PRELIMINARY

VFD CONTROLLER DRIVER

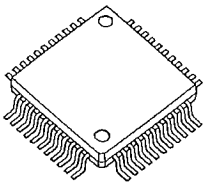
■ GENERAL DESCRIPTION

The **NJU3423** is a VFD (Vacuum Fluorescent Display) Controller Driver with key function.

It contains display data RAM, address counter, command register, high voltage drivers, and serial interface circuit.

The display data , the command data and the key scanning data can be transmitted with the serial interface, and VFD driving voltage is up to 45V. The **NJU3423** is useful for car audio,VCR and other VFD application items.

■ PACKAGE OUTLINE



NJU3423F

■ FEATURES

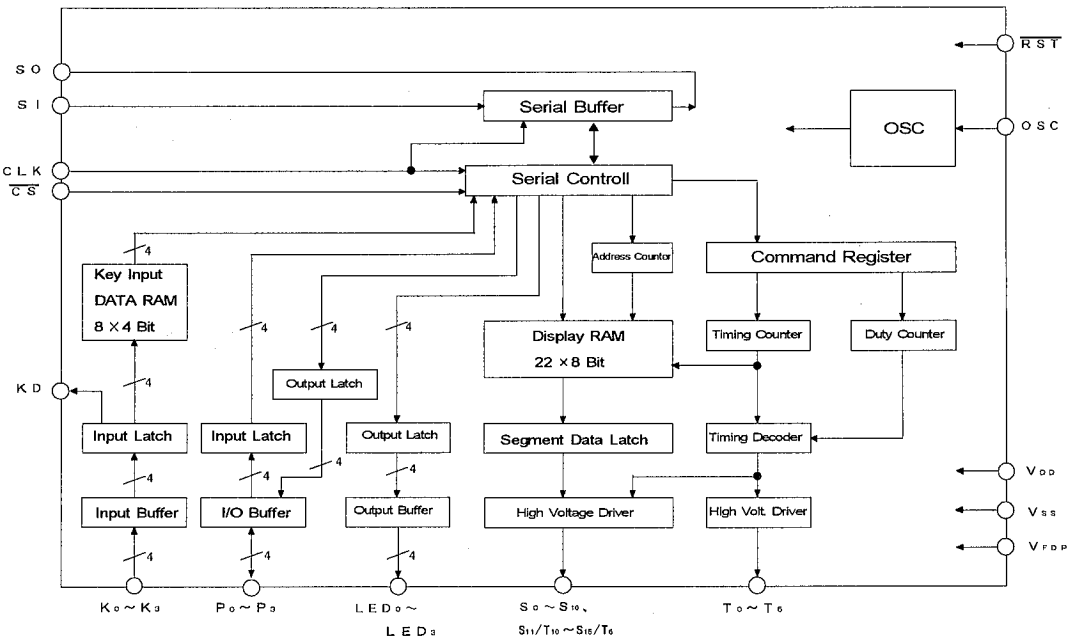
- VFD Driving Voltage $|V_{DD}-V_{FDP}|$ =45V
- Display Mode 11 Segments Display × 11 Digits
  16 Segments Display × 6 Digits
- Display ON/OFF Function
- Display Scan Function (Digit Signal)
- Display Data RAM 22 × 8 Bits
- Key Input Data RAM 8 × 4 Bits
- Key Scan Function 8 × 4 Key max.
- I/O Port (4 Ports)
- LED Driving Port(4 Ports)
- CR Oscillation Circuit on-chip (fosc=5.5MHz Typ)
- External CLK Terminal
- Serial Interface (8 Bit)
- Power On Initialization
- Operating Voltage 5V ± 10%
- Low Operating Current
- C-MOS Technology
- Package Outline QFP 44

■ VERSION

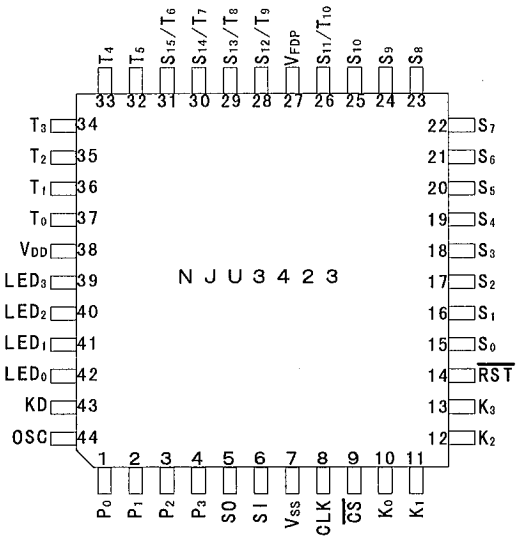
VERSION	$\overline{\text{RESET}}$ TERMINAL	KEY INPUT DETECT TERMINAL
NJU3423	HAVE	HAVE
NJU3423A	NO	NO

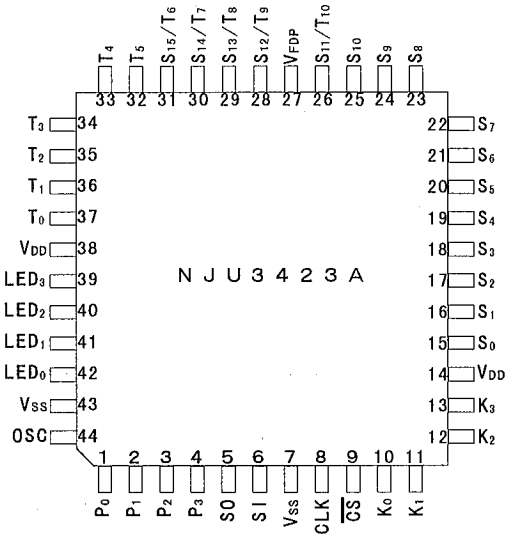
NOTE: Refer to the Pin Configuration

■ BLOCK DIAGRAM



■ PIN CONFIGURATION





■ TERMINAL DESCRIPTION

NO.		SYNBOL	FUNCTION
NJU3423	NJU3423A		
38	14,38	V_{DD}	POWER SOURCE 5 V
7	7,43	V_{SS}	GND 0 V
27	27	V_{FDP}	VFD Driving Voltage V_{DD}-45V
44	44	OSC	External CLK Terminal.(Normaly Open)
10～13	10～13	K_0～K_3	Key Input Terminals.(Pull-Down Resistance)
43	—	KD	Key Input Detection Teaminal. When Key is input, "H" level is output from this terminal.
15～25	15～25	S_0～S_{10}	Segment Output Terminals. (Pull-Down Resistance)
26 28～31	26 28～31	S_{11}/T_{10} S_{12}/T_9～ S_{15}/T_6	Segment/Timing Output Terminals.(Pull-Down Resistance)
32～37	32～37	T_5～T_0	Timing Output Terminals.(Pull-Down Resistance)
14	—	$\overline{RST}$	Reset Terminal(Pull-Up Resistance) RESET operation requires "L" levell over than 10 μS
1～4	1～4	P_0～P_3	I/O Ports(Pull-Up Resistance)
5	5	S0	Serial Data Output Terminal.(8-Bit / Word) Keyscan data (Port,Key data)are output from this terminal.
6	6	SI	Serial Data Input Terminal.(8-Bit / Word) Address, I/O Ports, Command, Display
8	8	CLK	Shift Clock Input Terminal.
9	9	$\overline{CS}$	Chip Select Input Terminal. Active "L".
39～42	39～42	LED_3 ～LED_0	Output Port Terminal. It can drive LED directly.

■ TABLE OF INSTRUCTIONS

INSTRUCTIONS	CODE								DESCRIPTION
	B7	B6	B5	B4	B3	B2	B1	B0	
Reset	0	0	1	1	1	1	0	1	Resets the system excepting for RAM.
Address Set	0	0	0	AD4	AD3	AD2	AD1	AD0	Sets DD RAM address. The data(15_H to 00_H) into address (AD4 to AD0).
Write Data to DDRAM	S7	S6	S5	S4	S3	S2	S1	S0	Sets Display Data. The data must be set continuously after the address set.
Function Set	1	DT2	DT1	DT0	DSP	TM2	TM1	TM0	Sets Duty Ratio(DT2～0), Disp.ON/OFF(DSP) and Display Digit(TM2～TM0).
Write Data and Input Control to I/O Port	0	1	0	0	D3	D2	D1	D0	Sets I/O Output Data. When the output data selected "H",Input port can use active "L".
Write Data to LED Port	0	1	1	0	LED3	LED2	LED1	LED0	Output Control of LED_0 to LED_3.
Read Data from I/O Port and Key Input Data	P3	P2	P1	P0	K3	K2	K1	K0	When the I/O port data selected "H". Upper 4bit:Port data Lower 4bit:Key data

■ DESCRIPTION OF EACH INSTRUCTIONS

(1) Reset Circuit

"Reset" operates the initialization by the following instruction and the condition of control logic circuits in the IC is kept during "CS" is low.

RESET

B7	B6	B5	B4	B3	B2	B1	B0
0	0	1	1	1	1	0	1

Reset by RST terminal and Power on reset are operated as same as the instruction reset. The condition of output terminals and registers are shown in bellow after reset operation.

・Initialization

① Display Off
② Display Mode:16-Segment/6-Character
③ Duty Ratio :2/16
④ Clear the Key Input Latch
⑤ Clear the I/O Port Latch
⑥ All I/O Port Output:"H"
⑦ All LED Port Output:"H"
⑧ Clear the serial buffer
⑨ Clear the Address Counter
⑩ Clear the Timing Counter
⑪ Clear the Duty Counter
⑫ Clear the Command Register

NOTE) DD RAM and Key Input RAM are not cleared.

(2) Address Counter

The address counter addresses the area of display data RAM to store the display data from the serial interface.

When the first word of the serial data is recognized as the address of the display data RAM(The upper three bits of a byte must be "0".), the lower 5bits are set into the address counter.

The display data, which are input sequentially after the address code are set into the addressed area of display data RAM and the address counter is incremented automatically for next data.

Though the address counter consists of the 5-bit counter, the effective range is from "00000"(00H) to "10101"(15H) and the invalid range is from "10110"(16H) to "11111"(1FH).

The next address of "10101"(15H) is "00000"(00H) with automatic increment operation.

The Address Data

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

The mapping of the display data RAM

	B7	B6	B5	B4	B3	B2	B1	B0		B7	B6	B5	B4	B3	B2	B1	B0	
00H									01H									T0
02H									03H									T1
04H									05H									T2
06H									07H									T3
08H									09H									T4
0AH									0BH									T5
0CH									0DH									T6
0EH									0FH									T7
10H									11H									T8
12H									13H									T9
14H									15H									T10
	S7	S6	S5	S4	S3	S2	S1	S0		S15	S14	S13	S12	S11	S10	S9	S8	

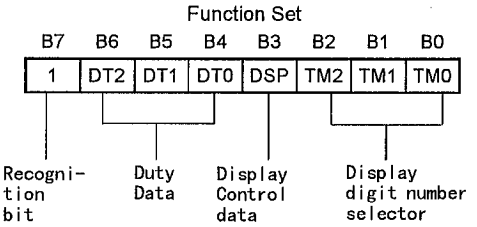
(3) COMMAND REGISTER

The Command Register is the register for function set of Display Duty, DisplayDigit Number and Display ON/OFF.

When the first word of serial transmitted data is "1", the lower 7bits are set into the commandregister.

The Display digit number selector effective range is from "000"(00H) to "101"(05H) and the invalid range is from "110"(06H) and "111"(07H).

The default condition of the display mode is display-off by the power on initialization.



(2-1) Duy set

DT2	DT1	DT0	Timing signal Duty
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

(2-2) Display control set

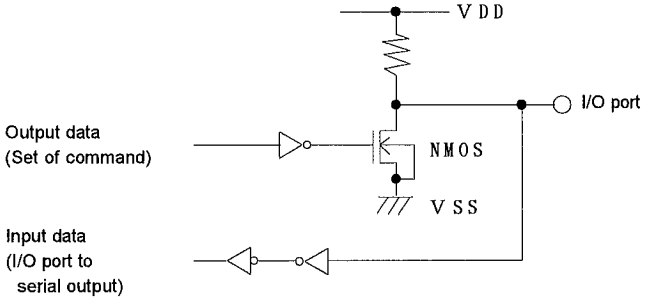
DSP	Display
0	OFF
1	ON

(2-3) Display digit number set

TM2	TM1	TM0	Digits
0	0	0	6
0	0	1	7
0	1	0	8
0	1	1	9
1	0	0	10
1	0	1	11
1	1	0	No use
1	1	1	No use

(4) I/O Port, LED Driving Port

The NJU3423 incorporates four I/O ports and four LED driver ports. I/O ports are constructed by the N-channel open-drain type FET with the pull-up resistor. When the output data is set into D3 ~ D0, these I/O ports can be used as the output terminal. In case of input mode "H" level must be set into D3 ~ D0, then these I/O ports can be used as the input terminal with pull-up resistor. The P3 ~ P0 data of input or output is transferred to the MPU with Key Input Data (K3 ~ K0), by the serial interface. When the power supply is turned on, the output data is "H". And the data is hold until the next data is transferred.



I/O port terminal

Each Terminals Instructions is shown below.

I/O port, Output data

B7	B6	B5	B4	B3	B2	B1	B0
0	1	0	0	D3	D2	D1	D0

Recognition data　　Output data

LED port, Output data

B7	B6	B5	B4	B3	B2	B1	B0
0	1	1	0	LED3	LED2	LED1	LED0

Recognition data　　Output data

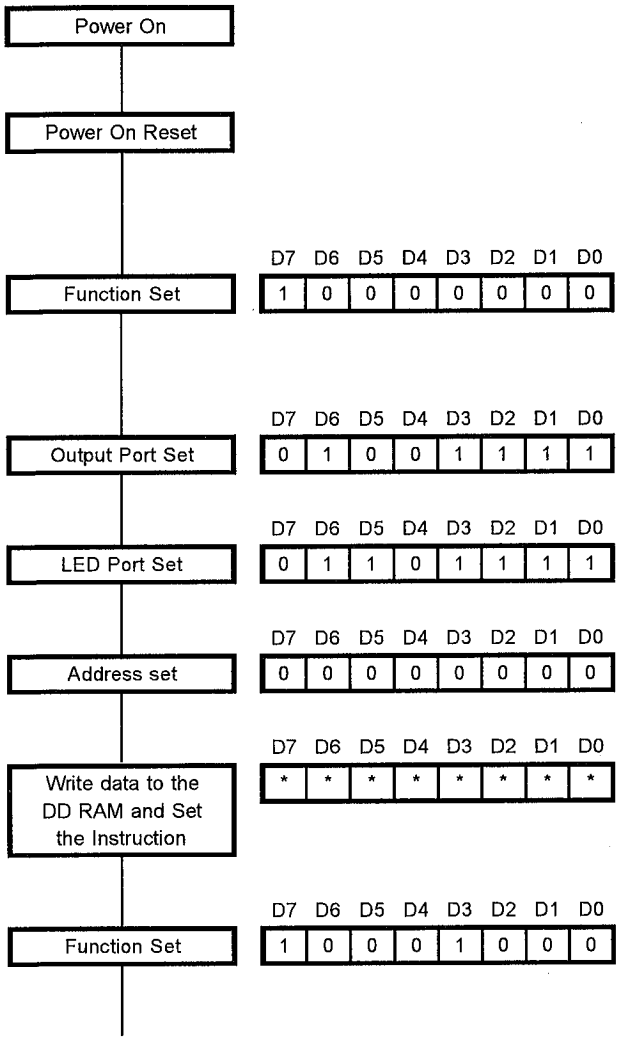
Serial port, Output data

B7	B6	B5	B4	B3	B2	B1	B0
P3	P2	P1	P0	K3	K2	K1	K0

I/O port data　　Key Input data

(4-1) INITIALIZATION

Initialization flow is shown below:



The Input voltage should be 4.5 to 5.5V between V_{DD} and V_{SS} terminal.

When the "L" level over than 10 μ S is input to the $\overline{RST}$ terminal, all system are initialized and the following initial procedure are executed.

Display Off
Display Mode:16-Segment/6-Character
Duty Ratio :2/16

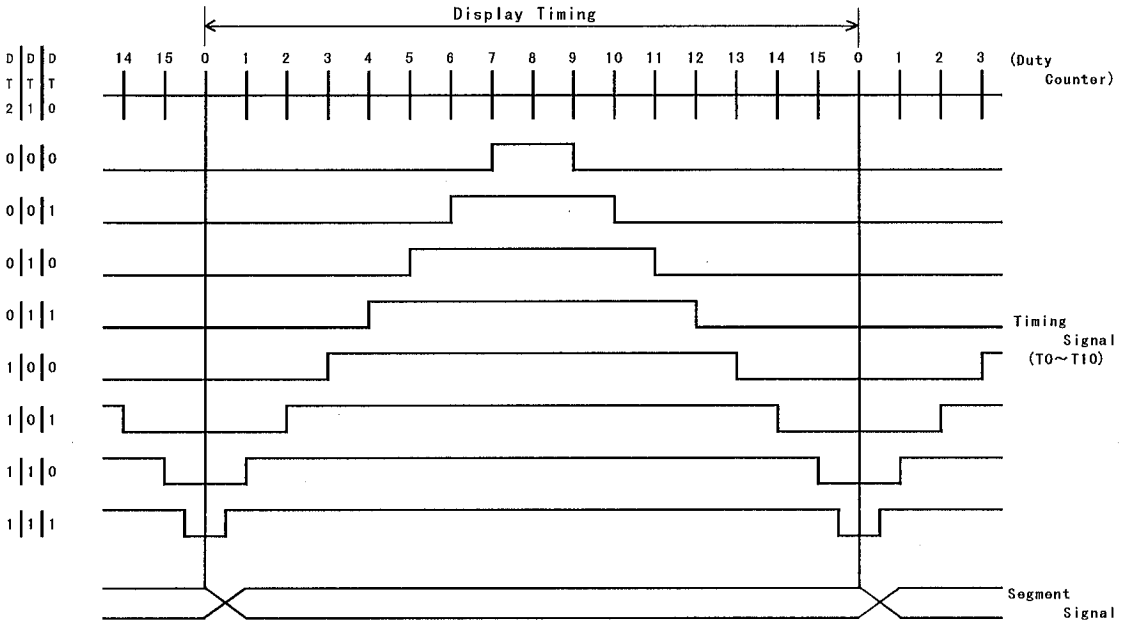
I/O Port Output:"H"

LED Port Output:"H"

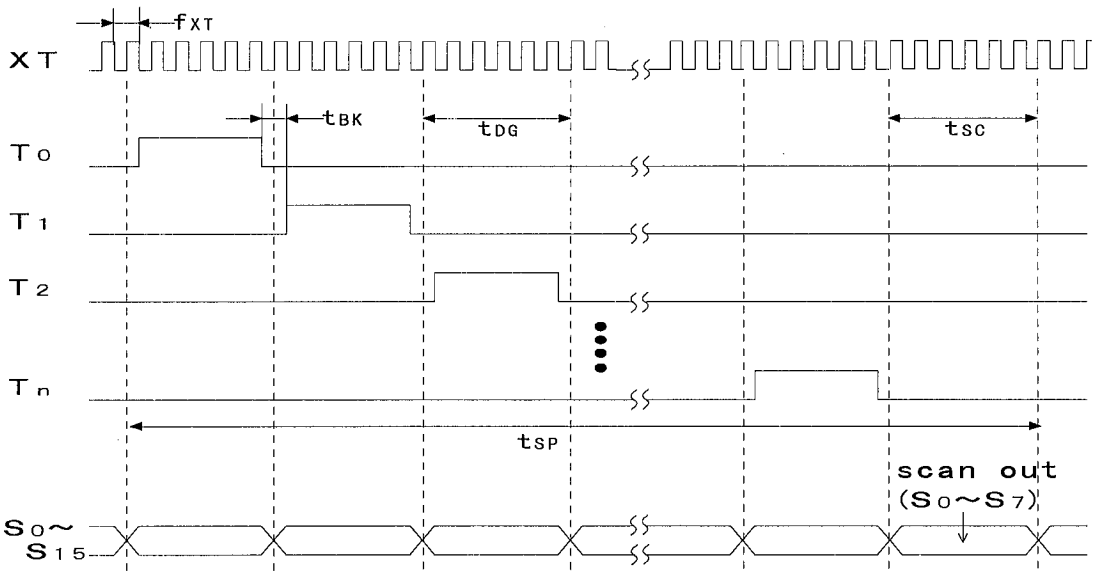
Address Set:"00H"

Display On
Display Mode:16-Segment/6-Character
Duty Ratio :2/16

■ TIMING SIGNAL / DUTY CHANGE WAVEFORM



■ DISPLAY TIMING CHART



Oscillation frequency	:f_{XT}
Minimum blanking time (Duty 15/16)	:$t_{BK}=(1/f_{XT}) \times 96$
1character display time	:$t_{DG}=t_{BK} \times 16$
Key scanning time	:$t_{SC}=t_{DG}$
1cycle display time	:$t_{SP}=t_{DG} \times$ character + t_{SC}

(5) KEY INPUT CIRCUIT

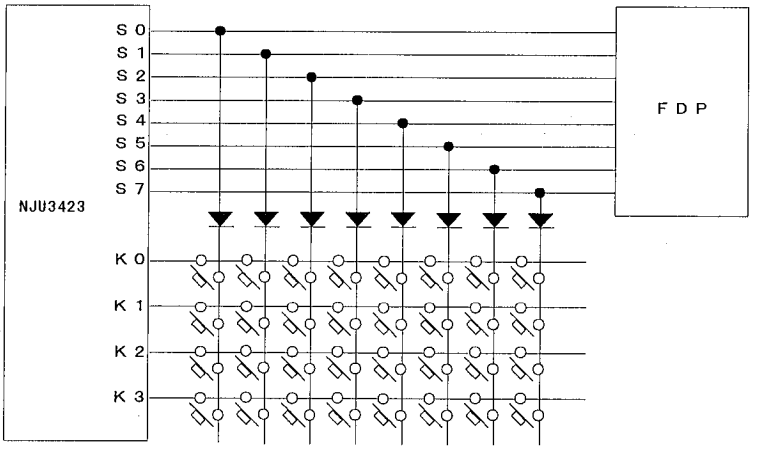
The key input circuit uses 8 terminals of the display segment output for key scanning and the key data are read from 4 input terminals (K0 ~ K3) on the each scanning timing. Then the key data are stored into the key input data RAM, and transmitted to MPU in serial transmission.

The condition of key input terminals are normally "L" and they go to "H" is the key on.

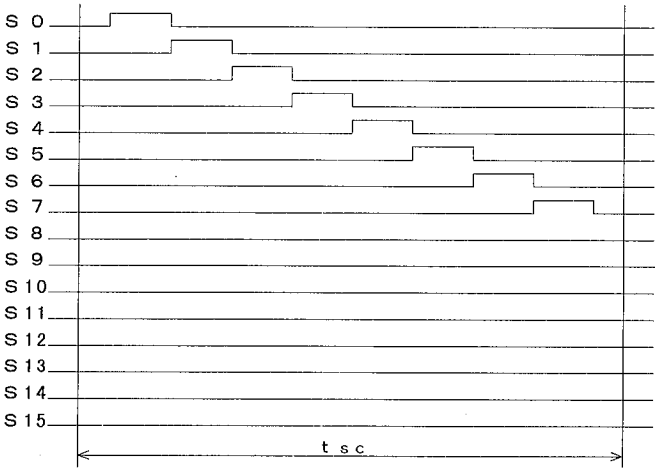
The key input detector function outputs "H" level during key is on at key scan.

(5-1) key condition vs key input terminal level

key condition	input level
key pushed	"H"
not key pushed	"L"



key matrix



key scan wave form

(6) SERIAL DATA TRANSMISSION

The NJU3423 provides the serial interface to communicate with external circuit. This interface circuit requires the external shift clock input and can operate the bi-directional (input/output) transmission synchronizing with clock.

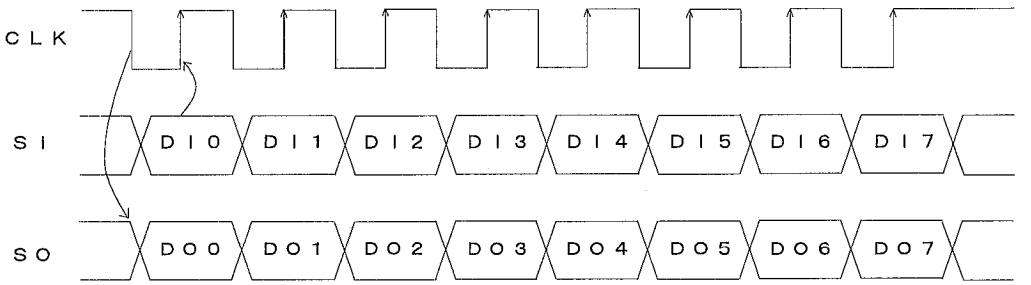
The serial data are grouped as a word which equals to byte(8 bits)for this device. The serial interface circuit is activated when the CS terminal is set to "L" level. While the CS is "L", the words of the serial data can be transmitted synchronizing the shift Clock (the CLK terminal) with the serial data input or output(the SI or SO terminal).

On the data input mode, the first transmitted word must be the address,the command or the I/O port output data. When the first word is the address data, the next words are the display data. When the first word is the command or I/O port output data, the next words are ineffective.

On the data output mode, the transmitted word consists of the key data in the lower 4 bits and the I/O port input data in the upper 4 bits (The MSB is invalid). The key data of the first word is the data by SO scanning, the second word is the data by S1,--- finally scanning, the 8th word means the data by S7 scanning. The I/O port input data means the last status data.For getting all key matrix data(8 X 4 max.),the data transmission of the 8 words is required.

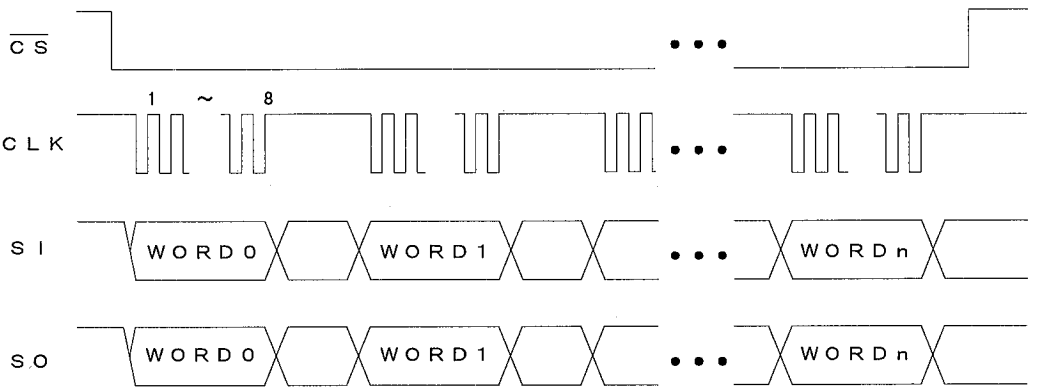
When the key data transmission is stopped at less than 8 words, the new key data transmission is start to read from the first (S0 scanning) word.

■ CLK and SI/SO TIMING CHART



Serial buffer shift timing

■ SERIAL TRANSMISSION FORMAT



(6-1) SERIAL INPUT DATA

WORD 0

The address data

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

The I/O port output data

B7	B6	B5	B4	B3	B2	B1	B0
0	1	0	0	D3	D2	D1	D0

The LED port output data

B7	B6	B5	B4	B3	B2	B1	B0
0	1	1	0	LED3	LED2	LED1	LED0

The command data

B7	B6	B5	B4	B3	B2	B1	B0
1	DT2	DT1	DT0	DSP	TM2	TM1	TM0

The RESET data

B7	B6	B5	B4	B3	B2	B1	B0
0	0	1	1	1	1	0	1

WORD 1 ~ n Display data are required when WORD 0 = address data
Any data are become ineffective when WORD 0 = not address data

(6-2) SERIAL OUTPUT DATA

WORD 0 ~ 7 (Key scan data)

Serial output data

B7	B6	B5	B4	B3	B2	B1	B0
P3	P2	P1	P0	K3	K2	K1	K0

WORD 8 ~ n Ineffective data

■ ABSOLUTE MAXIMUM RATINGS

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

PARAMETER	SYM.	RATING	UNIT	CONDITIONS
Operating Voltage	V_{DD}	-0.3～+7.0	V	
Input Voltage	V_{IN}	-0.3～V_{DD}+0.3	V	
Output Voltage	V_{OUT}	-0.3～V_{DD}+0.3	V	
VFD Driving Voltage	V_{FDP}	V_{DD}-45～V_{DD}+0.3	V	Specified as V_{DD}.
"H"level Output Current	I_{OH}	-5	mA	For a terminal except the display terminals
	I_{ODH1}	-15	mA	For a terminal, S_0～S_7 terminals only
	I_{ODH2}	-35	mA	For aterminal, T_0～T_5, T_6/S_{15}～T_{10}/S_{11} Terminals only
"H" level Total Output Current	ΣI_{OH}	-40	mA	Sum of the output terminal except the display Terminals
	ΣI_{ODH}	-100	mA	Sum of the display Terminals
"L"level Output Current	I_{OLC}	20	mA	For a terminal, LED_0～LED_3 Terminals only
"L"level Total Output Current	ΣI_{OL}	100	mA	Sum of the Output Terminals
Operating Temprature Range	T_{opr}	-30～+80	°C	
Storage Temprature Range	T_{stg}	-55～+125	°C	
Power Dissipation	P_D	300	mW	QFP-44 Package

Note) Decoupling capacitor should be connected between V_{DD} and V_{SS}, V_{FDP} and V_{SS}.

■ ELECTRICAL CHARACTERISTICS

(Ta=25°C, V_{SS}=0V)

PARAMETER	SYM.	CONDITIONS		MIN.	TYP.	MAX.	UNIT
Operating Voltage	V_{DD}	V_{DD} Terminal		4.5	-	5.5	V
"H"level Input Voltage	V_{IH1}	OSC, $\overline{RST}$, $\overline{CS}$, CLK, SI, P_0～P_3 Term.		0.8V_{DD}			V
	V_{IH2}	K_0～K_3 Terminal		0.4V_{DD}			V
"L"level Input Voltage	V_{IL1}	OSC, $\overline{RST}$, $\overline{CS}$, CLK, SI, P_0～P_3 Term.				0.2V_{DD}	V
	V_{IL2}	K_0～K_3 Terminal				0.16V_{DD}	V
"H"level Output Voltage	V_{OH1}	KD, S0 Terminal	V_{DD}=4.5V, I_{OH1}=-0.5mA	4.0			V
	V_{OH2}		V_{DD}=4.5V, I_{OH2}=-1.2mA	3.5			V
"L"level Output Voltage	V_{OL1}	KD, S0, P_0～P_3 Terminal	V_{DD}=4.5V, I_{OL1}= 1.8mA			0.4	V
	V_{OL2}		V_{DD}=4.5V, I_{OL2}= 3.6mA			0.6	V
	V_{OL3}	LED_0～LED_3 Term.	V_{DD}=4.5V, I_{OL3}= 10mA			0.4	V
Input Off Leak Current	I_{IZ}	$\overline{CS}$, CLK, SI Term.	V_{DD}=5.5V, V_I=0 or 5.5V			±1	μA
Display Output Current	I_{OH1}	S_0～S_{10} Term.	V_{DD}=4.5V, V_{OH}=V_{DD}-2.5V	-7			mA
	I_{OH2}	S_{11}/T_{10}～S_{15}/T_6, T_0～T_5 Terminal		-15			mA
Pull-up resistance	R_{UR}	$\overline{RST}$ Terminal	V_{DD}=5.0V, V_I=V_{SS}	140		260	KΩ
	R_{UP}	LED_0～LED_3, P_0～P_3 Terminal	V_{DD}=5.0V, V_I=V_{SS}	10		20	KΩ
Pull-Down resistance	R_{DK}	K_0～K_3 Terminal	V_{DD}=5.0V, V_I=V_{DD}	20		50	KΩ
	R_{DST}	S_{11}/T_{10}～S_{15}/T_6, T_0～T_5, S_0～S_{10} Terminal	V_{DD}=5.0V, V_O=V_{DD}, V_{FDP}=V_{DD}-40V	70		200	KΩ
Logic Operating Currrent	I_{DD1}	V_{SS} Terminal	V_{DD}=5.0V, CR Oscillation, Output Open, K_0～K_3, P_0～P_3 $\overline{RST}$ Term. Open, All Segment or Timing Output is OFF		2	4	mA
Display Operating Current	I_{DD2}	V_{FDP} Terminal	V_{DD}=5.0V, V_{FDP}=V_{DD}-40V Output Open except S_{11}/T_{10}～S_{15}/T_6, T_0～T_5, S_0～S_{10}, All Segment or Timing Output is ON		7	10	mA

■ AC Characteristics (Ta=25°C, V_{DD}=4.5V～5.5V, V_{SS}=0V)

PARAMETER	SYM.	CONDITION	MIN.	TYP.	MAX.	UNIT
Oscillation Frequency External Frequency	f_{CR}	Fig.1	3	5.5	8	MHz
External Clock Rise / Fall Time	t_{CLH} t_{CLL}	Fig.1			20	ns
Serial Input Setup Time	t_{SIS}	Fig.2	60			ns
Serial Input Hold Time	t_{SIH}	Fig.2	10			ns
Seral Output Delay Time	t_{SOD}	Fig.2 Load=50pF			120	ns
Shift Clock Frequency	f_{CLK}	Fig.3			f_{CR}/3	MHz
Shift Clock Interval Time	t_{CLK1}	Fig.3	10			μs
Minimum Blanking Time	t_{BK}	Fig.4 @f_{CR}=4MHz	20		30	μs
"L" level Time	t_{KSL}	Fig.5 @f_{CR}=4MHz, Key scan	20			μs
"H" level Time	t_{KST}	Fig.5 @f_{CR}=4MHz, Key scan	20		30	μs
Reset Pulse Width	t_{RST}		10			μs
Power Rise Time	t_R	Fig.6	0.05		50	ms

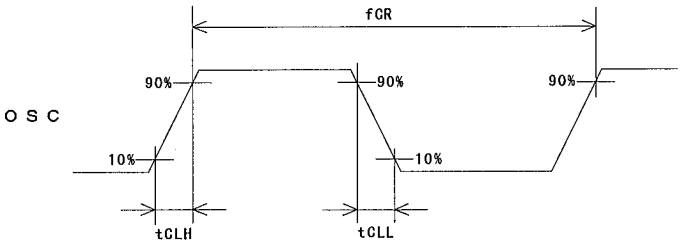


Fig.1

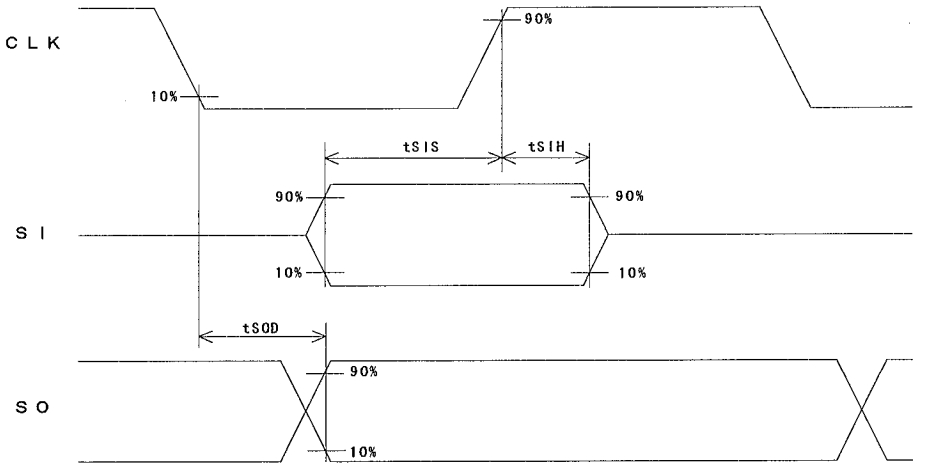


Fig.2

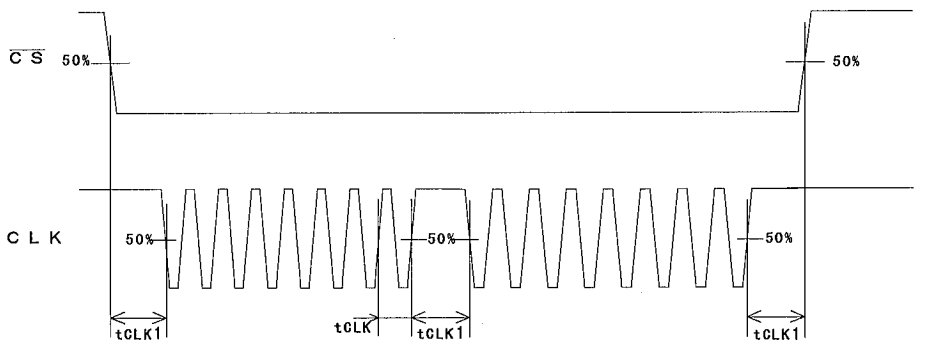


Fig.3

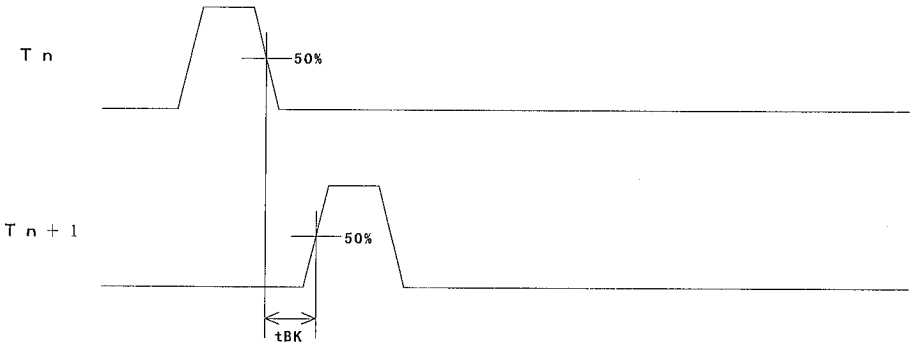


Fig.4

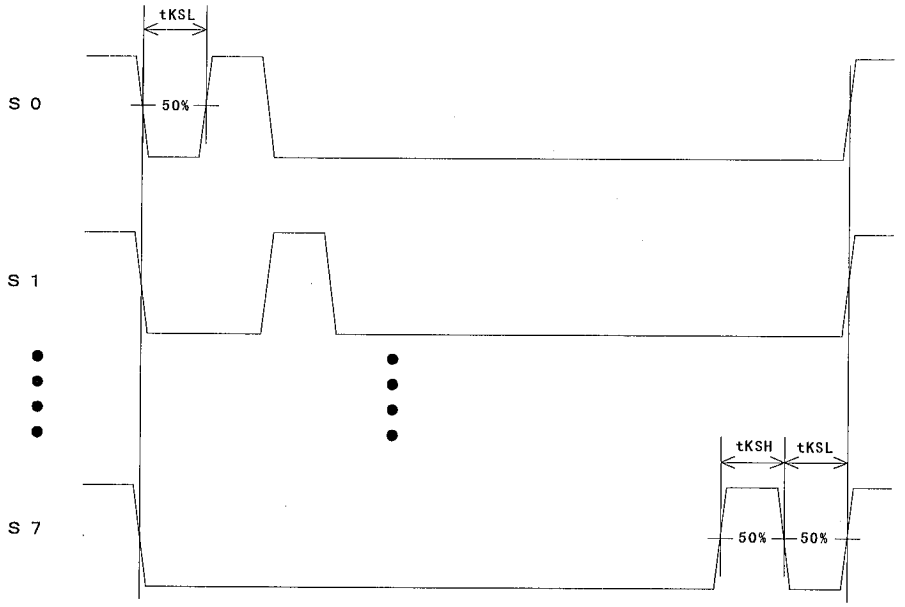


Fig.5

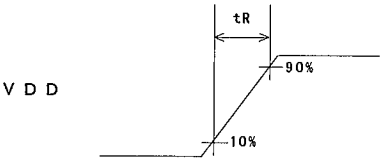
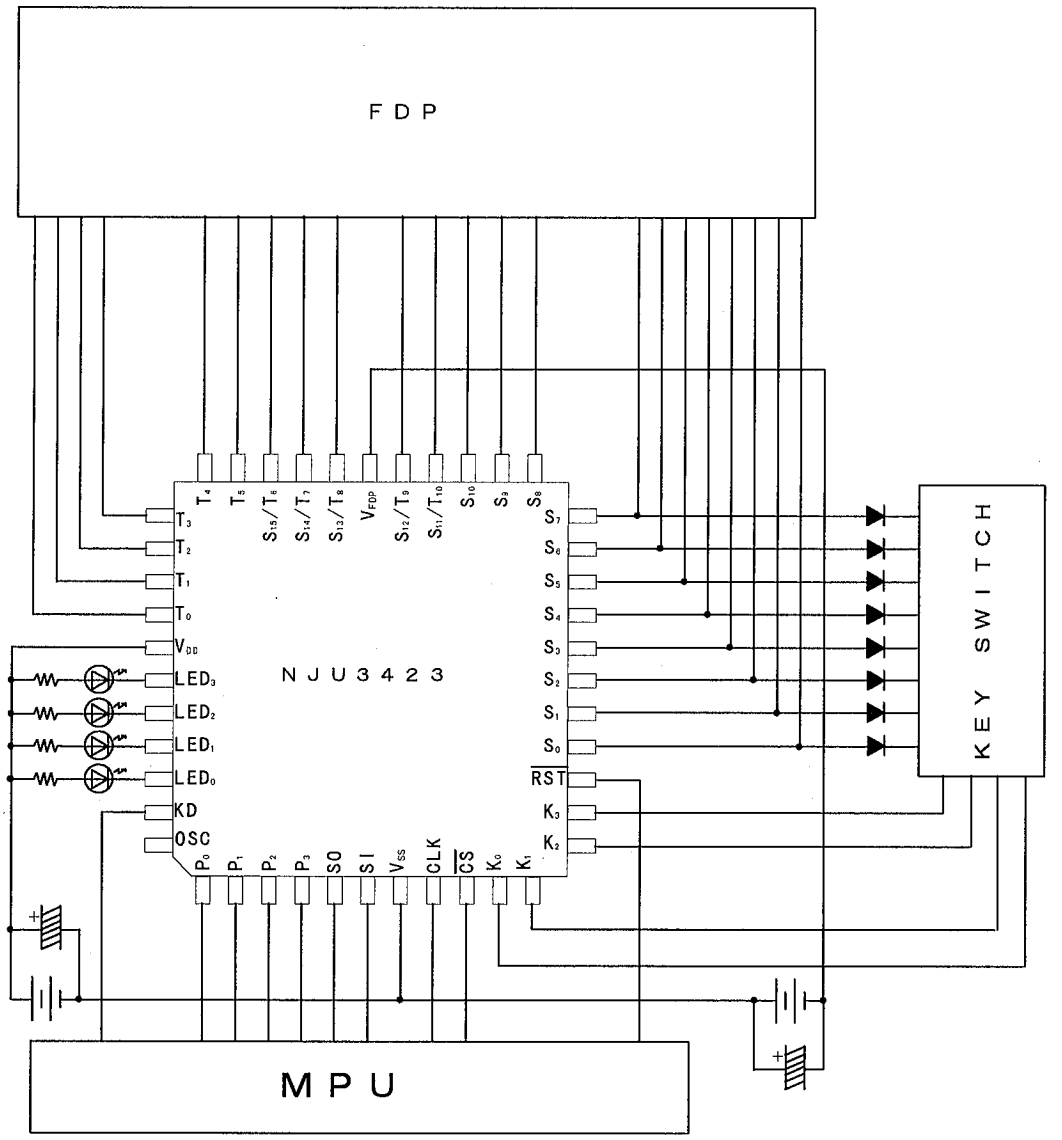


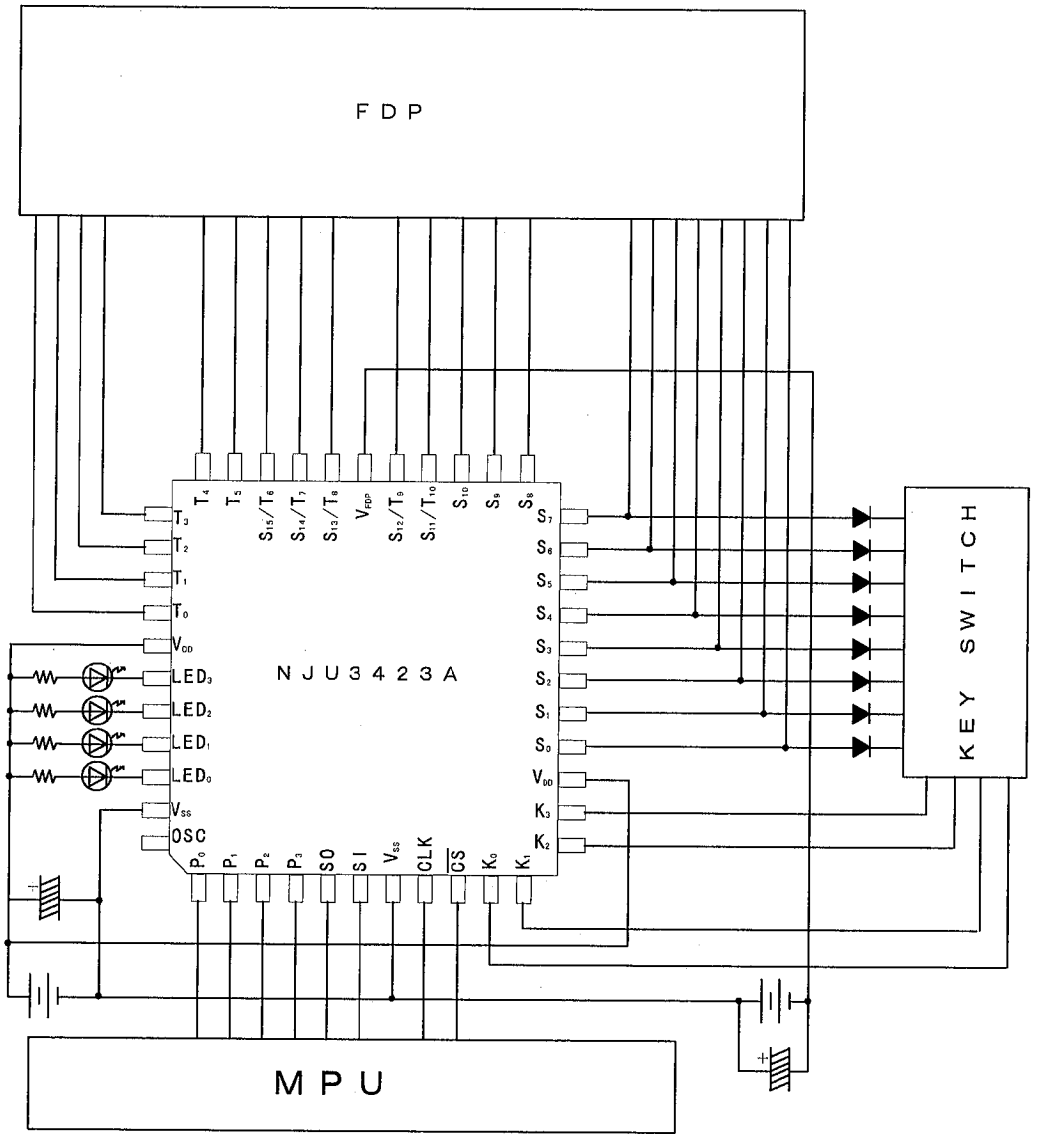
Fig.6

■ APPLICATION CIRCUIT

(1) NJU3423



(2) NJU3423A


FDP
NJU3423A
KEY SWITCH
MPU
T4
T5
S15/T6
S14/T7
S13/T8
VFDP
S12/T9
S11/T10
S10
S9
S8
T3
T2
T1
T0
VDD
LED3
LED2
LED1
LED0
VSS
OSC
P0
P1
P2
P3
SO
SI
VSS
CLK
CS
K0
K1
S7
S6
S5
S4
S3
S2
S1
S0
VDD
K3
K2

MEMO