

Features

- Logic voltage: 5V
- High-voltage output: V_{DD}–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 package

Applications

- Consumer products panel function control
- Industrial measuring instrument panel function control

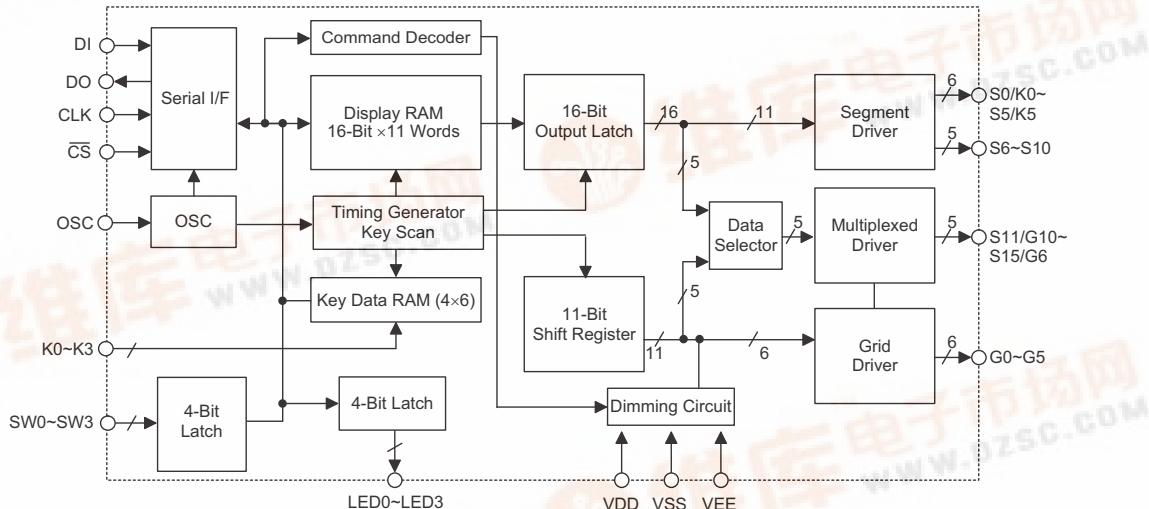
- Other similar application panel function control

General Description

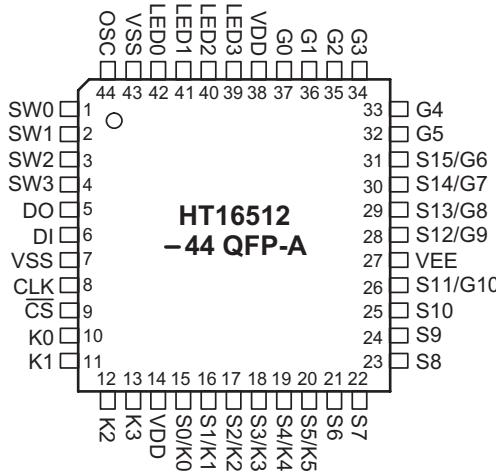
HT16512 is a VFD (Vacuum Fluorescent Display) controller/driver that is driven on a 1/4 to 1/11 duty factor. It consists of 11 segment output lines, 6 grid output lines, 5 segment/grid output drive lines, 4 LED output ports, a control circuit, a display memory, and a key scan circuit.

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

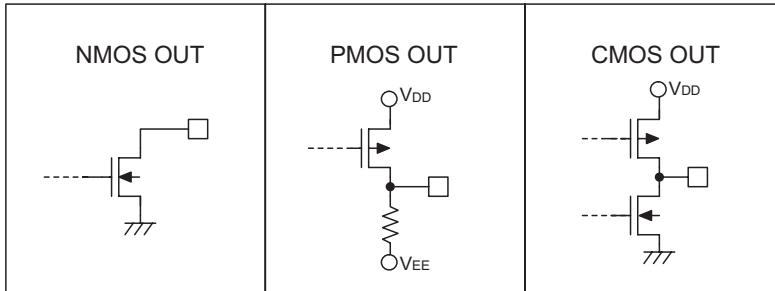


Pin Assignment



Pin Description

Pin No.	Pin Name	I/O	Description
1~4	SW0~SW3	I	4-bit general purpose input port Whether these pins are used or not, they should be connected to VDD or VSS.
5	DO	O	Output serial data at the falling edge of the shift clock, starting from low order bit. This is an NMOS open-drain output pin.
6	DI	I	Input serial data at the rising edge of the shift clock, starting from the low order bit.
7, 43	VSS	—	Negative power supply, ground Both of the VSS (pin 7 and pin 43) should be connected to ground.
8	CLK	I	Reads serial data at the rising edge, and outputs data at the falling edge.
9	CS	I	Initializes serial interface at the rising or falling edge of the HT16512. Then it waits to receive a command. Data input after CS has fallen is processed as a command. While command data is processed, current processing is stopped, and the serial interface is initialized. While CS is high, CLK is ignored.
10~13	K0~K3	I	Keying data input to these pins is latched at the end of the display cycle.
14, 38	VDD	—	Positive power supply
15~20	S0/K0~S5/K5	O	Segment or key source output pins (dual function). This is PMOS open-drain and pull-low resistor output.
21~25	S6~S10	O	Segment driver output pins (segment only). This is PMOS open-drain and pull-low resistor output.
26, 28~31	S11/G10~S15/G6	O	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.
27	VEE	—	VFD power supply
37~32	G0~G5	O	Grid driver output pins (Grid only). This is PMOS open-drain and pull-low resistor output.
42~39	LED0~LED3	O	LED driver output ports. This is a CMOS output pin.
44	OSC	I	Connected to an external resistor or an RC oscillator circuit.

Approximate Internal Connections

Absolute Maximum Ratings

Supply Voltage	$V_{SS}-0.3V$ to $V_{SS}+5.5V$	Operating Temperature	$-25^{\circ}C$ to $75^{\circ}C$
Input Voltage	$V_{SS}-0.3V$ to $V_{DD}+0.3V$	Storage Temperature	$-50^{\circ}C$ to $125^{\circ}C$

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

Symbol	Parameter	Test Conditions		Min.	Typ.	Max.	Unit
		V _{DD}	Conditions				
V _{DD}	Logic Supply Voltage	—	—	4.5	5	5.5	V
V _{EE}	VFD Supply Voltage	—	—	0	—	V _{DD} -35	V
f _{osc}	Oscillation Frequency	5V	R _{Osc} =51kΩ	350	500	650	kHz
R _{PL}	Output Pull-low Resistor	5V	Driver output	50	100	150	kΩ
I _{DD}	Operating Current	5V	No load, VFD display off	—	—	5	mA
I _{OL}	Driver Leakage Current	5V	V _O =V _{DD} -35V, VFD driver off	—	—	-10	μA
I _{OL1}	LED Sink Current	5V	V _{OL} =1V, LED0~LED3	20	—	—	mA
I _{OH1}	LED Source Current	5V	V _{OH} =0.9V _{DD} LED0~LED3	-1	—	—	mA
I _{OH21}	Segment/Key Source Current	5V	V _{OH} =V _{DD} -2V S0/K0~S5/K5, S6~S10	-3	—	—	mA
I _{OH22}	Segment/Grid Source Current	5V	V _{OH} =V _{DD} -2V G0~G5, S11/G10~S15/G6	-15	—	—	mA
I _{OL3}	DO Sink Current	5V	V _{OL} =0.4V	4	—	—	mA
V _{IH}	"H" Input Voltage	—	—	0.7V _{DD}	—	V _{DD}	V
V _{IL}	"L" Input Voltage	—	—	0	—	0.3V _{DD}	V
V _{OH1}	High-level Output Voltage	5V	LED0~LED3, I _{OH1} =-1mA	0.9V _{DD}	—	V _{DD}	V
V _{OL1}	Low-level Output Voltage	5V	LED0~LED3, I _{OL1} =20mA	0	—	1	V
V _{OL2}	Low-level Output Voltage	5V	DO, I _{OL2} =4mA	0	—	0.4	V

A.C. Characteristics

Ta=25°C

Symbol	Parameter	Test Conditions		Min.	Typ.	Max.	Unit
		V _{DD}	Conditions				
t _{PHL}	Propagation Delay Time	5V	CLK→DO	—	—	100	ns
t _{PLH}		5V	C _L =15pF, R _L =10kΩ	—	—	300	ns
t _{r1}	Rise Time	5V	C _L =300pF, S0~S10	—	—	2	μs
t _{r2}		5V	C _L =300pF, G0~G5, S11/G10~S15/G6	—	—	0.5	μs
t _f	Fall Time	5V	C _L =300pF, S _n , G _n	—	—	120	μs
t _{max}	Maximum Clock Frequency	5V	Duty=50%	1	—	—	MHz
C _i	Input Capacitance	5V	—	—	—	15	pF
t _{cw}	Clock Pulse Width	5V	—	400	—	—	ns
t _{sw}	Strobe Pulse Width	5V	—	1	—	—	us
t _{su}	Data Setup Time	5V	—	100	—	—	ns
t _h	Data Hold Time	5V	—	100	—	—	ns
t _{cs}	Clock-Strobe Time	5V	CLK rising edge to CS rising edge	1	—	—	μs
t _w	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
Address: 00H								01H			Digit0
	02H							03H			Digit1
	04H							05H			Digit2
	06H							07H			Digit3
	08H							09H			Digit4
	0AH							0BH			Digit5
	0CH							0DH			Digit6
	0EH							0FH			Digit7
	10H							11H			Digit8
	12H							13H			Digit9
	14H							15H			Digit10

Dimming Control

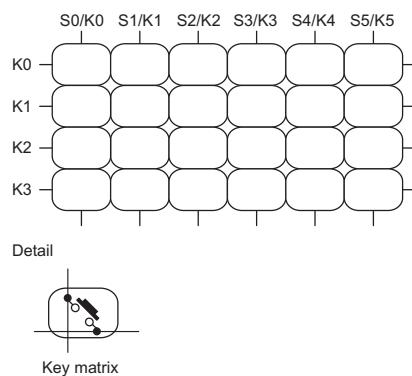
HT16512 provides 8-step dimmer function on display by controlling the 3-bit binary command code. The full pulse width of grid signal is divided into 16 uniform sections by PWM (pulse width modulation) technology.

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).

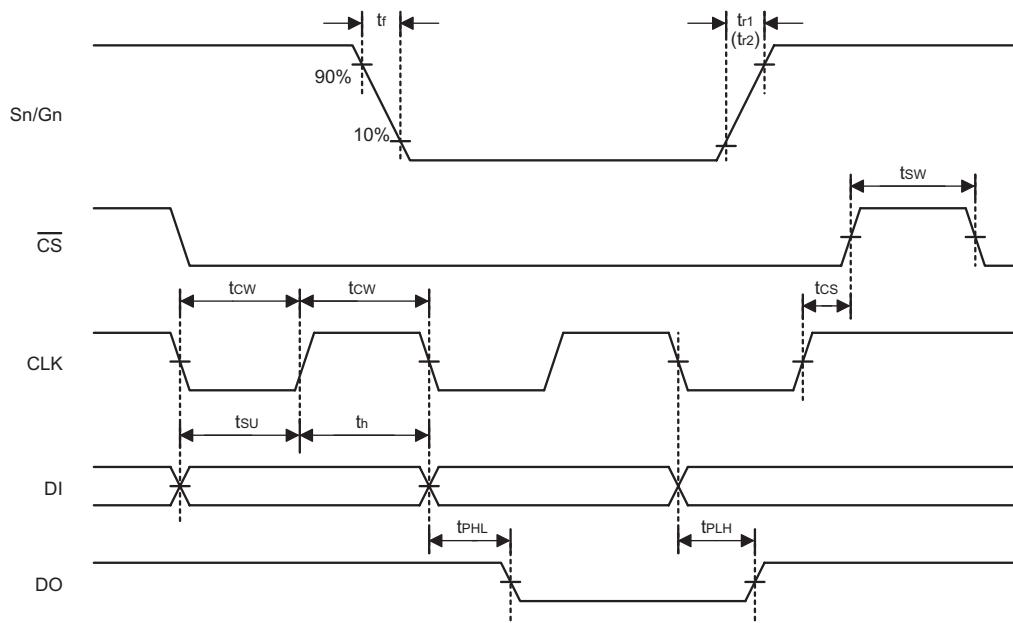
Key Matrix and Key-Input Data Storage RAM

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.

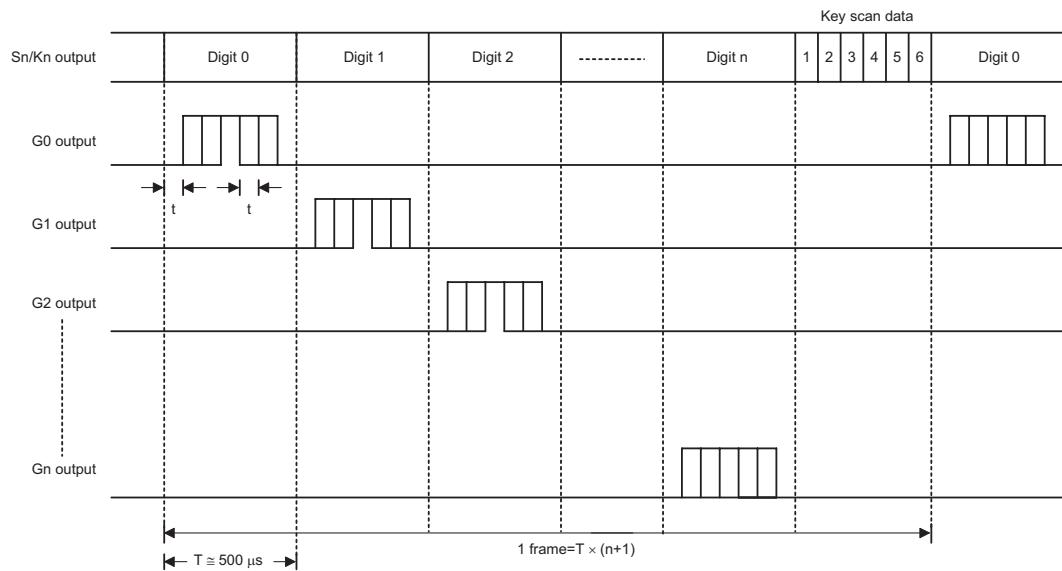
The key matrix is made up of a 6×4 matrix, as shown below.



Timing Diagrams



Key Scanning and Display Timing



Note: $n=0\sim 5$

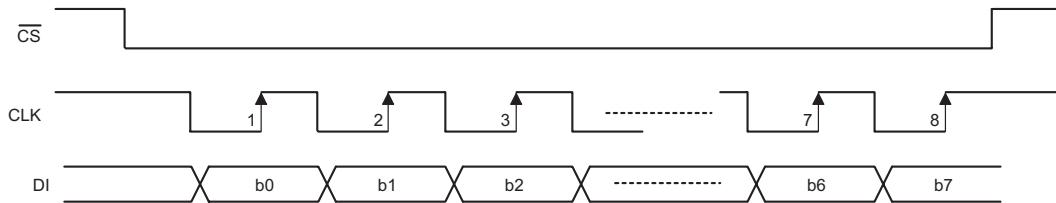
$t=1/16T$

T : pulse width of segment signal is decided by oscillator frequency

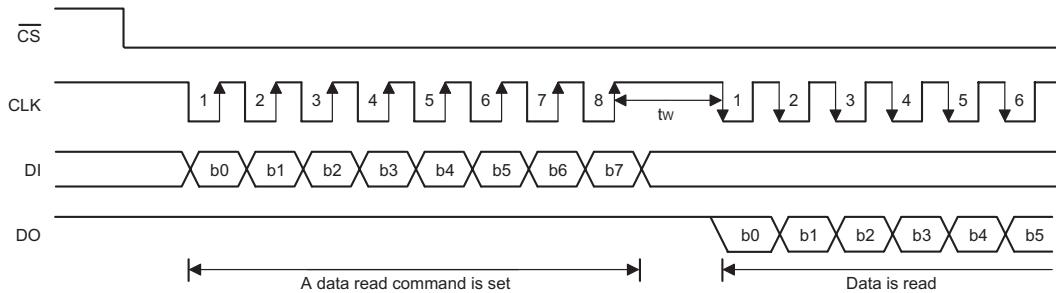
One cycle of key scanning consists of one frame.

Serial Communication Format

- Reception (command/data write)



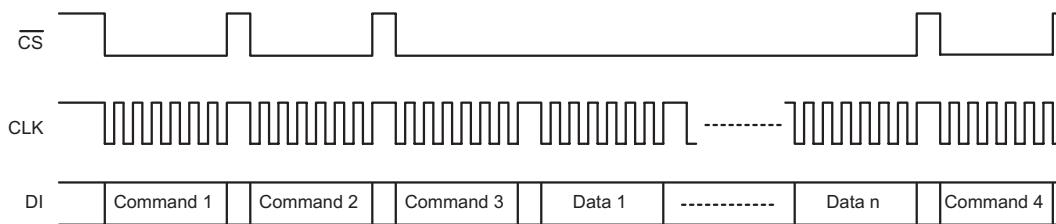
- Transmission (data read)



DO must be sure to connect an external pull-high resistor to this pin (1kΩ to 10kΩ).

Note: When data is read, a wait time "tw" of 1μs is necessary.

- Updating display memory by incrementing address



Command 1: sets display mode

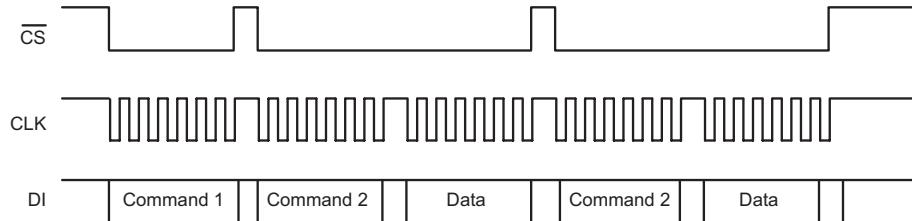
Command 2: sets data

Command 3: sets address

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

Command 4: controls display

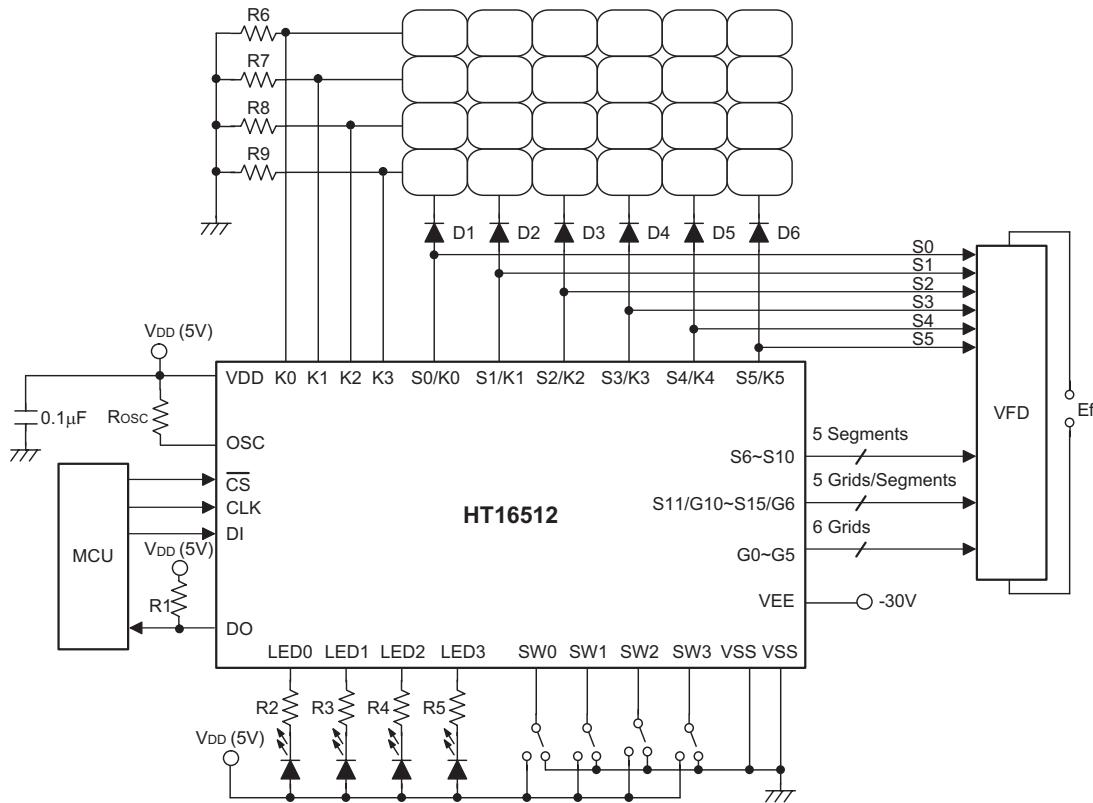
- Updating specific addresses



Command 1: sets data

Command 2: sets address

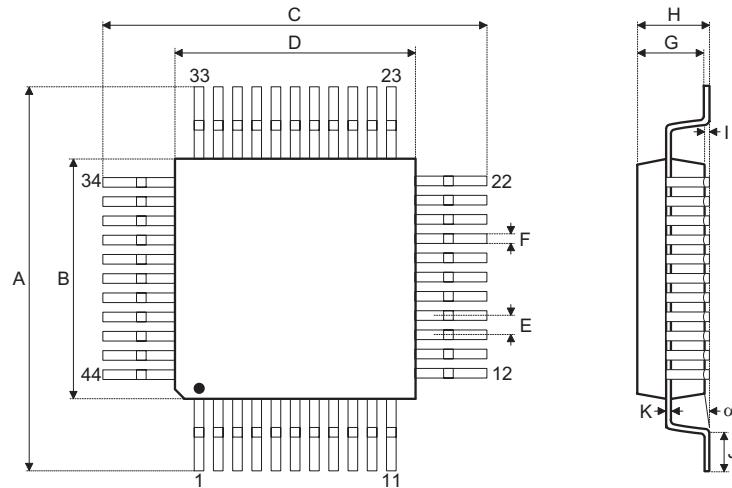
Data: display data

Application Circuits


Note:
 Rosc=51k Ω for oscillator resistor
 R1=1~10k Ω for external pull-high resistor
 R2~R5=750 Ω ~1.2k Ω
 R6~R9=10k Ω 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 (10×10) Outline Dimensions



Symbol	Dimensions in mm		
	Min.	Nom.	Max.
A	13	—	13.40
B	9.90	—	10.10
C	13	—	13.40
D	9.90	—	10.10
E	—	0.80	—
F	—	0.30	—
G	1.90	—	2.20
H	—	—	2.70
I	—	0.10	—
J	0.73	—	0.93
K	0.10	—	0.20
α	0°	—	7°

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