



PRELIMINARY

# 16-SEGMENT X 15-Digit VFD CONTROLLER / DRIVER

## GENERAL DESCRIPTION

The NJU3426 is a VFD (Vacuum Fluorescent Display) controller/driver to dynamically drive up to 16 segments x 15 digits. It consists of display data RAM, an address counter, command registers, a serial interface and high voltage drivers. The direct control from the MPU and high voltage drivers of 45V make the NJU3426 well suited for various VFD displays.

## PACKAGE OUTLINE

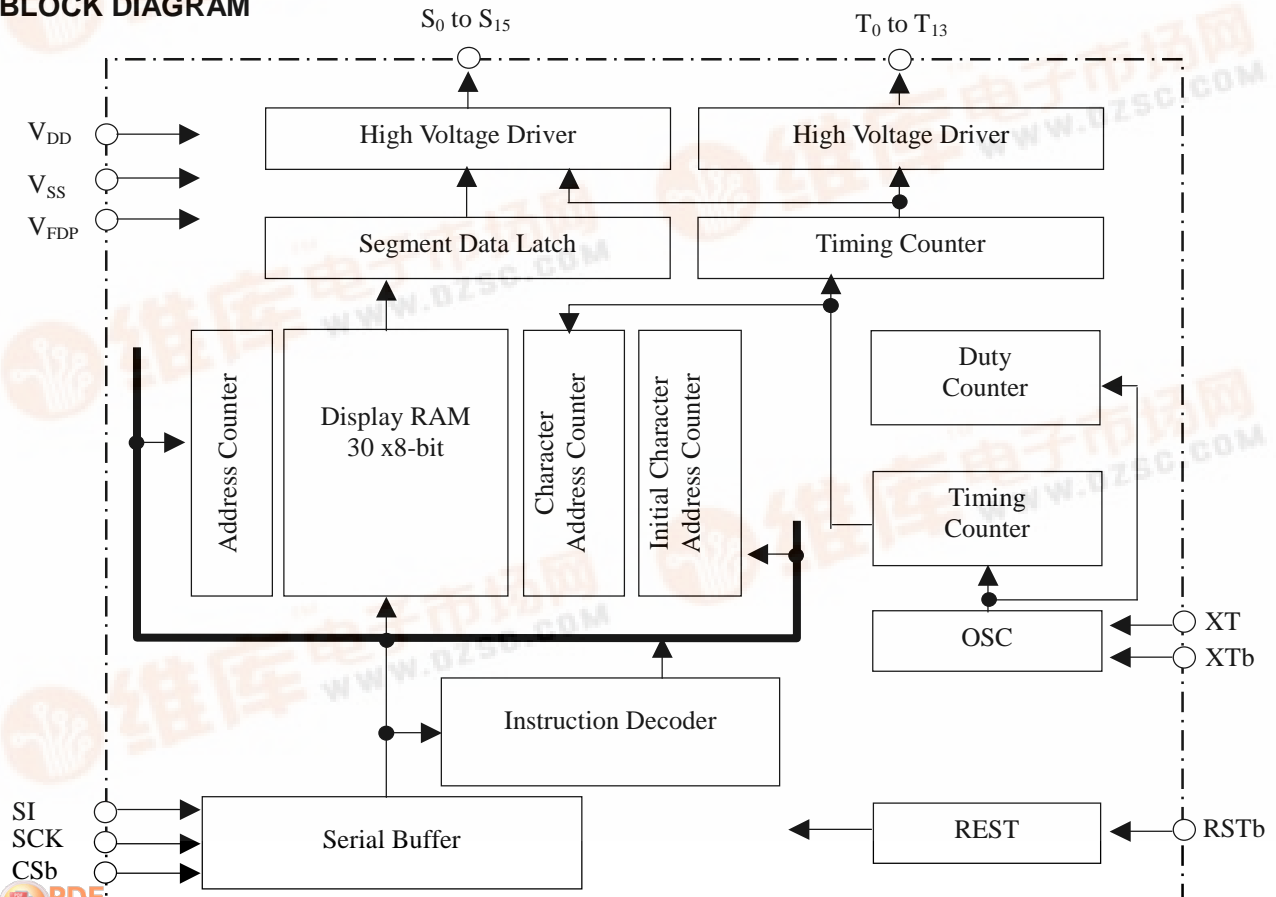


NJU3426FP1

## FEATURES

- Directly Drives 16-segment x 15-digit
- High VFD Driving Voltage :  $|V_{DD}-V_{FDP}|=45V$
- Display Shift Function
- Programmable Duty Ratio for Timing Signal : 2/16, 4/16, 6/16, 8/16, 10/16, 12/16, 14/16, 15/16 duty
- Display ON/OFF Control Function
- Display Data RAM : 30 x 8-bit
- Built-in Oscillator (Formed by Connecting an External Ceramic Resonator)
- 8-bit Serial Interface
- Power-ON Reset Function
- Operating Voltage : 3.0 to 5.5V
- C-MOS Technology
- Package Outline : QFP48-P1

## BLOCK DIAGRAM



# NJU3426

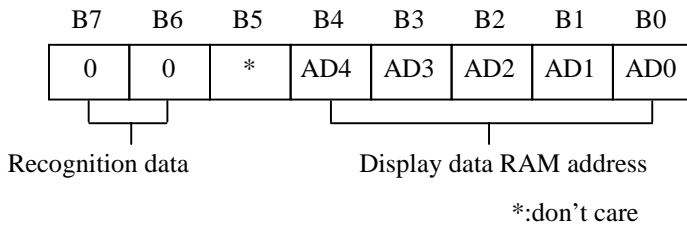
## FUNCTION DESCRIPTION

### (1) ADDRESS COUNTER

The address counter indicates the "Display data RAM address", in which the display data will be transferred and stored. For the data transmission, once an initial RAM address is determined, the display data can be continuously transmitted without setting the RAM address each time. When the upper 2 bits (B7 and B6) of the 1st word are "0,0", the lower 5 bits (B4 to B0) are recognized as RAM address data. And, the 2nd word is recognized as display data, which will be stored in the RAM address designated by the 1st word, and simultaneously the RAM address is counted up by an auto-increment operation.

The "Display data RAM address", which can be specified by the 1<sup>st</sup> word, ranges from "0,0,0,0,0" (00<sub>H</sub>) to "1,1,1,0,1" (1D<sub>H</sub>). However, the auto-increment keeps counting up to "1,1,1,1,1" (1F<sub>H</sub>) every display data transmission because of the 5-bit address counter, and finally the RAM address wraps to "0,0,0,0,0" (00<sub>H</sub>) and begins counting up. Note that the display data, stored in the RAM address of "1,1,1,1,0" (1E<sub>H</sub>) and "1,1,1,1,1" (1F<sub>H</sub>), is ignored in this sequence.

### DISPLAY DATA RAM ADDRESS



Character address	RAM Address								RAM Address										
	B7	B6	B5	B4	B3	B2	B1	B0											
									01 <sub>H</sub>									00 <sub>H</sub>	
T <sub>0</sub>	C <sub>1</sub>								03 <sub>H</sub>									02 <sub>H</sub>	
T <sub>1</sub>	C <sub>2</sub>								05 <sub>H</sub>									04 <sub>H</sub>	
T <sub>2</sub>	C <sub>3</sub>								07 <sub>H</sub>									06 <sub>H</sub>	
T <sub>3</sub>	C <sub>4</sub>								09 <sub>H</sub>									08 <sub>H</sub>	
T <sub>4</sub>	C <sub>5</sub>								0B <sub>H</sub>									0A <sub>H</sub>	
T <sub>5</sub>	C <sub>6</sub>								0D <sub>H</sub>									0C <sub>H</sub>	
T <sub>6</sub>	C <sub>7</sub>								0F <sub>H</sub>									0E <sub>H</sub>	
T <sub>7</sub>	C <sub>8</sub>								11 <sub>H</sub>									10 <sub>H</sub>	
T <sub>8</sub>	C <sub>9</sub>								13 <sub>H</sub>									12 <sub>H</sub>	
T <sub>9</sub>	C <sub>10</sub>								15 <sub>H</sub>									14 <sub>H</sub>	
T <sub>10</sub>	C <sub>11</sub>								17 <sub>H</sub>									16 <sub>H</sub>	
T <sub>11</sub>	C <sub>12</sub>								19 <sub>H</sub>									18 <sub>H</sub>	
T <sub>12</sub>	C <sub>13</sub>								1B <sub>H</sub>									1A <sub>H</sub>	
T <sub>13</sub>	C <sub>14</sub>								1D <sub>H</sub>									1C <sub>H</sub>	
		X	X	X	X	X	X	X	1F <sub>H</sub>	X	X	X	X	X	X	X	X	1E <sub>H</sub>	
		S <sub>15</sub>	S <sub>14</sub>	S <sub>13</sub>	S <sub>12</sub>	S <sub>11</sub>	S <sub>10</sub>	S <sub>9</sub>	S <sub>8</sub>		S <sub>7</sub>	S <sub>6</sub>	S <sub>5</sub>	S <sub>4</sub>	S <sub>3</sub>	S <sub>2</sub>	S <sub>1</sub>	S <sub>0</sub>	

⊗ : These display data is ignored.

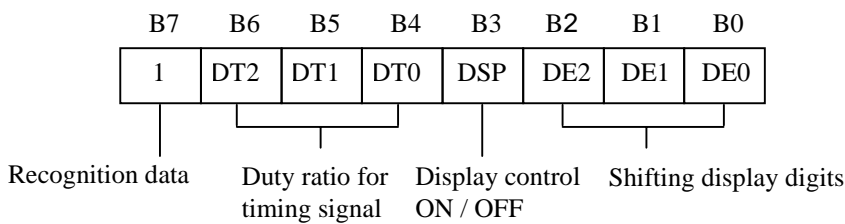
### DISPLAY DATA RAM MAPPING

## (2) COMMAND REGISTER 1

The “Command register 1” is used for setting “Duty ratio for timing signal”, “Display control ON/OFF” and “Shifting display digits”. When the upper 1 bit (B7) of the 1<sup>st</sup> word is “1”, the lower 7 bits (B6 to B0) are recognized as command data, and stored in the “Command register 1”. Note that changing the “Duty ratio” or “Shifting display digits” must be executed under the “Display control OFF”, otherwise it may cause flickering. The contents of the “Command register 1” is initially set up at power-ON reset or reset signal, as shown below.

### DEFAULT VALUES OF COMMAND REGISTER 1

- Duty ratio for timing signal : 2/16
- Display control ON/OFF : OFF
- Shifting display digits : 7



MD2	MD1	MD0	Duty ratio for timing signal
0	0	0	2/16
0	0	1	4/16
0	1	0	6/16
0	1	1	8/16
1	0	0	10/16
1	0	1	12/16
1	1	0	14/16
1	1	1	15/16

DSP	Display control
0	OFF
1	ON

Note.) When the “Display control is OFF” is set, all output pins become in display OFF state.

DE2	DE1	DE0	Shifting display digits
0	0	0	7
0	0	1	8
0	1	0	9
0	1	1	10
1	0	0	11
1	0	1	12
1	1	0	13
1	1	1	14

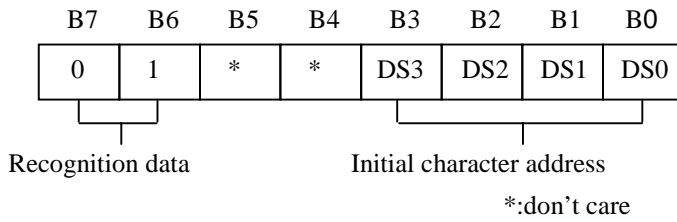
# NJU3426

## (3) COMMAND REGISTER 2

The “Command register 2” is used for setting the “Initial character address”, which corresponds to the T<sub>0</sub> pin. When the upper 2 bits (B7 and B6) of the 1<sup>st</sup> word is “0,1”, the lower 4 bits (B3 to B0) are recognized as command data, and stored in the “Command register 2”. The contents of the “Command register 2” is initially set up at power-ON reset or reset signal, as shown below.

### DEFAULT VALUES OF COMMAND REGISTER 2

- Initial character address : C1 (0,0,0,1)



DS3	DS2	DS1	DS0	Initial character address
0	0	0	0	C <sub>0</sub>
0	0	0	1	C <sub>1</sub>
0	0	1	0	C <sub>2</sub>
0	0	1	1	C <sub>3</sub>
0	1	0	0	C <sub>4</sub>
0	1	0	1	C <sub>5</sub>
0	1	1	0	C <sub>6</sub>
0	1	1	1	C <sub>7</sub>
1	0	0	0	C <sub>8</sub>
1	0	0	1	C <sub>9</sub>
1	0	1	0	C <sub>10</sub>
1	0	1	1	C <sub>11</sub>
1	1	0	0	C <sub>12</sub>
1	1	0	1	C <sub>13</sub>
1	1	1	0	C <sub>14</sub>
1	1	1	1	Prohibited

## (4) DISPLAY SHIFT OPERATION

The display shift operation can be performed by changing the “Initial character address” of the “Command register 2”. And, the number of digits for the display shift in the loop is determined by the “Shifting display digits” of the “Command register 1”. In other words, shifting display area ranges from the “Initial character address” specified by the “Command register 2” to the last address designated by the “Command register 1”.

The default value of the “Initial character address” is  $C_1$  (0,0,0,1), as shown in the table of “Display data RAM”. In addition, supposing that the value of the “Shifting display digits” is “N”, the “Initial character address” must be set in the range between  $C_0$  and  $C_N$  in order not to exceed the digit “N”. Because the display shift operation doesn’t apply to the addresses beyond the range of the digit “N”, the display images, initially set, appear on these addresses. Just for reference, one character of display image is composed of 16 segments.

### HOW TO SET LEFT DISPLAY SHIFT

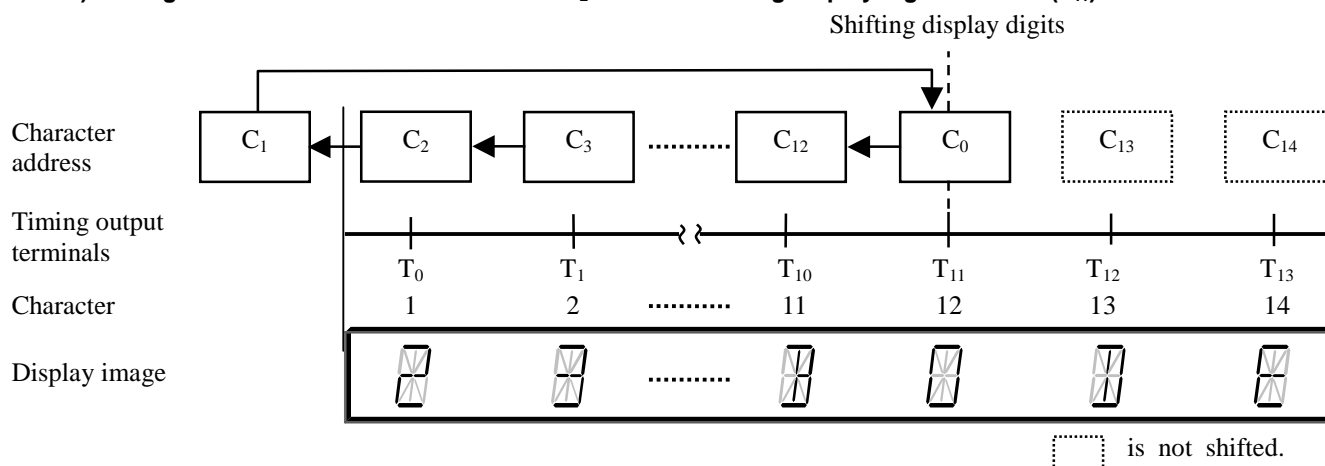
The left display shift is carried out by incrementing the “Initial character address” gradually like  $C_2, C_3, C_4, \dots, C_N$ . To the contrary, decrementing the address performs right display shift. The following description provides the example on how to set the left display shift, using alphanumeric display images such as “0”, “1”, “2”, ..., “9”, “A”, “B”, ..., and “E”.

#### STEP1) Setting display images in the display data RAM

- Display RAM data

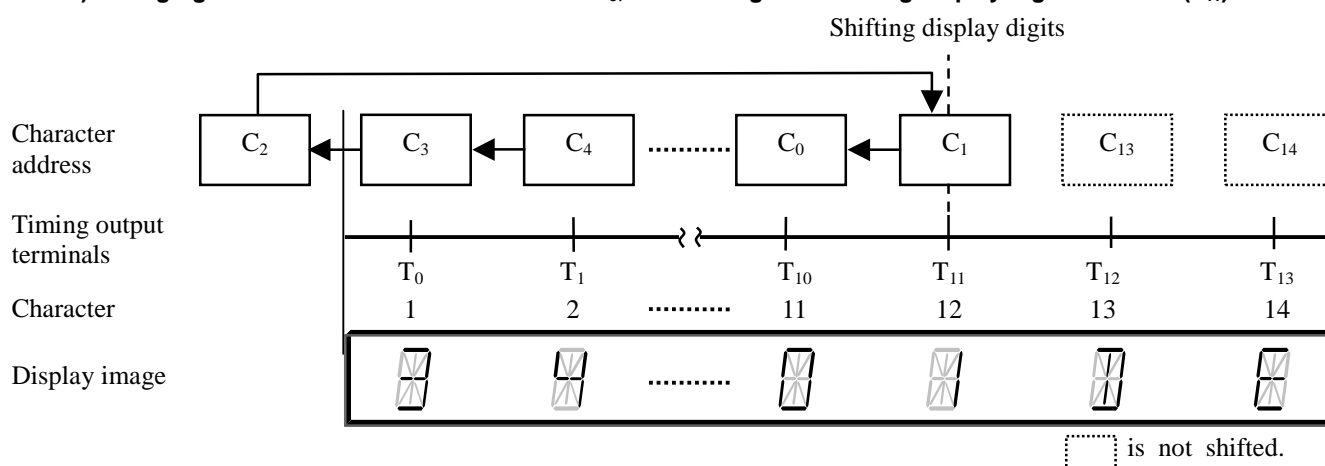
Character address	$C_0$	$C_1$	$C_2$	$C_3$	$C_4$	$C_5$	$C_6$	$C_7$	$C_8$	$C_9$	$C_{10}$	$C_{11}$	$C_{12}$	$C_{13}$	$C_{14}$
Display image	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E

#### STEP2) Setting the “Initial character address” to $C_2$ and the “Shifting display digits N” to 12 ( $T_{11}$ ).



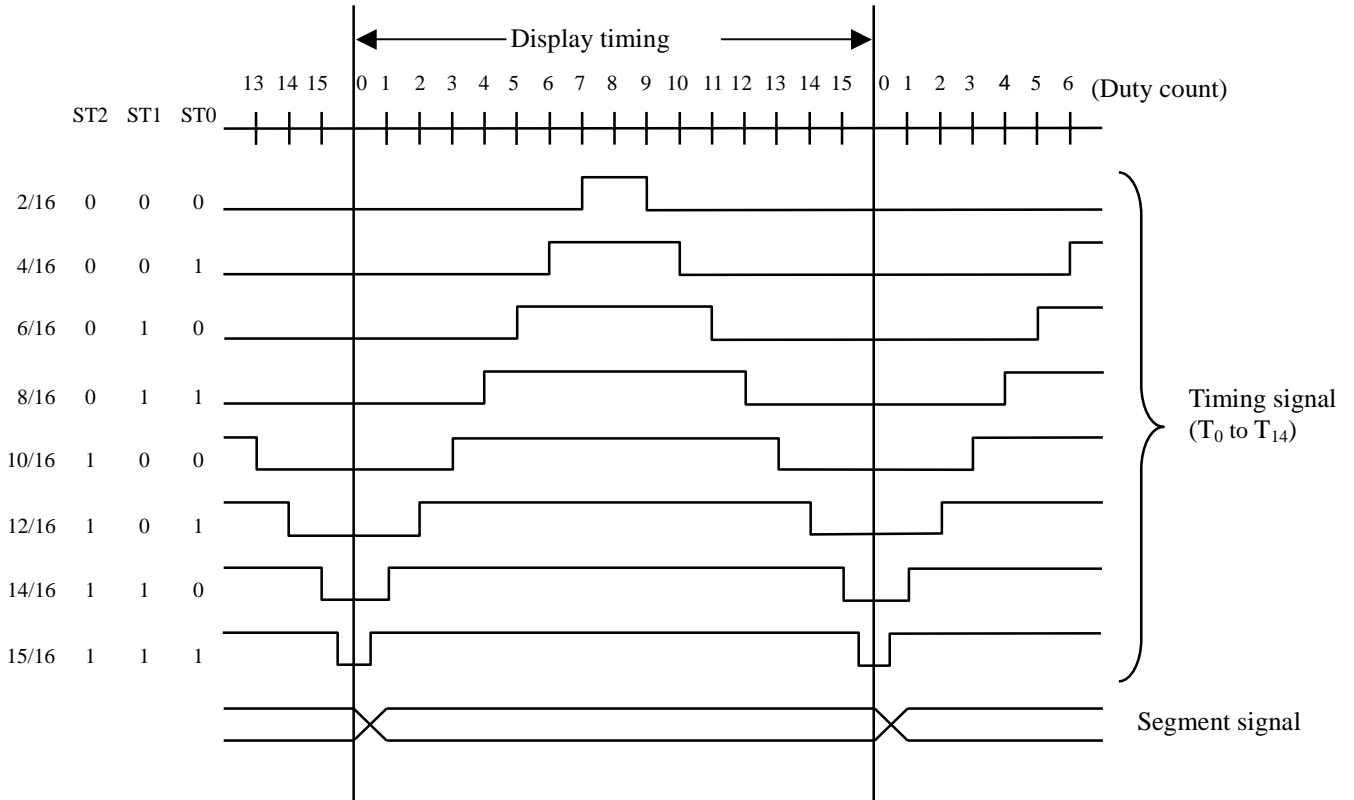
In this setting, the display images of “2”, “3”, ... appear on the  $T_0, T_1, T_2, \dots, T_{10}$  pins respectively, and the image “0” is on the  $T_{11}$  pin, which is assigned to the 12<sup>th</sup> character address. The display images “D” and “E” don’t shift but remain on the  $T_{12}$  and  $T_{13}$  pins, assigned to the 13<sup>th</sup> and 14<sup>th</sup> characters respectively, because their character addresses are outside of the digit “N”.

#### STEP3) Changing the “Initial character address” to $C_3$ , and leaving the “Shifting display digits N” as 12 ( $T_{11}$ ).

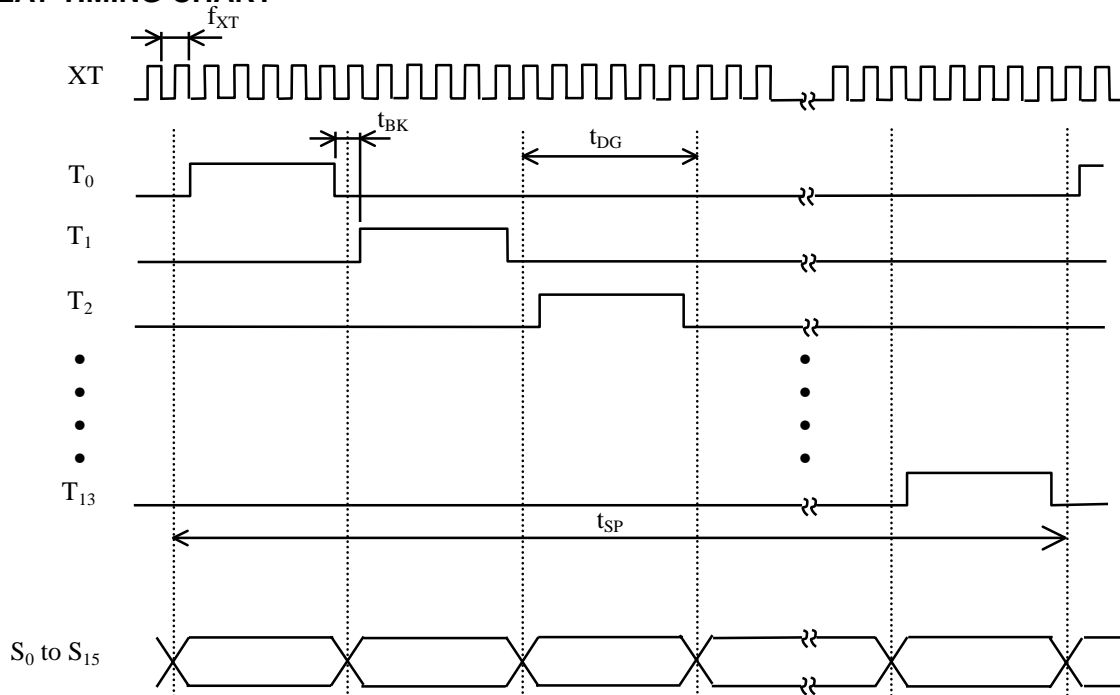


# NJU3426

## TIMING SIGNAL / DUTY-CHANGE WAVEFORM



## DISPLAY TIMING CHART

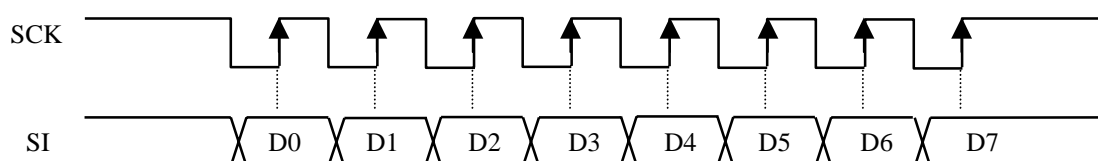


Oscillation frequency	: $f_{XT}$	: 800kHz to 3.5MHz
Minimum blanking time (duty15/16)	: $t_{BK} = (1/f_{XT}) \times 16 \times 2$	: 40 $\mu$ s to 9.2 $\mu$ s
1-character display time	: $t_{DG} = t_{BK} \times 16$	: 640 $\mu$ s to 147.2 $\mu$ s
1-cycle display time	: $t_{SP} = t_{DG} \times 14$	: 20.608ms to 8.96ms

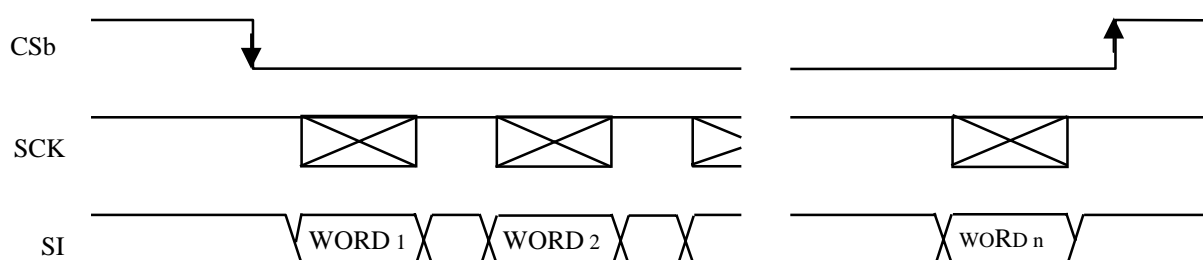
## (5) SERIAL DATA TRANSMISSION

Communication between the **NJU3426** and MPU uses the serial data transmission with synchronous clock, and 8 bits serial data constitutes 1 word. Each bit on the SI pin is fetched at the rising edge of the serial clock (SCK), and the entire 8 bits are loaded as 1 word at the rising edge of the chip select (CSb).

During one communication, multiple words can be transferred continuously. The 1<sup>st</sup> word must be either “Display data RAM address”, “Command register 1” or “Command register 2”. When the 1<sup>st</sup> word is RAM address data, the 2<sup>nd</sup> and ascending words must be display data. When it’s the “Command register 1 or 2”, the 2<sup>nd</sup> and ascending words are ignored.



**SERIAL DATA TIMING**



**SERIAL DATA TRANSMISSION FORMAT**

- Serial input data

### DATA FORMAT FOR THE 1<sup>ST</sup> WORD

#### DISPLAY DATA RAM ADDRESS

B7	B6	B5	B4	B3	B2	B1	B0
0	0	*	AD4	AD3	AD2	AD1	AD0

\*:don't care

#### COMMAND DATA 1

B7	B6	B5	B4	B3	B2	B1	B0
1	DT2	DT1	DT0	DSP	DE2	DE1	DE0

\*:don't care

#### COMMAND DATA 2

B7	B6	B5	B4	B3	B2	B1	B0
0	1	*	*	DS3	DS2	DS1	DS0

\*:don't care

### SERIAL DATA FOR THE 2<sup>ND</sup> AND ASCENDING WORDS

When the 1<sup>st</sup> word is the “Display data RAM address”, the 2<sup>nd</sup> and ascending words must be display data. When the 1<sup>st</sup> word is the “Command register 1 or 2”, the 2<sup>nd</sup> and ascending words are ignored.

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## ■ ABSOLUTE MAXIMAM RATINGS

( $V_{SS}=0V$ ,  $T_a=25^{\circ}C$ )

PARAMETER	SYMBOL	RATINGS	UNIT	CONDITIONS
Operation voltage	$V_{DD}$	-0.3 to +7.0	V	
Input voltage	$V_{IN}$	-0.3 to $V_{DD}+0.3$	V	
VFD driving voltage	$V_{FDP}$	$V_{DD}-45$ to $V_{DD}+0.3$	V	Relative to $V_{DD}$ .
“H” level output current	$I_{OH1}$	-15	mA	1 pin out of $S_0$ to $S_{15}$ pins
	$I_{OH2}$	-35	mA	1 pin out of $T_0$ to $T_{13}$ pins
“H” level Total output current	$\Sigma I_{OH}$	-100	mA	All output pins
“L” level output current	$I_{OL}$	20	mA	
“L” level Total output current	$\Sigma I_{OL}$	100	mA	All output pins
Operating temperature	$T_{opr}$	-40 to 85	$^{\circ}C$	
Storage temperature	$T_{stg}$	-55 to 125	$^{\circ}C$	
Power dissipation	PD	T.B.D.	mW	QFP

Note 1): The LSI must be used inside of the “Absolute maximum ratings”. Otherwise, an electrical or physical stress may cause permanent damage to the LSI.

Note 2): De-coupling capacitors for  $V_{DD}$  and  $V_{SS}$  and  $V_{FDP}$  and  $V_{SS}$  must be connected for stable operation.

Note 3): The following voltage relation must be maintained;  $V_{DD} > V_{SS} \geq V_{FDP}$ ,  $V_{SS}=0$ .



## ■ ELECTRICAL CHARACTERISTICS

• DC characteristics 1

( $V_{DD}=5.0V$ ,  $V_{SS}=0V$ ,  $T_a=-40$  to  $85^{\circ}C$ )

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNIT
Operating voltage	$V_{DD}$	$V_{DD}$ terminal	4.5		5.5	V
“H” level input voltage	$V_{IH}$	XT, RSTb, CSb, SCK, SI terminals	0.8 $V_{DD}$		0.2 $V_{DD}$	V
“L” level input voltage	$V_{IL}$					
Input off leak current	$I_{IZ}$	CSb, SCK, SI terminals $V_{DD}=5.5V$ , $V_I=0$ or $5.5V$			$\pm 1$	$\mu A$
Display output current	$I_{OH}$	$S_0$ to $S_{15}$ terminals	$V_{DD}=4.5V$ , $V_{FDP}=V_{DD}-40V$ , $V_{OH}=V_{DD}-2.5V$			mA
		$T_0$ to $T_{13}$ terminals				-15
Pull-Up resistance	$R_{UR}$	RSTb terminal, $T_a=25^{\circ}C$ $V_{DD}=5.0V$ , $V_I=V_{SS}$	140	200	260	k $\Omega$
Pull-down resistance	$R_{DST}$	$S_0$ to $S_{15}$ , $T_0$ to $T_{13}$ terminals, $T_a=25^{\circ}C$ $V_{DD}=5.0V$ , $V_I=V_{SS}$ , $V_{FDP}=V_{DD}-40V$	70	120	200	k $\Omega$
Display operating current	$I_{DD}$	$V_{FDP}$ terminal $V_{DD}=5.0V$ , $V_{FDP}=V_{DD}-40V$ , Ceramic resonator: 1MHz, All Segment/Timing output ON		10	15	mA

• DC characteristics 1

( $V_{DD}=5.0V$ ,  $V_{SS}=0V$ ,  $T_a=-40$  to  $85^{\circ}C$ )

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNIT
Operating oscillation frequency, External clock Input	$f_{XT}$ , $f_{CL}$	Fig. 1	0.8		3.5	MHz
External clock Input Rise time, Fall time	$t_{CLH}$ , $t_{CLL}$	Fig. 1			20	ns
Serial input data setup time	$t_{SIS}$	Fig. 2	60			ns
Serial input data hold time	$t_{SIH}$	Fig. 2	10			ns
Serial clock frequency	$f_{SCK}$	Fig. 3			1.5	MHz
Serial clock interval time	$t_{SCI}$	Fig. 3	10			$\mu s$
Reset pulse width	$t_{RSTb}$	Fig. 4	10			$\mu s$
Power rise time	$t_R$	Fig. 5	0.05		10	ms

# NJU3426

• DC characteristics 2

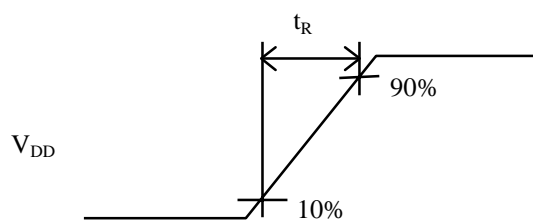
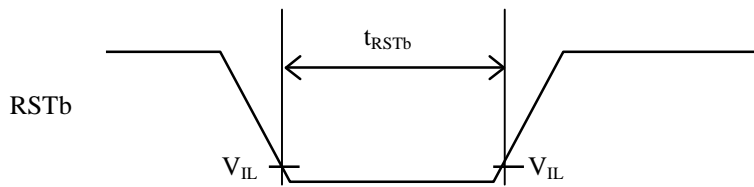
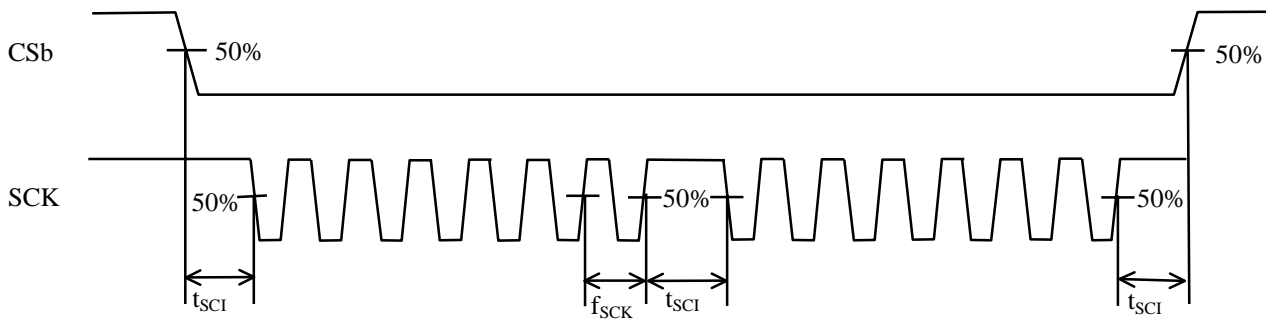
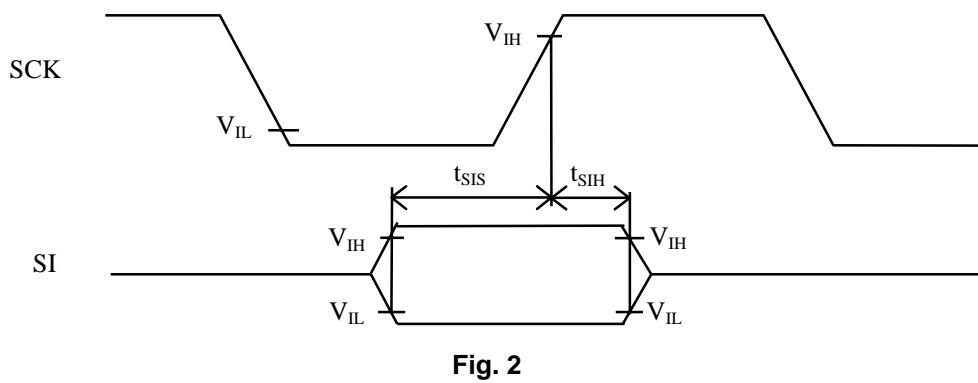
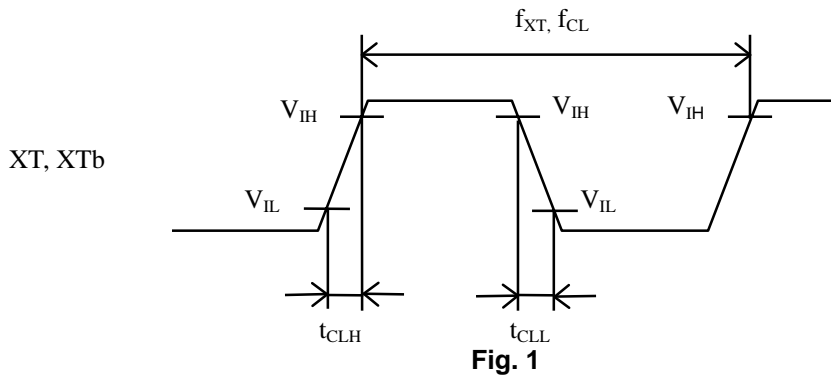
( $V_{DD}=3.3V$ ,  $V_{SS}=0V$ ,  $T_a=-40$  to  $85^{\circ}C$ )

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNIT
Operating voltage	$V_{DD}$	$V_{DD}$ terminal	3.0		3.6	V
“H” level input voltage	$V_{IH}$	XT, RSTb, CSb, SCK, SI terminals	0.8 $V_{DD}$		0.2 $V_{DD}$	V
“L” level input voltage	$V_{IL}$					
Input off leak current	$I_{IZ}$	CSb, SCK, SI terminals $V_{DD}=3.6V$ , $V_I=0$ or $3.6V$			$\pm 1$	$\mu A$
Display output current	$I_{OH}$	$S_0$ to $S_{15}$ terminals	-2.2			mA
		$T_0$ to $T_{13}$ terminals	-5.5			mA
Pull-Up resistance	$R_{UR}$	RSTb terminal, $T_a=25^{\circ}C$ $V_{DD}=3.0V$ , $V_I=V_{SS}$	140	200	260	k $\Omega$
Pull-down resistance	$R_{DST}$	$S_0$ to $S_{15}$ , $T_0$ to $T_{13}$ terminals, $T_a=25^{\circ}C$ $V_{DD}=3.0V$ , $V_I=V_{SS}$ , $V_{FDP}=V_{DD}-40V$	70	120	200	k $\Omega$
Display operating current	$I_{DD}$	$V_{FDP}$ terminal $V_{DD}=3.3V$ , $V_{FDP}=V_{DD}-40V$ , Ceramic resonator: 1MHz, All Segment/Timing output ON		10	15	mA

• AC characteristics 2

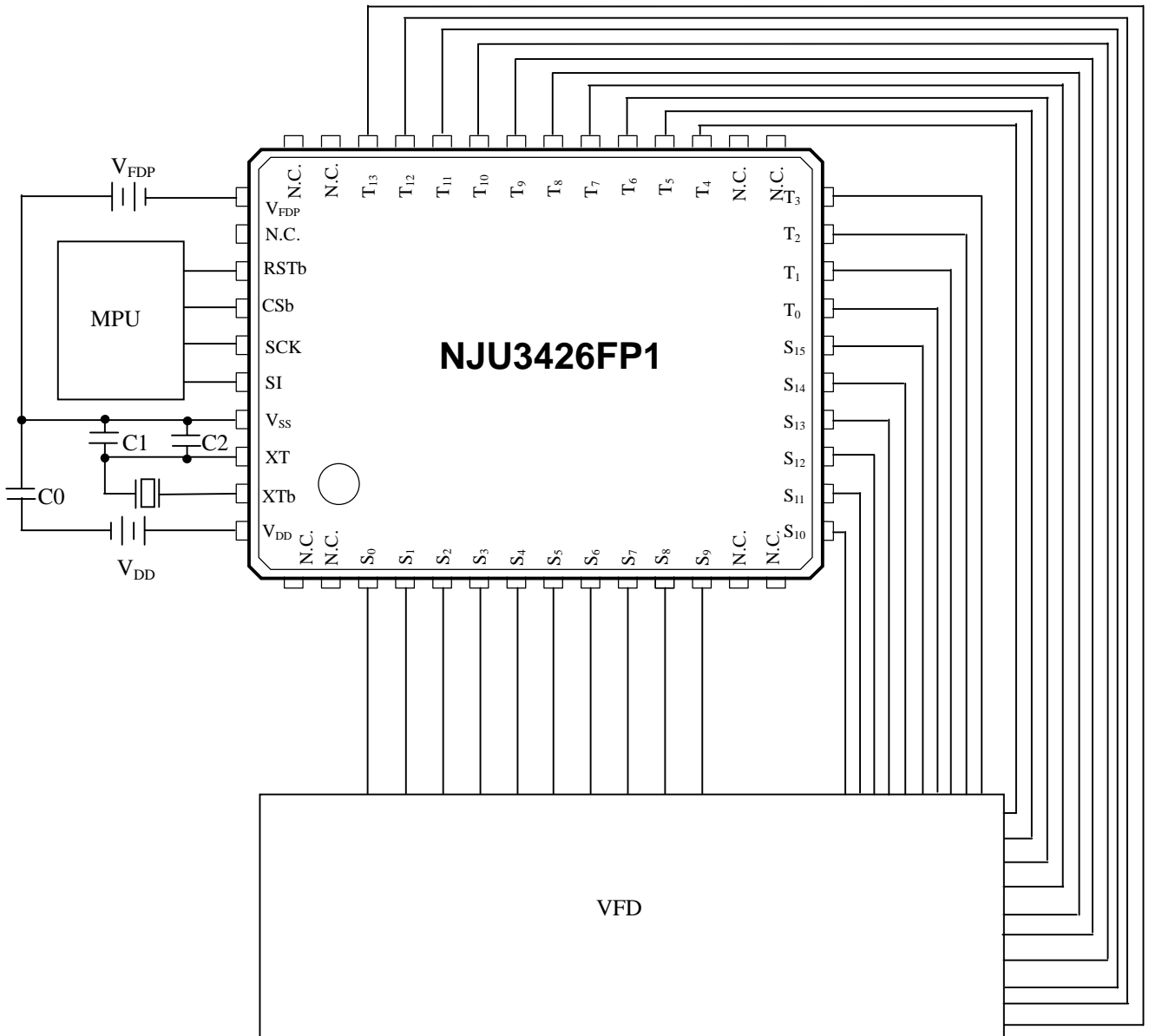
( $V_{DD}=3.3V$ ,  $V_{SS}=0V$ ,  $T_a=-40$  to  $85^{\circ}C$ )

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNIT
Operating oscillation frequency, External clock Input	$f_{XT}$ , $f_{CL}$	Fig. 1	0.8		2	MHz
External clock Input Rise time, Fall time	$t_{CLH}$ , $t_{CLL}$	Fig. 1			20	ns
Serial input data setup time	$t_{SIS}$	Fig. 2	120			ns
Serial input data hold time	$t_{SIH}$	Fig. 2	20			ns
Serial clock frequency	$f_{SCK}$	Fig. 3			0.8	MHz
Serial clock interval time	$t_{SCI}$	Fig. 3	10			$\mu s$
Reset pulse width	$t_{RSTb}$	Fig. 4	20			$\mu s$
Power rise time	$t_R$	Fig. 5	0.05		5	ms



# NJU3426

## ■ APPLICATION CIRCUIT



[CAUTION]  
 The specifications on this databook are only given for information, without any guarantee as regards either mistakes or omissions. The application circuits in this databook are described only to show representative usages of the product and not intended for the guarantee or permission of any right including the industrial rights.