GT5010A

6Pin, Accurate Primary-Side Constant Current Driver

Advanced

1. Features

- 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
- Programmable 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
- Built-in over temperature protection
- SOT-23-6 Package

2. General Description

GT5010A 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.

GT5010A multi-mode operations are utilized to achieve high efficiency and audio & noise free. The frequency jittering could also greatly reduce EMI filter cost.

GT5010A utilizes 6 Pin package to realize accurate CC regulation for cost effective and the device reliability is also enhanced.

GT5010A 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 GT5010A is available in an SOT-23-6 package.

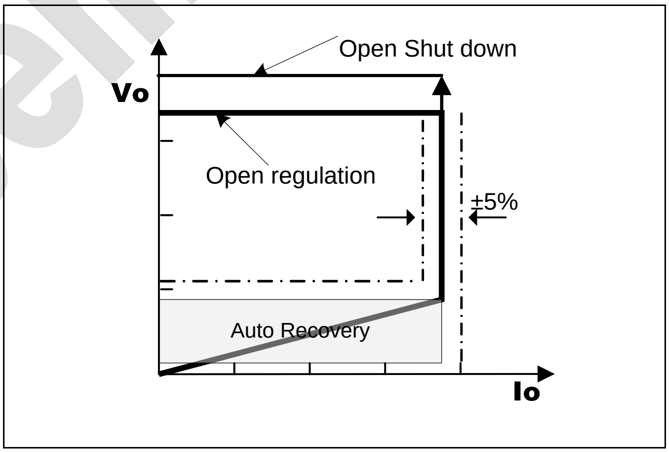


Figure 1. Typical CC Curve

3. Applications

- Sense LED Driver
- GU10 LED driver
- E14 LED driver
- E27 LED driver
- Others LED driver

4. Functional Block Diagram

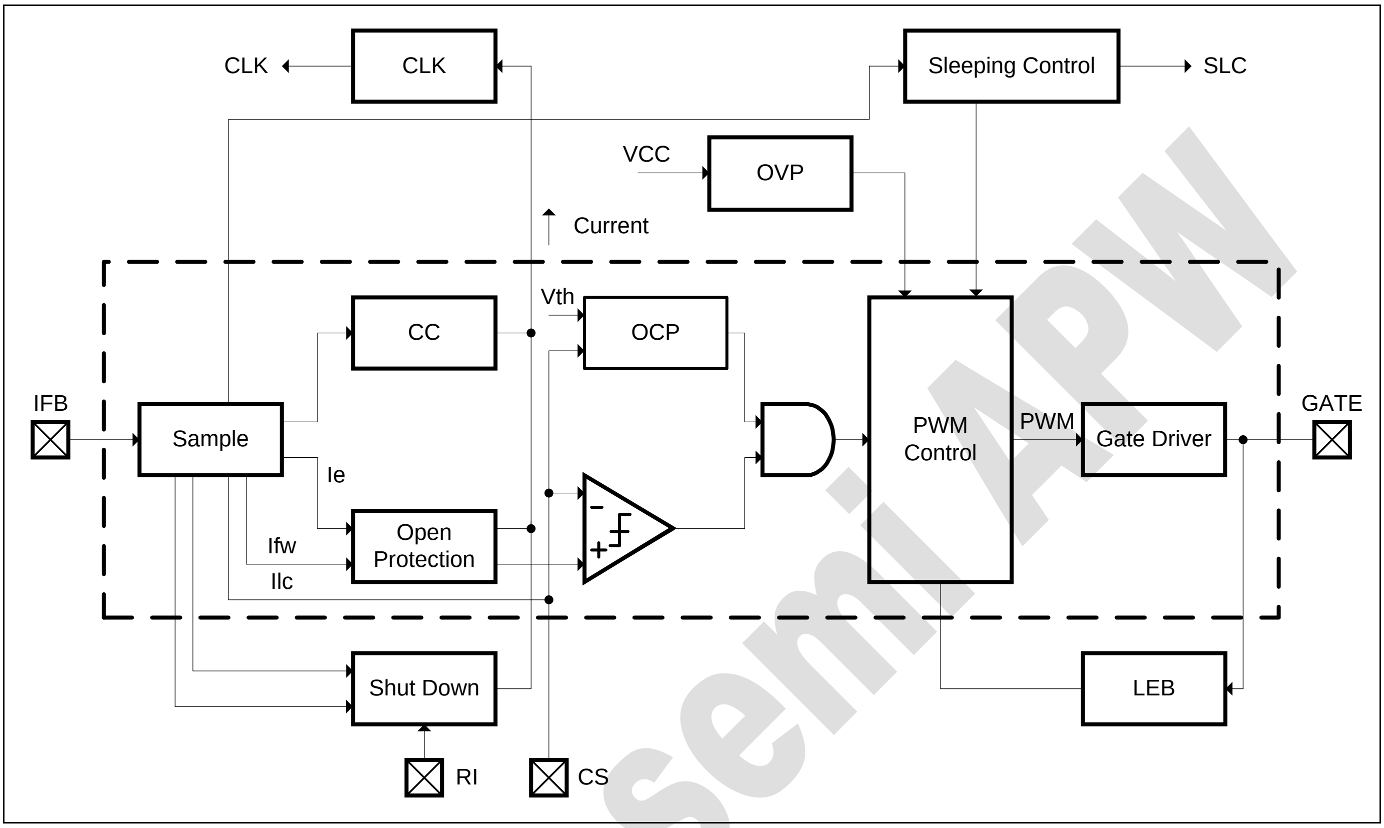


Figure 2. Functional Block Diagram

5. Pin Configuration

5.1 Pin Assignment Top View

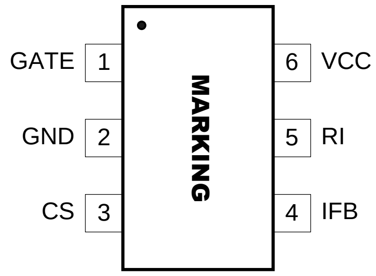


Figure 3. Pin Configuration (SOT-23-6 Package)

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

5.2 Pin Descriptions

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

6. Functional Description

The GT5010A is an innovative 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, 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 GT5010A 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 GT5010A 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 GATE 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 GT5010A. At the initial stage of start-up, the current consumed by GT5010A 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 GT5010A. The timing diagram of start-up is illustrated in ***Figure.4***.

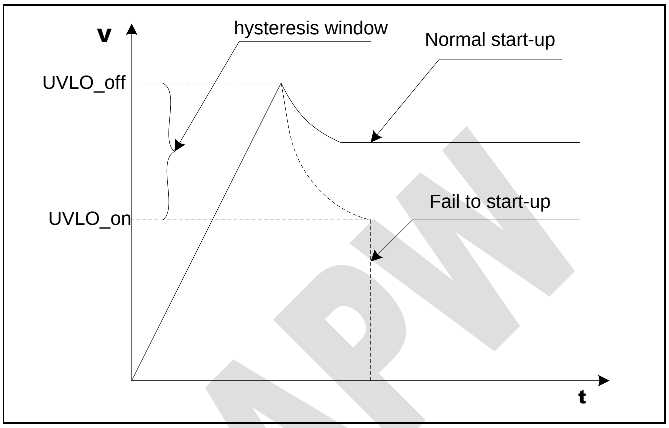


Figure 4. Timing Diagram of Start-up

As illustrated in ***Figure.4***, a hysteresis window for internal UVLO comparator is necessary to prevent the control IC GT5010A from shutting down due to voltage dip during start-up.

6.3 Voltage Operation

In order to achieve a precise output-voltage regulation, the information about output and load condition must be real-time sensed. For primary side control flyback converter, the output information can be feedback to primary side of the transformer via the auxiliary winding. ***Figure.5*** illustrates the waveform of auxiliary winding. As shown, during power switch-on, rectified input voltage VIN is mapped to the Auxiliary winding with a coefficient $-N_{AUX}/N_P$. The voltage can be expressed as:

$$V_{AUX} = -V_{IN} \times \frac{N_{AUX}}{N_P}$$

Where N_{AUX} is the turns of Auxiliary winding and N_P is the turns of primary winding.

During power switch-off, the voltage at secondary-side winding is mapped to the auxiliary winding, which is expressed as:

$$V_{AUX} = \frac{N_{AUX}}{N_S}(V_O + V_D)$$

Where N_S is the turns of secondary-side winding and V_D is the voltage drop through the output rectifier diode.

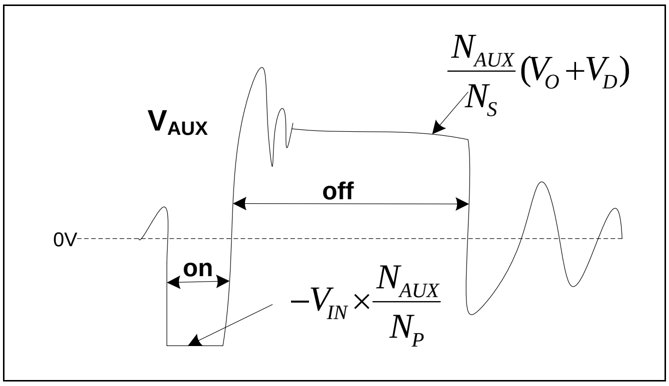


Figure 5. Waveform of Auxiliary Winding

As shown in the typical application circuit, R_{FB} is used to transform the V_{AUX} voltage to a feedback current signal which is fed into pin Ifb of GT5010.Ifb current is further regulated to the same level as an internal reference current Iref which can be set by an external resistor RI (connected to pin RI), eventually, the regulated output voltage is equal to:

$$V_O = \frac{N_S}{N_{AUX}} \cdot (\frac{R_{FB}}{4R_I}+1) - V_D$$

Where the internal reference current Iref equals to $1/4R_I$. The recommended range for RI is from 7kΩ to 20kΩ

6.3 Constant Current(CC) Operation

In battery charging and 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.6*** illustrates the theory of the algorithm. As shown in ***Figure.6*** 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.6*** 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 GT5010A, constant current can be defined as:

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

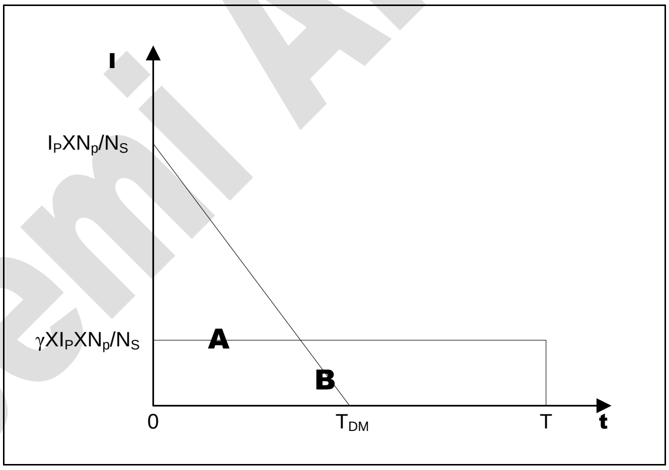


Figure 6. Diagram of output current

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.

6.4 Built-in Line Compensation

In the flyback converter system with GT5010A, line voltage compensation can be simply implemented and programmed by inserting a resistor RLN between pin CS and current sense resistor Rs.

The line compensation voltage Δ VLN can be calculated according to below equation:

$$\Delta V_{LN} = k \times V_{IN} \times \frac{N_{AUX}}{N_P} \times \frac{R_{LN}}{R_{FB}}$$

6.5 Mixed PWM/PFM operation

In order to trade off among different characteristics such as efficiency, no-load standby, audio noise, ripple, a mixed PWM/PFM operation mode is employed in GT5010A. Under constant voltage (CV) mode, from middle load to full load, the system with GT5010A operates on a pure PFM mode; from middle load to no-load, the system operates on a combined PWM/PFM mode. ***Figure.7*** illustrates the trend of frequency and CS peak following load-change.

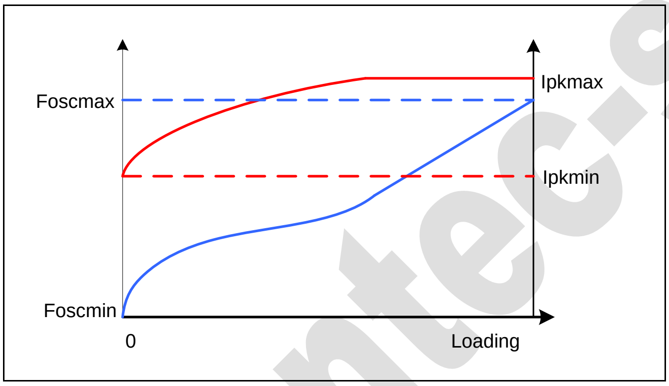


Figure 7. Fosc and Ipk vs. Loading

6.6 Protection Features

Complete protection features are integrated into GT5010A, which include built-in OVP, OTP, UVLO, OCP, output short/open protection and open loop protection.

With the pin CS, the GT5010A 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 CS 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 GT5010A 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 140 ^{o}C typically. When the die temperature rises above the threshold, the converter is shut down and enters into auto-restart sequence.

If open-loop happens, GT5010A can detect the fault condition and turn off the converter then enters into auto-restart sequence.

6.7 Sleeping control technology

In GT5010A, an innovative sleeping control technology is employed. As the converter load decreases from full-load to no-load, the current consummation of GT5010A dramatically drops from about 2mA to 200μA. Therefore, the efficiency of converter is significantly improved, and the standby is reduced to a very low level.

7. Electrical Characteristics

7.1 Absolute Maximum Ratings

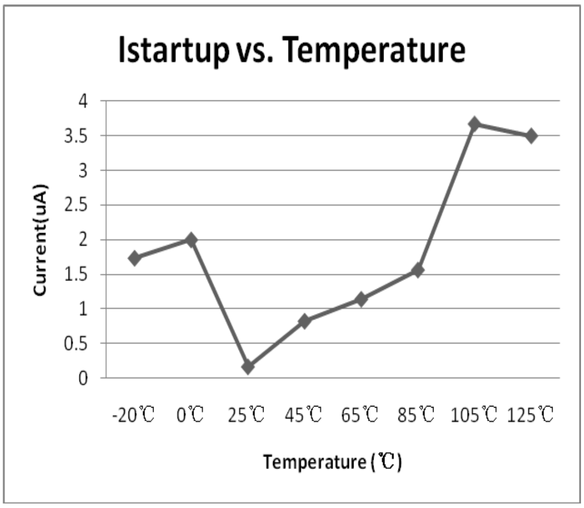
Parameter	Symbol	Value	Units
Power supply (pin6)	VCC	-0.3 to VCC clamp	V
Cab compensation (pin5)	RI	-0.3 to 7	V
IFB input (pin4)	IFB	-0.3 to 7	V
CS input (pin3)	CS	-0.3 to 7	V
Maximum junction temperature	T_{JMAX}	150	^oC
Storage temperature	T_{STO}	-55 to 150	^oC
Lead Temperature (Soldering, 10secs)	T_{LEA}	260	^oC

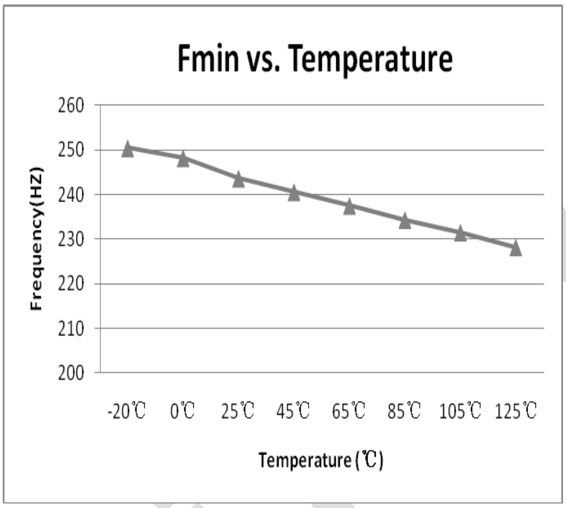
Note: Stress greater than those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other condition outside those indicated in the operational sections of this specification is not implied.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

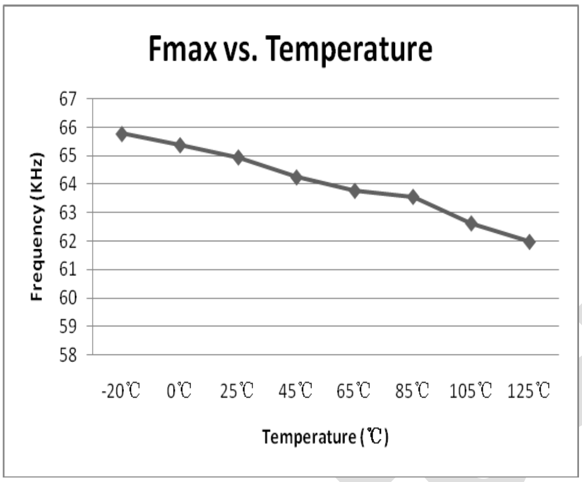
7.2 Electrical Characteristics

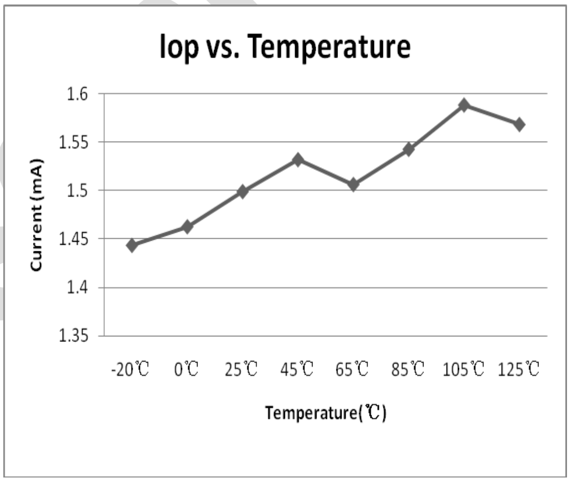
Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Unit
Supply Voltage (VCC) Section						
Start up current	$I_{STARTUP}$	VCC=13V	-	2	4	μA
Sleeping current	I_{DD_SD}	VCC=16V	-	250	-	μA
Operation current	I_{CC_OP}		-	1.5	2.5	mA
VCC Under Voltage Enter threshold	UVLO(ON)	VCC falling	8.1	9.0	9.8	V
VCC Under Voltage Exit threshold	UVLO(OFF)	VCC rising	13.5	14.5	15.5	V
VCC Over Voltage Protection Threshold	OVP	Ramp VCC until gate shut down	26	27.5	29	V
VCC Clamping voltage	VCC_{ZB}	I_{CC}=10mA	30	32.5	35	V
Frequency Section						
Maximum IC frequency	f_{MAX}		55	60	65	kHz
Minimal IC Frequency	f_{MIN}		200	260	320	Hz
Frequency shuffling range	Δf/Freq		-	±5	-	%
Current Sense Section						
Turn on LEB time	t_{LEB}		-	300	-	ns
Over current threshold	V_{TH}		925.9	940	954.1	mV
Input Impedance	Z_{SENSE}		100	-	-	kΩ
Soft start time	t_{SST}		-	2	-	ms
CC Protection control Section						
Reference current for open regulation	I_{REF}	R_I=10kΩ	23	25	27	μA
Over Temperature protection	OTP		-	150	-	°C
Output Section						
Gate Output Clamping	G_clamping		-	17	-	V
Gate Rising Time	t_R	C_L=0.5nF	-	44	-	nS
Gate Falling Time	t_F	C_L=0.5nF	-	30	-	nS
Max. Output Charge Current	I_{CH}		-	-	150	mA
Max. Output Sink Current	I_{SINK}		-	-	200	mA

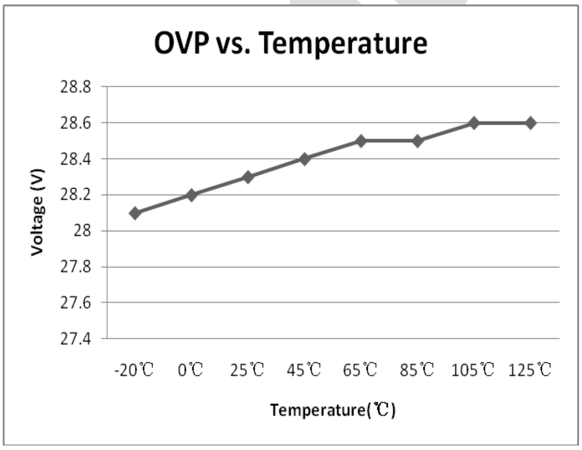
8. Typical Performance Characteristics

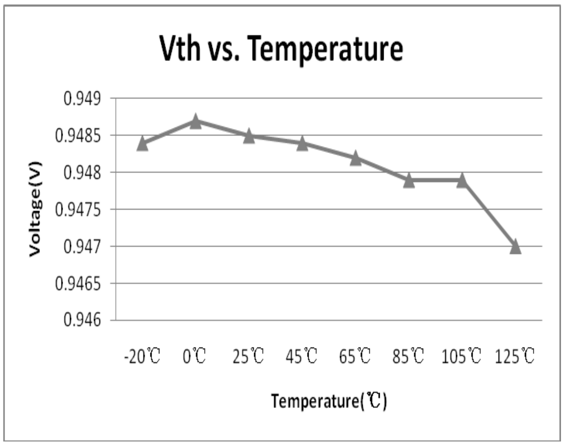




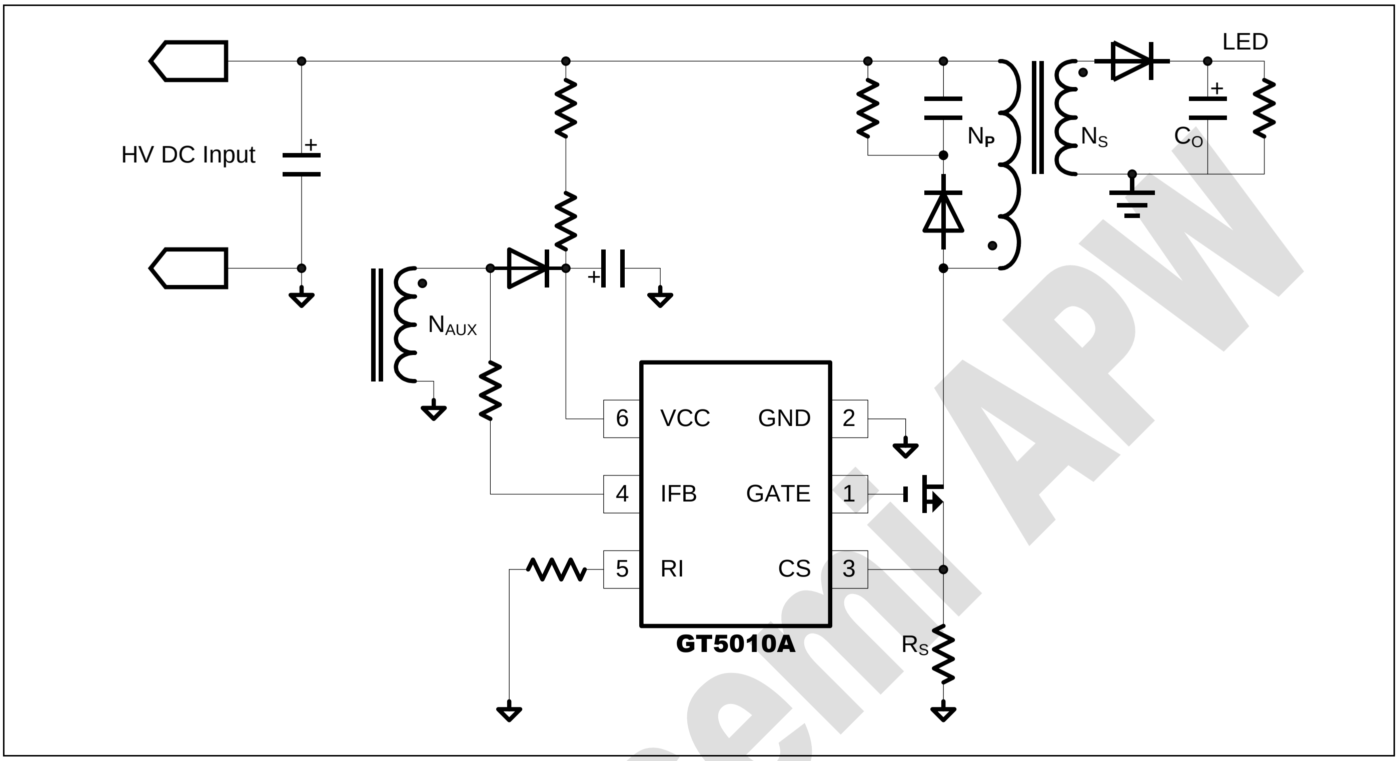








9. Typical Application Circuits



10. Ordering Information

GT XX XX X - XX X X

Temperature Range

I Industrial: -40℃~85°C

Pb Status

G GREEN

Package Type

TA SOT-23-6

Functional Option

A LED Driver

Part Number

Production Family

50 Power Management Product; AC-DC

Giantec Prefix

GT Giantec

Order Number	Package Description	Package Option
GT5010A-TAGI-TR	SOT-23-6	Tape and Reel 3000

11. Part Markings

11.1 GT5010A-TAGI (Top View)

0	1	0	A	Y W

010A	GT5010A-TAGI		
●	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-23-6

SOT-23-6L PACKAGE OUTLINE DIMENSIONS

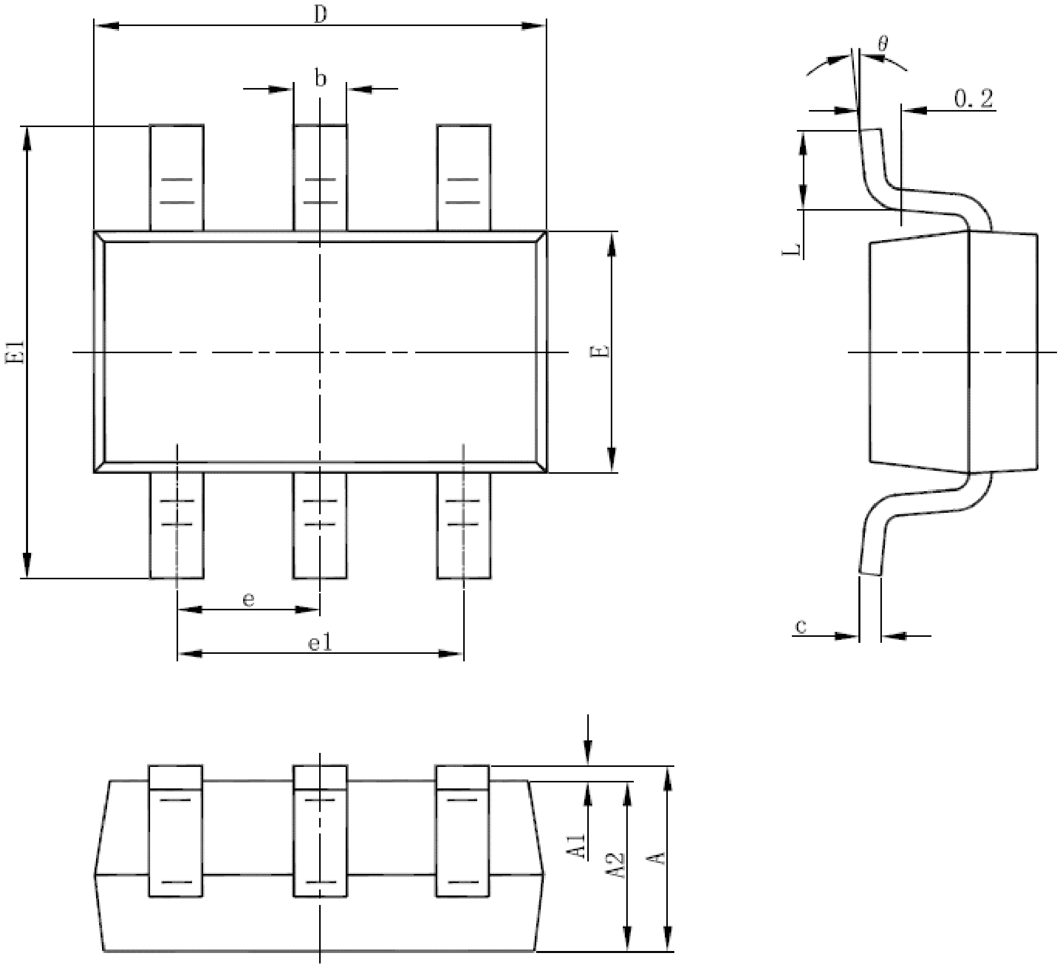


Table 1. Table of SOT-23-6 Package Dimensions

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.000	1.300	0.039	0.051
A1	0.000	0.150	0.000	0.006
A2	1.000	1.200	0.039	0.047
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.800	3.020	0.110	0.119
E	1.500	1.700	0.059	0.067
E1	2.600	3.000	0.102	0.118
e	0.950 (BSC)		0.037 (BSC)	
e1	1.800	2.000	0.071	0.079
L	0.300	0.600	0.012	0.024
θ	0º	8º	0º	8º

13. Revision History

Revision	Date	Descriptions
A0	July., 2012	Initial Version