



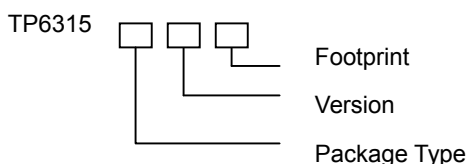
General Description

The TP6315 is a VFD (Vacuum Fluorescent Display) controller that is driven on 1/4 to 1/12-duty factor. It consists of 16 segment output lines, 4 grid output lines, 8 segment/grid output drivelines, a display memory, a control circuit, and a key scan circuit. The serial data is input to the TP6315 through a three-line serial interface. This VFD controller is ideal as a peripheral device for a single-chip microcomputer.

Features

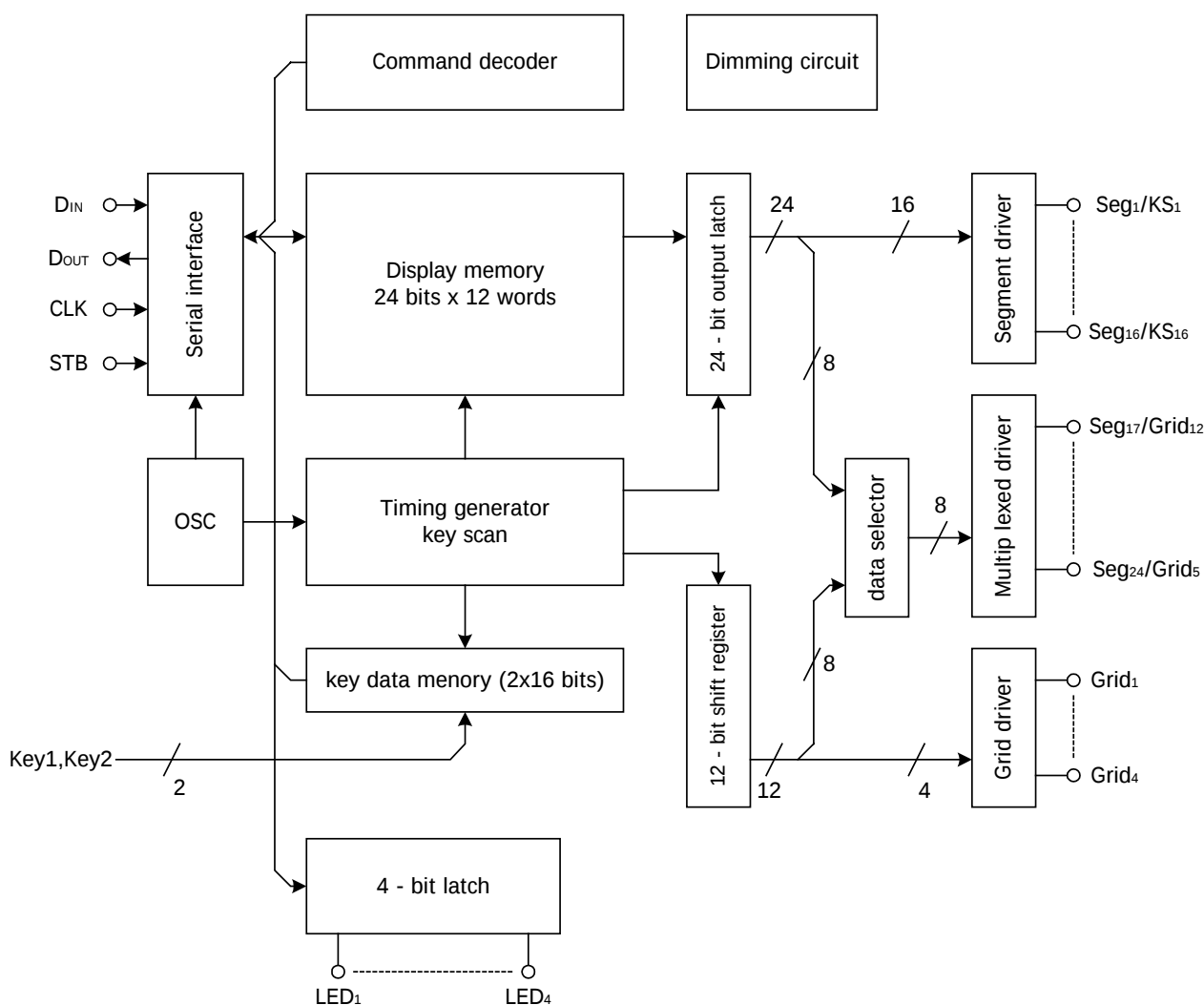
- Multiple display modes (16-segment & 12-digit to 24-segment & 4-digit)
- Key scanning (16×2 matrix)
- Dimming circuit (eight steps)
- High-voltage output (V_{DD} - 35V Max.)
- LED ports (4 chs, 20 mA Max.)
- No external resistors necessary for driver outputs (P-ch open-drain + pull-down resistor output)
- Serial interface (CLK, STB, D_{IN} , D_{OUT})

Ordering Information



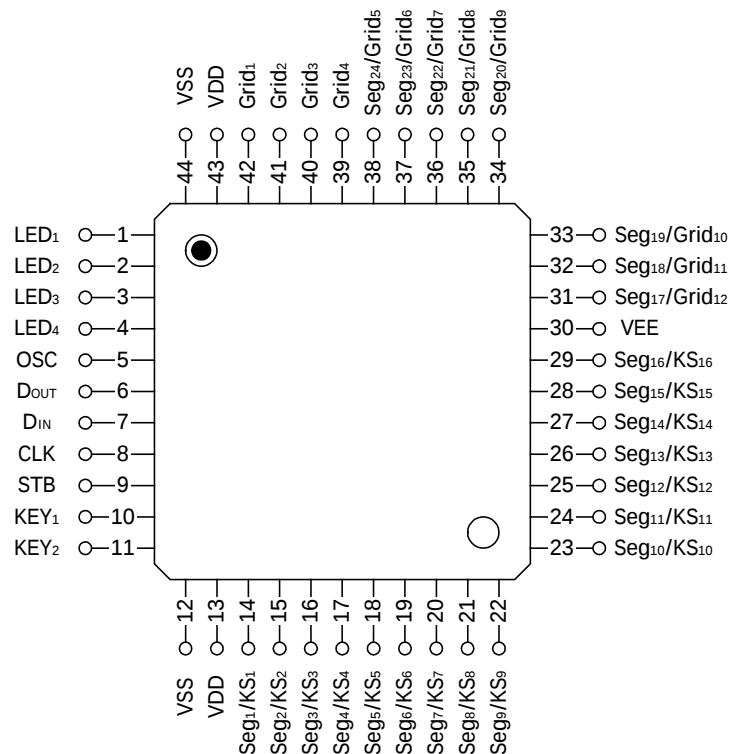
Package Type	F: LQFP
Footprint	S: 2.0mm

Block Diagram





Pin Configuration



Caution Use all the power supply pins.

Pin Description

Pin No.	Pin Name	Symbol	Description
7	Data input	D _{IN}	Input serial data at rising edge of shift clock, starting from the low order bit.
6	Data output	D _{OUT}	Output serial data at the falling edge of the shift clock, starting from low order bit. This is N-ch open-drain output pin.
9	Strobe	STB	Initializes serial interface at the rising or falling edge of the TP6315. It then waits for reception of a command. Data input after STB has fallen is processed as a command. While command data is processed, current processing is stopped, and the serial interface is initialized. While STB is high, CLK is ignored.
8	Clock input	CLK	Reads serial data at the rising edge, and outputs data at the falling edge.
5	Oscillator pin	OSC	Connect resistor to this pin to determine the oscillation frequency to this pin. Connect resistor between this pin and GND (VSS).
14 to 29	High-voltage output (Segment)	Seg ₁ /KS ₁ to Seg ₁₆ /KS ₁₆	Segment output pins (Dual function as key source)
39 to 42	High-voltage output (Grid)	Grid ₁ to Grid ₄	Grid output pins
31 to 38	High-voltage output (Segment/grid)	Seg ₁₇ /Grid ₁₂ to Seg ₂₄ /Grid ₅	These pins are selectable for segment or grid driving.
1 to 4	LED output	LED ₁ to LED ₄	CMOS output, +20mA Max.
10, 11	Key data input	KEY ₁ , KEY ₂	Data input to these pins is latched at the end of the display cycle.
★ 13, 43	Logic power	VDD	5 V ±10%
★ 12, 44	Logic ground	VSS	Connect this pin to system GND.
★ 30	Pull-down level	VEE	VDD -35V Max.

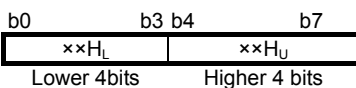


Functional Description

Display Ram Address and Display Mode

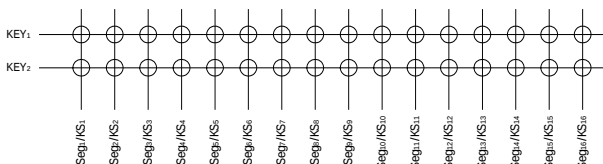
The display RAM stores the data transmitted to the TP6315 through the serial communication. The addresses are allocated in 8-bit units.

Seg ₁	Seg ₄	Seg ₈	Seg ₁₂	Seg ₁₆	Seg ₂₀	Seg ₂₄	
00H _L	00H _U	01H _L	01H _U	02H _L	02H _U		DIG ₁
03H _L	03H _U	04H _L	04H _U	05H _L	05H _U		DIG ₂
06H _L	06H _U	07H _L	07H _U	08H _L	08H _U		DIG ₃
09H _L	09H _U	0AH _L	0AH _U	0BH _L	0BH _U		DIG ₄
0CH _L	0CH _U	0DH _L	0DH _U	0EH _L	0EH _U		DIG ₅
0FH _L	0FH _U	10H _L	10H _U	11H _L	11H _U		DIG ₆
12H _L	12H _U	13H _L	13H _U	14H _L	14H _U		DIG ₇
15H _L	15H _U	16H _L	16H _U	17H _L	17H _U		DIG ₈
18H _L	18H _U	19H _L	19H _U	1AH _L	1AH _U		DIG ₉
1BH _L	1BH _U	1CH _L	1CH _U	1DH _L	1DH _U		DIG ₁₀
1EH _L	1EH _U	1FH _L	1FH _U	20H _L	20H _U		DIG ₁₁
21H _L	21H _U	22H _L	22H _U	23H _L	23H _U		DIG ₁₂



Key Matrix and Key-Input Data Storage Ram

The key matrix is made up of a 16x2 matrix, as shown below:

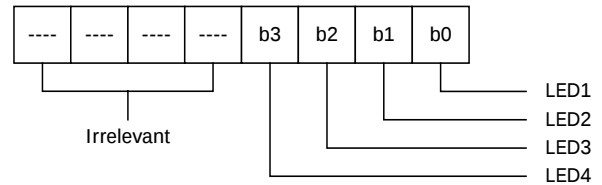


The data of each key is stored as follows, and is read with the read command starting from the least significant bit.

KEY ₁	KEY ₂	KEY ₁	KEY ₂	KEY ₁	KEY ₂	KEY ₁	KEY ₂
Seg ₁ /KS ₁	Seg ₂ /KS ₂	Seg ₃ /KS ₃	Seg ₄ /KS ₄	Seg ₅ /KS ₅	Seg ₆ /KS ₆	Seg ₇ /KS ₇	Seg ₈ /KS ₈
Seg ₉ /KS ₉	Seg ₁₀ /KS ₁₀	Seg ₁₁ /KS ₁₁	Seg ₁₂ /KS ₁₂	Seg ₁₃ /KS ₁₃	Seg ₁₄ /KS ₁₄	Seg ₁₅ /KS ₁₅	Seg ₁₆ /KS ₁₆
b0	b1	b2	b3	b4	b5	b6	b7

Led Port

Data is written to the LED port with the write command, starting from the least significant bit. "L" output when the bit of this port is 0, and "H" output when the bit is 1. The data of bits after the 5th bit are ignored.



Remark On power application, all the LED ports are "L" output.

Commands

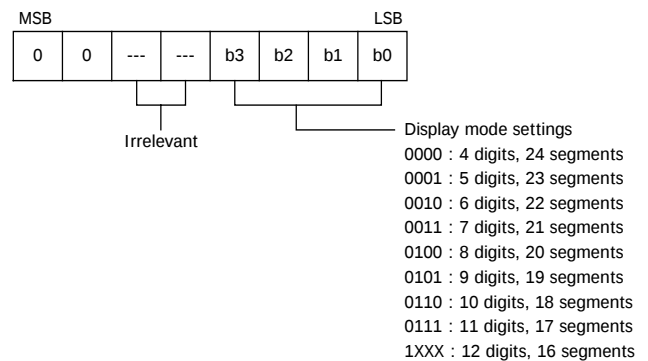
Commands set the display mode and status of the VFD controller.

The first 1 byte input to the TP6315 through the DIN pin after the STB pin has fallen is regarded as a command. If STB is set high while commands/data are transmitted, serial communication is initialized, and the commands/data being transmitted are invalid (however, the commands/data previously transmitted remain valid).

(1) Display mode setting commands

These commands initialize the TP6315 and select the number of segments and the number of grids (1/4- to 1/12- duty, 16 segments to 24 segments).

When these commands are executed, the display is forcibly turned off, and key scanning is also stopped. To resume display, the display command "ON" must be executed. If the same mode is selected, however, nothing happens.

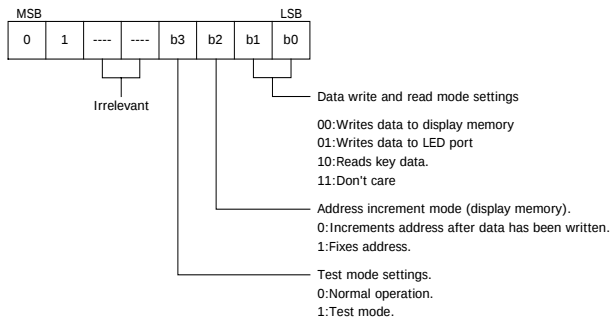


Remark On power application, the 12-digit and 16-segment mode is selected.



(2) Data setting commands

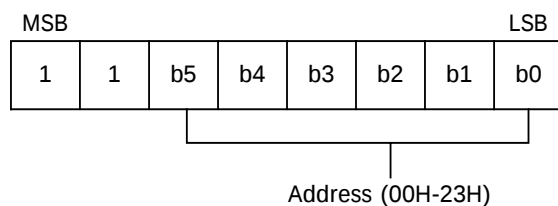
These commands set data write and data read modes.



Remark On power application, the normal operation and address increment modes are set.

(3) Address setting commands

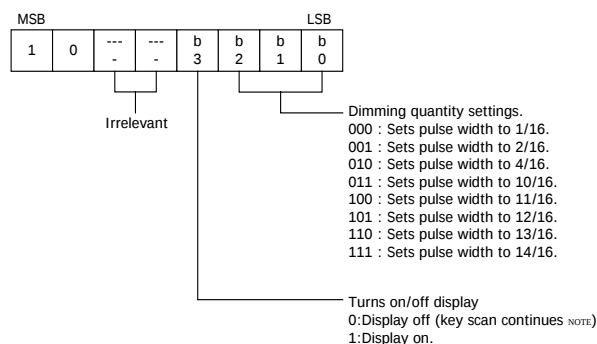
These commands set an address of the display memory.



Remarks

1. If address 24H or higher is set, data is ignored until a valid address is set.
2. On power application, the address is set to 00H.

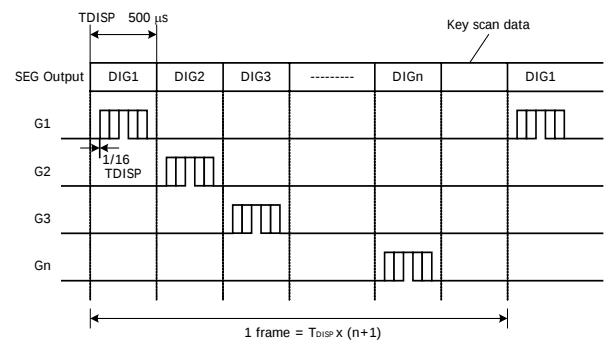
(4) Display control commands



Note On power application, key scanning is stopped.

Remark On power application, the 1/16 pulse width is set and the display is turned off.

Key Scanning And Display Timing



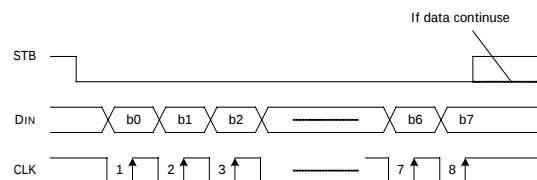
Remark One cycle of key scanning consists of two frames, and data in a 16x2 matrix is stored in RAM.

Key Scan Expansion

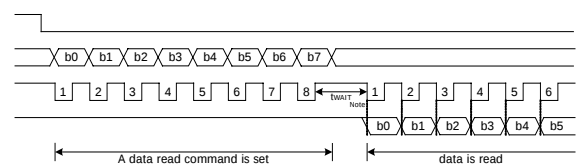


Serial Communication Format

Reception (command/data write)



Transmission (data read)



Note When data is read, a wait time (tWAIT) of 1 ms 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.

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



Absolute Maximum Ratings

Parameter	Symbol	Ratings	Unit
Logic Supply Voltage	V _{DD}	-0.5 to +6.0	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}	±20	mA
VFD Driver Output Current	I _{O2}	-40 (grid) -15 (segment)	mA
Power Dissipation	P _D	800 ^{NOTE}	mW
Operating Ambient Temperature	T _A	-40 to +85	°C
Storage Temperature	T _{stg}	-65 to +150	°C

Note Derate at -6.4 mW/°C at T_A = 25°C or higher.

Caution If the absolute maximum rating of even one of the above parameters is exceeded even momentarily, the quality of the product may be degraded. Absolute maximum ratings, therefore, specify the values exceeding which the product may be physically damaged. Be sure to use the product within the range of the absolute maximum ratings.

Recommended Operating Conditions (T_A = -20 to 70°C, V_{SS} = 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}	0.7 V _{DD}	-	V _{DD}	V	-
Low-Level Input Voltage	V _{IL}	0	-	0.3 V _{DD}	V	-
Driver Supply Voltage	V _{EE}	0	-	V _{DD} - 35	V	-

Remark Maximum power consumption (P_{MAX}) = VFD driver dissipation + RL dissipation + LED driver dissipation + dynamic power consumption

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

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

RL dissipation @ (V_{DD} - V_{EE}) 2/50 × (number of segments + 1) (mW)

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

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

DC Electrical Characteristics

(T_A = -20 to +70°C, V_{DD} = 4.5 to 5.5V, V_{SS} = 0V, V_{EE} = V_{DD} - 35V)

Parameter	Symbol	Min	Typ	Max	Unit	Test Conditions
High-Level Output Voltage	V _{OH1}	V _{DD} - 1	-	-	V	LED ₁ - LED ₄ , I _{OH1} = -15 mA
Low-Level Output Voltage	V _{OL1}	-	-	1	V	LED ₁ - LED ₄ , I _{OL1} = +15 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} - 2 V, Seg ₁ / KS ₁ to Seg ₁₆ / KS ₁₆
High-Level Output Current	I _{OH22}	-15	-	-	mA	V _O = V _{DD} - 2 V, Grid ₁ to Grid ₄ Seg ₁₇ / Grid ₁₂ to Seg ₂₄ / Grid ₅
Driver Leakage Current	I _{OLEAK}	-	-	-10	mA	V _O = V _{DD} - 35 V, driver off
Output Pull-Down Resistor	R _L	40	65	120	kΩ	Driver output
Input Current	I _I	-	-	±1	mA	V _I = V _{DD} or V _{SS}
High-Level Input Voltage	V _{IH}	0.7 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

DC Switching Characteristics ($T_A = -20$ to $+70^\circ\text{C}$, $V_{DD} = 4.5$ to 5.5V , $V_{EE} = -30\text{V}$)

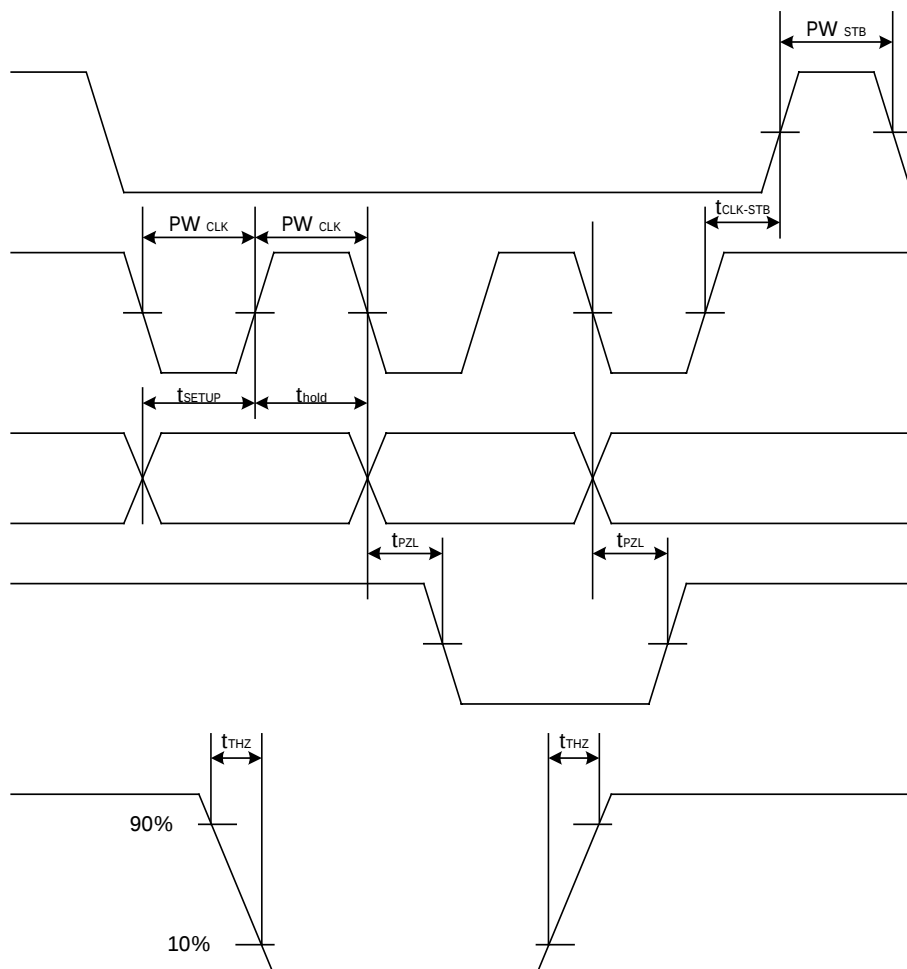
Parameter	Symbol	Min	Typ	Max	Unit	Test Conditions
Oscillation Frequency	f_{OSC}	350	500	650	KHz	$R = 82\text{ k}\Omega$
Propagation Delay Time	t_{PLZ}	-	-	300	ns	$CLK \text{ @ } D_{OUT}$
Rise Time	t_{PZL}	-	-	100	ns	$C_L = 15\text{ pF}$, $R_L = 10\text{ k}\Omega$
	t_{TZH1}	-	-	2	μs	$C_L = 300\text{ pF}$ Seg1/KS1 to Seg16/KS16 Grid ₁ to Grid ₄ , Seg ₁₇ /Grid ₁₂ to Seg ₂₄ /Grid ₅
	t_{TZH2}	-	-	0.5	μs	
Fall Time	t_{THZ}	-	-	160	μs	$C_L = 300\text{ pF}$, Seg _n , Grid _n
Maximum Clock Frequency	f_{MAX}	1	-	-	MHz	Duty = 50 %
Input Capacitance	C_i	-	-	15	pF	

Timing Conditions of AC Electrical Characteristics
($T_A = -20$ to 70°C , $V_{DD} = 4.5$ to 5.5V)

Parameter	Symbol	Min	Unit	Test Conditions
Clock Pulse Width	PWCLK	400	ns	
Strobe Pulse Width	PWSTB	1	μs	
Data Setup Time	tSETUP	100	ns	
Data Hold Time	tHOLD	100	ns	
Clock-Strobe Time	tCLK-STB	1	μs	$CLK \uparrow \rightarrow STB \uparrow$
Wait Time	tWAIT	1	μs	$CLK \uparrow \rightarrow CLK \downarrow$ ^{Note}

Note Refer to the **SERIAL COMMUNICATION FORMAT**.

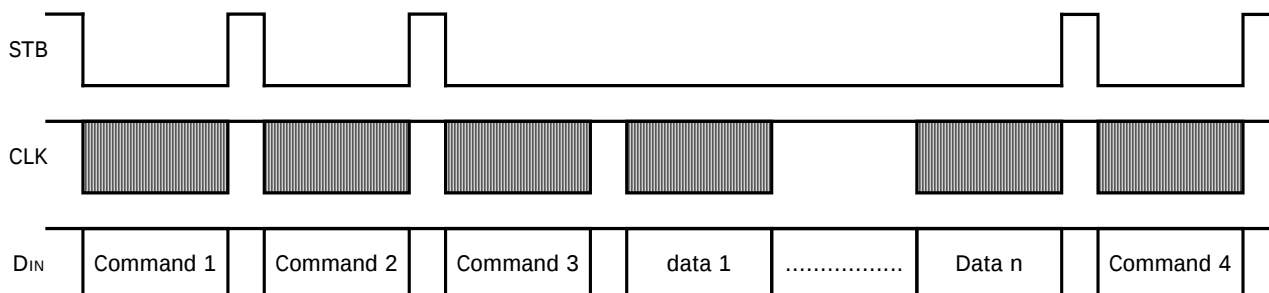
Switching Characteristic Waveforms





Application

Updating display memory by incrementing address



Command 1: sets display mode

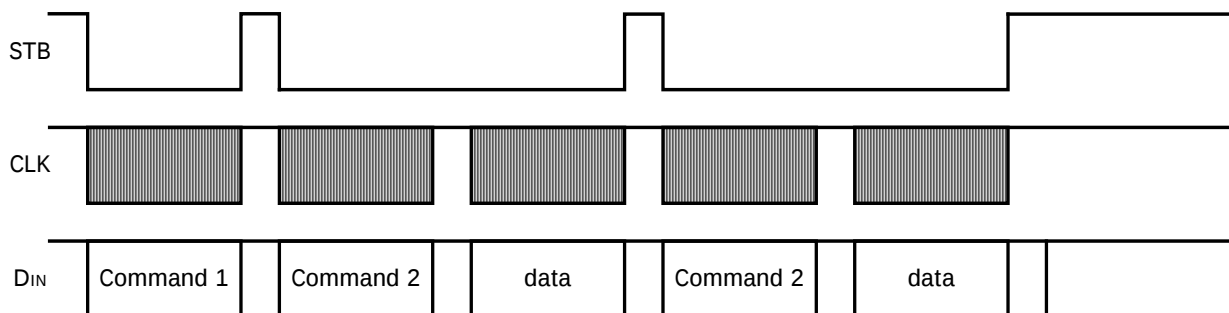
Command 2: sets data

Command 3: sets address

Data 1 to n: transfers display data (36 bytes MAX.)

Command 4: controls display

Updating specific address

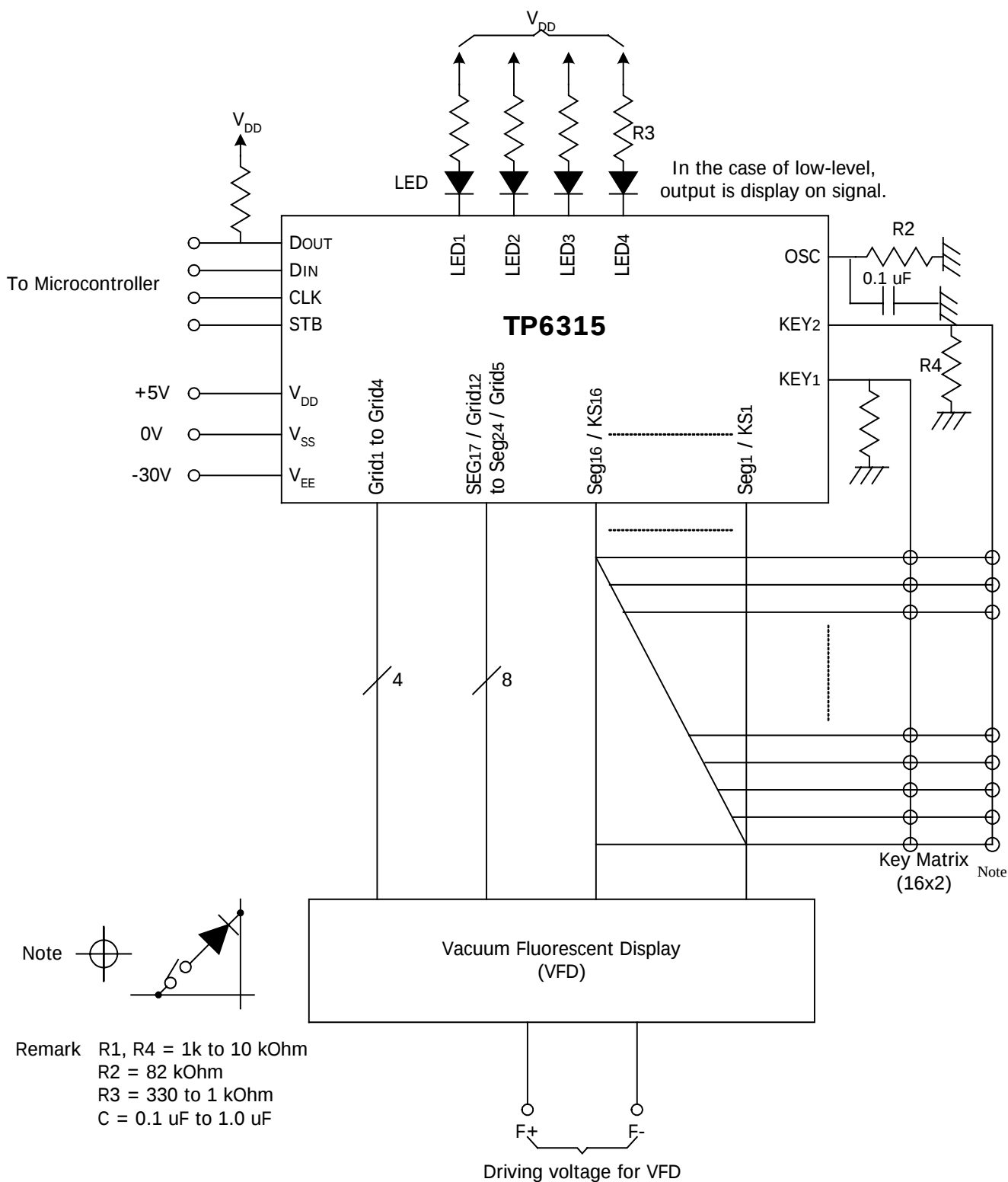


Command 1: sets data

Command 2: sets address

Data: display data

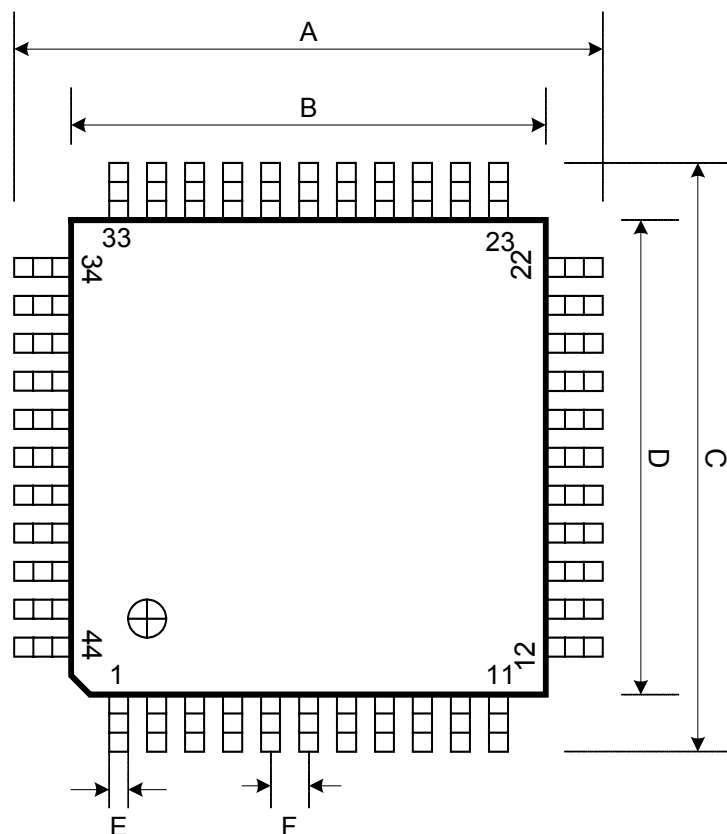
Diagram (Circuit Example for Application)





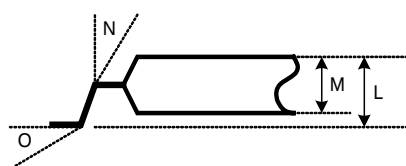
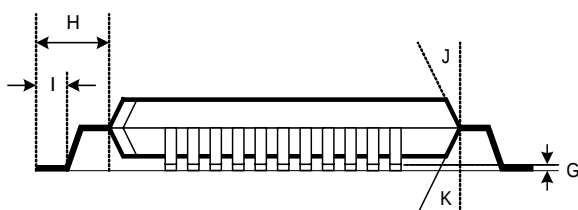
Package Information

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° ± 1°
K	12° ± 1°
L	1.7 MAX
M	1.4 ± 0.1
N	0° MIN
O	+3° ^{+7°} _{-3°}



TP6315

1/4 TO 1/12-DUTY VFD CONTROLLER/DRIVER

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