I. General

TM1651 is a LED (Light Emitting Diode) driver control IC with keyboard scan interface. Its internal integration includes MCU digital interface, data latch, LED high-voltage drive, keyboard scan, etc. With good performance and reliable quality, the product is mainly applied to display driver of electromagnetic oven, microwave oven and small household appliances. It adopts SOP16/DIP16 packaging.

II. Features

- Power CMOS technology.
- Display (7 segments× 4 bits), CA LED display supported
- Key scanning (7×1bit): enhanced anti-jamming key identification circuit
- Brightness adjustment circuit (8 levels of duty ratio, adjustable)
- Serial interface (CLK, DIO)
- Oscillation: built-in RC oscillator (450KHz±5%)
- Built-in power-on reset circuit
- Built-in automatic blanking circuit
- Packaging: DIP16/SOP16

III. Pin Definitions

```
GND  1  16  K1
SEG1/KS1  2  15  CLK
SEG2/KS2  3  14  DIO
SEG3/KS3  4  13  VDD
SEG4/KS4  5  12  GRID1
SEG5/KS5  6  11  GRID2
SEG6/KS6  7  10  GRID3
SEG7/KS7  8  9  GRID4
```

Fig. 1 Pin Definitions
IV. Pin Functions

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Pin name</th>
<th>Pin No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIO</td>
<td>Data input/output</td>
<td>14</td>
<td>Serial data input/output, input data changing at low level of CLK, transmitted at high level of CLK; for each transmission of one byte, one ACK will be generated at the 9th clock inside the chip.</td>
</tr>
<tr>
<td>CLK</td>
<td>Clock input</td>
<td>15</td>
<td>Rising-edge input/output data</td>
</tr>
<tr>
<td>K1</td>
<td>Key scan data input</td>
<td>16</td>
<td>Data inputted to this pin will be latched after the end of display cycle.</td>
</tr>
<tr>
<td>SEG1~SEG7</td>
<td>Output (segment)</td>
<td>2-8</td>
<td>Segment output (also for key scan), N tube open-drain output</td>
</tr>
<tr>
<td>GRIG4~GRIG1</td>
<td>Output (bit)</td>
<td>9-12</td>
<td>Bit output, P tube open-drain output</td>
</tr>
<tr>
<td>VDD</td>
<td>Logic power</td>
<td>13</td>
<td>To system power</td>
</tr>
<tr>
<td>VSS</td>
<td>Logic ground</td>
<td>1</td>
<td>To system ground</td>
</tr>
</tbody>
</table>

V. Display Register Address

The register stores the data transmitted from peripheral device to TM1651 via serial interface. The address 00H-03H has 4 byte units, respectively corresponding to the LED lights connected with chip SEG and GRID pins, as shown in the figure below:

The operation of writing LED display data shall follow the principle of “from low bit to high bit” of display address and “from low bit to high bit” of data byte.
VI. Key Scan & Key Scan Data Register

Key scan matrix is 7×1bit, as shown below:

When there is a key pressed, reading key data are as follows:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>K1</td>
<td>1110_1111</td>
<td>0110_1111</td>
<td>1010_1111</td>
<td>0010_1111</td>
<td>1100_1111</td>
<td>0100_1111</td>
</tr>
</tbody>
</table>

Note: when there is no key pressed, reading key data is 1111_1111, with low bits ahead of high bits.

VII. Instruction Description

Instruction is to set display mode and state of LED driver.
After CLK falling edge, the first byte inputted by DIO is an instruction. After decoding, the highest two bits, B7 and B6, are used as instructions for differentiating from each other.

<table>
<thead>
<tr>
<th>B7</th>
<th>B6</th>
<th>Command</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>display mode setting</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>data command setting</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>display control command setting</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>address command setting</td>
</tr>
</tbody>
</table>

7.1 Data command setting:

This instruction is to set data writing and reading, and B1 and B0 bits shall not be set 01 or 11.

<table>
<thead>
<tr>
<th>MSB</th>
<th>LSB</th>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>B7</td>
<td>B6</td>
<td>B5</td>
<td>B4</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

7.2 Address command setting:

<table>
<thead>
<tr>
<th>MSB</th>
<th>LSB</th>
<th>Display address</th>
</tr>
</thead>
<tbody>
<tr>
<td>B7</td>
<td>B6</td>
<td>B5</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

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V1.1
This instruction is to set the address of display register. If the address is set 0C4H or higher, the data will be omitted until a valid address is set. When power on, the default address is 00H.

### 7.3 Display control

<table>
<thead>
<tr>
<th>MSB</th>
<th>B7</th>
<th>B6</th>
<th>B5</th>
<th>B4</th>
<th>B3</th>
<th>B2</th>
<th>B1</th>
<th>B0</th>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 0</td>
<td>1 0</td>
<td>1 0</td>
<td>1 0</td>
<td>1 0</td>
<td>1 0</td>
<td>1 0</td>
<td>1 0</td>
<td>To set gray scale</td>
<td>Set pulse width 1/16</td>
</tr>
<tr>
<td></td>
<td>1 0</td>
<td>1 0</td>
<td>1 0</td>
<td>1 0</td>
<td>1 0</td>
<td>1 0</td>
<td>1 0</td>
<td>1 0</td>
<td>To set display on/off</td>
<td>Display off</td>
</tr>
<tr>
<td></td>
<td>1 0</td>
<td>1 0</td>
<td>1 0</td>
<td>1 0</td>
<td>1 0</td>
<td>1 0</td>
<td>1 0</td>
<td>1 0</td>
<td>To set display on/off</td>
<td>Display on</td>
</tr>
</tbody>
</table>

#### VIII. Serial Data Transmission Format

The data of microprocessor communicate with TM1651 via two-line bus interface. During data input, DIO signal must keep unchanged when CLK is at high level. Only when CLK clock signal is at low level can DIO signal be changed. The condition of starting data input is that DIO changes from high to low when CLK is at high level, and its condition of ending is that DIO changes from low to high when CLK is at high level.

TM1651 data transmission has the acknowledge signal ACK. When data is correct, at the falling edge of the 8th clock, one ACK will be generated inside the chip and DIO pin will be pulled low; and the rising edge of the 9th clock releases port line.
Process of command data transmission is shown as below (time sequence of reading key data):

Command: read key command

S0, S1, S2 and K1 compose key information code. S0, S1 and S2 are codes of SG; and K1 and K2 are codes of K1. Reading keys, CLK frequency shall be less than 250K, first low bits and then high bits.

Writing SRAM data, address automatic plus 1 mode

Command1: set data
Command2: set address
Data1~N: transmit display data.
Command3: control display

Writing SRAM data, fixed address mode

Command1: set data
Command2: set address
Data1~N: transmit display data.
Command3: control display
IX. Flow Chart of Program

Flow chart of address automatic plus 1 mode:

Start

Initialize

Send data command of writing display memory

Set initial address

Transmit multiple bytes continuously

Send display control command

Send reading key command

Read key data and store in MCU register

With key pressed?

YES

Key processing program

NO

End
Flow chart of fixed address mode:

- Start
- Initialize
- Send data command of writing display memory
- Set display memory address
- Transmit 1Byte data
- Data transmission finished?
- Send display control command
- Send reading key command
- Read key data and store in MCU register
- With key pressed?
  - YES: Key processing program
  - NO: DATA transmission finished
- End
X. Application Circuits

The LED display in the circuit is CA type.

XI. Electrical Parameters:
Limit parameters (Ta = 25°C, Vss = 0 V)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Range</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logic supply voltage</td>
<td>VDD</td>
<td>-0.5 ~+7.0</td>
<td>V</td>
</tr>
<tr>
<td>Logic input voltage</td>
<td>VI1</td>
<td>-0.5 ~ VDD + 0.5</td>
<td>V</td>
</tr>
<tr>
<td>LED SEG drive sink current</td>
<td>IO1</td>
<td>50</td>
<td>mA</td>
</tr>
<tr>
<td>LED GRID drive source current</td>
<td>IO2</td>
<td>200</td>
<td>mA</td>
</tr>
<tr>
<td>Power loss</td>
<td>PD</td>
<td>400</td>
<td>mW</td>
</tr>
<tr>
<td>Operating temperature</td>
<td>Topt</td>
<td>-40 ~ +85</td>
<td>°C</td>
</tr>
<tr>
<td>Storage temperature</td>
<td>Tstg</td>
<td>-65 ~+150</td>
<td>°C</td>
</tr>
</tbody>
</table>
# LED Driver Control IC

**TM1651**

## Normal operating range (Ta = -40~+85°C, Vss = 0 V)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Min.</th>
<th>Typical</th>
<th>Max.</th>
<th>Unit</th>
<th>Test conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logic supply voltage</td>
<td>VDD</td>
<td>5</td>
<td></td>
<td>V</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>High-level input voltage</td>
<td>VIH</td>
<td>0.7 VDD</td>
<td>-</td>
<td>VDD</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Low-level input voltage</td>
<td>VIL</td>
<td>0</td>
<td></td>
<td>0.3 VDD</td>
<td>V</td>
<td></td>
</tr>
</tbody>
</table>

## Electrical features (Ta = -40~+85°C, VDD = 4.5~5.5 V, Vss = 0 V)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Min.</th>
<th>Typical</th>
<th>Max.</th>
<th>Unit</th>
<th>Test conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRID drive source current</td>
<td>Ioh1</td>
<td>80</td>
<td>120</td>
<td>180</td>
<td>mA</td>
<td>GRID1~GRID4, Vo = Vdd-2V</td>
</tr>
<tr>
<td>Grid drive source current</td>
<td>Ioh2</td>
<td>80</td>
<td>140</td>
<td>200</td>
<td>mA</td>
<td>GRID1~GRID4, Vo = Vdd-3V</td>
</tr>
<tr>
<td>SEG drive sink current</td>
<td>IOL1</td>
<td>20</td>
<td>30</td>
<td>50</td>
<td>mA</td>
<td>SEG1~SEG7, Vo = 0.3V</td>
</tr>
<tr>
<td>DOUT pin output low-level current</td>
<td>Idout</td>
<td>4</td>
<td>-</td>
<td>-</td>
<td>mA</td>
<td>Vo = 0.4V, dout</td>
</tr>
<tr>
<td>Output pull down resistance</td>
<td>RL</td>
<td>10</td>
<td>-</td>
<td>-</td>
<td>KΩ</td>
<td></td>
</tr>
<tr>
<td>Input current</td>
<td>II</td>
<td>-</td>
<td>-</td>
<td>±1</td>
<td>μA</td>
<td>VI = VDD / VSS</td>
</tr>
<tr>
<td>High-level input voltage</td>
<td>VIH</td>
<td>0.7 VDD</td>
<td>-</td>
<td>-</td>
<td>V</td>
<td>CLK, DIO</td>
</tr>
<tr>
<td>Low-level input voltage</td>
<td>VIL</td>
<td>-</td>
<td>-</td>
<td>0.3 VDD</td>
<td>V</td>
<td>CLK, DIO</td>
</tr>
<tr>
<td>Lagging voltage</td>
<td>VH</td>
<td>-</td>
<td>0.35</td>
<td>-</td>
<td>V</td>
<td>CLK, DIO</td>
</tr>
<tr>
<td>Dynamic current loss</td>
<td>IDDdyn</td>
<td>-</td>
<td>-</td>
<td>5</td>
<td>mA</td>
<td>Load-free, display off</td>
</tr>
</tbody>
</table>
Switch features (Ta = -40~+85°C, VDD = 4.5~5.5 V)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Min.</th>
<th>Typical</th>
<th>Max.</th>
<th>Unit</th>
<th>Test conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oscillation frequency</td>
<td>fosc</td>
<td>-</td>
<td>450</td>
<td>-</td>
<td>KHz</td>
<td></td>
</tr>
<tr>
<td>Propagation delay time</td>
<td>tPLZ</td>
<td>-</td>
<td></td>
<td>300</td>
<td>ns</td>
<td>CLK → DIO</td>
</tr>
<tr>
<td></td>
<td>tPZL</td>
<td>-</td>
<td></td>
<td>100</td>
<td>ns</td>
<td>CL = 15pF, RL = 10K Ω</td>
</tr>
<tr>
<td>Rise time</td>
<td>TTZH</td>
<td>-</td>
<td></td>
<td>2</td>
<td>μs</td>
<td>CL = 300pF</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SEG1/KS1 ~ SEG7/KS7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fall time</td>
<td>TTHZ</td>
<td>-</td>
<td></td>
<td>120</td>
<td>μs</td>
<td>CL = 300pF, SEGn, GRIDn</td>
</tr>
<tr>
<td>Max. clock frequency</td>
<td>Fmax</td>
<td>-</td>
<td></td>
<td>500</td>
<td>KHz</td>
<td>Duty ratio 50%</td>
</tr>
<tr>
<td>Input capacitance</td>
<td>CI</td>
<td>-</td>
<td></td>
<td>15</td>
<td>pF</td>
<td></td>
</tr>
</tbody>
</table>

● Time sequence features (Ta = -40~+85°C, VDD = 4.5~5.5 V)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Min.</th>
<th>Typical</th>
<th>Max.</th>
<th>Unit</th>
<th>Test conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clock pulse width</td>
<td>PWCLK</td>
<td>400</td>
<td>-</td>
<td>-</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>Data setup time</td>
<td>tSETUP</td>
<td>100</td>
<td>-</td>
<td>-</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>Data holding time</td>
<td>tHOLD</td>
<td>100</td>
<td>-</td>
<td>-</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>Waiting time</td>
<td>tWAIT</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>μs</td>
<td>CLK↑→CLK↓</td>
</tr>
</tbody>
</table>
XII. Diagrammatic Sketches of IC Encapsulation:

SOP16:

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>MIN/mm</th>
<th>NOM/mm</th>
<th>MAX/mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
<td>1.75</td>
</tr>
<tr>
<td>A1</td>
<td>0.10</td>
<td>0.15</td>
<td>0.25</td>
</tr>
<tr>
<td>A2</td>
<td>1.35</td>
<td>1.45</td>
<td>1.55</td>
</tr>
<tr>
<td>A3</td>
<td>0.55</td>
<td>0.65</td>
<td>0.75</td>
</tr>
<tr>
<td>b</td>
<td>0.36</td>
<td></td>
<td>0.51</td>
</tr>
<tr>
<td>b1</td>
<td>0.35</td>
<td>0.40</td>
<td>0.45</td>
</tr>
<tr>
<td>c</td>
<td>0.18</td>
<td></td>
<td>0.25</td>
</tr>
<tr>
<td>c1</td>
<td>0.17</td>
<td>0.20</td>
<td>0.23</td>
</tr>
<tr>
<td>D</td>
<td>9.80</td>
<td>9.90</td>
<td>10.00</td>
</tr>
<tr>
<td>E</td>
<td>5.80</td>
<td>6.00</td>
<td>6.20</td>
</tr>
<tr>
<td>E1</td>
<td>3.80</td>
<td>3.90</td>
<td>4.00</td>
</tr>
<tr>
<td>e</td>
<td>1.22</td>
<td>1.27</td>
<td>1.32</td>
</tr>
<tr>
<td>L</td>
<td>0.45</td>
<td>0.60</td>
<td>0.80</td>
</tr>
<tr>
<td>L1</td>
<td></td>
<td>1.04REF</td>
<td></td>
</tr>
<tr>
<td>L2</td>
<td></td>
<td>0.25BSC</td>
<td></td>
</tr>
<tr>
<td>R</td>
<td>0.07</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R1</td>
<td>0.07</td>
<td></td>
<td></td>
</tr>
<tr>
<td>h</td>
<td>0.30</td>
<td>0.40</td>
<td>0.50</td>
</tr>
<tr>
<td>(\theta)</td>
<td>0°</td>
<td></td>
<td>8°</td>
</tr>
<tr>
<td>(\theta) 1</td>
<td>6°</td>
<td>8°</td>
<td>10°</td>
</tr>
<tr>
<td>(\theta) 2</td>
<td>6°</td>
<td>8°</td>
<td>10°</td>
</tr>
<tr>
<td>(\theta) 3</td>
<td>5°</td>
<td>7°</td>
<td>9°</td>
</tr>
<tr>
<td>(\theta) 4</td>
<td>5°</td>
<td>7°</td>
<td>9°</td>
</tr>
<tr>
<td>Symbol</td>
<td>Dimensions In Millimeters</td>
<td>Dimensions In Inches</td>
<td></td>
</tr>
<tr>
<td>--------</td>
<td>---------------------------</td>
<td>----------------------</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Min</td>
<td>Max</td>
<td>Min</td>
</tr>
<tr>
<td>A</td>
<td>3.710</td>
<td>4.310</td>
<td>0.146</td>
</tr>
<tr>
<td>A1</td>
<td>0.510</td>
<td></td>
<td>0.020</td>
</tr>
<tr>
<td>A2</td>
<td>3.200</td>
<td>3.600</td>
<td>0.126</td>
</tr>
<tr>
<td>B</td>
<td>0.380</td>
<td>0.570</td>
<td>0.015</td>
</tr>
<tr>
<td>B1</td>
<td>1.524 (BSC)</td>
<td></td>
<td>0.060 (BSC)</td>
</tr>
<tr>
<td>C</td>
<td>0.204</td>
<td>0.360</td>
<td>0.008</td>
</tr>
<tr>
<td>D</td>
<td>18.800</td>
<td>19.200</td>
<td>0.740</td>
</tr>
<tr>
<td>E</td>
<td>6.200</td>
<td>6.600</td>
<td>0.244</td>
</tr>
<tr>
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<td>7.920</td>
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<td>e</td>
<td>2.540 (BSC)</td>
<td></td>
<td>0.100 (BSC)</td>
</tr>
<tr>
<td>L</td>
<td>3.000</td>
<td>3.600</td>
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<tr>
<td>E2</td>
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- All specs and applications shown above subject to change without prior notice.