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# IS32FL3738

## 6×8 DOTS MATRIX LED DRIVER WITH INDIVIDUAL AUTO BREATH FUNCTION

May 2018

### GENERAL DESCRIPTION

The IS32FL3738 is a general purpose 6×8 LEDs matrix driver with 1/12 cycle rate. The device can be programmed via an I2C compatible interface. Each LED can be dimmed individually with 8-bit × 4 PWM data which allowing 512 steps of linear dimming.

IS32FL3738 features 3 Auto Breathing Modes which are noted as ABM-1, ABM-2 and ABM-3. For each Auto Breathing Mode, there are 4 timing characters which include current rising / holding / falling / off time and 3 loop characters which include Loop-Beginning / Loop-Ending / Loop-Times. Every LED can be configured to be any Auto Breathing Mode or No-Breathing Mode individually.

Additionally each LED open and short state can be detected, IS32FL3738 store the open or short information in Open-Short Registers. The Open-Short Registers allowing MCU to read out via I2C compatible interface. Inform MCU whether there are LEDs open or short and the locations of open or short LEDs.

The IS32FL3738 operates from 2.7V to 5.5V and features a very low shutdown and operational current.

IS32FL3738 is available in eTSSOP-28 package. It operates from 2.7V to 5.5V over the temperature range of -40°C to +125°C.

### FEATURES

- Supply voltage range: 2.7V to 5.5V
- 8 current source outputs for row control
- 6 switch current inputs for column scan control
- Up to 48 LEDs (6×8) in dot matrix
- Programmable 6×8 (16 RGBs) matrix size with de-ghost function
- 1MHz I2C-compatible interface
- Selectable 3 Auto Breath Modes for each dot
- Auto breath loop features interrupt pin inform MCU auto breath loop completed
- Auto breath offers 128 steps gamma current, interrupt and state look up registers
- 256 steps global current setting
- Individual on/off control
- Individual 512 PWM control steps
- Individual Auto Breath Mode select
- Individual open and short error detect function
- Cascade for synchronization of chips
- eTSSOP-28 package
- Automotive AEC-Q100 qualified

### APPLICATIONS

- Automotive clusters
- Dashboards
- Automotive interiors

# IS32FL3738

## TYPICAL APPLICATION CIRCUIT

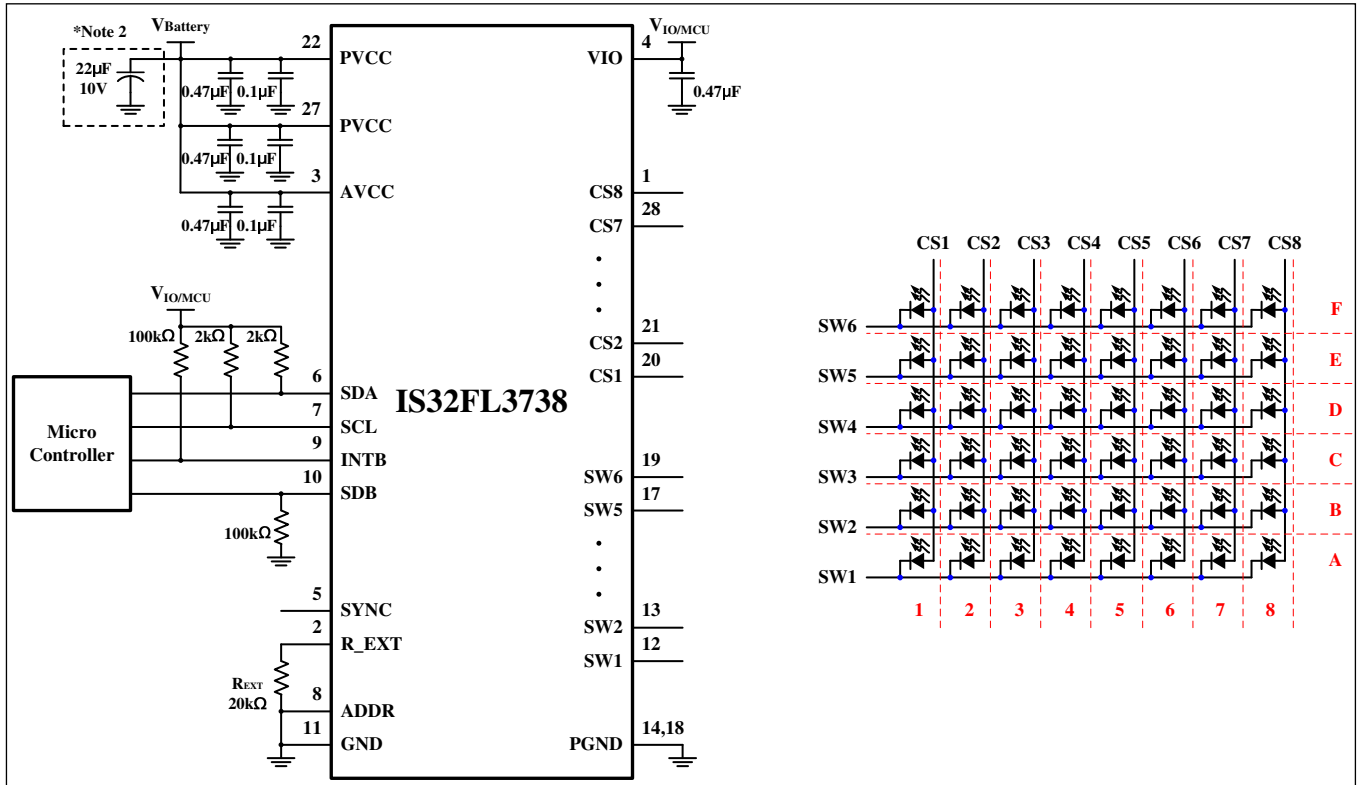


Figure 1 Typical Application Circuit (6x8)

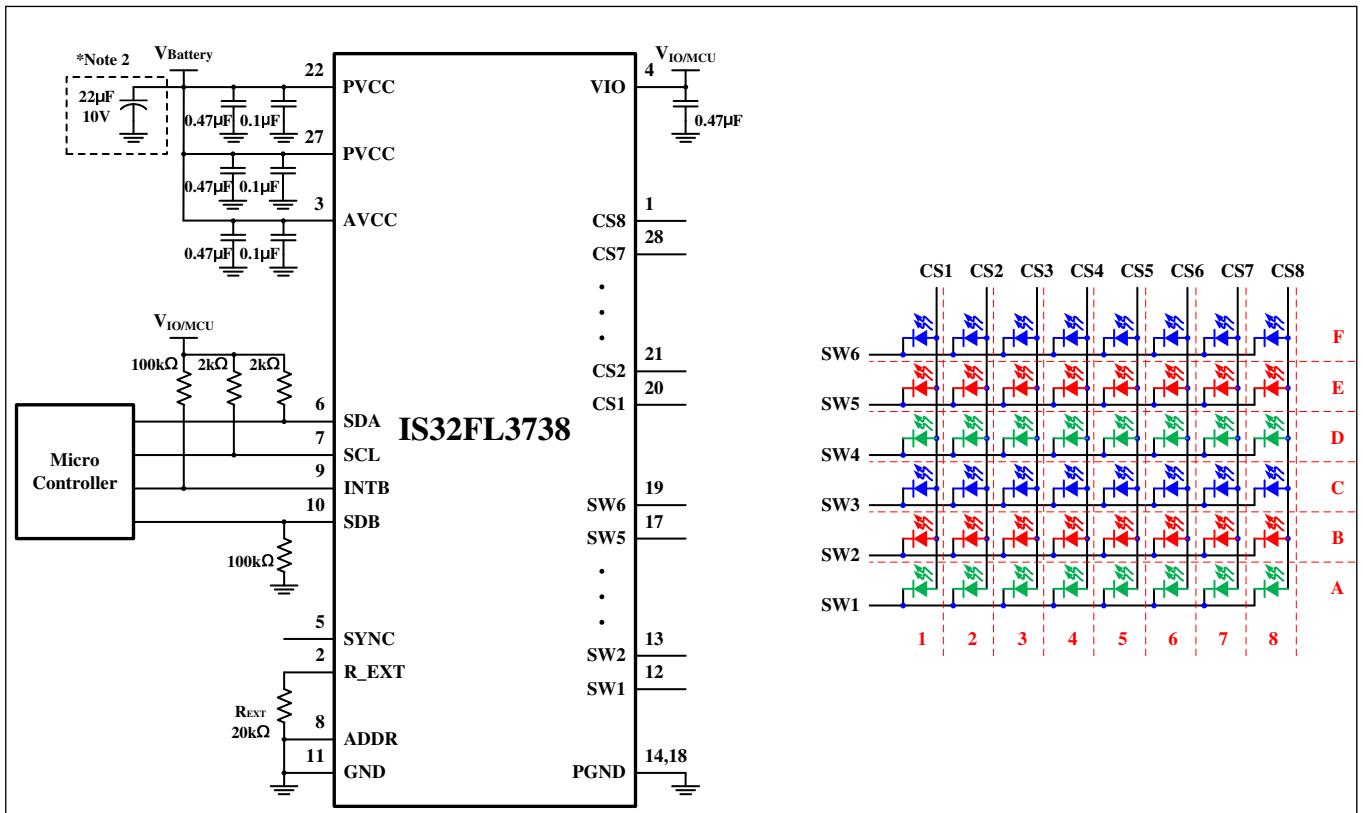


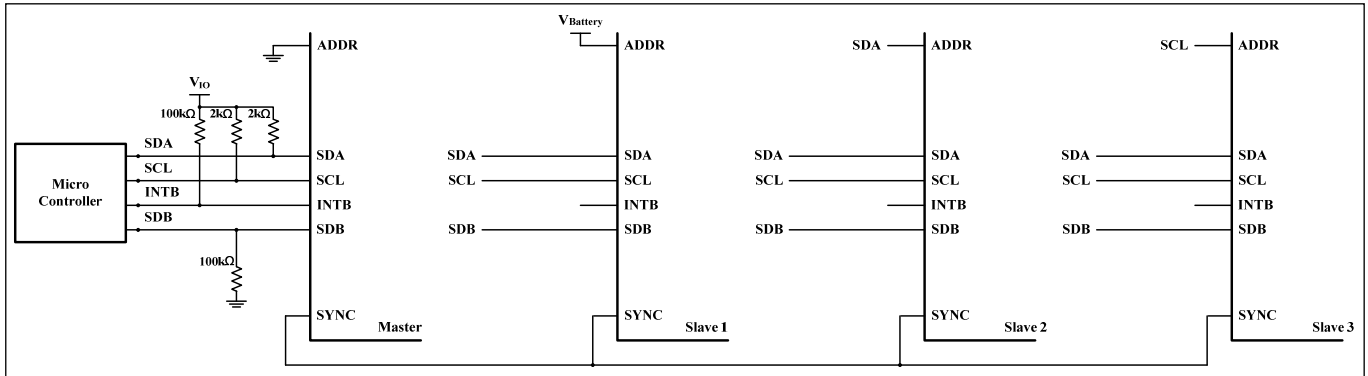
Figure 2 Typical Application Circuit (RGB)

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

**Note 2:** Electrolytic/Tantalum Capacitor maybe considered for high current application to avoid audible noise interference.

# IS32FL3738

## TYPICAL APPLICATION CIRCUIT (CONTINUED)



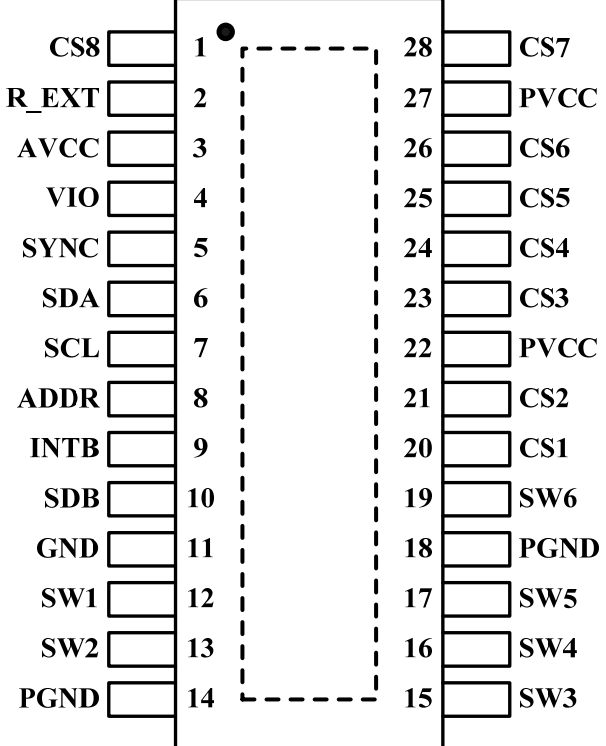
**Figure 3** Typical Application Circuit (Four Parts Synchronization-Work)

**Note 3:** One system should contain only one master, all slave parts should be configured as slave mode before the master is configured as master mode. Work as master mode or slave mode specified by Configuration Register (Function register, address 00h). Master part output master clock, and all the other parts which work as slave input this master clock.

**Note 4:** The  $V_{IO}$  should be  $1.8V \leq V_{IO} \leq V_{CC}$ . And it is recommended to be equal to  $V_{OH}$  of the micro controller. For example, if  $V_{OH}=1.8V$ , set  $V_{IO}=1.8V$ , if  $V_{OH}=3.3V$ , set  $V_{IO}=3.3V$ .

# IS32FL3738

## PIN CONFIGURATION

Package	Pin Configuration (Top View)
eTSSOP-28	

# IS32FL3738

## PIN DESCRIPTION

No.	Pin	Description
1	CS8	Current source.
2	R_EXT	Input terminal used to connect an external resistor. This regulates current source DC current value.
3	AVCC	Power for analog circuits.
4	VIO	Input logic reference voltage.
5	SYNC	Synchronize pin. It is used for more than one part work synchronize. If it is not used please float this pin.
6	SDA	I2C compatible serial data.
7	SCL	I2C compatible serial clock.
8	ADDR	I2C address setting.
9	INTB	Interrupt output pin. Register F0h sets the function of the INTB pin and active low when the interrupt event happens. Can be NC (float) if interrupt function no used.
10	SDB	Shutdown the chip when pull to low.
11	GND	Ground
12, 13	SW1, SW2	Switch pin for LED matrix scanning.
14, 18	PGND	Power GND, connect to GND.
15~17	SW3~ SW5	Switch pin for LED matrix scanning.
19	SW6	Switch pin for LED matrix scanning.
20, 21	CS1, CS2	Current source.
22, 27	PVCC	Power for current source.
23~26	CS3~ CS6	Current source.
28	CS7	Current source.
	Thermal Pad	Need to connect to GND pins.



# IS32FL3738

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## ORDERING INFORMATION

Automotive Range: -40°C to +125°C

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Order Part No.	Package	QTY/Reel
IS32FL3738-ZLA3-TR	eTSSOP-28, Lead-free	2500

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- a.) the risk of injury or damage has been minimized;
- b.) the user assume all such risks; and
- c.) potential liability of Integrated Silicon Solution, Inc is adequately protected under the circumstances

# IS32FL3738

## 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, $T_A$	-40°C ~ +125°C
Package thermal resistance, junction to ambient (4 layer standard test PCB based on JEDEC standard), $\theta_{JA}$	30.1°C/W
Package thermal resistance, junction to thermal PAD (4 layer standard test PCB based on JEDEC standard), $\theta_{JP}$	11.08°C/W
ESD (HBM)	±2kV
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  $V_{CC} = 3.6V$ ,  $T_A = 25^\circ C$ , 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		2.17		mA
$I_{SD}$	Shutdown current	$V_{SDB} = 0V$		3		µA
		$V_{SDB} = V_{CC}$ , Configuration Register written “0000 0000”		3		
$I_{OUT}$	Maximum constant current of CS1~CS8	$R_{EXT}=20k\Omega$		84		mA
$I_{LED}$	Average current on each LED $I_{LED} = (I_{OUT}/12.75)\times 2$	$R_{EXT}=20k\Omega$ , $GCC=255$ , $PWM = 255$		13.2		mA
$V_{HR}$	Current sink headroom voltage SW1~SW6	$I_{SINK} = 672mA$ (Note 6, 7)		350		mV
	Current source headroom voltage CS1~C8	$I_{SOURCE} = 84mA$ (Note 6)		350		
$t_{SCAN}$	Period of scanning			128		µs
$t_{NOL}$	Non-overlap blanking time during scan, the SWy and CSx are all off during this time			8		µs

## Logic Electrical Characteristics (SDA, SCL, ADDR, SYNC, SDB)

$V_{IL}$	Logic “0” input voltage	$V_{IO}=3.6V$	GND		$0.2V_{IO}$	V
$V_{IH}$	Logic “1” input voltage	$V_{IO}=3.6V$	$0.75V_{IO}$		$V_{IO}$	V
$V_{HYS}$	Input Schmitt trigger hysteresis	$V_{IO}=3.6V$		0.2		V
$V_{OL}$	Logic “0” output voltage for SYNC	$I_{OL} = 8mA$			0.4	V
$V_{OH}$	Logic “1” output voltage for SYNC	$I_{OH} = 8mA$	$0.75V_{IO}$			V
$I_{IL}$	Logic “0” input current	$V_{INPUT} = 0V$ (Note 8)		5		nA
$I_{IH}$	Logic “1” input current	$V_{INPUT} = V_{IO}$ (Note 8)		5		nA



# IS32FL3738

## DIGITAL INPUT SWITCHING CHARACTERISTICS (NOTE 8)

Symbol	Parameter	Fast Mode			Fast Mode Plus			Units
		Min.	Typ.	Max.	Min.	Typ.	Max.	
$f_{SCL}$	Serial-clock frequency	-		400	-		1000	kHz
$t_{BUF}$	Bus free time between a STOP and a START condition	1.3		-	0.5		-	$\mu$ s
$t_{HD, STA}$	Hold time (repeated) START condition	0.6		-	0.26		-	$\mu$ s
$t_{SU, STA}$	Repeated START condition setup time	0.6		-	0.26		-	$\mu$ s
$t_{SU, STO}$	STOP condition setup time	0.6		-	0.26		-	$\mu$ s
$t_{HD, DAT}$	Data hold time	-		-	-		-	$\mu$ s
$t_{SU, DAT}$	Data setup time	100		-	50		-	ns
$t_{LOW}$	SCL clock low period	1.3		-	0.5		-	$\mu$ s
$t_{HIGH}$	SCL clock high period	0.7		-	0.26		-	$\mu$ s
$t_R$	Rise time of both SDA and SCL signals, receiving	-		300	-		120	ns
$t_F$	Fall time of both SDA and SCL signals, receiving	-		300	-		120	ns

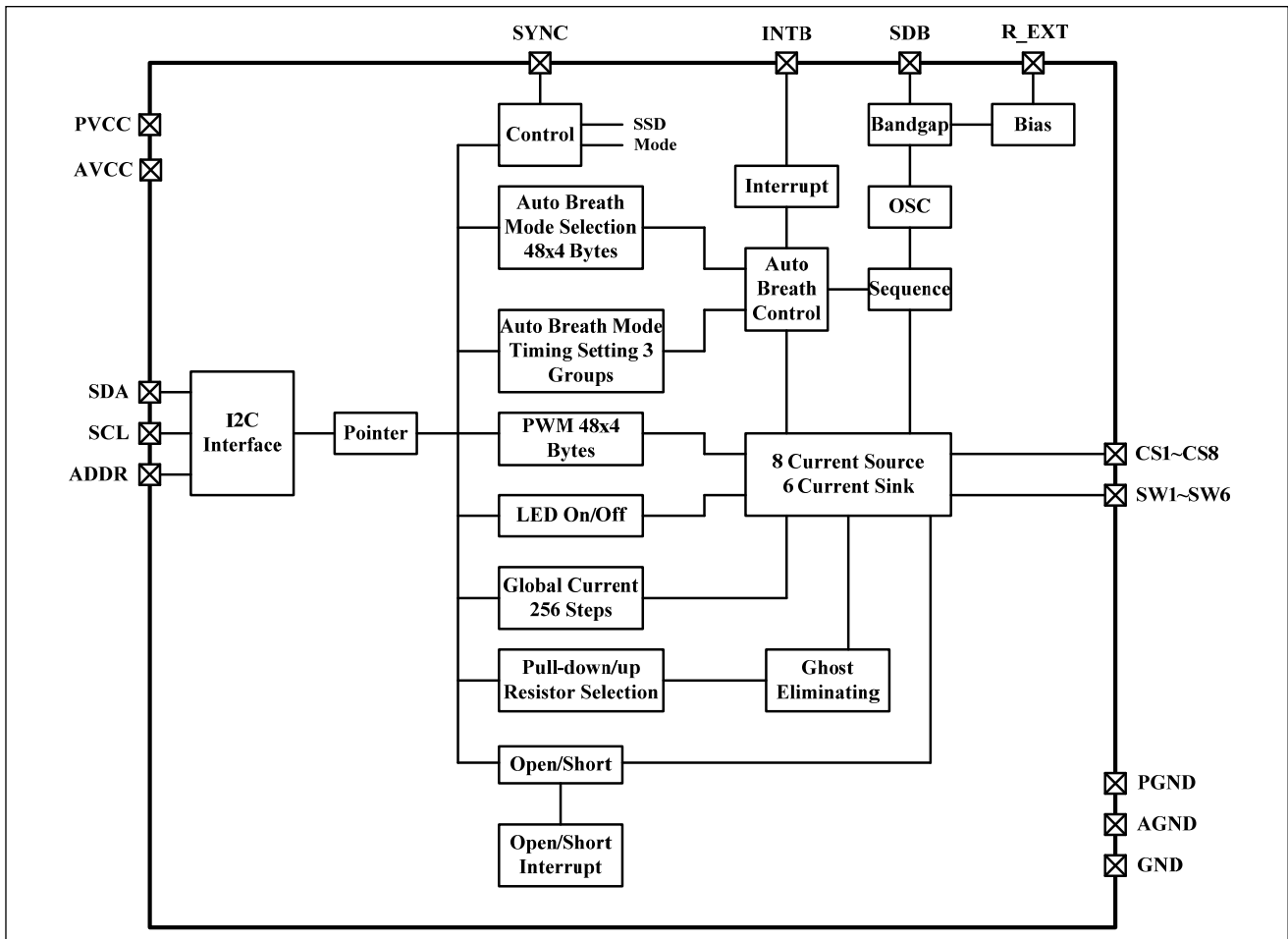
**Note 6:** In case of  $R_{EXT} = 20k\Omega$ , Global Current Control Register (PG3, 01h) written "1111 1111", GCC = "1111 1111".

**Note 7:** All LEDs are on and PWM = "1111 1111", GCC = "1111 1111".

**Note 8:** Guaranteed by design.

# IS32FL3738

## FUNCTIONAL BLOCK DIAGRAM



# IS32FL3738

## DETAILED DESCRIPTION

### I2C INTERFACE

The IS32FL3738 uses a serial bus, which conforms to the I2C protocol, to control the chip's functions with two wires: SCL and SDA. The IS32FL3738 has a 7-bit slave address (A7:A1), followed by the R/W bit, A0. Set A0 to "0" for a write command and set A0 to "1" for a read command. The value of bits A4:A1 are decided by the connection of the ADDR pin. The complete slave address is:

**Table 1 Slave Address:**

ADDR2	ADDR1	A7:A5	A4:A1	A0
GND	GND	101	0000	0/1
SCL	SCL		0101	
SDA	SDA		1010	
VCC	VCC		1111	

ADDR connected to GND, (A4:A1)=0000;  
 ADDR connected to VCC, (A4:A1)=1111;  
 ADDR connected to SCL, (A4:A1)=0101;  
 ADDR connected to SDA, (A4:A1)=1010;

The SCL line is uni-directional. The SDA line is bi-directional (open-collector) with a pull-up resistor (typically 1kΩ). The maximum clock frequency specified by the I2C standard is 1MHz. In this discussion, the master is the microcontroller and the slave is the IS32FL3738.

The timing diagram for the I2C is shown in Figure 4. The SDA is latched in on the stable high level of the SCL. When there is no interface activity, the SDA line should be held high.

The "START" signal is generated by lowering the SDA signal while the SCL signal is high. The start signal will alert all devices attached to the I2C bus to check the incoming address against their own chip address.

The 8-bit chip address is sent next, most significant bit first. Each address bit must be stable while the SCL level is high.

After the last bit of the chip address is sent, the master checks for the IS32FL3738's acknowledge. The master releases the SDA line high (through a pull-up resistor). Then the master sends an SCL pulse. If the IS32FL3738 has received the address correctly, then it holds the SDA line low during the SCL pulse. If the

SDA line is not low, then the master should send a "STOP" signal (discussed later) and abort the transfer.

Following acknowledge of IS32FL3738, the register address byte is sent, most significant bit first. IS32FL3738 must generate another acknowledge indicating that the register address has been received.

Then 8-bit of data byte are sent next, most significant bit first. Each data bit should be valid while the SCL level is stable high. After the data byte is sent, the IS32FL3738 must generate another acknowledge to indicate that the data was received.

The "STOP" signal ends the transfer. To signal "STOP", the SDA signal goes high while the SCL signal is high.

### ADDRESS AUTO INCREMENT

To write multiple bytes of data into IS32FL3738, load the address of the data register that the first data byte is intended for. During the IS32FL3738 acknowledge of receiving the data byte, the internal address pointer will increment by one. The next data byte sent to IS32FL3738 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 IS32FL3738 (Figure 7).

### READING OPERATION

Register FEh, F1h and 18h~2Dh, 30h~45h of Page 0, 11h of Page 3 can be read.

To read the FEh and F1h, after I2C start condition, the bus master must send the IS32FL3738 device address with the  $\overline{R/W}$  bit set to "0", followed by the register address (FEh or F1h) which determines which register is accessed. Then restart I2C, the bus master should send the IS32FL3738 device address with the  $\overline{R/W}$  bit set to "1". Data from the register defined by the command byte is then sent from the CHROMA-96 to the master (Figure 8).

To read the 18h~2Dh, 30h~45h of Page 0, 11h of Page 3, the FDh should write with 00h before follow the Figure 8 sequence to read the data, that means, when you want to read 18h~2Dh, 30h~45h of Page 0, 11h of Page 3, the FDh should point to Page 0 or Page 3 first and you can read the Page 0 and Page 3 data.

# IS32FL3738

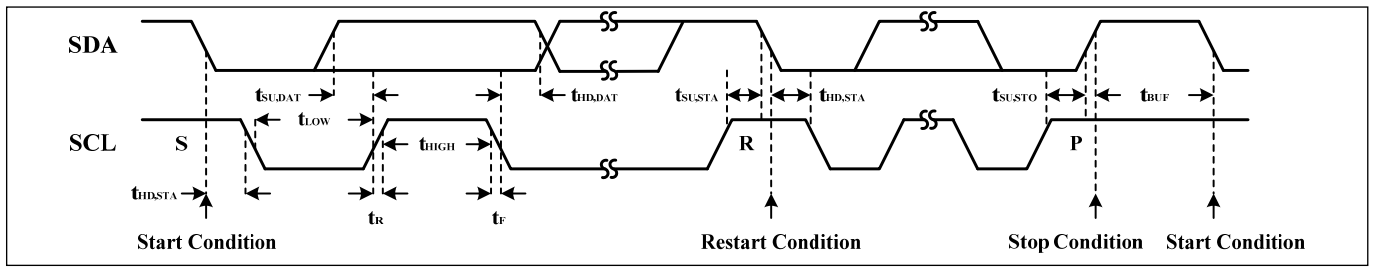


Figure 4 Interface timing

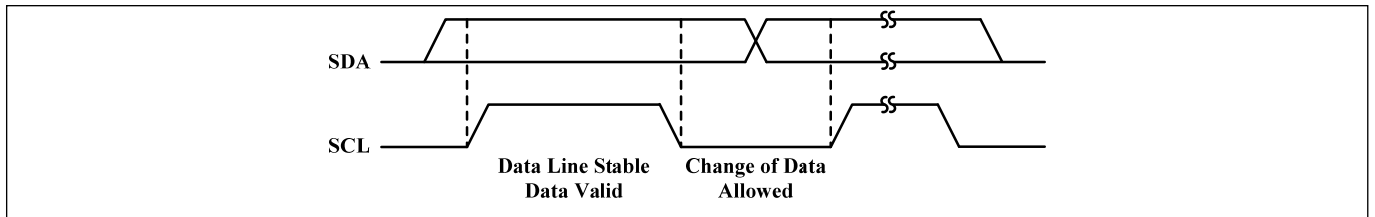


Figure 5 Bit transfer

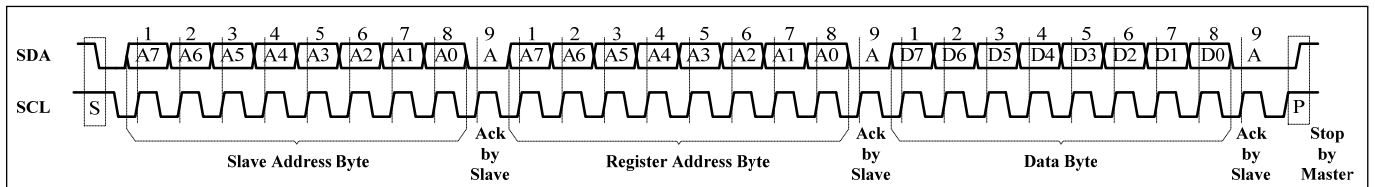


Figure 6 Writing to IS32FL3738 (Typical)

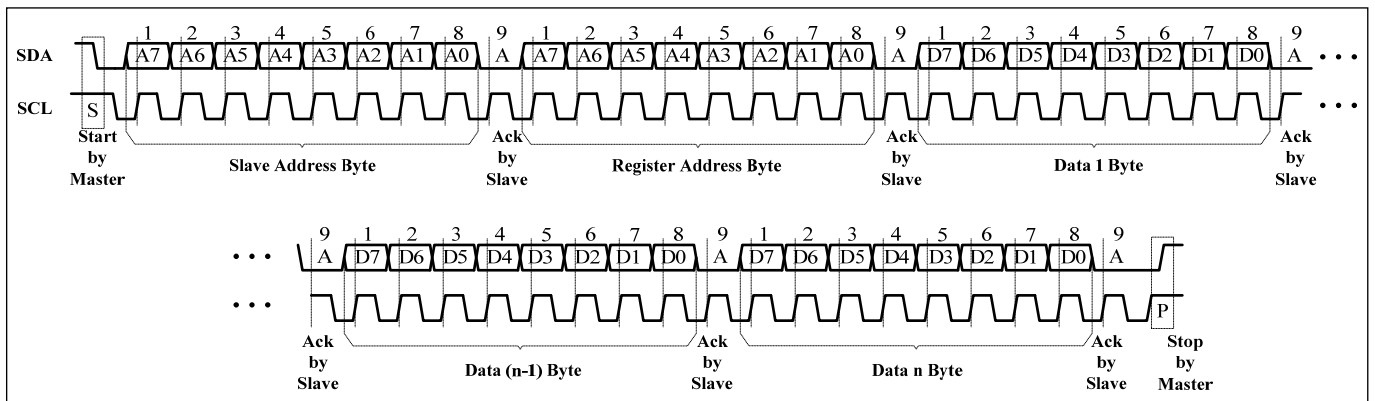


Figure 7 Writing to IS32FL3738 (Automatic address increment)

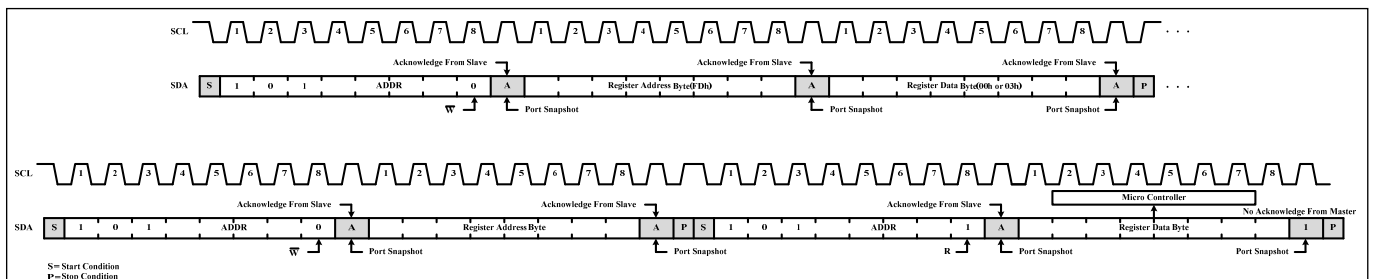


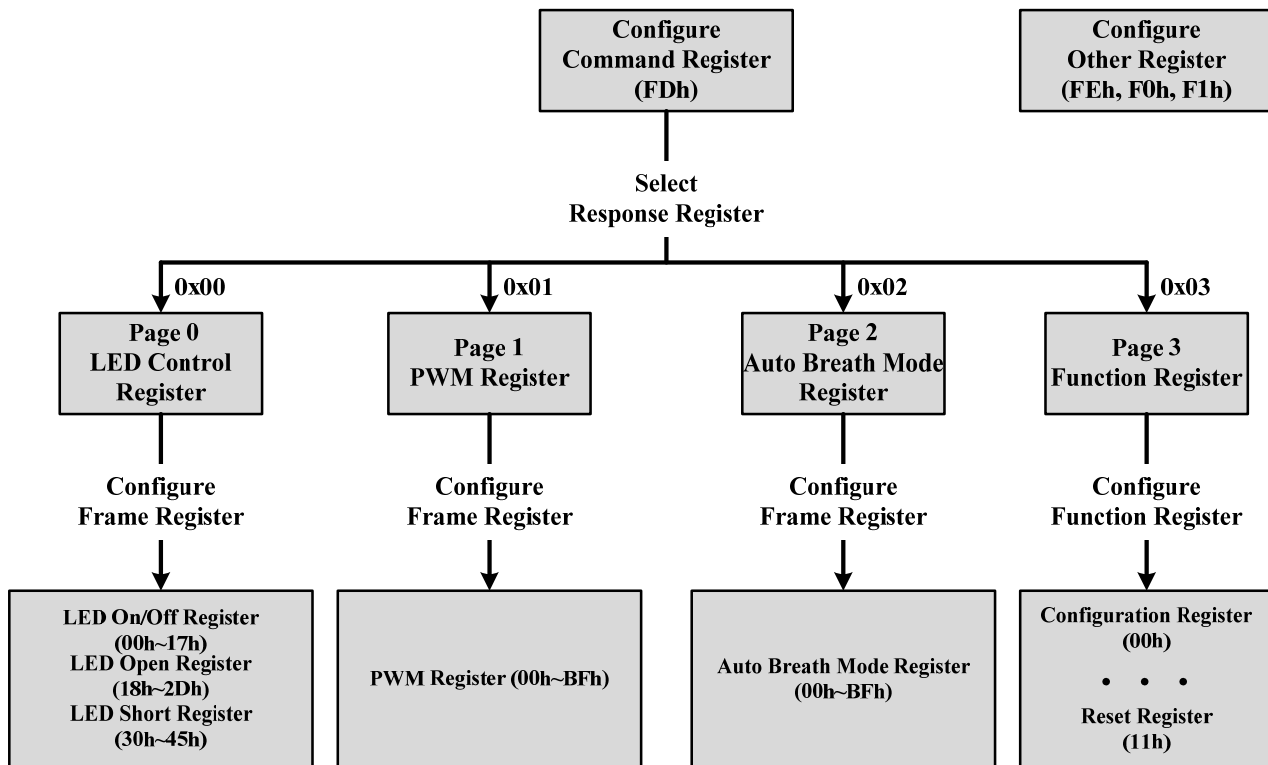
Figure 8 Reading from IS32FL3738

# IS32FL3738

## REGISTER DEFINITION-1

Address	Name	Function	Table	R/W	Default
FDh	Command Register	Available Page 0 to Page 3 Registers	2	W	xxxx xxxx
FEh	Command Register Write lock	To lock/unlock Command Register	3	R/W	0000 0000
F0h	Interrupt Mask Register	Configure the interrupt function	4	W	
F1h	Interrupt Status Register	Show the interrupt status	5	R	

## REGISTER CONTROL



**Table 2 FDh Command Register (Write Only)**

Data	Function
0000 0000	Point to Page 0 (PG0, LED Control Register is available)
0000 0001	Point to Page 1 (PG1, PWM Register is available)
0000 0010	Point to Page 2 (PG2, Auto Breath Mode Register is available)
0000 0011	Point to Page 3 (PG3, Function Register is available)
Others	Reserved

**Note:** FDh is locked when power up, need to unlock this register before write command to it. See Table 3 for detail.

The Command Register should be configured first after writing in the slave address to choose the available register. Then write data in the choosing register. Power up default state is "0000 0000".

For example, when write "0000 0001" in the Command Register (FDh), the data which writing after will be stored in the PWM Register (Page1). Write new data can configure other registers.

# IS32FL3738

**Table 3 FEh Command Register Write Lock (Read/Write)**

Bit	D7:D0
Name	CRWL
Default	0000 0000 (FDh write disable)

To select the PG0~PG3, need to unlock this register first, with the purpose to avoid misoperation of this register. When FEh is written with 0xC5, FDh is allowed to modify once, after the FDh is modified the FEh will reset to be 0x00 at once.

**CRWL** Command Register Write Lock  
 0x00 FDh write disable  
 0xC5 FDh write enable once

**Table 4 F0h Interrupt Mask Register**

Bit	D7:D4	D3	D2	D1	D0
Name	-	IAC	IAB	IS	IO
Default	0000	0	0	0	0

Configure the interrupt function for IC.

**IAC** Auto Clear Interrupt Bit  
 0 Interrupt could not auto clear  
 1 Interrupt auto clear when INTB stay low exceeds 8ms

**IAB** Auto Breath Interrupt Bit  
 0 Disable auto breath loop finish interrupt  
 1 Enable auto breath loop finish interrupt

**IS** Dot Short Interrupt Bit  
 0 Disable dot short interrupt  
 1 Enable dot short interrupt

**IO** Dot Open Interrupt Bit  
 0 Disable dot open interrupt  
 1 Enable dot open interrupt

**Table 5 F1h Interrupt Status Register**

Bit	D7:D5	D4	D3	D2	D1	D0
Name	-	ABM3	ABM2	ABM1	SB	OB
Default	000	0	0	0	0	0

Show the interrupt status for IC.

**ABM3** Auto Breath Mode 3 Finish Bit  
 0 ABM3 not finish  
 1 ABM3 finish

**ABM2** Auto Breath Mode 2 Finish Bit  
 0 ABM2 not finish  
 1 ABM2 finish

**ABM1** Auto Breath Mode 1 Finish Bit  
 0 ABM1 not finish  
 1 ABM1 finish

**SB** Short Bit  
 0 No short  
 1 Short happens

**OB** Open Bit  
 0 No open  
 1 Open happens

# IS32FL3738

## REGISTER DEFINITION-2

Address	Name	Function	Table	R/W	Default
<b>PG0 (0x00): LED Control Register</b>					
00h ~ 17h	LED On/Off Register	Set on or off state for each LED	7	W	0000 0000
18h ~ 2Dh	LED Open Register	Store open state for each LED	8	R	
30h ~ 45h	LED Short Register	Store short state for each LED	9	R	
<b>PG1 (0x01): PWM Register</b>					
00h~BFh	PWM Register	Set PWM duty for LED	10	W	0000 0000
<b>PG2 (0x02): Auto Breath Mode Register</b>					
00h~BFh	Auto Breath Mode Register	Set operating mode of each dot	11	W	0000 0000
<b>PG3 (0x03) : Function Register</b>					
00h	Configuration Register	Configure the operation mode	13	W	0000 0000
01h	Global Current Control Register	Set the global current	14	W	
02h	Auto Breath Control Register 1 of ABM-1	Set fade in and hold time for breath function of ABM-1	15	W	
03h	Auto Breath Control Register 2 of ABM-1	Set the fade out and off time for breath function of ABM-1	16	W	
04h	Auto Breath Control Register 3 of ABM-1	Set loop characters of ABM-1	17	W	
05h	Auto Breath Control Register 4 of ABM-1	Set loop characters of ABM-1	18	W	
06h	Auto Breath Control Register 1 of ABM-2	Set fade in and hold time for breath function of ABM-2	15	W	
07h	Auto Breath Control Register 2 of ABM-2	Set the fade out and off time for breath function of ABM-2	16	W	
08h	Auto Breath Control Register 3 of ABM-2	Set loop characters of ABM-2	17	W	
09h	Auto Breath Control Register 4 of ABM-2	Set loop characters of ABM-2	18	W	
0Ah	Auto Breath Control Register 1 of ABM-3	Set fade in and hold time for breath function of ABM-3	15	W	
0Bh	Auto Breath Control Register 2 of ABM-3	Set the fade out and off time for breath function of ABM-3	16	W	
0Ch	Auto Breath Control Register 3 of ABM-3	Set loop characters of ABM-3	17	W	
0Dh	Auto Breath Control Register 4 of ABM-3	Set loop characters of ABM-3	18	W	
0Eh	Time Update Register	Update the setting of 02h ~ 0Dh registers	-	W	
0Fh	SWy Pull-Up Resistor Selection Register	Set the pull-up resistor for SWy	19	W	
10h	CSx Pull-Down Resistor Selection Register	Set the pull-down resistor for CSx	20	W	
11h	Reset Register	Reset all register to POR state	-	R	

Table 6-1 Page 0 (PG0, 0x00): LED Control Register - On Off Register

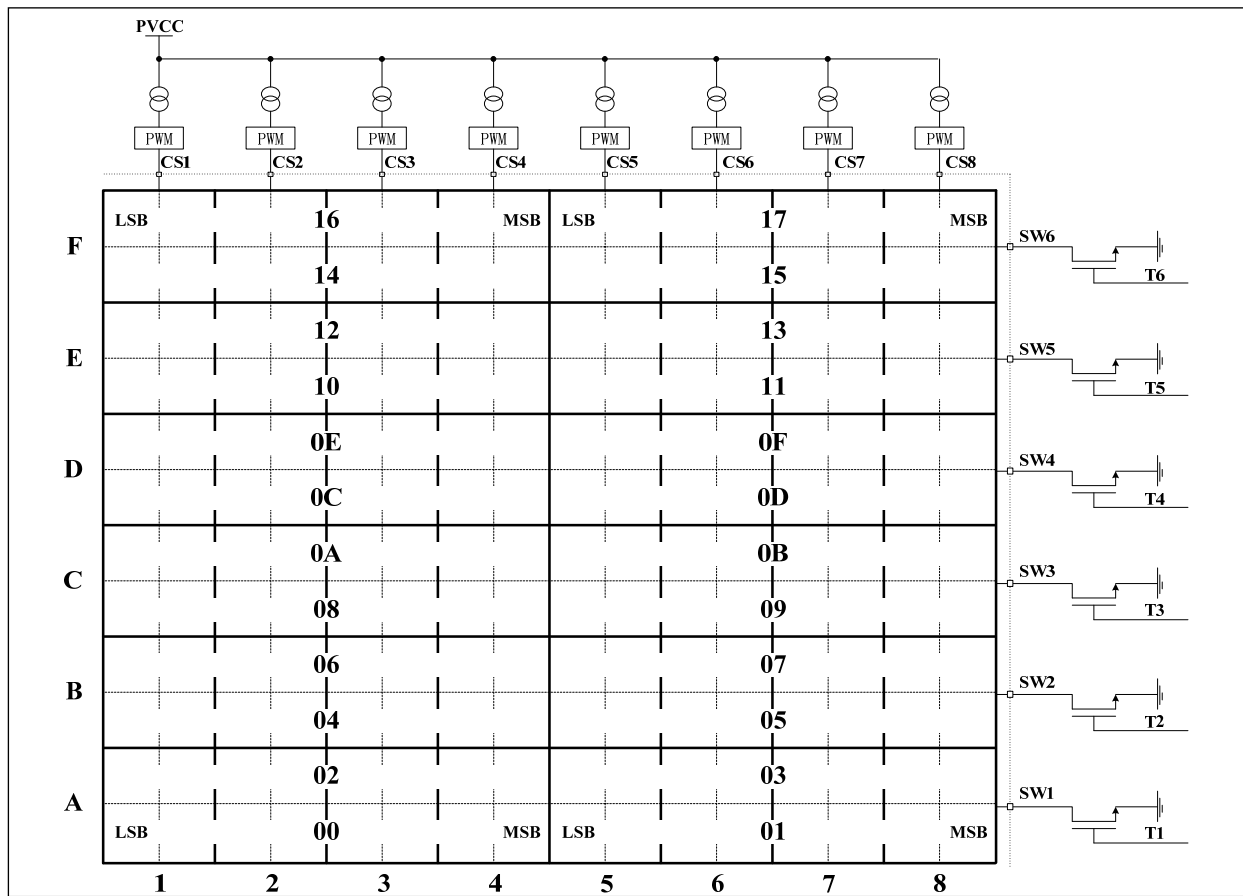


Figure 9 On Off Register

Table 7 00h ~ 17h LED On/Off Register

Bit	D7:D0
Name	C <sub>CS8</sub> : C <sub>CS1</sub> or C <sub>CS16</sub> : C <sub>CS9</sub>
Default	0000 0000

The LED On/Off Registers store the on or off state of each LED in the Matrix.

Each LED has 4 bits on and off state, need to turn on/off them when turn on/off the LED.

For example:

When turn on LED 1-A, need to turn on D1:D0 of 00h, and D1:D0 of 02h

- C<sub>x-y</sub> LED State Bit
- 0 LED off
- 1 LED on



Table 6-2 Page 0 (PG0, 0x00): LED Control Register – Open Detect Register

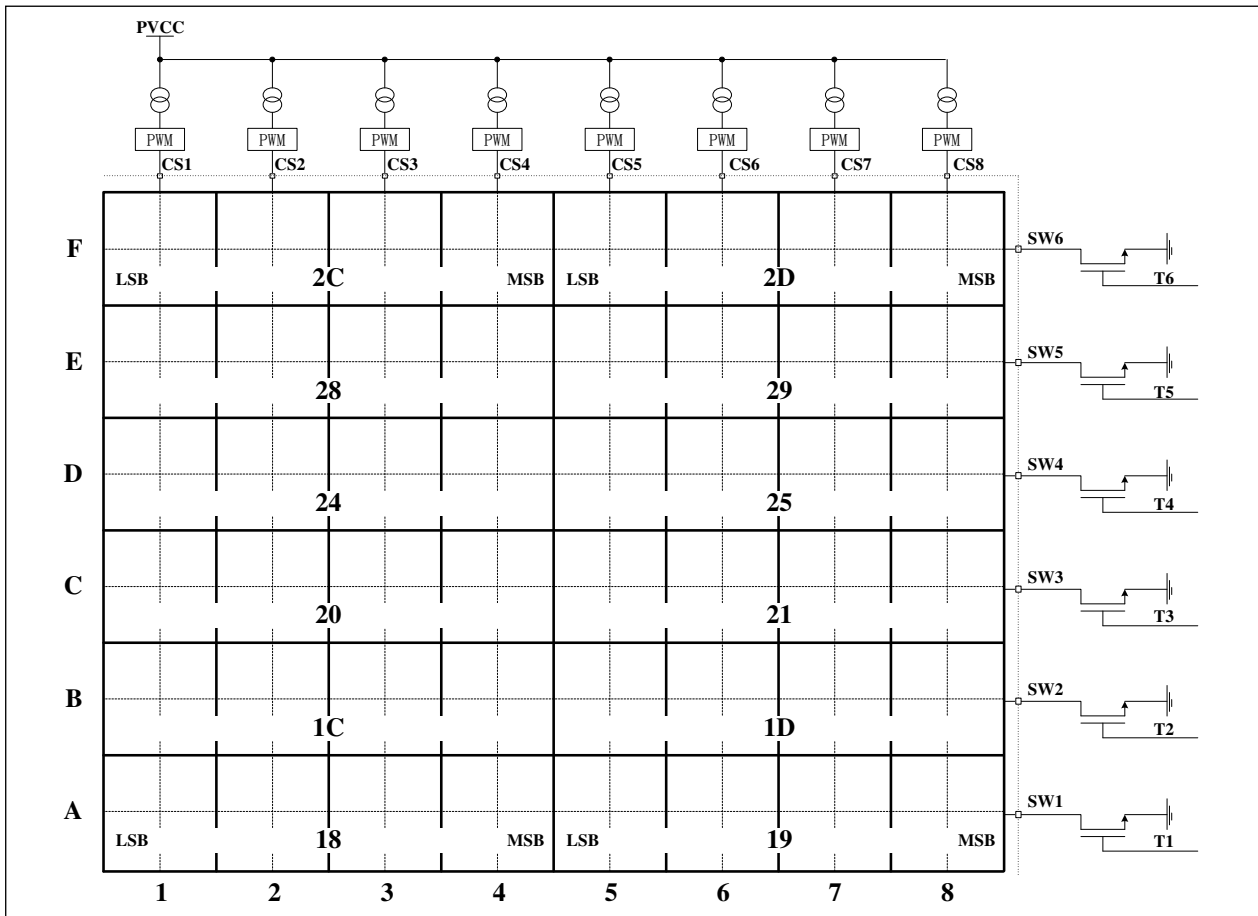


Figure 10 Open Detect Register

Table 8 18h ~ 2Dh LED Open Register

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	OP <sub>8</sub>	-	OP <sub>6</sub>	-	OP <sub>4</sub>	-	OP <sub>2</sub>	-
Default	0	-	0	-	0	-	0	-

The LED Open Registers store the open or normal state of each LED in the Matrix.

- OP<sub>x</sub>** LED Open Bit
- 0 LED normal
- 1 LED open

# IS32FL3738

Table 6-3 Page 0 (PG0, 0x00): LED Control Register – Short Detect Register

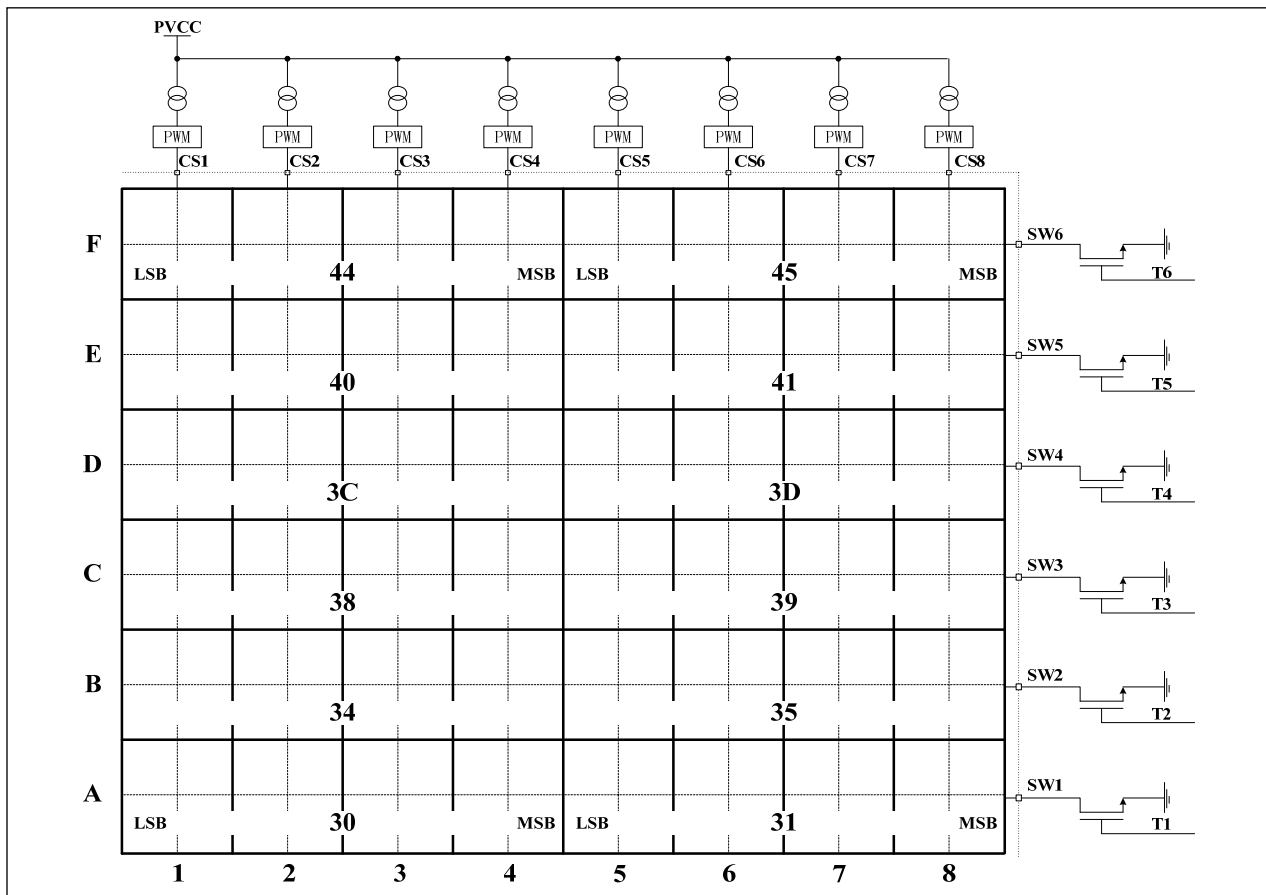


Figure 10 Short Detect Register

Table 9 30h ~ 45h LED Short Register

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	ST <sub>8</sub>	-	ST <sub>6</sub>	-	ST <sub>4</sub>	-	ST <sub>2</sub>	-
Default	0	-	0	-	0	-	0	-

The LED Short Registers store the short or normal state of each LED in the Matrix.

- ST<sub>x</sub>** LED Short Bit
- 0 LED normal
- 1 LED short

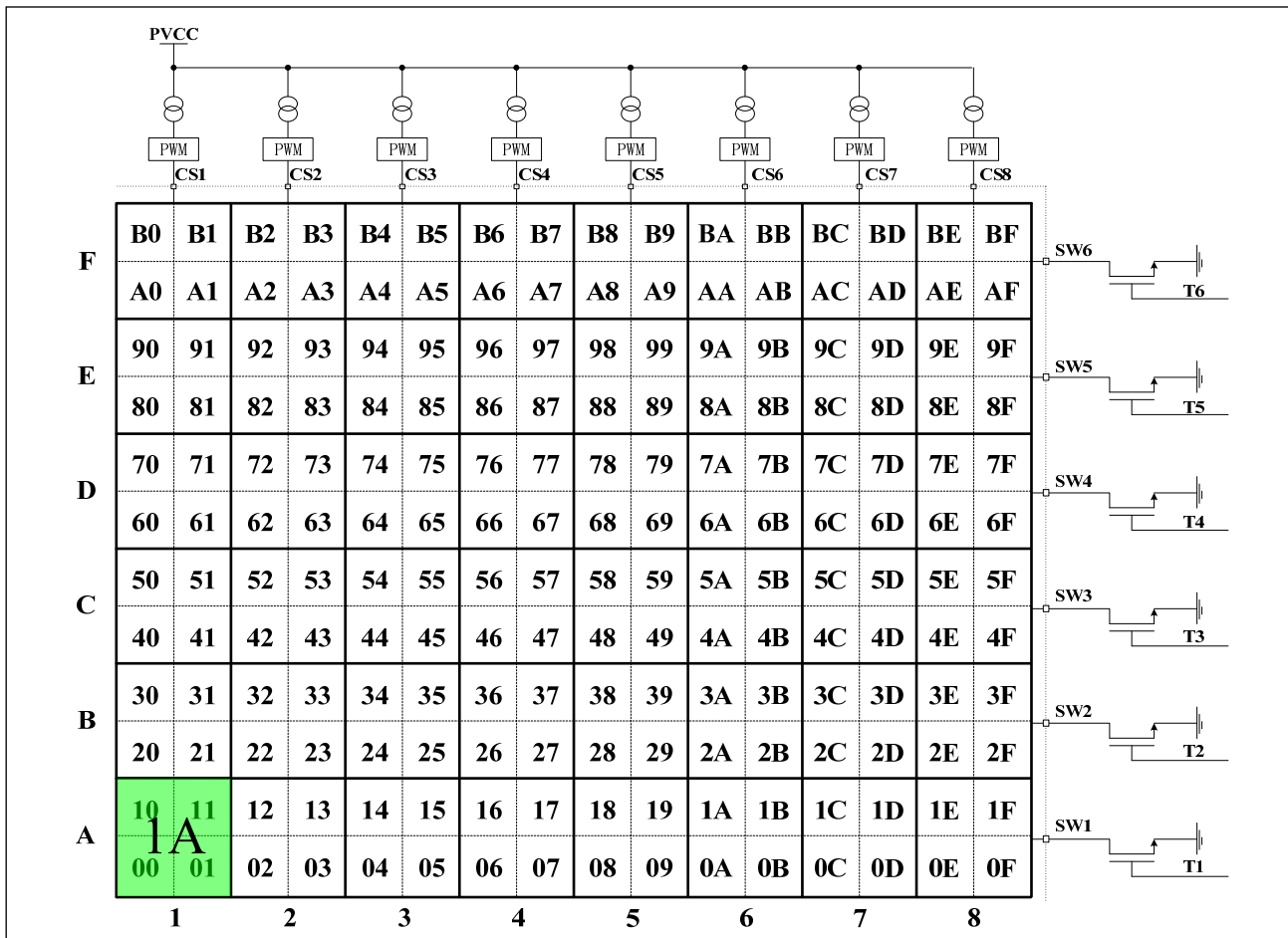
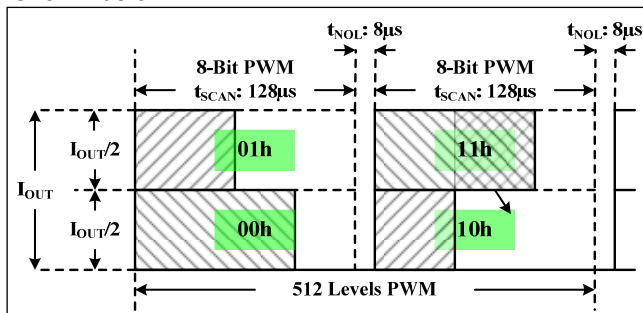


Figure 11 PWM Register

Table 10 00h ~ BFh PWM Register

Bit	D7:D0
Name	PWM
Default	0000 0000

Each dot has 4 bytes to modulate the PWM duty in 512 steps. Each byte controls half of the  $I_{OUT}$  and half of the duty, like LED 1A, the current will be as shown below:



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

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

$$I_{LED} = \frac{\sum PWM}{512} \times I_{OUT} \times Duty \quad (1)$$

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

Where Duty is the duty cycle of SWy/2,

$$Duty = \frac{128\mu s}{(128\mu s + 8\mu s)} \times \frac{1}{6} \times \frac{1}{2} = \frac{1}{12.75} \quad (2)$$

$I_{OUT}$  is the output current of CSx (x=1~8),

$$I_{OUT} = \frac{840}{R_{EXT}} \times \frac{GCC}{256} \times 2 \quad (3)$$

GCC is the Global Current Control register (PG3, 01h) value and  $R_{EXT}$  is the external resistor of R\_EXT pin. D[n] stands for the individual bit value, 1 or 0, in location n.

For example 1:

If 00h=0xff, 01h=0xff, 10h=0xff, 11h=0xff, GCC=255,  $R_{EXT}$ =20kΩ ( $I_{OUT}$ =84mA),

## IS32FL3738

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$$I_{LED-1A} = \frac{0xff + 0xff + 0xff + 0xff}{512} \times I_{OUT} \times \frac{1}{12.75}$$
$$= 13.13mA$$

For example 2:

If 00h=0x80, 01h=0x80, 10h=0x80, 11h=0x00,  
GCC=255. R<sub>EXT</sub>=20kΩ (I<sub>OUT</sub>=84mA),

$$I_{LED-1A} = \frac{0x80 + 0x80 + 0x80 + 0x00}{512} \times I_{OUT} \times \frac{1}{12.75}$$
$$= 4.94mA$$

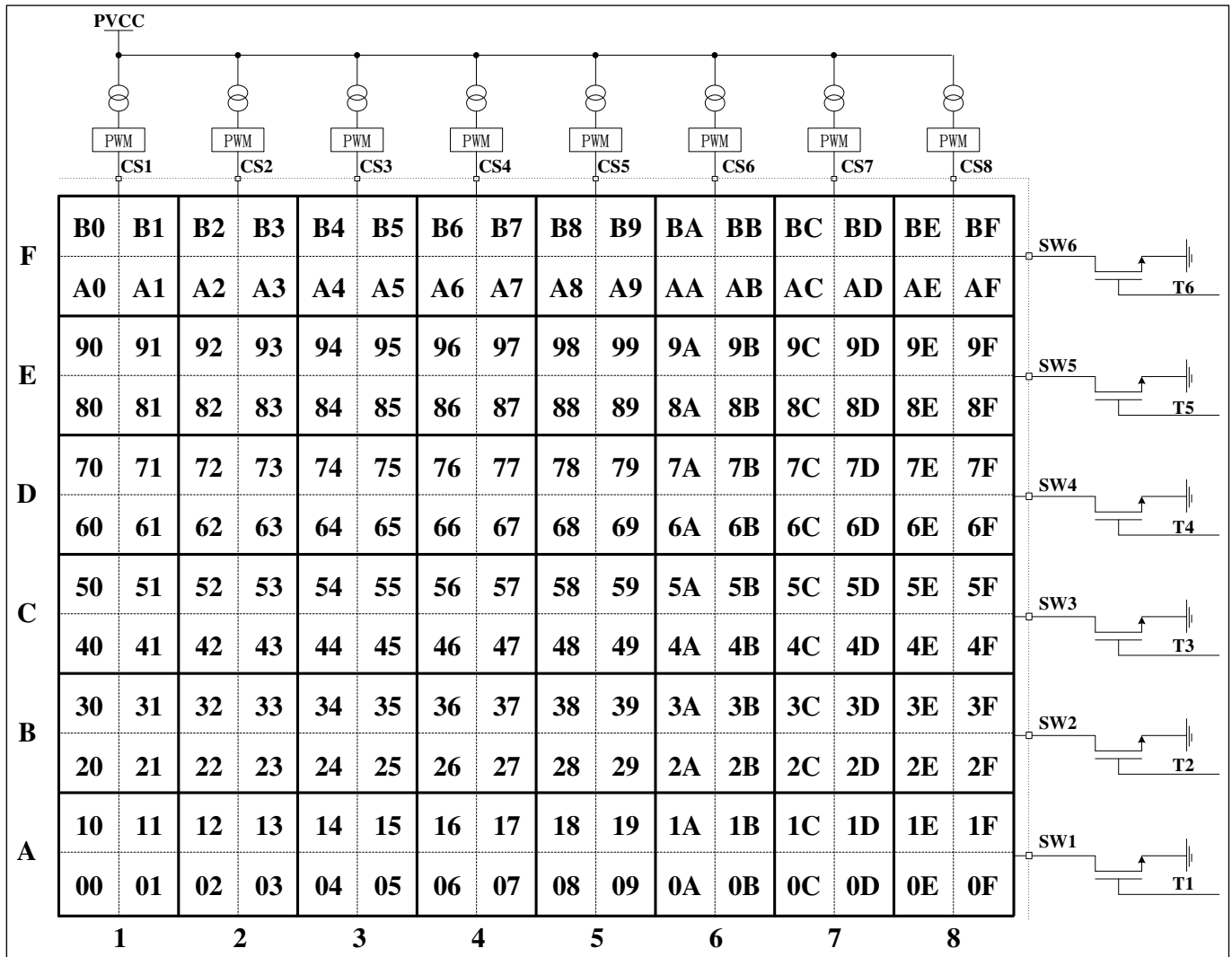


Figure 12 Auto Breath Mode Selection Register

Table 11 00h ~ BFh Auto Breath Mode Register

Bit	D7:D2	D1:D0
Name	-	ABMS
Default	-	00

**ABMS** Auto Breath Mode Selection Bit

- 00 PWM control mode
- 01 Select Auto Breath Mode 1 (ABM-1)
- 10 Select Auto Breath Mode 2 (ABM-2)
- 11 Select Auto Breath Mode 3 (ABM-3)

The Auto Breath Mode Register sets operating mode of each dot, notice four registers should be the same value when you selecting the mode.

For example, if 00h=0x01, 01h=0x01, 10h=0x01, 11h=0x01, then LED 1A work as ABM-1 mode.

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**Table 12 Page 3 (PG3, 0x03): Function Register**

Register	Name	Function	R/W	Default
00h	Configuration Register	Configure the operation mode	W	0000 0000
01h	Global Current Control Register	Set the global current	W	
02h	Auto Breath Control Register 1 of ABM-1	Set fade in and hold time for breath function of ABM-1	W	
03h	Auto Breath Control Register 2 of ABM-1	Set the fade out and off time for breath function of ABM-1	W	
04h	Auto Breath Control Register 3 of ABM-1	Set loop characters of ABM-1	W	
05h	Auto Breath Control Register 4 of ABM-1	Set loop characters of ABM-1	W	
06h	Auto Breath Control Register 1 of ABM-2	Set fade in and hold time for breath function of ABM-2	W	
07h	Auto Breath Control Register 2 of ABM-2	Set the fade out and off time for breath function of ABM-2	W	
08h	Auto Breath Control Register 3 of ABM-2	Set loop characters of ABM-2	W	
09h	Auto Breath Control Register 4 of ABM-2	Set loop characters of ABM-2	W	
0Ah	Auto Breath Control Register 1 of ABM-3	Set fade in and hold time for breath function of ABM-3	W	
0Bh	Auto Breath Control Register 2 of ABM-3	Set the fade out and off time for breath function of ABM-3	W	
0Ch	Auto Breath Control Register 3 of ABM-3	Set loop characters of ABM-3	W	
0Dh	Auto Breath Control Register 4 of ABM-3	Set loop characters of ABM-3	W	
0Eh	Time Update Register	Update the setting of 02h ~ 0Dh registers	W	
0Fh	SWy Pull-Up Resistor Selection Register	Set the pull-up resistor for SWy	W	
10h	CSx Pull-Down Resistor Selection Register	Set the pull-down resistor for CSx	W	
11h	Reset Register	Reset all register to POR state	R	

**Table 13 00h Configuration Register**

Bit	D7:D6	D5:D3	D2	D1	D0
Name	SYNC	-	OSD	B_EN	SSD
Default	00	000	0	0	0

The Configuration Register sets operating mode of IS32FL3738.

When SYNC bits are set to “01”, the IS32FL3738 is configured as the master clock source and the SYNC pin will generate a clock signal distributed to the clock slave devices. To be configured as a clock slave device and accept an external clock input the slave device’s SYNC bits must be set to “10”.

When OSD set high, open/short detection will be trigger once, the user could trigger OS detection again by set OSD from 0 to 1.

When B\_EN enable, those dots select working in ABM-x mode will start to run the pre-established timing. If it is disabled, all dots work in PWM mode. Following Figure 16 to enable the Auto Breath mode. When SSD is “0”, IS32FL3738 works in software shutdown mode and to normal operate the SSD bit should set to “1”.

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**SYNC** Synchronize Configuration  
 00/11 High Impedance  
 01 Master  
 10 Slave

**OSD** Open/Short Detection Enable Bit  
 0 Disable open/short detection  
 1 Enable open/short detection

**B\_EN** Auto Breath Enable  
 0 PWM Mode Enable  
 1 Auto Breath Mode Enable

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

**T1** T1 Setting  
 000 0.21s  
 001 0.42s  
 010 0.84s  
 011 1.68s  
 100 3.36s  
 101 6.72s  
 110 13.44s  
 111 26.88s

**T2** T2 Setting  
 0000 0s  
 0001 0.21s  
 0010 0.42s  
 0011 0.84s  
 0100 1.68s  
 0101 3.36s  
 0110 6.72s  
 0111 13.44s  
 1000 26.88s  
 Others Unavailable

**Table 14 01h Global Current Control Register**

Bit	D7:D0
Name	GCCx
Default	0000 0000

The Global Current Control Register modulates all CSx (x=1~8) DC current which is noted as I<sub>OUT</sub> in 256 steps.

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

$$I_{OUT} = \frac{840}{R_{EXT}} \times \frac{GCC}{256} \quad (3)$$

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

Where D[n] stands for the individual bit value, 1 or 0, in location n, R<sub>EXT</sub> is the external resistor of R<sub>EXT</sub> pin.

For example: if D7:D0 = 1011 0101,

$$I_{OUT} = \frac{2^0 + 2^2 + 2^4 + 2^5 + 2^7}{256} \times \frac{840}{R_{EXT}}$$

**Table 15 02h, 06h, 0Ah Auto Breath Control Register 1 of ABM-x**

Bit	D7:D5	D4:D1	D0
Name	T1	T2	-
Default	000	0000	0

Auto Breath Control Register 1 set the T1&T2 time in Auto Breath Mode.

**Table 16 03h, 07h, 0Bh Auto Breath Control Register 2 of ABM-x**

Bit	D7:D5	D4:D1	D0
Name	T3	T4	-
Default	000	0000	0

Auto Breath Control Register 2 set the T3&T4 time in Auto Breath Mode.

**T3** T3 Setting  
 000 0.21s  
 001 0.42s  
 010 0.84s  
 011 1.68s  
 100 3.36s  
 101 6.72s  
 110 13.44s  
 111 26.88s

**T4** T4 Setting  
 0000 0s  
 0001 0.21s  
 0010 0.42s  
 0011 0.84s  
 0100 1.68s  
 0101 3.36s  
 0110 6.72s  
 0111 13.44s  
 1000 26.88s  
 1001 53.76s  
 1010 107.52s  
 Others Unavailable

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**Table 17 04h, 08h, 0Ch Auto Breath Control Register 3 of ABM-x**

Bit	D7:D6	D5:D4	D3:D0
Name	LE	LB	LTA
Default	00	00	0000

Total loop times= LTA ×256 + LTB.

For example, if LTA=2, LTB=100, the total loop times is 256×2+100= 612 times.

For the counting of breathing times, do follow Figure 16 to enable the Auto Breath Mode.

If the loop start from T4,

T4->T1->T2->T3(1)->T4->T1->T2->T3(2)->T4->T1->... and so on.

If the loop not start from T4,

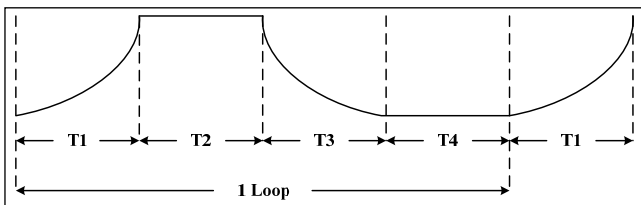
Tx->T3(1) ->T4->T1->T2->T3(2)->T4-> T1->... and so on.

If the loop ends at off state (End of T3), the LED will be off state at last. If the loop ends at on state (End of T1), the LED will run an extra T4&T1, which are not included in loop.

**LE** Loop End Time  
 00 Loop end at off state (End of T3)  
 01 Loop end at on state (End of T1)  
 Others Unavailable

**LB** Loop Beginning Time  
 00 Loop begin from T1  
 01 Loop begin from T2  
 10 Loop begin from T3  
 11 Loop begin from T4

**LTA** 8-11 Bits Of Loop Times  
 0000 Endless loop  
 0001 1  
 0010 2  
 ... ...  
 1111 15



**Figure 13** Auto Breathing Function

**Table 18 05h, 09h, 0Dh Auto Breath Control Register 4 of ABM-x**

Bit	D7:D0
Name	LTB
Default	0000 0000

Total loop times= LTA ×256 + LTB.

For example, if LTA=2, LTB=100, the total loop times is 256×2+100= 612 times.

**LTB** 0-7 Bits Of Loop Times  
 0000 0000 Endless loop  
 0000 0001 1  
 0000 0010 2  
 ... ...  
 1111 1111 255

### 0Eh Time Update Register (02h~0Dh)

The data sent to the time registers (02h~0Dh) will be stored in temporary registers. A write operation of "0000 0000" data to the Time Update Register is required to update the registers (02h~0Dh). Please follow Figure 16 to enable the Auto Breath mode and update the time parameters.

**Table 19 0Fh SWy Pull-Up Resistor Selection Register**

Bit	D7:D3	D2:D0
Name	-	PUR
Default	00000	000

Set pull-up resistor for SWy.

**PUR** SWy Pull-up Resistor Selection Bit  
 000 No pull-up resistor  
 001 0.5kΩ  
 010 1.0kΩ  
 011 2.0kΩ  
 100 4.0kΩ  
 101 8.0kΩ  
 110 16kΩ  
 111 32kΩ



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**Table 20 10h CSx Pull-Down Resistor Selection Register**

Bit	D7:D3	D2:D0
Name	-	PDR
Default	00000	000

Set the pull-down resistor for CSx.

<b>PDR</b>	CSx Pull-down Resistor Selection Bit
000	No pull-down resistor
001	0.5kΩ
010	1.0kΩ
011	2.0kΩ
100	4.0kΩ
101	8.0kΩ
110	16kΩ
111	32kΩ

## 11h Reset Register

Once user read the Reset Register, IS32FL3738 will reset all the IS32FL3738 registers to their default value. On initial power-up, the IS32FL3738 registers are reset to their default values for a blank display.

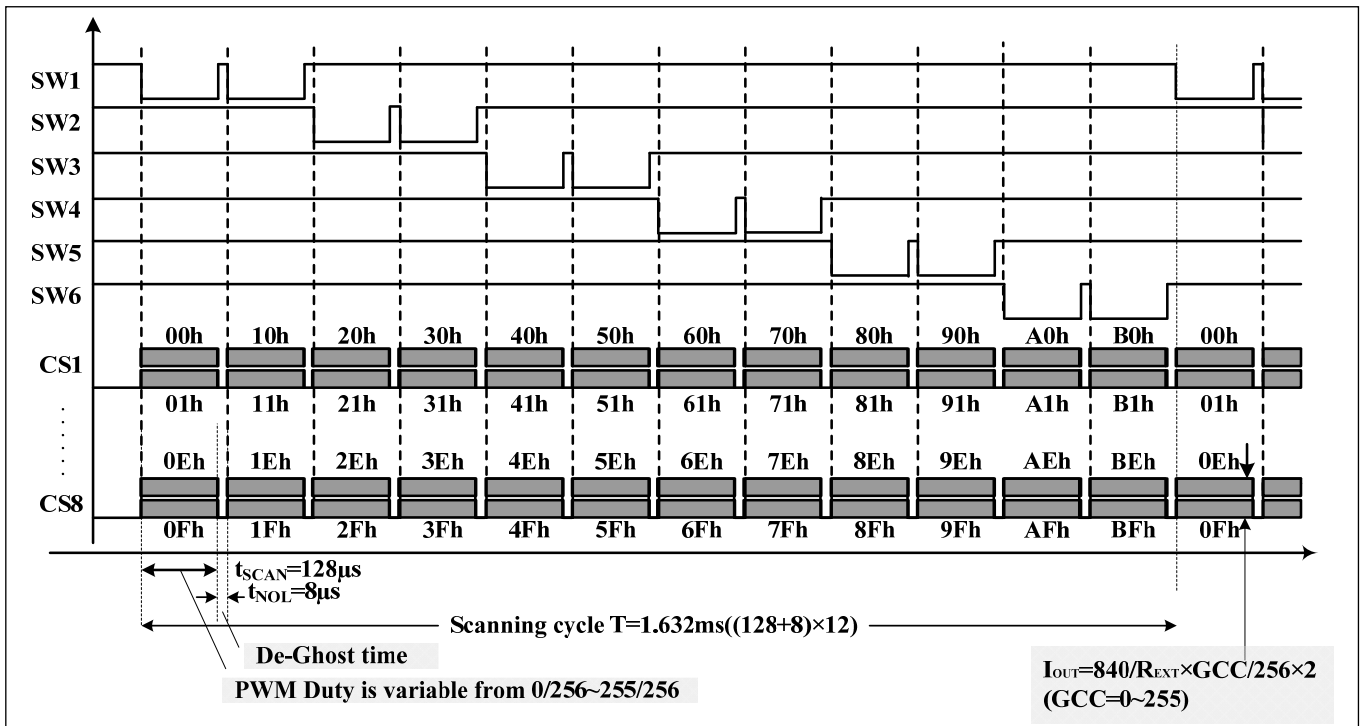


Figure 14 Scanning Timing

### SCANNING TIMING

As shown in Figure 12, the SW1~SW6 is turned on by serial, LED is driven 8 by 8 within the SWy (x=1~6) on time (SWy, y=1~6) is sink and pull low when LED on), including the non-overlap blanking time during scan, the duty cycle of SWy (active low, y=1~6) is:

$$Duty = \frac{128\mu s}{(128\mu s + 8\mu s)} \times \frac{1}{6} \times \frac{1}{2} = \frac{1}{12.75} \quad (2)$$

Where 128µs is  $t_{SCAN}$ , the period of scanning and 8µs is  $t_{NOL}$ , the non-overlap time.

### EXTERNAL RESISTOR ( $R_{EXT}$ )

The output current for each CSx can be set by a single external resistor,  $R_{EXT}$ , as described in Formula (3).

$$I_{OUT} = \frac{840}{R_{EXT}} \times \frac{GCC}{256} \times 2 \quad (3)$$

GCC is Global Current Control Register (PG3, 01h) data showing in Table 14.

### PWM CONTROL

After setting the  $I_{OUT}$  and GCC, the brightness of each LEDs (LED average current ( $I_{LED}$ )) can be modulated with 512 steps by PWM Register, as described in Formula (1).

$$I_{LED} = \frac{\sum PWM}{512} \times I_{OUT} \times Duty \quad (1)$$

Where PWM is PWM Registers (PG1, 00h~BFh) data showing in Table 10.

For example, in Figure 1, 00h=0xff, 01h=0xff, 10h=0xff, 11h=0xff, GCC=255.  $R_{EXT}$ =20kΩ ( $I_{OUT}$ =84mA),

$$I_{LED-1A} = \frac{0xff + 0xff + 0xff + 0xff}{512} \times I_{OUT} \times \frac{1}{12.75} = 13.13mA$$

For example 2:

In Figure 1, 00h=0x80, 01h=0x80, 10h=0x80, 11h=0x00, GCC=255.  $R_{EXT}$ =20kΩ ( $I_{OUT}$ =84mA),

$$I_{LED-1A} = \frac{0x80 + 0x80 + 0x80 + 0x00}{512} \times I_{OUT} \times \frac{1}{12.75} = 4.94mA$$

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

### LED AVERAGE CURRENT ( $I_{LED}$ )

As described in Formula (1), the LED average current ( $I_{LED}$ ) is effected by 3 factors: