GT5311

3Pin, Accurate Primary-Side, Constant Current Driver

Advanced

1. Features

- Patented 3pin package for cost effective and enhanced reliability
- High Accuracy ±5% CC Regulation
- No current overshoot during start-up
- Eliminates Opto-coupler and all secondary CC control circuitry
- Adaptive on time PWM control mode
- Innovative current sampling technology
- Built-in line compensation for tighter CC regulation
- Built-in compensation for transformer inductance tolerances
- Built-in Leading Edge Blanking (LEB)
- Cycle-by-Cycle Current Limiting
- VCC Under Voltage Lockout with Hysteresis (UVLO)
- Built-in two stage open voltage protection and inherent short load protection
- Operating Temperature: -40^{o}C to +85^{o}C
- SOT-23-3 Package

2. General Description

GT5311 simplifies low power CC LED driver designs by eliminating opto-coupler and secondary control circuitry through patented current sampling technology. Very tight output voltage and current regulation is realized as shown in the ***Figure 1*** below.

GT5311 multi-mode operations are utilized to achieve high efficiency and audio & noise free. The frequency jittering could also greatly reduce EMI filter cost.

GT5311 utilizes 3 Pin package to realize accurate CC regulation for cost effective and the device reliability is also enhanced.

GT5311 offers rich protection features including Cycle-by-Cycle peak current limiting, VCC UVLO, OVP and Clamp. The controller continues attempting start-up until the fault condition is removed. Every restart is a soft start.

The GT5311 is available in an SOT-23-3 package.

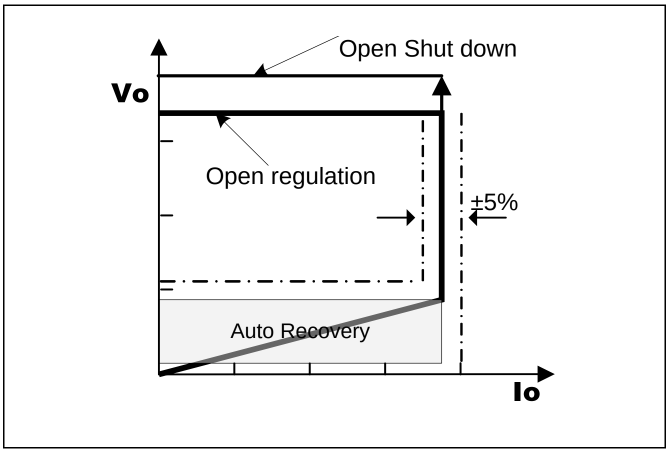


Figure 1. Typical CC Curve

3. Applications

- GU10 LED driver
- E14 LED driver
- E27 LED driver
- Others LED driver

4. Functional Block Diagram

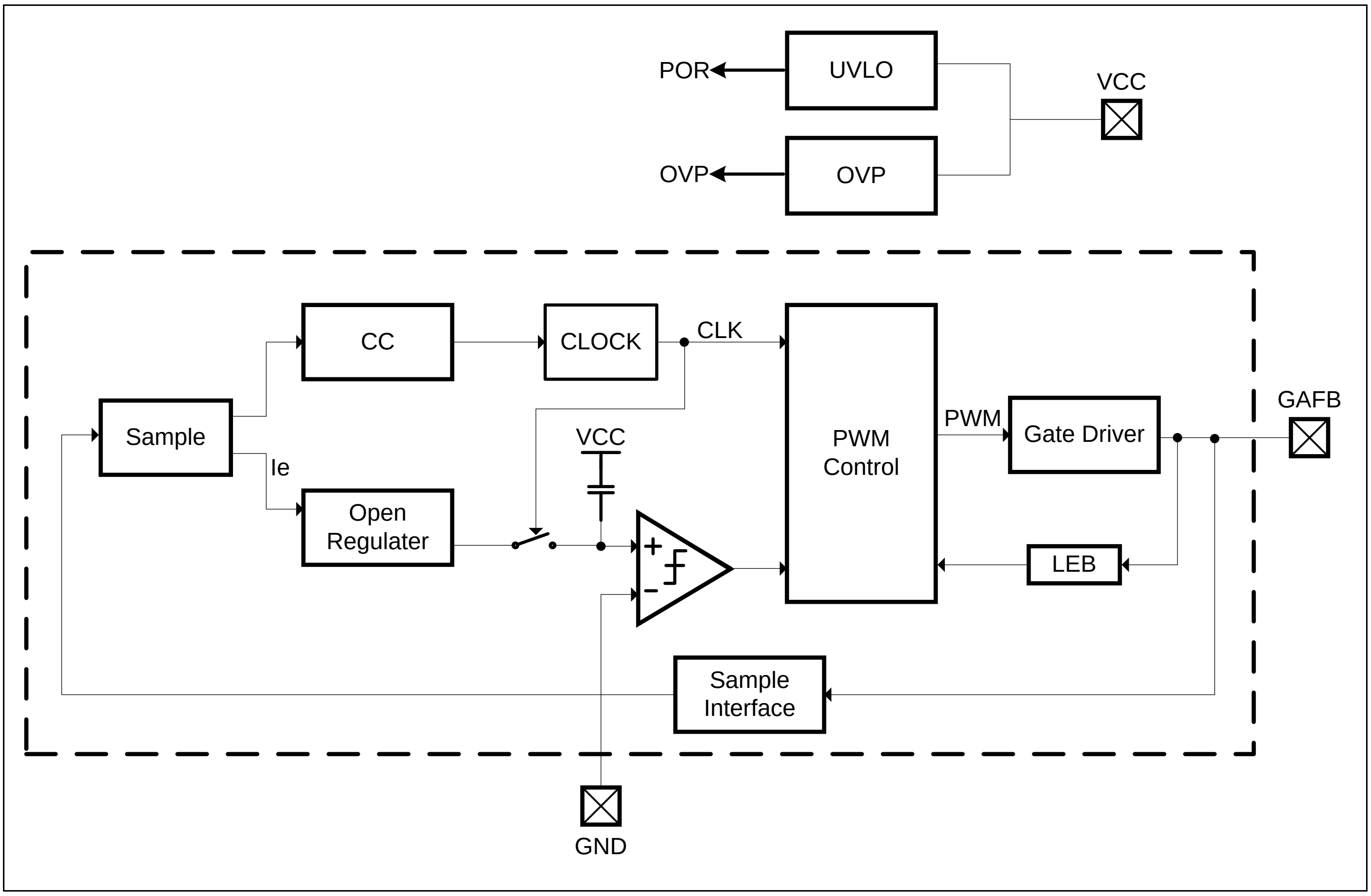


Figure 2. Functional Block Diagram

5. Pin Configuration

5.1 Pin Assignment Top View

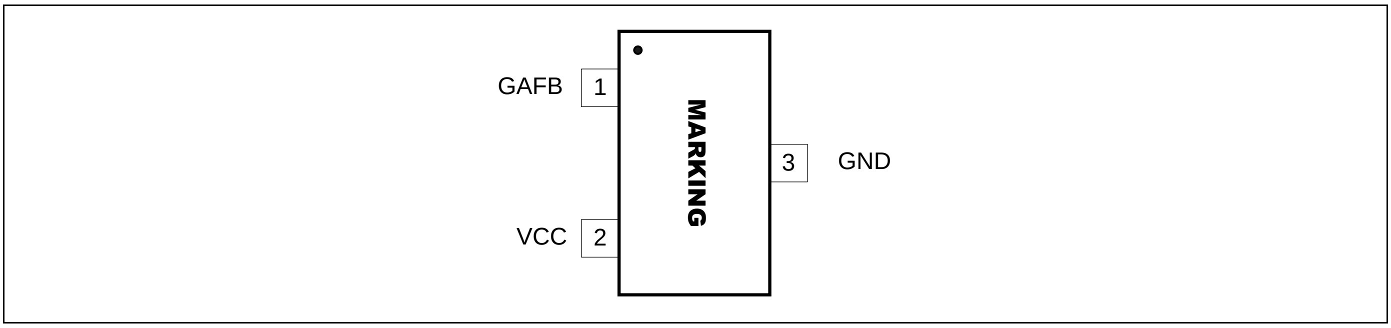


Figure 3. Pin Configuration (SOT-23-3 Package)

Note: Please see section "**Part Markings**" for detailed Marking Information.

5.2 Pin Descriptions

Pin #	Name	I/O	Function
1	GAFB	I/O	Gate driver output for power MOSFET. Detecting the output information by current sampling
2	VCC	-	IC power supply
3	GND	-	IC ground This pin could detect the primary current by the voltage of sensing resistor connected from Source to primary GND.

6. Functional Description

The GT5311 is an innovative 3-pin AC-DC controller in which a new proprietary primary-side control technology is employed to eliminate the opto-isolated feedback and secondary regulation circuits required in traditional designs. Additionally, patented 3-pin package design is adopted for cost effective and enhanced reliability. And some new technology is adopted to further improve performance.

6.1 Start-up

Due to an innovative internal start-up circuit and adaptive sleeping control technology adopted, when the system with GT5311 is powered on, pin VCC can be charged to a voltage higher than start-up threshold UVLO_off by a very large start-up resistor (>8MΩ) , which causes GT5311 to enter into normal operation state. Meanwhile the VCC decoupling capacitor is allowed to use a smaller value (<2µF) compared with traditional design, therefore the start-time can be limited within a reasonable range. After the system enters into normal operation state, pin GAFB of IC begins to output PWM driving signal to drive the external Power MOS switch and transfer power to the secondary stage, while a 1~2mA of operation current is required by the controller IC GT5311. At the initial stage of start-up, the current consumed by GT5311 is provided by VCC decoupling capacitor, therefore the voltage on VCC decoupling capacitor will gradually decrease; at the same time, as the output voltage rises up, the voltage of auxiliary coil of the transformer increases proportionally also. Eventually, when the voltage of auxiliary coil reaches the voltage of decoupling capacitor, the auxiliary coil will replace the decoupling capacitor as power supply of the control IC GT5311. The timing diagram of start-up is illustrated in ***Figure.4***.

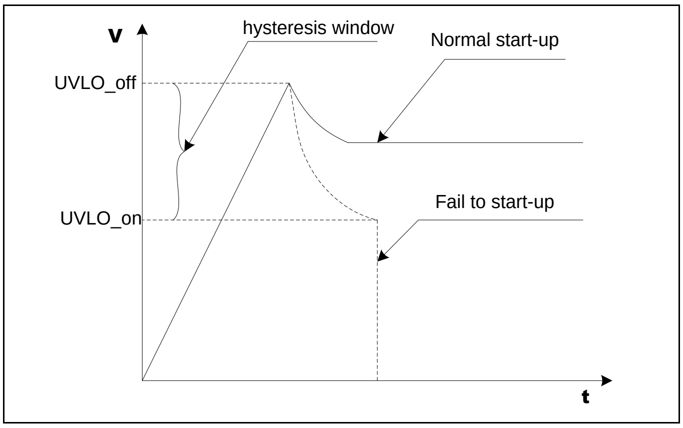


Figure 4. Timing Diagram of Start-up

As illustrated in ***Figure.4***, a hysteresis window for internal UVLO comparator is necessary to prevent the control IC GT5311 from shutting down due to voltage dip during start-up.

6.2 Constant current (CC) Operation

In LED lighting applications, constant output current is required regardless of output voltage. In order to regulate output current to a constant level, a ratio regulation algorithm is employed in the control IC. ***Figure.5*** illustrate the theory of the algorithm. As shown in ***Figure.5*** Ip is the peak current flowing through the primary-side sense resistor. When switch turns off, the peak current is mapped to secondary-side with a coefficient N_P/N_S. Due to the demagnetization of secondary-side winding, peak current linearly decreases to zero. The area of the triangle in ***Figure.5*** indicates the current integration of a cycle at secondary-side winding where t_{DM} is demagnetization time of the secondary-side inductance Ls, T is a switching period of the power converter system and $I_P \times N_P/N_S$ is the peak current of secondary-side winding. So, the average output current can be expressed as:

$$I_O = \frac{1}{2} \times \frac{T_{DM}}{T} \times \frac{N_P}{N_S} \times I_P = \frac{1}{2} \times \gamma \times \frac{N_P}{N_S} \times I_P$$

where γ is the ratio of the demagnetizing time to the switching period. Assuming the primary-side peak current I_P is regulate to a constant level, the constant output current can be obtained by regulating γ to a constant. In the power converter system based on GT5311, constant current can be defined as:

$$I_O = 0.245 \times \frac{N_P}{N_S} \times I_P$$

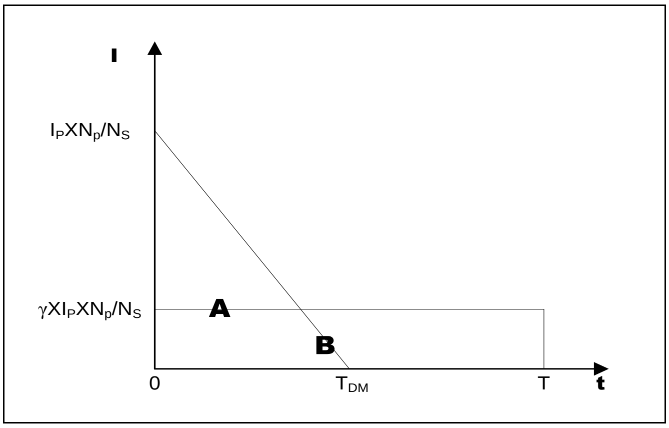


Figure 5. Diagram of output current

On the other hand, maximum output power can be expressed as:

$$P_{O\_MAX} = \frac{1}{2} \times L_P \times I_{P\_MAX}^2 \times f_{MAX}$$

Therefore, constant maximum output current can also be expressed as:

$$I_{O\_MAX} = \frac{1}{2} \times \frac{1}{V_{O\_MAX}} \times L_P \times I_{P\_MAX}^2 \times f_{MAX}$$

Where I_{O_MAX} indicates the constant maximum output current, V_{O_MAX} indicates the maximum output voltage, Lp is the inductance of primary-side winding, I_{P_MAX} is the maximum primary peak current, f_{MAX} is the maximum operation frequency.

Obviously, for a given I_{O_MAX}, I_{P_MAX}, V_{O_MAX}, the maximum operation frequency can be defined through setting the inductance L_P of primary-side winding.

6.3 Built-in Line Compensation

In the flyback converter system with GT5311, line voltage compensation can be simply implemented by adjusting the on-time of power MOSFET.

The line compensation voltage ΔV_{LN} can be calculated according to below equation:

$$\Delta V_{LN} = 5000 \times T_{on}(uS)$$

Where T_{on} is the on-time of power MOSFET.

6.4 Adaptive on time PWM control mode operation

In order to trade off among different characteristics such as efficiency, no-load standby, audio noise and ripple, an adaptive on-time PWM control mode is employed in GT5311. Under constant current (CC) mode, the system with GT5311 operates on a pure PFM mode; when output load opens, or the output voltage reaches the Max. output regulation voltage, the system operates on a combined adaptive on-time mode in which operation frequency and primary-side peak current are dynamically modulated based on the change of load. ***Figure.6*** illustrates the trend of frequency and peak current following load-change under Max. output voltage condition.

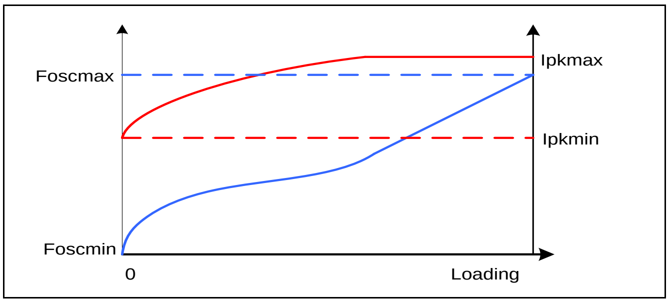


Figure 6. Fosc and Ipk vs. Loading

6.5 Protection Features

Complete protection features are integrated into GT5311, which include built-in OVP, OTP, UVLO, OCP, output short protection, innovative two stage open voltage protection and open loop protection.

With the pin GND, the GT5311 is able to monitor the peak primary current. This allows for cycle by cycle peak current control and limit. When the voltage level of pin GND hits the internal OCP threshold, over current is detected and the IC will immediately turn off the power MOS switch, until the next pulse is generated.

The VCC protections are implemented by UVLO and OVP. The output of GT5311 is shut down when VCC drops below UVLO (ON) threshold or rises above OVP threshold and the power system enters auto-restart sequence. In the event of output short or open, the UVLO (ON) and OVP can be triggered, and the converter can be shut down and enter into auto-restart sequence.

The over temperature protection (OTP) circuitry senses the die temperature. The threshold is set at 150 ^{o}C typically. When the die temperature rises above the threshold, the converter is shut down and enters into auto-restart sequence.

The two-stage open voltage protection provides more safer protection for LED open. When LED is open, the output firstly is clamped at a safe voltage under which the power consumption is kept as minimum. Once this output voltage increases further and reaches to the second protection threshold value, the system is turned off and enters into auto-restart sequence.

If open-loop happens, GT5311 can detect the fault condition and turn off the converter then enters into auto-restart sequence.

7. Electrical Characteristics

7.1 Absolute Maximum Ratings

Parameter	Symbol	Value	Units
Power supply (pin2)	VCC	-0.3 to VCC clamp	V
Maximum junction temperature	T_{JMAX}	150	^{o}C
Storage temperature	T_{STO}	-55 to 150	^{o}C
Lead Temperature (Soldering, 10secs)	T_{LEA}	260	^{o}C

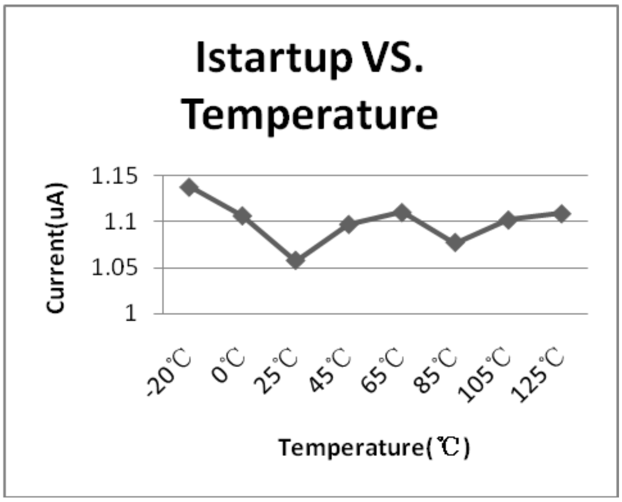
Note: Stress greater than those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other condition outside those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

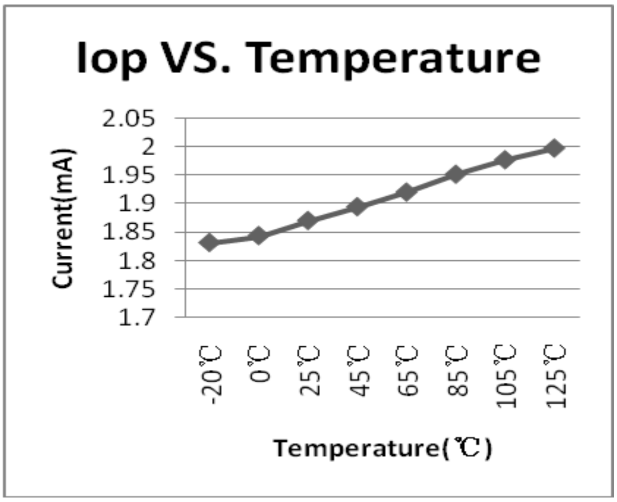
7.2 Electrical Characteristics

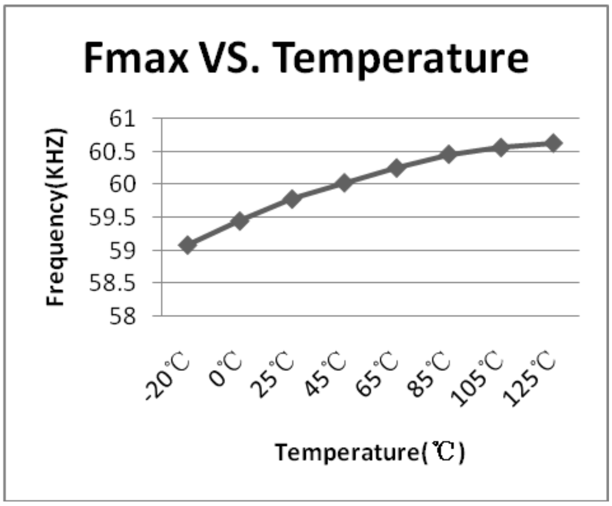
T_A=25°C, unless otherwise specified.

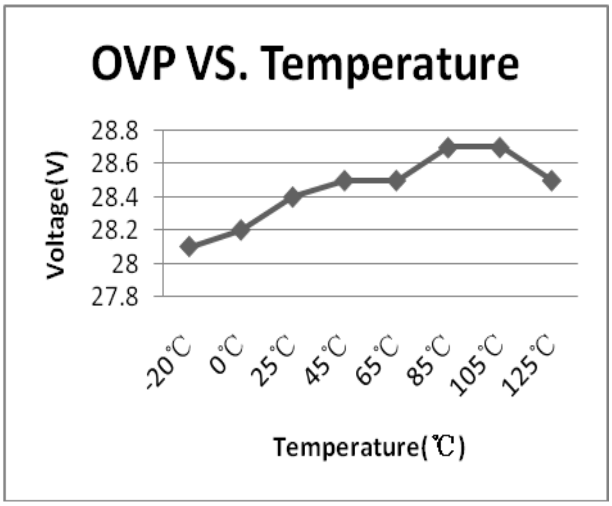
Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Unit
Supply Voltage (VCC) Section						
Start up current	$I_{STARTUP}$	VCC=14V	-	1.5	5	μA
Operation current	I_{CC_OP}		-	1.5	2.5	mA
VCC Under Voltage Enter threshold	UVLO(ON)	VCC falling	8.5	9.6	10.4	V
VCC Under Voltage Exit threshold	UVLO(OFF)	VCC rising	15.2	16.4	17.6	V
VCC Over Voltage Protection Threshold	OVP	Ramp VCC until gate shut down	26	28.5	31	V
VCC Clamping voltage	VCC_{ZB}	I_{CC}=10mA	32	33.5	34.5	V
Frequency Section						
Maximum IC frequency	f_{MAX}		54	60	66	kHz
Minimal IC Frequency	f_{MIN}		-	1000	-	Hz
Frequency jittering range	Δf/Freq		-	±4	-	%
Current Sense Section						
Turn on LEB time	t_{LEB}		-	400	-	ns
Over current threshold	V_{TH}		1182	1200	1218	mV
Soft start time	t_{SST}		-	2	-	ms
CC Protection control Section						
Reference current for open regulation	I_{REF}		156	168	182	μA
Over Temperature protection	OTP		-	150	-	^oC
Output Section						
Gate Output Clamping	G_clamping		-	17	-	V
Gate Rising Time	t_R	C_L=0.5nF	-	50	-	ns
Gate Falling Time	t_F	C_L=0.5nF	-	40	-	ns
Max. Output Charge Current	I_{CH}		-	-	150	mA
Max. Output Sink Current	I_{SINK}		-	-	200	mA

8. Typical Performance Characteristics

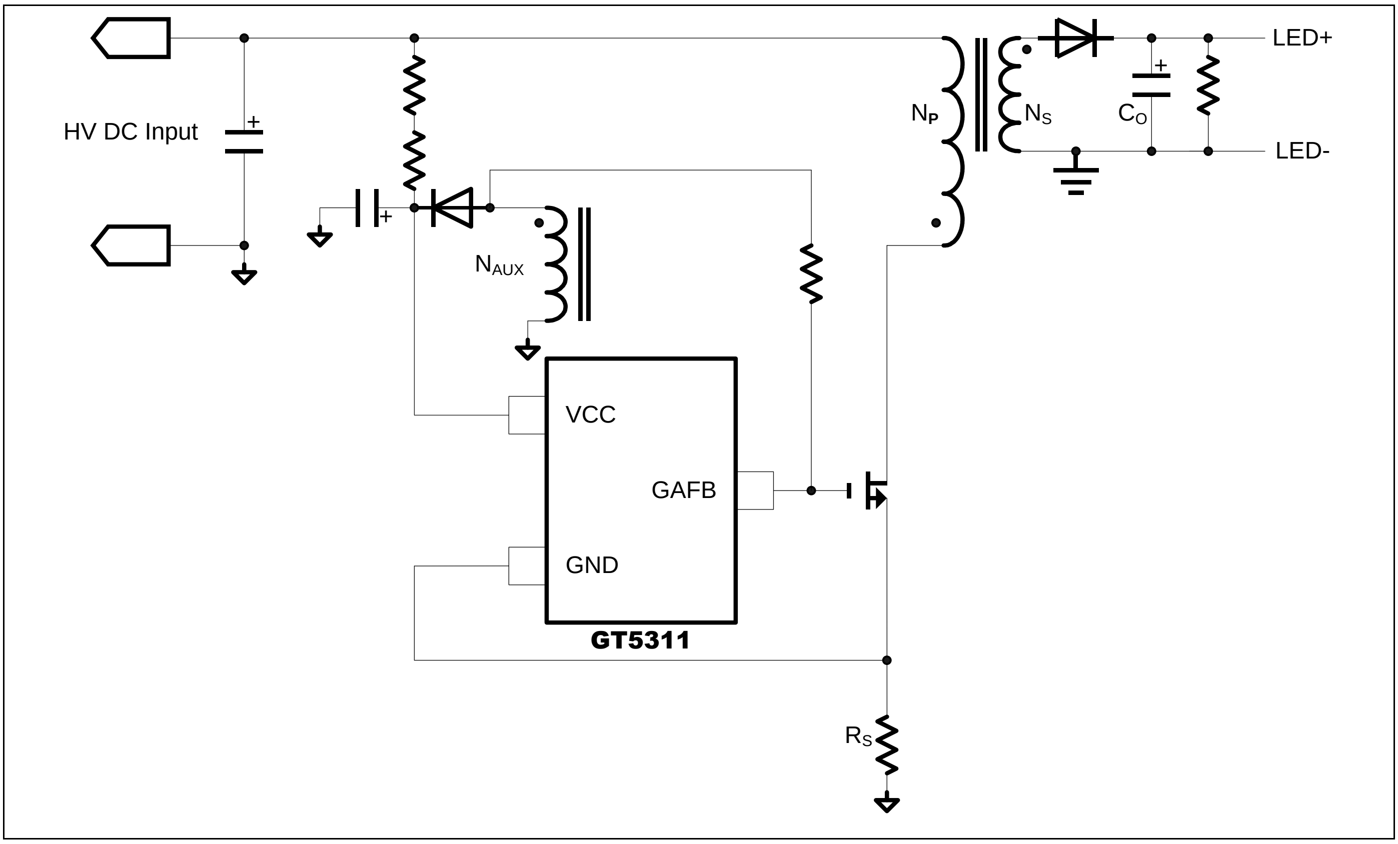








9. Typical Application Circuits



10. Ordering Information

GT XX XX X - XX X X

Temperature Range

I Industrial: -40°C ~85 °C

Pb Status

G GREEN

Package Type

TB SOT-23-3

Functional Option

Blank

Part Number

Production Family

53 Power Management Product: LED Driver

Giantec Prefix

GT Giantec

Order Number	Package Description	Package Option
GT5311-TBGI-TR	SOT-23-3	Tape and Reel 3000

11. Part Markings

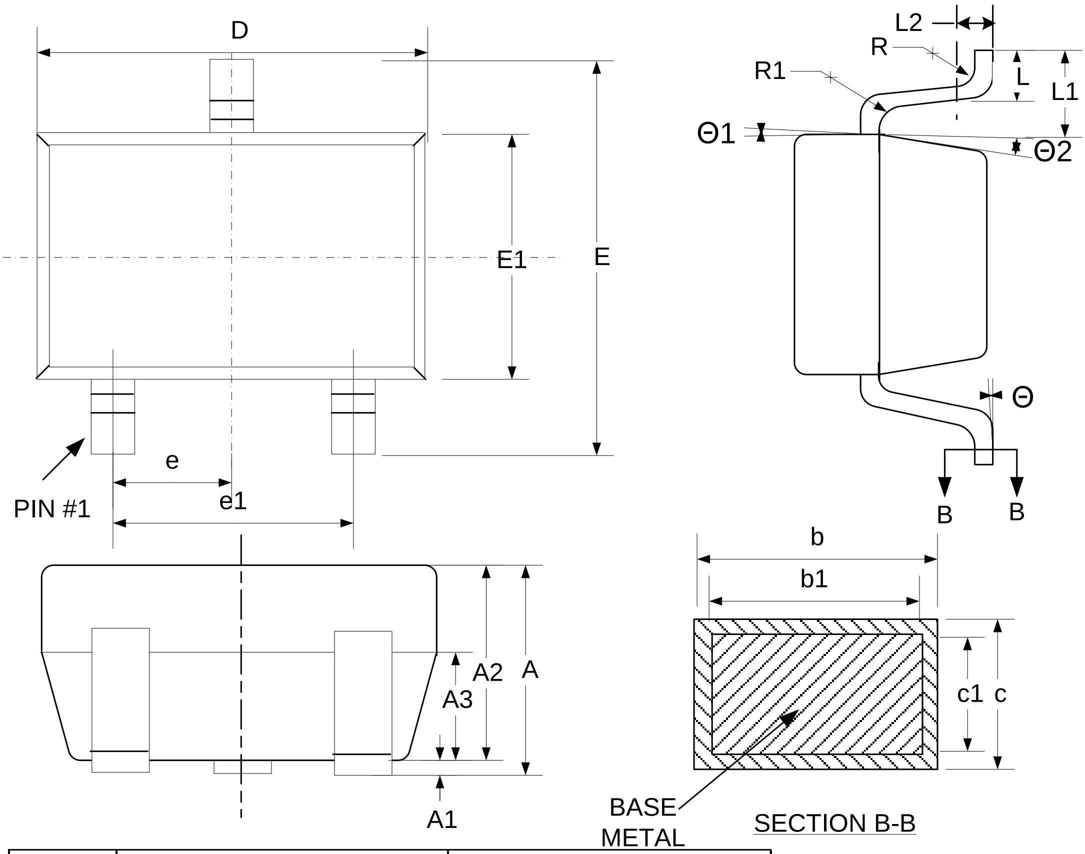
11.1 GT5311-TBGI-TR (Top View)

3	1	1	Y	W

311	GT5311-TBGI-TR		
●	Pin 1 Indicator		
Y	Seal Year	**W**	Seal Week
2010 (1st half year)	A	Week 01	A
2010 (2nd half year)	B	Week 02	B
2011 (1st half year)	C	……	
2011 (2nd half year)	D	Week 26	Z
2012 (1st half year)	E	Week 27	A
2012 (2nd half year)	F	Week 28	B
……	……	……	……
2022 (2nd half year)	Z	Week 52	Z

12. Package Information

12.1 SOT-23-3



SYMBOLS	DIMENSIONS IN MILLIMETERS			DIMENSIONS IN INCHES		
	MIN	NOM	MAX	MIN	NOM	MAX
A	--	--	1.25	--	--	0.049
A1	0.00	--	0.15	0.000	--	0.006
A2	1.00	1.10	1.20	0.039	0.043	0.047
A3	0.60	0.65	0.70	0.024	0.026	0.028
b	0.36	--	0.50	0.014	--	0.020
b1	0.36	0.38	0.45	0.014	0.015	0.018
c	0.14	--	0.20	0.006	--	0.008
c1	0.14	0.15	0.16	0.006	0.006	0.006
D	2.826	2.926	3.026	0.111	0.115	0.119
E	2.60	2.80	3.00	0.102	0.110	0.118
E1	1.526	1.626	1.726	0.060	0.064	0.068
e	0.90	0.95	1.00	0.035	0.037	0.039
e1	1.80	1.90	2.00	0.071	0.075	0.079
L	0.35	0.45	0.60	0.014	0.018	0.024
L1	0.59REF			0.023REF		
L2	0.25BSC			0.010BSC		
R	0.05	--	--	0.002	--	--
R1	0.05	--	0.20	0.002	--	0.008
Θ	0°	--	8°	0°	--	8°
Θ1	3°	5°	7°	3°	5°	7°
Θ2	6°	--	14°	6°	--	14°

Note:
1. Controlling Dimension:MM
2. Dimension D and E1 do not include Mold protrusion
3. Dimension b does not include dambar protrusion/intrusion.
4. Refer to Jedec standard MO-178 AB
5. Drawing is not to scale

13. Revision History

Revision	Date	Descriptions
A2	July, 2012	Optimize Constant Current Characteristics
A1	March, 2012	SOT23-3 Package Drawing Update
A0	May, 2012	Initial Version