

# HT16512 1/4 to 1/11 Duty VFD Controller

#### **Features**

- · Logic voltage: 5V
- High-voltage output: V<sub>DD</sub>-35V max.
- Multiple display (11-segment & 11-digit to 16-segment & 6-digit)
- 6×4 matrix key scanning
- 8 steps dimmer circuit
- · 4 LED output ports

- 4-bit general purpose input port
- No external resistors necessary for driver output (provides PMOS open-drain and pull-low resistor output)
- Serial interface with MCU (CLK, CS, DI, DO)
- 44-pin QFP/LQFP package

#### **Applications**

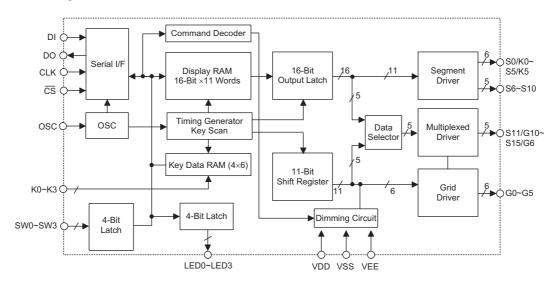
- · Consumer products panel function control
- · Industrial measuring instrument panel function control
- · Other similar application panel function control

## **General Description**

HT16512 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 drive lines, 4 LED output ports, a control circuit, a display memory, and a key scan circuit.

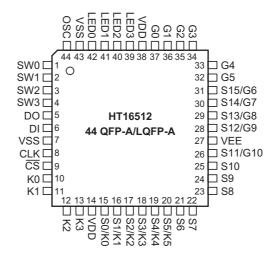
Serial data inputs to the HT16512 through a three-line serial interface. This VFD controller/driver is ideal as a peripheral device for an MCU.

## **Block Diagram**





## **Pin Assignment**

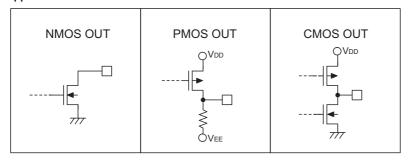


## **Pin Description**

Pin Name	I/O	Description
SW0~SW3	I	4-bit general purpose input port Whether these pins are used or not, they should be connected to VDD or VSS.
DO	0	Output serial data at the falling edge of the shift clock, starting from low order bit. This is an NMOS open-drain output pin.
DI	I	Input serial data at the rising edge of the shift clock, starting from the low order bit.
VSS	_	Negative power supply, ground Both of the VSS (pin 7 and pin 43) should be connected to ground.
CLK	I	Reads serial data at the rising edge, and outputs data at the falling edge.
<del>CS</del>	I	Initializes serial interface at the rising or falling edge of the HT16512. Then it waits to receive a command. Data input after $\overline{CS}$ has fallen is processed as a command. While command data is processed, current processing is stopped, and the serial interface is initialized. While $\overline{CS}$ is high, CLK is ignored.
K0~K3	I	Keying data input to these pins is latched at the end of the display cycle.
VDD	_	Posistive power supply
S0/K0~S5/K5	0	Segment or key source output pins (dual function). This is PMOS open-drain and pull-low resistor output.
S6~S10	0	Segment driver output pins (segment only). This is PMOS open-drain and pull-low resistor output.
S11/G10~S15/G6	0	Segment or Grid driver output pins. These pins are selectable for segment or grid driving. This is PMOS open-drain and pull-low resistor output.
VEE		VFD power supply
G0~G5	0	Grid driver output pins (Grid only). This is PMOS open-drain and pull-low resistor output.
LED0~LED3	0	LED driver output ports. This is a CMOS output pin.
osc	1	Connected to an external resistor or an RC oscillator circuit.
	SW0~SW3  DO  DI  VSS  CLK  CS  K0~K3  VDD  S0/K0~S5/K5  S6~S10  S11/G10~S15/G6  VEE  G0~G5  LED0~LED3	SW0~SW3       I         DO       O         DI       I         VSS       —         CLK       I         K0~K3       I         VDD       —         S0/K0~S5/K5       O         S6~S10       O         S11/G10~S15/G6       O         VEE       —         G0~G5       O         LED0~LED3       O



## **Approximate Internal Connections**



## **Absolute Maximum Ratings**

Supply VoltageV <sub>SS</sub> -0.3V to V <sub>SS</sub> +5.5V	Operating Temperature25°C to 75°C
Input VoltageV <sub>SS</sub> -0.3V to V <sub>DD</sub> +0.3V	Storage Temperature50°C to 125°C

Note: These are stress ratings only. Stresses exceeding the range specified under "Absolute Maximum Ratings" may cause substantial damage to the device. Functional operation of this device at other conditions beyond those listed in the specification is not implied and prolonged exposure to extreme conditions may affect device reliability.

## D.C. Characteristics Ta=25°C

Committee I	Domenication		Test Conditions	Min.	_		Unit
Symbol	Parameter	V <sub>DD</sub>	V <sub>DD</sub> Conditions		Тур.	Max.	Offic
$V_{DD}$	Logic Supply Voltage				5	5.5	V
V <sub>EE</sub>	VFD Supply Voltage	_	_	0	_	V <sub>DD</sub> -35	V
fosc	Oscillation Frequency	5V	$R_{OSC}$ =51k $\Omega$	350	500	650	kHz
R <sub>PL</sub>	Output Pull-low Resistor	5V	Driver output	50	100	150	kΩ
I <sub>DD</sub>	Operating Current	5V	No load, VFD display off	_	_	5	mA
I <sub>OL</sub>	Driver Leakage Current		$V_{\rm O} = V_{\rm DD} - 35 \rm V, \ VFD \ driver$ off	_	_	-10	μА
I <sub>OL1</sub>	LED Sink Current	5V	V <sub>OL</sub> =1V, LED0~LED3	20	_	_	mA
I <sub>OH1</sub>	LED Source Current	5V	V <sub>OH</sub> =0.9V <sub>DD</sub> LED0~LED3	-1	_	_	mA
I <sub>OH21</sub>	Segment/Key Source Current	5V	V <sub>OH</sub> =V <sub>DD</sub> -2V S0/K0~S5/K5, S6~S10	-3		_	mA
I <sub>OH22</sub>	Segment/Grid Source Current	5V	V <sub>OH</sub> =V <sub>DD</sub> -2V G0~G5, S11/G10~S15/G6	-15	_	_	mA
I <sub>OL3</sub>	DO Sink Current	5V	V <sub>OL</sub> =0.4V	4	_	_	mA
V <sub>IH</sub>	"H" Input Voltage	_	_	0.7V <sub>DD</sub>	_	V <sub>DD</sub>	V
V <sub>IL</sub>	"L" Input Voltage	_	_	0	_	0.3V <sub>DD</sub>	V
V <sub>OH1</sub>	High-level Output Voltage	5V	LED0~LED3, I <sub>OH1</sub> =-1mA	0.9V <sub>DD</sub>	_	V <sub>DD</sub>	V
V <sub>OL1</sub>	Low-level Output Voltage	5V	LED0~LED3, I <sub>OL1</sub> =20mA	0	_	1	V
V <sub>OL2</sub>	Low-level Output Voltage	5V	DO, I <sub>OL2</sub> =4mA	0	_	0.4	V



#### A.C. Characteristics

Ta=25°C

Sumah al	Davamatav	Test Conditions			T	Man	Unit
Symbol	Parameter	$V_{DD}$	Conditions	Min.	Тур.	Max.	Ullit
t <sub>PHL</sub>	December Delevities	5V	CLK→DO	_	_	100	ns
t <sub>PLH</sub>	Propagation Delay Time	5V	$C_L=15pF, R_L=10k\Omega$	_	_	300	ns
t <sub>r1</sub>		5V	C <sub>L</sub> =300pF, S0~S10	_	_	2	μS
t <sub>r2</sub>	Rise Time		C <sub>L</sub> =300pF, G0~G5, S11/G10~S15/G6	_	_	0.5	μS
t <sub>f</sub>	Fall Time	5V	C <sub>L</sub> =300pF, Sn, Gn	_	_	120	μS
t <sub>max</sub>	Maximum Clock Frequency	5V	Duty=50%	1	_	_	MHz
Ci	Input Capacitance	5V	_	_	_	15	pF
t <sub>CW</sub>	Clock Pulse Width	5V	_	400	_	_	ns
t <sub>SW</sub>	Strobe Pulse Width	5V	_	1	_	_	us
t <sub>SU</sub>	Data Setup Time	5V	_	100	_	_	ns
t <sub>h</sub>	Data Hold Time	5V	_	100	_	_	ns
t <sub>CS</sub>	Clock-Strobe Time	5V	CLK rising edge to CS rising edge	1	_	_	μS
t <sub>W</sub>	Wait Time	5V	CLK rising edge to CLK falling edge	1	_	_	μS

## **Functional Description**

## **Display RAM and Display Mode**

The static display RAM is organized into 22×8 bits and stores the data transmitted from an external device to the HT16512 through a serial interface. The contents of the RAM are directly mapped to the contents of the VFD driver. Data in the RAM can be accessed through the data setting, address setting and display control commands. It is assigned addresses in 8-bit unit as follows:

S0	~	S3	S4	~	S7	S8	~	S11 S12	~	S15	
Ad	dres	ss: 0	ОН					01H			Digit0
		0:	2H					03H			Digit1
		04	4H					05H			Digit2
		0	6H					07H			Digit3
		0	вн					09H			Digit4
		0,	ΑН					0BH			Digit5
		00	CH					0DH			Digit6
		01	EΗ					0FH			Digit7
		10	OΗ					11H			Digit8
		1:	2H					13H			Digit9
		14	4H					15H			Digit10
		- 4						<b>↑</b>			
b0 b	1 b2	2 b3	b4 b	5 b6	b7	b0	b1	b2 b3 b4	b5 b	6 b7	

#### **Dimming Control**

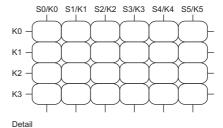
HT16512 provides 8-step dimmer function on display by controlling the 3-bit binary command code. The full pulse width of grid signal is divides into 16 uniform sections by PWM (pulse width modulation) technology.

The 16 uniform sections available form 8 steps dimmer via 3-bit binary code. The 8-step dimmer includes 1/16, 2/16, 4/16, 10/16, 11/16, 12/16, 13/16 and 14/16. The 1/16 pulse width indicates minimum lightness. The 14/16 pulse width represents maximum lightness. (Refer to the display control command).

## Key Matrix and Key-Input Data Storage RAM

The key matrix scans the series key states at each level of the key strobe signal (S0/K0~S5/K5) output of the HT16512. The key strobe signal outputs are time-multiplexed signals from S0/K0~S5/K5. The states of inputs K0~K3 are sampled by strobe signal S0/K0~S5/K5 and latched into the register.

The key matrix is made up of a  $6\times4$  matrix, as shown below.

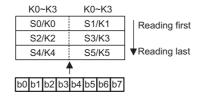


Key matrix

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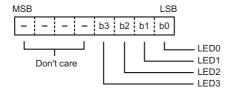
The data of each key is stored as illustrated below, and is read with the read command, starting from the least significant bit.



#### I FD Port

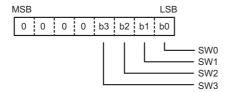
The LED port belongs to the CMOS output configura-

Data is written to the LED port with the write command, starting from the least port's least significant bit. In our application (see application circuits), the user adopts an internal NMOS device to a driver LED component by connecting VDD. When a bit of this port is 0, the corresponding LED lights; when the bit is 1, the LED turns off. The data of bits 5 through 8 are ignored.



#### SW Data

HT16512 provides an extra 4-bit general input port. The SW data is provided with available binary code. The SW data is read with the read command, starting from the least significant bit. Bits 5 through 8 of the SW data are



## Commands

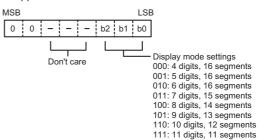
Commands set the display mode and status of the VFD driver

The first 1 byte input to the HT16512 through the DI pin after the  $\overline{CS}$  pin has fallen, is regarded as a command. If  $\overline{CS}$  is set high while commands/data are transmitted, serial communication is initialized, and the commands/data being transmitted are not valid (however, the commands/data previously transmitted remains valid).

#### · Display mode setting commands

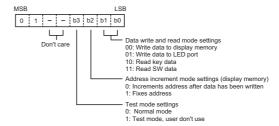
These commands initialize the HT16512 and select the number of segments and the number of grids ( $1/4\sim1/11$  duty, 11 segments to 16 segments).

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, nothing happens.



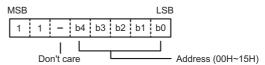
#### · Data setting commands

These commands set the data write and data read modes.



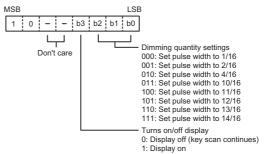
#### · Address setting commands

These commands set the address of the display memory.



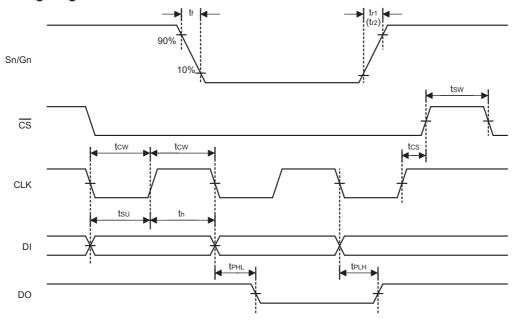
If address 16H or higher is set, data is ignored until a valid address is set.

#### · Display control commands

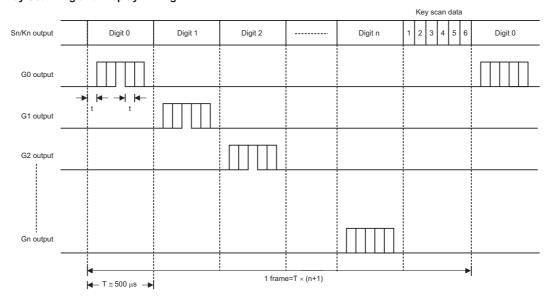




## **Timing Diagrams**



## **Key Scanning and Display Timing**

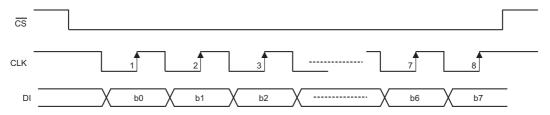


Note: n=0~5
t=1/16T
T: pulse width of segment signal is decided by oscillator frequency
One cycle of key scanning consists of one frame.

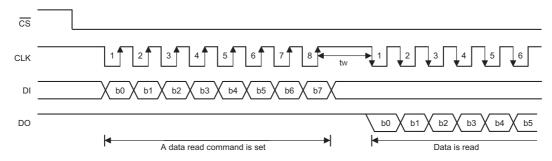


## **Serial Communication Format**

• Reception (command/data write)



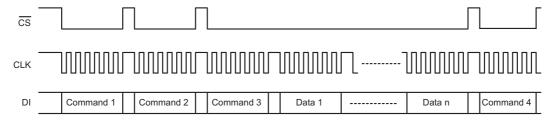
• Transmission (data read)



DO must be sure to connect an external pull-high resistor to this pin ( $1k\Omega$  to  $10k\Omega$ ).

Note: When data is read, a wait time "tw" of  $1\mu s$  is necessary.

· Updating display memory by incrementing address



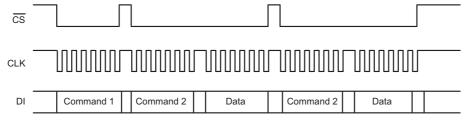
Command 1: sets display mode

Command 2: sets data Command 3: sets address

Data 1 to n: transfers display data (22 bytes max.)

Command 4: controls diplay

· Updating specific addresses

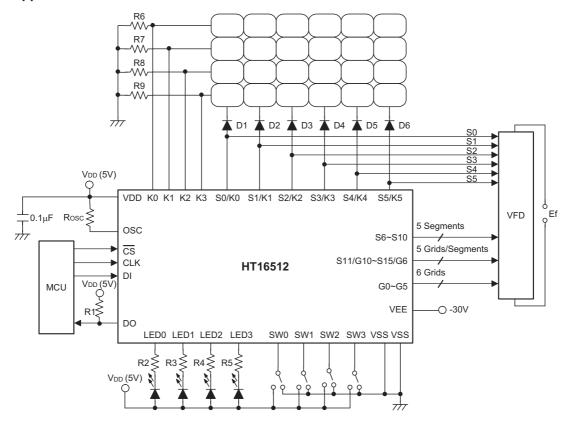


Command 1: sets data Command 2: sets address

Data: display data



## **Application Circuits**



Note:  $R_{OSC}$ =51k $\Omega$  for oscillator resistor

R1=1~10k $\Omega$  for external pull-high resistor

R2~R5=750Ω~1.2kΩ

R6~R9=10k $\Omega$  for external pull-low resistor

D1~D6=1N4001

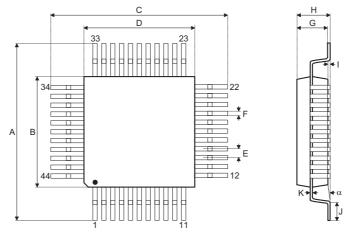
Ef=Filament voltage for VFD

Both of the VSS (pin 7 and pin 43) should be connected to ground.



## Package Information

## 44-pin QFP (10mm×10mm) Outline Dimensions

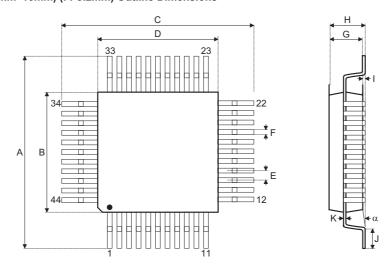


Symbol	Dimensions in inch					
	Min.	Nom.	Max.			
Α	0.512	_	0.528			
В	0.390	_	0.398			
С	0.512	_	0.528			
D	0.390	_	0.398			
E	_	0.031	_			
F	_	0.012	_			
G	0.075	_	0.087			
Н	_	_	0.106			
I	0.010	_	0.020			
J	0.029	_	0.037			
K	0.004	_	0.008			
L	_	0.004	_			
α	0°	_	7°			

Symbol	Dimensions in mm					
	Min.	Nom.	Max.			
А	13.00	_	13.40			
В	9.90	_	10.10			
С	13.00	_	13.40			
D	9.90	_	10.10			
E	_	0.80	_			
F	_	0.30	_			
G	1.90	_	2.20			
Н	_	_	2.70			
I	0.25	_	0.50			
J	0.73	_	0.93			
K	0.10	_	0.20			
L	_	0.10	_			
α	0°	_	7°			



## 44-pin LQFP (10mm×10mm) (FP3.2mm) Outline Dimensions



Symbol	Dimensions in inch					
	Min.	Nom.	Max.			
Α	0.512	0.520	0.528			
В	0.390	0.394	0.398			
С	0.512	0.520	0.528			
D	0.390	0.394	0.398			
E	_	0.031	_			
F	_	0.012				
G	0.053	0.055	0.057			
Н	_	_	0.063			
I	0.004	_	0.010			
J	0.041	0.047	0.053			
K	0.004	_	0.008			
α	0°	_	7°			

Cumbal	Dimensions in mm					
Symbol	Min.	Nom.	Max.			
Α	13.00	13.20	13.40			
В	9.90	10.00	10.10			
С	13.00	13.20	13.40			
D	9.90	10.00	10.10			
E	_	0.80	_			
F	_	0.30	_			
G	1.35	1.40	1.45			
Н	_	_	1.60			
I	0.10	_	0.25			
J	1.05	1.20	1.35			
K	0.10	_	0.25			
α	0°	_	7°			



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