SM2235EGH

Features

- "Xin" our patented intelligent dimming control technology
- OUTI, OUT2, OUT3 Max Current 64mA，500 V
- OUT4, OUT5 Max Current 80mA, 500V
- 5 OUT ports can be open simultaneously
- <=4% output current deviation between outputs
- Input Voltage: 120Vac/220Vac
- Integrated High-Voltage power supply
- Class I2C signal input
- <80uA Standby current
- Adjustable max current gain
- Single channel independent 1024-bit grayscale
- Maximum current program setting, no REXT resistor needed
- Thermal Regulation
- Bluetooth, Wifi, 2.4G, zigbee, other smart modules
- Package Form： ESOP8

Typical Application

- LED Bulb
- LED Downlight
- Other LED Lighting

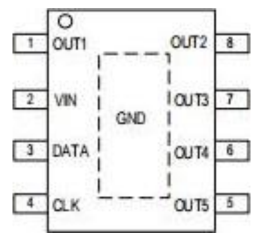
Overview

SM2235EGH is a five-channel intelligent dimming LED linear flow control chip, suitable for driving low-power LED lamps.

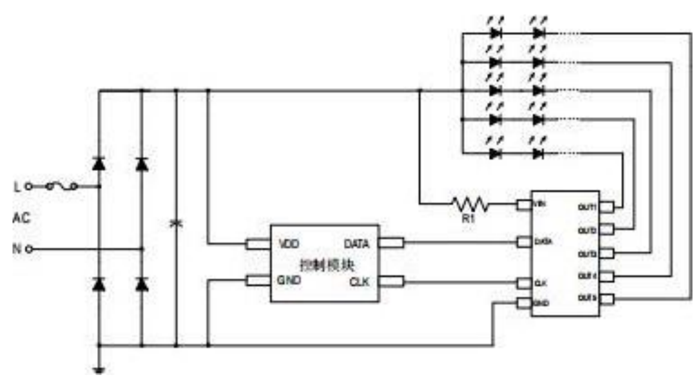
SM2235EGH has 5 independent high voltage output ports, integrated DA function, I2C protocol input from MCU to adjust the current of each output with no flicker.

Each OUT port of SM2235EGH can generate 1024-level current grayscale changes, to drive the LED on and off to realize intelligent dimming.

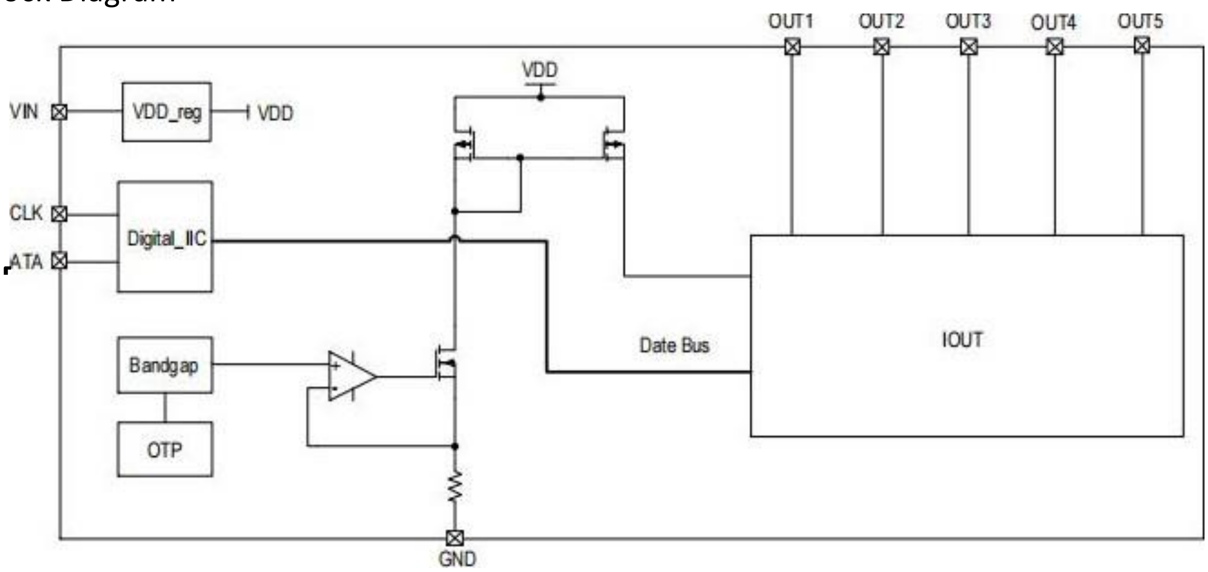
Pin Diagram



ESOP8



Block Diagram



Pin Description

Pin Number	Pin Name	Pin Description
1	OUT1	Constant current output port 1 (default red/blue)
2	VIN	Power Input Port
3	DATA	I2C SDL Port
4	CLK	I2C SCK Port
5	OUT5	Constant current output port 5 (default Yellow/White)
6	OUT4	Constant current output port 4 (default Yellow/White)
7	OUT3	Constant current output port 3 (default Red/Green/Blue)
8	OUT2	Constant current output port 2 (default Red/Green/Blue)
PAD	GND	Chip Ground

Ordering Information

Model	Form Package	Packing		Reel Size
		Tube	Tape	
SM2235EGH	ESOP8	1m	4000	13

Operating Parameters（Note 4, 5）

Unless otherwise specified，T_{A}=25°C.

Symbol	Description	Condition	Min	Typ	Max	Unit
Supply Voltage (VCC)						
VIN_BV	Breakdown voltage	-	500	-	-	V
VIN_ON	Min Turn-On Voltage	-	-	11	-	V
IDD	Working Current	VIN=20V	0.65	0.70	0.75	mA
IDD_STB	Stand-by current	VIN=20V, After standby mode, CLK, DATA are set to high level	-	-	80	uA
Output Port (OUT1-OUT5)						
VOUT_BV	OUT	-	500	-	-	V
VOUT_MIN	Constant current inflection point	VIN=20V, IOUT=30mA	-	-	4	V
		VIN=20V, IOUT=60mA	-	-	12	V
DIOUT	IOUT deviation	IOUT=30mA	-	+/- 4	-	%
IOUT1, IOUT2, IOUT3	OUT1, OUT2, OUT3 output current	-	-	64	-	mA
IOUT4, IOUT5	OUT4, OUT5 output current	-	-	80	-	mA
IOUT_MIN	Minimum dimming depth	-	-	0.1	-	%
I2C Signal						
F_DATA	DATA input frequency	-	1	-	1000	KHz
F_CLK	CLK input frequency	-	1	-	1000	KHz
VH_DATA	DATA input high level	VIN=20V	2.4	-	5.0	V
VH_CLK	CLK input high level	VIN=20V	2.4	-	5.0	V
VL_DATA	DATA input low level	VIN=20V	0	-	1.3	V
VL_CLK	CLK input low level	VIN=20V	0	-	1.3	V
V_SUP	IIC interface supply voltage	-	-	3.1	-	V
R_DATA	DATA pin pull-up resistor	VIN=20V	-	30	-	KΩ
R_CLK	CLK pin pull-up resistor	VIN=20V	-	30	-	KΩ
Over-Temperature Protection						
TSC	Current Negative temperature compensation starting point (Note 6)		-	145	-	°C

Guaranteed under test

注 5，烟貉书的最小、最大参数范由瀏试保 ilf，奧型值由设让、试或统让分析保证· 注 6：

电薇负度补偿起始点为芯片内设定度 145C·

Functional Statement

SM2235EGH is a five-channel intelligent dimming LED linear constant current control chip, which can connect red/green/li three-color LED lights and white/yellow two-color LED lights in parallel.
Controlled by the control module to realize red/green/li three-color, white/yellow two-color intelligent dimming/color temperature.

SM2235EGH can set the maximum current output of the chip through the forum control, without external REXT resistor.

- **Efficiancy Design**

Calculate working efficiency:

$$n = \frac{PLED}{PIN} = \frac{n * VLED * ILED}{VIN * ILED} = \frac{n * VLED}{VIN} \qquad \eta = \frac{P_{LED}}{P_{IN}} = \frac{n^{*} V_{LED} {}^{*} I_{LED}}{V_{IN} {}^{*} I_{LED}} = \frac{n^{*} V_{LED}}{V_{IN}}$$

Where V is the system input power supply voltage, VLED is the operating voltage drop of a single LED, and ILED is the averaged single LED current. The number of LEDs connected in series in the system can be seen with the effect of a larger amount n, the higher the system work efficiency. During the system design process, it is necessary to adjust the working voltage of the OUT port of the SM2235EGH according to the application environment and the total number of LEDs used.

- Design the number of LEDs in series

The following two aspects should be considered in the design of the number of LEDs connected in series:
1) The full OUT port voltage Vour = WW~ mVp, in order to ensure the normal operation of the chip, it is necessary to ensure that the OUT port Vour> Vourws suddenly.
2) The lower the voltage of the OUT port of the chip, the higher the system work efficiency
Combining the above two points, the number n of LEDs connected in series in the system is calculated as:

$$n = \frac{V_{IN} - V_{OUT}}{V_{LED}}$$

- Cooling Measures

There is a temperature compensation circuit inside the SM2235EGH chip. In order to avoid current drop caused by high chip temperature, the system needs to have good heat dissipation to ensure that
The SM2235EGH chip works in a reasonable temperature range, and the common cooling measures are as follows:

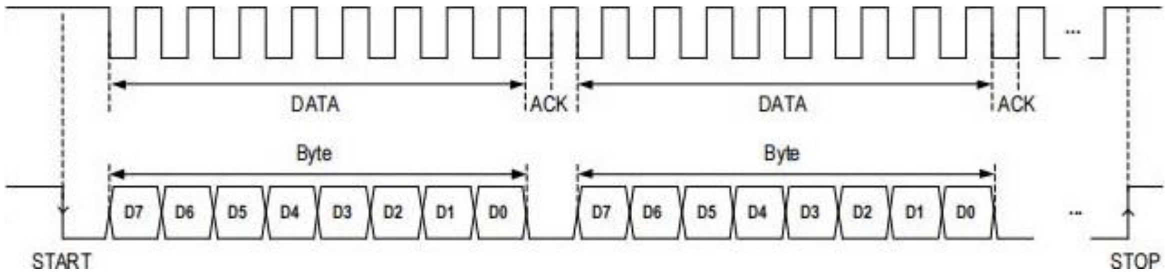
1) The system adopts aluminum substrate;
2) Increase the cladding area of the SM2235EGH substrate:
3) Increase the heat dissipation base of the whole lamp;

When the internal temperature of the LED lamp is too high, it will cause serious light decay of the LED lamp and reduce the service life of the LED. SM2235EGH integrates temperature compensation function, when the inside of the chip reaches the over-temperature point of 145sC, the chip will automatically reduce the output current to reduce the internal temperature of the lamp.

Intelligent Dimming Method

I2C Protocol

Send dimming signal through the control module for intelligent dimming control. This chip adopts the two-wire communication protocol of I2C. The dimming signal is divided into clock signal CLK and data signal DATA, the handshake rules are as follows:



The control module sends 10 bits of dimming signal, The working mode of port 10 is recommended to be configured as push-pull mode.

Protocol Description：

1) START, Protocol start code, CLK， CLK high level with DATA falling edge：

2) Address setting command, display setting command, dimming data signal, the rising edge of CLK samples the DATA data, and the high-order bits are sent first：

3) ACK: Each byte of the clock port sends 8 clock signals and 1 ACK signal. ACK pulse signal, DATA does not need to send acknowledgement.

4) STOP: Protocol end code, the rising edge of DATA is included in the high level of CLK.

Dimming Data Format

Dimming control data consists of 12 Byte (Byte0-Byte11), A total of 96 bits of data (8 bits of data per byte). The control function of each byte data is as follows：

Effect	Byte 0-1	Byte 2-3	Byte 4-5	Byte 6-7	Byte 8-9	Byte 10-11
Data Content	Set address and parameters	OUT1 (R) Port Grayscale data	OUT2 (G) Port Grayscale data	OUT3 (B) Port Grayscale data	OUT4 (C) Port Grayscale data	OUT5 (W) Port Grayscale data

The data shows:

1) Byte0: B7~B6 is the decoding identification bit, the default value is 1. B5 is reserved bit, default value is 0. B4~B3 is channel selection mode, 00 is standby, 01 selects 3-channel output, 10 selects 2-channel output, 1 selects 5-channel output. B2~B0 is the starting address setting command, 000 is OUT1 (R-LED) grayscale data address, 001 is the OUT2 (G-LED) grayscale data address, 010 is the OUT3 (B-LED) grayscale data address, 011 is the OUT4 (C-LED) grayscale data address, 100 is the OUT5 (W-LED) grayscale data address.

2) Byte1: the maximum current setting command, used to set the maximum output of OUT1-OUT5. B7~B4 are the current gain adjustment bits of RGB lights, the adjustment level is 16. B3-B0 is the current gain adjustment bits of the C and W LEDs, the adjustment level is 16.

3) Byte 2-11: Grayscale data, used to control the grayscale level of the OUT1-OUT5 ports, each port is controlled by 10bit data, a total of 1024 levels. The specific control status is as follows:

Address and parameter commands

(Byte0)

B7 … B0

1	1	0	B4	B3	B2	B1	B0

11: Decoding flag bit
Default: 11

00: Standby mode
01: Select 3 channels
10: Select 2 channels
11: Select 5 channels
Default: 00

B[2:0]: Start address selection
000: OUT1 (R lamp) grayscale data address
001: OUT2 (G lamp) grayscale data address
010: OUT3 (B lamp) grayscale data address
011: OUT4 (C lamp) grayscale data address
100: OUT5 (W lamp) grayscale data address
Default: 000

(Byte1)

B7 … B0

B7	B6	B5	B4	B3	B2	B1	B0

B[7:4]: R/G/B Light
Maximum current selection
0000: 4mA
0001: 8mA
0010: 12mA
0011: 16mA
0100: 20mA
0101: 24mA
0110: 28mA
0111: 32mA
1000: 36mA
1001: 40mA
1010: 44mA
1011: 48mA
1100: 52mA
1101: 56mA
1110: 60mA
1111: 64mA
Default: 0010

B[3:0]: C/W Light
Maximum current selection
0000: 5mA
0001: 10mA
0010: 15mA
0011: 20mA
0100: 25mA
0101: 30mA
0110: 35mA
0111: 40mA
1000: 45mA
1001: 50mA
1010: 55mA
1011: 60mA
1100: 65mA
1101: 70mA
1110: 75mA
1111: 80mA
Default: 0100

OUT1 (R lamp) Grayscale data

(Byte2)

B7 … B0

0	0	0	0	0	0	B1	B0

(Byte3)

B7 … B0

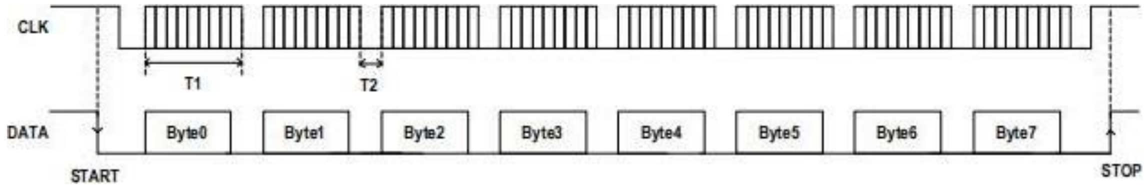
B7	B6	B5	B4	B3	B2	B1	B0

B2[7:0],B3[7:0]: Grayscale selection
00000000,00000000: 0/1023 Grayscale
00000000,00000001: 1/1023 Grayscale
00000000,00000010: 2/1023 Grayscale
…
00000000,10000000: 128/1023 Grayscale
…
00000000,11111111: 255/1023 Grayscale
…
00000010,00000000: 512/1023 Grayscale
…
00000011,11111111: 1023/1023 Grayscale
Default: 00000000,00000000

Application example

1) Select OUT1-OUT3 to control RGB lamp brightness, the maximum current is set to 64mA, and the gray level of OUT1-OUT3 is 88/1023.

The data transmission format is as follows:



Note： T1： sampling clock, 9 CLK cycles：

T2: Data group interval time, greater than or equal to one CLK clock：

Hardware connections: OUT1to R light, OUT2 to G Light, OUT3 to B Light.

Following the protocol rules above, the control input procedure is as follows:

1) START (start command):

2) 1100 0000, 1111 0100 (Write Byte0,Byte1, select 3 channels, point to the grayscale data starting from OUT1, set maximum current of OUT1-OUT3 to 64mA.)

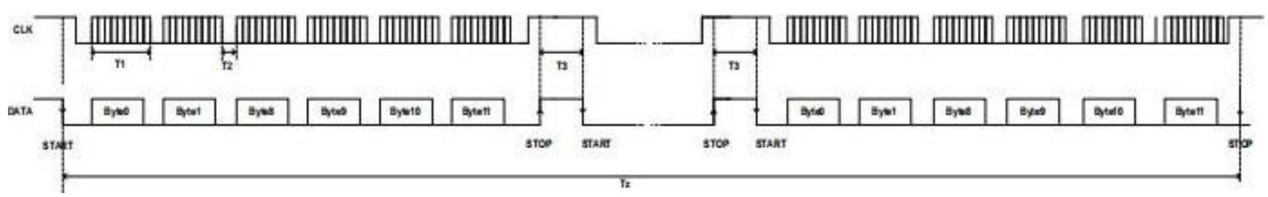
3) 0000 0000, 0101 1000 (Write Byte2,Byte3, set the gray level of OUT1 to 88/1023).

4) 0000 0000, 0101 1000 (Write Byte4, Byte5, set the gray level of OUT2 to 88/1023).

5) 0000 0000, 0101 1000 (Write Byte6, Byte7, set the gray level of OUT3 to 88/1023).

6) STOP (End command)

2) Select OUT4-OUT5 to control C light (cool white), W light (warm white), the maximum current is 60mA, Set OUT4 port output to 0%. The brightness gradually changes to 10% brightness, OUT5 port does not output, and the total time of the change process is 1s.



Note： T1: sampling clock, 9 CLK cycles

T2: data group interval time greater than or equal to one CLK.

T3: Frame interval time (adjusted according to refresh rate requirements):

Corresponding hardware connection: OUT4 port is connected to C light, OUT4 port is connected to W light.

The program is designed as follows:

The output brightness of the system gradually changes to the specified value, that is, the output current of the OUT port of the chip is changed from the minimum value to the specified output value. The gray of the OUT port is gradually changed from small to large. When the gray level is incremented by 1, the display effect of the system brightness gradient is the best. The total time of intensity change T_Z=1s, and the grayscale decimal data when calculating the output at 10% brightness is 102 (1023*10%), that is, the number of changed gray levels n=102 (can be adjusted according to the actual brightness requirements n).

The first frame data set the chip 2 channel output, set the maximum current, point to the slave OUT4 port as the initial grayscale data, Byte4 grayscale data. And set it to the lowest brightness (0/1023), the Byte5 grayscale data is (0/1023): the second frame data still points to the OUT4 port, BYTE4 grayscale data (1/1023), Byte5 grayscale data is (0/1023): and so on, the 102nd frame data still points to the OUT4 port, Byte4 grayscale data (102/1023), Byte5 grayscale degree data is (0/1023).

Time $T3=\frac{T_z}{n}-\left(\frac{1}{f}\times 9+T_2\right)\times N_{byte}$ between each frame of grayscale data sets.

Among them, T_z is the total time of the change process, f is the frequency of the I2C signal, N_{byte} is the number of bytes contained in each frame of data, and T_2 is the interval between each byte time $(T2\geq\frac{1}{f})$, n is the number of gray levels that change.

According to the above algorithm, the working frequency of the I2C signal is assumed to be 20KHz: the interval between each data group is T_2=100us, each frame of grayscale data group contains the number of bytes is 3 groups, and the number of gray levels = 102. Substitute into the above formula to get the time T3=6.8ms between each frame of grayscale data groups.

Following the protocol rules above, the control procedure is as follows:

1) START (start command):

2) 1101 0011, 0010 1011 (Write Byte0, Byte1, select 2 channels, point to the grayscale data starting from OUT4, set the maximum current of OUT4/OUT5 to 60mA.)

3) 0000 0000, 0000 0001 (Write Byte4, set the gray level of OUT4 to 1/1023).

4) 0000 0000, 0000 0000 (Write Byte5, set the gray level of OUT5 to 0/1023).

5) STOP (End command)

6) Delay (T3=6.8ms)

7) …..(Grayscale data for increase operation)

8) START (start command)

9) 1101 0011, 0010 1011 (Write Byte0, Byte1, select 2 channels, point to the grayscale data starting from OUT4, set the maximum current of OUT4-OUT5 to 60mA)

10) 0000 0000, 0110 0110 (Write Byte4, set the gray level of OUT4 to 102/1023);

11) 0000 0000, 0000 0000 (Write Byte5, set the gray level of OUT5 to 0/1023);

12) STOP (End command)

Constant current setting during color matching

The maximum current of the chip is ~!s, the chip sets the maximum current out, and the rules for constant power setting are as follows:

1: 3-way RGB output, R data+G data+B data <_ 1023*(I a/Iout).

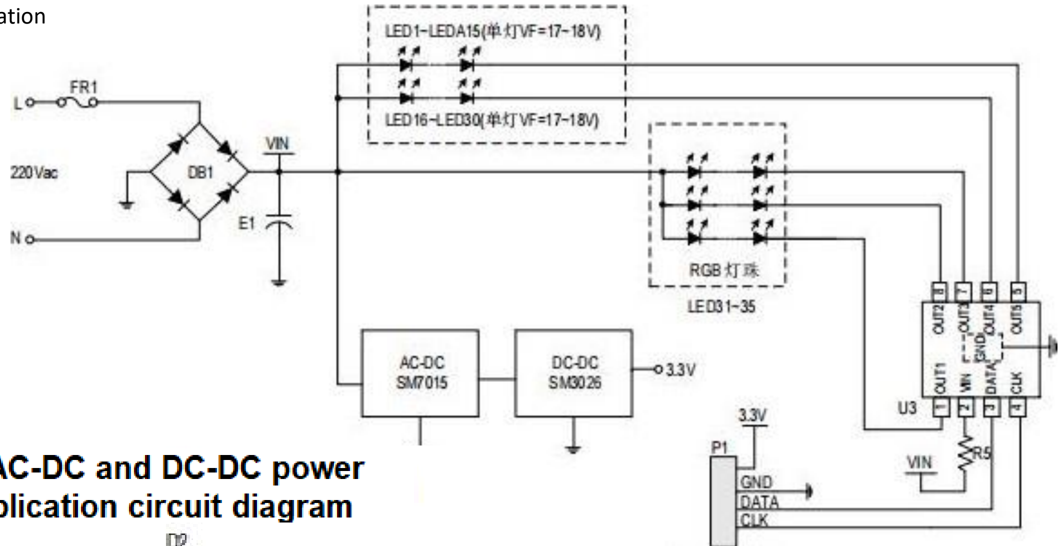
2: 2-way C/W output, C data+W data <_ 1023*(I a/Iout).

For example:

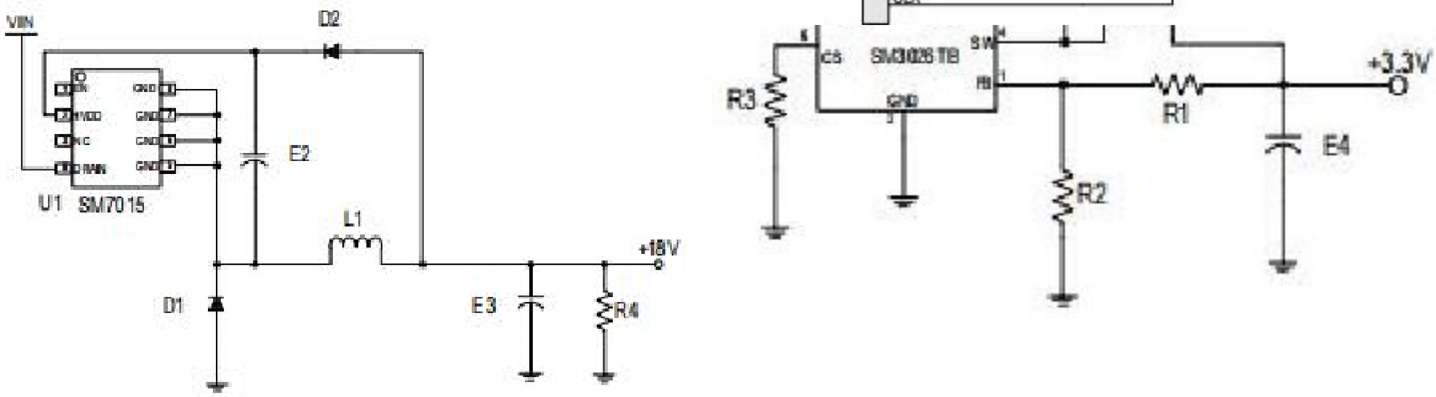
Make 220Vac input, 9W low-PF scheme, set the maximum current Ia=30mA. The chip sets the maximum current for R/G/B to Iout=24mA, then the R light is grayscale data + lamp grayscale data and lamp grayscale data <=1023*(Ig/Iout)=1023*(30/24)=1278 levels. Such as R light gray data = 500 levels, G light gray number=511 levels, only the gray level data of B light can be set to 1278-500-500-278 level, after 1ms, the R light level data is -300 level, and the G light gray level data is 30 level. Only then can you set the B lamp grayscale data level <=1278-300-300=678.

Make 220Vac input, 9W low PF scheme, set the maximum current I=30mA. The chip is set to C/W max current of Iout=50mA, then C light grayscale data < 1023*(I g/Iout)=1023*(30/50)=613 levels. If C lamp grayscale data = 100 levels, only the W lamp grayscale data can be set <=613-100=513 level, after 1ms, the C light grayscale data = 0 levels, then only the W light grayscale data can be set to <=613-50=563 levels.

Typical Application



Attached AC-DC and DC-DC power supply application circuit diagram



SM2235EGH+SM7015+SM3026TB BOM

Identifier	Desc	Identifier	Desc
FR1	10R 1W wire-wound resistor	E1	10uF/400V/
DB1	MB6S	E2	1uF/50V
D1, D2	E1J	E3	220uF/25V
R1	150K/0805	E4	220uF/6.3V
R2	56K/0805	U1	SM7015-SOP8
R3	0R/0805	U2	SM3026TB-SOT23-5
R4	43K/0805	U3	SM2235EGH-ESOP8
R5	10K/1206	LED1-LED30	2835 17-18V, 3000K/6000K 15PCS
L1	1mH/EE10	LED31-LED35	3030 54V RGB
L2	10uH/Power Inductor’.	P1	Intelligent control module
C1, C2	0.1uF/16V/0805		

PCB Layout