General Description

The TP6312 is a VFD (Vacuum Fluorescent Display) controller/driver that is driven on a 1/4 to 1/11-duty factor. It consists of 11 segment output lines, 6 grid output lines, 5 segment/grid output drivelines, a display memory, a control circuit, and a Key scan circuit. Serial data is input to TP6312 through a three-line serial interface. This VFD controller/driver is ideal as a peripheral device of a single-chip microcomputer.

Features

- Multiple display modes (11-segment & 11-digit to 16-segment & 4-digit)
- Key scanning (6 × 4 matrices)
- Dimming circuit (eight steps)
- High-voltage output (V_{DD} – 35V max)
- LED ports (4 chs, 20 mA max)
- General-purpose input port (4 bits)
- No external resistor necessary for driver outputs (P-ch open-drain + pull-down resistor output)
- Serial interface (CLK, STB, D_{IN}, D_{OUT})

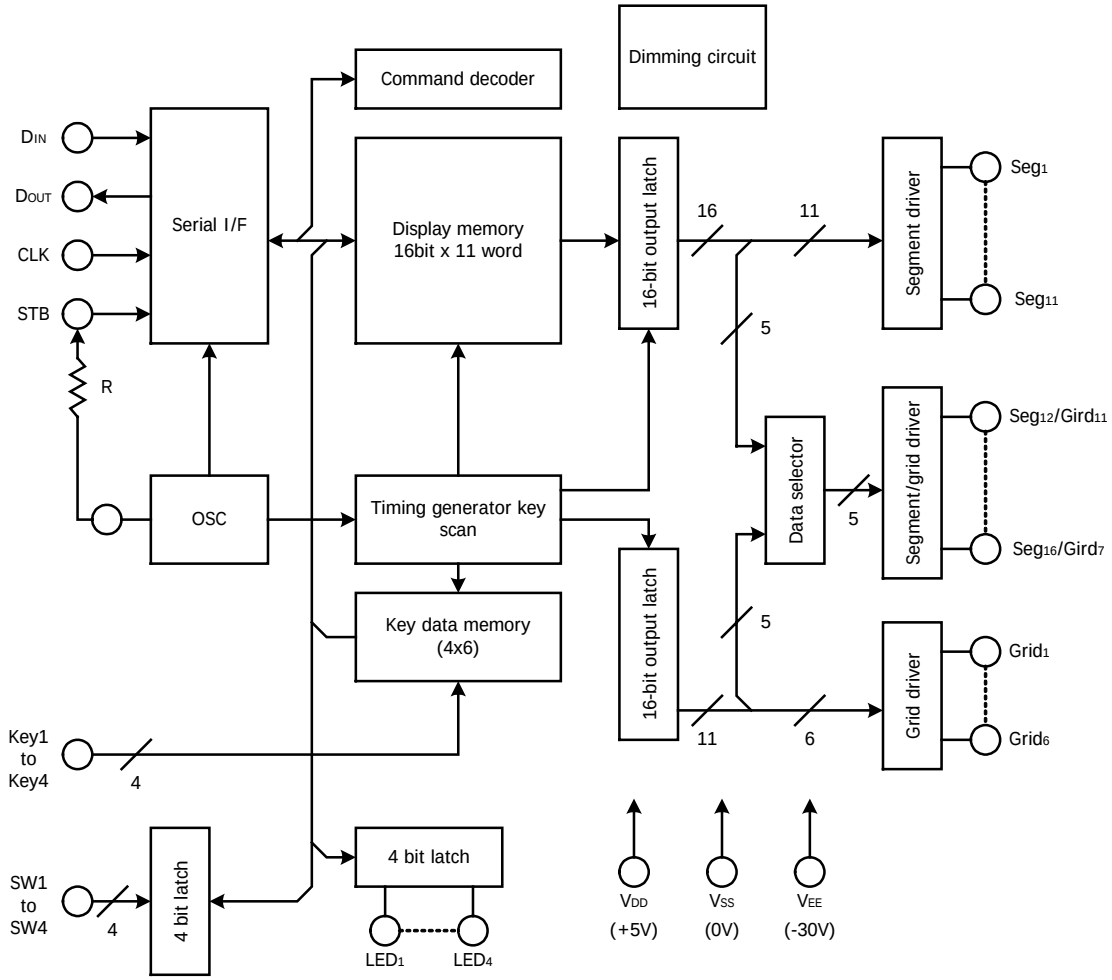
Ordering Information

TP 6312 □ □ □

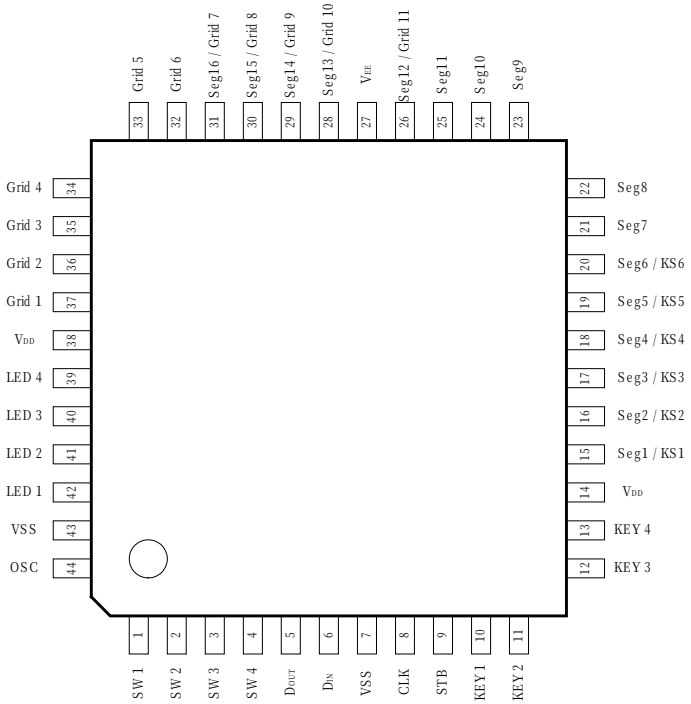
- Footprint
- Version
- Package Type

Package Type	F: LQFP
Footprint	S: 2.0 mm L: 3.2 mm

Block Diagram



Pin Configuration (Top View)



Use all the power pins.

Pin Description

Pin No	Symbol	Pin Name	Description
6	D_{IN}	Date input	Inputs serial data at rising edge of shift clock, starting from the lower bit.
5	D_{OUT}	Date output	Outputs serial data at falling edge of shift clock, starting from the lower bit. This is N-ch open-drain output pin.
9	STB	Strobe	Initializes the serial interface at rising or falling edge to make TP6312 waiting for reception of command. Data input after STB has fallen is processed as command. While command data is processed, current processing is stopped and serial interface is initialized. While STB is high, CLK is ignored.
8	CLK	Clock input	Reads serial data at rising edge, and outputs data at falling edge.
44	OSC	Oscillator pin	Connects a resistor to this pin to determine the oscillation frequency to this pin.
15 to 20	Seg_1/KS_1 to Seg_6/KS_6	High-voltage output	Segment output pins (Dual function as Key source).
21 to 25	Seg_7 to Seg_{11}	High-voltage output (Segment)	Segment output pins.
37 to 32	$Grid_1$ to $Grid_6$	High-voltage output (Grid)	Grid output pins.
26, 28 to 31	$Seg_{11}/Grid_{11}$ to $Seg_{16}/Grid_7$	High-voltage output (Segment/grid)	These pins are selectable for segment or grid driving.
42 to 39	LED_1 to LED_4	LED output	CMOS output. +20 mA max.
10 to 13	Key_1 to Key_4	Key data input	Data input to these pins is latched at the end of display cycle.
1 to 4	SW_1 to SW_4	Switch input	These pins constitute 4-bit general-purpose input port.
14, 38	V_{DD}	Logic power	5V ± 10%
7, 43	V_{SS}	Logic ground	Connect this pin to system GND.
27	V_{EE}	Pull-down level	V_{DD} – 35 V max

Functional Description

Display RAM Address and Display Mode

The display RAM stores the data transmitted from an external device to TP6312 through the serial interface, and is assigned addresses as follows, in units of 8 bits:

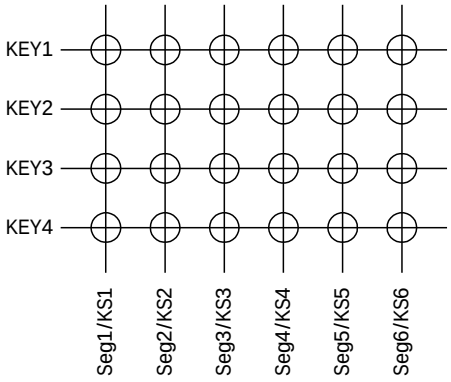
Seg_1	Seg_4	Seg_8	Seg_{12}	Seg_{16}
$00H_L$	$00H_U$	$01H_L$	$01H_U$	DIG1
$02H_L$	$02H_U$	$03H_L$	$03H_U$	DIG2
$04H_L$	$04H_U$	$05H_L$	$05H_U$	DIG3
$06H_L$	$06H_U$	$07H_L$	$07H_U$	DIG4
$08H_L$	$08H_U$	$09H_L$	$09H_U$	DIG5
$0AH_L$	$0AH_U$	$0BH_L$	$0BH_U$	DIG6
$0CH_L$	$0CH_U$	$0DH_L$	$0DH_U$	DIG7
$0EH_L$	$0EH_U$	$0FH_L$	$0FH_U$	DIG8
$10H_L$	$10H_U$	$11H_L$	$11H_U$	DIG9
$12H_L$	$12H_U$	$13H_L$	$13H_U$	DIG10
$14H_L$	$14H_U$	$15H_L$	$15H_U$	DIG11

b_0 b_3	b_4 b_7
XX H_L	XX H_U

Lower 4 bits Higher 4 bits.

Key Matrix and Key-Input Data Storage RAM

The Key matrix is of 6 × 4 configuration, as shown below.

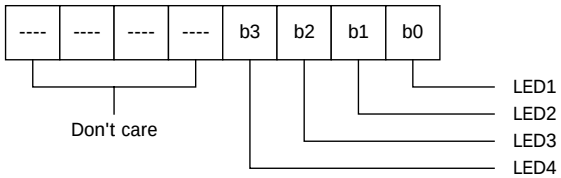


The data of each Key is stored as illustrated below, and is read by a read command, starting from the least significant bit.

Key_1	Key_4 Key_1	Key_4
Seg_1 / KS_1	Seg_2 / KS_2	
Seg_3 / KS_3	Seg_4 / KS_4	Reading sequence
Seg_5 / KS_5	Seg_6 / KS_6	
b0	b3 b4	b7

LED Port

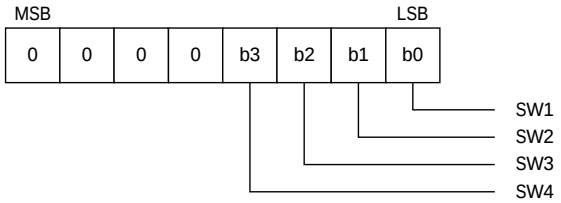
Data is written to the LED port by a write command, starting from the least significant bit of the port. When a bit of this port is 0, the corresponding LED lights; when the bit is 1, the LED goes off. The data of bits 5 through 8 is ignored.



On power application, all LEDs are unlit.

SW Data

The SW data is read by a read command, starting from the least significant bit. Bits 5 through 8 of the SW data are 0.



Commands

A command sets the display mode and status of the VFD driver.

The first 1 byte input to TP6312 through the D_{IN} pin after the STB pin has fallen is regarded as a command.

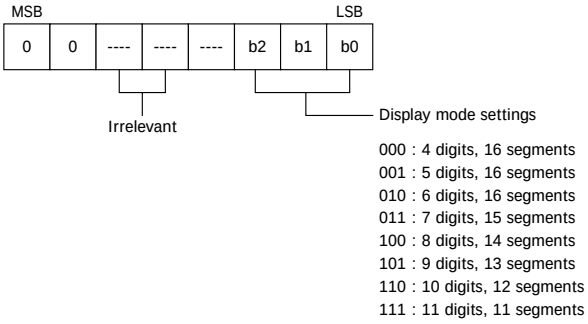
If STB is high while a command/data is transmitted, serial communication is initialized, and the transmitting command/data is invalid; however, the

command/data already transmitted remains valid.

(1) Display mode setting command

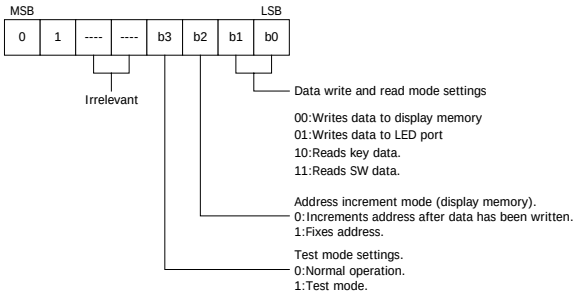
This command initializes TP6312 and selects the number of segments and number of grids (1/4 to 1/11-duty, 11 segments to 16 segments).

On power application, the 11-digit, 11-segment mode is selected.



(2) Data setting commands

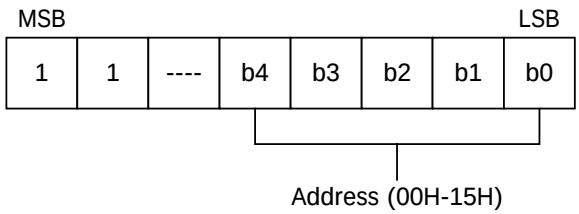
This command sets data write and read modes.



On power application, the normal operation mode and address increment mode set.

(3) Address setting command

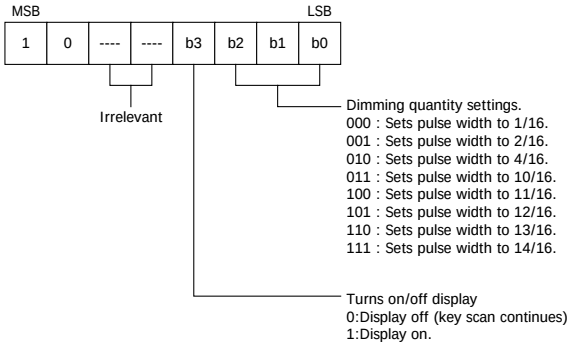
This command sets an address of the display memory.



If address 16H or higher is set, the data is ignored and unit a correct address is set.

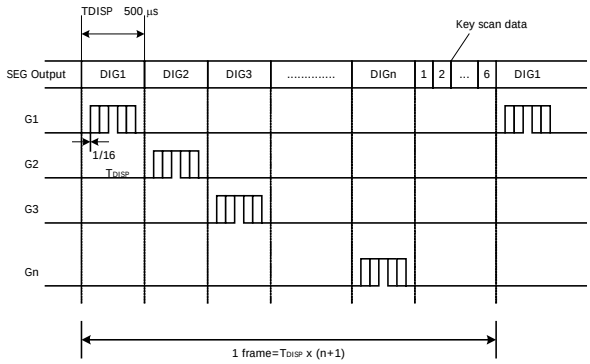
On power application, the address is set to 00H.

(4) Display control command



On power application, the 14/16-pulse width is set and the display is turned off.

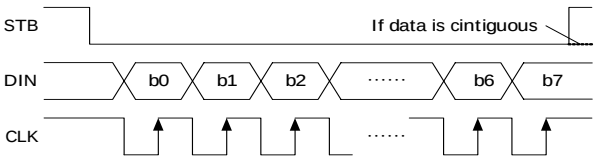
Key Scanning and Display Timing



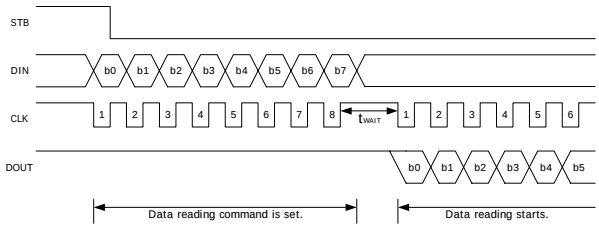
One cycle of Key scanning consists of two frames, and data of 6 × 4 matrices is stored in RAM.

Serial Communication Format

Reception (command/data write)



Transmission (data read)



Because the D_{OUT} pin is an N-ch open-drain output pin, be sure to connect an external pull-up resistor to this pin (1kΩ to 10 kΩ).

*: When data is read, a wait time (t_{WAIT}) of 1μs is necessary from the rising of the eighth clock that has set the command till the falling of the first clock that has read the data.

Absolute Maximum Ratings (Ta = 25°C, Vss = 0V)

Parameter	Symbol	Ratings	Unit
Logic Supply Voltage	V_{DD}	-0.5 to + 7.0	V
Driver Supply Voltage	V_{EE}	V_{DD} +0.5 to V_{DD} -40	V
Logic Input Voltage	V_{i1}	-0.5 to V_{DD} +0.5	V
VFD Driver Output Voltage	V_{o2}	V_{EE} –0.5 to V_{DD} +0.5	V
LED Driver Output Current	I_{o1}	+25	mA
VFD Driver Output Current	I_{o2}	-40 (grid) -15 (segment)	mA
Power Dissipation	P_D	800*	mW
Operating Ambient Temperature	T_{opt}	-40 to +70	℃
Storage Temperature	T_{stg}	-65 to +150	℃

* Derate at –6.4 mW/℃ at Ta = 25℃ or higher.

Recommended Operating Conditions (Ta = -20°C to +70°C, Vss = 0V)

Parameter	Symbol	Min.	Typ.	Max.	Unit	Test Condition
Logic Supply Voltage	V_{DD}	4.5	5	5.5	V	
High-Level input Voltage	V_{IH}	0.7V_{DD}		V_{DD}	V	
Low-Level input Voltage	V_{IL}	0		0.3V_{DD}	V	
Driver Supply Voltage	V_{EE}	0		V_{DD}-35	V	

Maximum power consumption P_{MAX} = VFD driver dissipation + R_L dissipation + LED driver dissipation + dynamic power consumption.

Where segment current = 3 mA, grid current = 15mA, and LED current = 20 mA,

VFD driver dissipation = number of segments x 6 + number of grids/(number of grids + 1) x 30(mW)

R_L dissipation $(V_{DD}-V_{EE})^2/50$ x (segment+1) (mW)

LED driver dissipation = number of LEDs x 20(mW)

Dynamic power consumption = V_{DD} x 5(mW)

Electrical Characteristics (Ta = -20°C to +70°C, V_{DD} = 4.5V to 5.5V, V_S = 0V, V_{EE} = V_{DD} - 35V)

Parameter	Symbol	Min	Typ.	Max.	Unit	Test Conditions
High-Level Output Voltage	V_{OH1}	0.9 V_{DD}			V	LED_1 – LED_4, I_{OH1} = -1 mA
Low-Level Output Voltage	V_{OL1}			1	V	LED_1 – LED_4, I_{OL1} = 20 mA
Low-Level Output Voltage	V_{OL2}			0.4	V	D_{OUT}, I_{OL2} = 4 mA
High-Level Output Current	I_{OH21}	-3			mA	V_O = V_{DD} –2V, Seg_1 to Seg_{11}
High-Level Output Current	I_{OH22}	-15			mA	V_O = V_{DD} –2V,$Grid_1$ to $Grid_6$, Seg_{12}/Seg_{11} to Seg_{16}/Seg_7
Driver Leakage Current	I_{OLEAK}			-10	μA	V_O = V_{DD} - 35V, Drive off
Output Pull-Down Resistor	R_L	50	100	150	kΩ	Drive output
Input Current	I_i			±1	μA	V_I = V_{DD} or V_{SS}
High-Level Input Voltage	V_{IH}	0.6 V_{DD}			V	
Low-Level Input Voltage	V_{IL}			0.3 V_{DD}	V	
Hysteresis Voltage	V_H		0.35		V	CLK, D_{IN}, STB
Dynamic Current Consumption	I_{DDdyn}			5	mA	Under no load, display off

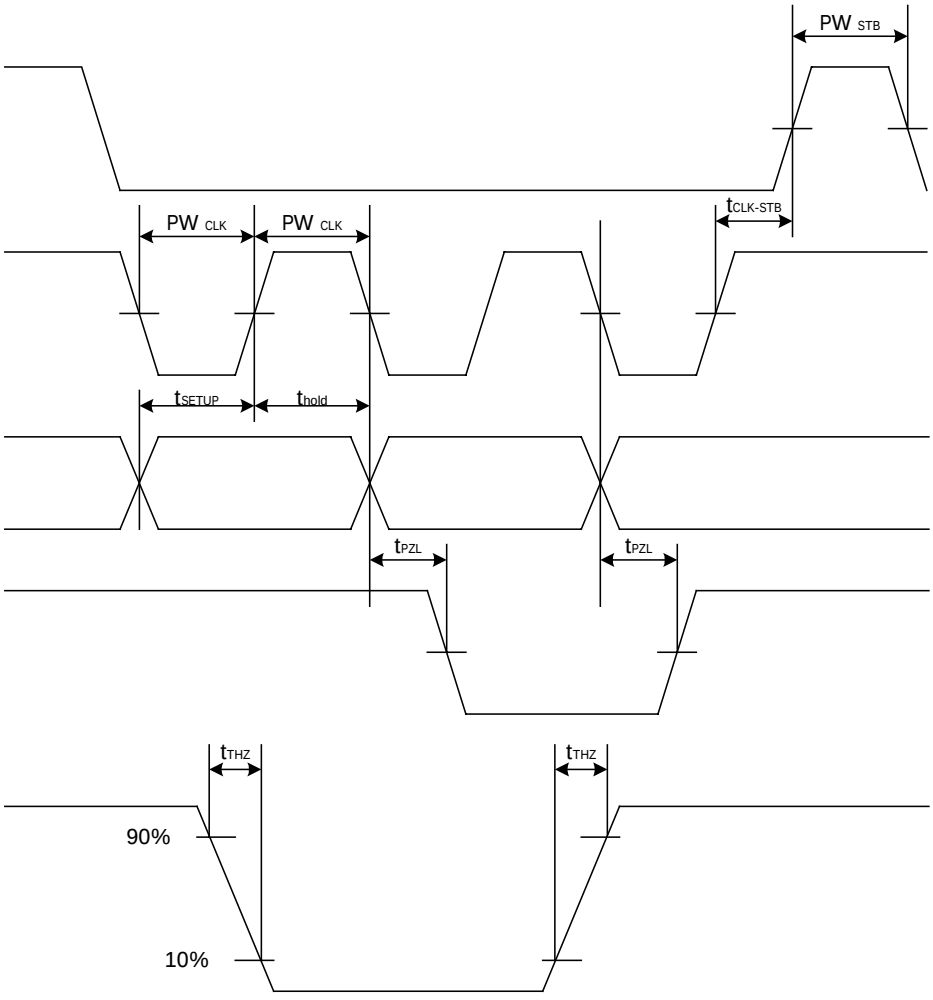
Switching Characteristics (Ta = -20°C to +70°C, V_{DD} = 4.5V to 5.5V, V_{EE} = -30V)

Parameter	Symbol	Min	Typ.	Max.	Unit	Test Conditions	
Oscillation Frequency	f_{OSC}	350	500	650	kHz	R = 56kΩ	
Propagation Delay Time	t_{PLZ}			300	ns	CLK ⇒ DOUT	
	t_{PZL}			100	ns	CL = 15pF,RL = 10kΩ	
Rise Time	t_{TZH1}			2	µs	CL = 300 PF	Seg1 to Seg11
	t_{TZH2}			0.5	µs	CL = 300 PF	Grid1 to Grid6 Seg12/Grid11 to Seg16/Grid7
Fall Time	t_{THZ}			120	µs	CL = 300 pF, Segn, Gridn	
Maximum Clock Frequency	f_{max}	1			MHz	Duty = 50%	
Input Capacitance	C1			15	pF		

Timing Conditions (Ta = -20°C to +70°C, V_{dd} = 4.5V to 5.5V)

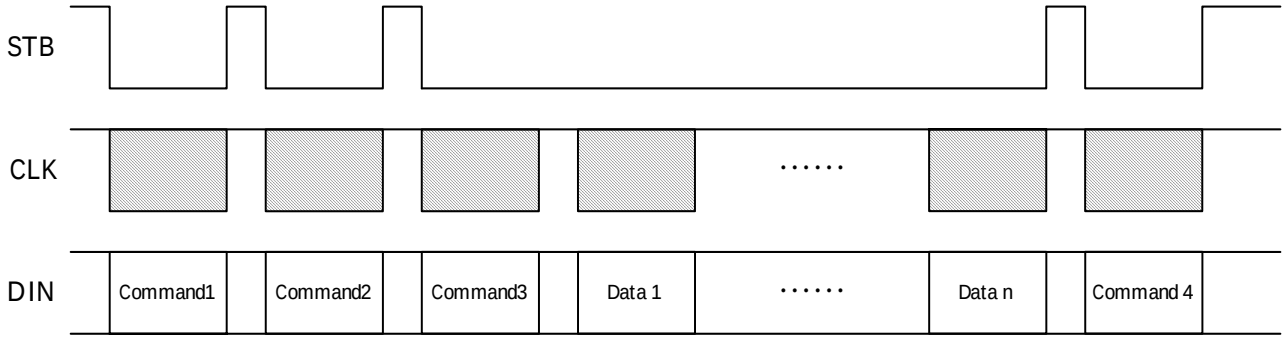
Parameter	Symbol	Min	Typ.	Max.	Unit	Test Conditions
Clock Pulse Width	PWCLK	400			ns	
Strobe Pulse Width	PWSTB	1			µs	
Data Setup Time	t_{SETUP}	100			ns	
Data Hold Time	t_{HOLD}	100			ns	
Clock-Strobe Time	$t_{CLK-STB}$	1			µs	CLK ↑→ STB ↑
Wait Time	t_{WAIT}	1			µs	CLK ↑→ CLK ↓

Switching Characteristic Waveform



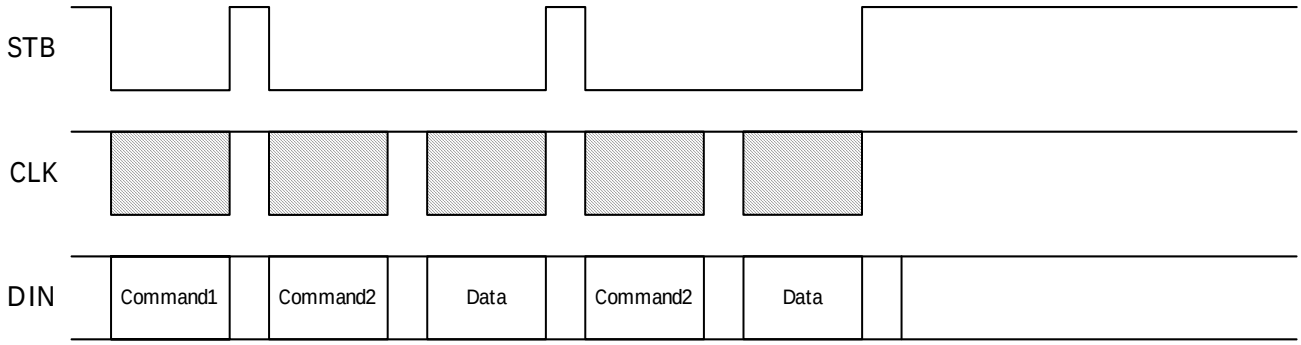
Application

Updating display memory by incrementing address



Command1: sets display mode
Command2: sets data
Command3: sets address
Data 1 to n: transfers display data (22 bytes max.)
Command4: controls display

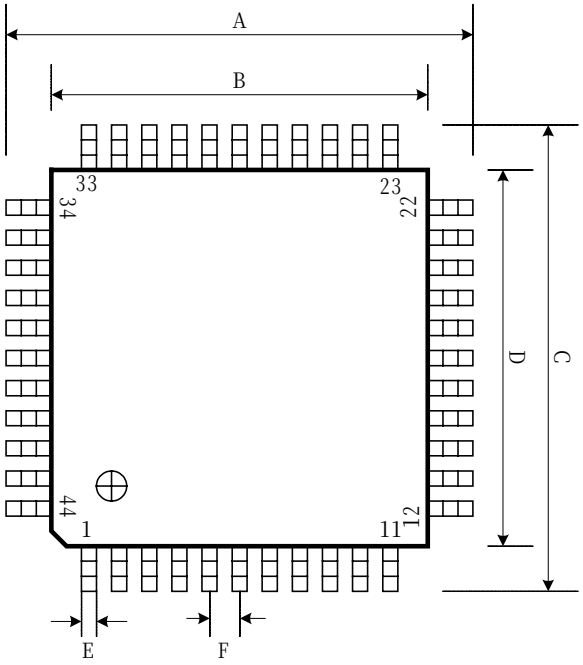
Updating specific address



Command1: sets data
Command2: sets address
Data: display data

Package Information

44-Pin Plastic LQFP Short-Lead (Footprint = 2.0mm)

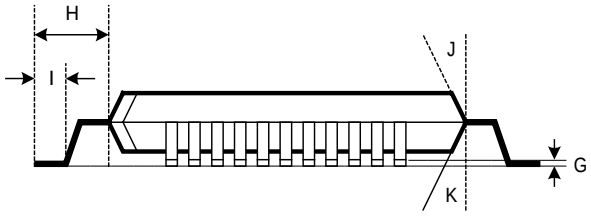


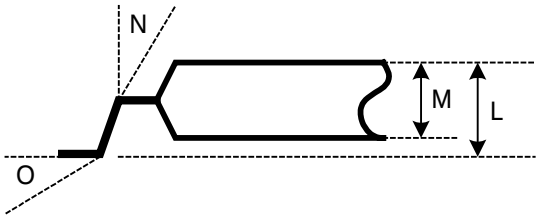
NOTE

Each lead centerline is located within 0.16 mm of its true position (T.P.) at maximum material

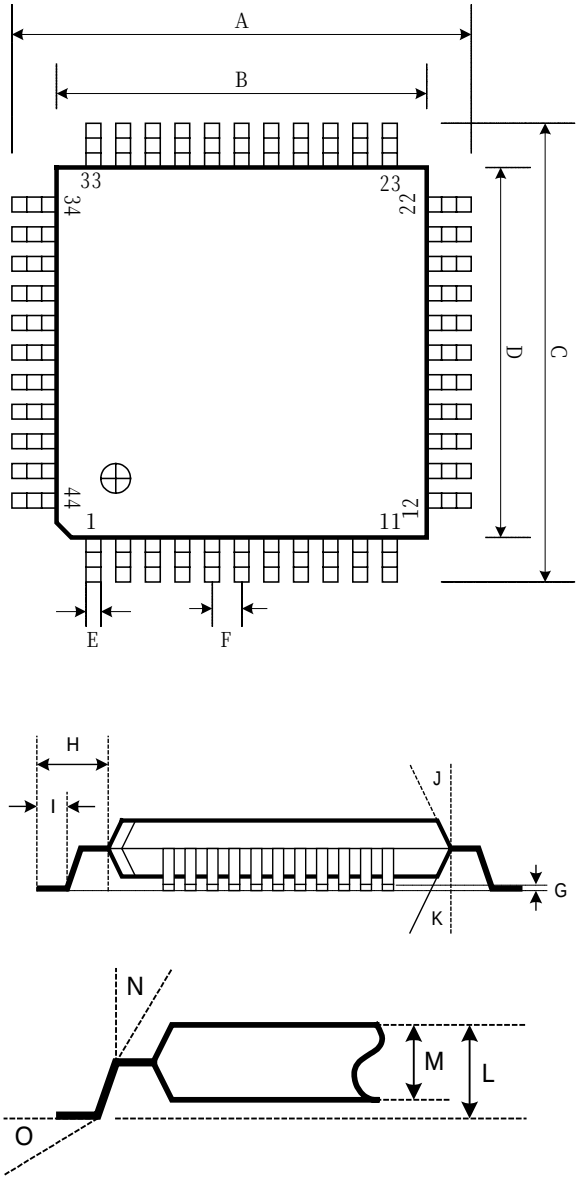
(Unit: mm)

Item	Millimeters
A	12.0 ± 0.2
B	10.0 ± 0.2
C	12.0 ± 0.2
D	10.0 ± 0.2
E	0.37(TYP.)
F	0.8 BSC
G	$0.3^{+0.2}_{-0.1}$
H	1.0
I	0.6 ± 0.15
J	$12^{o} \pm 1^{o}$
K	$12^{o} \pm 1^{o}$
L	1.7 MAX
M	1.4± 0.1
N	0^{o} MIN
O	$+3^{o}{}^{+7^{o}}_{-3^{o}}$





44-Pin Plastic LQFP Long- Lead (Footprint = 3.2mm)



NOTE

Each lead centerline is located within 0.16 mm of its true position (T.P.) at maximum material

(Unit: mm)

Item	Millimeters
A	13.2 ± 0.2
B	10.0 ± 0.2
C	13.2 ± 0.2
D	10.0 ± 0.2
E	0.37(TYP.)
F	0.8 BSC
G	0.3 +0.2 -0.1
H	1.6
I	1.2 ± 0.15
J	$12^{o} \pm 1^{o}$
K	$12^{o} \pm 1^{o}$
L	1.7 MAX
M	1.4± 0.1
N	0^{o} MIN
O	$+3^{o}$ $+7^{o}$ -3^{o}

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