

# IS31FL3746B

## 18x4 DOTS MATRIX LED DRIVER WITH 12MHZ SPI

December 2018

### GENERAL DESCRIPTION

The IS31FL3746B is a general purpose 18x $n$  ( $n=1\sim 4$ ) LED Matrix programmed via 12MHz SPI interface. Each LED can be dimmed individually with 8-bit PWM data and 8-bit DC scaling data which allowing 256 steps of linear PWM dimming and 256 steps of DC current adjustable level.

Additionally each LED open state can be detected, IS31FL3746B store the open information in Open-Registers. The Open Registers allowing MCU to read out via SPI, inform MCU whether there are LEDs open or short LEDs.

The IS31FL3746B operates from 2.7V to 5.5V and features a very low shutdown and operational current.

IS31FL3746B is available in QFN-32 (4mmx4mm) package. It operates from 2.7V to 5.5V over the temperature range of  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ .

### FEATURES

- Supply voltage range: 2.7V to 5.5V
- 18 current sinks
- Support 18x $n$  ( $n=1\sim 4$ ) LED matrix configurations
- Accurate color rendition
  - 8-bit PWM
  - 8-bit dot correction
  - 8-bit global current adjust
- SDB rising edge reset SPI module
- 29kHz PWM frequency
- 12MHz SPI interface
- Individual open and short error detect function
- 180 degree phase delay operation to reduce power noise
- Spread spectrum
- De-ghost
- QFN-32 (4mmx4mm) package

### APPLICATIONS

- Hand-held devices for LED display
- Gaming device (Keyboard, Mouse etc.)
- LED in white goods application

### TYPICAL APPLICATION CIRCUIT

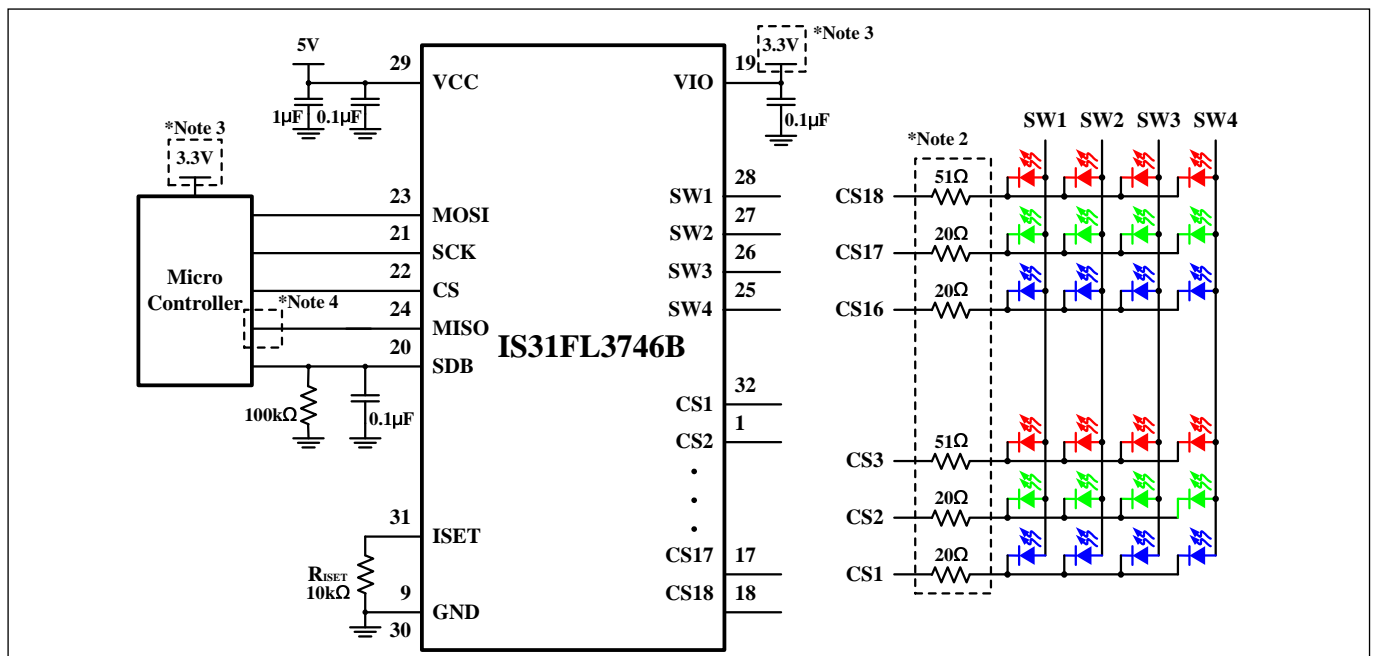
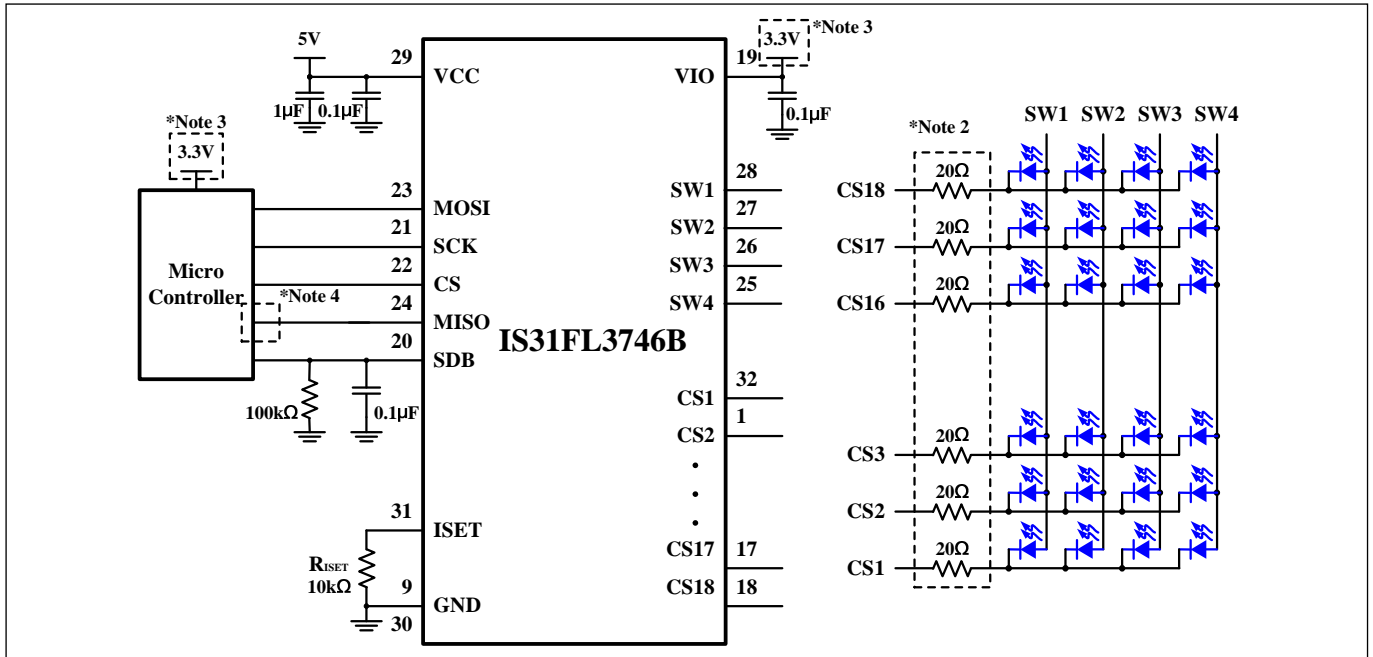


Figure 1 Typical Application Circuit: 24 RGBs

# IS31FL3746B

## TYPICAL APPLICATION CIRCUIT (CONTINUED)



**Figure 2** Typical Application Circuit: 72 Mono Color LEDs

**Note 1:** IC should be placed far away from the antenna in order to prevent the EMI.

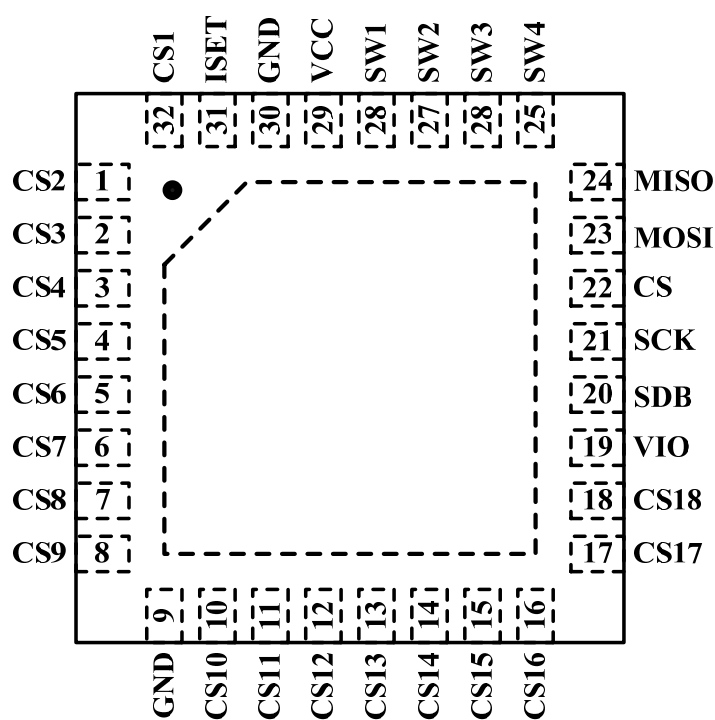
**Note 2:** The 20Ω or 51Ω resistors between LED and IC are only for thermal reduction, for mono red LED, if  $V_{CC}=3.3V$ , don't need these resistors.

**Note 3:** The  $V_{IH}$  of SPI bus should be same as VIO pin. VIO pin need to connect to a reference voltage and usually it is same as the VCC of MCU. If VCC of MCU is 1.8V,  $V_{IO}=1.8V$ , if VCC of MCU is 5V,  $V_{IO}=5V$ .

**Note 4:** MISO  $V_{OH}=V_{IO}$ .

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## PIN CONFIGURATION

| Package | Pin Configuration (Top View)  |
|---------|---|
| QFN-32  |  <p>The diagram shows a top view of a QFN-32 package. The pins are arranged in a square pattern. The top row (pins 32 to 25) includes CS1, ISET, GND, VCC, SW1, SW2, SW3, and SW4. The right side (pins 24 to 17) includes MISO, MOSI, CS, SCK, SDB, VIO, CS18, and CS17. The bottom row (pins 9 to 16) includes GND, CS10, CS11, CS12, CS13, CS14, CS15, and CS16. The left side (pins 1 to 8) includes CS2, CS3, CS4, CS5, CS6, CS7, CS8, and CS9. A thermal pad is located at the top-left corner of the package.</p> |

## PIN DESCRIPTION

| No.        | Pin         | Description                                      |
|------------|-------------|--|
| 1~8, 10~18 | CS2~CS18    | Current sink pin for LED matrix.                 |
| 9,30       | GND         | Ground.  |
| 19         | VIO         | Input logic reference voltage, can't be floated. |
| 20         | SDB         | Shutdown pin.                                    |
| 21         | SCK         | SPI clock.                                       |
| 22         | CS          | CS of SPI.                                       |
| 23         | MOSI        | SPI input data.                                  |
| 24         | MISO        | MISO of SPI.                                     |
| 25~28      | SW4~SW1     | Power SW.  |
| 29         | VCC         | Power for current source SW and analog.          |
| 31         | ISET        | Set the maximum IOU current.                     |
| 32         | CS1         | Current sink pin for LED matrix.                 |
|            | Thermal Pad | Connect to GND.                                  |



# IS31FL3746B

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## ORDERING INFORMATION

Industrial Range: -40°C to +125°C

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| Order Part No.       | Package           | QTY/Reel |
|----------------------|-------------------|----------|
| IS31FL3746B-QFLS4-TR | QFN-32, Lead-free | 2500     |

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## ABSOLUTE MAXIMUM RATINGS

|  |                       |
|--|-----------------------|
| Supply voltage, $V_{CC}$   | -0.3V ~ +6.0V         |
| Voltage at any input pin   | -0.3V ~ $V_{CC}+0.3V$ |
| Maximum junction temperature, $T_{JMAX}$   | +150°C                |
| Storage temperature range, $T_{STG}$   | -65°C ~ +150°C        |
| Operating temperature range, $T_A=T_J$   | -40°C ~ +125°C        |
| Package thermal resistance, junction to ambient (4 layer standard test PCB based on JESD 51-2A), $\theta_{JA}$ | 52°C/W                |
| ESD (HBM)  | ±8kV                  |
| ESD (CDM)  | ±750V                 |

**Note 5:** Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other condition beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

## ELECTRICAL CHARACTERISTICS

The following specifications apply for  $V_{CC}=5V$ ,  $T_A=25^\circ C$ , unless otherwise noted.

| Symbol     | Parameter  | Conditions   | Min. | Typ. | Max. | Unit    |
|------------|--|--|------|------|------|---------|
| $V_{CC}$   | Supply voltage   |  | 2.7  |      | 5.5  | V       |
| $I_{CC}$   | Quiescent power supply current   | $V_{SDB}=V_{CC}$ , all LEDs off                                    |      | 2.3  | 3    | mA      |
| $I_{SD}$   | Shutdown current   | $V_{SDB}=0V$   |      | 2.8  | 4    | $\mu A$ |
|            |  | $V_{SDB}=V_{CC}$ , Configuration Register written “0000 0000”      |      | 2.8  | 4    |         |
| $I_{OUT}$  | Maximum constant current of CSx  | $R_{ISET}=10k\Omega$ , $GCC=0xFF$ , $SL=0xFF$                      |      | 34.5 |      | mA      |
| $I_{LED}$  | Average current on each LED<br>$I_{LED} = I_{OUT(PEAK)}/Duty(1/4.14)$                          | $R_{ISET}=10k\Omega$ , $GCC=0xFF$ , $SL=0xFF$                      |      | 8.33 |      | mA      |
| $V_{HR}$   | Current switch headroom voltage SWx  | $I_{SWITCH}=612mA$ , $R_{ISET}=10k\Omega$ , $GCC=0xFF$ , $SL=0xFF$ |      | 450  |      | mV      |
|            | Current sink headroom voltage CSx  | $I_{SINK}=34mA$ , $R_{ISET}=10k\Omega$ , $GCC=0xFF$ , $SL=0xFF$    |      | 250  |      |         |
| $t_{SCAN}$ | Period of scanning   |  |      | 33   |      | $\mu s$ |
| $t_{NOL1}$ | Non-overlap blanking time during scan, the SWx and CSy are all off during this time            |  |      | 0.83 |      | $\mu s$ |
| $t_{NOL2}$ | Delay total time for CS1 to CS18, during this time, the SWx is on but CSx is not all turned on | (Note 6)   |      | 0.3  |      | $\mu s$ |

## Logic Electrical Characteristics (SCK, MISO, MOSI, CS, SDB)

|           |                                  |   |               |     |             |    |
|-----------|----------------------------------|---|---------------|-----|-------------|----|
| $V_{IL}$  | Logic “0” input voltage          | $V_{IO}=1.8V$ , $V_{IO}=3.3V$                 | GND           |     | $0.2V_{IO}$ | V  |
| $V_{IH}$  | Logic “1” input voltage          | $V_{IO}=1.8V$ , $V_{IO}=3.3V$                 | $0.75V_{IO}$  |     | $V_{IO}$    | V  |
| $V_{HYS}$ | Input Schmitt trigger hysteresis | $V_{IO}=3.3V$                                 |               | 0.2 |             | V  |
| $V_{OH}$  | H level MISO pin output voltage  | $I_{OH}=-8mA$ , $V_{IO}=1.8V$ , $V_{IO}=3.3V$ | $V_{IO}-0.4V$ |     | $V_{IO}$    | V  |
| $V_{OL}$  | L level MISO pin output voltage  | $I_{OL}=8mA$ , $V_{IO}=1.8V$ , $V_{IO}=3.3V$  | 0             |     | 0.4         | V  |
| $I_{IL}$  | Logic “0” input current          | SDB=L, $V_{INPUT} = L$ (Note 6)               |               | 5   |             | nA |
| $I_{IH}$  | Logic “1” input current          | SDB=L, $V_{INPUT} = H$ (Note 6)               |               | 5   |             | nA |

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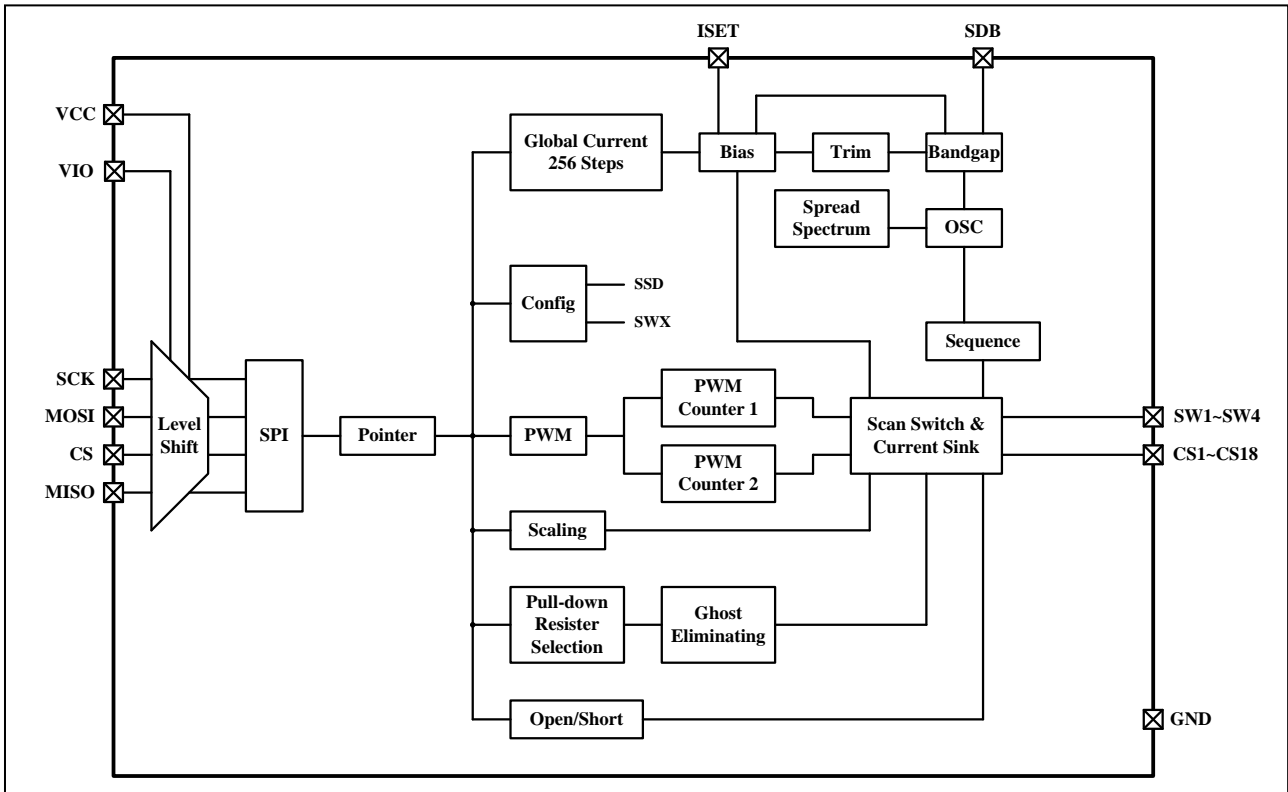
## DIGITAL INPUT SPI SWITCHING CHARACTERISTICS (NOTE 6)

| Symbol     | Parameter                 | Min. | Typ. | Max. | Units |
|------------|---------------------------|------|------|------|-------|
| $f_C$      | Clock frequency           | -    |      | 12   | MHz   |
| $t_{SLCH}$ | CS active set-up time     | 34   |      |      | ns    |
| $t_{SHCH}$ | CS not active set-up time | 17   |      |      | ns    |
| $t_{SHSL}$ | CS detect time            | 167  |      |      | ns    |
| $t_{CHSH}$ | CS active hold time       | 34   |      |      | ns    |
| $t_{CHSL}$ | CS not active hold time   | 17   |      |      | ns    |
| $t_{CH}$   | Clock high time           | 34   |      |      | ns    |
| $t_{CL}$   | Clock low time            | 34   |      |      | ns    |
| $t_{CLCH}$ | Clock rise time           |      |      | 9    | ns    |
| $t_{CHCL}$ | Clock fall time           |      |      | 9    | ns    |
| $t_{DVCH}$ | Data in set-up time       | 7    |      |      | ns    |
| $t_{CHDX}$ | Data in hold time         | 9    |      |      | ns    |
| $t_{SHQZ}$ | Output disable time       |      |      | 34   | ns    |
| $t_{CLQV}$ | Clock low to output valid |      |      | 39   | ns    |
| $t_{CLQX}$ | Output hold time          | 0    |      |      | ns    |
| $t_{QLQH}$ | Output rise time          |      |      | 17   | ns    |
| $t_{QLQH}$ | Output fall time          |      |      | 17   | ns    |

**Note 6:** Guaranteed by design.

# IS31FL3746B

## FUNCTIONAL BLOCK DIAGRAM



# IS31FL3746B

## DETAILED DESCRIPTION

### SPI INTERFACE

IS31FL3746B uses a SPI protocol to control the chip's function with four wires: CS, SCK, MOSI and MISO. SPI transfer starts from CS pin from high to low controlled by Master (Microcontroller), and IS31FL3746B latches data when clock rising.

SPI data format is 8-bit length. The first command byte composite of 1-bit R/W bit, 3-bit chip ID bit and 4-bit page bit. The command byte must be sent first, and is followed by register address byte then the register data. If the R/W bit is "0", it will be write operation and Master (Micro-controller) can write the register data into the register.

The maximum SCK frequency supported in IS31FL3746B is 12MHz.

**Table 1 SPI Command Byte**

| Name  | R/W                 | ID bit | Page No.                                       |
|-------|---------------------|--------|--|
| Bit   | D7                  | D6:D4  | D3:D0  |
| Value | 0: Write<br>1: Read | 100    | 0x00: Point to Page 0<br>0x01: Point to Page 1 |

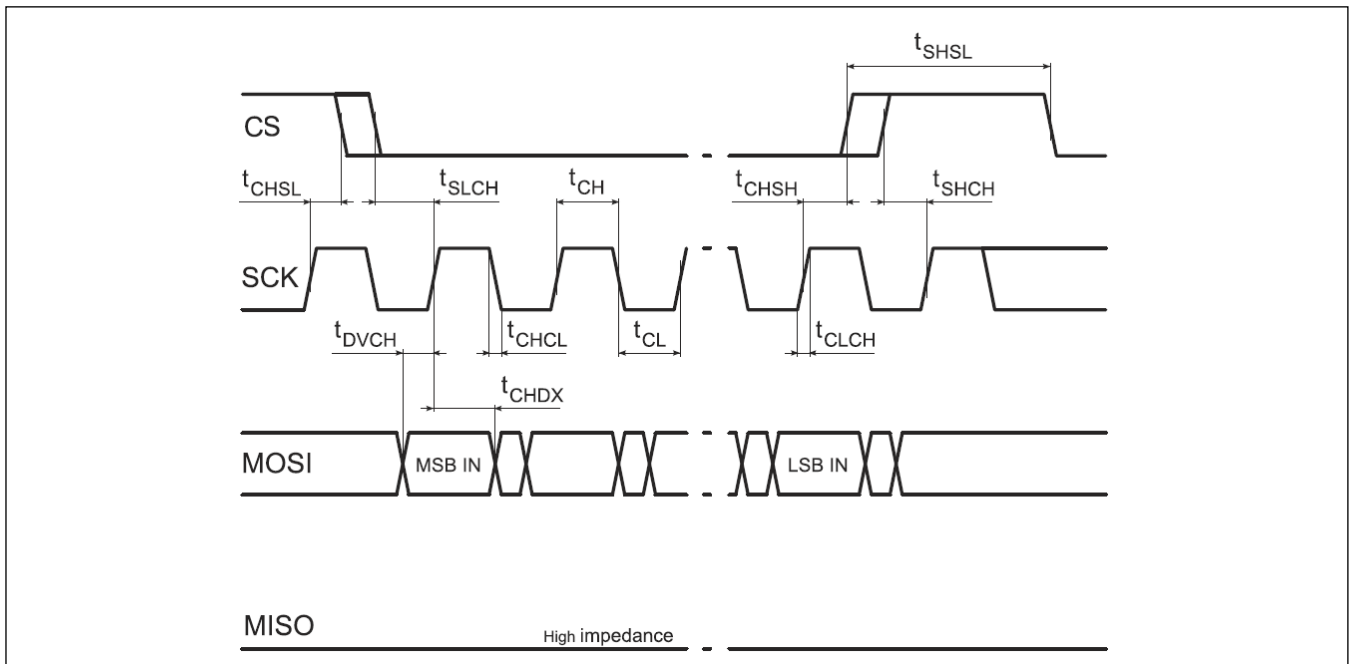
### ADDRESS AUTO INCREMENT

To write multiple bytes of data into IS31FL3746B, load the address of the data register that the first data byte is intended for. During the 8<sup>th</sup> rising edge of receiving the data byte, the internal address pointer will increment by one. The next data byte sent to IS31FL3746B will be placed in the new address, and so on. The auto increment of the address will continue as long as data continues to be written to IS31FL3746B (Figure 6).

### READING OPERATION

Page 0~Page 1 registers can be read by SPI.

To read the registers of Page 0 thru Page 1, The D7 of the Command Byte need to be set to "1" and select the page number. If read one register, as shown in figure 7, read the MISO data after sending the command byte and register address. If read more registers, as shown in figure 8, the register address will auto increase during the 8<sup>th</sup> rising edge of receiving the last bit of the previous register data.



**Figure 3 SPI Input Timing**



# IS31FL3746B

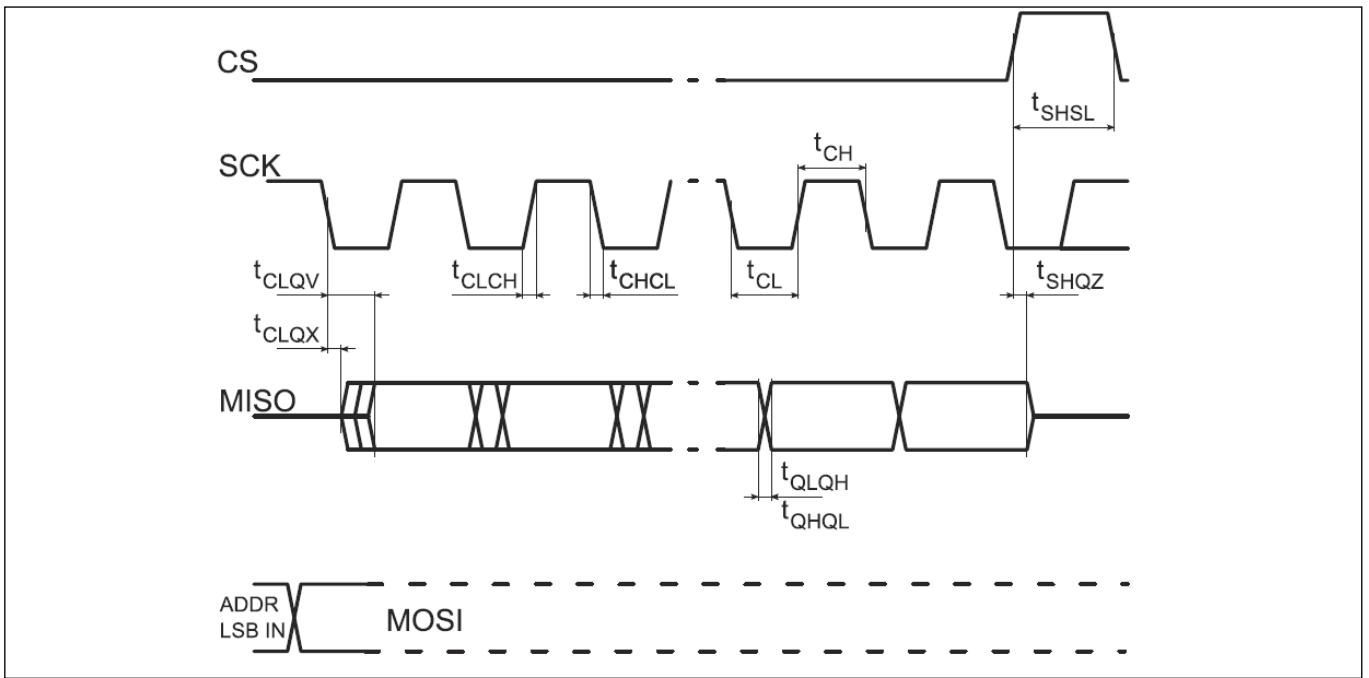


Figure 4 SPI Input Timing

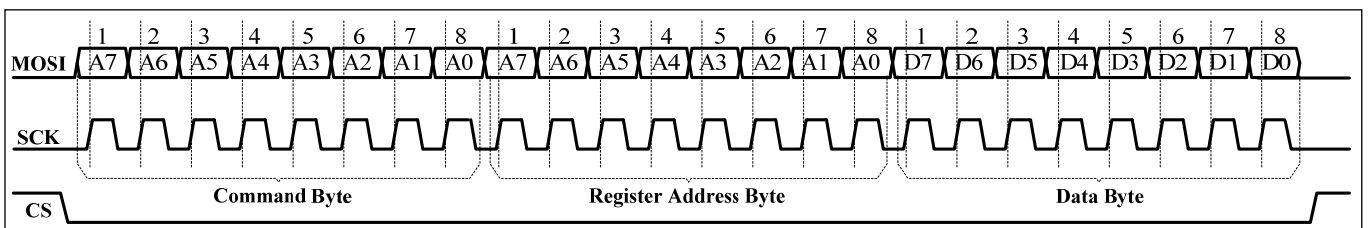


Figure 5 SPI writing to IS31FL3746B (Typical)

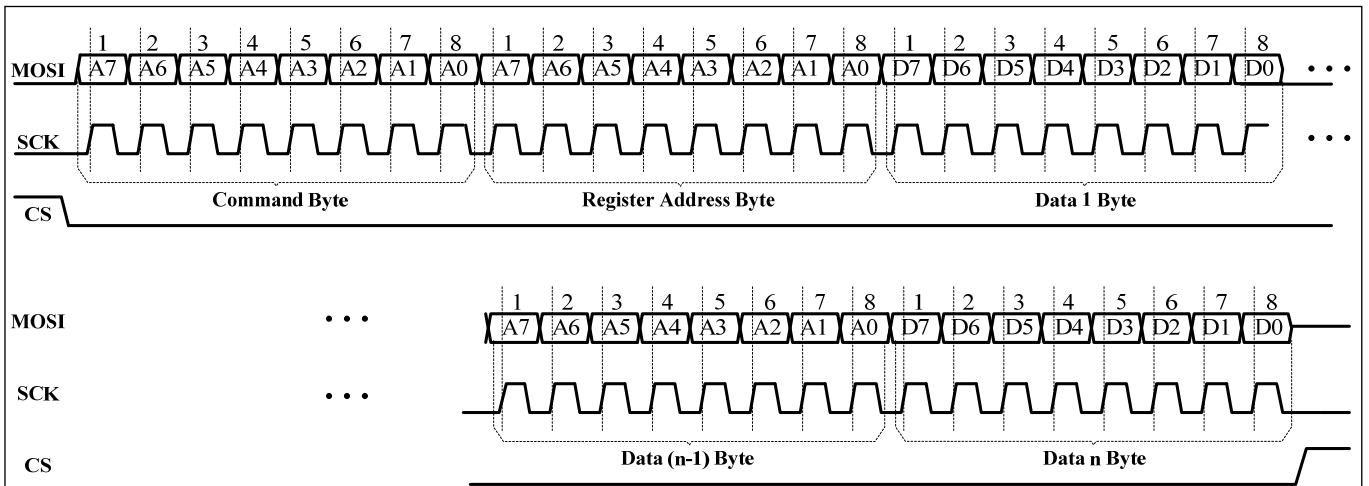


Figure 6 SPI writing to IS31FL3746B (Automatic Address Increment)

# IS31FL3746B

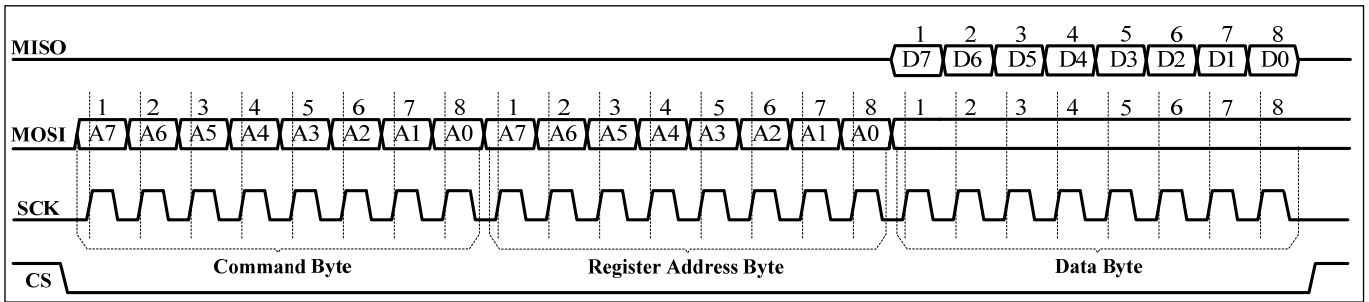


Figure 7 SPI Reading From IS31FL3746B (Typical)

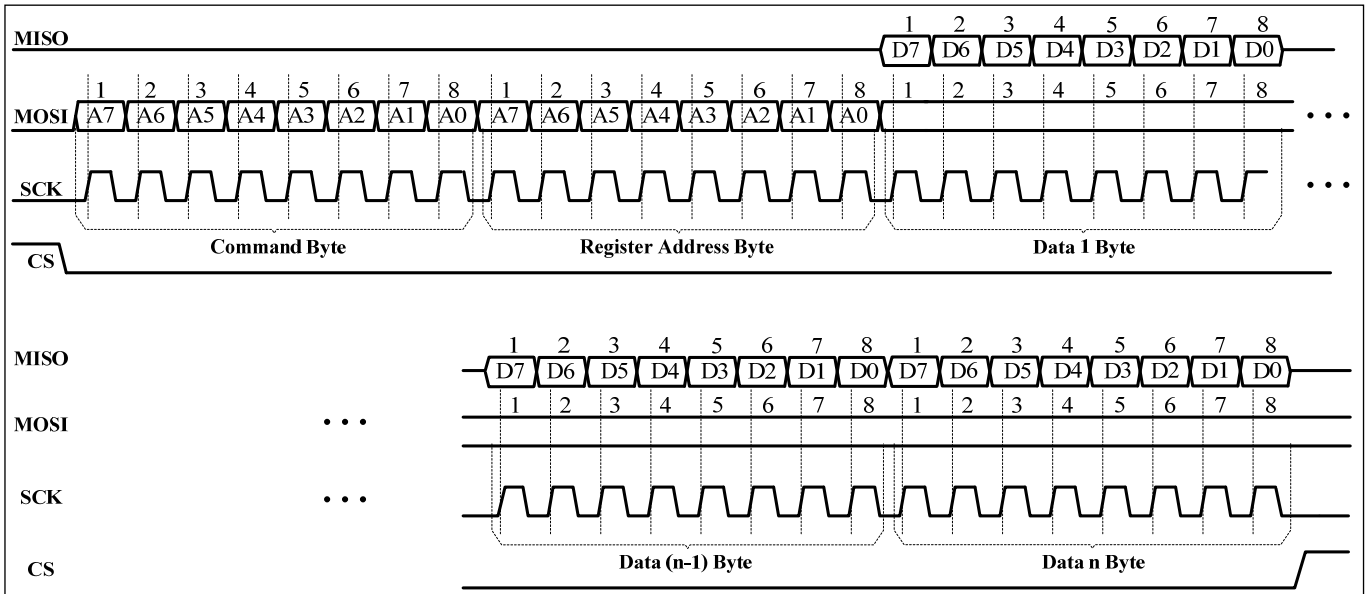


Figure 8 SPI Reading From IS31FL3746B (Automatic Address Increment)

# IS31FL3746B

**Table 2 Register Definition**

| Address                                 | Name                                     | Function  | Table | R/W | Default   |
|---|--|---|-------|-----|-----------|
| <b>PG0 (0x40): PWM Register</b>         |  |   |       |     |           |
| 01h~48h                                 | PWM Register                             | Set PWM for each LED  | 3     | R/W | 0000 0000 |
| <b>PG1 (0x41): LED Scaling Register</b> |  |   |       |     |           |
| 01h~48h                                 | Scaling Register                         | Set Scaling for each LED  | 4     | R/W | 0000 0000 |
| 50h                                     | Configuration Register                   | Configure the operation mode                                    | 6     | R/W | 0000 0000 |
| 51h                                     | Global Current Control Register          | Set the global current  | 7     | R/W | 0000 0000 |
| 52h                                     | Pull Down/Up Resistor Selection Register | Set the pull down resistor for SWx and pull up resistor for CSy | 8     | R/W | 0011 0011 |
| 53h~5Eh                                 | Open/Short Register                      | Store the open information                                      | 9     | R   | 0000 0000 |
| 5Fh                                     | Temperature Status                       | Store the temperature point of the IC                           | 10    | R/W | 0000 0000 |
| 60h                                     | Spread Spectrum Register                 | Spread spectrum function enable                                 | 11    | R/W | 0000 0000 |
| 8Fh                                     | Reset Register                           | Reset all register to POR state                                 | -     | W   | 0000 0000 |
| E0h                                     | PWM Frequency Enable Register            | Enable PWM frequency setting                                    | 12    | W   | 0000 0000 |
| E2h                                     | PWM Frequency Setting Register           | Set the PWM frequency   | 13    | W   | 0000 0000 |

# IS31FL3746B

Page 0 (PG0, Page No. = 0x40): PWM Register

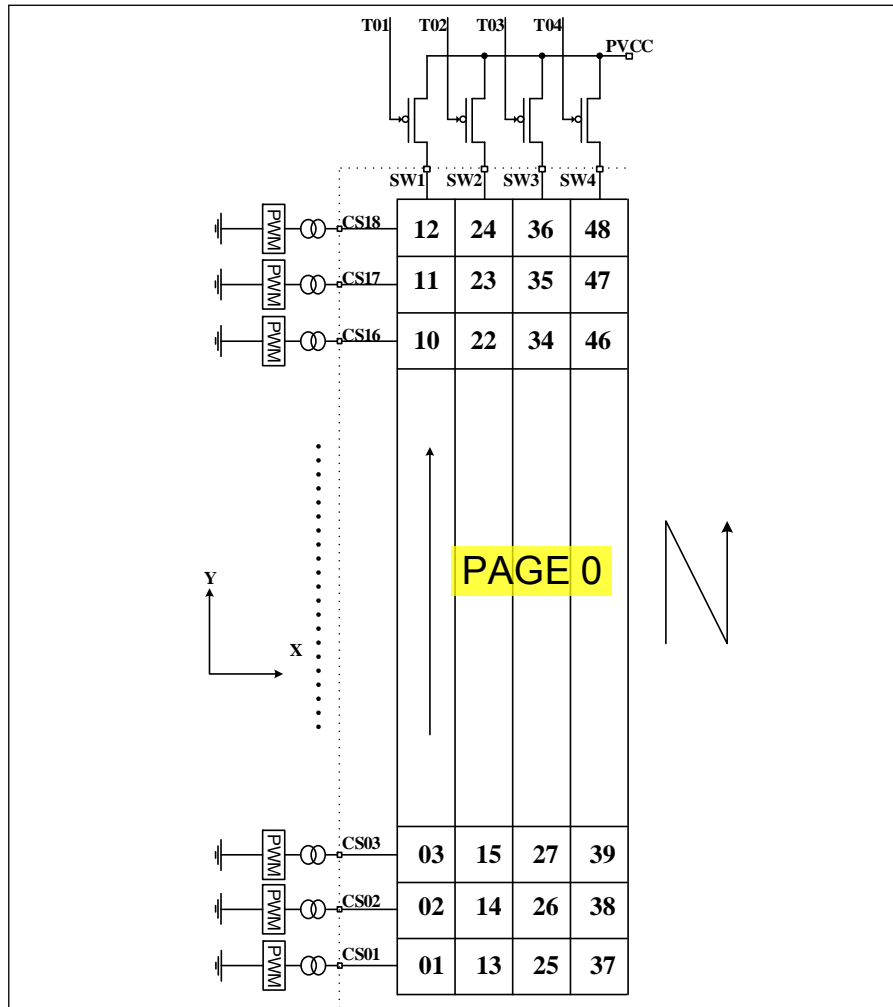


Figure 9 PWM Register

Table 3 PG0: 01h ~ 48h PWM Register

| Bit     | D7:D0     |
|---------|-----------|
| Name    | PWM       |
| Default | 0000 0000 |

Each dot has a byte to modulate the PWM duty in 256 steps.

The value of the PWM Registers decides the average current of each LED noted  $I_{LED}$ .

$I_{LED}$  computed by Formula (1):

$$I_{LED} = \frac{PWM}{256} \times I_{OUT(PEAK)} \times Duty \quad (1)$$

$$PWM = \sum_{n=0}^7 D[n] \cdot 2^n$$

Where Duty is the duty cycle of SWx,

$$Duty = \frac{33\mu s}{(33\mu s + 0.83\mu s + 0.3s)} \times \frac{1}{4} = \frac{1}{4.14} \quad (2)$$

$I_{OUT}$  is the output current of CSy (y=1~18),

$$I_{OUT(PEAK)} = \frac{343}{R_{ISET}} \times \frac{GCC}{256} \times \frac{SL}{256} \quad (3)$$

GCC is the Global Current Control Register (PG1, 51h) value, SL is the Scaling Register value as Table 9 and  $R_{ISET}$  is the external resistor of ISET pin. D[n] stands for the individual bit value, 1 or 0, in location n.

For example: if D7:D0=1011 0101 (0xB5, 181), GCC=1111 1111,  $R_{ISET}$  =10k $\Omega$ , SL=1111 1111:

$$I_{LED} = \frac{343}{10k\Omega} \times \frac{255}{256} \times \frac{255}{256} \times \frac{1}{4.14} \times \frac{181}{256}$$

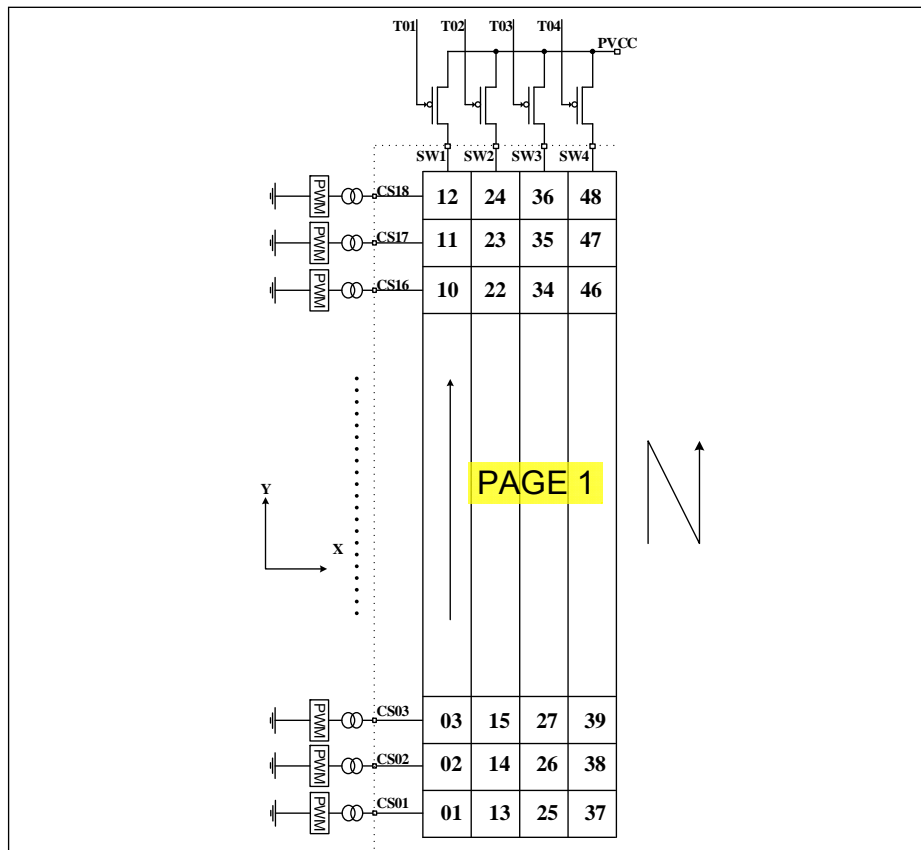


Figure 10 Scaling Register

Table 4 PG1: 01h ~ 48h Scaling Register

| Bit     | D7:D0     |
|---------|-----------|
| Name    | SL        |
| Default | 0000 0000 |

Scaling register control the DC output current of each dot. Each dot has a byte to modulate the scaling in 256 steps.

The value of the Scaling Register decides the peak current of each LED noted  $I_{OUT(PEAK)}$ .

$I_{OUT(PEAK)}$  computed by Formula (3):

$$I_{OUT(PEAK)} = \frac{343}{R_{ISET}} \times \frac{GCC}{256} \times \frac{SL}{256} \quad (3)$$

$$SL = \sum_{n=0}^7 D[n] \cdot 2^n$$

$I_{OUT}$  is the output current of CSy (y=1~18), GCC is the Global Current Control Register (PG1, 51h) value and  $R_{ISET}$  is the external resistor of ISET pin. D[n] stands for the individual bit value, 1 or 0, in location n.

For example: if  $R_{ISET}=10k\Omega$ ,  $GCC=1111\ 1111$ ,  $SL=0111\ 1111$ :

$$SL = \sum_{n=0}^7 D[n] \cdot 2^n = 127$$

$$I_{OUT} = \frac{343}{10k\Omega} \times \frac{255}{256} \times \frac{127}{256} = 16.8mA$$

$$I_{LED} = 16.8mA \times \frac{1}{4.14} \times \frac{PWM}{256}$$

# IS31FL3746B

**Table 5 Page 1 (PG1, Page No. = 0x41): Function Register**

| Register | Name                                     | Function  | Table | R/W | Default   |
|----------|--|---|-------|-----|-----------|
| 50h      | Configuration Register                   | Configure the operation mode                                    | 6     | R/W | 0000 0000 |
| 51h      | Global Current Control Register          | Set the global current  | 7     | R/W | 0000 0000 |
| 52h      | Pull Down/Up Resistor Selection Register | Set the pull down resistor for SWx and pull up resistor for CSy | 8     | R/W | 0011 0011 |
| 53h~5Eh  | Open/Short Register                      | Store the open/short information                                | 9     | R   | 0000 0000 |
| 5Fh      | Temperature Status                       | Store the temperature point of the IC                           | 10    | R/W | 0000 0000 |
| 60h      | Spread Spectrum Register                 | Spread spectrum function enable                                 | 11    | R/W | 0000 0000 |
| 8Fh      | Reset Register                           | Reset all register to POR state                                 | -     | W   | 0000 0000 |
| E0h      | PWM Frequency Enable Register            | Enable PWM frequency setting                                    | 12    | W   | 0000 0000 |
| E2h      | PWM Frequency Setting Register           | Set the PWM frequency   | 13    | W   | 0000 0000 |

**Table 6 50h Configuration Register**

| Bit     | D7:D4 | D3 | D2:D1 | D0  |
|---------|-------|----|-------|-----|
| Name    | SWS   | -  | OSDE  | SSD |
| Default | 0000  | 0  | 00    | 0   |

The Configuration Register sets operating mode of IS31FL3746B.

**SSD** Software Shutdown Control  
 0 Software shutdown  
 1 Normal operation

**OSDE** Open Short Detection Enable  
 00 Disable open/short detection  
 01/11 Enable open detection  
 10 Enable short detection

**SWS** SWx Setting  
 0000 SW1~SW4, 1/4  
 0001 SW1~SW3, 1/3, SW4 no-active  
 0010 SW1~SW2, 1/2, SW3~SW4 no-active  
 0011 All CSx work as current sinks only, no scan  
 Others SW1~SW4, 1/4

When OSDE set to "01", open detection will be trigger once, the user could trigger open detection again by set OSDE from "00" to "01".

When OSDE set "10", short detection will be trigger once, the user could trigger short detection again by set OSDE from "00" to "10".

When SSD is "0", IS31FL3746B works in software shutdown mode and to normal operate the SSD bit should set to "1".

SWS control the duty cycle of the SWx, default mode is 1/4.

**Table 7 51h Global Current Control Register**

| Bit     | D7:D0     |
|---------|-----------|
| Name    | GCC       |
| Default | 0000 0000 |

The Global Current Control Register modulates all CSy (y=1~18) DC current which is noted as I<sub>OUT</sub> in 256 steps.

I<sub>OUT</sub> is computed by the Formula (3):

$$I_{OUT(PEAK)} = \frac{343}{R_{ISET}} \times \frac{GCC}{256} \times \frac{SL}{256} \quad (3)$$

$$GCC = \sum_{n=0}^7 D[n] \cdot 2^n$$

Where D[n] stands for the individual bit value, 1 or 0, in location n.

**Table 8 52h Pull Down/Up Resistor Selection Register**

| Bit     | D7  | D6:D4 | D3 | D2:D0 |
|---------|-----|-------|----|-------|
| Name    | PHC | SWPDR | -  | CSPUR |
| Default | 0   | 011   | 0  | 011   |

Set pull down resistor for SWx and pull up resistor for CSy.

**PHC** Phase choice  
 0 0 degree phase delay  
 1 180 degree phase delay

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**SWPDR** SWx Pull down Resistor Selection Bit

|     |                            |
|-----|----------------------------|
| 000 | No pull down resistor      |
| 001 | 0.5kΩ only in SWx off time |
| 010 | 1.0kΩ only in SWx off time |
| 011 | 2.0kΩ only in SWx off time |
| 100 | 1.0kΩ all the time         |
| 101 | 2.0kΩ all the time         |
| 110 | 4.0kΩ all the time         |
| 111 | 8.0kΩ all the time         |

**CSPUR** CSy Pull up Resistor Selection Bit

|     |                            |
|-----|----------------------------|
| 000 | No pull up resistor        |
| 001 | 0.5kΩ only in CSx off time |
| 010 | 1.0kΩ only in CSx off time |
| 011 | 2.0kΩ only in CSx off time |
| 100 | 1.0kΩ all the time         |
| 101 | 2.0kΩ all the time         |
| 110 | 4.0kΩ all the time         |
| 111 | 8.0kΩ all the time         |

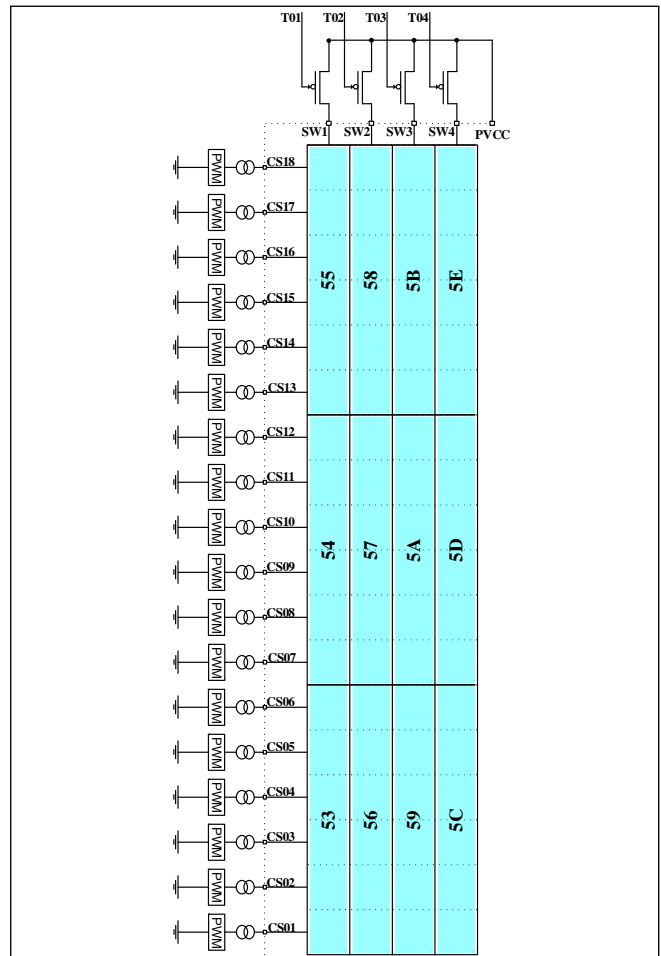
**Table 9 53h~5Eh Open/Short Register (Read Only)**

| Bit     | D7:D6 | D5:D0                             |
|---------|-------|-----------------------------------|
| Name    | -     | CS18:CS13,<br>CS12:CS07,CS06:CS01 |
| Default | 00    | 00 0000                           |

When OSDE (PG1, 50h) is set to "01", open detection will be trigger once, and the open information will be stored at 53h~5Eh.

When OSDE (PG1, 50h) set to "10", short detection will be trigger once, and the short information will be stored at 53h~5Eh.

Before set OSDE, the GCC should set to 0x0F~0x40 and the 52h should set to 0x00.



**Figure 11** Open/Short Register

**Table 10 5Fh Temperature Status**

| Bit     | D7:D4 | D3:D2 | D1:D0 |
|---------|-------|-------|-------|
| Name    | -     | TS    | TROF  |
| Default | 0000  | 00    | 00    |

TS store the temperature point of the IC. If the IC temperature reaches the temperature point the IC will trigger the thermal roll off and will decrease the current as TROF set percentage.

**TROF** percentage of output current

|    |      |
|----|------|
| 00 | 100% |
| 01 | 75%  |
| 10 | 55%  |
| 11 | 30%  |

**TS** Temperature Point, Thermal roll off start point

|    |       |
|----|-------|
| 00 | 140°C |
| 01 | 120°C |
| 10 | 100°C |
| 11 | 90°C  |

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**Table 11 60h Spread Spectrum Register**

| Bit     | D7:D6 | D4  | D3:D2 | D1:D0 |
|---------|-------|-----|-------|-------|
| Name    | -     | SSP | RNG   | CLT   |
| Default | 00    | 0   | 00    | 00    |

When SSP enable, the spread spectrum function will be enabled and the RNG & CLT bits will adjust the range and cycle time of spread spectrum function.

**SSP** Spread spectrum function enable  
 0 Disable  
 1 Enable

**RNG** Spread spectrum range  
 00 ±5%  
 01 ±15%  
 10 ±24%  
 11 ±34%

**CLT** Spread spectrum cycle time  
 00 1980µs  
 01 1200µs  
 10 820µs  
 11 660µs

**8Fh Reset Register**

Once user writes the Reset Register with 0xAE, IS31FL3746B will reset all the IS31FL3746B registers to their default value. On initial power-up, the IS31FL3746B registers are reset to their default values for a blank display.

**Table 12 E0h PWM Frequency Enable Register**

| Bit     | D7:D1    | D0   |
|---------|----------|------|
| Name    | -        | PFEN |
| Default | 0000 000 | 0    |

The PWM Frequency Enable Register enables or disables to change the PWM frequency. If PFEN="1", user can change the PWM frequency by modifying the E2h register.

**PFEN** PWM Frequency Enable  
 0 Disable  
 1 Enable

**Table 13 E2h PWM Frequency Setting Register**

| Bit     | D7:D5 | D4:D0  |
|---------|-------|--------|
| Name    | PF    | -      |
| Default | 000   | 0 0000 |

PWM Frequency Setting Register is used to set the PWM frequency.

**PF** PWM Frequency  
 000/111 29kHz  
 001 14.5kHz  
 010 7.25kHz  
 011 3.63kHz  
 100 1.81kHz  
 101 906Hz  
 110 453Hz



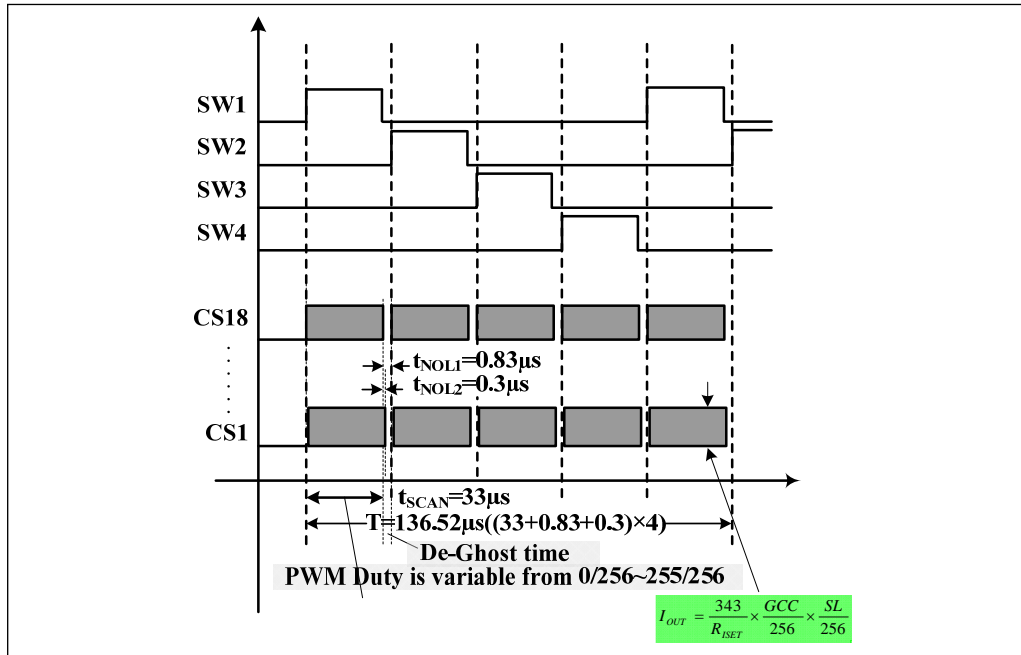


Figure 12 Scanning Timing

### SCANING TIMING

As shown in Figure 12, the SW1~SW4 is turned on by serial, LED is driven 4 by 4 within the SWx (x=1~4) on time (SWx, x=1~4 is source and it is high when LED on), including the non-overlap blanking time during scan, the duty cycle of SWx (active high, x=1~4) is:

$$Duty = \frac{33\mu s}{(33\mu s + 0.83\mu s + 0.3\mu s)} \times \frac{1}{4} = \frac{1}{4.14} \quad (2)$$

Where 33µs is  $t_{SCAN}$ , the period of scanning, 0.83µs is  $t_{NOL1}$ , 0.3µs is  $t_{NOL2}$ , the non-overlap time and CSy (y=1~18) delay time.

### PWM CONTROL

After setting the  $I_{OUT}$  and GCC, the brightness of each LEDs (LED average current ( $I_{LED}$ )) can be modulated with 256 steps by PWM Register, as described in Formula (1).

$$I_{LED} = \frac{PWM}{256} \times I_{OUT(PEAK)} \times Duty \quad (1)$$

Where PWM is PWM Registers (PG0, 01h~48h /PG0) data showing in Table 6.

For example, in Figure 1, if  $R_{SET} = 10k\Omega$ , PWM= 255, and GCC= 255, SL= 255, then

$$I_{OUT(PEAK)} = \frac{243}{10k\Omega} \times \frac{255}{256} \times \frac{255}{256} = 34mA$$

$$I_{LED} = I_{OUT(PEAK)} \times \frac{1}{4.14} \times \frac{PWM}{256}$$

Writing new data continuously to the registers can modulate the brightness of the LEDs to achieve a breathing effect.

### GAMMA CORRECTION

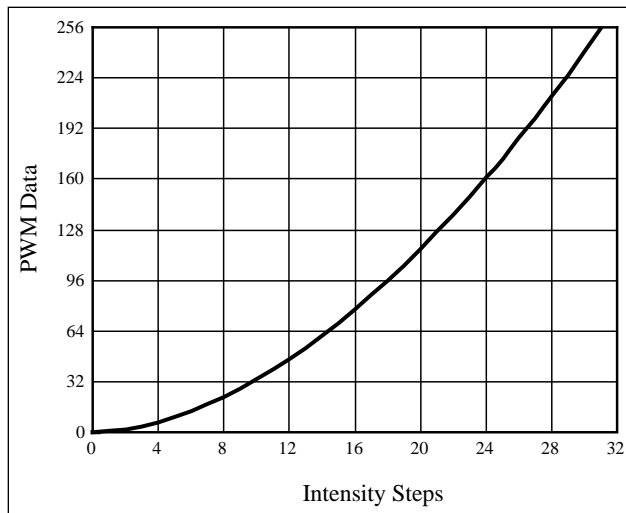
In order to perform a better visual LED breathing effect we recommend using a gamma corrected PWM value to set the LED intensity. This results in a reduced number of steps for the LED intensity setting, but causes the change in intensity to appear more linear to the human eye.

Gamma correction, also known as gamma compression or encoding, is used to encode linear luminance to match the non-linear characteristics of display. Since the IS31FL3746B can modulate the brightness of the LEDs with 256 steps, a gamma correction function can be applied when computing each subsequent LED intensity setting such that the changes in brightness matches the human eye's brightness curve.

Table 14 32 Gamma Steps with 256 PWM Steps

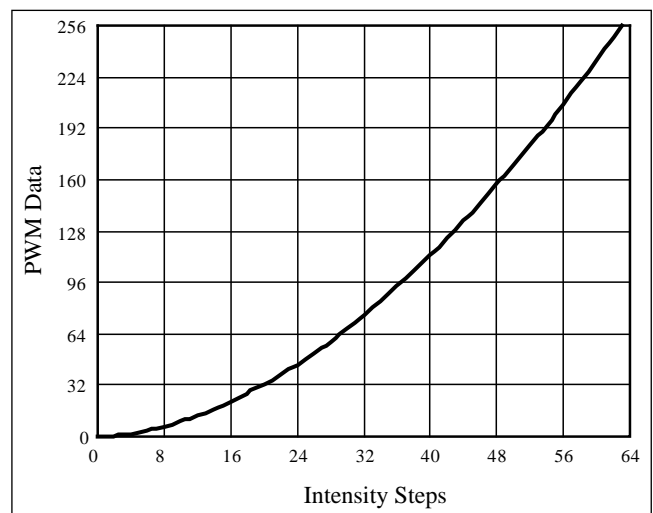
|       |       |       |       |       |       |       |       |
|-------|-------|-------|-------|-------|-------|-------|-------|
| C(0)  | C(1)  | C(2)  | C(3)  | C(4)  | C(5)  | C(6)  | C(7)  |
| 0     | 1     | 2     | 4     | 6     | 10    | 13    | 18    |
| C(8)  | C(9)  | C(10) | C(11) | C(12) | C(13) | C(14) | C(15) |
| 22    | 28    | 33    | 39    | 46    | 53    | 61    | 69    |
| C(16) | C(17) | C(18) | C(19) | C(20) | C(21) | C(22) | C(23) |
| 78    | 86    | 96    | 106   | 116   | 126   | 138   | 149   |
| C(24) | C(25) | C(26) | C(27) | C(28) | C(29) | C(30) | C(31) |
| 161   | 173   | 186   | 199   | 212   | 226   | 240   | 255   |

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**Figure 13** Gamma Correction (32 Steps)

Choosing more gamma steps provides for a more continuous looking breathing effect. This is useful for very long breathing cycles. The recommended configuration is defined by the breath cycle T. When T=1s, choose 32 gamma steps, when T=2s, choose 64 gamma steps. The user must decide the final number of gamma steps not only by the LED itself, but also based on the visual performance of the finished product.



**Figure 14** Gamma Correction (64 Steps)

**Note 7:** The data of 32 gamma steps is the standard value and the data of 64 gamma steps is the recommended value.

## OPERATING MODE

IS31FL3746B can only operate in PWM Mode. The brightness of each LED can be modulated with 256 steps by PWM registers. For example, if the data in PWM Register is "0000 0100", then the PWM is the fourth step.

Writing new data continuously to the registers can modulate the brightness of the LEDs to achieve a breathing effect.

## OPEN/SHORT DETECT FUNCTION

IS31FL3746B has open and short detect bit for each LED.

By setting the OSD bits of the Configuration Register (PG1, 50h) from "00" to "01" or "10", the LED Open/short Register will start to store the open/short information and after at least 2 scanning cycles and the MCU can get the open/short information by reading the 53h~5Eh, for those dots are turned off via LED Scaling Registers (PG1, 01h~48h), the open/short data will not get refreshed when setting the OSD bit of the Configuration Register.

To get the correct open and short information, two configurations need to set before setting the OSD bits:

- 1 0x0F ≤ GCC ≤ 0x40
- 2 52h = 0x00

Where GCC is the Global Current Control Register (PG1, 51h) and 52h is the Pull Down/UP Resistor Selection Register and set to 0x00 is to disable the SWx pull-down and CSx pull-up function.

The detect action is one-off event and each time before reading out the open/short information, the OSDE bit of the Configuration Register (PG1, 50h) need to be set from "00" to "01"/"10" (clear before set operation).

**Table 15** 64 Gamma Steps with 256 PWM Steps

|       |       |       |       |       |       |       |       |
|-------|-------|-------|-------|-------|-------|-------|-------|
| C(0)  | C(1)  | C(2)  | C(3)  | C(4)  | C(5)  | C(6)  | C(7)  |
| 0     | 1     | 2     | 3     | 4     | 5     | 6     | 7     |
| C(8)  | C(9)  | C(10) | C(11) | C(12) | C(13) | C(14) | C(15) |
| 8     | 10    | 12    | 14    | 16    | 18    | 20    | 22    |
| C(16) | C(17) | C(18) | C(19) | C(20) | C(21) | C(22) | C(23) |
| 24    | 26    | 29    | 32    | 35    | 38    | 41    | 44    |
| C(24) | C(25) | C(26) | C(27) | C(28) | C(29) | C(30) | C(31) |
| 47    | 50    | 53    | 57    | 61    | 65    | 69    | 73    |
| C(32) | C(33) | C(34) | C(35) | C(36) | C(37) | C(38) | C(39) |
| 77    | 81    | 85    | 89    | 94    | 99    | 104   | 109   |
| C(40) | C(41) | C(42) | C(43) | C(44) | C(45) | C(46) | C(47) |
| 114   | 119   | 124   | 129   | 134   | 140   | 146   | 152   |
| C(48) | C(49) | C(50) | C(51) | C(52) | C(53) | C(54) | C(55) |
| 158   | 164   | 170   | 176   | 182   | 188   | 195   | 202   |
| C(56) | C(57) | C(58) | C(59) | C(60) | C(61) | C(62) | C(63) |
| 209   | 216   | 223   | 230   | 237   | 244   | 251   | 255   |

# IS31FL3746B

## De-Ghost Function

The “ghost” term is used to describe the behavior of an LED that should be OFF but instead glows dimly when another LED is turned ON. A ghosting effect typically can occur when multiplexing LEDs. In matrix architecture any parasitic capacitance found in the constant-current outputs or the PCB traces to the LEDs may provide sufficient current to dimly light an LED to create a ghosting effect.

To prevent this LED ghost effect, the IS31FL3746B has integrated Pull down resistors for each SWx (x=1~4) and Pull up resistors for each CSy (y=1~18). Select the right SWx Pull down resistor (PG1, 52h) and CSy Pull up resistor (PG1, 52h) which eliminates the ghost LED for a particular matrix layout configuration.

Typically, selecting the 8kΩ will be sufficient to eliminate the LED ghost phenomenon.

The SWx Pull down resistors and CSy Pull up resistors are active only when the CSy/SWx output working the OFF state and therefore no power is lost through these resistors.

When IS31FL3746B works in hardware shutdown mode, the de-ghost function should be disabled, otherwise it will be extra about 1μA shutdown current.

## I2C RESET

The I2C will be reset if the SDB pin is pull-high from 0V to logic high, at the operating SDB rising edge, the I2C operation is not allowed.

## SHUTDOWN MODE

Shutdown mode can be used as a means of reducing power consumption. During shutdown mode all registers retain their data.

## Software Shutdown

By setting SSD bit of the Configuration Register (PG1, 50h) to “0”, the IS31FL3746B will operate in software shutdown mode. When the IS31FL3746B is in software shutdown, all current sources are switched off, so that the matrix is blanked. All registers can be operated. Typical current consume is 2.8μA.

## Hardware Shutdown

The chip enters hardware shutdown when the SDB pin is pulled low. All analog circuits are disabled during hardware shutdown, typical the current consume is 2.8μA.

The chip releases hardware shutdown when the SDB pin is pulled high. During hardware shutdown state Function Register can be operated.

If V<sub>CC</sub> has risk drop below 1.75V but above 0.1V during SDB pulled low, please re-initialize all Function Registers before SDB pulled high.

## LAYOUT

The IS31FL3746B consumes lots of power so good PCB layout will help improve the reliability of the chip. Please consider below factors when layout the PCB.

## Power Supply Lines

When designing the PCB layout pattern, the first step should consider about the supply line and GND connection, especially those traces with high current, also the digital and analog blocks' supply line and GND should be separated to avoid the noise from digital block affect the analog block.

At least one 0.1μF capacitor, if possible with a 0.47μF or 1μF capacitor is recommended to connected to the ground at each power supply pins of the chip, and it needs to close to the chip and the ground net of the capacitor should be well connected to the GND plane.

## R<sub>ISSET</sub>

R<sub>ISSET</sub> should be close to the chip and the ground side should well connect to the GND plane.

## Thermal Consideration

The over temperature of the chip may result in deterioration of the properties of the chip. IS31FL3746B has thermal pad but the chip could be very hot if power is very large. So do consider the ground area connects to the GND pins and thermal pad. Other traces should keep away and ensure the ground area below the package is integrated, and the back layer should be connected to the thermal pad thru 9 or 16 vias to be maximized the area size of ground plane.

# IS31FL3746B

## Current Rating Example

For a  $R_{SET}=10k\Omega$  application, the current rating for each net is as follows:

- VCC and SWx pins=  $34mA \times 18=612mA$ , recommend trace width:  $0.2032mm \sim 0.5mm$ .
- CSy pins=  $34mA$ , recommend trace width:  $0.1016mm \sim 0.254mm$ .
- All other pins <  $3mA$ , recommend trace width:  $0.1016mm \sim 0.254mm$ .

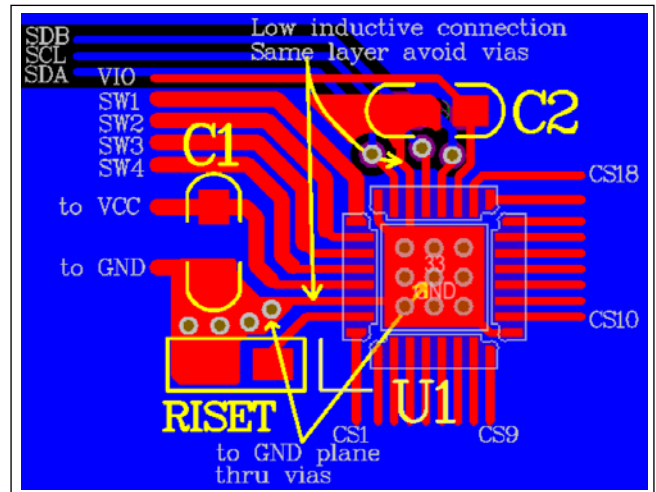


Figure 15 Layout Example

# IS31FL3746B

## CLASSIFICATION REFLOW PROFILES

| Profile Feature   | Pb-Free Assembly                 |
|---|----------------------------------|
| <b>Preheat &amp; Soak</b><br>Temperature min (T <sub>smin</sub> )<br>Temperature max (T <sub>smax</sub> )<br>Time (T <sub>smin</sub> to T <sub>smax</sub> ) (t <sub>s</sub> ) | 150°C<br>200°C<br>60-120 seconds |
| Average ramp-up rate (T <sub>smax</sub> to T <sub>p</sub> )   | 3°C/second max.                  |
| Liquidous temperature (T <sub>L</sub> )<br>Time at liquidous (t <sub>L</sub> )  | 217°C<br>60-150 seconds          |
| Peak package body temperature (T <sub>p</sub> )*  | Max 260°C                        |
| Time (t <sub>p</sub> )** within 5°C of the specified classification temperature (T <sub>c</sub> )   | Max 30 seconds                   |
| Average ramp-down rate (T <sub>p</sub> to T <sub>smax</sub> )   | 6°C/second max.                  |
| Time 25°C to peak temperature   | 8 minutes max.                   |

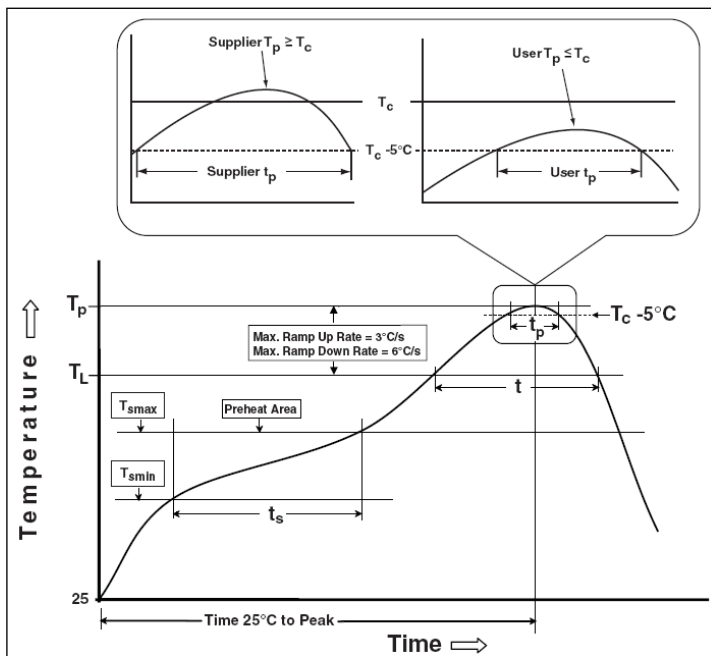
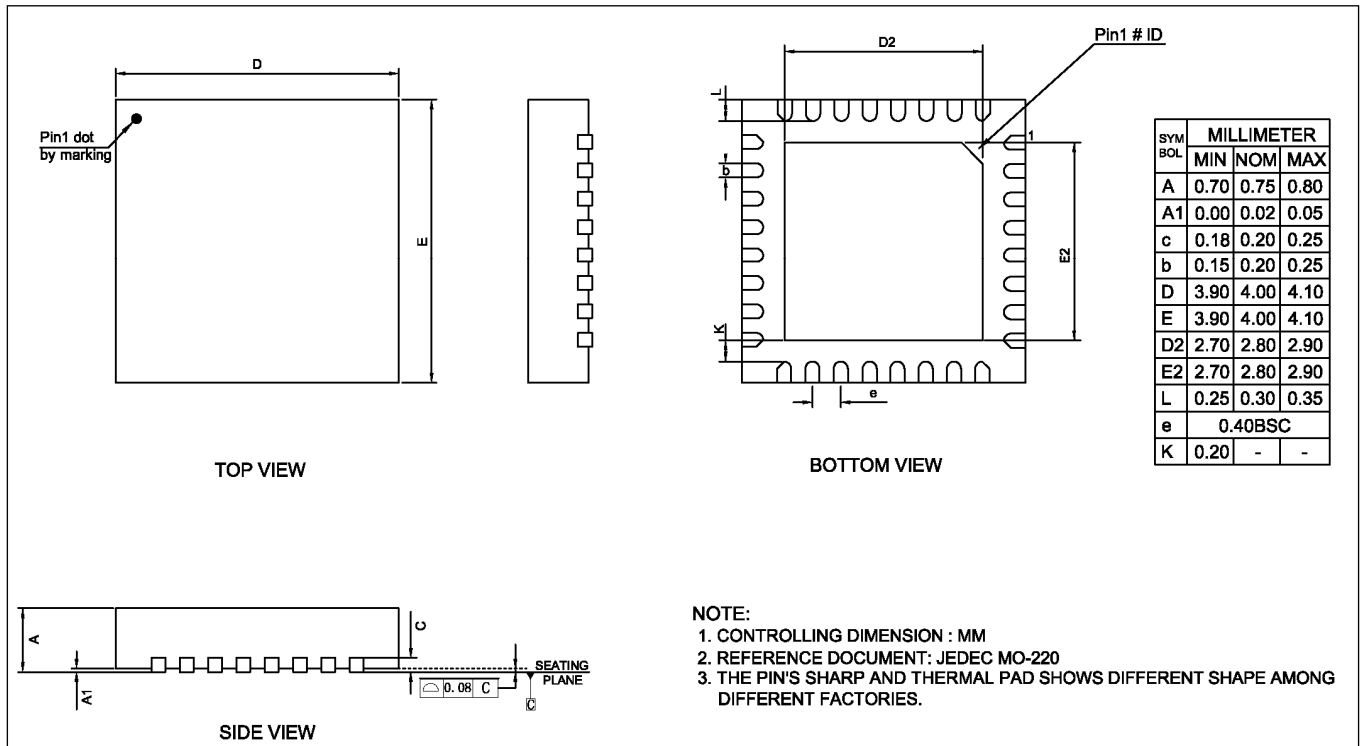


Figure 16 Classification Profile

# IS31FL3746B

## PACKAGE INFORMATION

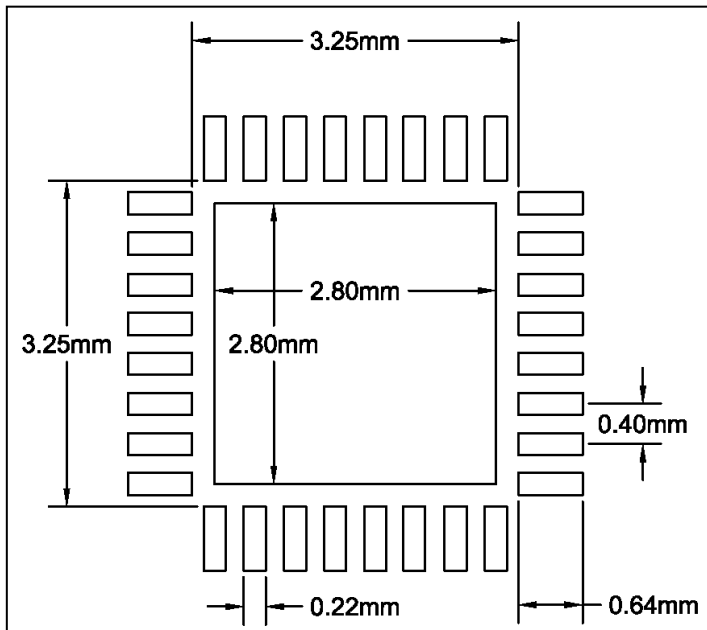
### QFN-32



# IS31FL3746B

## RECOMMENDED LAND PATTERN

### QFN-32



#### Note 8:

1. Land pattern complies to IPC-7351.
2. All dimensions in MM.
3. This document (including dimensions, notes & specs) is a recommendation based on typical circuit board manufacturing parameters. Since land pattern design depends on many factors unknown (eg. User's board manufacturing specs), user must determine suitability for use.



# IS31FL3746B

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## REVISION HISTORY

| Revision | Detail Information                              | Date       |
|----------|---|------------|
| 0B       | Initial release                                 | 2018.10.22 |
| A        | Update EC table, features and other information | 2018.12.11 |