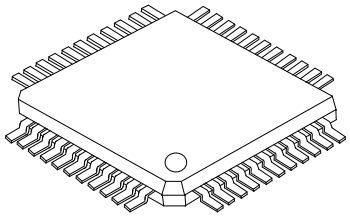
# UL319

*LINEAR INTEGRATED CIRCUIT*

# SERIAL-INTERFACED 16-DIGIT LED CONTROLLER IC WITH KEYSCAN



QFP-44(10×10)

## ■ DESCRIPTION

The **UL319** is a compact LED controller and driver that interface microprocessors to LED displays through a serial 4-wire interface. It drives LED connected in common anode configuration. The **UL319** drives up to 128 discrete LEDs in 16 segment/8 digit configuration while functioning from a supply voltage of 5.0V.

## ■ FEATURES

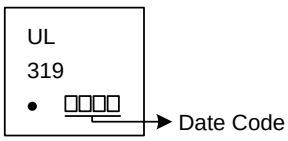
* LED driver with 24 outputs (16 segments/8 digits)
* Output pins connected directly to the LEDs
* Key-scanning (8 x 4 matrix)
* 3-wire serial bus interface (CLK, STB, DI/O)
* 8-step dimming circuit to control the overall display brightness
* Inputs with Schmitt trigger give superior noise immunity
* 5.0 V (± 10%) for $V_{DD}$
* Drives common-anode LED digits
* Built-in power on reset circuits
* Built-in pull-up resistor (CLK,STB,DOUT)

## ■ ORDERING INFORMATION

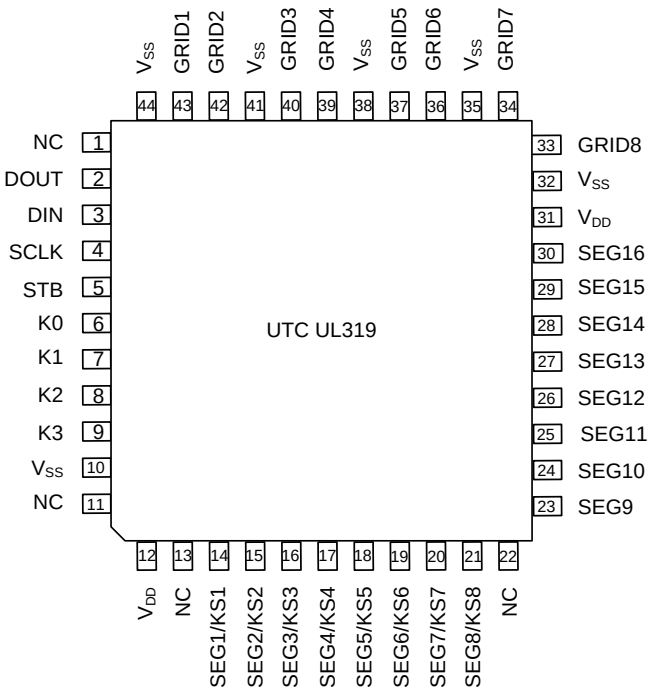
| Ordering Number | | Package | Packing |
|---|---|---|---|
| Lead Free | Halogen Free | | |
| UL319L-QM1-Y | UL319G-QM1-Y | QFP-44 | Tray |

| | |
|---|---|
| UL319G-QM1-Y<br>(1)Packing Type<br>(2)Package Type<br>(3)Green Package | (1) R: Tape Reel<br>(2) QM1: QFP-44(10×10)<br>(3) G: Halogen Free and Lead Free, L: Lead Free |

## ■ MARKING



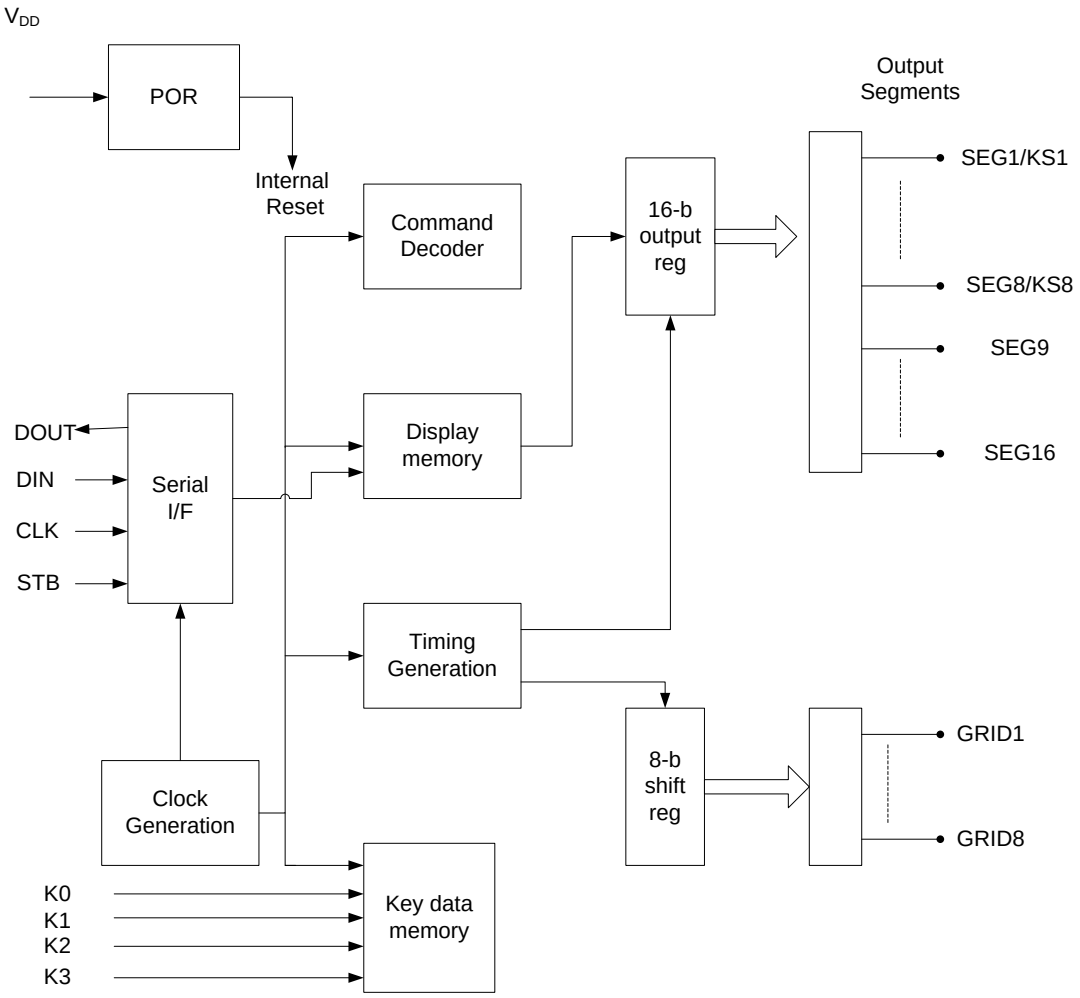
## ■ PIN CONFIGURATIONS




## ■ PIN CONFIGURATIONS

| PIN NUMBER | SYMBOL | TYPE | FUNCTION |
|---|---|---|---|
| 2 | DOUT | OUT | Output serial data at falling edge of the shift clock, starting from lower bit. |
| 3 | DIN | IN | Input serial data is clocked in at rising edge of the shift clock, starting from lower bit. |
| 4 | CLK | IN | Reads serial data at rising edge, and outputs data at falling edge. |
| 5 | STB | IN | Initializes serial interface at rising or falling edge for reception of command. Data input after the falling edge of STB are processed as a command. While command data are processed, current processing is stopped, and the serial interface is initialized. While STB is high, instructions are ignored. |
| 6 ~ 9 | K0 ~ K3 | IN | Key input |
| 14 ~ 21 | SEG1/KS1<br>∫<br>SEG8/KS8 | OUT | Segment output pin (dual function as key source) |
| 23~ 30 | SEG9<br>∫<br>SEG16 | OUT | Segment output pin |
| 43,42,40,39,37<br>,36,34,33 | GRID1<br>∫<br>GRID8 | OUT | Digit output pin |
| 12, 31 | $V_{DD}$ | PWR | 5.0 V ± 10% Core main supply voltage. Bypass to GND through a 0.1 μF capacitor as close to the pin as possible |
| 10,32,35,38,41<br>,44 | $V_{SS}$ | PWR | Connect this pin to system GND |
| 1,11,13,22 | NC | / | NC |

## ■ BLOCK DIAGRAM



## ■ ABSOLUTE MAXIMUM RATINGS (all voltages are referenced to GND)

| PARAMETER | SYMBOL | VALUES | UNIT |
|---|---|---|---|
| Supply Voltage to Ground | $V_{DD}$ | 7 | V |
| Logic Input Voltage | $V_{IN}$ | $V_{DD}$ | V |
| Junction Temperature | $T_J$ | +150 | °C |
| Operating Ambient Temperature | $T_{OPR}$ | -40 ~ +85 | °C |
| Storage Temperature | $T_{STG}$ | -65 to +150 | °C |

Note: Absolute maximum ratings are those values beyond which the device could be permanently damaged. Absolute maximum ratings are stress ratings only and functional device operation is not implied.

## ■ DC ELECTRICAL CHARACTERISTICS

DC electrical characteristics ($T_A$ = -40 to +85 °C, $V_{CC}$ = 5.0 V ± 10%, GND = 0 V)

| PARAMETER | SYMBOL | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| Logic Supply Voltage | $V_{DD}$ | | 4.5 | 5.0 | 5.5 | V |
| High Level Input Voltage | $V_{IH}$ | High Level Guaranteed Digital Pins | 0.7×$V_{DD}$ | | $V_{DD}$ | V |
| Low Level Input Voltage | $V_{IL}$ | Low Level Guaranteed Digital Pins | 0 | | 0.3×$V_{DD}$ | V |
| Hysteresis Voltage (DIN, CLK, STB pins) | $V_{HYS}$ | | | 0.35 | | V |
| Low Level Output Voltage | $V_{OL(DOUT)}$ | $D_{OUT}$, $I_{OL2}$=4mA | | | 0.4 | V |
| Segment Drive LED Source Current | $I_{OH}$ | $V_O$=$V_{DD}$–3V | -40 | -75 | -110 | mA |
| GRID Drive LED Sink Current | $I_{OL}$ | $V_O$=0.3V | 80 | 120 | | mA |
| Segment Drive Current Matching | $I_{TOLSEG}$ | $V_{CC}$=5.0V, $T_A$ =25°C, $V_{LED}$=2.5 V | | 3 | | % |

## ■ POWER SUPPLY CHARACTERISTICS ($T_A$ = -40 to +85 °C, unless otherwise specified)

| PARAMETER | SYMBOL | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| Quiescent Power Supply Current | $I_{STBY}$ | $V_{DD}$=5.0V, All Inputs=$V_{DD}$ or GND | | | 1 | mA |
| Operating Power Supply Current (display ON) | $I_{CC}$ | All Segments ON, All Digits Scanned, Intensity Set to Full, Internal Oscillator, No Display Load Connected | | | 5 | mA |

## ■ TIMING CHARACTERISTICS

($T_A$= -40 ~ +85°C, $V_{CC}$=5.0V±10%, Typical values are at 25 °C, unless otherwise specified)

| PARAMETER | SYMBOL | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| Clock Pulse Width | $PW_{CLK}$ | | | 400 | | ns |
| Strobe Pulse Width | $PW_{STB}$ | | | 1 | | µs |
| Data Setup Time | $t_{SETUP}$ | | | 100 | | ns |
| Data Hold Time | $t_{HOLD}$ | CLK Rising Edge to STB Rising Edge | | 100 | | ns |
| Clock-Strobe Time | $t_{CLK-STB}$ | | | 1 | | µs |

## ■ DISPLAY REGISTER ADDRESS AND DISPLAY MODE

The storage of this register is transferred from external component to **UL319** through serial port, with an address of 16 bytes unit in total from 00H－ODH, corresponding to the LED lamps connected to the chip's SGE and GRID pin respectively. The distribution is shown as the following figure:

When writing LED display data, operate in the order from lower position to higher position of the display address and the data byte.

**Table 1**

| | SEG1 | SEG2 | SEG3 | SEG4 | SEG5 | SEG6 | SEG7 | SEG8 | SEG9 | SEG10 | SEG11 | SEG12 | SEG13 | SEG14 | SEG15 | SEG16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | XxHL (Four Low Positions) | | | | XxHU (Four Low Positions) | | | | XxHL (Four Low Positions) | | | | XxHU (Four Low Positions) | | | |
| | B0 | B1 | B2 | B3 | B4 | B5 | B6 | B | B0 | B1 | B2 | B3 | B4 | B5 | B6 | B |
| GRID1 | 00HL | | | | 00HU | | | | 01HL | | | | 01HU | | | |
| GRID2 | 02HL | | | | 02HU | | | | 03HL | | | | 03HU | | | |
| GRID3 | 04HL | | | | 04HU | | | | 05HL | | | | 05HU | | | |
| GRID4 | 06HL | | | | 06HU | | | | 07HL | | | | 07HU | | | |
| GRID5 | 08HL | | | | 08HU | | | | 09HL | | | | 09HU | | | |
| GRID6 | 0AHL | | | | 0AHU | | | | 0BHL | | | | 0BHU | | | |
| GRID7 | 0CHL | | | | 0CHU | | | | 0DHL | | | | 0DHU | | | |
| GRID8 | 0EHL | | | | 0EHU | | | | 0FHL | | | | 0FHU | | | |

Write LED display data when, according to from the low address to address, from low to high byte operation in the use of no use to the SEG output port, in the corresponding BIT address bits to write 0.

## ■ KEY SCANNING AND KEY SCANNING REGISTER

The key scanning matrix is 8×4bit, shown as below:

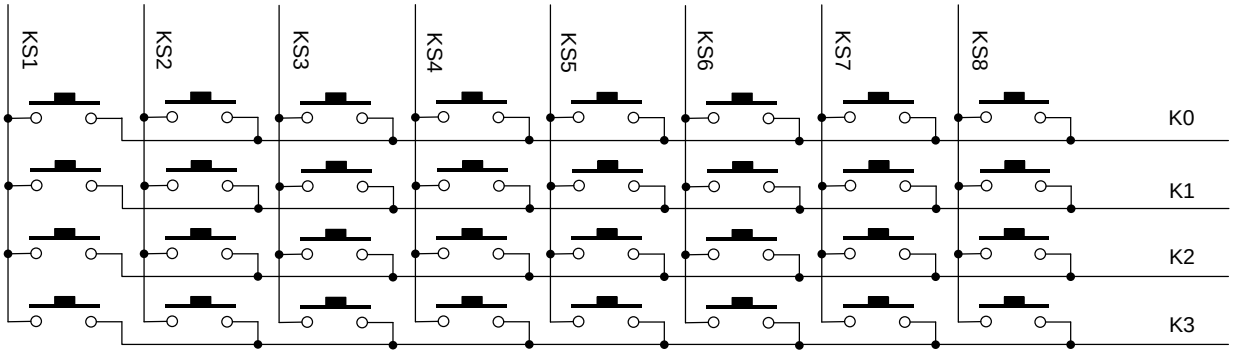



**Figure 1.**

Key scan data storage address Table 2 shows, first read key commands, began to read the key data of BYTE1 - BYTE4 bytes, reading data from the low output, K chip and KS pins corresponding key is pressed, the corresponding bytes within the BIT bit 1.

**Table 2.**

| | B0 | B1 | B2 | B3 | B4 | B5 | B6 | B |
|---|---|---|---|---|---|---|---|---|
| | K3 | K2 | K1 | K0 | K3 | K2 | K1 | K0 |
| BYTE1 | KS1 | | | | KS2 | | | |
| BYTE2 | KS3 | | | | KS4 | | | |
| BYTE3 | KS5 | | | | KS6 | | | |
| BYTE4 | KS7 | | | | KS8 | | | |

Notes: 1. **UL319** can read 4 bytes in total, and no more is allowed.

2. Order of reading can only be from BYTE1 to BYTE4, no trans-byte reading is allowed.

   For instance, when the keys corresponding to K2 and KS8 on the hardware are pressed, the data in such keys can only be read when reading to 4BIT of the fifth bytes When the three keys K1 and KS8, K2 and KS8, K3 and KS8 are pressed at the same time, the reading of BYTE4 at B4, B5 and B6 are all "1".

3. The compound key can only be the same KS, and only different K pins can form a compound keys the same K and different KS pins can not from a compound key.

## ■ DESRIPTION TO COMMANDS

Commands are used to set display mode and state of LED driver.

The first byte input by DIO at the falling edge of STB is taken as the first command. Through decoding, take the highest two bits B7 and B6 to distinguish different commands.

**Table 3.**

| B7 | B6 | Command |
|---|---|---|
| 0 | 1 | Data reading/writing setting command |
| 1 | 0 | Display control command |
| 1 | 1 | Address setting command |

If STB is set to high level during command or data transmission, the serial communication will be initialized, and the command or data being transmitted are invalid (previously transmitted commands or data are still valid).

**1. Display Mode Setting Command**

The command is used to set the data write and read, B1 and B0 bit is set to 01 or 11 is not allowed.

**Table 4.**

MSB LSB

| B7 | B6 | B5 | B4 | B3 | B2 | B1 | B0 | Function | Description |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 1 | N/A, fill in 0 | | | | 0 | 0 | Data reading/writing mode setting | Write data to display register |
| 0 | 1 | | | | | 1 | 0 | | Read key scanning data |
| 0 | 1 | | | | 0 | | | Ddress increase mode setting | Auto increase of address |
| 0 | 1 | | | | 1 | | | | Fixed address |
| 0 | 1 | | | 0 | | | | Test mode setting (for internal use only) | Normal mode |
| 0 | 1 | | | 1 | | | | | Test mode |

**2. Address Command Setting**

**Table 5.**

MSB LSB

| B7 | B6 | B5 | B4 | B3 | B2 | B1 | B0 | Display Address |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | N/A, fill in 0 | | 0 | 0 | 0 | 0 | 00H |
| 1 | 1 | | | 0 | 0 | 0 | 1 | 01H |
| 1 | 1 | | | 0 | 0 | 1 | 0 | 02H |
| 1 | 1 | | | 0 | 0 | 1 | 1 | 03H |
| 1 | 1 | | | 0 | 1 | 0 | 0 | 04H |
| 1 | 1 | | | 0 | 1 | 0 | 1 | 05H |
| 1 | 1 | | | 0 | 1 | 1 | 0 | 06H |
| 1 | 1 | | | 0 | 1 | 1 | 1 | 07H |
| 1 | 1 | | | 1 | 0 | 0 | 0 | 08H |
| 1 | 1 | | | 1 | 0 | 0 | 1 | 09H |
| 1 | 1 | | | 1 | 0 | 1 | 0 | 0AH |
| 1 | 1 | | | 1 | 0 | 1 | 1 | 0BH |
| 1 | 1 | | | 1 | 1 | 0 | 0 | 0CH |
| 1 | 1 | | | 1 | 1 | 0 | 1 | 0DH |
| 1 | 1 | | | 1 | 1 | 1 | 0 | 0EH |
| 1 | 1 | | | 1 | 1 | 1 | 1 | 0FH |

This command is used to set the address of display register.

## ■ DESRIPTION TO COMMANDS (Cont.)

### 3. Display Control

**Table 6.**

| MSB | | | | | | | LSB | | |
|---|---|---|---|---|---|---|---|---|---|
| B7 | B6 | B5 | B4 | B3 | B2 | B1 | B0 | Function | Description |
| 0 | 1 | N/A, fill in 0 | | | 0 | 0 | 0 | Extinction number setting | Set the pulse width to 1/16 |
| 0 | 1 | | | | 0 | 0 | 1 | | Set the pulse width to 2/16 |
| 0 | 1 | | | | 0 | 1 | 0 | | Set the pulse width to 4/16 |
| 0 | 1 | | | | 0 | 1 | 1 | | Set the pulse width to 10/16 |
| 0 | 1 | | | | 1 | 0 | 0 | | Set the pulse width to 11/16 |
| 0 | 1 | | | | 1 | 0 | 1 | | Set the pulse width to 12/16 |
| 0 | 1 | | | | 1 | 1 | 0 | | Set the pulse width to 13/16 |
| 0 | 1 | | | | 1 | 1 | 1 | | Set the pulse width to 14/16 |
| 0 | 1 | | | 0 | | | | Display switch setting | Display is OFF |
| 0 | 1 | | | 1 | | | | | Display is ON |

## ■ SERIAL DATA TRANSMISSION FORMAT

### 1. Data Receiving (Write Data)

Reading and receiving 1 BIT are both happened at the rising edge of the clock.

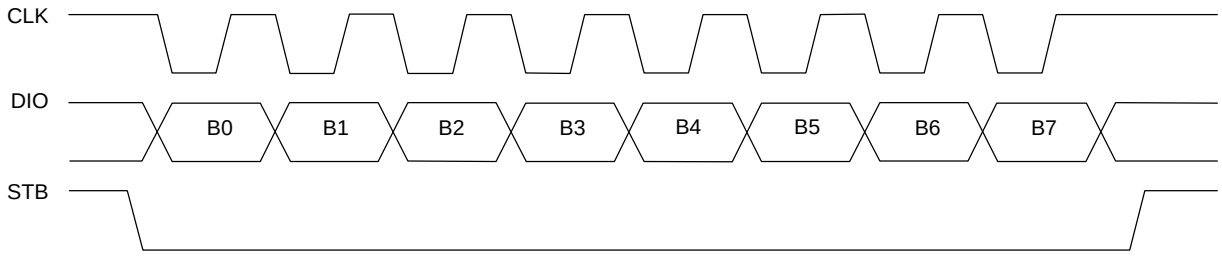



**Figure 2.**

### 2. Data Reading (Reading Data)

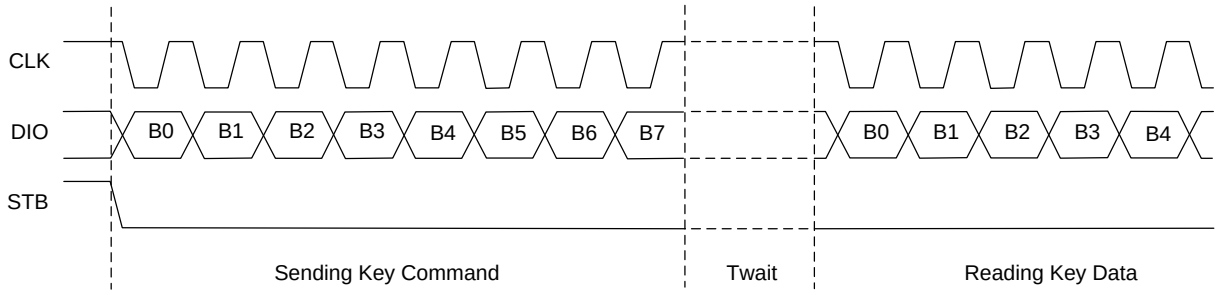



**Figure 3.**

Note: when reading data, it requires for a waiting time Twait to set the command to the falling edge of CLK for data reading starting from the eighth rising edge of the serial clock CLK.

## ■ DISPLAY AND KEYS

### 3. Drive common cathode digital tube

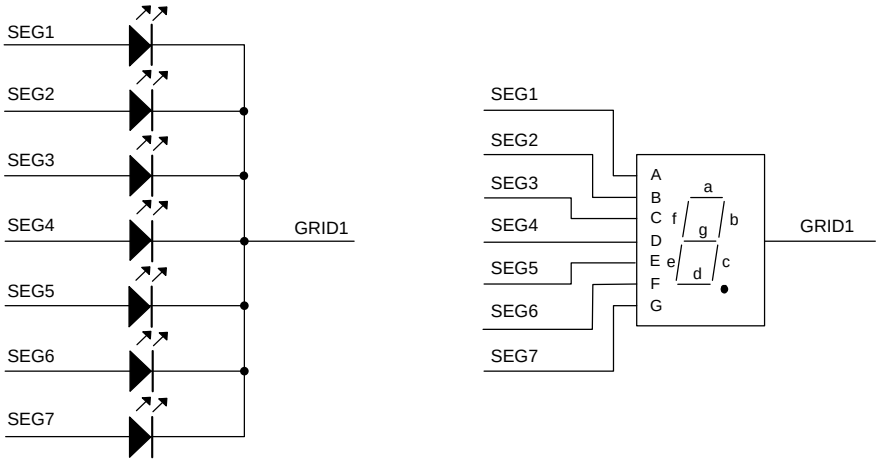



**Figure 4.**

Figure 4 shows the connection diagram of common cathode digital tube to make the digital tube display "0", set SEG1, SEG2, SEG3, SEG4, SEG5 and SEG6 to high level and SEG7 to low level when GRID1 is low level, view the address table shown in Table 1, and write data 3FH in 00H address unit.

**Table 7**

| | SEG8 | SEG7 | SEG6 | SEG5 | SEG4 | SEG3 | SEG2 | SEG1 |
|---|---|---|---|---|---|---|---|---|
| 00H | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| | B7 | B6 | B5 | B4 | B3 | B2 | B1 | B0 |

### 4. Drive common anode digital tube

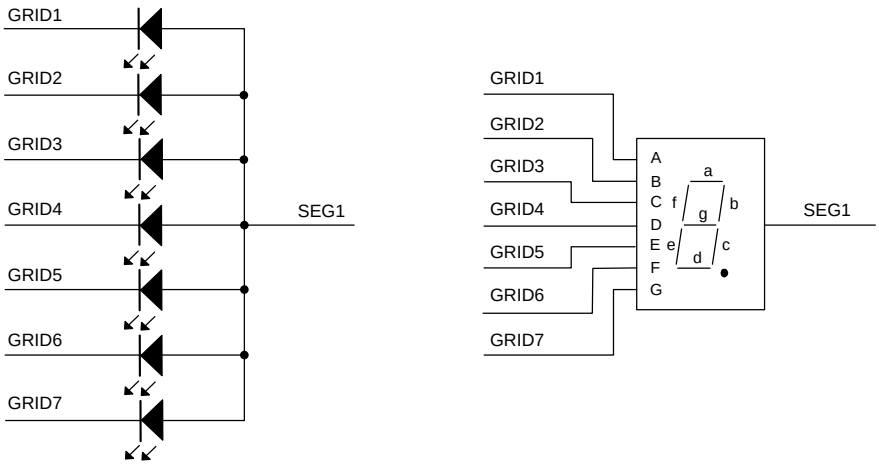



**Figure 5.**

## ■ DISPLAY AND KEYS (Cont.)

**Table 8**

| | SEG8 | SEG7 | SEG6 | SEG5 | SEG4 | SEG3 | SEG2 | SEG1 |
|---|---|---|---|---|---|---|---|---|
| 00H | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 02H | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 04H | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 06H | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 08H | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 0AH | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 0CH | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | B7 | B6 | B5 | B4 | B3 | B2 | B1 | B0 |

Note: SEG1-11 is P pipe open-drain output, and GRID1-7 is N pipe open-drain output while operating, SEG1-11 only can be connected to LED anode, GRID only can be connected to LED cathode, and shouldn't be connected reversely.

**5. Keys**

Key scanning is completed by **UL319** automatically and cannot be controlled by user.

Users only have to read the key value according to the time sequence. It requires two display circles to complete a key scanning, and one display circle requires about T=8×500μs. Two different keys are pressed one after another, and the two readings are both the key value of the key firstly pressed.

According to figure 6, observe the output key scanning waveforms of SEG1/KS1 and SEG2/KS2 with an oscilloscope, as shown in figure 7.

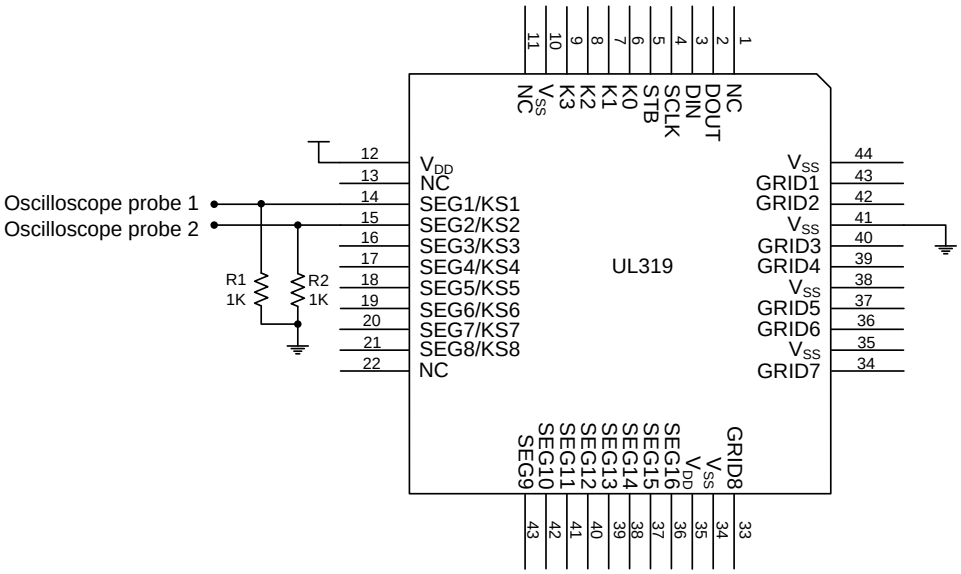



**Figure 6.**

## ■ DISPLAY AND KEYS (Cont.)

**Waveforms of SEGN/KSN when IC is scanning keyboard**

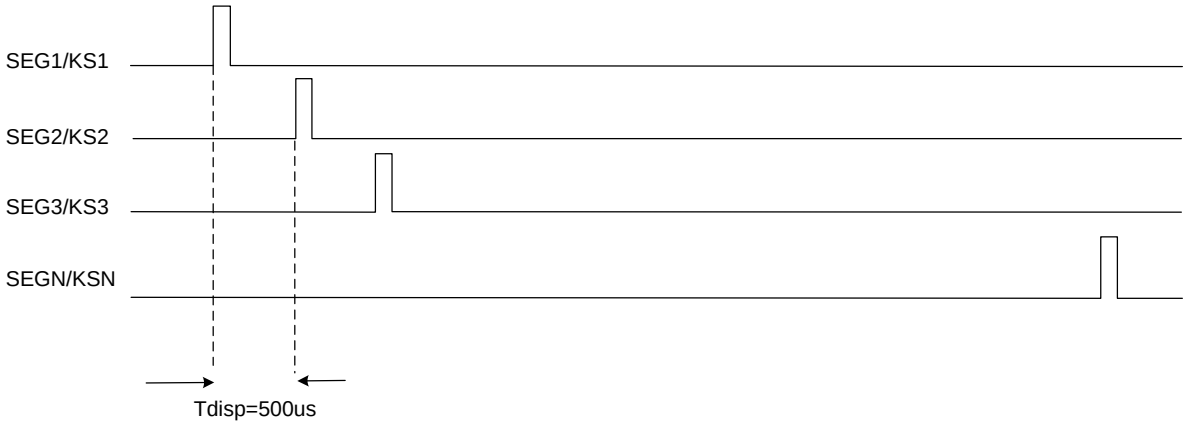



**Figure 7.**

Tdisp relates to the working oscillation frequency of the IC. As the improvements of **UL319** provided by our company, the oscillation may differ. 500μs is only for reference and the actual measurements shall prevail .Generally, Figure 8 can meet the requirements of key design.

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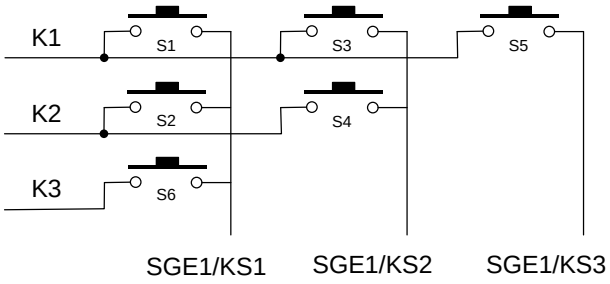



**Figure 8.**

When S1 is pressed down, B0 of the first byte reads "1" . If several keys are pressed down, several "1" will be reads when S2 and S3 are pressed down, B1 and B3 of the first byte will read "1".

Note: Precautions for composite key note:

SEG1/KS1-SEG10/KS10 is for display and key scanning multiplexing. Figure 9 for example, to make D1 on, D2 off, please set SEG1 to "1", SEG2 to "0", if S1 and S2 are pressed at the same time, equivalent to SEG1 and SEG2 short circuit, D1 and D2 are lit.

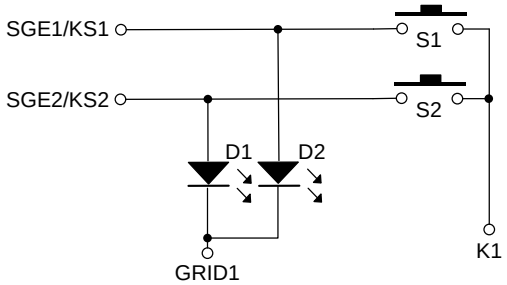



**Figure 9.**

## ■ DISPLAY AND KEYS (Cont.)

**Solution**

1. On hardware, set the keys that should be pressed simultaneously to different K lines, as shown in Figure 10.

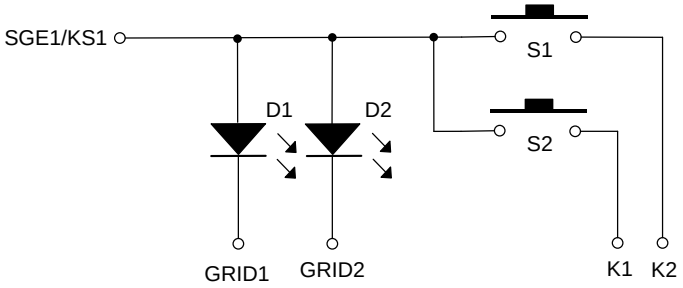



**Figure 10.**

2. Connect the resistors in series on SEG1 - SEG N, as shown in Figure 11 the resistance should be 510 Ω too large resistance will cause key invalid, and too low resistance can't solve the problem of display interference.

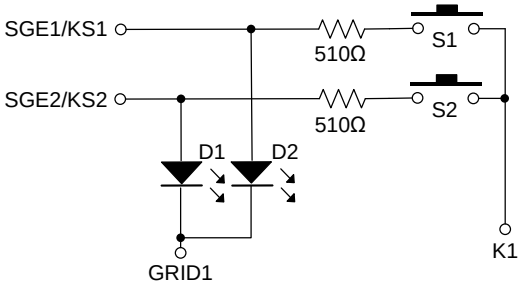



**Figure 11.**

3. Or connect the diodes in series, as shown in Figure 12.

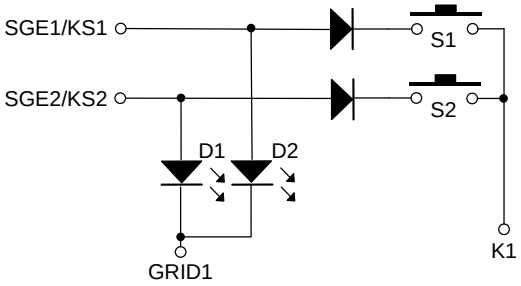
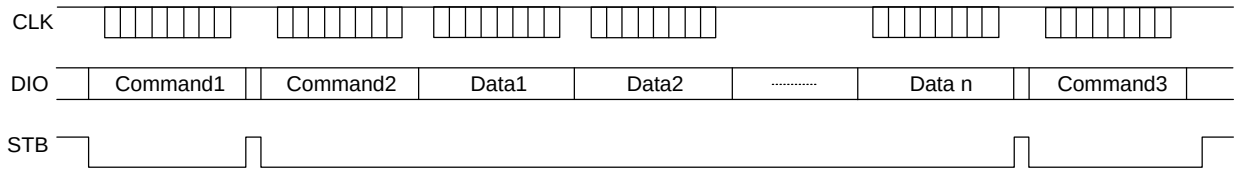



**Figure 12.**

## ■ TRANSMISSION OF SERIAL DATA IN APPLICATION

**Address increase mode**

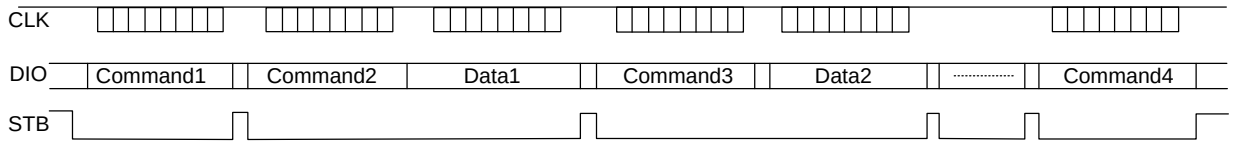
In the address auto +1 mode, to set an address actually means to set the initial address stored in the transferred data flow. When the initial address command is completely sent, send the data (16 byte at most) immediately without having to set "STB" to high position, and only do it when data sending completes.




Command1: Display mode setting command
Command2: Data reading/writing setting command
Data1～n: Display address setting command

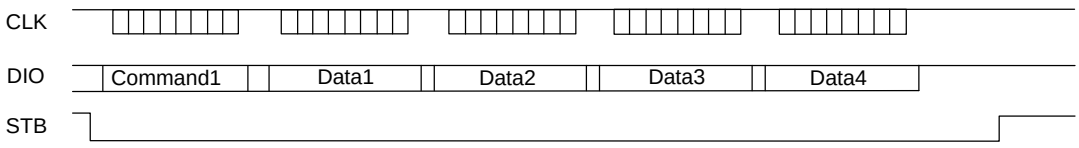
**Fixed address mode**

In the fixed address mode, to set the address actually means to set the address stored in the to-be-transferred 1 byte data. When the address is sent completely, send the 1 byte data immediately without having to set "STB" to high position (only do it when data sending completes), then, set the address to be stored in the second data, and when the data (16 byte at most) sending completes, set "STB" to high position.



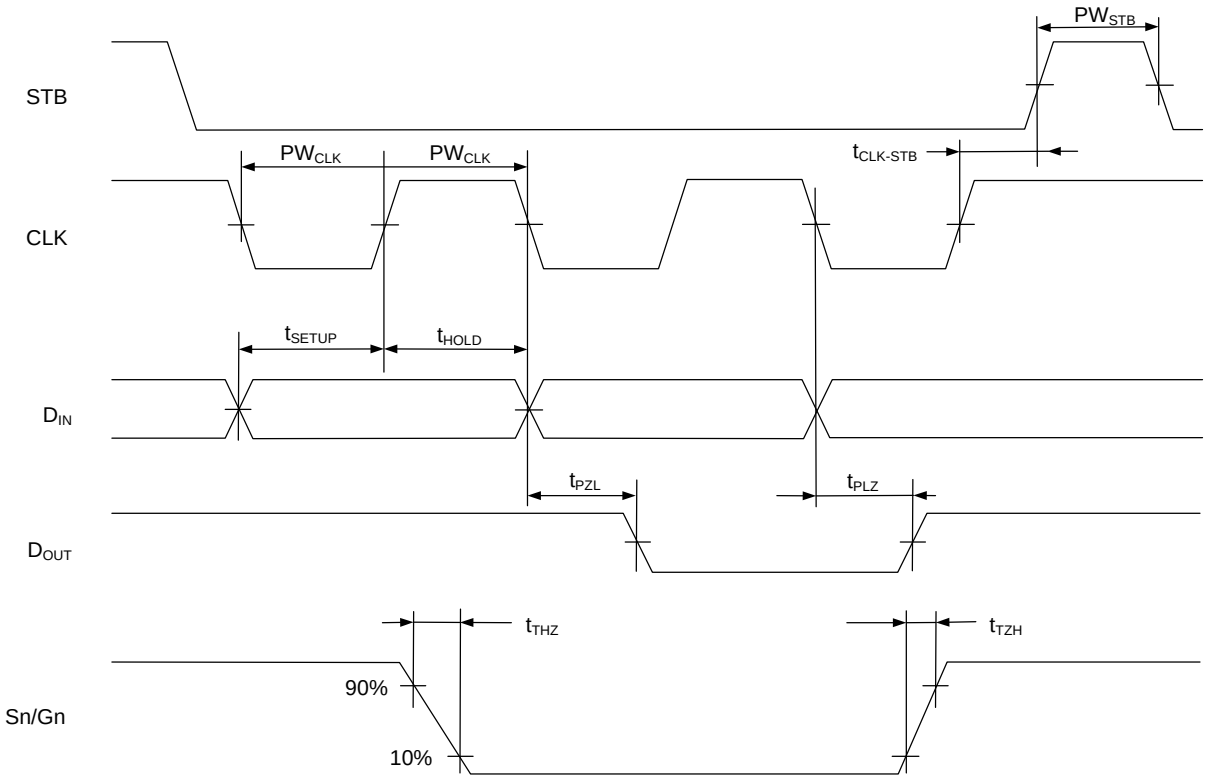

Command1: Display mode setting command
Command2: Data reading/writing setting command
Command3: Display address setting command, to set display address 1
Data1: Display data 1, save to the address unit specified by Command3
Command4: Display address setting command, to set display address 2
Data2: Display data 2, save to the address unit specified by Command4
Command5: Display control command

**Read time sequence of keys**



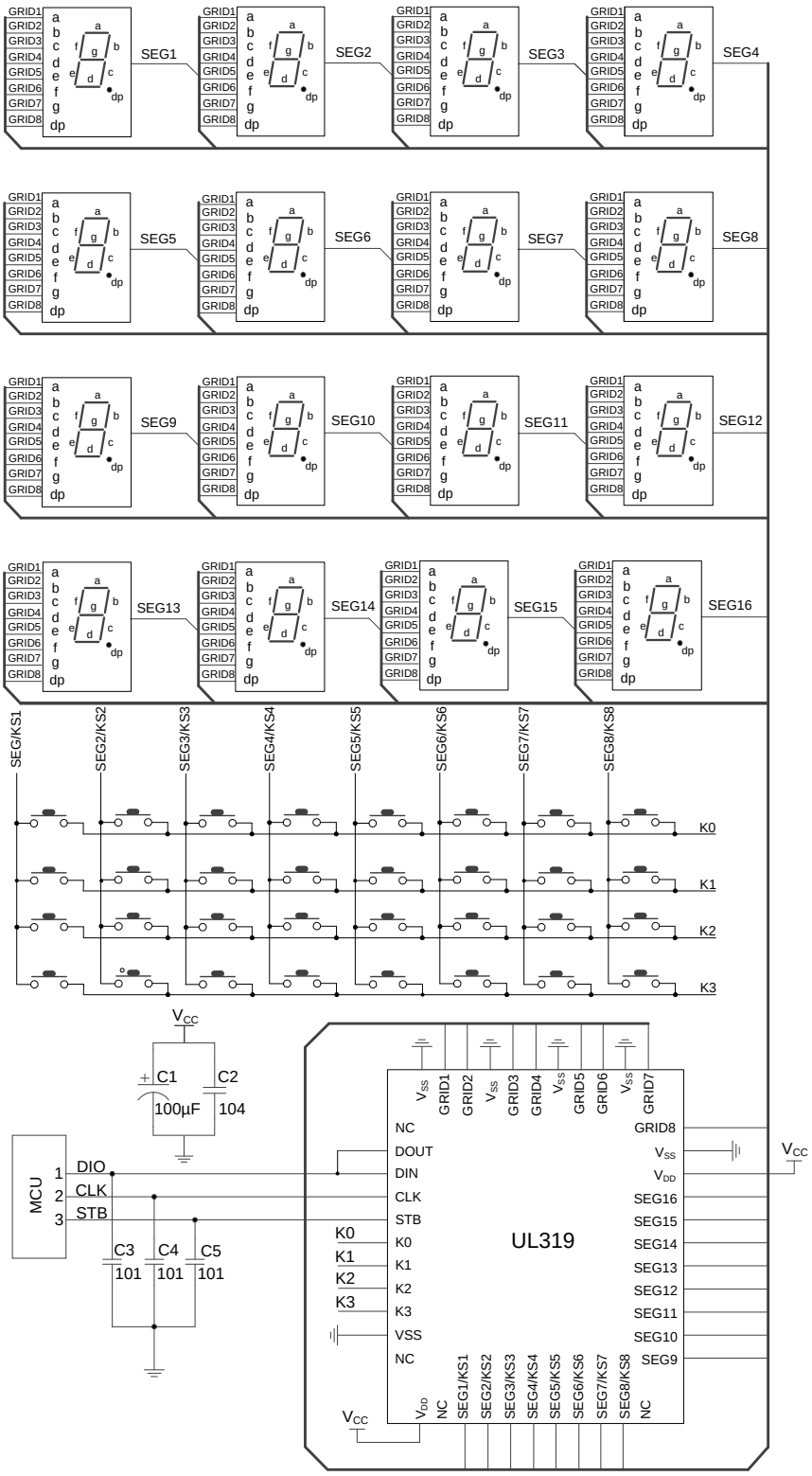

Command1: Reading key command
Data1~5: Reading key data

## ■ SWITCHING CHARACTERISTICS WAVEFORM



## ■ TYPICAL APPLICATION CIRCUIT

**UL319 driver total of anode digital screen hardware circuit**



## ■ TYPICAL APPLICATION CIRCUIT (Cont.)

**UL319 driver Common cathode digital screen hardware circuit**