GT5011

3Pin, Accurate CV/CC Primary-Side Controller

Advanced

1. Features

- Patented 3pin package for cost effective and enhanced reliability
- ±5% CV/CC Regulation
- Low standby power less than 30mW
- Eliminates Opto-coupler and all secondary CV/CC control circuitry
- Eliminates control loop compensation
- Innovative current sampling technology
- Built-in line compensation for tighter CC regulation
- Built-in compensation for transformer inductance tolerances
- Built-in Output Cable Compensation
- Built-in Leading Edge Blanking (LEB)
- Cycle-by-Cycle Current Limiting
- VCC Under Voltage Lockout with Hysteresis (UVLO)
- Built-in short circuit protection and output overvoltage protection
- Operating Temperature: -40℃ to +85℃
- SOT-23-3 and TO92 Package
- Option for Part-number

Part-Number	Built-in Output Cable Compensation
GT5011-TBGI-TR	150mV
GT5011A-TBGI-TR	350mV
GT5011B-TBGI-TR	CC for LED Lighting

2. General Description

GT5011 simplifies low power CV/CC charger/adaptor 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.

GT5011 multi-mode operations and proprietary Sleeping-mode are utilized to achieve low standby power less than 30mW, high efficiency and audio & noise free. The frequency jittering could also greatly reduce EMI filter cost.

GT5011 utilizes 3 Pin package to realize accurate CV/CC regulation for cost effective and the device reliability is also enhanced.

GT5011 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 GT5011 is available in an SOT-23-3 or TO92 package.

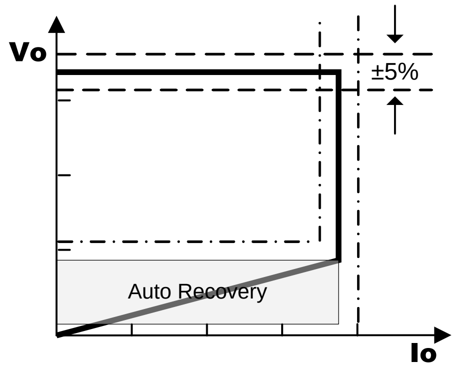

Figure 1. Typical CC/CV Curve

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3. Applications

- Cell/cordless Phone Charger
- PDAs/Portable audio devices Charger
- Small Power Adaptor/Charger
- LED driver
- Standby supplies for consumer electronics

4. Functional Block Diagram

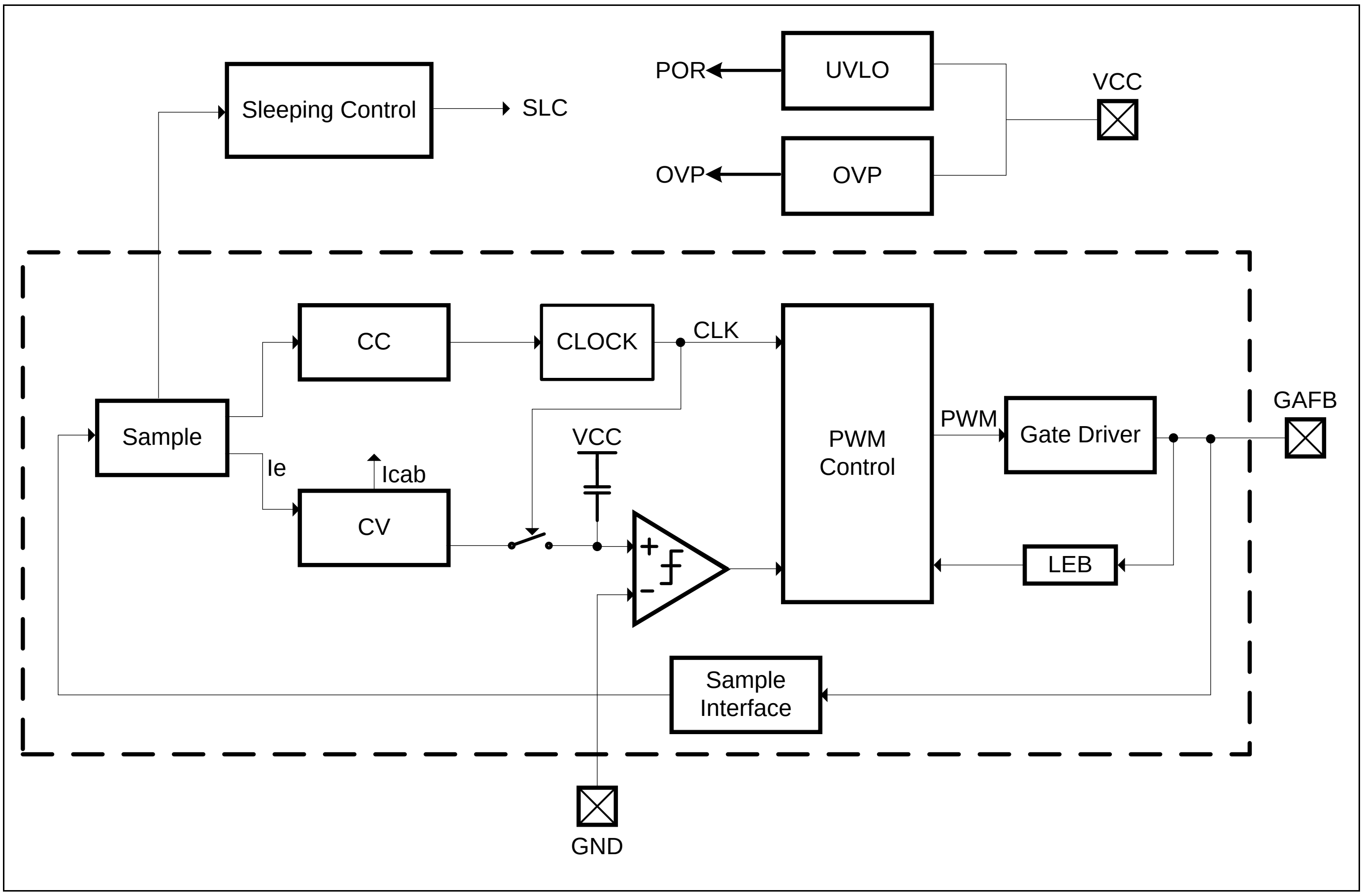


Figure 2. Functional Block Diagram

5. Pin Configuration

5.1 Pin Assignment Top View

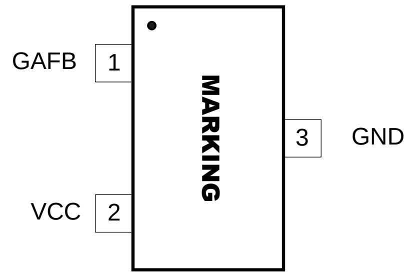


Figure 3. Pin Configuration (SOT-23-3 Package)

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 GT5011 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 GT5011 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 GT5011 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 GT5011. At the initial stage of start-up, the current consumed by GT5011 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 GT5011. The timing diagram of start-up is illustrated in ***Figure.4***.

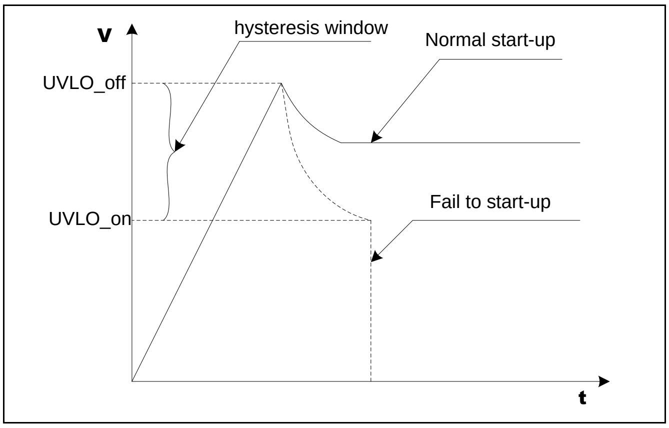


Figure 4. Timing Diagram of Start-up

As illustrated in ***Figure.4***, a hysteresis window for internal UVLO comparator is necessary to prevent the control IC GT5011 from shutting down due to voltage dip during start-up.

6.2 Constant Voltage (CV) 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. Based on the no-overlapping characteristics of power MOSFET driving signal and the feedback signal of the auxiliary winding, in GT5011, GAFB pin can not only drive power MOSFET, but also sense the feedback signal of the auxiliary winding.***Figure.5*** illustrates the waveform of power MOSFET driving signal, the auxiliary winding and the sampling signal. 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.

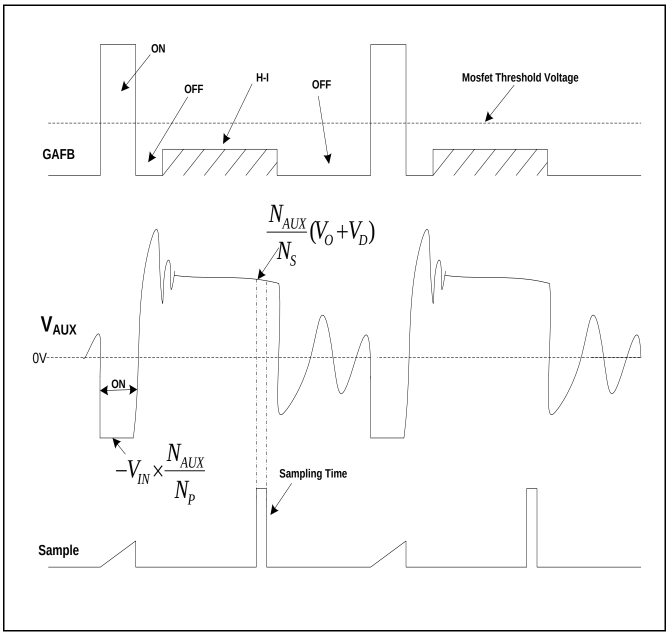


Figure 5. Waveform of the sampling timing

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 GAFB of GT5011. When GAFB signal is at the high impedance state, the feedback current can be sampled under the control of the sampling signal. The feedback current is further regulated to the same level as an internal reference current Iref which is constant, eventually, the regulated output voltage is equal to:

$$V_O = \frac{N_S}{N_{AUX}} \cdot (R_{FB} \times I_{ref} + 1) - V_D$$

Where the internal reference current Iref equals to 168μA (typical value).

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 GT5011, constant current can be defined as:

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

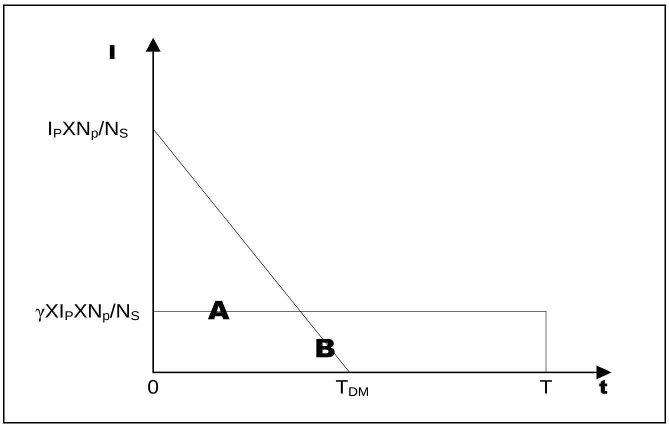


Figure 6. Diagram of output current

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 Output Cable Compensation

The cable compensation is implemented by adding up an offset current over internal reference current Iref. The offset current that is used to compensate cable drop proportionally increases with output load. The amount of compensation added upon output load can be defined according to below equation:

$$\Delta V_c = 0.029 \times (V_o + V_D)$$

6.5 Built-in Line Compensation

In the flyback converter system with GT5011, 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.

6.6 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 GT5011. Under constant voltage (CV) mode, from middle load to full load, the system with GT5011 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 peak current following load-change.

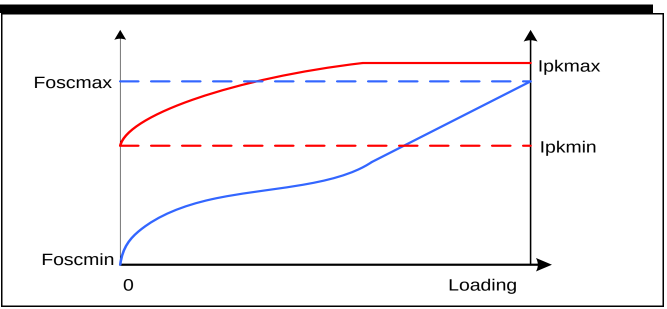


Figure 7. Fosc and Ipk vs. Loading

6.7 Protection Features

Complete protection features are integrated into GT5011, which include built-in OVP, OTP, UVLO, OCP, output short/open protection and open loop protection.

With the pin GND, the GT5011 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 GT5011 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 ^oC typically. When the die temperature rises above the threshold, the converter is shut down and enters into auto-restart sequence.

If open-loop happens, GT5011 can detect the fault condition and turn off the converter then enters into auto-restart sequence.

6.8 Sleeping control technology

In GT5011, an innovative sleeping control technology is employed. As the converter load decreases from full-load to no-load, the current consummation of GT5011 dramatically drops from about 2mA to 300μA. 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

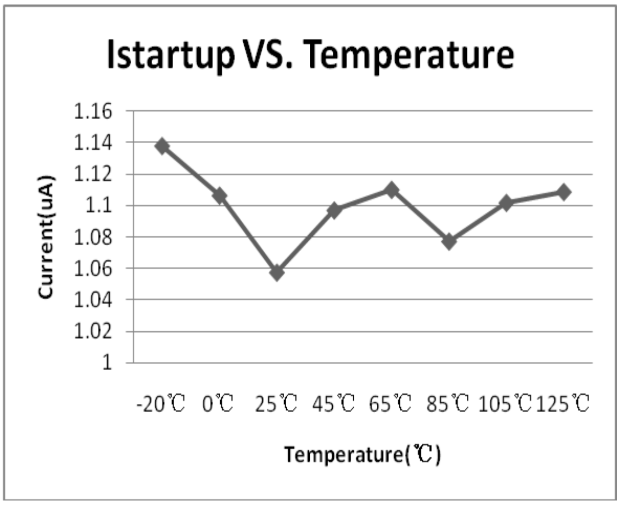
Parameter	Symbol	Value	Units
Power supply (pin2)	VCC	-0.3 to VCC clamp	V
Maximum junction temperature	T_{JMAX}	150	^{o}C
Storage temperature	T_{STO}	-55 to 150	^{o}C
Lead Temperature (Soldering, 10secs)	T_{LEA}	260	^{o}C

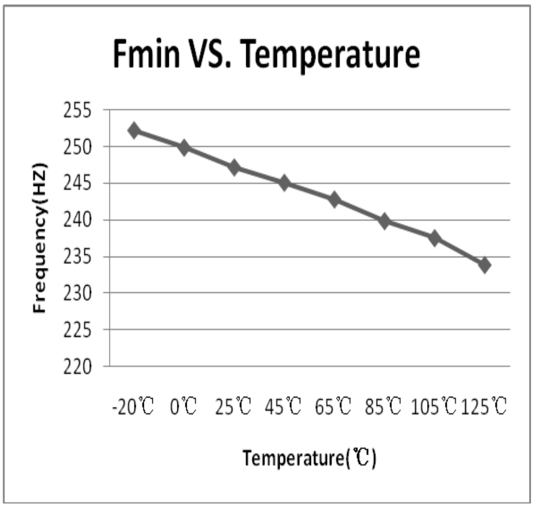
Note: Stress greater than those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other condition outside those indicated in the operational sections of this specification is not implied.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

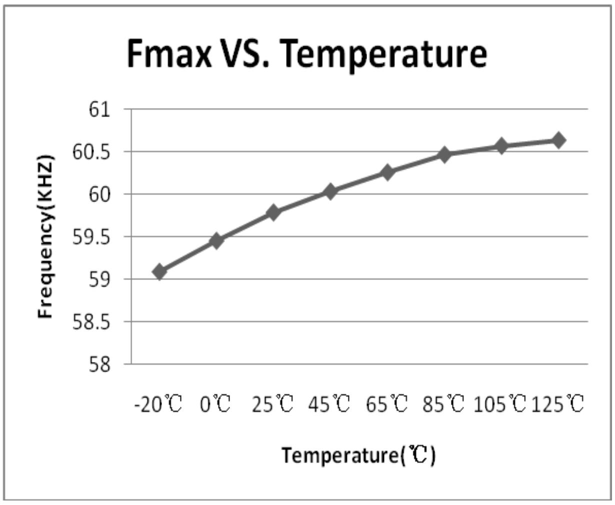
7.2 Electrical Characteristics

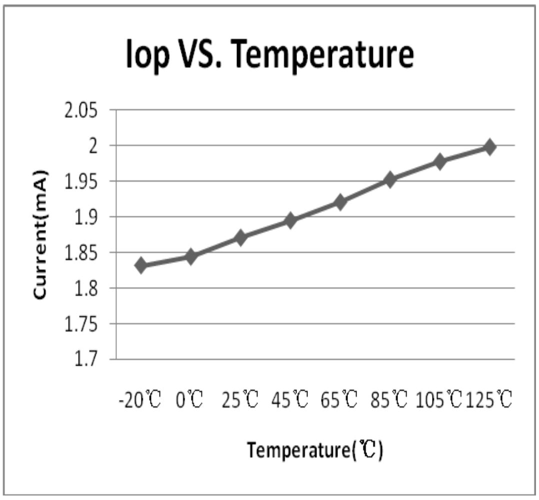
Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Unit
Supply Voltage (VCC) Section						
Start up current	$I_{STARTUP}$	VCC=14V	-	1.5	5	μA
Sleeping current	I_{DD_SD}	VCC=17V	-	300	-	μA
Operation current	I_{CC_OP}		-	1.5	2.5	mA
VCC Under Voltage Enter threshold	UVLO(ON)	VCC falling	8.8	9.6	10.4	V
VCC Under Voltage Exit threshold	UVLO(OFF)	VCC rising	15.4	16.4	17.4	V
VCC Over Voltage Protection Threshold	OVP	Ramp VCC until gate shut down	27.5	28.5	29.5	V
VCC Clamping voltage	VCC_{ZB}	I_{CC}=10mA	32	33.5	35	V
Frequency Section						
Maximum IC frequency	f_{MAX}		55	60	65	kHz
Minimal IC Frequency	f_{MIN}		-	250	-	Hz
Frequency jittering range	Δf/Freq		-	±4	-	%
Current Sense Section						
Turn on LEB time	t_{LEB}		-	400	-	ns
Over current threshold	V_{TH}		1160	1200	1240	mV
Soft start time	t_{SST}		-	2	-	ms
CC/CV control Section						
Reference current for CM EA	I_{REF}		161.7	165	168.3	μA
Max. Cable compensation current	I_{CMP_MAX}		-	4.4	-	μA
Over Temperature protection	OTP		-	150	-	^{o}C
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

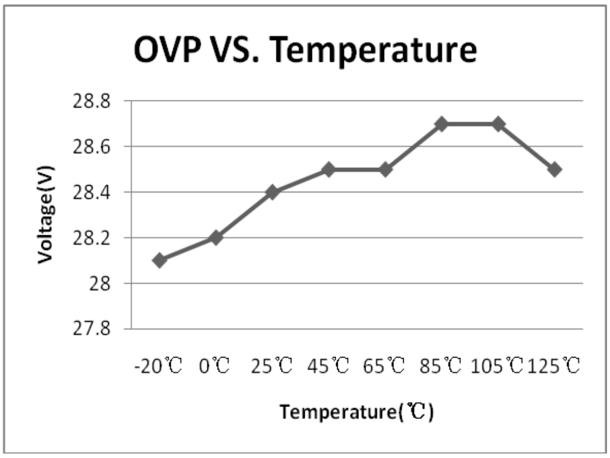
8. Typical Performance Characteristics



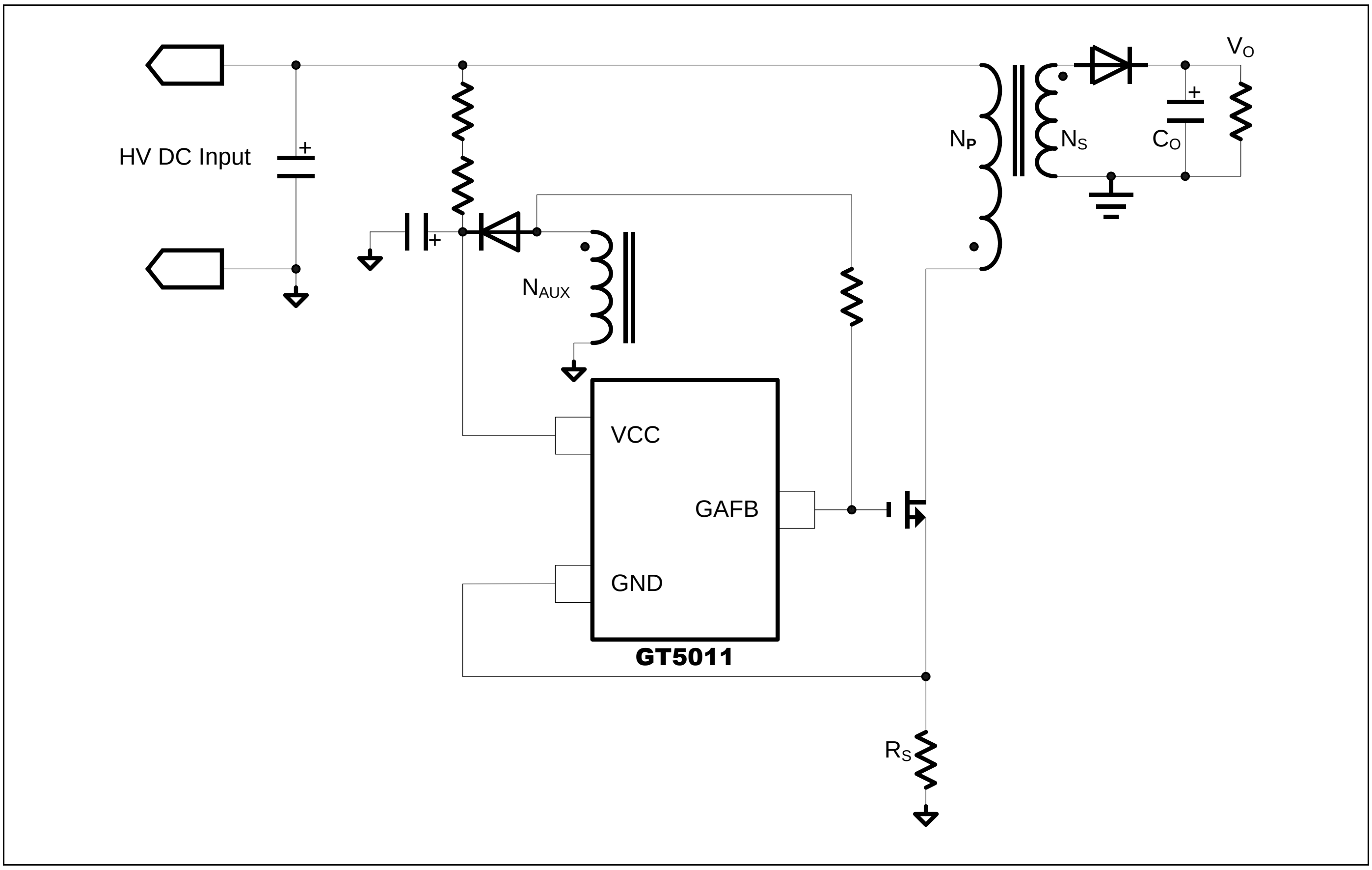








9. Typical Application Circuits



10. Ordering Information

GT XX XX X - XX X X

Temperature Range

I Industrial: -40℃~85°C

Pb Status

G GREEN

Package Type

TB SOT-23-3
TC TO92

Functional Option

Blank 150mV
A 350mV
B CC for LED Lighting

Part Number

Production Family

50 Power Management Product; AC-DC

Giantec Prefix

GT Giantec

Order Number	Package Description	Package Option
GT5011-TBGI-TR	SOT-23-3	Tape and Reel 3000
GT5011A-TBGI-TR	SOT-23-3	Tape and Reel 3000
GT5011B-TBGI-TR	SOT-23-3	Tape and Reel 3000

11. Part Markings

11.1 GT5011-TBGI (Top View)

0	1	1	Y	W

011	GT5011-TBGI		
●	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

11.2 GT5011A-TBGI (Top View)

0	1	1	A	Y W

011A	GT5011A-TBGI		
●	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

11.3 GT5011B-TBGI (Top View)

0	**1**	**1**	**B**	**Y** **W**

011B	GT5011B-TBGI		
●	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

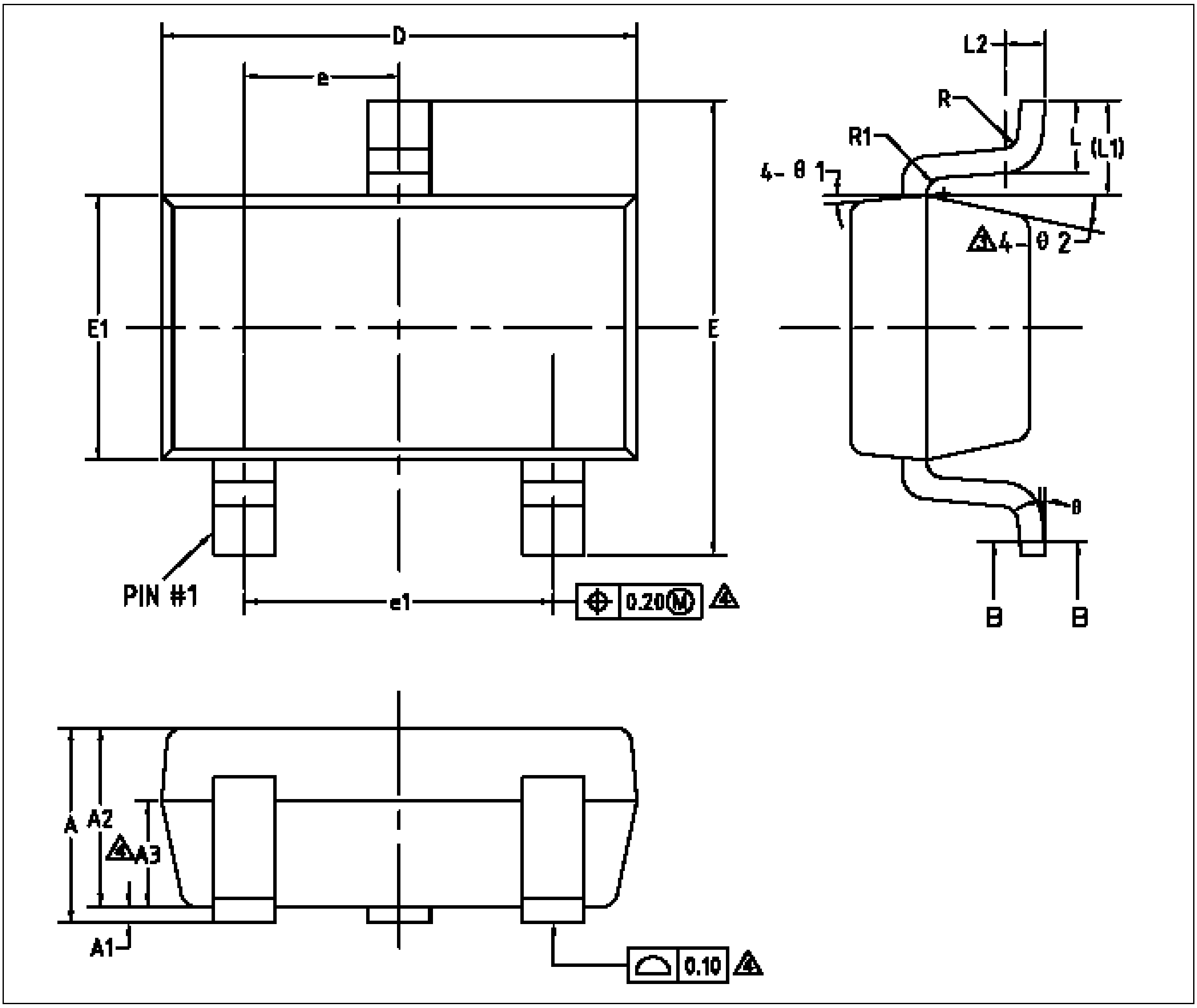
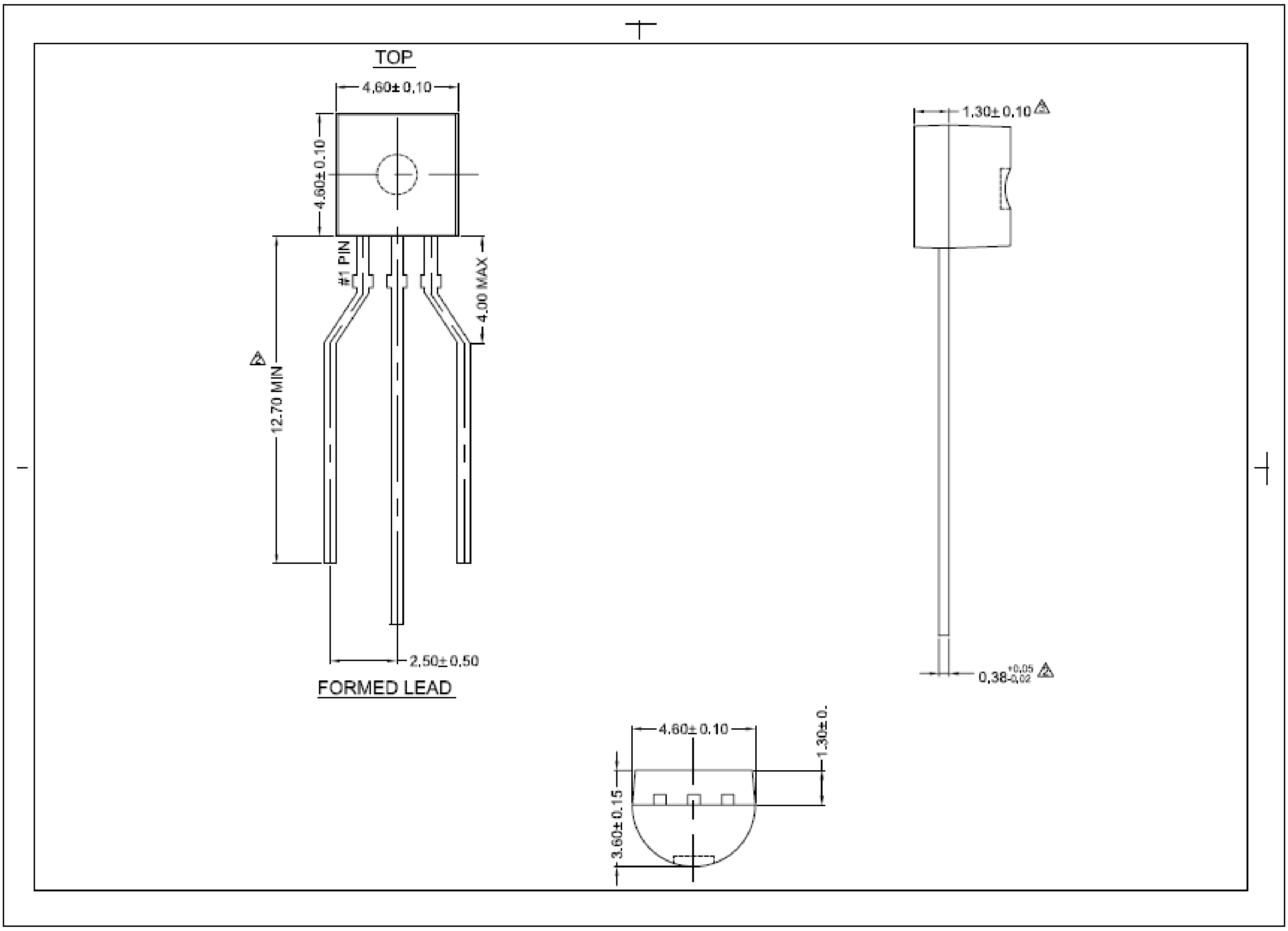


Table 1. Table of SOT-23-3 Package Dimensions

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	-	1.250	-	0.049
A1	0.000	0.150	0.000	0.006
A2	1.000	1.200	0.039	0.047
b	0.360	0.500	0.014	0.020
c	0.140	0.200	0.006	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	0.350	0.600	0.014	0.024
θ	0º	8º	0º	8º

12.2 TO92


TOP
4.60± 0.10
4.60± 0.10
#1 PIN
4.00 MAX
12.70 MIN
2.50± 0.50
FORMED LEAD
1.30± 0.10
0.38+0.05 -0.02
4.60± 0.10
1.30± 0.
3.60± 0.15

13. Revision History

Revision	Date	Descriptions
A2	Sept., 2011	Add GT5011B part number for LED lighting application.
A1	Aug., 2011	Release Version
A0	May., 2011	Initial Version