16x8 阵列 LED 驱动器

16x8 MATRIX LED DRIVER

■ FEATURES

- Supply voltage range: 2.5V to 5.5V
- 16 current sinks
- Support 16×n (n=1~8), 15×9 LED matrix configurations
- Individual 256 PWM control steps
- 256 DC current steps for each CSx
- 64 global current steps
- SDB rising edge reset I²C module
- 32kHz PWM frequency
- 1MHz I²C-compatible interface
- Individual open and short error detect function
- PWM 180 degree phase shift
- Spread Spectrum
- De-Ghost
- QFN-32 (4mm×4mm) package

- 输入电压范围：2.5V-5.5V
- 16路电流源
- 支持16×n (n=1~8), 15×9 LED 阵列配置
- 独立的256阶PWM控制台阶
- 每个CSx有256个直流台阶
- 64个整体电流台阶
- SDB上升沿复位I²C模块
- 32kHz的PWM频率
- 支持1MHz的I²C接口
- 独立的开路和短路错误检测功能
- PWM信号180度相位转变功能
- 扩频功能
- De-Ghost
- QFN-32 (4mm×4mm)

■ APPLICATIONS

- White goods LED display panel
- IOT device
- 白色家电LED面板显示
- IOT设备

■ DESCRIPTION

LED Matrix programmed via 1MHz I²C compatible interface. Each LED can be dimmed individually with 8-bit PWM data, and each CSx has 8-bit DC scaling (Color Calibration) data which allowing 256 steps of linear PWM dimming for each dot and 256 steps of DC current adjustable level for each CSx.

Additionally, each LED open and short state can be detected, HTR3229 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.

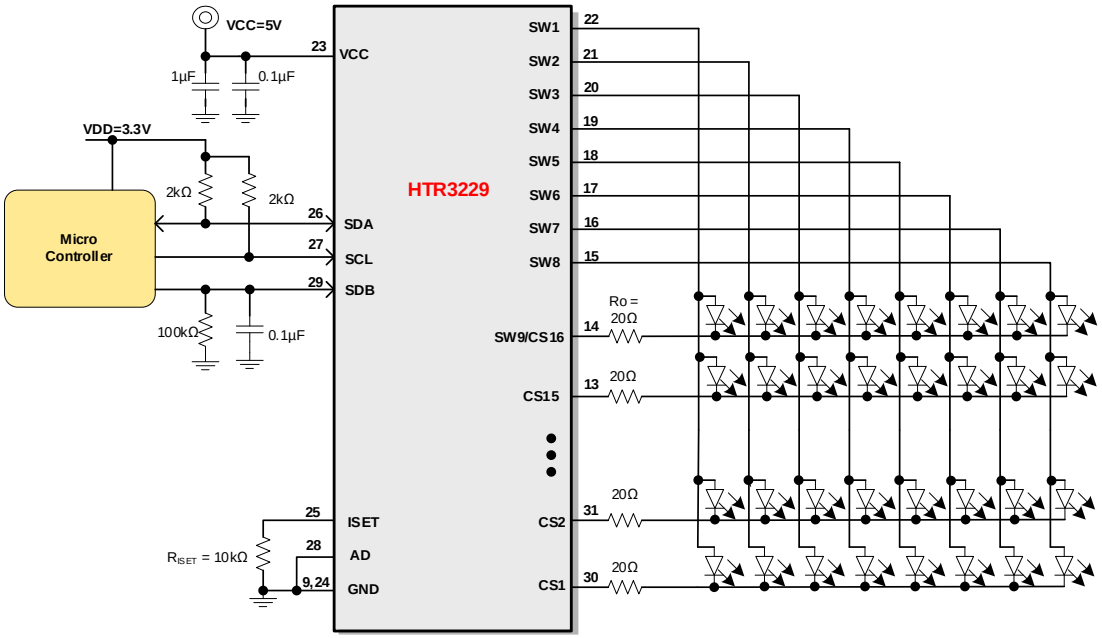
The HTR3229 operates from 2.5V to 5.5V and features a very low shutdown and operational current. HTR3229 is available in QFN-32 (4mm×4mm) package. It operates from 2.5V to 5.5V over the temperature range of -40°C to +125°C.

HTR3229是一款通过1MHz的I²C接口进行编程的支持16×8或15×9阵列的LED驱动芯片，每路LED都支持8位PWM数据进行独立调光，并且每路CSx都有8位的直流扫描数据用来支持每个点的256阶的线性PWM调光，并且每个CSx都支持256阶的直流电流可调节等级。

另外，每个LED的开路和短路状态都能被检测，HTR3229能够把开路和短路信息存储在Open-Short寄存器组中。这个寄存器组允许MCU通过I²C接口读取用以告诉MCU这些LED灯是否是在开路或者短路状态以及位置信息。

HTR3229的工作电压在2.5V到5.5V之间，并且关断电流和工作电流都非常小。HTR3229支持QFN-32 (4mm×4mm)封装，可在2.5V到5.5V和-40° C to +125° C下工作。

■ TYPICAL APPLICATION



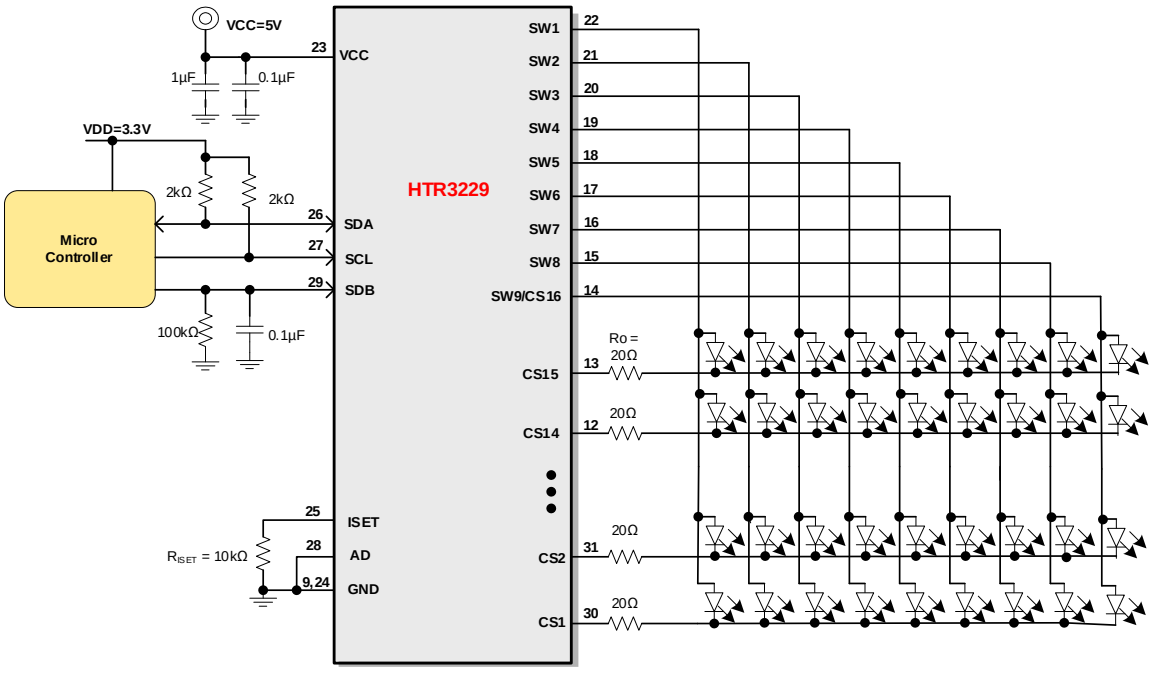
Driving 16×8 LEDs

The VDD should be smaller than VCC. And if VDD is lower than 3.0V, it is recommended to add a level shift circuit to avoid extra shutdown current.

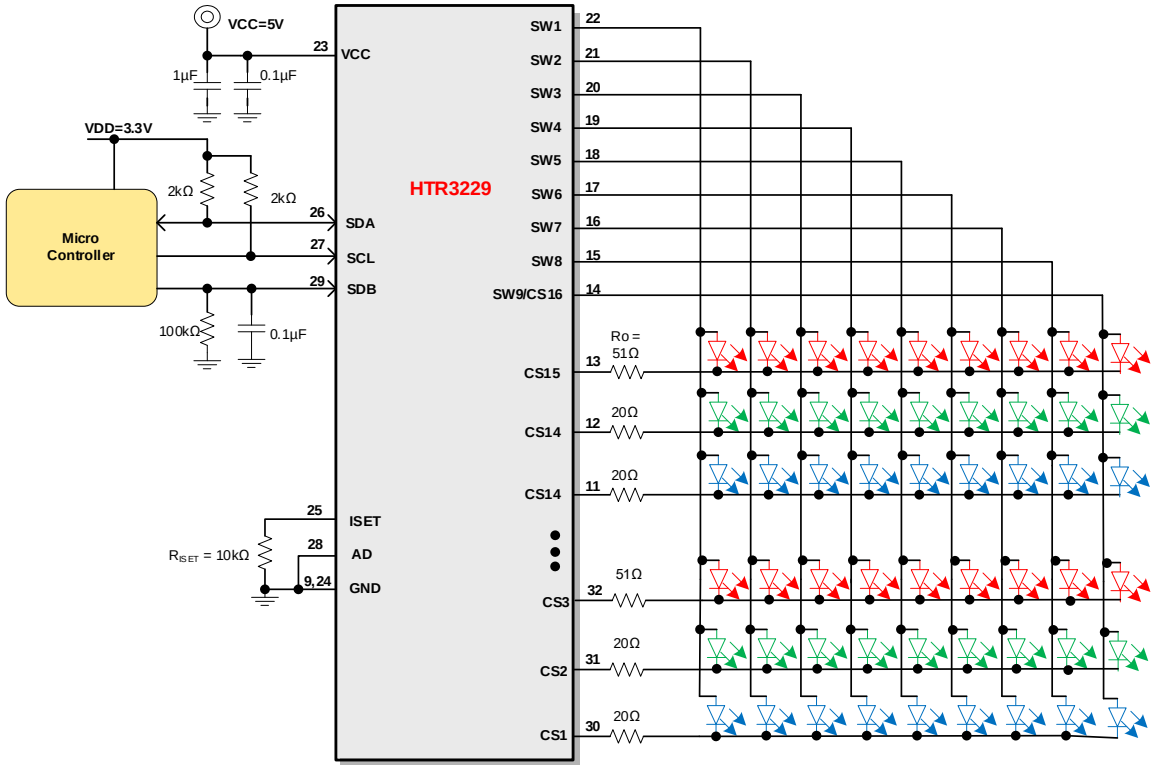
These Ro resistors are for offloading the thermal dissipation ($P=I^2R$) away from the HTR3229, for mono red/yellow/orange LED, if VCC = 3.3V, Ro resistors are not needed.

VDD应小于VCC。如果VDD小于3.0V，建议增加使用电平转换电路，以避免额外的关断电流。

Ro电阻是为了减少HTR3229的热耗散。若VCC=3.3V，驱动的是单色灯（红/黄/橙），可不接Ro电阻。



Driving 15×9 LEDs



Driving 45 RGBs

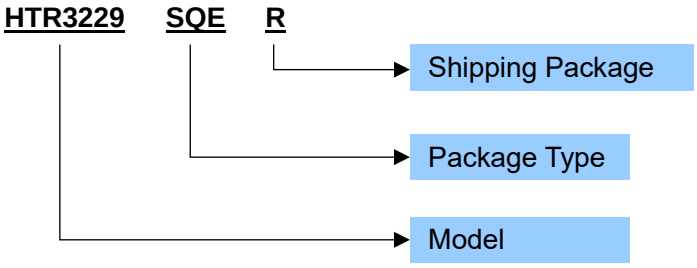
These Ro resistors are for offloading the thermal dissipation ($P=I^2R$) away from the HTR3229, for red LED, it is recommended to use about 30Ohm more than blue/green LED, to offload more extra voltage due to lower forward voltage of red LED.

Ro电阻是为了减少HTR3229的热耗散。红灯的Ro电阻建议使用51Ohm，比蓝灯/绿灯的Ro电阻大约30 Ohm。

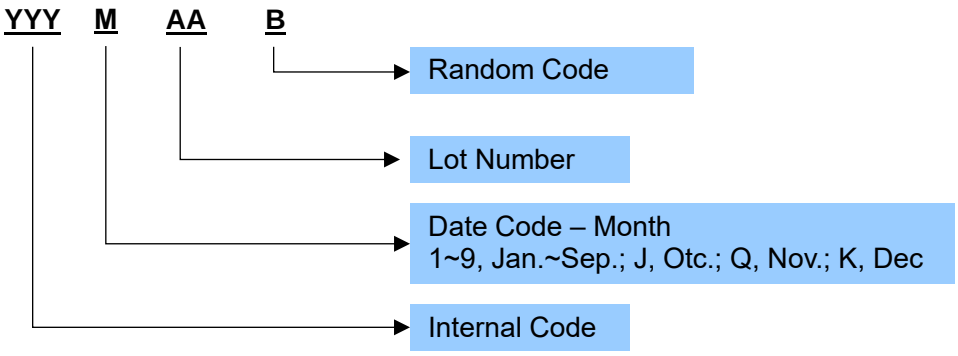
■ ORDERING INFORMATION

Part Number	Package Type	Marking	Operating Temperature Range	Shipping Package / MOQ
HTR3229SQER	QFN4×4-32L (SQE)	HTR3229 YYYMAAB[1]	-40℃～125℃	Tape and Reel (R) / 5000pcs

Part Number

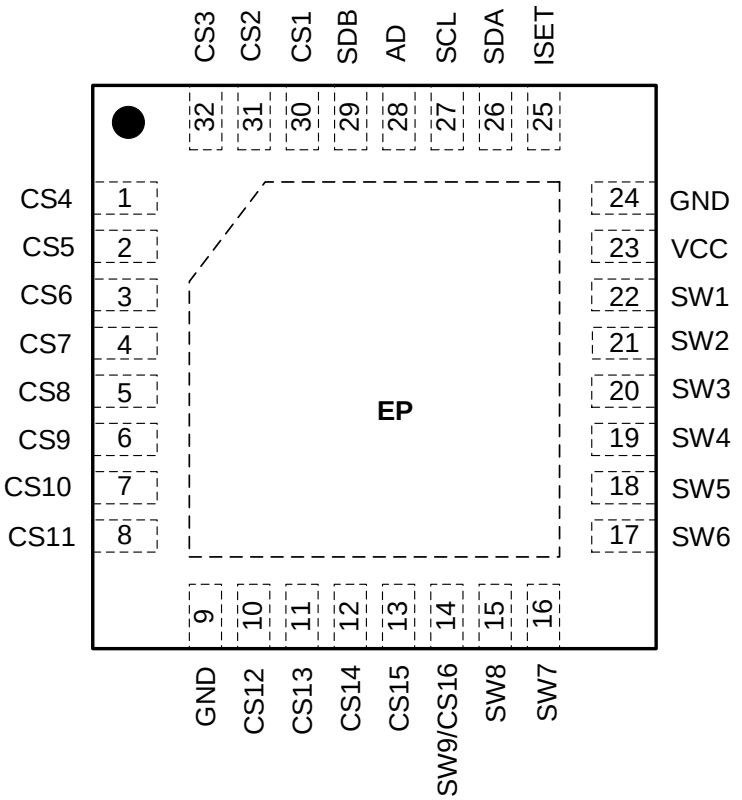


Production Tracking Code



[1] YYYMAAB is production tracking code

■ TERMINAL CONFIGURATION



Top View

■ TERMINAL FUNCTION

Terminal No.	Name	Description
1~8, 10~13	CS4~CS15	Current sinks output.电流源输出
9,24	GND	Ground. 地
14	SW9/CS16	Switch power source / current sinks output. 开关电源/电流源输出
15~22	SW8~SW1	Switch power source 开关电源
23	VCC	Power supply. 电源输入端
25	I_SET	Current setting pin.电流设置引脚
26	SDA	I^2C serial data. I^2C时钟
27	SCL	I^2C serial clock. I^2C数据
28	AD	I^2C Address setting.I^2C的地址设置端
30~32	SDB	Shutdown the chip when pull to low.当拉低时关闭芯片
EP	Thermal Pad	Connect to GND. 接地散热。

■ SPECIFICATIONS[1]

● Absolute Maximum Ratings [2]

PARAMETER	Symbol	MIN	TYP	MAX	UNIT
Power supply voltage for VCC	VCC	-0.3		6	V
Voltage at SCL, SDA, SDB, OUT1 to OUT36	V_I	-0.3		VCC+0.3	V
Moisture Sensitivity Level (MSL)			MSL3		
Ambient Operating Temperature	T_A	-40		125	℃
Junction Temperature	T_J	-40		125	℃
Storage Temperature	T_{STG}	-65		150	℃
Package thermal resistance, junction to ambient (4 layer standard test PCB based on JEDEC standard)	θ_{JA}		52		°C/W（QFN4X4-32L）
ESD (HBM)			±8		kV
ESD (CDM)			±1		kV

● Main Electrical Characteristics

Condition: T_A = 25°C, VCC = 3.6V, unless otherwise specified

PARAMETER	Symbol	CONDITION	MIN	TYP	MAX	UNIT
Power supply voltage for VCC	VCC		2.5		5.5	V
Quiescent power supply current	I_{CC}	V_{SDB}= Vcc,all LEDs off		2	3	mA
Shutdown current	I_{SD}	V_{SDB}= 0V		3	5	uA
		V_{SDB}= Vcc，Configuration Register written “0000 0000”		3	5	uA
Maximum constant current of CSX	I_{OUT}	R_{ISET}=10kΩ, GCC= “100 0000”, SL=0xFF		35		mA
Average current on each LED I_{LED} = $I_{OUT(PEAK)}$/Duty	I_{LED}	R_{ISET}=10kΩ, GCC= “100 0000” SL=0xFF, n=8, Duty=1/8.29		4.22		mA
Current switch headroom voltage SWx	V_{HR}	I_{SWITCH}=600mA R_{ISET}=10kΩ, GCC= “100 0000”, SL=0xFF		500	550	mV
Current sink headroom voltage CSx		I_{SINK}=34mA, R_{ISET}=10kΩ, GCC= “100 0000”, SL=0xFF		400	500	mV
Period of scanning	t_{SCAN}			30		uA
Non-overlap blanking time during scan, the SWx and CSy are all off during this time	t_{NOL1}			0.8		uA
Delay total time for CS1 to CS16, during this time, the SWx is on but CSx is not all turned on	t_{NOL2}			0.27		uA
Thermal shutdown	T_{SD}			160		℃
Thermal shutdown hysteresis	T_{SD_HYS}			20		℃
Output voltage of ISET pin	VISET			1		V

● Logic Electrical Characteristics (SDA, SCL, AD，SDB)

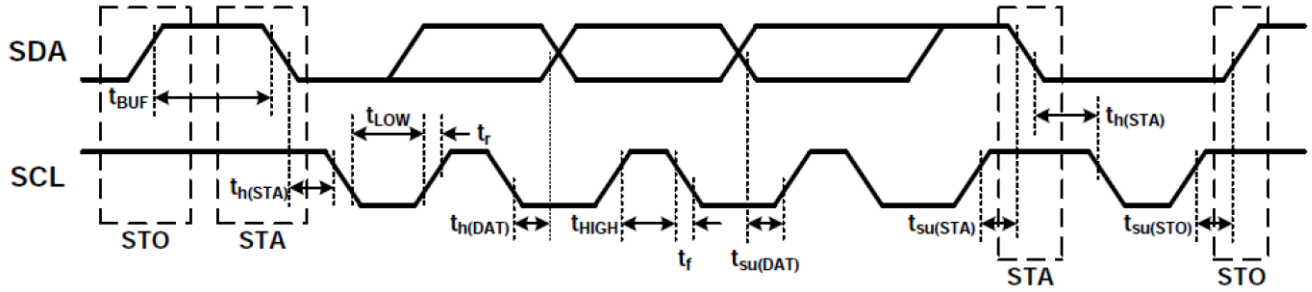
PARAMETER	Symbol	CONDITION	MIN	TYP	MAX	UNIT
Logic “0” input voltage	V_{IL}	V_{CC}= 2.5V~5.5V，LGC= “0”	GND		0.4	V
Logic “1” input voltage	V_{IH}	V_{CC}= 2.5V~5.5V，LGC= “0”	1.4		Vcc	V
Logic “0” input voltage	V_{IL}	V_{CC}= 2.5V~5.5V，LGC= “1”	GND		0.6	V
Logic “1” input voltage	V_{IH}	V_{CC}= 2.5V~5.5V，LGC= “1”	2.4		Vcc	V
Input schmitt trigger hysteresis	V_{HYS}	V_{CC}=3.6V, LGC= “0”, LGC= “1”		0.2		V
Logic “0” input current	I_{IL}	SDB=L, V_{INPUT}= L		5		nA

[1] Depending on parts and PCB layout, characteristics may be changed.
[2] 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 conditions beyond those indicated under recommended operating conditions is not implied. Exposure to absolute–maximum–rated conditions for extended periods may affect device reliability.

Logic “1” input current	I_{IH}	SDB=L, V_{INPUT}= H		5		nA

- **I²C Control Port**

PARAMETER	Symbol	MIN	TYP	MAX	MIN	TYP	MAX	UNIT
Serial-Clock frequency	f_{SCL}			400			1000	kHz
Bus free time between a STOP and a START condition	t_{BUF}	1.3			0.5			us
Hold time (repeated) START condition. After this period, the first clock pulse is generated.	$t_{h(STA)}$	0.6			0.26			us
Setup time for a repeated START condition	$t_{su(STA)}$	0.6			0.26			us
Setup Time for SCL to STOP condition	$t_{su(STO)}$	0.6			0.26			us
Data hold time	$t_{h(DAT)}$							us
Setup Time, SDA to SCL	$t_{su(DAT)}$	100			60			ns
Required Pulse Duration, SCL HIGH	t_{HIGH}	0.7			0.26			us
Required Pulse Duration, SCL LOW	t_{LOW}	1.3			0.5			us
Rise Time, SCL and SDA	T_r			300			120	ns
Fall Time, SCL and SDA	T_f			300			120	ns



■ APPLICATION INFORMATION

1 Power Supplies

The HTR3229 uses a serial bus, which conforms to the I²C protocol, to control the chip's functions with two wires: SCL and SDA. The chip has a 7-bit slave address (A7:A1), followed by the R/W bit, A0.

The HTR3229 supports 1MHz write and read operations. The value of bits A1 and A2 are decided by the connection of the AD pin.

The complete slave address is:

HTR3229 使用两条符合 I²C 通信协议的串行传输线 SDA 和 SCL 来控制芯片的工作方式。HTR3229 使用 7 位的从地址（A7:A1），最后一位为读写位

HTR3229 支持 1MHz 的读写操作，A1 和 A2 位由 AD 引脚的连接来决定。

完整的地址为：

Table1 Slave Address (Write only)

Bit	A7:A3	A2:A1	A0
Value	01101	AD	0/1

AD connected to GND, AD = 00;. AD connected to VCC, AD = 11; AD connected to SCL, AD = 01; AD connected to SDA, AD = 10;

The SCL line is uni-directional. The SDA line is bi-directional (open-collector) with a pull-up resistor (typically 400K IIC with 4.7kΩ ,1MHz IIC with 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 HTR3229.

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 HTR3229's acknowledge. The master releases the SDA line high (through a pull-up resistor). Then the master sends an SCL pulse. If the HTR3229 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 HTR3229, the register address byte is sent, most significant bit first. HTR3229 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 HTR3229 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..

AD 连接至 GND, AD = 00; AD 连接至 VCC, AD = 11; AD 连接至 SCL, AD = 01; AD 连接至 SDA, AD = 10;

I²C 总线支持数据双向传输。SCL 为单向端口；SDA 为双向端口，开漏输出驱动，需外接上拉电阻（典型值为 400k 下为 4.7k，1M 下为 1k）。最大时钟频率为 1MHz。在这种情况下，主控器件为单片机等控制器，从器件为 HTR3229。

在 SCL 为稳定的高电平时，SDA 为闭锁状态，并且在不使用的时候应保持高电平。

"开始"信号由 SCL 为高电平时将 SDA 拉低产生。"开始"信号会提醒所有的设备接收 I²C 总线上即将到来的地址与自己的地址进行比较。

接着发送的是 8bit 芯片地址，高位优先。在 SCL 为高电平的时候每个地址位必须保持稳定。

在最后一位传送出去后，主控器件应检测 HTR3229 的应答信号。主控器件通过上拉电阻释放 SDA 为高电平，然后使 SCL 发送一个脉冲。如果 HTR3229 正确的接收到 8 位数据，在 SCL 的脉冲期间它将使 SDA 拉低；如果 SDA 线不为低，则表示数据没有正确接收，主控器件将会发送一个"停止"信号并且中断数据传递。

在 HTR3229 的应答信号发送之后，寄存器的地址将被发送，高位优先。寄存器地址发出后，HTR3229 必须再产生一个应答位来表示寄存器地址已被正确接收。

接下来传送的是 8 位的寄存器数据。在 SCL 保持稳定的高电平时每位数据都是有效的。8 位数据传送完后，HTR3229 同样需要产生一个应答位来表示数据的正确接收。

传送结束后需要发送"停止"信号。结束信号由 SCL 为高时将 SDA 拉高。

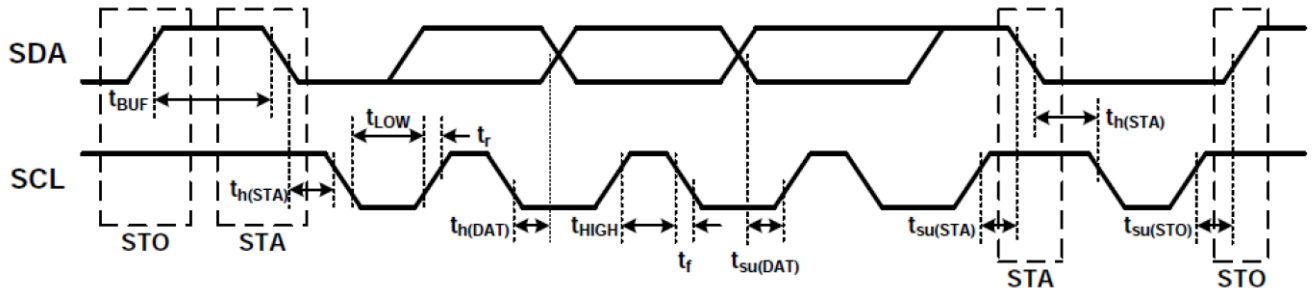


Figure 1 I²C Interface Timing

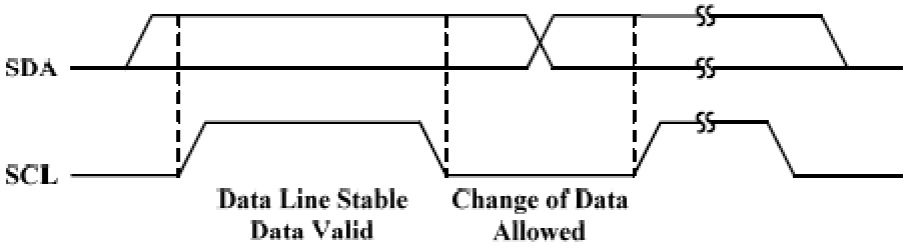


Figure 2 Bit Transfer

ADDRESS AUTO INCREMENT

To write multiple bytes of data into HTR3229, load the address of the data register that the first data byte is intended for. During the HTR3229 acknowledge of receiving the data byte, the internal address pointer will increment by one. The next data byte sent to HTR3229 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 HTR3229 (Figure 4).

如果有多个数据要传送给 HTR3229，只需发送第一个数据写入的寄存器地址。在 HTR3229 接收数据器件，寄存器地址会自动加 1，下一个传送的数据将写入新的寄存器地址中，如此继续，直到 I²C 写入“停止”信号。如下图 4。

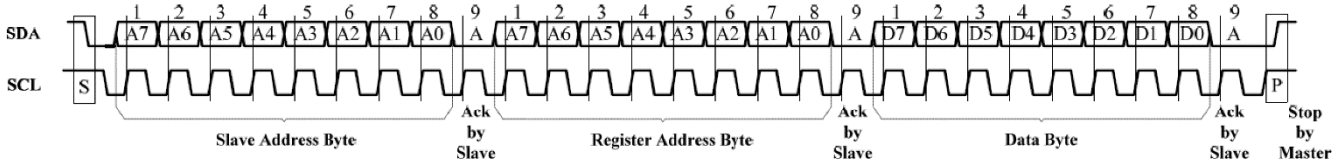


Figure 3 Typical I²C Writing

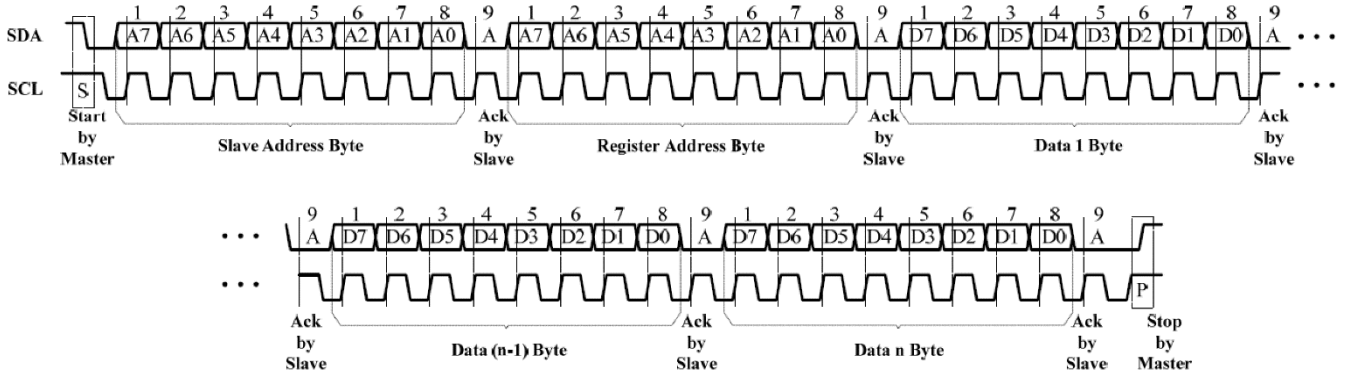


Figure 4 I²C Writing with Automatic Address Increment

READ OPERATION

Most of the registers can be read.

To read the register, after I²C start condition, the bus master must send the HTR3229 device address with the R/W bit set to “0”, followed by the register address which determines which register is accessed. Then restart I²C, the bus master should send theHTR3229 device address with the R/W bit set to “1”. Data from the register defined by the command byte is then sent from the HTR3229 to the master. (Figure 5)

大部分的寄存器都是可读的。

要读取寄存器的话，在 I²C 启动信号以后，主机在发送 HTR3229 的器件地址时 R/W 位给 0，然后发送寄存器地址决定哪个寄存器被选中，然后发送 I²C 重启信号，之后主机在发送 HTR3229 的器件地址时 R/W 位给 1，之后倍选中的寄存器中的数据就会由HTR3229发送到主机(如图 5）。

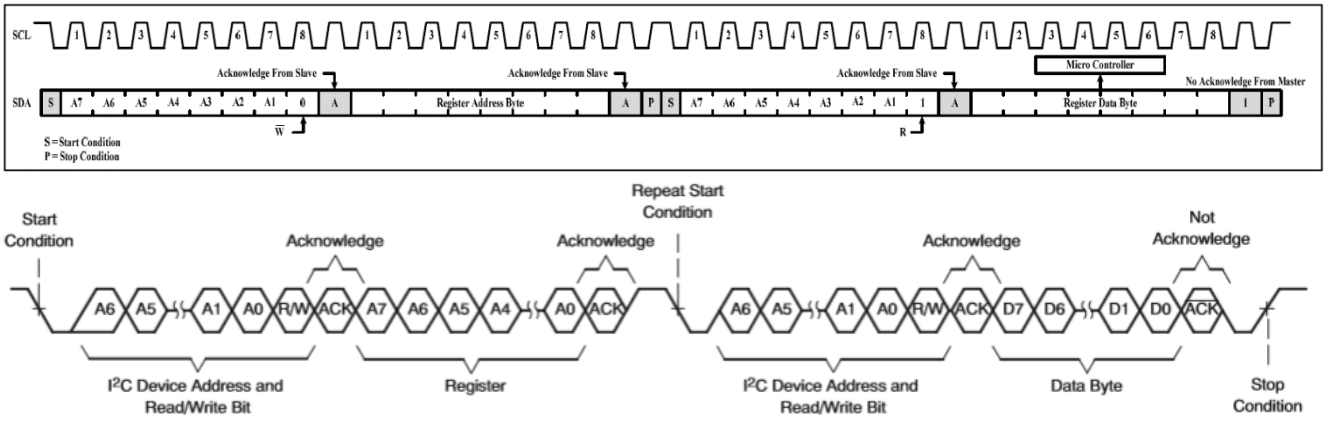


Figure 5 I²C Reading

2 SCANNING TIMING

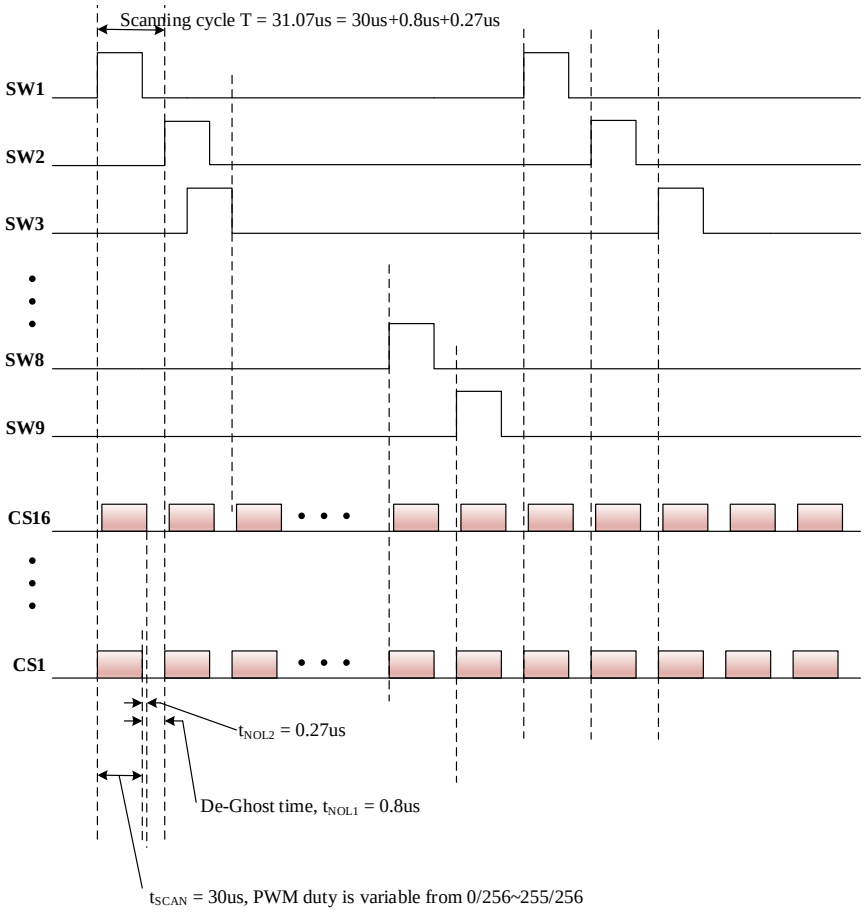


Figure 6 Scanning Timing

As shown in Figure above, the SW1~SW9 is turned on by serial, LED is driven 15 by 9 within the SWx (x=1~9) on time (SWx, x=1~9 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=1~9) is(n=9):

$$Duty = \frac{30us}{30us + 0.8us + 0.27us} \times \frac{1}{9}$$

Or (n=8):

$$Duty = \frac{30us}{30us + 0.8us + 0.27us} \times \frac{1}{8}$$

Where 30μs is t_{SCAN}, the period of scanning and 0.8μs is t_{NOL1}, the non-overlap time and 0.27μs is the CSx delay time.

如上图所示，SW1~SW9 依次打开，15×9 个 LED 随着 SWx 依次打开（SW 是电源，当它为高时 LED 打开），在扫描时包含了不相交空余时间，SWx 的占空比（高有效，x=1~9）：

$$Duty = \frac{30us}{30us+0.8us+0.27us} \times \frac{1}{9} \text{ (n=9)}$$

$$Duty = \frac{30us}{30us+0.8us+0.27us} \times \frac{1}{8} \text{ (n=8)}$$

30us 是 t_{SCAN}，是扫描周期，0.8us 是 t_{NOL1}，确保不相交的时间，0.27us 是各路 CSx 的之间的延时。

3 PWM CONTROL

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

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

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

在设置好 I_{OUT} 和 GCC 之后，每个 LED 灯的亮度都可以通过 PWM 寄存器进行 256 级调节，公式如下：

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

连续不断地对寄存器写入新的数据就可以调节灯的亮度，从而实现呼吸效果。

4 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 HTR3229 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.

Choosing more gamma steps provides for a more continuous looking breathing effect. This is useful for long reathing 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.

使用 HTR3229 实现 LED 呼吸效果时，为得到更好的呼吸效果，建议对呼吸控制进行非线性修正。

HTR3229 内部实现线性的 256 级 PWM 调光。由于人视觉对亮度的误差，电流线性增加时，视觉上会感觉到呼吸开始时亮度变化快，然后很快进入亮度饱和的问题。为了解决这个问题，在呼吸时，引入伽马补偿的方法，达到视觉效果的线性。

为了显示更细腻的效果，可采取更多级的输出，防止呼吸时产生可观察到的亮度跳变。推荐的经验值是，从最暗到最亮的呼吸周期 T 内，当 T=1s，推荐伽马补偿 32 级；当 T=2s，推荐伽马补偿 64 级，以此类推。此推荐是 LED 没有任何遮挡下的经验值。若 LED 有挡光板，可采用更少的亮度登记实现。具体等级数，可根据实际测试调节。

Table2 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

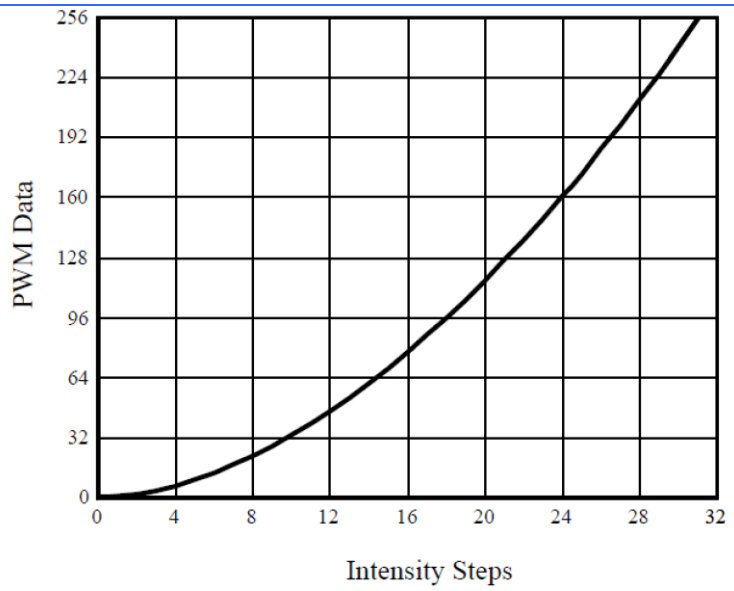


Figure 7 Gamma Correction (32 Steps)

Table3 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	233	230	237	244	251	255

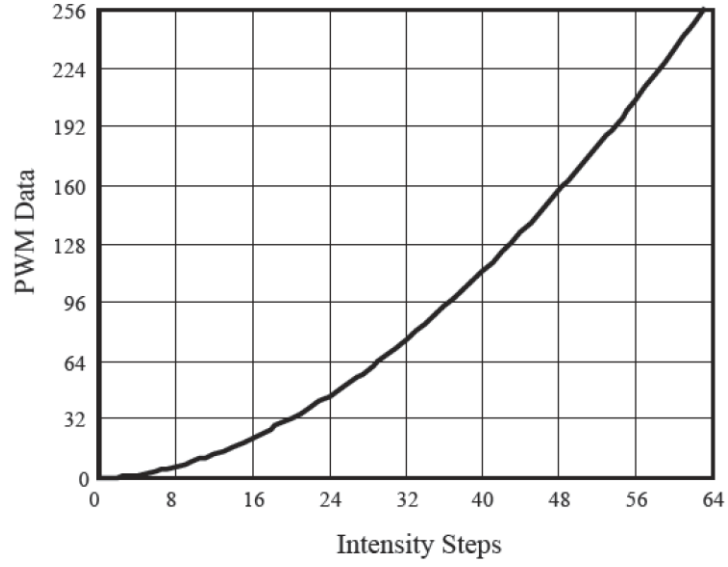


Figure 8 Gamma Correction (64 Steps)

5 OPEN/SHORT DETECT FUNCTION

HTR3229 has open and short detect bit for each LED.

Before using the open/short detect function, the following settings should be followed:

(1) The SSD of reg 0xA0 should be enabled;

(2) GCC (reg 0xA1) should be not “0x00”;

(3) LSB of SL (reg 0x90 ~ 0x9F) should be “1”;

(4) PWM (reg 0x01~ 0x8F) should be not “0x00”;

(5) Write reg 0xB0 as 0x00, so that neither pullup nor pulldown resistor exists for SWx.

After that, by setting the OSDE bits of the Configuration Register (A0h) 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 B3h~C4h, the open/short data will not get refreshed when setting the OSDE bit of the Configuration Register.

The detect action is one-off event and each time before reading out the open/short information, the OSDE bit of the Configuration Register (A0h) need to be set from “0” to “1” (clear before set operation).

HTR3229 每个 LED 都有一个开路和短路检测位。

在使用开短路检测功能前需要设置：

(1) 0xA0 中的 SSD 需使能；

(2) 0xA1 的全局电流设置为非 0；

(3) 0x90~0x9F 的 SL 最低位为 1；

(4) 0x01~0x8F 的 PWM 设置为非 0；

(5) 0xB0 写 0，不要有上拉下拉。

随后通过设置配置寄存器（A0h）的 OSDE 位从 “00”到 “01” 或 “10”，LED 开路/短路寄存器会开始存储开路/短路信息，在过了至少 2 个扫描周期后，MCU 就可以从 B3h~C4h 寄存器中读取到开路/短路信息，在设置配置寄存器的 OSDE 位的时候，开路/短路数据是不会被刷新的。

检测行为是一种一次性的行为，每次在读取开路/短路信息之前，配置寄存器的 OSDE 位需要从 0 变为 1。

6 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 HTR3229 has integrated Pull down resistors for each SWx (x=1~9) and Pull up resistors for each CSy (y=1~16). Select the right SWx Pull down resistor (B0h) and CSy Pull up resistor (B0h) which eliminates the ghost LED for a particular matrix layout configuration.

“ghost” 这个词是用来描述某个 LED 灯处于 OFF 态，但在别的 LED 灯打开时，却有比较淡的发光。鬼影现象通常发生在 LED 多路复用的时候。在阵列结构中，任何在恒流输出端或者 PCB 到 LED 灯的寄生电容都可能提供足够的电流去点亮某个 LED 灯，从而导致鬼影现象。

为了防止这种鬼影，在 HTR3229 中，对于每个 SWx 有多组下拉电阻，对于每个 CSy 有多组上拉电阻，选择合适的下拉和上拉电阻可以有效限制鬼影现象。

7 SHUTDOWN MODE

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

芯片关断模式可用于减少功耗。在芯片关断模式下，所有寄存器保持原数据不变。

Software Shutdown

By setting SSD bit of the Configuration Register (A0h) to “0”, the HTR3229 will operate in software shutdown mode. When the HTR3229 is in software shutdown, all current sources are switched off, so that the matrix is blanked. All registers can be operated.

通过对配置寄存器（A0h）中的 SSD 位置“0”，芯片进入软件关断模式，所有的电流输出端口关闭，所有的寄存器都可以改写。

Hardware Shutdown

The chip enters hardware shutdown when the SDB pin is pulled low. All analog circuits are disabled during hardware shutdown The chip releases hardware shutdown when the SDB pin is pulled high. During hardware shutdown state Function Register can be operated.

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

当 SDB 脚拉低时，芯片进入硬件关断模式。所有的模拟电路都被关断。

当 SDB 脚拉高时，芯片退出硬件关断模式。在硬件关断模式下，寄存器可以被操作。

如果在 SDB 拉低的时候 VCC 电压掉到了 0.1V 到 1.75V 之间，那么在 SDB 拉高之前请重新配置寄存器的值。

8 Register Map

Table4 Register Map

Register Address	Name	Function	R/W	Default Value
01h~8Fh	PWM Register	Set PWM value for LED 设置 PWM 的值	R/W	0000 0000
90h~9Fh	Scaling Register	Control the DC output current of each CSy 控制每一路 CS 的直流输出	R/W	0000 0000
A0h	Configuration Register	Configure the operation mode 配置运行模式	R/W	0001 0000
A1h	Global Current Control Register	Set the global current 设置全局电流	R/W	0000 0000
B0h	Pull Down/Up Resistor Selection Register	Set the pull down resistor for SWx and pull up resistor for CSy 设置 SWx 的下拉电阻和 CSy 的上拉电阻	R/W	0011 0011
B1h	Spread Spectrum Register	Spread spectrum function enable 扩频功能使能	R/W	0000 0000
B2h	PWM Frequency Register	Set the PWM frequency 设置 PWM 频率	R/W	0000 0001
B3h~C4h	Open/Short Register	Store the open or short information 存储开路或者短路的信息	R	0000 0000
CFh	Reset Register	Reset all register to POR state 重启所有寄存器	W	0000 0000

Register Address: 01h~8Fh, PWM Register (default 0000 0000)

Bit	Label	Default	Description
D7:D0	PWM	0000000	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, see the following formula. 每个点都有一个字节去控制 256 个台阶的 PWM 占空比，每个 PWM 寄存器的值决定了每个 LED 电路的平均电流，具体可参考公式说明.

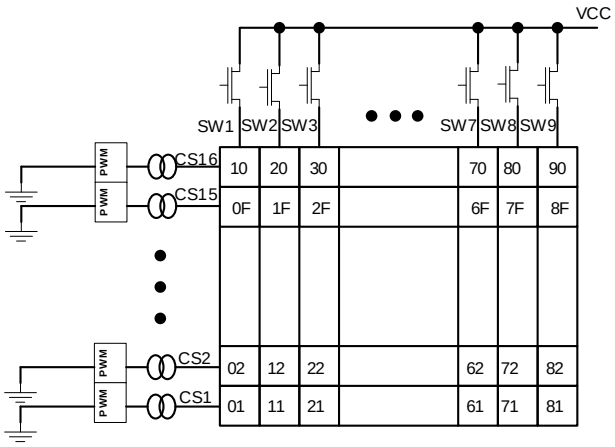


Figure 9 PWM Register Map

The average current of each LED I_{LED} can be computed by Formula:

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

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

Where Duty is the duty cycle of SWx,n=9 or 8 .....:

$$Duty = \frac{30\mu s}{30\mu s + 0.8\mu s + 0.27\mu s} \times \frac{1}{n}$$

I_{OUT} is the output current of CSy (y=1~16):

$$I_{OUT(PEAK)} = \frac{342}{R_{ISET}} \times \frac{GCC}{64} \times \frac{SL}{256}$$

GCC is the Global Current Control Register (A1h) value, SL is the Scaling Register value (90h~9Fh) and R_{ISET} is the external resistor of I_{SET} pin.

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

每个 LED 电路的平均电流 I_{LED} 计算如下：

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

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

Duty 是 SW 的占空比时间，其中 n 表示路数。

$$Duty = \frac{30\mu s}{30\mu s + 0.8\mu s + 0.27\mu s} \times \frac{1}{n}$$

I_{OUT} 的输出电流为

$$I_{OUT(PEAK)} = \frac{342}{R_{ISET}} \times \frac{GCC}{64} \times \frac{SL}{256}$$

GCC 是 Global Current Control Register (A1h) SL 是 Scaling Register value (90h~9Fh) R_{ISET} 是 I_{SET} 引脚上的外部电阻值

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

Register Address: 90h~9Fh, Scaling Register (default 00000000)

Bit	Label	Default	Description
D7:D0	SL	00000000	Scaling register control the DC output current of each CSy. Each CSy has a byte to modulate the scaling in 256 steps. The value of the Scaling Register decides the peak current of each LED noted $I_{OUT(PEAK)}$. 扫描寄存器控制 CSy 每一路的的直流输出电流，每一个 CSy 都有 1byte 在 256 阶范围内控制扫描信号。扫描寄存器的值决定了每个 LED 的 peak 电流。具体可参考公式说明。

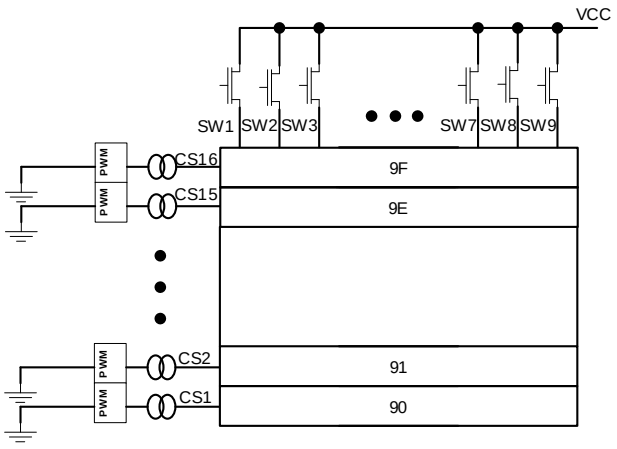


Figure 10 Scaling Register Map

Register Address: A0h, Configuration Register (default 00010000)

Bit	Label	Default	Description
D7:D4	SWS	0001	SWx Setting 0000: SW1~SW9, 9SWx15CS matrix 0001: SW1~SW8, 8SWx16CS matrix 0010: SW1~SW7, 7SWx16CS matrix, SW8 no-active 0011: SW1~SW6, 6SWx16CS matrix, SW7~SW8 no-active 0100: SW1~SW5, 5SWx16CS matrix, SW6~SW8 no-active 0101: SW1~SW4, 4SWx16CS matrix, SW5~SW8 no-active 0110: SW1~SW3, 3SWx16CS matrix, SW4~SW8 no-active 0111: SW1~SW2, 2SWx16CS matrix, SW3~SW8 no-active 1000: SW1~SW8 with same phase, all on. Others nosue
D3	LGC	0	H/L logic 高低逻辑电平 0：1.4V/0.4V 1：2.4V/0.6V
D2:D1	OSDE	00	Open Short Detection Enable 开路短路检测使能 00：关闭开路短路检测 Disable open/short detection 01/11：开路检测使能 Enable open detection 10：短路检测使能 Enable short detection
D0	SSD	0	Software Shutdown Control 软件关闭控制 0：软件关闭 Software shutdown 1：正常工作 Normal operation

Register Address: A1h, Global Current Control Register (default 00000000)

Bit	Label	Default	Description
D7	Reserved	0	
D6:D0	GCC	0000000	The Global Current Control Register modulates all CSy (y=1~18) DC current which is noted as I_{OUT} in 65 steps, maximum GCC is “100 0000’, if GCC>“1000000”, GCC= “100 0000”. 全局电流控制寄存器控制 CSy(y=1~18)的直流电流（65 个台阶），最大设置值为 1000000，如果 GCC 大于 1000000，则 GCC 为 1000000

Register Address: B0h, Pull Down/Up Resistor Selection Register (default 00110011)

Bit	Label	Default	Description
D7	PHC	0	Phase choice，相位选择 0：0 度相位延迟 0 degree phase delay 1:180 度相位延迟 180 degree phase delay
D6:D4	SWPDR	011	SWx Pull down Resistor Selection，SWx 下拉电阻选择寄存器 000: No pull-down resistor 001: 4.0kΩ only in SWx off time 010: 8.0kΩ only in SWx off time 011: 0.5kΩ only in SWx off time 100: 8.0kΩ all the time 101: 0.5kΩ all the time 110: 1.0kΩ all the time 111: 2.0kΩ all the time
D3	Reserved	0	
D2:D0	CSPUR	011	CSy Pull up Resistor Selection CSy 上拉电阻选择寄存器 000: No pull up resistor 001: 4.0kΩ only in CSx off time 010: 8.0kΩ only in CSx off time 011: 0.5kΩ only in CSx off time 100: 8.0kΩ all the time 101: 0.5kΩ all the time

			110: 1.0kΩ all the time 111: 2.0kΩ all the time

Register Address: B1h, Spread Spectrum Register (default 00000000)

Bit	Label	Default	Description
D7:D6	Reserved	00	
D5	SSP	0	Spread spectrum function enable 扩频使能 0：禁止 Disable 1：使能 Enable
D3:D2	RNG	00	Spread spectrum range 扩频范围 00 ±5% 01 ±15% 10 ±24% 11 ±34%
D1:D0	CLT	00	Spread spectrum cycle time 扩频周期选择 00 1980μs 01 1200μs 10 820μs 11 660μs

Register Address: B2h, PWM Frequency Register (default 00000001)

Bit	Label	Default	Description
D7:D3	Reserved	00000	
D2:D0	PWMF	001	PWM frequency setting PWM 频率设置 000 55kHz 001 32kHz 010 4kHz 011 2kHz 100 1kHz 101 0.5kHz(n≤4) 110 0.25kHz(n≤2) 111 80kHz

Register Address: B3h~C4h, Open/Short Register (Read Only)

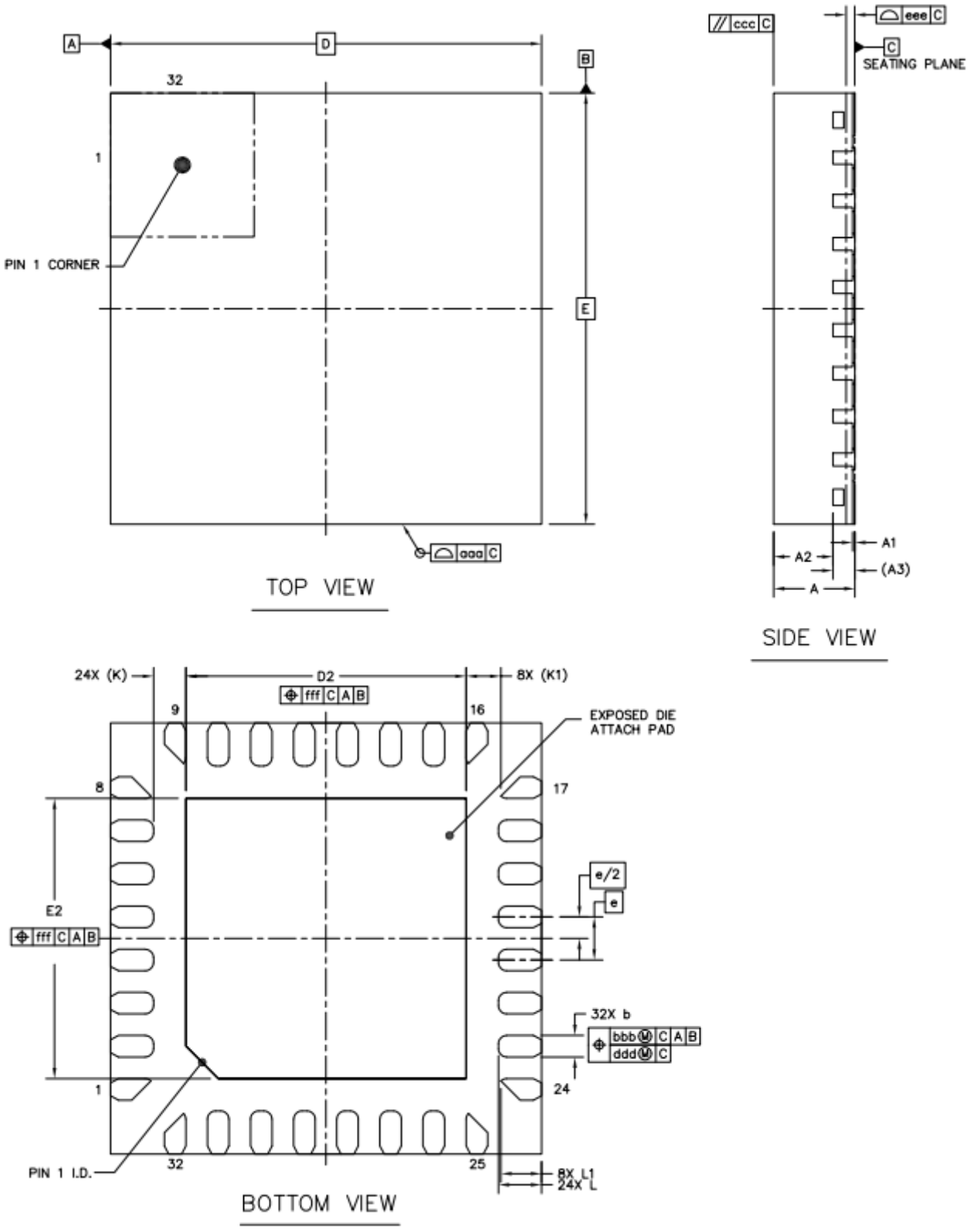
Bit	Label	Default	Description
D5:D0	CS16:CS09, CS08:CS01	00000000	When OSDE (A0h) is set to “01”, open detection will be triggered once, and the open information will be stored at B3h~C4h. 当 0SDE(A0h) 设置为“01”开路检测会检测一次，开路信息就会存储到 B3h~C4h When OSDE (A0h) set to “10”, short detection will be triggered once, and the short information will be stored at B3h~C4h 当 0SDE(A0h) 设置为“10”短路检测会检测一次，短路信息就会存储到 B3h~C4h

Register Address: CFh, Reset Register

Bit	Label	Default	Description
D7:D0	Reset	00000000	Once user writes the Reset Register with any value, HTR3229 will reset all the HTR3229 registers to their default value. On initial power-up, the HTR3229 registers are reset to their default values for a blank display. 当用户在 Reset 寄存器中写入任意值，HTR3229 会复位所有的寄存器到他们的初始值。在初始上电的过程中，HTR3229 也会被复位到初始值

■ PACKAGE OUTLINE

SQE (QFN4×4-32L)



Symbol	Dimensions in Millimeters		
	Min.	NOM	Max.
A	0.7	0.75	0.8
A1	0	0.02	0.05
A2		0.55	
A3		0.23REF	
b	0.15	0.2	0.25
D		4 BSC	
E		4 BSC	
e		0.4 BSC	
D2	2.5	2.6	2.7
E2	2.5	2.6	2.7
L	0.3	0.4	0.5
L1	0.277	0.377	0.477
K		0.3REF	
K1		0.323	
aaa		0.1	
ccc		0.1	
eee		0.08	
bbb		0.07	
ddd		0.05	
fff		0.1	

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