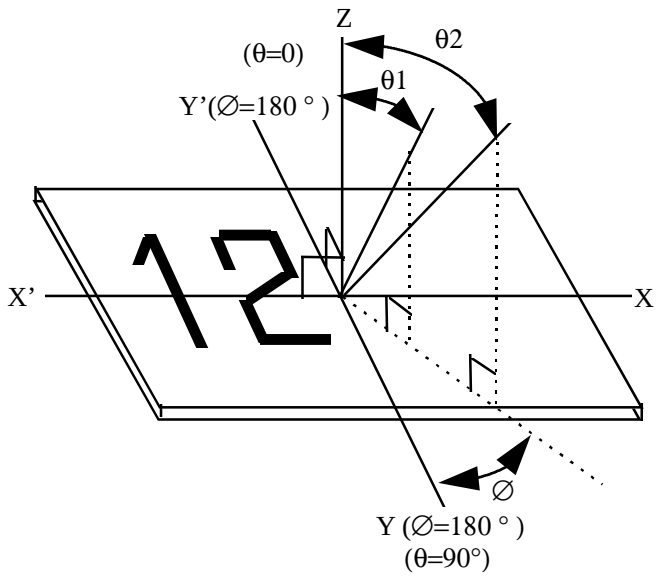
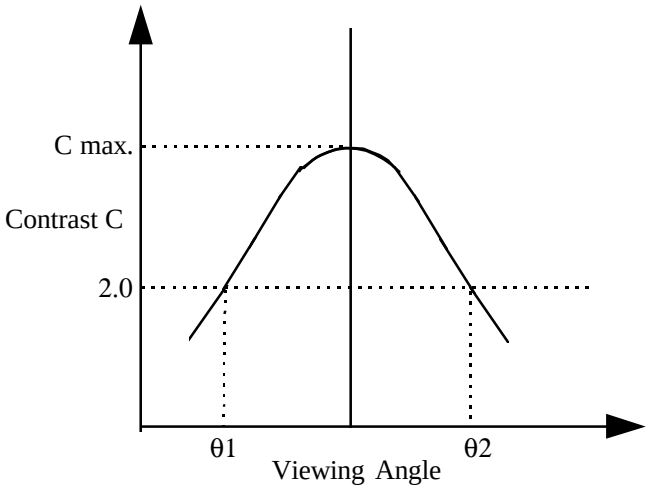
Definition of Optical Characteristics Term

■ Angles ∅ and θ

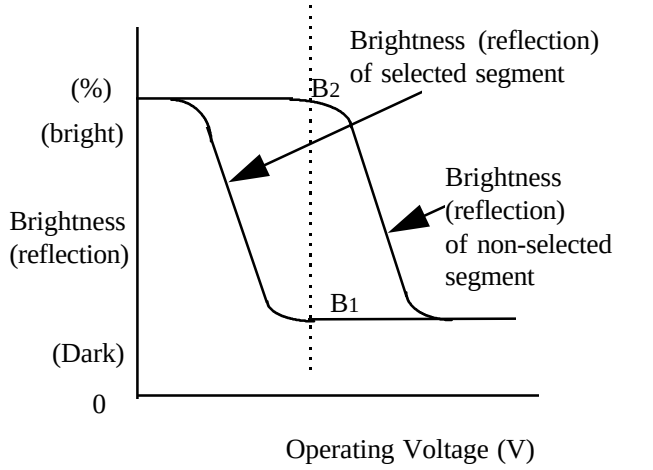


■ Viewing Angle θ1 and θ2

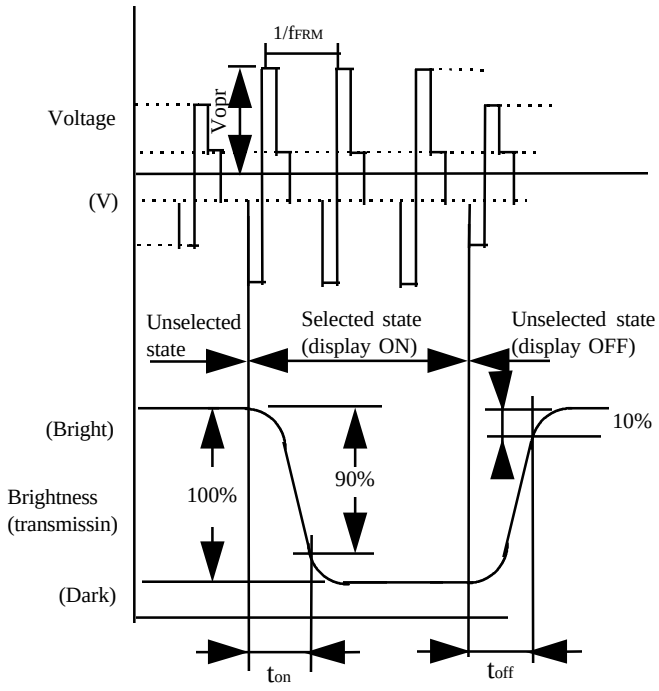


■ Contrast C

$$C = \frac{\text{Brightness (reflection) of non-selected segment } (B_2)}{\text{Brightness (reflection) of selected segment } (B_1)}$$



■ Response Time



Vopr : Operating Voltage
f_{FRM} : Frame Frequency
t_{on} : Response time (rise)
t_{off} : Response time (fall)

- **16 Characters x 1 line**
- **5 x 7 Dot Matrix + Cursor**
- **1/16 Duty**
- **5V single Power Supply**
- **Available in EL and LED Backlight type**

■ Absolute Maximum Ratings

V_{SS}=0V, Ta=25ºC

Item		Symbol	Conditions	Min.	Max.	Unit
Power supply voltage		V_{DD}		-0.3	6.0	V
		V_{LC}		-0.3	V_{DD}	V
Input voltage		Vin		-0.3	V_{DD} +0.3	V
Operating temperature						
	Normal	Topr		0	+50	ºC
	Wide	Topr		-20	+70	ºC
Storage temperature						
	Normal	Tstg		-20	+60	ºC
	Wide	Tstg		-30	+80	ºC
Storage humidity			< 48 hrs	+20	+85	%RH
			<1000 hrs	+20	+65	%RH

■ Mechanical Characteristics

Item		Specifications	Unit
Module size (H x V)		80.0 x 36.0	mm
Thickness	Reflective/EL	11.3	mm
	LED	15.8	mm
Viewing area (H x V)		64.5 x 13.8	mm
Character size with cursor (H x V)		3.07 x 6.56	mm
Mounting hole distance (H x V)		75.0 x 31.0	mm
Weight	Reflective	25	g
	EL backlight	30	g
	LED backlight	35	g

H : Horizontal, V : Vertical

■ Electrical Characteristics

V_{DD}=5V± 5%, V_{SS}=0V, Ta=0 ~ 50ºC

Item		Symbol	Conditions	Min.	Typ.	Max.	Unit
Power supply voltage		V_{DD}		4.75	5.00	5.25	V
		V_{DD} - V_{LC}		3.0	-	6.3	V
Input voltage	High	V_{IH1}		2.2	-	V_{DD}	V
	Low	V_{IL1}		0	-	0.6	V
Output voltage	High	V_{OH1}	-I_{OH}=0.205mA	2.4	-	-	V
	Low	V_{LH1}	-I_{OL}=1.2mA	-	-	0.4	V
Current consumption *							
Normal Temp type		I_{DD}	Ta=25ºC	-	1.3	2.0	mA
		I_{LC}	V_{LC}=0.25V	-	0.2	0.6	mA
Wide Temp. type		I_{DD}	Ta=25ºC	-	1.6	2.5	mA
		I_{LC}	V_{LC}=-0.6V	-	0.3	1.0	mA

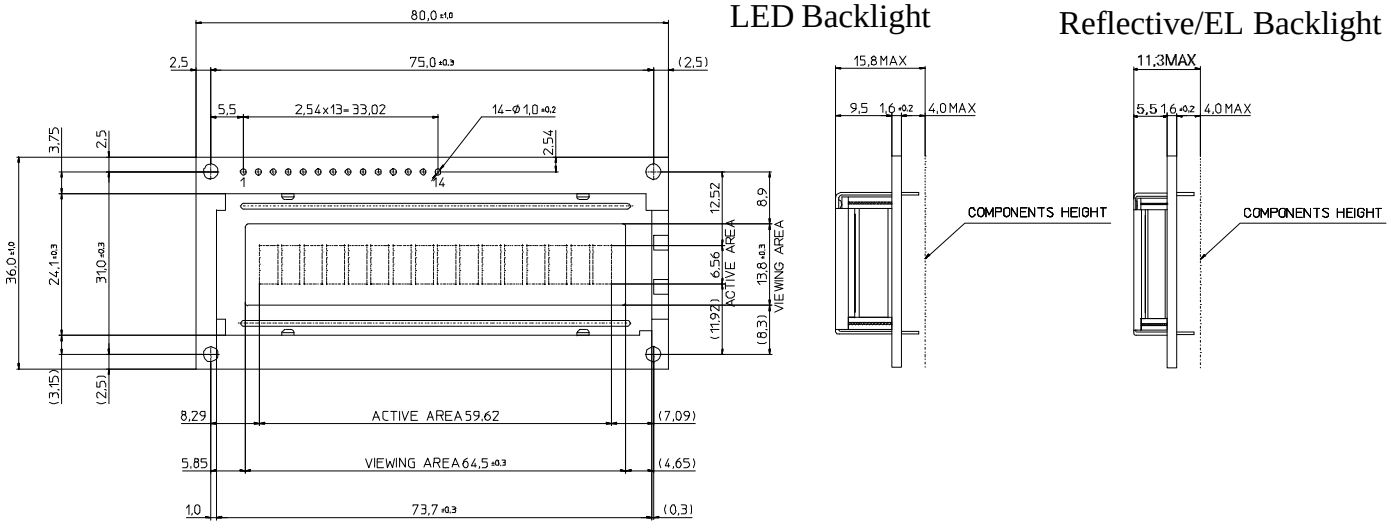
* test pattern : check board pattern

■ Pin Function

No.	Name	Function
1	VSS	GND
2	VDD	Power supply voltage +5V
3	VLC	Liquid crystal driving voltage
4	RS	L : Instruction code input H: Data input
5	R/W	L : Data write from MPU to LCM H : Data read from LCM to MPU
6	E	Enable
7	DB0	Data bus line
8	DB1	Data bus line
9	DB2	Data bus line
10	DB3	Data bus line
11	DB4	Data bus line
12	DB5	Data bus line
13	DB6	Data bus line
14	DB7	Data bus line

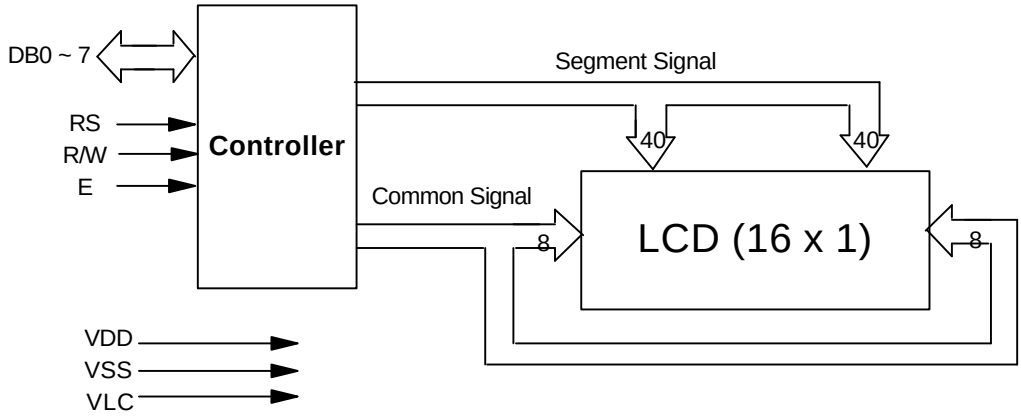
■ Dimensions

M1641 (1x16) Unit: mm. General tolerance ±0,5 mm



Note : Only dimension changes between Reflective/EL and LED backlight is the thickness

■ Circuit Block diagram



■ Recommended Operating Voltage

The recommended value (Vopr) for an ambient temperature is as follow s. Vopr=V_{DD} - V_{LC}

Temperature (ºC)		-20	0	+25	+50	+70
Vopr (V)	Normal	-	5.00	4.75	4.50	-
	Wide	6.20	5.90	5.60	5.40	5.20

■ Optical Characteristics

1. Normal Temperature Range Type

Ta=21ºC, Vopr=4.75V

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
Viewing angle	q_1	C≥2	-	-	-15	deg.
	q_2	F = 0º	55	-	-	
	q_2 - q_1		70	-	-	
Contrast	C	q =+25º, F = 0º	-	5	-	-
Response time	ton (rise)	q =0º	-	150	200	msec
	toff (fall)	F =0º	-	200	220	msec
	ton (rise)	q =0º, F = 0º	-	750	800	msec
	toff (fall)	Ta = 0ºC, Vopr=5.0V	-	600	700	msec

Measuring equipment : Canon illuminater LC-4SR

2.Wide Temperature Range Type

Ta=21ºC, 1/16 Duty, Vopr=V_{DD} - V_{LC}

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
Viewing angle	q_1	C≥2	-	-	-15	deg.
	q_2	F = 0º	55	-	-	
	q_2 - q_1		70	-	-	
Contrast	C	q =+20º, F = 0º Vop=5,6v	-	5	-	-
Response time	ton (rise)	q =0º, F = 0º	-	150	200	msec
	toff (fall)	Ta = 21ºC, Vopr=5.6V	-	200	220	msec
	ton (rise)	q =0º, F = 0º	-	750	800	msec
	toff (fall)	Ta = 0ºC, Vopr=5.9V	-	600	700	msec

Measuring equipment : Canon illuminater LC-4SR

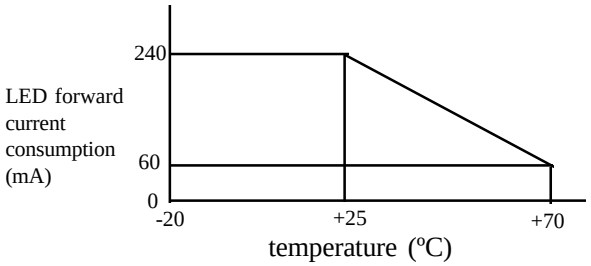
■ LED Backlight

1. Absolute Maximum Ratings

Ta=25ºC

Item	Symbol	Specifications	Unit
LED forw ard current consumption *	I_F	240	mA
LED reverse voltage	V_R	8	V
Allow able loss	P_D	1.05	W
Operating temperature	Topr	-20 ~ +70	ºC
Storage Temperature	Tstg	-40 ~ +80	ºC

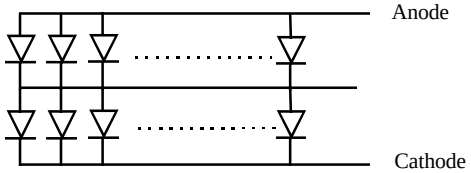
* LED forward current consumption and operating temperature characteristics are as follows.



2. Electrical Characteristics

Ta=25ºC

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
LED forw ard input voltage	V_F	I_F=120mA	3.8	4.1	4.4	V
LED reverse current	I_R	V_R=8V	-	-	0.16	mA
Peak Emitting w avelength		IF=120mA*	-	570	-	nm
Spectral half-w idth		IF=120mA*	-	30	-	nm
Brightness	L	IF=120mA*	120	150	-	cd/m²



total number of LED chips =2 x 8 = 16 pcs

■ EL Backlight

1.Absolute Maximum Ratings

Item	Symbol	Standard	Unit
Operating voltage	Vopr	AC 150V, 1KHz Sinew ave	V
Operating temperature	Topr	0 ~ +50	ºC
Storage temperature	Tstg	-20 ~ + 60	ºC
Storage humidity		0 ~ 10 % RH (60 ºC) 0 ~ 30 % RH (40 ºC)	

2. Brightness, Current, Life Characteristics

Item	Conditions	Specifications	Unit
Brightness	100V, 400Hz Sinew ave	40 min.	cd/m²
Current	100V, 400Hz Sinew ave	1.5 max.	mA
Life	100V, 400Hz, Sinew ave 25ºC,50%RH	3,000	hrs
	Using 5S Inverter 25ºC,50%RH	6,000	

3. Suitable Inverter 5S

3.1 Electrical Characteristics (When combined with EL lamp)

Ta=25ºC

Item	Symbol	Conditions	Specifications	Unit
Oscillating frequency	f_{INV}	V_{IN}=5VDC	550 typ.	Hz
Output voltage	V_{OUT}	V_{IN}=5VDC	100 typ.	V
Output current	I_{OUT}	V_{IN}=5VDC	1.5 typ.	mA
Input current	V_{IN}		10	Vrms
Voltage	I_{IN}	V_{IN}=5VDC	5 typ	VDC

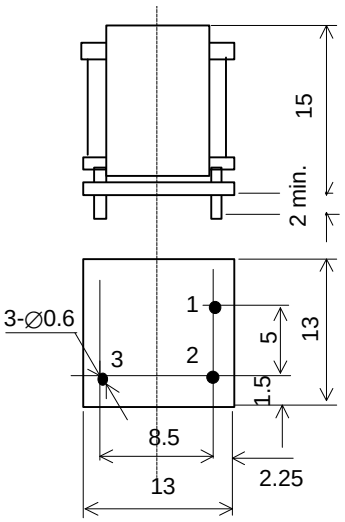
3.2 Tolerance (Inverter only)

Item	Specifications	Unit
Input voltage	3.0 to 6.0	V
Load range	25 to 40	cm²

3.3 Maximum Ratings (Inverter only)

Item	Specifications	Unit
Input voltage	7.0	V
Load range	50	cm²
Operating temperature	-10 to +60	ºC
Storage temperature	-20 to +70	ºC

3.4 Inverter Dimensions (unit : mm)



Pin No.	Function
1	Input : 5V DC
2	Common : GND
3	Output

- **16 Characters x 2 line**
- **5 x 7 Dot Matrix + Cursor**
- **1/16 Duty**
- **5V single Power Supply**
- **Available in EL and LED Backlight type**

■ Absolute Maximum Ratings

V_{SS}=0V, Ta=25ºC

Item		Symbol	Conditions	Min.	Max.	Unit
Power supply voltage		V_{DD}		-0.3	6.0	V
		V_{LC}		-0.3	V_{DD}	V
Input voltage		Vin		-0.3	V_{DD} +0.3	V
Operating temperature						
	Normal	Topr		0	+50	ºC
	Wide	Topr		-20	+70	ºC
Storage temperature						
	Normal	Tstg		-20	+60	ºC
	Wide	Tstg		-30	+80	ºC
Storage humidity			< 48 hrs	+20	+85	%RH
			<1000 hrs	+20	+65	%RH

■ Mechanical Characteristics

Item		Specifications	Unit
Module size (H x V)		122.0 x 44.0	mm
Thickness	Reflective/EL	11.3	mm
	LED	15.8	mm
Viewing area (H x V)		99.0 x 24.0	mm
Character size with cursor (H x V)		4.84 x 9.66	mm
Mounting hole distance (H x V)		115.0 x 37.0	mm
Weight	Reflective	50	g
	EL backlight	55	g
	LED backlight	65	g

H : Horizontal, V : Vertical

■ Electrical Characteristics

V_{DD}=5V± 5%, V_{SS}=0V, Ta=0 ~ 50ºC

Item		Symbol	Conditions	Min.	Typ.	Max.	Unit
Power supply voltage		V_{DD}		4.75	5.00	5.25	V
		V_{DD} - V_{LC}		3.0	-	6.3	V
Input voltage	High	V_{IH1}		2.2	-	V_{DD}	V
	Low	V_{IL1}		0	-	0.6	V
Output voltage	High	V_{OH1}	-I_{OH}=0.205mA	2.4	-	-	V
	Low	V_{LH1}	-I_{OL}=1.2mA	-	-	0.4	V
Current consumption *							
Normal Temp type		I_{DD}	Ta=25ºC	-	1.8	3.0	mA
		I_{LC}	V_{LC}=0.25V	-	0.4	1.0	mA
Wide Temp. type		I_{DD}	Ta=25ºC	-	2.0	3.0	mA
		I_{LC}	V_{LC}=-0.6V	-	0.5	1.0	mA

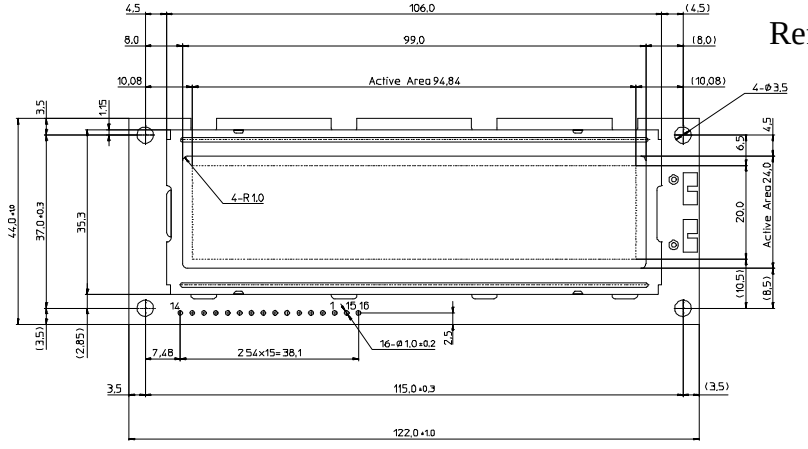
* test pattern : check board pattern

■ Pin Function

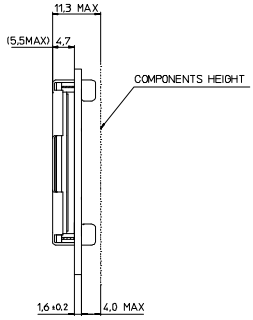
No.	Name	Function
1	VSS	GND
2	VDD	Power supply voltage +5V
3	VLC	Liquid crystal driving voltage
4	RS	L : Instruction code input H: Data input
5	R/W	L : Data write from MPU to LCM H : Data read from LCM to MPU
6	E	Enable
7	DB0	Data bus line
8	DB1	Data bus line
9	DB2	Data bus line
10	DB3	Data bus line
11	DB4	Data bus line
12	DB5	Data bus line
13	DB6	Data bus line
14	DB7	Data bus line
(15)	A	Anode (+) for LED backlight
(16)	K	Cathode (-) for LED backlight

■ Dimensions

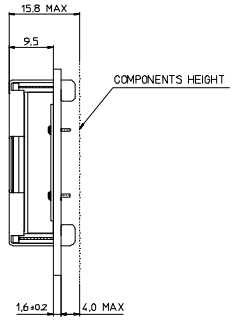
L1652 (2x16) Unit: mm, General tolerance ±0.5 mm



Reflective/EL Backlight

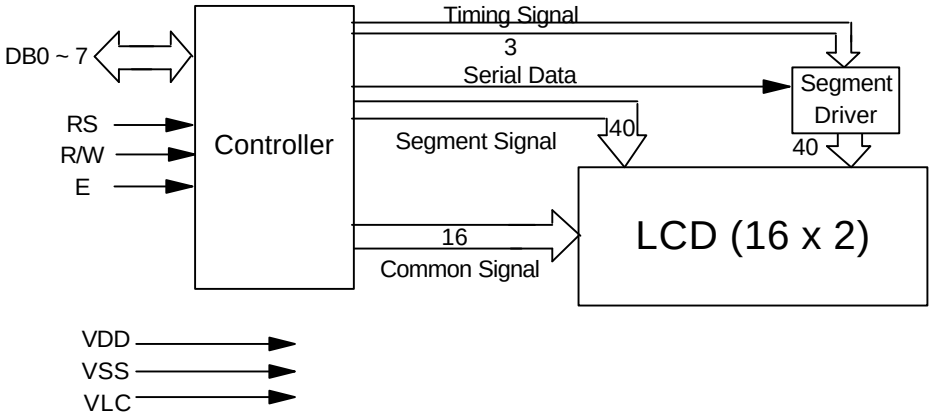


LED Backlight



Note : Only dimension changes between Reflective/EL and LED backlight is thickness.

■ Circuit Block diagram



■ Recommended Operating Voltage

The recommended value (Vopr) for an ambient temperature is as follows. Vopr=V_{DD} - V_{LC}

Temperature (ºC)		-20	0	+25	+50	+70
Vopr (V)	Normal	-	5.00	4.75	4.50	-
	Wide	6.20	5.90	5.60	5.40	5.20

■ Optical Characteristics

1. Normal Temperature Range Type

Ta=21ºC, 1/16 Duty, Vopr=4.75V

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
Viewing angle	θ 1	C≥2	-	-	-15	deg.
	θ 2	ϕ = 90º	55	-	-	
	θ 2- θ 1		70	-	-	
Contrast	C	θ =+5º, ϕ = 90º	-	5	-	-
Response time	ton (rise)	θ =0º	-	150	200	msec
	toff (fall)	ϕ =0º	-	200	220	msec
	ton (rise)	θ =0º, ϕ = 0º	-	750	800	msec
	toff (fall)	Ta = 0ºC, Vopr=5.0V	-	600	700	msec

Measuring equipment : Canon illuminater LC-4SR

2.Wide Temperature Range Type

Ta=21ºC, 1/16 Duty, Vopr=V_{DD} - V_{LC}

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
Viewing angle	θ 1	C≥2	-	-	-15	deg.
	θ 2	ϕ = 90º	55	-	-	
	θ 2- θ 1	Vop=5,6v	70	-	-	
Contrast	C	θ =+20º, ϕ = 90º Vop=5,6v	-	5	-	-
Response time	ton (rise)	θ =0º, ϕ = 90º	-	150	200	msec
	toff (fall)	Ta = 21ºC, Vopr=5.6V	-	200	220	msec
	ton (rise)	θ =0º, ϕ = 90º	-	750	800	msec
	toff (fall)	Ta = 0ºC, Vopr=5.9V	-	600	700	msec

Measuring equipment : Canon illuminater LC-4SR

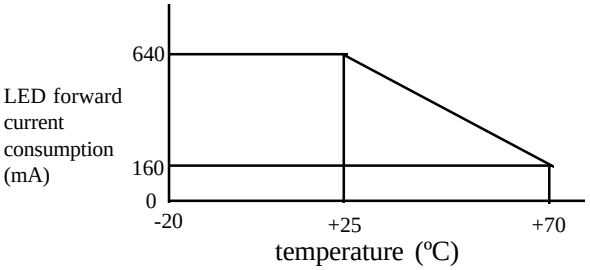
■ LED Backlight

1. Absolute Maximum Ratings

Ta=25ºC

Item	Symbol	Specifications	Unit
LED forward current consumption *	I_F	640	mA
LED reverse voltage	V_R	8	V
Allowable loss	P_D	2.8	W
Operating Temperature	Topr	- 20 ~ +70	ºC
Storage Temperature	Tstg	- 40 ~ + 80	ºC

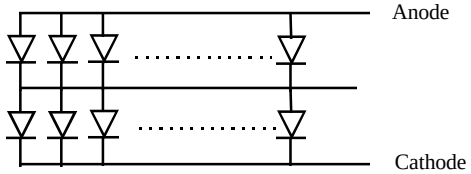
* LED forward current consumption and operating temperature characteristics are as follows.



2. Electrical Characteristics

Ta=25ºC

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
LED forward input voltage	V_F	I_F=320mA	3.8	4.1	4.4	V
LED reverse current	I_R	V_R=8V	-	-	0.2	mA
Peak emitting wavelength	IR	IF=320mA*	-	570	-	nm
Spectral half-width	Dl	IF=320mA*	-	30	-	nm
Brightness	L	IF=320mA*	150	170	-	cd/m²



total number of LED chips =2 x 32 = 64 pcs

■ EL Backlight

1.Absolute Maximum Ratings

Item	Symbol	Standard	Unit
Operating voltage	Voprr	AC 150V, 1KHz Sinew ave	V
Operating temperature	Topr	- 10 ~ +50	ºC
Storage temperature	Tstg	-20 ~ + 60	ºC
Storage humidity		0 ~ 10 % RH (60 ºC) 0 ~ 30 % RH (40 ºC)	

2. Brightness, Current, Life Characteristics

Item	Conditions	Specifications	Unit
Brightness	100V, 400Hz Sinew ave	40 min. 50 typ.	cd/m²
Current	100V, 400Hz Sinew ave	3.0 typ. 4.5 max	mA
Life	100V, 400Hz, Sinew ave 25ºC,50%RH	1,500	hrs
	Using 5C Inverter 25ºC,50%RH	3,500	

3. Suitable Inverter 5C

3.1 Electrical Characteristics (When combined with EL lamp)

Ta=25ºC

Item	Symbol	Conditions	Specifications	Unit
Oscillating frequency	f_{INV}	V_{IN}=5VDC	490 typ.	Hz
Output voltage	V_{OUT}	V_{IN}=5VDC	92 typ.	V
Output current	I_{OUT}	V_{IN}=5VDC	3.0 typ.	mA
Input current voltage	V_{IN}		5	Vrms
	I_{IN}	V_{IN}=5VDC	35 typ	mA

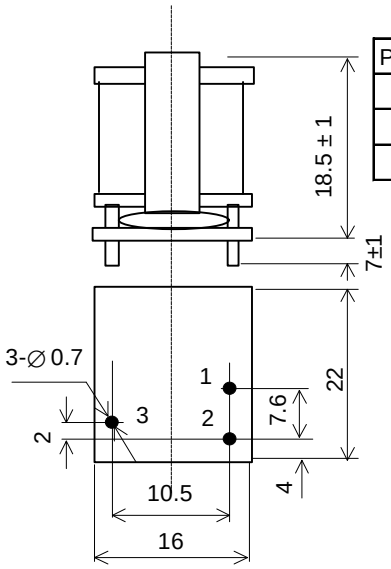
3.2 Tolerance (Inverter only)

Item	Specifications	Unit
Input voltage	3.0 to 6.0	V
Load range	25 to 40	cm²

3.3 Maximum Ratings (Inverter only)

Item	Specifications	Unit
Input voltage	7.0	V
Load range	50	cm²
Operating temperature	-10 to +60	ºC
Storage temperature	-20 to +70	ºC

3.4 Inverter Dimensions (unit : mm)



Pin No.	Function
1	Input : 5V DC
2	Common : GND
3	Output

1. Timing Characteristics

1.1 Write operation

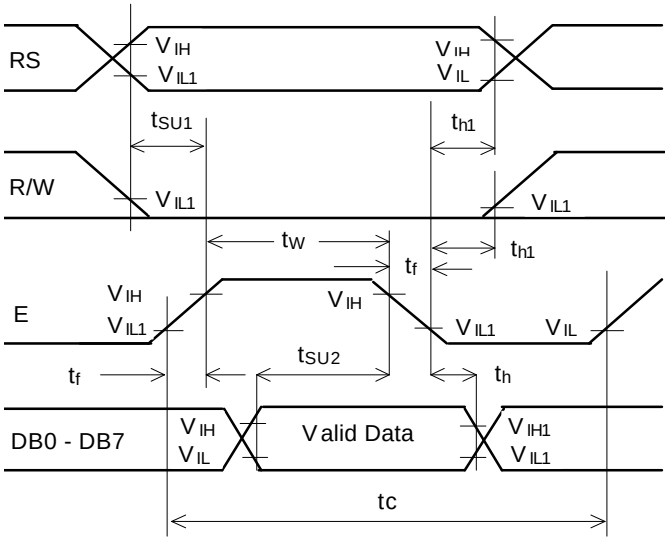
VDD=5V ± 10%. VSS=0V, Ta=25ºC

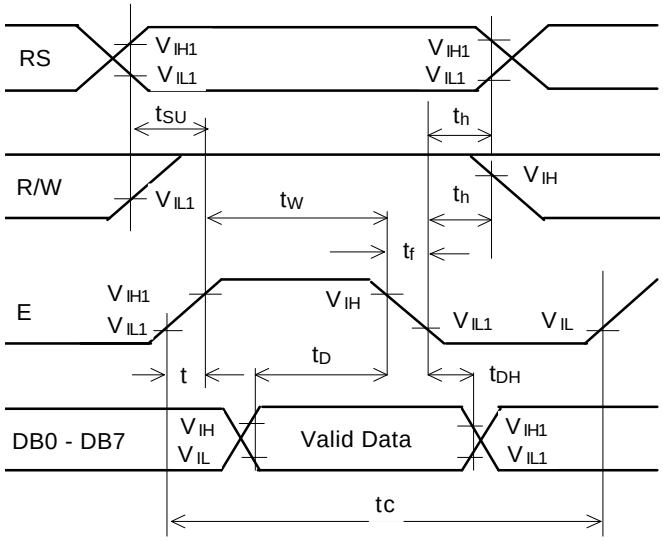
Item	Symbol	Min.	Max.	Unit
Enabel cycle time	tc	500	-	ns
Enable rise time	tr	-	25	ns
Enable fall time	tf	-	25	ns
Enable pulse width	tw	220	-	ns
Setup time R/W, RS	t_{SU1}	40	-	ns
Hold time R/S, RS	th1	10	-	ns
Data setup time	t_{SU2}	60	-	ns
Data hold time	th2	10	-	ns

1.2 Read operation

VDD=5V ± 10%. VSS=0V, Ta=25ºC

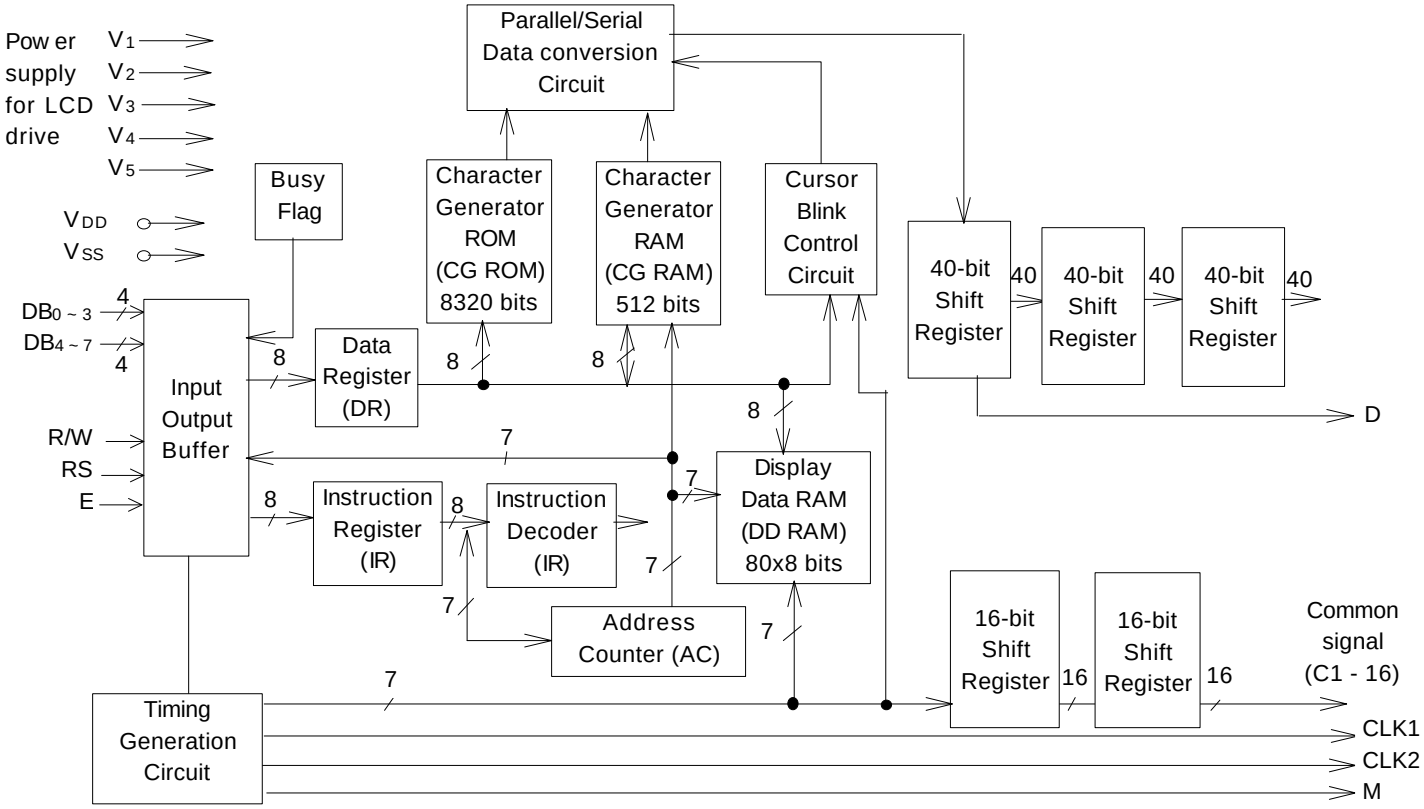
Item	Symbol	Min.	Max.	Unit
Enabel cycle time	tc	500	-	ns
Enable rise time	tr	-	25	ns
Enable fall time	tf	-	25	ns
Enable pulse width	tw	220	-	ns
Setup time R/W, RS	t_{SU}	40	-	ns
Hold time R/S, RS	th	10	-	ns
Data delay time	t_D	-	120	ns
Data hold time	t_{DH}	10	-	ns





2. Basic Operation

2.1 Block Diagram of Controller KS0066



2.2 Registers

The controller (KS0066) has to kinds of eight-bit registers ; the instruction register (IR) and the data register (DR). They are selected by the register select (RS) signal as shown below table 1. The IR stores instruction codes such as Display Clear and Cursor Home, and the address information of display data RAM (DD RAM) and character generator RAM (CG RAM). They can be written from the MPU, but can not be read to the MPU. The DR temporarily stores data to be written into DD RAM or CG RAM, or data read from D RAM or CG RAM. For data write, the data written into the DR from the MPU is automatically written into DD RAM or CG RAM by internal operation. For data read, when the data address is written into the IR, the specified data is read out to the DR by internal operation. Then the MPU reads it from the DR. After the read operation, the next address is set and DD RAM or CG RAM data at the address is read into the DR for the next read operation.

Table 1 Register Selection

RS	R/W	Operation
0	0	IR selection, IR write. Internal operation : Display Clear, Cursor Home, etc
0	1	Busy flag (DB7) and address counter (DB0 to DB6) read
1	0	DR selection, DR write. Internal operation : DR to DD RAM or to CG RAM
1	1	DR selection, DR read. Internal operation : DD RAM or CG RAM to DR

2.3 Busy Flag (BF)

The busy flag indicates whether the module is ready to accept the next instruction. As shown in table, the signal is output to DB_7, if RS=0 and R/W=1. If the busy flag is 0, the next instruction can be written. Therefore, the busy flag status needs to be checked before executing an instruction. To execute an instruction without checking the flag status, wait for more than the execution time of prior instruction. For the execution time of each instruction, see section 3 "Instruction Outline".

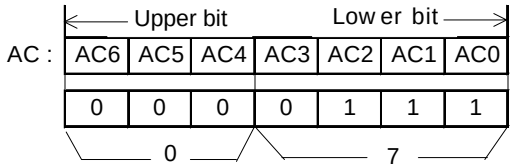
2.4 Address Counter (AC)

The address counter specifies an address when data is written into DD RAM or CG RAM and when the data stored in DD RAM or CG RAM is read out. If an address Set instruction (for DD RAM orCG RAM) is written into IR, the address information is transferred from the IR to the AC. When display data is written into or read from DD RAM or CG RAM, the AC is automatically incremented or decremented by one according to the Entry Mode Set. The contents of the AC are output to DB_0 to DB_6 if RS=0 and R/W=1 as shown in table 1.

2.5 Display Data RAM (DD RAM)

DD RAM has a capacity of up to 80 x 8 bits and stores display data of 80 eight-bit character codes. Some storage areas of DD RAM that are not used for display can be used as general data RAM. A DD RAM address to be set in the AC is expressed in hexadecimal form as follows. Example : DD RAM address "07"

The correspondence between the DD RAM address and the display digits of the LCD panel is described in the followings.



2.6 Address Location

The DD RAM address and the display digit of the LCD panel correspond as follows for LCD modules driven by 1/16duty and one controller can display maximum 80 characters.

	1	2	3	----------	15	16	17	18	19	20	----------	38	39	40	Display digit
Line 1	00	01	02	----------	0E	0F	10	11	12	13	----------	25	26	27	DD RAM
Line 2	40	41	42	----------	4E	4F	50	51	52	53	----------	65	66	67	address (HEX)

When the display digits are less than 40, the display begins at the head positions of the two lines. In this case, first line end address and the second line start address are not consecutive.

2.6.1 M1641

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Display digit
Line 1	00	01	02	03	04	05	06	07	40	41	42	43	44	45	46	47	DD RAM address (HEX)

Note : This is initialised as a 2 line display because of no LCD driver. Character No.9 must be addressed as first position of 2nd line, which is 40 (HEX).

2.6.2 M1632, L1642, L1652

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Display digit
Line 1	00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F	DD RAM
Line 2	40	41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F	address (HEX)

2.6.3 L1614

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Display digit
Line 1	00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F	
Line 2	40	41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F	DD RAM
Line 3	10	11	12	13	14	15	16	17	18	19	1A	1B	1C	1D	1E	1F	address (HEX)
Line 4	50	51	52	53	54	55	56	57	58	59	5A	5B	5C	5D	5E	5F	

Consequently, the end address of line 1 and the start address of line 3 are consecutive. Also, the end address of line 2 and the start address of line 4 are consecutive. The DD RAM address 00H to 27H are displayed in line 1 and line 3 and 40H to 67H in line 2 and line 4 by executing Display Shift.

2.6.4 L2012, L2022

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Display digit
Line 1	00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F	10	11	12	13	DD RAM
Line 2	40	41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F	50	51	52	53	address (HEX)

2.6.5 L2014

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Display digit
Line 1	00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F	10	11	12	13	
Line 2	40	41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F	50	51	52	53	DD RAM
Line 3	14	15	16	17	18	19	1A	1B	1C	1D	1E	1F	20	21	22	23	24	25	26	27	address (HEX)
Line 4	54	55	56	57	58	59	5A	5B	5C	5D	5E	5F	60	61	62	63	64	65	66	67	

Consequently, the end address of line 1 and the start address of line 3 are consecutive. Also, the end address of line 2 and the start address of line 4 are consecutive. The DD RAM address 00H to 27H are displayed in line 1 and line 3 and 40H to 67H in line 2 and line 4 by executing Display Shift

2.6.6 L2432

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Display digit
Line 1	00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F	10	11	12	13	14	15	16	17	DD RAM
Line 2	40	41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F	50	51	52	53	54	55	56	57	address (HEX)

2.6.3 L4042

	1	2	3	----------	15	16	17	18	19	20	----------	38	39	40	Display digit
Line 1	00	01	02	----------	0E	0F	10	11	12	13	----------	25	26	27	DD RAM
Line 2	40	41	42	----------	4E	4F	50	51	52	53	----------	65	66	67	address (HEX)

2.6.4 M4024

	1	2	3	----------	15	16	17	18	19	20	----------	38	39	40	Display digit
Line 1	00	01	02	----------	0E	0F	10	11	12	13	----------	25	26	27	
Line 2	40	41	42	----------	4E	4F	50	51	52	53	----------	65	66	67	DD RAM
Line 3	00	01	02	----------	0E	0F	10	11	12	13	----------	25	26	27	address (HEX)
Line 4	40	41	42	----------	4E	4F	50	51	52	53	----------	65	66	67	

M4024 has two LCD controllers. Since the capacity for each is 80 characters (40 characters x 2 lines), M4024 can display 160 characters (40 characters x 4 lines) by using two LCD controllers. Line 1 and 2 are activated by E1. Line 3 and 4 are activated by E2. All the four lines cannot be shifted at the same time. Instructions must be written using E1 and E2 to distinguish the upper two lines from the lower two lines.

2.7 Character Generator ROM (CG ROM)

CG ROM generates 5x7 dot-matrix character patterns from eight-bit character codes. In LCD modules of 5x7 dot-matrix character pattern, CG generates 192 types of 5x7 characters. Table 2 shows the correspondence between the CG ROM character codes and character patterns of 5x7 dot-matrix.

2.8 Character Generator RAM (CG RAM)

CG RAM is used to create character patterns freely by program. Eight types of 5x7 dot-matrix character patterns can be written into a CG RAM. Table 3 shows the character patterns created from CG RAM addresses and CG RAM data. To display a created character pattern, the character code in the left column of the table is written into DD RAM corresponding to the display position (digit). The areas not used for display are available as general data RAM.

2.9 Cursor/Blink Control Circuit

The circuit generates the cursor or blink. When the address counter (AC) selects the address of DD RAM, the cursor or the blink appears in the digit corresponding to the address. When the address counter is 08_H, a cursor or blink position is in the 9th digit in line 1 as shown below.

The cursor or blink also appears when the character generator RAM (CG RAM) is selected by the address counter. In this case, the cursor or blink position has no meaning.

	AC_6	AC_5	AC_4	AC_3	AC_2	AC_1	AC_0
AC	0	0	0	1	0	0	0

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Display digit
Line 1	00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F	DD RAM
Line 2	40	41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F	address (HEX)

Table 2 Correspondence between character codes and character pattern (5x7 dot -matrix)

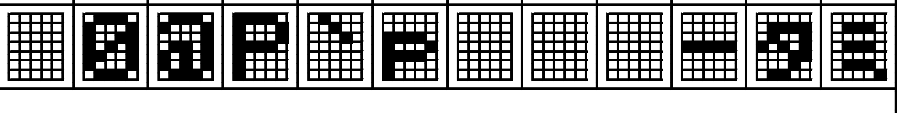
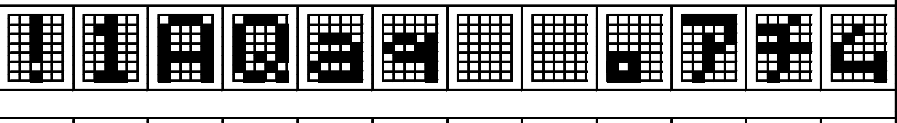
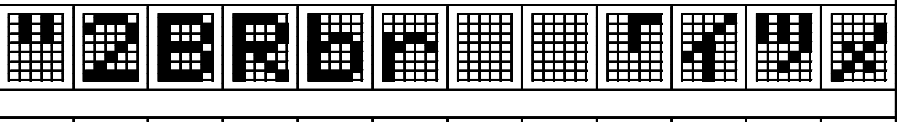
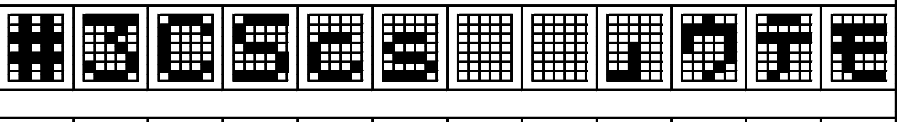
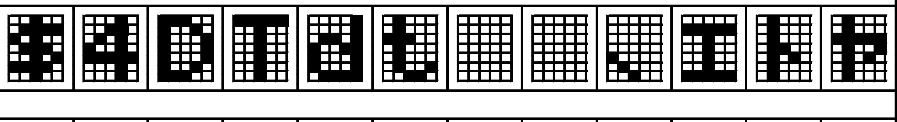
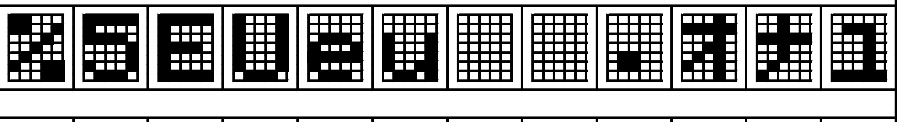
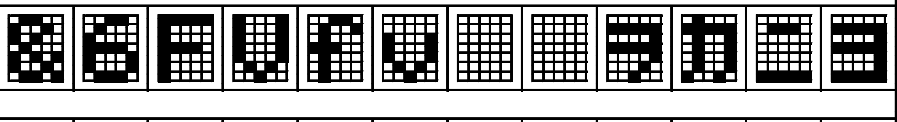
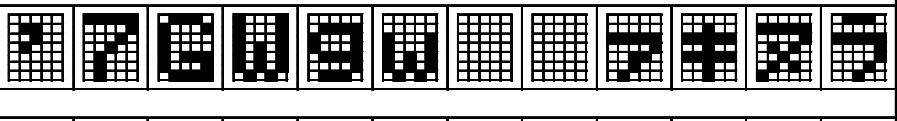
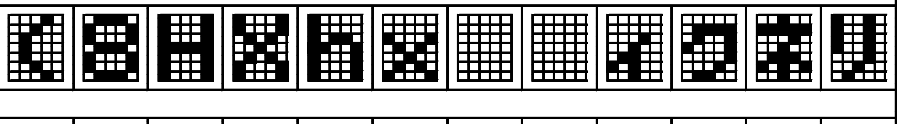
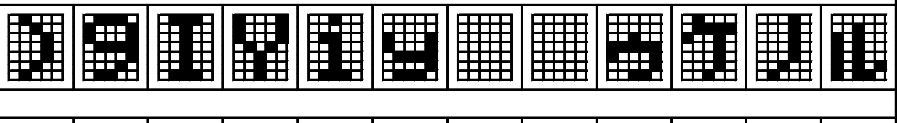
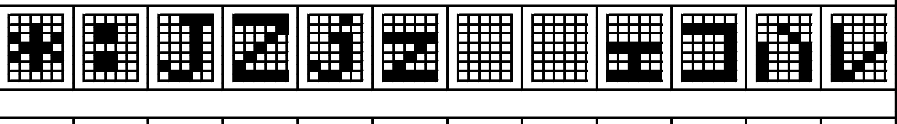
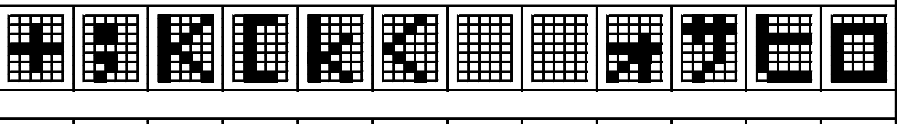
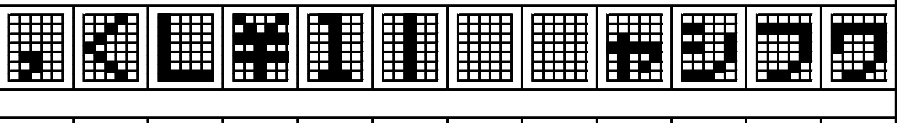
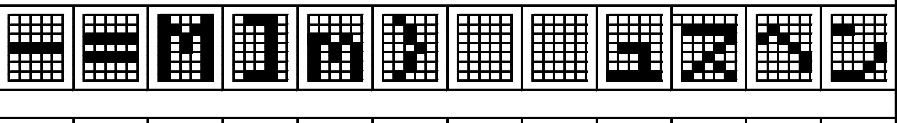
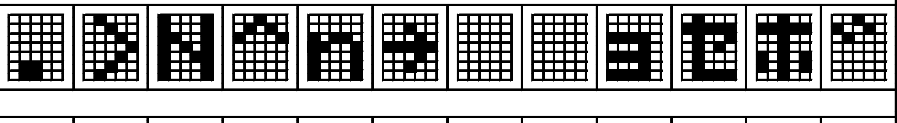
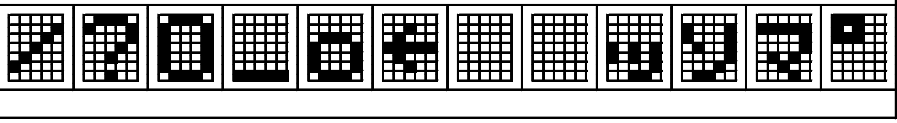
Upper 4 bits / Low er 4 bits	0000	0010	0011	0100	0101	0110	0111	1000	1001	1010	1011	1100	1101	1110	1111
XXXX0000	CG RAM (1)														
XXXX0001	(2)														
XXXX0010	(3)														
XXXX0011	(4)														
XXXX0100	(5)														
XXXX0101	(6)														
XXXX0110	(7)														
XXXX0111	(8)														
XXXX1000	(1)														
XXXX1001	(2)														
XXXX1010	(3)														
XXXX1011	(4)														
XXXX1100	(5)														
XXXX1101	(6)														
XXXX1110	(7)														
XXXX1111	(8)														

Table 3 Relation between CG RAM addresses and character codes (DD RAM) and character patterns (CG RAM) (5x7 dot-matrix)

Character Code (DD RAM data)		CG RAM Address		Character Pattern (CG RAM data)	
7 6 5 4 3 2 1 0		5 4 3 2 1 0		7 6 5 4 3 2 1 0	
← Upper bit Lower bit →		← Upper bit Lower →		← Upper bit Lower bit →	
0 0 0 0 * 0 0 0		0 0 0	0 0 0	* * *	1 1 1 1 0
			0 0 1		1 0 0 0 1
			0 1 0		1 0 0 0 1
			0 1 1		1 1 1 1 0
			1 0 0		1 0 1 0 0
			1 0 1		1 0 0 1 0
			1 1 0		1 0 0 0 1
			1 1 1	* * *	0 0 0 0 0
0 0 0 0 * 0 0 1		0 0 1	0 0 0	* * *	1 0 0 0 1
			0 0 1		0 1 0 1 0
			0 1 0		1 1 1 1 1
			0 1 1		0 0 1 0 0
			1 0 0		1 1 1 1 1
			1 0 1		0 0 1 0 0
			1 1 0		0 0 1 0 0
			1 1 1	* * *	0 0 0 0 0
0 0 0 0 * 1 1 1		1 1 1	0 0 0	* * *	
			0 0 1		
			0 1 0		
			1 0 1		
			1 1 0		
			1 1 1	* * *	

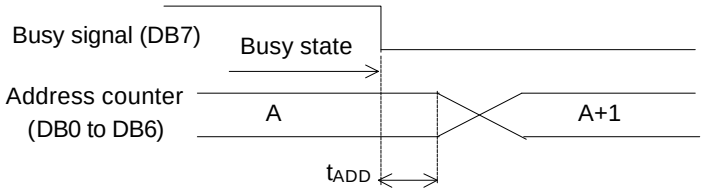
Example of character pattern (R) and (¥)

* : don't care bit

Notes :
- In CG RAM data, "1" corresponds to Selection and "0" to Non-selection on the display.
- Character code bits 0 to 2 and CG RAM address bits 3 to 5 correspond to each other (three bits, eight bytes).
- CG RAM address bits 0 to 2 specify a line position for a character pattern, Line 8 of a character pattern is the cursor position where the logical OR of the cursor and CG RAM data is displayed. Set the data of line 8 to "0" to display the cursor. If the data is changed to "1" , bit 1 lights, regardless of the cursor.
- The character pattern column positions correspond to CG RAM data bits 0 to 4 and bit 4 comes to the left end. CG RAM data bits 5 to 7 are not displayed but can be used as general data RAM.
- When regarding a character pattern from CG RAM, set to "0" all of character code bits 4 to 7. Bits 0 to 2 determine which pattern will be read out. Since bit 3 is not valid, 00_H and 08_H select the same character.

3. Instruction Outline

When MPU controls LCD controller on the LCD module, MPU directly controls only two registers of the controllers; the Instruction Register (IR) and the Data Register (DR). Prior to internal operation start, the controller temporarily stores control information in these registers, so as to interface with various types of MPUs or peripheral control ICs which operate at different speeds from speed of controller internal operation.
Table 4 shows the instructions and their execution time.
While the controller is executing an instruction and internal operation is in progress, the controller will accept and execute no instruction other than the Busy Flag/Address Read instruction.
Since the busy flag is set to "1" while an instruction is being executed, check the busy flag status and make sure it is "0" before sending an instruction from the MPU to the controller.
To send instructions without checking the busy flag, make sure that the interval between two instructions is much longer than the execution time of the prior instruction.
After the execution of writing/reading data instruction to/from CG/DD RAM, RAM address counter is automatically incremented or decrement by one. This increment/decrement / is executed after the busy flag is set to "0". The time from the fall edge of busy flag to the end of address counter renewal (tADD) is as shown below.



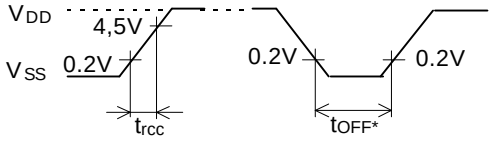
tADD depends on the clock oscillation frequency (fosc)

$t_{ADD} = \frac{1.5\ (s)}{fosc}$

4. Initialization

4.1 Automatic Initialisation

The system is automatically initialised at power-on if the following power supply conditions are satisfied.



0,1ms ≤ trcc ≤ 10ms $t_{OFF} \geq$ 1ms

t_{OFF*} : Time when power supply is OFF if cut instantaneously or turned ON and OFF repeatedly

In automatic initialisation, the following instructions are executed.

* Display Clear
* Function Set
  DL = 1 : Interface data length : Eight bits
  N = 0, F = 0 : 1/8 duty, character font : 5 x 7 dot-matrix
* Display ON/OFF control
  D = 0 : Display OFF
  C = 0 : Cursor OFF
  B = 0 : Blink OFF
* Entry Mode Set
  I/D = 1 : Increment
  S = 0 : No display shift

Since some conditions set by initialisation may not be suitable for the LCD module, execute further Function Set instruction.
The busy flag (BF) is kept busy until initialisation ends. The busy state remains for 20ms after VDD reaches to 4.5V.
If the power supply conditions are not satisfied and automatic initialisation is not executed. Execute initialisation using instruction according to section 4.2, "Initialisation by Instruction".

4.2 Initialisation by Instruction

If automatic initialisation is not executed because the power supply conditions are not satisfied, use interface data length of eight bits or four bits instructions shown in table 4 and table 5 to implement initialisation.
Since it is unknown whether the interface data length is set to eight bits or four bits at power on, execute Function Set twice to set the interface data length to eight bits and then set the required interface data length by executing further Function Set instruction.

Table 4 List of Instruction

Instruction	Code										Function	Execution time **
	RS	R/W	DB_7	DB_6	DB_5	DB_4	DB_3	DB_2	DB_1	DB_0		
(1) Display Clear	0	0	0	0	0	0	0	0	0	1	Clears all display and returns cursor to home position (address 0)	1,64 ms
(2) Cursor Home	0	0	0	0	0	0	0	0	1	*	Returns cursor to home position, shifted display returns to home position and DD RAM contents do not change	1,64 ms
(3) Entry Mode Set	0	0	0	0	0	0	0	1	I/D	S	Sets direction of cursor movement and w hether display w ill be shifted w hen data is w ritten or read	40 µm
(4) Display ON/OFF Control	0	0	0	0	0	0	1	D	C	B	Turns ON/OFF total display (D) and cursor (C), and makes cursor position column start blinking (B)	40 µm
(5) Cursor/Display Shift	0	0	0	0	0	1	S/C	R/L	*	*	Moves cursor and shifts display w ithout changing DD RAM contents.	40 µm
(6) Function Set	0	0	0	0	1	DL	N	F	*	*	Sets interface data length (DL), the duty (N), and character fonts (F)	40 µm
(7) CG RAM Address Set	0	0	0	1	A_{CG}						Sets CG RAM address to start transmitting or receiving CG RAM data	40 µm
(8) DD RAM Address Set	0	0	1	A_{DD}							Sets DD RAM address to start transmitting or receiving DD RAM data	40 µm
(9) BF/Address Read	0	1	BF	AC							Reads BF indicating module in internal operation and AC contents (use for both CG RAM and DD RAM)	0 µm
(10) Data Write to CG RAM or DD RAM	0	1	Write Data								Writes data into DD RAM or CG RAM	40 µm t_{ADD}=6µm
(11) Data Read from CG RAM or DD RAM	1	1	Read Data								Reads data from DD RAM or CG RAM	40 µm t_{ADD}=6µm

* : Don't care bit
A_{CG} : CG RAM address
A_{DD} : DD RAM address
AC : Address counter

I/D = 1 : Increment
I/D = 0 : Decrement

S = 1 : Display shift
S = 0 : No display shift

D = 1 : Display ON
D = 0 : Display OFF

C = 1 : Cursor ON
C = 0 : Cursor OFF

B = 1 : Blink ON
B = 0 : Blink OFF

S/C = 1 : Display shift
S/C = 0 : Cursor movement

R/L = 1 : Right shift
R/L = 0 : Left shift:

DL = 1 : 8 bits
DL = 0 : 4 bits

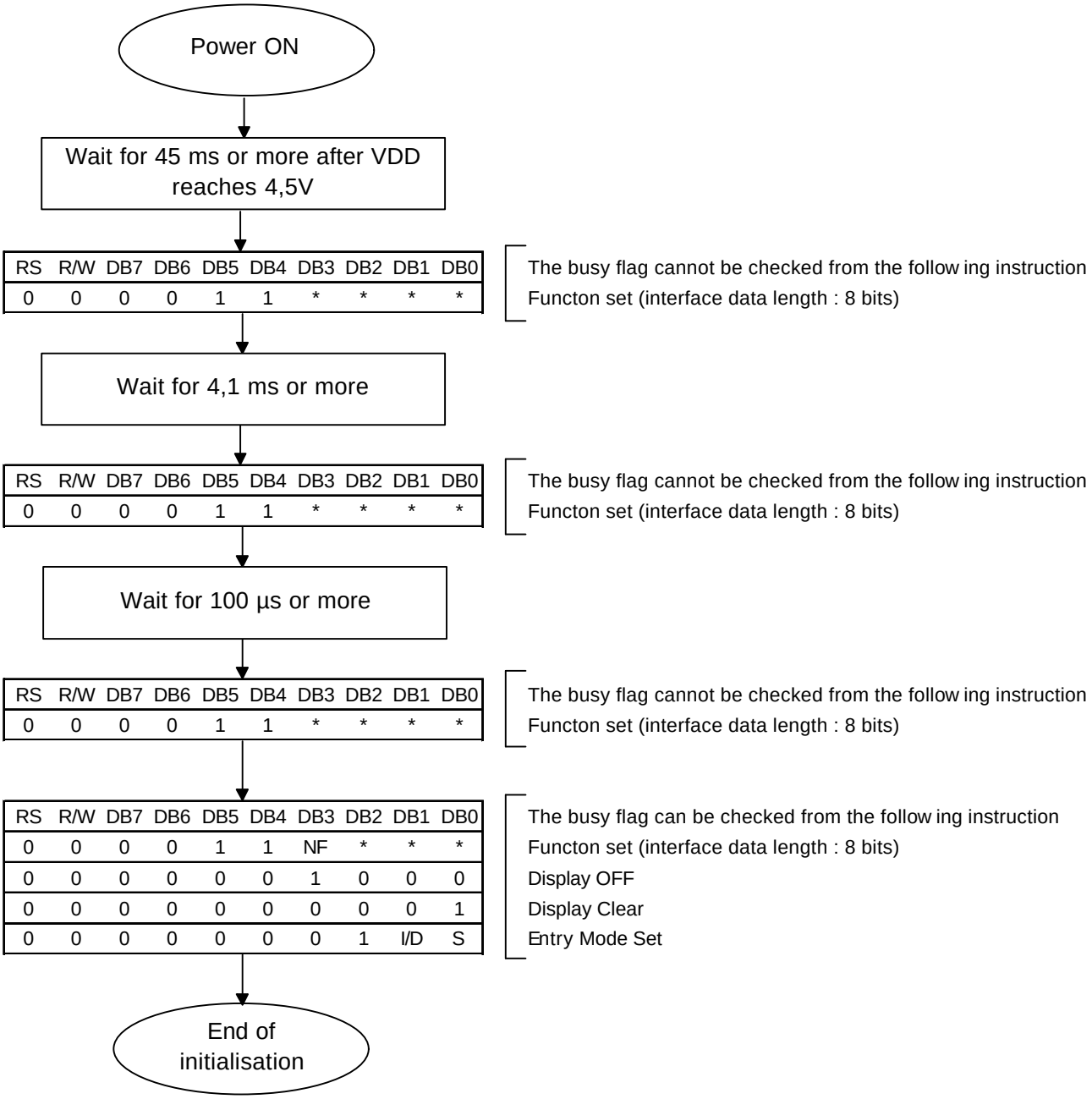
N = 1 : 1/16 duty
N = 0 : 1/8 duty or 1/11 duty

F = 1 : 5 x 10 dot matrix
F = 0 : 5 x 7 dot matrix

BF = 1 : Internal operation in progress
BF = 0 : Instruction can be accepted

** Execution time in the above Table indicated the maximum value w hen fosc is 250KHz. It changes w hen fosc changes.
When fosc = 270 KHz : 40 µs x 250 / 270 = 37 µs

Table 5. Interface Data Length : Eight bits



5. Instruction Detail

2.5.1 Display Clear

	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Code	0	0	0	0	0	0	0	0	0	1

Display CLEAR clears all display and returns cursor to home position (address 0). Space code 20H is written into all the addresses of DD RAM, and DD RAM address 0 is set to the AC, if it was shifted, the display returns to the original position. The cursor or blink go to the left end on line 1, except M4024. In M4024, if the cursor or blink is on line 3 or line 4, it returns to the left end of line 3. After execution of the Display Clear instruction, I/D = 1 (increment) of Entry Mode is set.

2.5.2 Cursor Home

	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Code	0	0	0	0	0	0	0	0	1	*

CURSOR Home returns cursor to home position (address 0). DD RAM address 0 is set to the AC. The display returns to the original position if it was shifted. The DD RAM contents do not change. If the cursor or blinking is ON, it returns to the left end, except M4024. In M4024, if the cursor or blink on line 3 or line 4, it returns to the left end of line 3.

2.5.3 Entry Mode Set

	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Code	0	0	0	0	0	0	0	1	I/D	S

ENTRY Mode Set sets the direction of cursor movement and determines whether display is shifted.

I/D :The DD RAM address is incremented or decremnted by one when a character code is written into or read from DD RAM. This is also true for writing into or reading from CG RAM.
When I/D = 1, the address is incremented by one and the cursor or blink moves to the right.
When I/D = 0, the address is decremented by one and the cursor or blink moves to the left.

S : If S = 1, the entire display is shifted either to the right or left for writing into DD RAM. The cursor position does not changed only the display moves, There is no display shift for reading form DD RAM.
When S = 1 and I/D = 1, the display shifts one digit to the left after data write to DD RAM.
When S = 1 and I/D = 0, the display shifts one digit to the right after data write to DD RAM.
If S = 0, the display does not shift.

2.5.4 Display ON/OFF Control

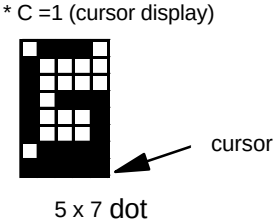
	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Code	0	0	0	0	0	0	1	D	C	B

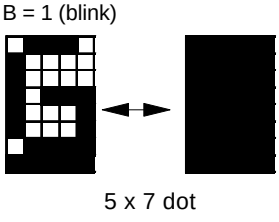
Display ON/OFF Control turns the total display and the cursor ON and OFF, and makes the character on the cursor position start blinking Cursor ON/OFF and blinking is done at the digit indicated by the DD RAM address specified by the AC

D : When D = 1, the display is turned ON
When D = 0, the display is turned OFF
If D = 0 is used, display data remains in DD RAM. Therefore the data can be displayed again by setting D = 1.

C : When C = 1, the cursor is displayed
When C = 0, the cursor is not displayed.
The cursor is displayed in the dot line below the character fonts.

B : When B = 1, the character at the cursor position starts blinking.
When B = 0, it does not blink.
For blinking, all-black dots and the character are switched about every 0.4 seconds when fosc is 250KHz. The cursor and blinking can be set at the same time.





2.5.5 Cursor/Display Shift

	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Code	0	0	0	0	0	1	S/C	R/L	*	*

* : don't care bit

Cursor/Display Shift moves the cursor and shifts the display without changing the DD RAM contents. The cursor position and the AC contents match. This instruction is useful for display correction and retrieval because the cursor position or display can be shifted without writing or reading display data, In a 2-line display, the cursor is shifted from digit 40 (DD RAM address 27) of line 1 to digit 1 of line 2. Displays of lines 1 and 2 are shifted at the same time Display shift moves the display of each line only horizontally. Therefore, the display pattern of line 2 is not shifted to line 1 and display pattern of line 1 is not shifted to line 2.

Note : M1641 operates internally as 8 characters x 2 line display, L1614 as 32 characters x 2 line-display, L2014 as 40 characters x 2 line-display and M4024 as two 40 characters x 2 line-display. See section 2.6 Address Location.

S/C	R/L	Operation
0	0	The cursor position is shifted to the left (the AC is decremented by one)
0	1	The cursor position is shifted to the right (the AC is incremented by one)
1	0	The entire display is shifted to the left with the cursor
1	1	The entire display is shifted to the right with the cursor

2.5.6 Function Set

	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Code	0	0	0	0	1	DL	N	F	*	*

* : don't care bit

Function Set sets the interface data length, the number of display lines and the character font.

DL : Interface data length
When DL = 1, the data length is set at eight bits (DB7 to DB0)
When DL = 0, the data length is set at four bits (DB7 to DB4). In 4-bit interface, the upper four bits are transferred first, then the lower four bits follow.

N : When N = 1, the duty is set to 1/16
When N = 0, the duty is set to 1/8 or 1/11

F : Character font
When F = 1, the character font is set to 5 x10 dot matrix
When F = 0, the character font is set to 5 x 7 dot matrix.
If N is set to 1, F becomes " Don't care bit"

N	F	Number of display line	Character font	Duty	LCD module
0	0	1	5 x 7	1/8	-
0	1	1	5 x 10	1/11	-
1	*	2	5 x 7	1/16	M1641, M1632, L1642, L1652, L1614, L2012 L2022, L2014, L2432, L4042, M4024

Function Set instruction must be executed prior to all other instructions except Busy Flag/Address Read. If another instruction is executed first, no interface data length is effective.

2.5.7 CG RAM Address Set

	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Code	0	0	0	1	A	A	A	A	A	A

Upper bit Lower bit

CG RAM addresses expressed as binary AAAAAA are set to the AC. The data written from or read to the MPU is for the CG RAM.

2.5.8 DD RAM Address Set

	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Code	0	0	1	A	A	A	A	A	A	A

Upper bit Lower bit

DD RAM address expressed as binary AAAAAA are set to the AC. Then data written from or read to the MPU is for the DD RAM. When N = 0 (one-line display) the addresses are 00H to 4HH. When N=1 (two-line display : M1632, L1642, L1652, L2012, L2022, L2432, L4042), the addresses used for display in line 1 (AAAAAA) are 00H to 27H and those for line 2 (AAAAAA) are 40H to 67H. As for M1641, L1614, L2014 and M4024, see section 2.6 Address Location.

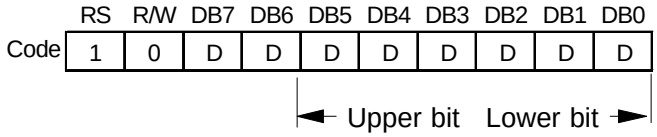
2.5.9 Busy Flag/Address Read

	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Code	0	1	BF	1	A	A	A	A	A	A

Upper bit Lower bit

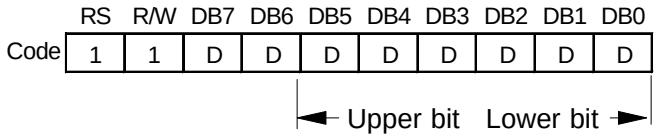
The BF signal is read out, indicating whether the module is working internally because of the previous instruction.
When BF = 1, the module is working internally and the next instruction cannot be accepted until the BF value becomes 0.
When BF = 0, the next instruction can be accepted, Therefore, make sure that BF = 0 before writing the next instruction.
The AC values binary AAAAAA are read out at the same time as the busy flag read. The AC addresses are used for both CG RAM and DD RAM, and the Address Set before the execution of this instruction determines whether the address is for CF RAM or DD RAM.

2.5.10 Data Write to CG RAM or DD RAM



Binary eight-bit data DDDDDDDD is written into CG RAM or DD RAM. CG RAM Address Set or DD RAM Address Set before this instruction selects either RAM. After the write operation, the address is incremented or decremented automatically according to Entry Mode Set. Entry Mode Set also determines whether display shifts or not after the write operation.

2.5.11 Data Read from CG RAM or DD RAM



Binary eight-bit data DDDDDDDD is read from CG RAM or from DD RAM. CG RAM Address Set or the DD RAM Address Set before this instruction selects either RAM. CG RAM Address Set or the DD RAM Address Set must be executed immediately before this instruction. If no Address Set instruction is executed before a read instruction, the first read data is invalid. Data is normally read from the second time, if read instructions are executed consecutively. For DD RAM, if Cursor Shift instruction is executed just before reading DD RAM< there is no need to execute an Address set instruction because the Cursor Shift instruction does this.
After a read operation, the address is automatically incremented or decremented by one according to Entry Mode Set, but the display isn't shifted regardless of Entry Mode set.

Note : The AC is automatically incremented or deremented by one according to Entry Mode Set after Data Write to CG RAM or DD RAM instruction is executed. If a read instruction is executed immediately after this instruction, RAM data specified by the AC is not read out. Correct data is read out under the following conditions.

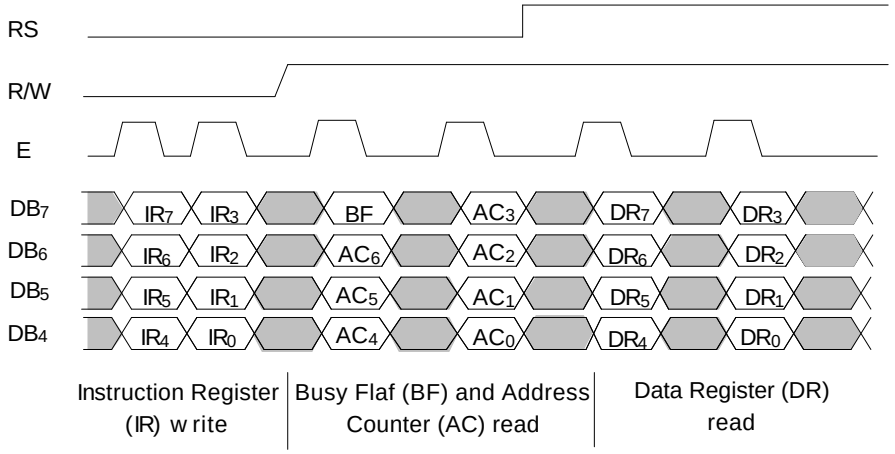
* An Address Set instruction is executed immediately before a read instruction
* For DD RAM. the Cursor Shift instruction is executed immediately before a read instruction
* The second, or later, instruction is executed in consecutive execution of read instructions

6. Interfacing to MPU

LCD modules containing controller can interface to both 4-bit and 8-bit MPU

6.1 Interface in 4-bit operation

When interface data is 4 bits long, data is transferred using only four buses; DB_4 to DB_0. DB_0 to DB_3 are not used. Data transfer between the controller and the MPU ends when 4-bit data is transferred twice. Data of the higher order 4 bits (contents of DB_4 to DB_7 when interface data is 8 bits long) are transferred first, then lower order 4 bits (content of DB_0 to DB_3 when interface data is 8 bits long) are transferred. Check the busy flag after 4-bit data has been transferred twice. Then the busy flag and address counter data are read out by two transfers.



6.2 Interface in 8-bit operation

When interface data is 8 bits long, data is transferred using the 8 data buses of DB_0 to DB_7.