LD1970

16 SEGMENT X 12 GRID VFD DRIVER

with KEYSCAN

Ver. 4.0 / Dec. 2012

Description

LD1970 is a Vacuum Fluorescent Display (VFD) Controller driven on a 1/4 to 1/12 duty factor. 16 segment output lines, 4 grid output lines, 8 segment/grid output drive lines, one display memory, control circuit and key scan circuit are all incorporated into a single chip to build a highly reliable peripheral device for a single chip micro computer. Serial data is fed to LD1970 via a three-line serial interface. It is housed in a 48QFN, 44LQFP & 44MQFP package.

Device name	Package Type
LD1970	48 QFN, 44LQFP, 44MQFP

Features

- CMOS Technology
- Low Power Consumption
- Key Scanning (16X2) Matrix
- Multiple Display Modes (16 segments, 12 digits to 24 segments, 4 digits)
- 8-Step Dimming Circuitry
- LED Ports Provide (4 channels, 20mA max.)
- Serial Interface for Clock, Data Input, Data Output, Strobe Pins
- No External Resistors Needed for Driver Outputs
- Available in 48 QFN , 44LQFP, 44MQFP

Device name	LD1970
Package Type	48 QFN (include 4NC), 44LQFP, 44MQFP
Power / Ground	VDD1, VDD2, VEE / VSS(2)
DI / DO / AIO	DI:3 EA, DO:1EA, AIO:1EA
FIP Output	34 EA (LED1~4, K1,K2,SG1~24, GR1~4)

Applications

- Microcomputer Peripheral Devices
- Digital Audio/Video System : CD/MD/VCD/DVD players
- Car Audio
- VCR
- Electric scale meter
- P.O.S
- Electronic equipment with instructional display

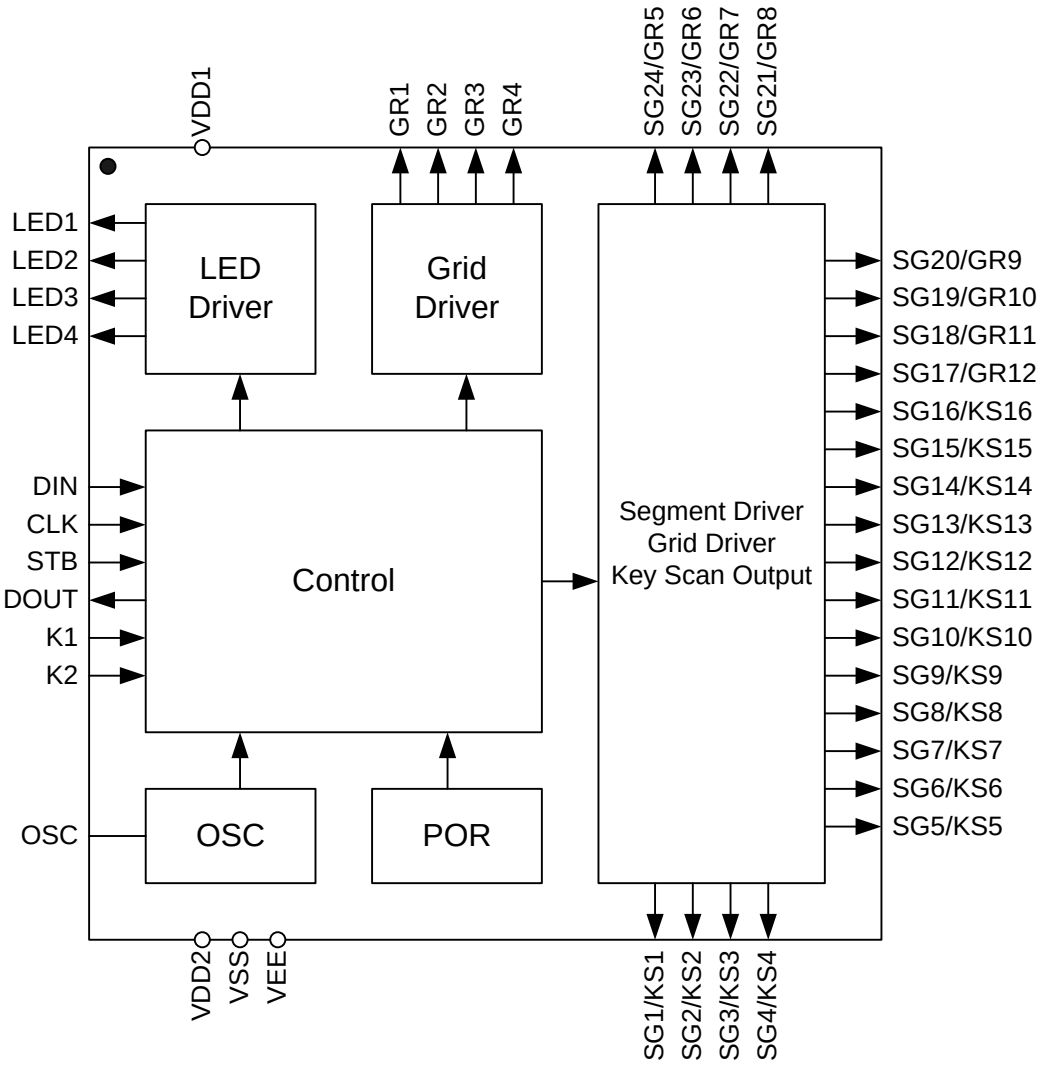
ORDERING INFORMATION

Device name	Segment	Grid	Key Scanning	PKG Type
LD1970-QFN	16~ 24 Segment	12~4Grid	16X2 matrix	48QFN
LD1970-LQFP	16~24 Segment	12~4Grid	16X2 matrix	44LQFP
LD1970-MQFP	16~24 Segment	12~4Grid	16X2 matrix	44MQFP

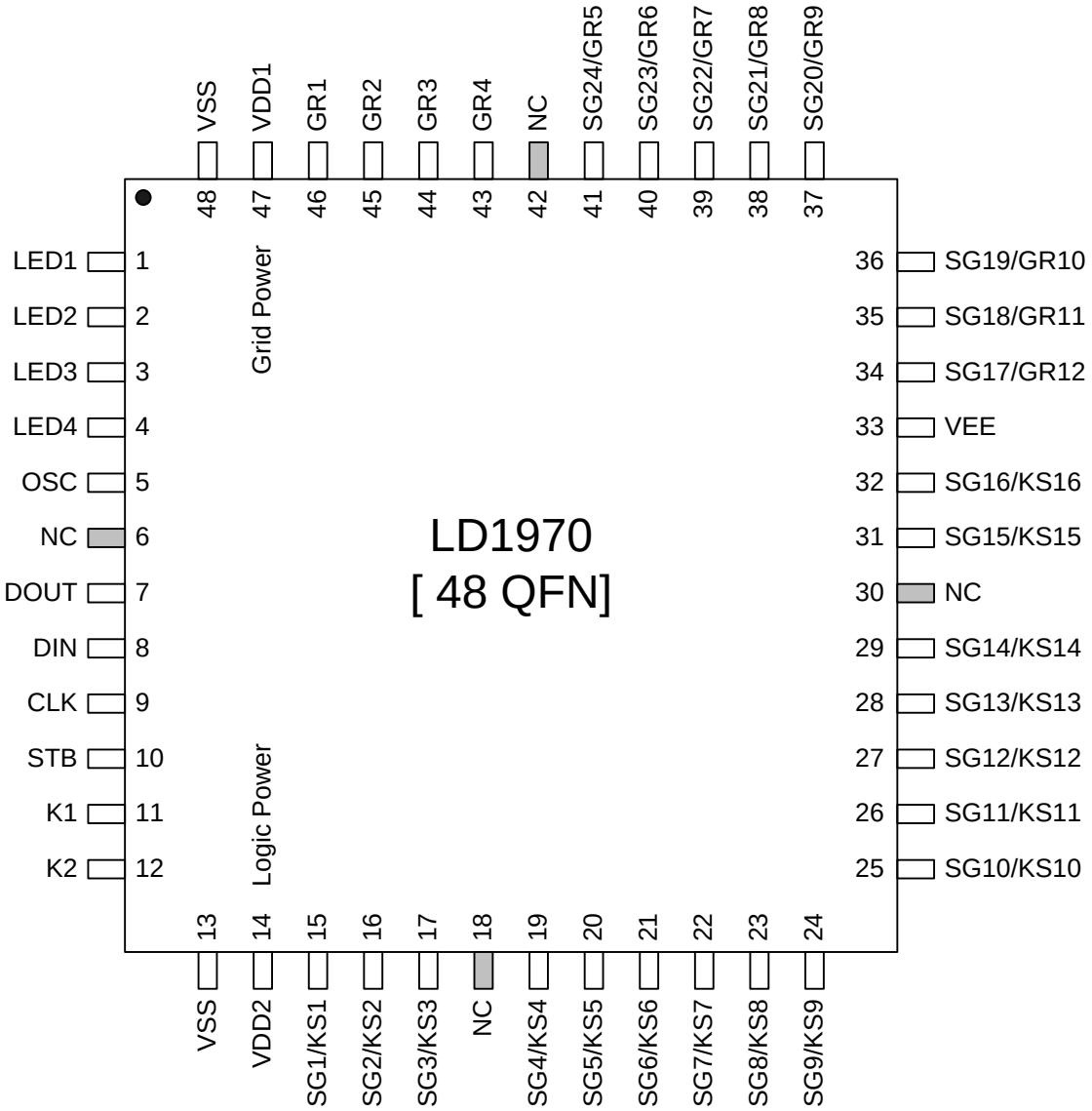
Pin Description

Pin name	Type	Description	Pin No.	
			QFN	LQFP,MQFP
LED1 ~ LED4	O	LED Output Pin	1~4	1~4
OSC	I/O	Oscillator I/O Pin A resistor is connected to this pin to determine the oscillation frequency.	5	5
DOUT	O	Data Output Pin (N-Channel, Open-Drain) This pin outputs serial data at the falling edge of the shift clock (starting from the lower bit)	7	6
DIN (Schmitt Trigger)	I	Data Input Pin This pin inputs serial data at the rising edge of the shift clock (starting from the lower bit)	8	7
CLK (Schmitt Trigger)	I	Clock Input Pin This pin reads serial data at the rising edge and outputs data at the falling edge of the shift clock	9	8
STB (Schmitt Trigger)	I	Serial Interface Strobe Pin The data input after the STB has fallen is processed as a command. When this pin is “HIGH”, CLK is ignored.	10	9
K1, K2	I	Key Data Input Pins The data inputted to these pins is latched at the end of the display cycle.	11,12	10,11
VSS	G	Logic Ground Pin	13,48	12,44
VDD1, VDD2	P(+)	Logic Positive Power Pin	47,14	43, 13
SG1/KS1 ~ SG16/KS16	O	High-Voltage Segment Output Pins, Also acts as the Key Source.	15~32	14~29
VEE	P(-)	Pull-Down Level / Negative Power Pin	33	30
SG17/GR12 ~ SG24/GR5	O	High-Voltage Segment/Grid Output Pins	34~41	31~38
GR1~GR4	O	High-Voltage Grid Output Pins	43~46	39~42

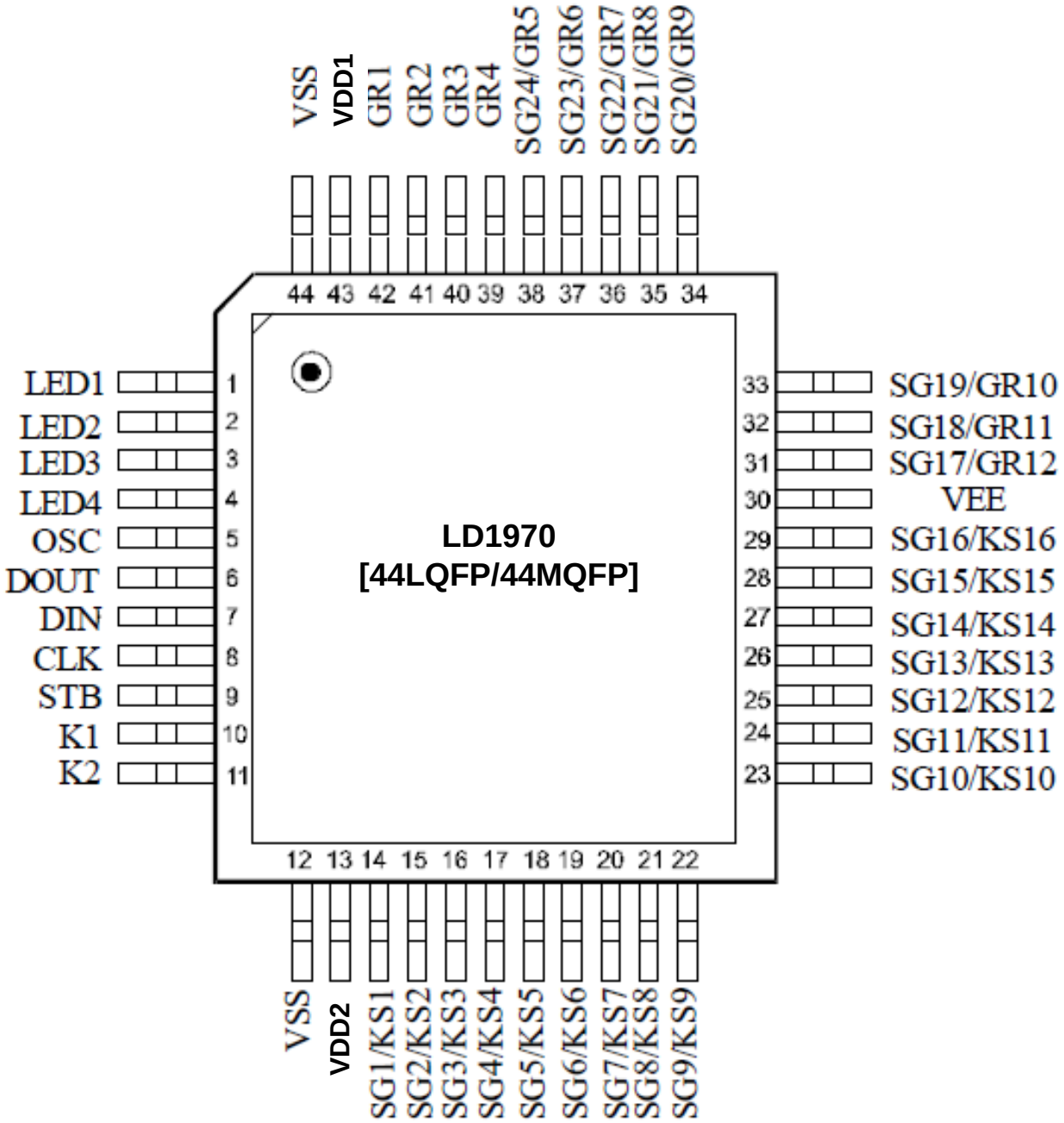
Block Diagram



Pin Configuration 48 QFN

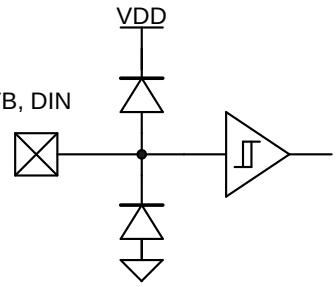


Pin Configuration 44 LQFP & 44MQFP

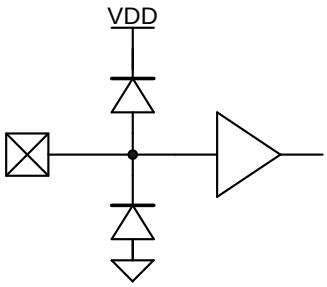


I/O Pins Schematic Diagram

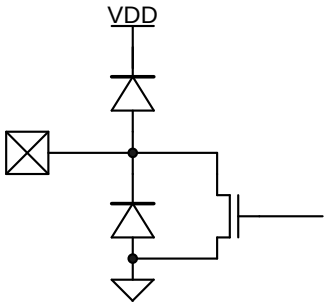
Input pins: CLK, STB, DIN



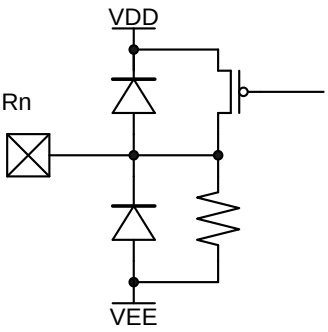
Input pins: K1, K2



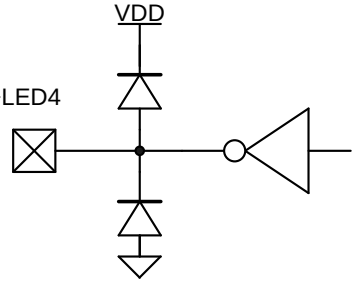
Output pin: DOUT



Output pins: SGn, GRn



Output pins: LED1~LED4



Absolute Maximum Ratings

(Unless otherwise stated, Ta=25°C, GND=0V)

Parameters	Symbol	Ratings	Unit
Logic Supply Voltage	VDD	-0.3 ~ +7.0	V
Driver Supply Voltage	VEE	VDD+0.3 ~ VDD-40	V
Logic Input Voltage	VI	-0.3 ~ VDD+0.3	V
VFD Driver Output Voltage	VO	VEE-0.3 ~ VDD+0.3	V
LED Driver Output Current	IOLED	± 20	mA
VFD Drive Output Current	IOVFD	-40 @ Grid, -15 @ Segment	mA
Operating Temperature	Topr	-40 ~ 85	°C
Storage Temperature	Tstg	-65 ~ 150	°C

Recommended Operating Range

(Unless otherwise stated, Ta=25°C, GND=0V)

Parameters	Symbol	Ratings			Unit
		Min.	Typ.	Max.	
Logic Supply Voltage	VDD	3.0	5.0	5.5	V
High-Level Input Voltage	VIH	0.7*VDD	-	VDD	V
Low-Level Input Voltage	VIL	0	-	0.3*VDD	V
Driver Supply Voltage	VEE	VDD-35	-	0	V

Electrical Characteristics

(Unless otherwise stated, VDD=5.0V, GND=0V, VEE=VDD-35V, Ta=25°C)

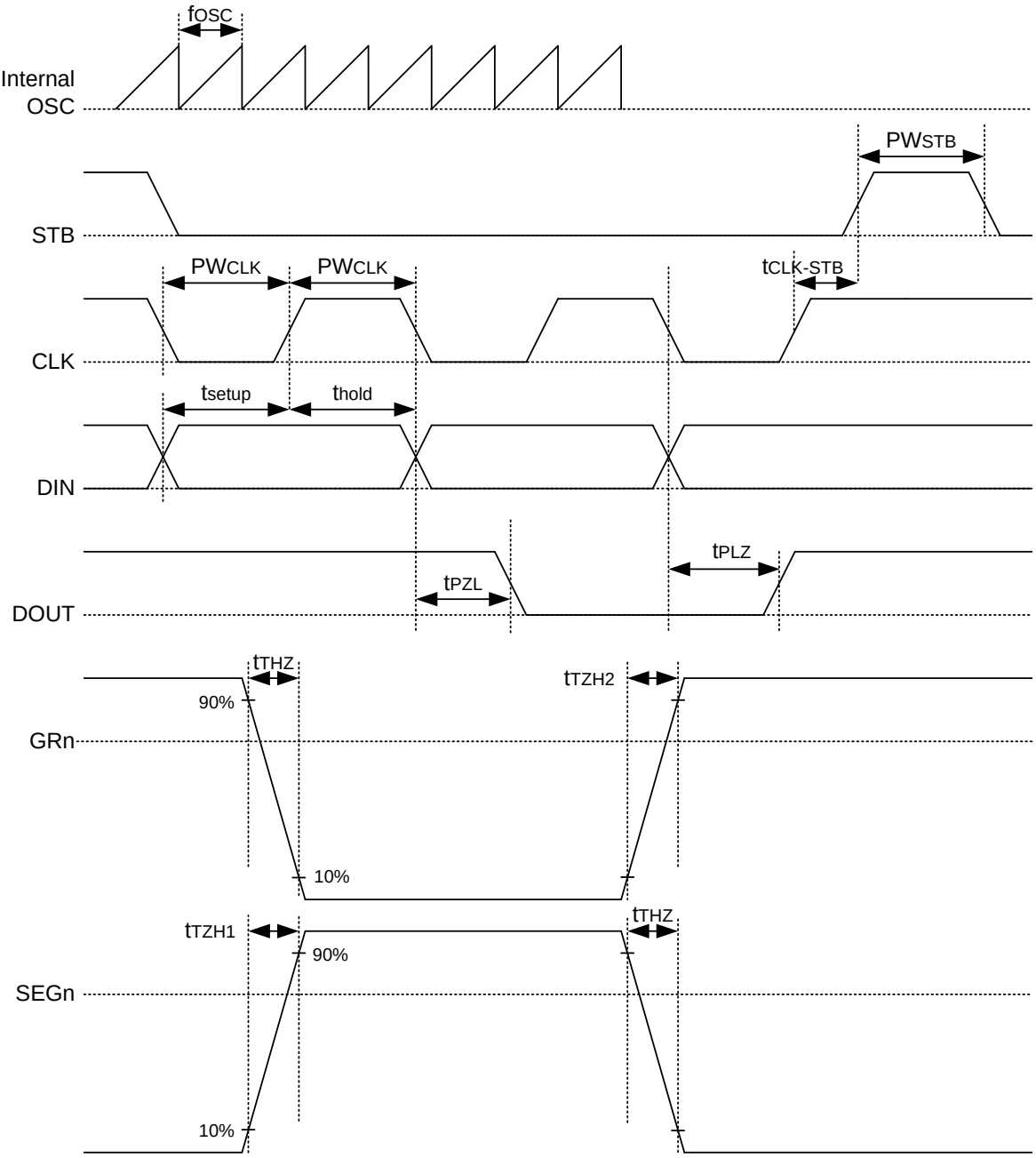
Parameters	Symbol	Test Conditions	Min.	Typ.	Max.	Unit
High-Level Output Voltage	VOHLED	IOHLED=-12mA LED1 ~ LED4	VDD-1	-	-	V
Low-Level Output Voltage	VOLLED	IOHLED=+15mA LED1 ~ LED4	-	-	1	V
Low-Level Output Voltage	VOLDOUT	IOLDOUT=4mA DOUT	-	-	0.4	V
High-Level Output Current	IOHSG	VO=VDD-2V SG1/KS1~SG16/KS16	-3	-	-	mA
High-Level Output Current	IOHGR	VO=VDD-2V GR1~GR4 SG17/GR12~SG24/GR5	-15	-	-	mA
Oscillation Frequency	fOSC	R=82KΩ	350	500	650	KHz
Schmitt-Trigger Transfer Voltage(+)	VT+	VDD=5V DIN, CLK, STB	2.7	3.0	3.3	V
Schmitt-Trigger Transfer Voltage(-)	VT-	VDD=5V DIN, CLK, STB	0.7	1.0	1.3	V
Hysteresis Voltage	Vhys	VDD=5V DIN, CLK, STB	1.4	2.0	-	V
Input Current	II	VI=VDD or VSS	-	-	±1	uA
Dynamic Current Consumption	IDDdyn	Under no load Display Off	-	-	5	mA

Electrical Characteristics

(Unless otherwise stated, VDD=3.3V, GND=0V, VEE=VDD-35V, Ta=25°C)

Parameters	Symbol	Test Conditions	Min.	Typ.	Max.	Unit
High-Level Output Voltage	VOHLED	IOHLED=-6mA LED1 ~ LED4	VDD-1	-	-	V
Low-Level Output Voltage	VOLLED	IOHLED=+15mA LED1 ~ LED4	-	-	1	V
Low-Level Output Voltage	VOLDOUT	IOLDOUT=4mA DOUT	-	-	0.4	V
High-Level Output Current	IOHSG	VO=VDD-2V SG1/KS1~SG16/KS16	-1.5	-	-	mA
High-Level Output Current	IOHGR	VO=VDD-2V GR1~GR4 SG17/GR12~SG24/GR5	-6	-	-	mA
Oscillation Frequency	fOSC	R=82KΩ	350	500	650	KHz
Schmitt-Trigger Transfer Voltage(+)	VT+	VDD=3.3V DIN, CLK, STB	1.8	2.0	2.2	V
Schmitt-Trigger Transfer Voltage(-)	VT-	VDD=3.3V DIN, CLK, STB	0.2	0.4	0.6	V
Hysteresis Voltage	Vhys	VDD=3.3V DIN, CLK, STB	1.0	1.6	-	V
Input Current	II	VI=VDD or VSS	-	-	±1	uA
Dynamic Current Consumption	IDDdyn	Under no load Display Off	-	-	3	mA

Switching Characteristic Waveform



fOSC = Oscillation Frequency

PWSTB (Strobe Pulse Width) ≥ 1us

PWCLK (Clock Pulse Width) ≥ 400ns

tCLK-STB (Clock-Strobe Time) ≥ 1us

tsetup (Data Setup Time) ≥ 100ns

thold (Data Hold Time) ≥ 100ns

tPZL (Propagation Delay Time) ≤ 100ns

tPLZ (Propagation Delay Time) ≤ 400ns

tTHZ (Grid Fall Time) ≤ 150us

tTHZ (Segment Fall Time) ≤ 150us

tTZH1 (Segment Rise Time) < 2.0us(VDD=5.0V)

tTZH2 (Grid Rise Time) ≤ 0.5us(VDD=5.0V)

tTZH1 (Segment Rise Time) < 4.0us(VDD=3.3V)

tTZH2 (Grid Rise Time) ≤ 1.2us(VDD=3.3V)

Functional Description

Commands

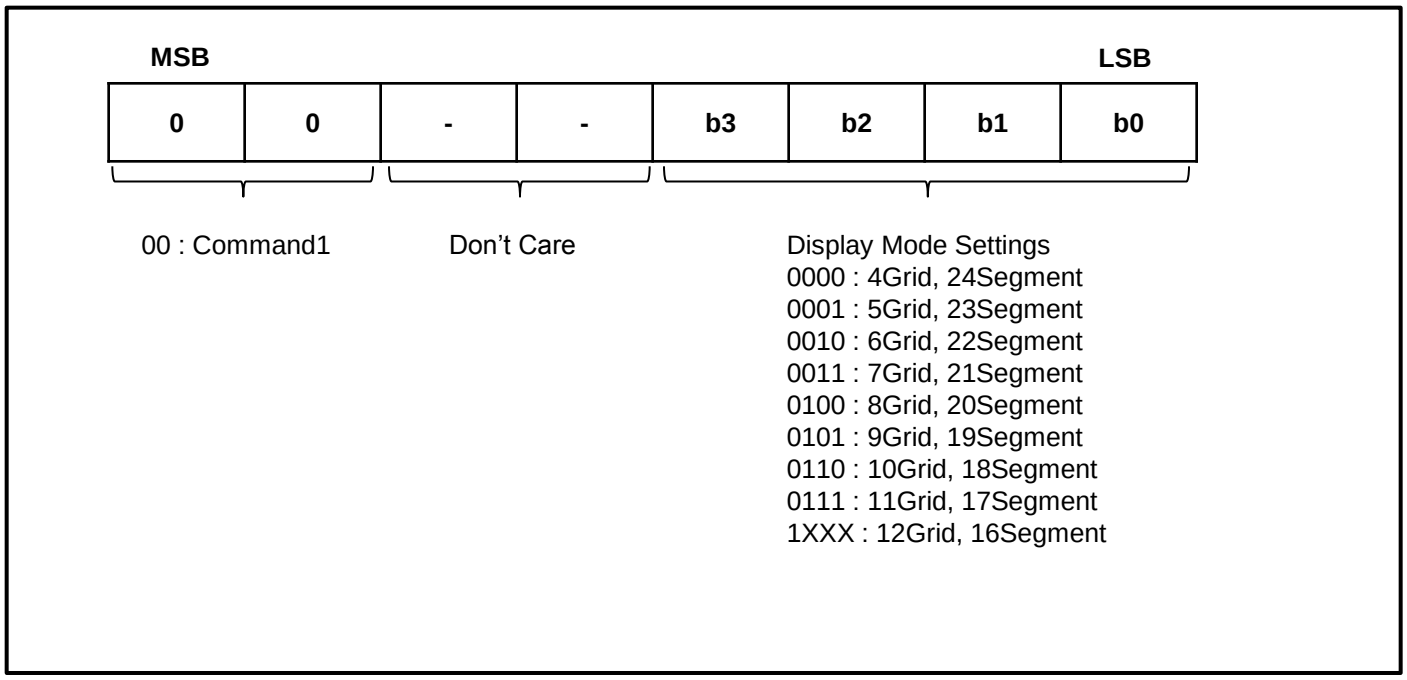
Commands determine the display mode and status of LD1970. A command is the first byte (b0 to b7) inputted to LD1970 via the DIN pin after STB pin has changed from “High” to “Low” state. If for some reason the STB pin is set to “High” while data or commands are being transmitted, the serial communication is initialized, and the data/commands being transmitted are considered invalid.

Command 1 : Display Mode Setting command

LD1970 provides 8 display mode settings as shown in the diagram below : As stated earlier a command is the first one byte(b0 to b7) transmitted to LD1970 via the DIN pin when STB pin is “Low”. However, for this command, the bits 5 to 6 (b4 to b5) are ignored, bits 7 & 8 (b6 to b7) are given a value of “0”.

The Display Mode Setting command determines the number of segments and grids to be used(1/4 to 1/12 duty, 16 to 24 segments). When this command is executed, the display is forcibly turned off, the key scanning stops. A display command “ON” must be executed in order to resume display. If the same mode setting is selected, no command execution is taken place, therefore nothing happens.

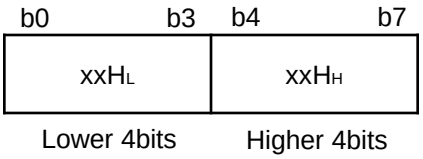
When Power is turned “ON”, the 12-grid, 16-segment mode is selected.



Display Mode and Memory Address

Data transmitted from an external device to LD1970 via the serial interface are stored in the Display Memory and are assigned addresses. The Memory Addresses of LD1970 are given below in the 8bits unit.

SG1	SG4	SG5	SG8	SG9	SG12	SG13	SG16	SG17	SG20	SG21	SG24	
$00H_L$		$00H_H$		$01H_L$		$01H_H$		$02H_L$		$02H_H$		Grid1
$03H_L$		$03H_H$		$04H_L$		$04H_H$		$05H_L$		$05H_H$		Grid2
$06H_L$		$06H_H$		$07H_L$		$07H_H$		$08H_L$		$08H_H$		Grid3
$09H_L$		$09H_H$		$0AH_L$		$0AH_H$		$0BH_L$		$0BH_H$		Grid4
$0CH_L$		$0CH_H$		$0DH_L$		$0DH_H$		$0EH_L$		$0EH_H$		Grid5
$0FH_L$		$0FH_H$		$10H_L$		$10H_H$		$11H_L$		$11H_H$		Grid6
$12H_L$		$12H_H$		$13H_L$		$13H_H$		$14H_L$		$14H_H$		Grid7
$15H_L$		$15H_H$		$16H_L$		$16H_H$		$17H_L$		$17H_H$		Grid8
$18H_L$		$18H_H$		$19H_L$		$19H_H$		$1AH_L$		$1AH_H$		Grid9
$1BH_L$		$1BH_H$		$1CH_L$		$1CH_H$		$1DH_L$		$1DH_H$		Grid10
$1EH_L$		$1EH_H$		$1FH_L$		$1FH_H$		$20H_L$		$20H_H$		Grid11
$21H_L$		$21H_H$		$22H_L$		$22H_H$		$23H_L$		$23H_H$		Grid12

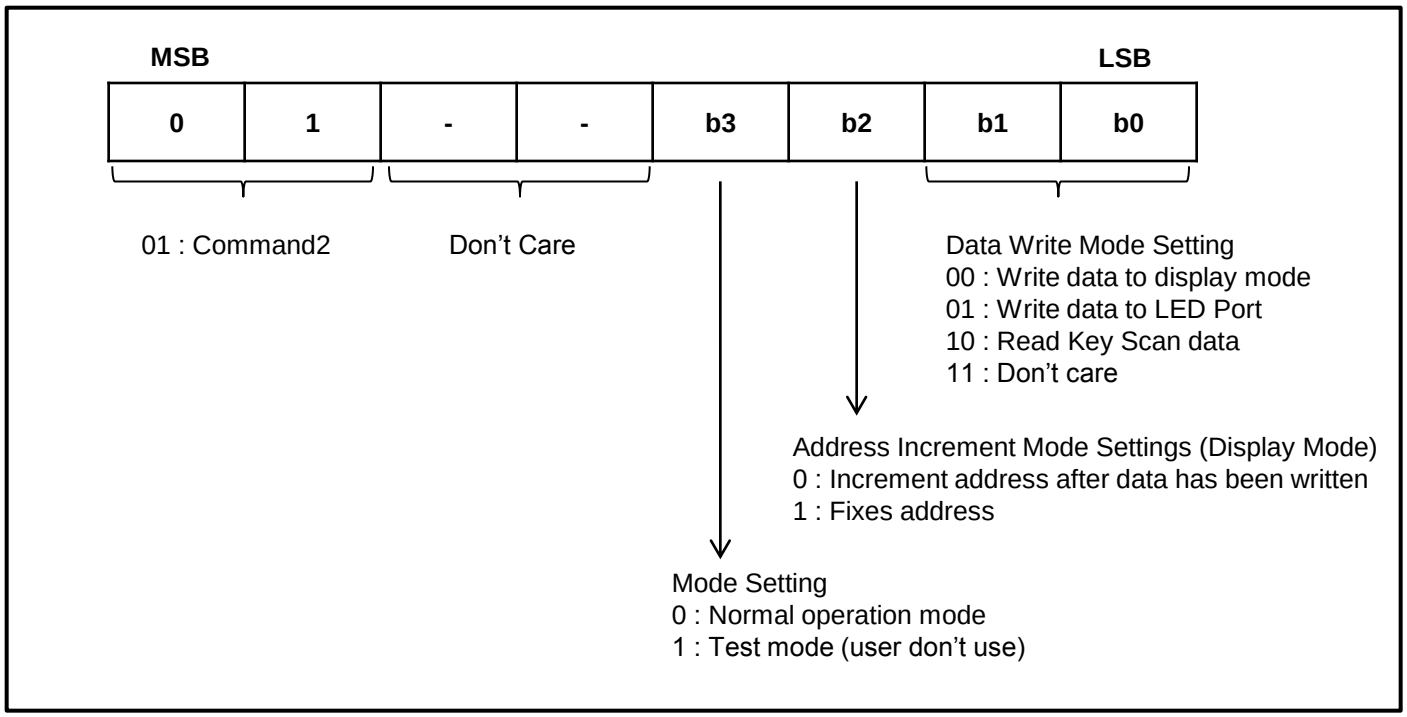


Command 2 : Data Setting command

The Data Setting command executes the Data Write or Data Read Modes for LD1970. The Data Setting Command, the bits 5 and 6 (b4, b5) are ignored, bit 7 (b6) is given the value of “1” while bit 8 (b7) is given the value of “0”.

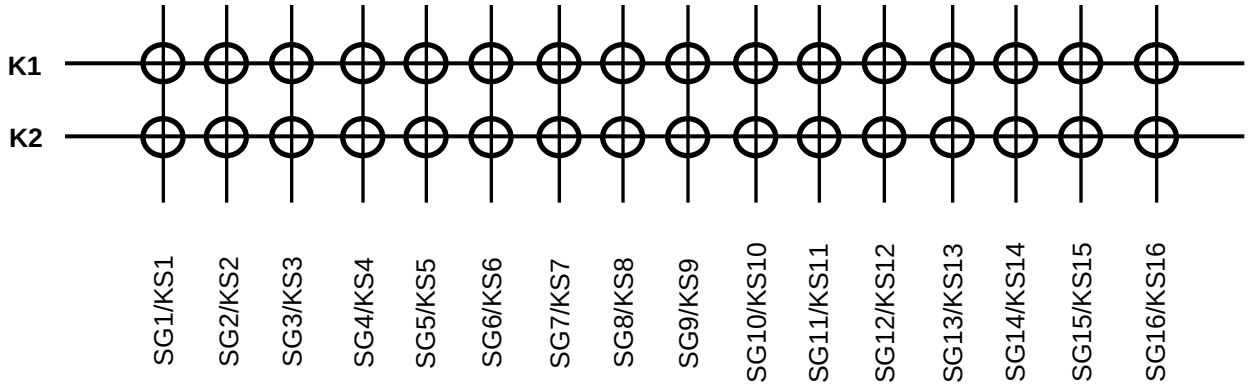
Please refer to the diagram below.

When Power is turned “ON”, the bit 4 to bit1 (b3 to b0) are given the value of “0”.



LD1970 Key Matrix & Key Input Data Storage Memory

LD1970 Key Matrix consists of 16 x 2 array as shown below.



Each data inputted by each key are stored as follows. They are read by a READ command, starting from the least significant bit. When the most significant bit of the data (SG16, b7) has been read, the least significant bit if the next data (SG1, b0) is read.

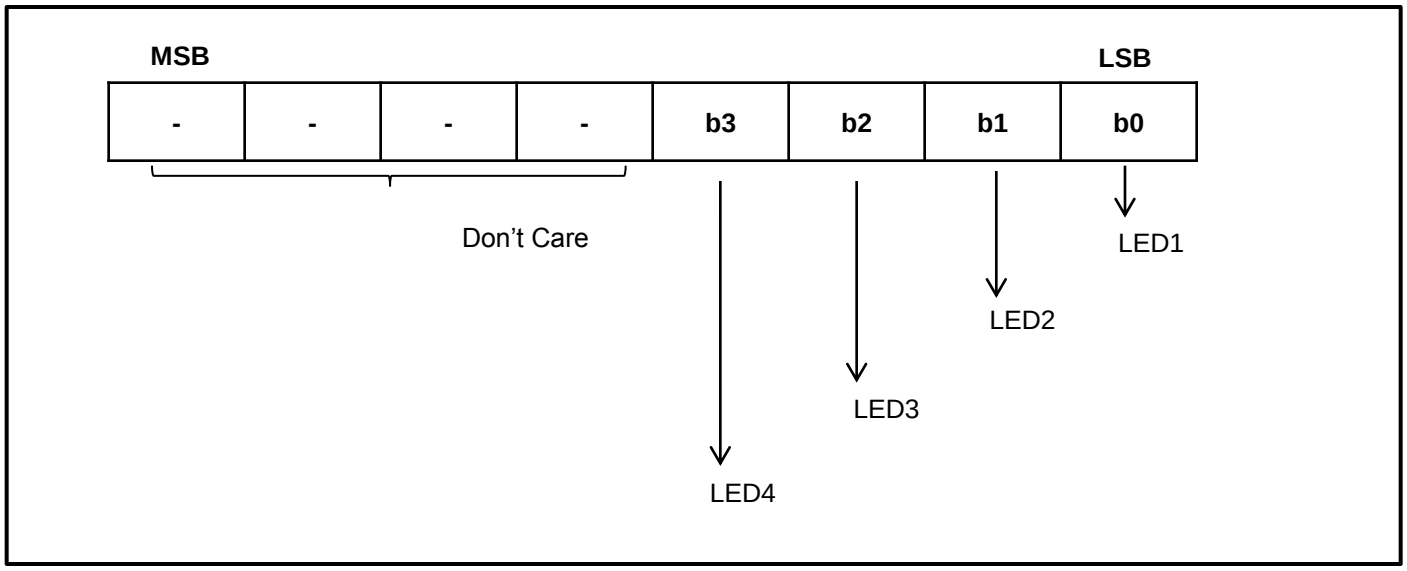
K1	K2	K1	K2	K1	K2	K1	K2
SG1/KS1		SG2/KS2		SG3/KS3		SG4/KS4	
SG5/KS5		SG6/KS6		SG7/KS7		SG8/KS8	
SG9/KS9		SG10/KS10		SG11/KS11		SG12/KS12	
SG13/KS13		SG14/KS14		SG15/KS15		SG16/KS16	
b0	b1	b2	b3	b4	b5	b6	b7

Reading Sequence

LED Display

LD1970 provides 4 LED Display Terminals, namely LED1 to LED4. Data is written to the LED Port starting from the least significant bit (b0) of the port using a Write Command. Each bit starting from the least significant (b0) activates a specific LED Display Terminal – b0 corresponds LED1 Display,b1 activates LED2 and so forth. Since there are only 4 LED Display Terminals, bit5 to bit8 (b4 ~ b7) are not used and therefore ignored. This means that b4 to b7 does not in anyway activate any LED Display and they are totally ignored.

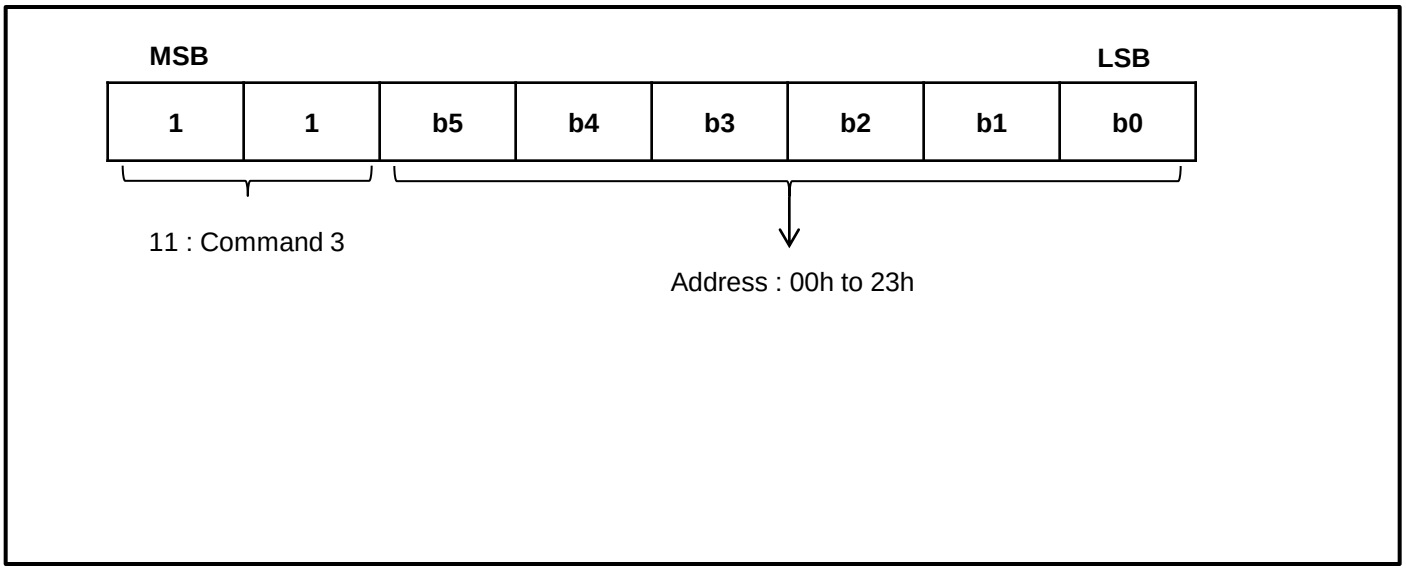
When a bit (b0 ~ b3) in the LED Port is “1”, the corresponding LED is Off. Conversely, when the bit is “0”, the LED Display is turned On. For example, Bit1 (as designated by b0) has the value of “1”, then this means that LED1 is Off. It must be noted that when power is turned on, bit1 to bit4 (b0 to b3) are given the value of “0” (All LEDs are turned On). Please refer to the diagram below.



Command 3 : Address Setting command

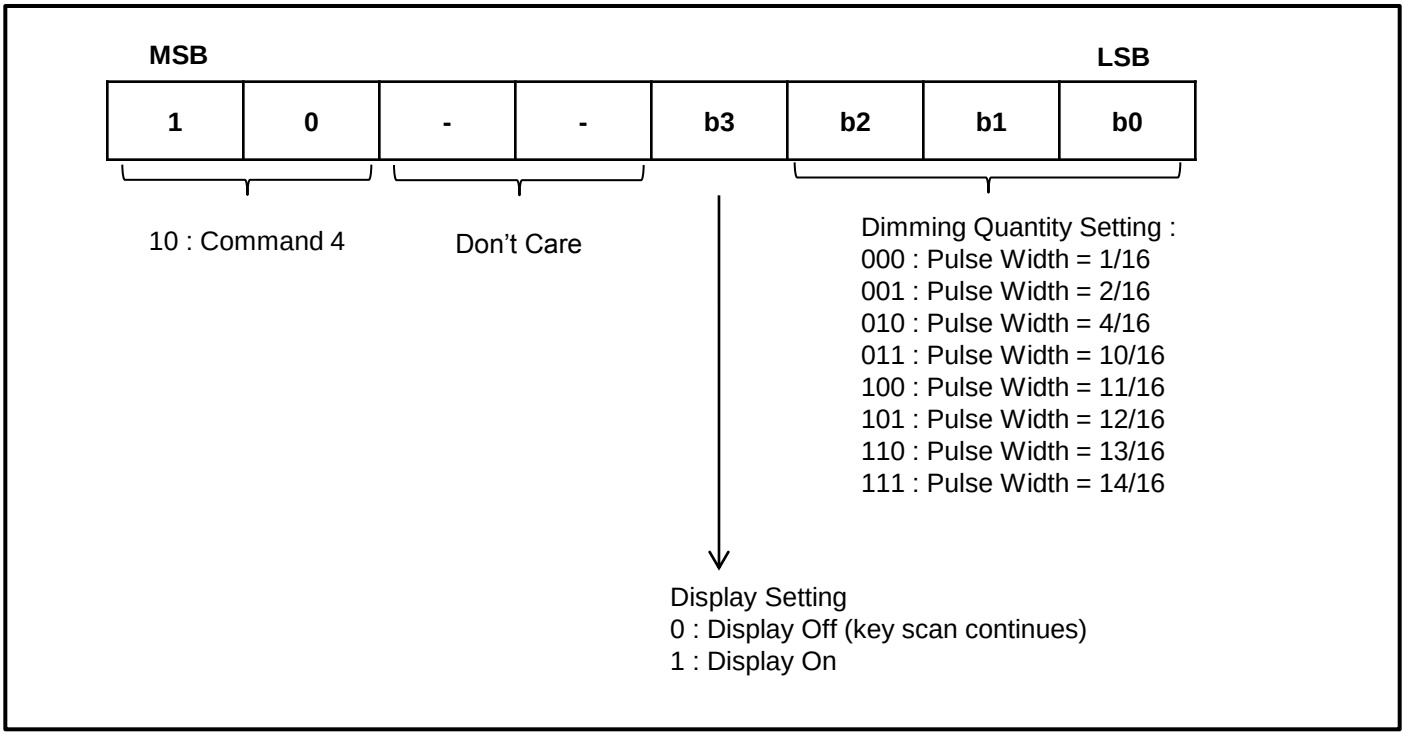
The display memory is addressed by Address Setting command. The valid address range is from “00h” to “23h”. If the address is set to 24h or higher, the data is ignored until a valid address is set. When the power is turned On, the address is set at “00h”.

Please refer to the diagram below.



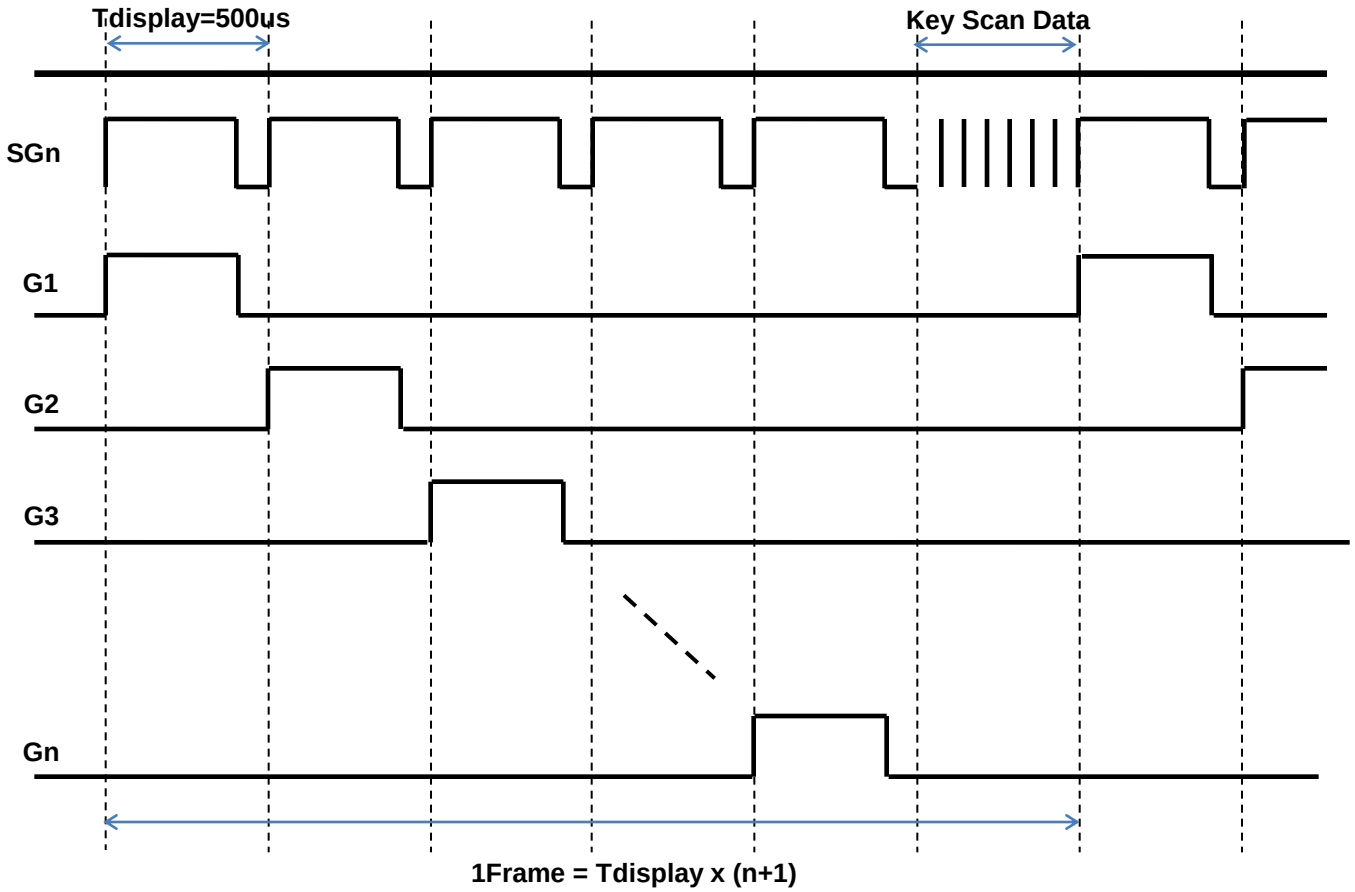
Command 4 : Display Control command

The Display Control command is used to turn On or Off a display. It is also used to set the pulse width. Please refer to the diagram below. When the power is turned On, a 1/16 pulse width is selected and the display is turned Off (the key scanning is stopped).



Scanning and Display Timing

The key scanning and display timing diagram is given below. One cycle of key scanning consists of 2 frames. The data of the 16 x 2 matrix is stored in the Memory.

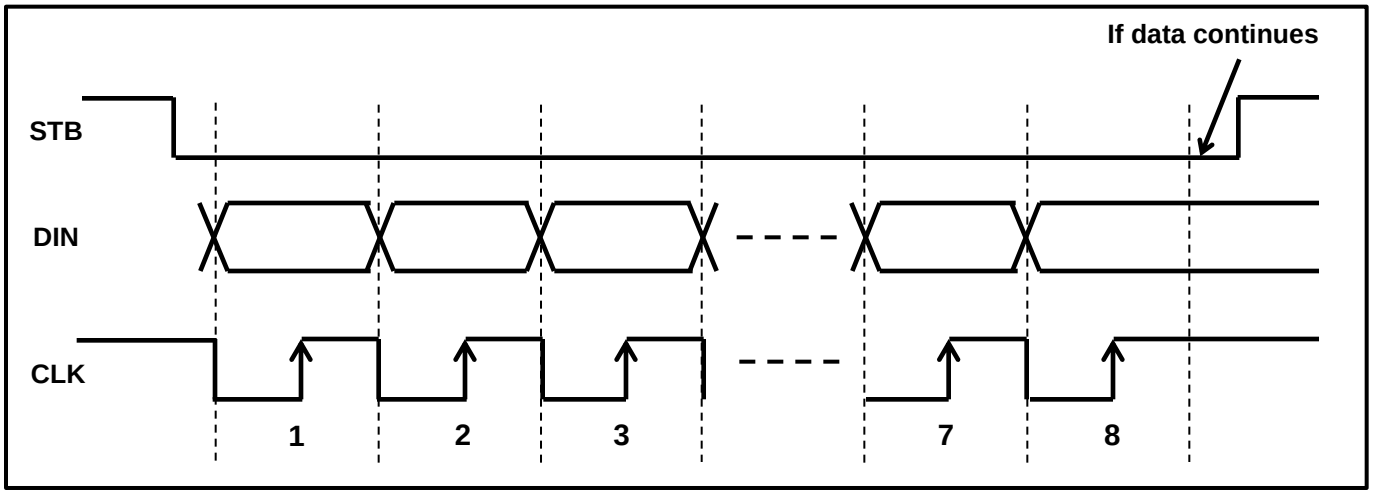


Note : Tdisplay is the width of segment only

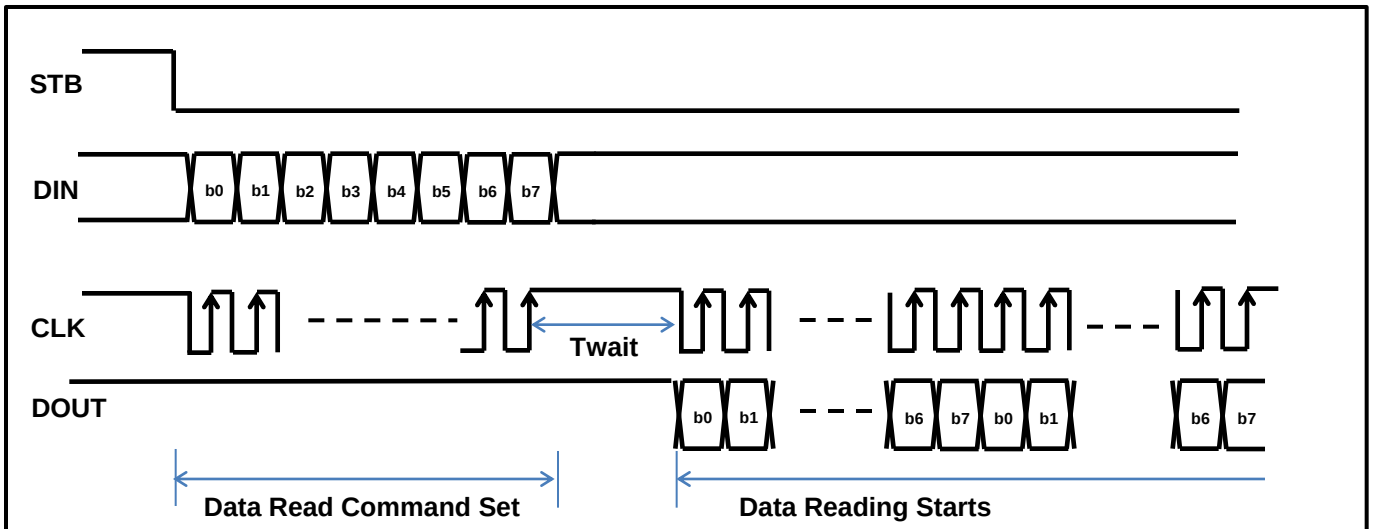
Serial Communication Format

The following diagram shows the LD1970 serial communication format. The DOUT pin is an N-channel open drain output pin, therefore , it is highly recommended that an external pull-up resistor (1kΩ ~ 10kΩ) must be connected to DOUT.

Reception (Data/Command Write)



Transmission (Data Read)

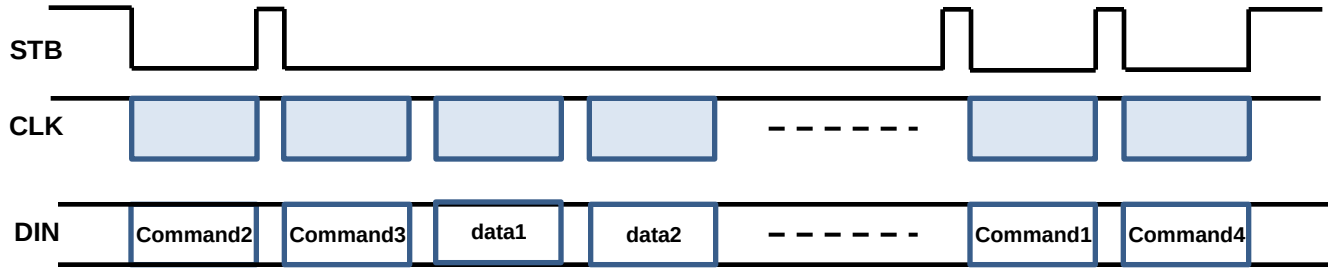


Where : Twait (waiting time) ≥ 1us

It must be noted that when the data is read, the waiting time (Twait) between the rising of the 8th clock that has set the command and the falling of the 1st clock that has the data is greater or equal to 1us.

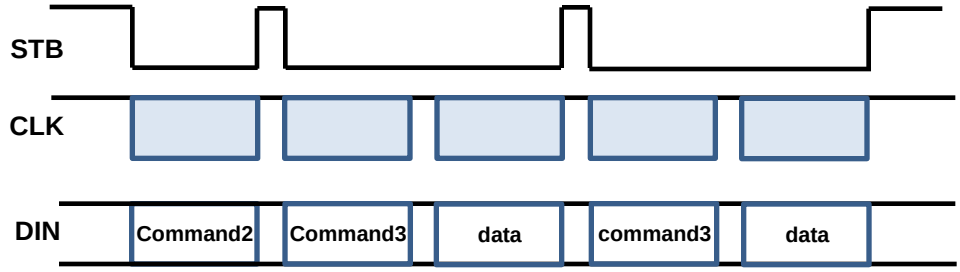
Serial Communication Example

Serial communication timing diagram for initialization setting



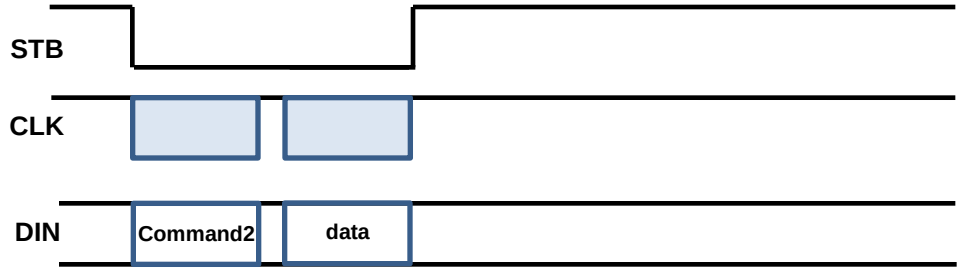
Where : Command1 : Display Mode Setting
Command2 : Data Setting Command
Command3 : Address Setting Command
Data1 to n : Transfer Display Data (36 byte max.)
Command4 : Display Control Command

Transmission diagram for new Data on specific addresses.



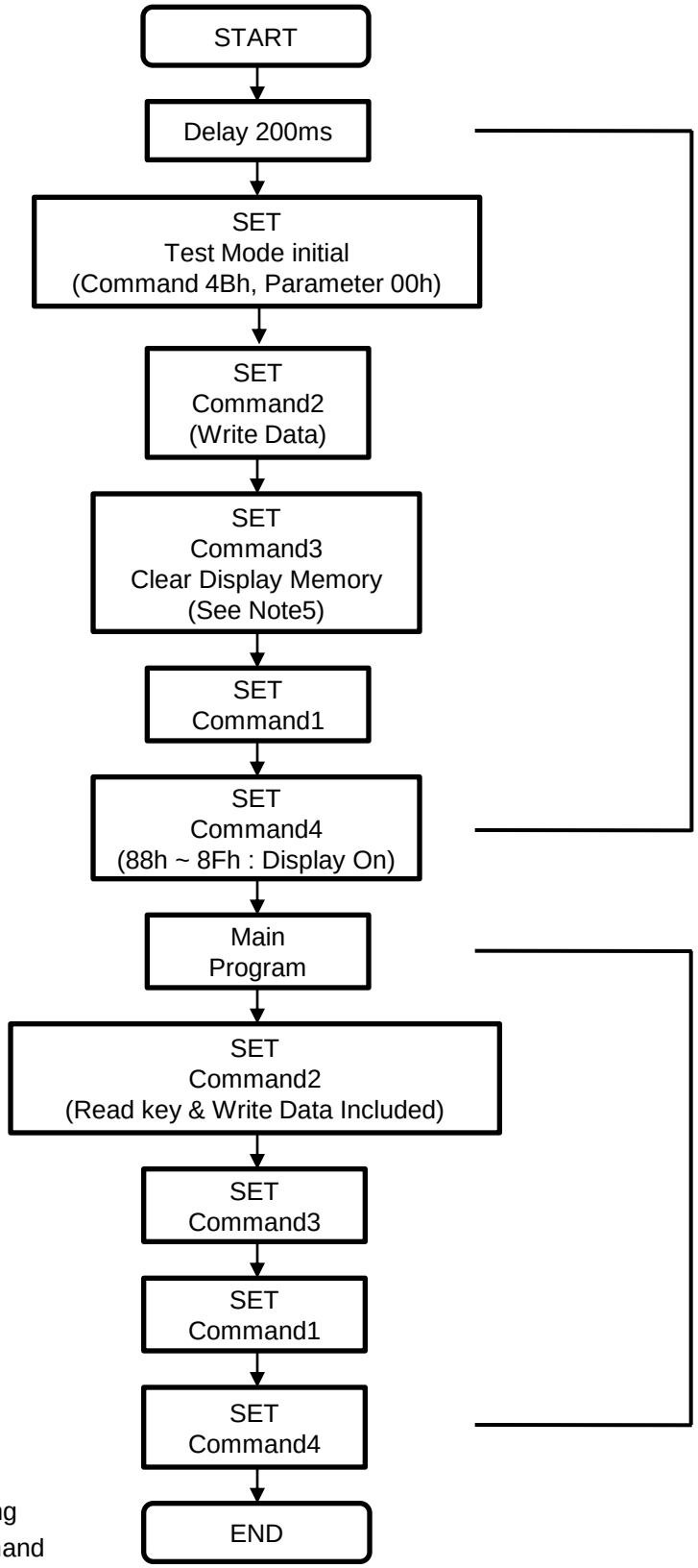
Where : Command2 : Data Setting Command
Command3 : Address Setting Command
Data : Display Data

Transmission diagram for LED Data setting diagram.



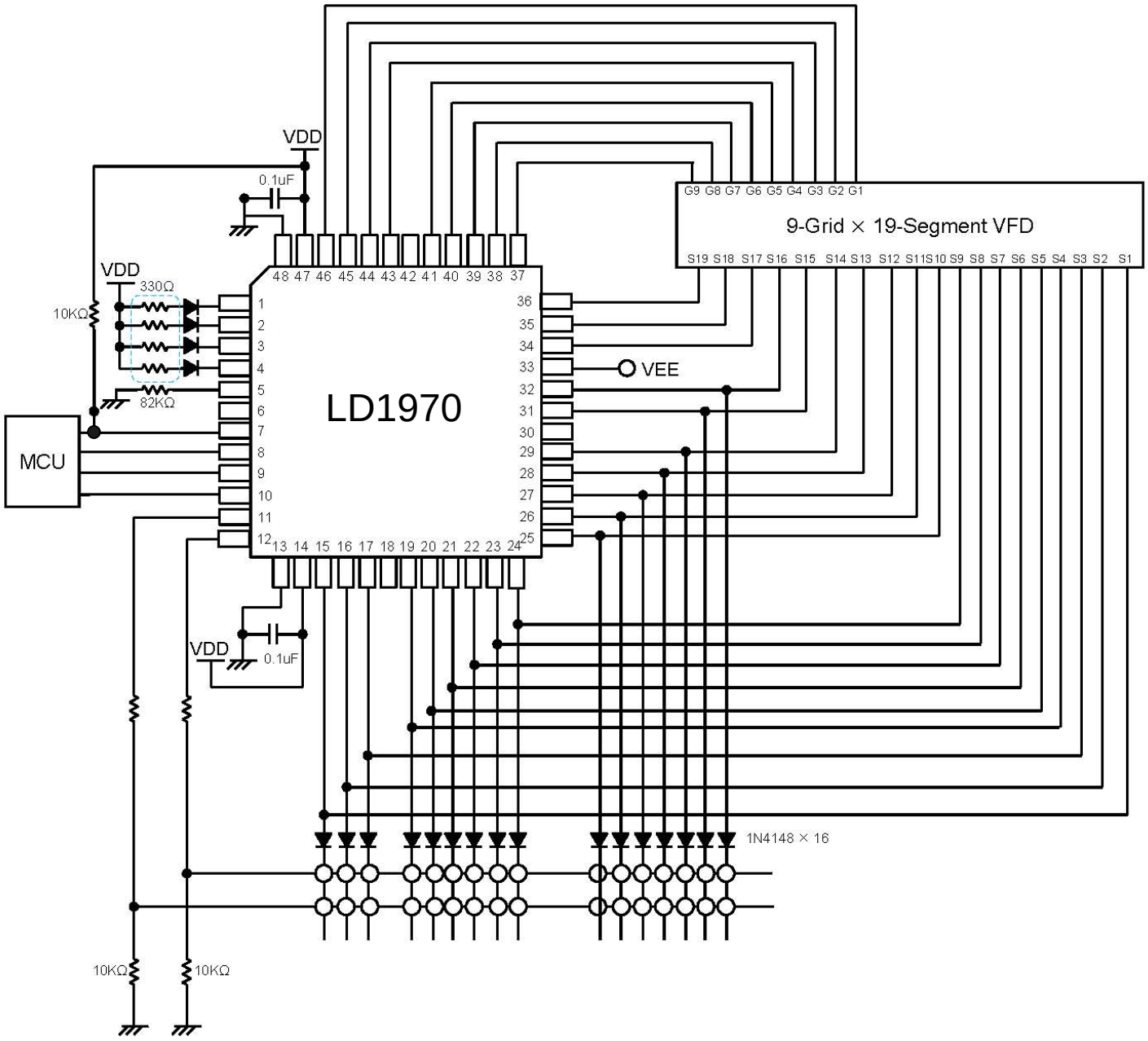
Where : Command2 : Data Setting Command
LED Data : 4 LED (LED1 to LED4) Display Data

Recommended Software Programming Flow Chart



Note : 1. Command1 : Display Mode Setting
2. Command2 : Data Setting Command
3. Command3 : Address Setting Command
4. Command4 : Display Control Command
5. When IC Power is applied for the first time, the contents of the Display Memory are not defined. Thus, it is strongly suggested that the contents of the Display Memory must be cleared during the initial setting.

Application Circuit

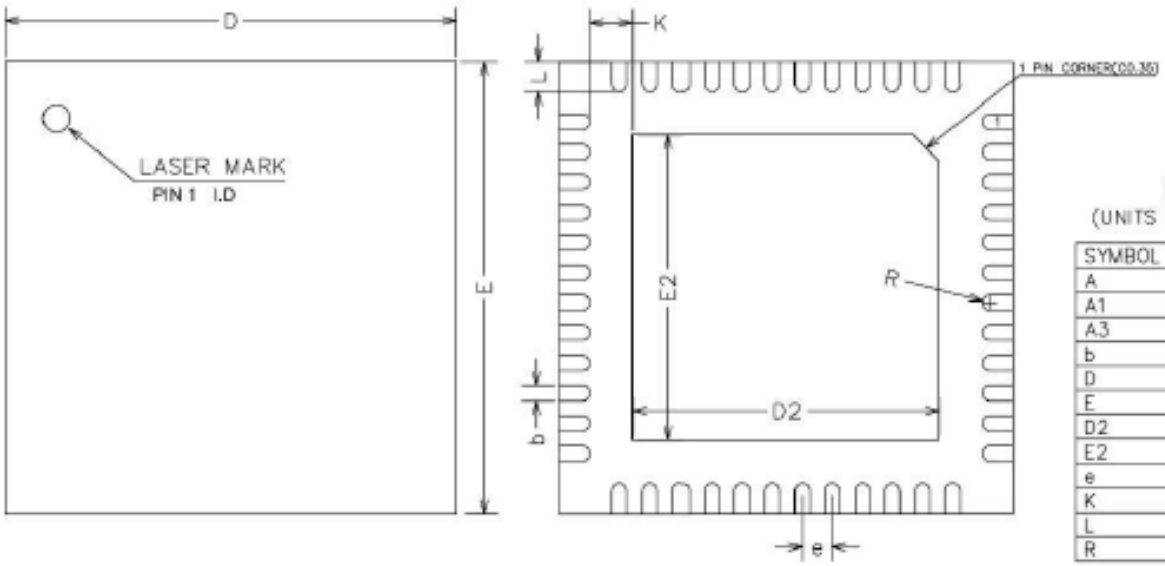


Note : The capacitor(0.1uF) connected between the GND and the VDD pins must be located as close as possible to the LD1970 chip.

PACKAGE INFORMATION

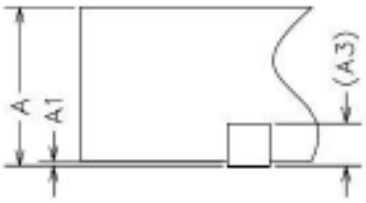
48 QFN Package (Bode Size : 6mm x 6mm; Pitch : 0.4mm; THK Body: 0.75mm)

Unit : mm



COMMON DIMENSIONS
(UNITS OF MEASURE=MILLIMETER)

SYMBOL	MIN	NOM	MAX
A	0.70	0.75	0.80
A1	0	0.02	0.05
A3		0.20REF	
b	0.15	0.20	0.25
D	5.90	6.00	6.10
E	5.90	6.00	6.10
D2	3.95	4.05	4.15
E2	3.95	4.05	4.15
e	0.35	0.40	0.45
K	0.20	–	–
L	0.35	0.40	0.45
R	0.09	–	–

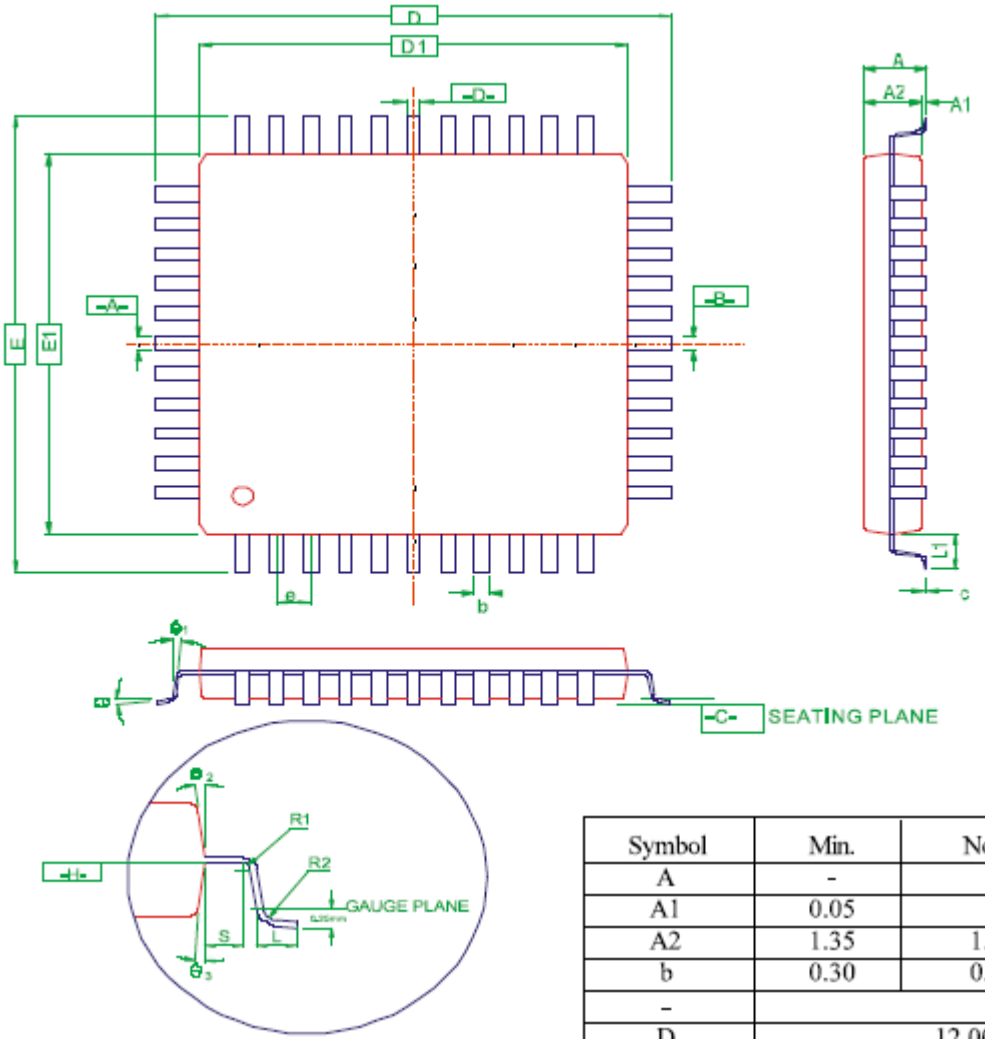


NOTES

ALL DIMENSIONS REFER TO JEDEC STANDARD MO-220 (VJJE)

44-Pin LQFP Package (Bode Size : 10mm x 10mm; Pitch : 0.8mm; THK Body: 1.40mm)

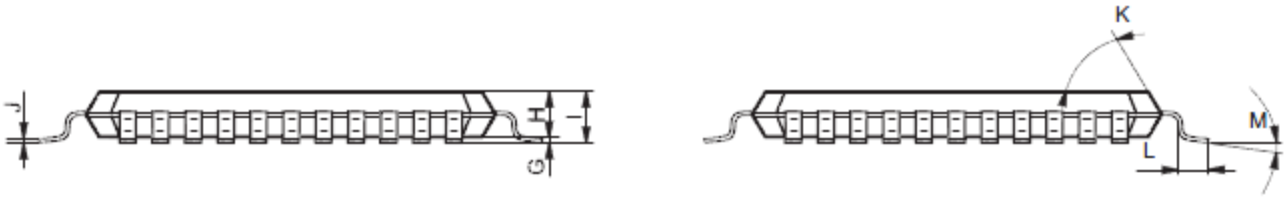
Unit : mm

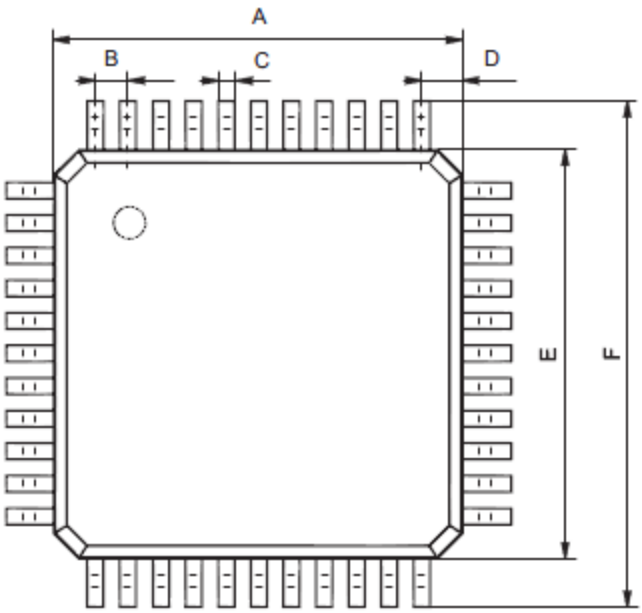


Symbol	Min.	Nom.	Max.
A	-	-	1.60
A1	0.05	-	0.15
A2	1.35	1.40	1.45
b	0.30	0.37	0.45
-	-		
D	12.00 BSC		
D1	10.00 BSC		
e	0.80 BSC		
E	12.00 BSC		
E1	10.00 BSC		
θ	0°	3.5°	7°
θ1	0°	-	-
θ2	11°	12°	13°
θ3	11°	12°	13°
C	0.09	-	0.20
L	0.45	0.60	0.75
L1	1.00 REF		
R1	0.08	-	-
R2	0.08	-	0.20
S	0.20	-	-

44-Pin MQFP Package (Bode Size : 10mm x 10mm; Pitch : 0.8mm; THK Body: 2.10mm)

Unit : mm





[mm]		
	Min.	Max.
A	10 BSC	
B	0.80 BSC	
C	0.30	0.45
D	1 REF	
E	10 BSC	
F	13.20 BSC	
G	0.10	0.25
H	1.95	2.10
I	-	2.35
J	-	-
K	12 DEG	16 DEG
L	0.73	1.03
M	0 DEG	7 DEG