FS5610

60V/1A Single Channel, Multi String, High Power RGB LED Driver with 20mA LDO

November 2015

GENERAL DESCRIPTION

The FS5610 provides a simple circuit for single channel, multi string LED dimming solution. It saves two extra power stages for typical RGB application thereby reducing external circuitry while maintain a high efficiency. It has a built-in buck current regulator that provides excellent current tracking and dimming performance. The dimming range will be greater than 1024:1 at 100Hz dimming frequency. PWM frequency can be set between 100Hz~20kHz. This dimming solution can be designed to be noise free making it an ideal choice for household and commercial lighting products.

For this application, user often needs a MCU and an interface part, FS5610 integrates a LDO to provide 20mA 3.3V bias power for the external IC's.

An automatic current foldback function allows power savings when all the three LED strings turn off time is longer than 10ms. Open LED and over temperature protection ensures robust operation.

FS5610 can operate over an input voltage to 60V. It comes in a thermally enhanced eTSSOP-16 EDP package.

FEATURES

- LED drive current preset to 1A
- Total string range 6.5V~60V
- Noise free
- Flicker free
- Internal 3.3V LDO output for RF+MCU: 20mA/3.3V
- PWM Dimming frequency range 100Hz~20kHz
- Up to 1024: 1 PWM dimming range 100Hz
- Each FS5610 has 3 segment
- Direct PWM input (three strings)
- eTSSOP-16 package

APPLICATIONS

- Dimming bulb and color dimming
- Automotive environment lighting
- Architectural LED lighting
- Outdoor building color lighting
- Stage light, RGB floodlight/wall washer

TYPICAL APPLICATION CIRCUIT

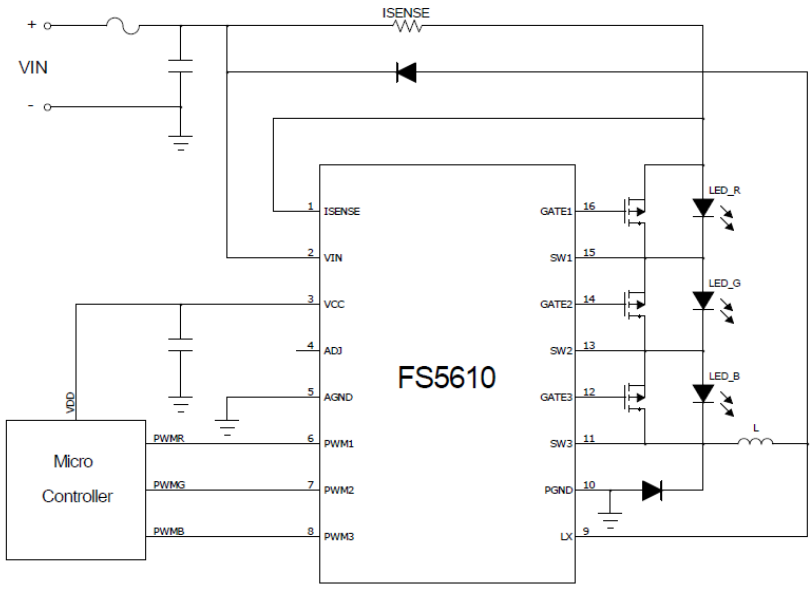
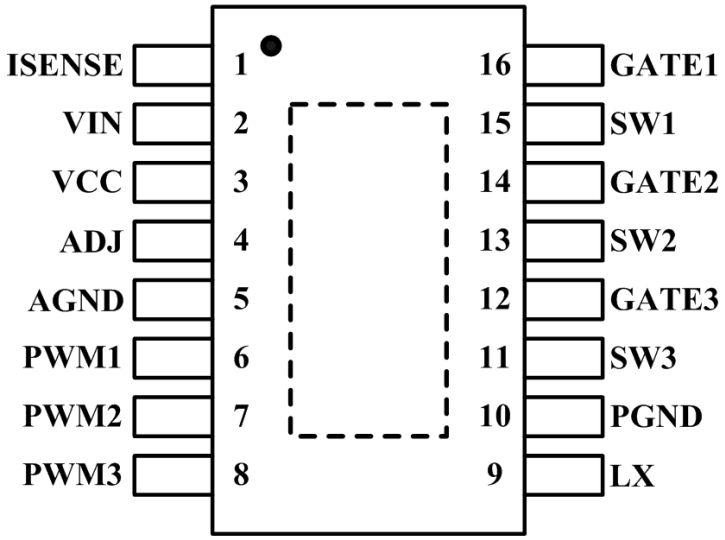


Figure 1 Typical Application Circuit

PIN CONFIGURATION

Package	Pin Configuration (Top View)
eTSSOP-16	

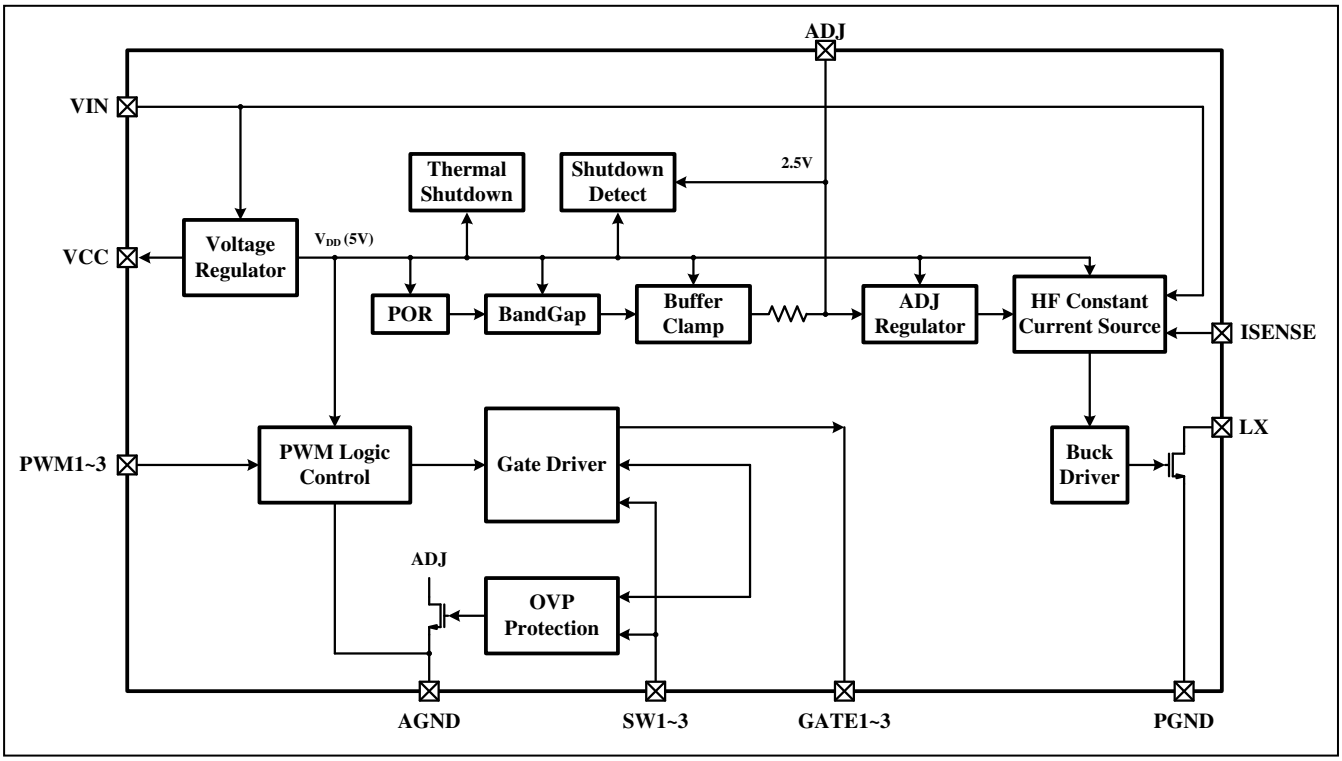
PIN DESCRIPTION

No.	Pin	Description
1	ISENSE	Connect resistor R_S from this pin to VIN to define current.
2	VIN	Input voltage (6.5V ~ 60V). Ground for PWM and MCU.
3	VCC	3.3V LDO output for MCU and RF chip (optional/TBD).
4	ADJ	Brightness control for Inductor current, report fault condition and reset FS5610.
5	AGND	Ground for PWM and MCU.
6	PWM1	PWM1 string 1 input signal from MCU.
7	PWM2	PWM2 string 2 input signal from MCU.
8	PMW3	PWM3 string 3 input signal from MCU.
9	LX	Switch node for high side buck regulator.
10	PGND	GND for constant current source.
11	SW3	SW node for string 3.
12	GATE3	GATE for PMOS 3.
13	SW2	SW node for string 2.
14	GATE2	Gate for PMOS 2.
15	SW1	SW node for string 1.
16	GATE1	Gate for PMOS 1.

ORDERING INFORMATION
Industrial Range: -40°C to +125°C

Order Part No.	Package	QTY
FS5610-XXX-TR FS5610-XXXY	eTSSOP-16, Lead-free	2500/Reel 96/Tube

FUNCTIONAL BLOCK DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Input voltage, V_{IN}	-0.3V~65V
ISENSE voltage, V_{ISENSE}	-0.3V~ V_{IN}+0.3V
Buck switch node voltage, V_{LX}	-0.3V~65V
Vg1, Vg2, Vg3, Vsw1, Vsw2, Vsw3	-0.3V~65V
PWM1, PWM2, PWM3, V_{ADJ}	-0.3V~6.0V
Total power dissipation, P_{TOT}	1.5w (T_S ≤100°C)
Maximum junction temperature, T_{JMAX}	150°C
Storage temperature range, T_{STG}	-65°~+150°C
Operating temperature range, T_A	-40°C~+125°C
Operation Input voltage range	6.5V~60V
ESD (HBM) ESD (CDM)	TBD

Note:
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 (TBD)

Test condition is T_A = −40°C ~ +125°C. Typical values are at T_A = 25°C, unless otherwise specified.

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
V_{IN}	Input voltage operation range		6.5		60	V
I_Q	Chip quiescent current (Excluding LDO)	V_{IN}=36V, V_{ADJ}=2.5V		1.2		mA
V_{SENSE}	Mean current sense threshold	T_A = 25°C	98	100	102	mV
		T_A = -40°C ~ +125°C	97	100	103	mV
$V_{SENSE\ HYS}$	Sense threshold hysteresis			15		%
I_{SENSE}	ISENSE pin input current			8		μA
I_{LX_LEAK}	LX switch leakage current				2.5	uA
I_{LX_MEAN}	Continuous LX switch current	For buck switch		1.0		A
R_{LX}	LX switch 'ON' resistance	For buck switch		0.35		Ω
t_{ON_MIN}	Minimum switch 'ON' time	LX switch 'ON'		200		ns
t_{OFF_MIN}	Minimum switch 'OFF' time	LX switch 'OFF'		200		ns
T_{SD}	Thermal shutdown temperature			150		°C
T_{SD_HYS}	Thermal shutdown hysteresis			15		°C
V_{ADJ}	External control voltage range on ADJ pin for dc brightness control	From 0.7V to 2.5V will adjust peak current threadhold	0.7		2.5	V
V_{ADJ_ON}	External control voltage range on ADJ pin for enable voltage	Pulling up above 0.7V will enable the buck.		0.7		V
V_{ADJ_OFF}	External control voltage range on ADJ pin for shutdown voltage	Pulling down bellow 0.6V will shut down the buck.		0.6		V
I_{SW_MEAN}	Continuous MOSFET current	For SW1, SW2, SW3			1	A
t_{ON_SW}	MOSFT switch turn on speed	V_{SW}-V_G=2V (C_{LOAD}=1nF)		100		ns
t_{OFF_SW}	MOSFET switch turn off speed	@V_{GX}=2V		100		ns
f_{RE}	Dimming frequency		0.1		20	kHz
DR	Dimming ratio	At 100Hz dimming		1024		
V_{LDO}	LDO voltage		3.1	3.3	3.5	V
I_{LDO}	LDO current (mA)		20	25		mA

V_{IH}	PWM logic high				1.4	V
V_{IL}	PWM logic low		0.4			V

APPLICATION INFORMATION

FS5610 module will provide the constant current sourcing and maintain the LED current for all three LED string in serial connection. The three channel PWM inputs will individually control each string duty to be desired value. Take an example, when PWM1 is high, the LED_R string will be shorted with external bypassing MOSFET. Thus each LED string current can be PWM dimming to the desired value while maintain the peak current for all three LED strings to main remain same which would be set by the hysteretic buck stage.

Setting LED string current

ADJ pin should be used to control total output LED current.

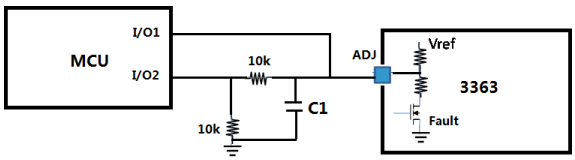
In normal operation ADJ voltage should be ranging from 0.7V to 2.5V (when over 2.5V should represent full current while 0.7V represent to minimal duty capable.

LED Open condition: (Latched fault)

1) Open LED string condition should be able to detect with over voltage on each of the LED strings.

2) Any open LED condition (or over voltage on individual string) will stop the current source from switching and would require input power recycling or ADJ recycling. (V_{IN} bellow 6.5V to clear the flag, or require V_{ADJ} pin pull down to zero and then pull high to clear).

When Fault condition happened, (LED open) ADJ pin voltage will be pull down to low by FS5610. (bellow 0.6V). This would be able to use ADJ pin as a fault flag pin which can be used to report fault condition to MCU. When MCU provides a voltage higher than 0.7V again, fault will be released and ADJ PIN can be control by MCU.



See the above figure. MCU I/O1 is a Bidirectional I/O. when MCU power up, it is input pin. So when fault condition happens, ADJ PIN will be pull down.

And MCU can catch the signal. Then I/O1 will be set to output pin, it can provide high voltage to restart buck. I/O2 is PWM signal. It can be used to control buck current by RC filter in ADJ pin.

Table 1 LED All PWM Operation Condition

Condition	PFET
PWM PIN= H	TURN ON
PWM PIN= L	TURN OFF
Shutdown	TURN OFF
System power up	TURN OFF

LED Short condition:

When all the LED PWM is low, and all PFETs turn on time is longer than 10ms, the LED current should be folding back to a low level (but not to zero) to about 20% of the normal current to reduce power dissipation. A minimal current is maintained to deduce the transition period from PWM low to one channel PWM on condition.

1) If any one of the LED string is short. Nothing would happen, part will under normal operation and provide regular constant current as indicated by V_{ADJ} and R_{SENSE}.

2) If all three LED string is shorted, and short time is longer than 10ms, peak inductor current will be fold back to 20% of the current level.

3) LDO will remain active under short condition.

4) Recover from LED short: once short condition is removed, the LED current should be back to normal automatically.

LDO voltage and current requirement:

1) Since PWM dimming always associated with MCU 3.3V LDO onboard would be needed. The current should be able to support a low current MCU to operate continuously. Current we set at 20mA with 25mA at high range.

Startup sequence:

1) Once LDO is operation and MCU is pre-loaded, The LED will start output current as command by V_{ADJ} pin.

2) The system power up default is shutdown, because ADJ pin can be connected to ground by 10kΩ resistor. So there is no LED flashing can be observed when initial power up. If MCU I/O provides a voltage higher than 0.7V, FS5610 will start up and buck current will be set up.

CLASSIFICATION REFLOW PROFILES

Profile Feature	Pb-Free Assembly
Preheat & Soak Temperature min (Tsmin) Temperature max (Tsmax) Time (Tsmin to Tsmax) (ts)	150°C 200°C 60-120 seconds
Average ramp-up rate (Tsmax to Tp)	3°C/second max.
Liquidous temperature (TL) Time at liquidous (tL)	217°C 60-150 seconds
Peak package body temperature (Tp)*	Max 260°C
Time (tp)** within 5°C of the specified classification temperature (Tc)	Max 30 seconds
Average ramp-down rate (Tp to Tsmax)	6°C/second max.
Time 25°C to peak temperature	8 minutes max.

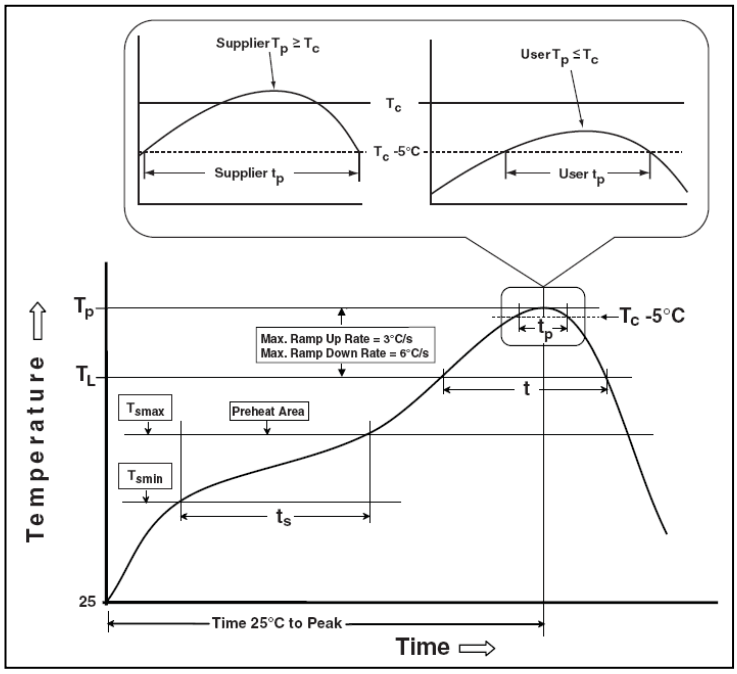
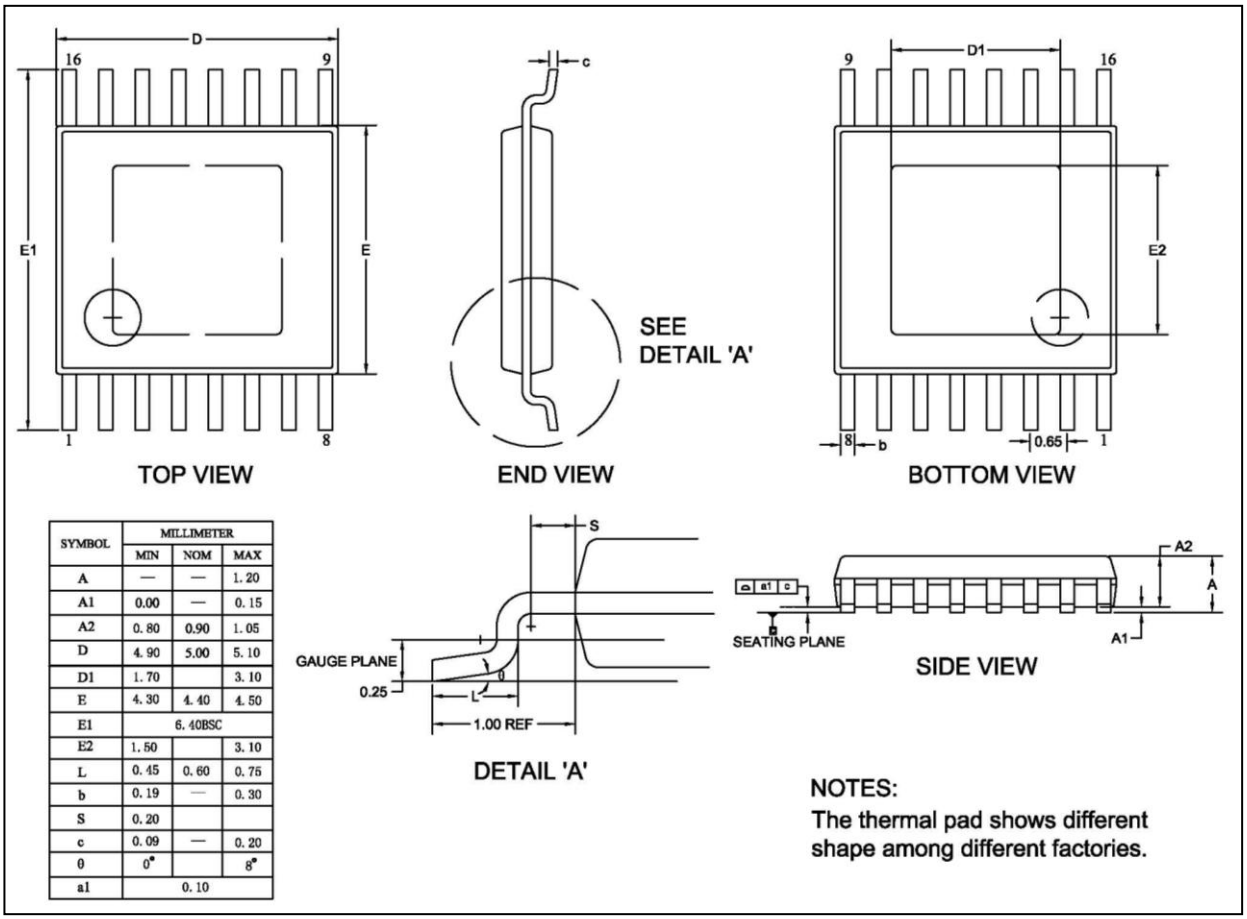


Figure 2 Classification Profile

PACKAGE INFORMATION

eTSSOP-16



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	—	—	1.20
A1	0.00	—	0.15
A2	0.80	0.90	1.05
D	4.90	5.00	5.10
D1	1.70		3.10
E	4.30	4.40	4.50
E1	6.40BSC		
E2	1.50		3.10
L	0.45	0.60	0.75
b	0.19	—	0.30
S	0.20		
c	0.09	—	0.20
θ	0°		8°
a1	0.10		

Note: All dimensions in millimeters unless otherwise stated.