GT5110

2A, Non-Synchronous Step-Down DC-DC Converter

Advanced

1. Features

- High Efficiency: Up to 96%
- Up to 2A Output Current
- Very Low Shutdown Current: 20µA at maximum input supply voltage
- Integrated 0.2Ω Switch
- Operating Switching Frequency from 380kHz to 1.2MHz
- 4.5V to 24V Input Voltage Range
- Programmable Output Voltage from 1.25V to 21V.
- Current Mode Operation with External Compensation for Optimized Loop Bandwidth
- Internal Soft Start
- Over Temperature Shutdown
- Cycle-by-Cycle Over Current Protection
- Programmable Under Voltage Lockout
- Operating Temperature: -40℃ to +85℃
- Package 8-Pin: SOP8 and HSOP8

2. General Description

The GT5110 device is a high efficiency monolithic step-down bulk regulator using current mode architecture with an integrated high-side power MOSFET. This device delivers up to 2A of output current over a wide operating voltage supply range from 4.5V to 24V which makes this device ideally suited for many applications such as battery powered systems, distributed power systems, battery chargers and wall adapter. Current mode operation provides fast transient response and excellent load and line regulation.

The switching frequency is adjustable from 380kHz (default) to 1.2MHz. The higher switching frequency can be easily set by connecting a resistor between Rex Pin and GND pin. Higher switching frequency reduces the output ripples for given inductor value; for the same output ripples it can reduce the inductor size. Higher switching frequency can make the converter bandwidth higher. The GT5110 devices provide the easy way for customers optimize the system performance and cost.

The fault condition protections such as cycle-by-cycle current limiting and over temperature hysteretic shutdown are implemented. In shutdown mode the converter draws 20µA of supply current at the maximum input supply voltage. Additional features include soft start, and enable.

The GT5110 is available in an 8-Pin SOP package and thermal enhanced HSOP package.

3. Applications

- Industrial Control and Medical Equipment
- Communication Equipment
- LCD Monitor/LCD TV
- Set-top Box
- Multimedia Devices
- Portable DVD
- Backup Power Supply
- Battery-Powered Systems

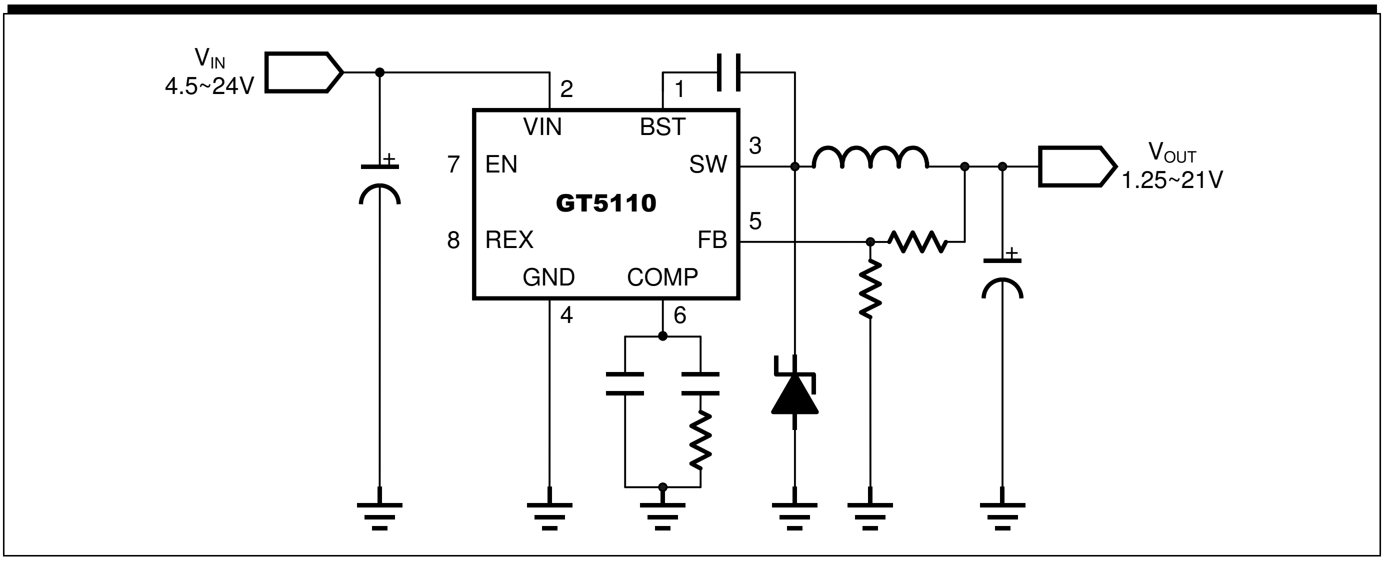


Figure 1. Typical Application Circuit

4. Functional Block Diagram

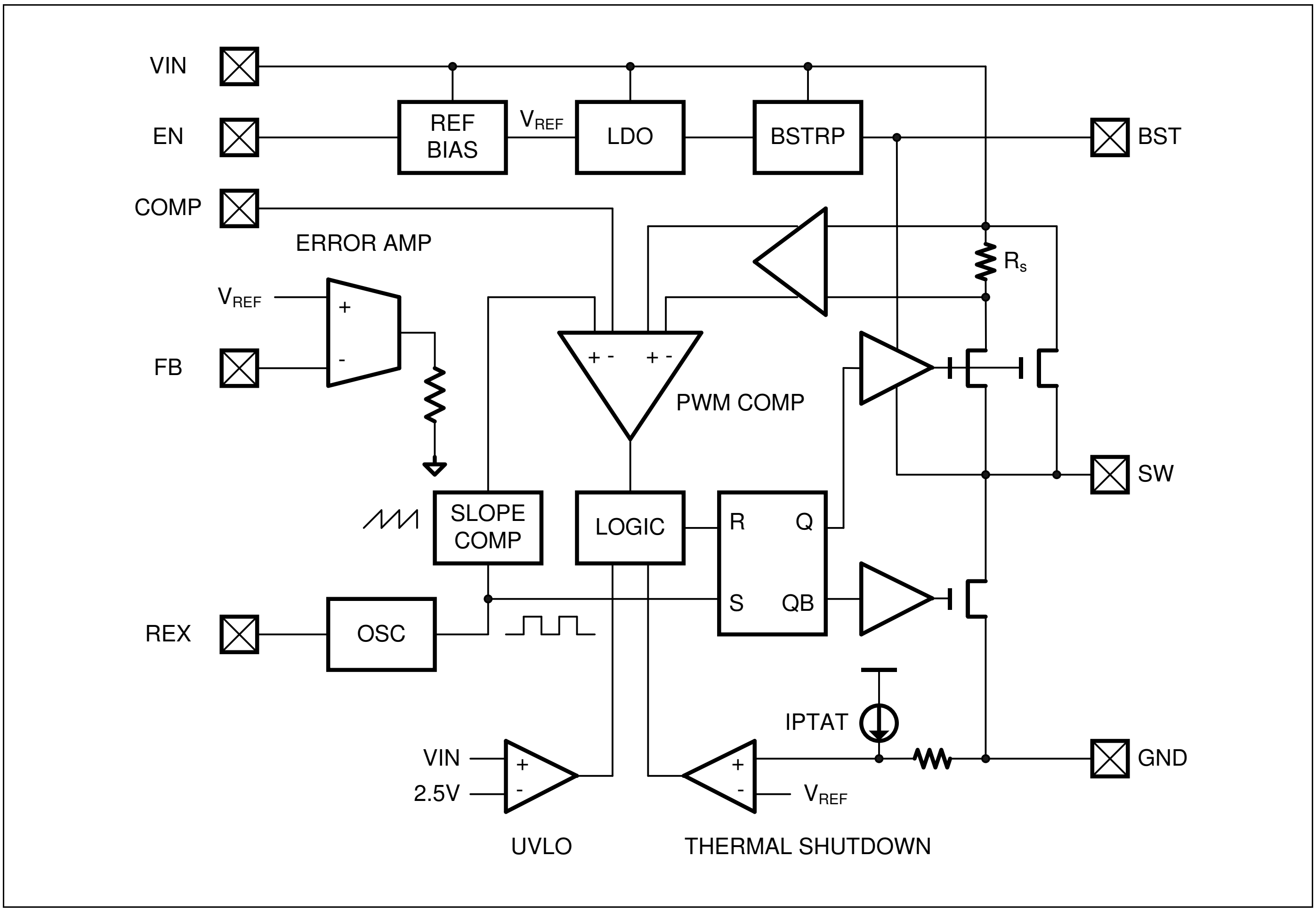


Figure 2. Current Mode Buck Converter

5. Pin Configuration

5.1 SOP8 (Top View)

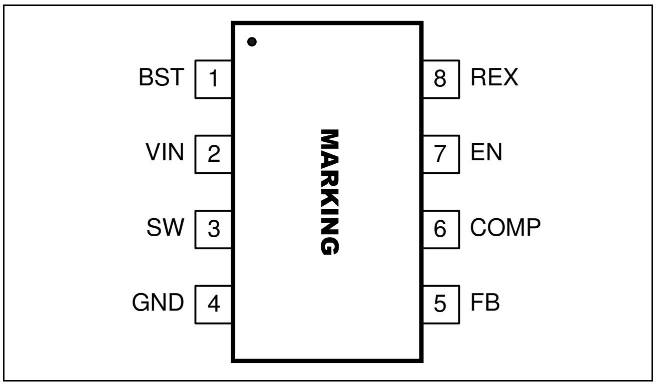


Figure 3. Pin Assignment Diagram (SOP8 Package)

5.2 HSOP8 (Top View)

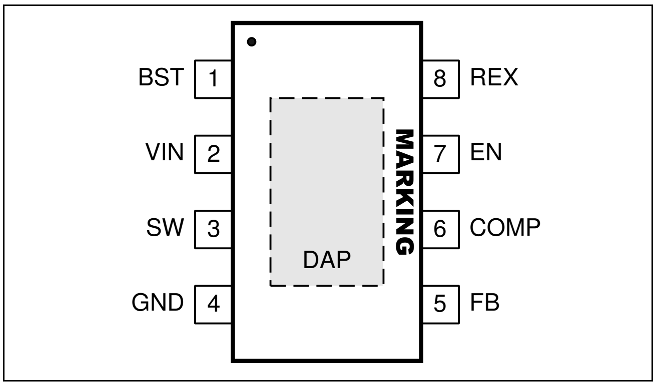


Figure 4. Pin Assignment Diagram (HSOP8 Package)

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

5.3 Pin Descriptions

Pin No.	Name	I/O	Function
1	BST	I	A 1~10nF ceramic capacitor is connected from this pin to the SW pin to drive the power switch's gate above Bootstrap the power supply voltage.
2	VIN	-	Supply. Connect this pin to a supply voltage from 4.5V to 24V
3	SW	O	Switching node for the converter. Connect inductor to this node.
4	GND	-	Ground. This pin is the voltage reference for the regulated output voltage.
5	FB	I	Feedback. An external resistor divider sets the output voltage.
6	COMP	I	Compensation. Connect a compensation network to stable the loop and optimize the loop bandwidth.
7	EN	I	Enable. Pull down to ground to turn-off the converter. Leave EN open if it is unused.
8	REX	I	Setting of internal Oscillator frequency. A resistor is connected from REX to GND to set the Oscillator frequency from 380kHz to 1.2MHz.

6. Functional Description

6.1 Operation

The GT5110 uses current mode PWM step-down architecture with internal top power switch. The switching frequency of the regulator is variable from 380kHz to 1.2MHz set by external resistor connected at REX pin. The default switching frequency is 380kHz.

The operating description is referring to functional block diagram (***Figure 1***). During normal operation, the rising edge of internal oscillator clock sets the RS latch and the top NMOS switch is turned on each switching cycle. The inductor current is sensed and amplified by current sense amplifier. Ramp compensation is summed to the error amplifier output and compare to the COMP pin voltage with PWM comparator. The output of PWM comparator resets the RS latch and turns of the top NMOS switch until next cycle. During the off-time, most inductor current discharges through Schottky diode D1, which forces the SW pin to swing~0.7V below ground. The bottom NMOS switch ensures the bootstrap capacitor fully charged during DCM mode.

6.2 Enable

Logic low EN forces the GT5110 into shut down mode. In shutdown, this device only draws 20µA supply current at maximum supply voltage.

6.3 Soft Start

Soft-start function of GT5110 limits the inrush current during start-up, and eliminates possible voltage drops of the input voltage when a battery or a high-impedance power source is connect to the GT5110. Typical start-up time is about 750µs.

6.4 Short-Circuit Protection

The frequency of the oscillator is reduced to 1/8 of the normal frequency when the output is shorted to ground. This function ensures enough time for inductor current to decay.

6.5 Thermal Shutdown

The device goes into thermal shutdown mode when the junction temperature exceeds 160℃. It continues normal operation when the temperature falls below 120℃.

6.6 Boost Function

A 1~10nF capacitor C_{BOOST} is used to generate a voltage V_{BOOST} to drive the gate of top NMOS switch above the supply voltage. The voltage across this capacitor is about 5V.

6.7 Under Voltage Lockout

The under voltage lockout circuit prevents the device from miss operation at low-input voltages. It turns off the switches under undefined conditions. The minimum input voltage to start up the GT5110 is 4.5V and device will shut down at 2.5V.

7. Theory or operation/design procedure

7.1 Inductor Selection

There are two main considerations when selecting optimal inductors. First, the inductor should not saturate, and second, the inductor current ripple should be small enough to achieve the desired output voltage ripple. The dc resistance of the inductance directly influences the efficiency of the converter. Therefore, an inductor with lowest dc resistance should be selected for highest efficiency.

In order to avoid saturation of the inductor, the inductor should be rated at least for the maximum output current plus the inductor ripple current which is calculated as:

$$I_{PEAK} = I_{LOAD} + \frac{V_{OUT} \times (V_{IN} - V_{OUT})}{2L \times f \times V_{IN}} \qquad (1)$$

Where

f= Switching frequency (380kHz typical)

L= Inductor value

Table 1: Recommended Components for Standard Output Voltages

F_S V_{OUT}	1.5	1.8	2.5	3.3	5	12
default	6.8µH	10µH	10µH	15µH	22µH	33µH
800kHz	2.8µH	3.6µH	4.7µH	6.2µH	8.2µH	15µH
1.25MHz	1.8µH	2.2µH	2.8µH	3.7µH	5.1µH	8.8µH

7.2 Output Capacitor Selection

A 22µF (typical) output capacitor is needed with a 6.8µH inductor. Ceramic capacitors with low ESR are used for the lowest output voltage ripple.

The overall output ripple voltage is the sum of the voltage spike caused by the output ESR plus the voltage ripple caused by charge and discharging the output capacitor

$$V_{RIPPLE} = V_{OUT} \times \frac{1 - \frac{V_{OUT}}{V_{IN}}}{L \times f} \times \left(\frac{1}{8 \times C_{OUT} \times f} + R_{ESR}\right) \qquad (2)$$

The largest output voltage ripple occurs at the highest input voltage.

7.3 Input Capacitor Selection

In continuous mode, the input current to the device is discontinuous, therefore a low ESR input capacitor is required for best input voltage filtering and minimizing the interference with other circuits caused by high input voltage spikes. This capacitor should have a minimum value of 10µF.

Since it absorbs the input switching current it requires an adequate ripple current rating. Its RMS current rating should be greater than approximately 1/2 of the output current.

For insuring stable operation the capacitor should be placed as close to the IC possible.

7.4 Schottky Catch Diode Selection

The diode supplies most of the current to the inductor when the top NMOS switch is off. Schottky diode is used due to small losses from the forward schottky voltage and recovery times.

The diode's maximum voltage rating should be greater than the maximum input voltage, and whose average current rating must be above the average load current.

Table 2: Diode selection guide

V_{IN}(Max.)	1A Diodes	2A Diodes
15	10BQ15	30BQ15
20	1N5817 B120 SS12	B220 SK23 SR22

7.5 Feedback divider resistors to set output voltage - R2, R1

The output voltage is set by R2 and R1, $V_{OUT} = 1.25 \times (1 + R_2 / R_1)$. 10kΩ is a good typical value, and can be as high as 100kΩ. Too high impedance can make feedback node prone to noise injection particularly if unshielded inductors are used.

7.6 Frequency selection

The frequency is set by external R_{EXT} and internal resistor as $f_s = 380k \times [1 + 300k / R_{EXT})]$

7.7 Stability compensation

Follow the following steps to compensate the IC:

STEP 1: set the cross over frequency at 1/10 of the switching frequency

$$fc = Gcs \times Gea \times Rcomp \times \frac{V_{ref}}{Vout} \times \frac{1}{2\pi \times Cout} \tag{3}$$

$$Rcomp = \frac{2\pi \times Cout}{Gcs \times Gea \times \frac{V_{ref}}{Vout}} \times \frac{1}{10} \times fs \tag{4}$$

STEP 2: set the zero fz1 at 1/4 frequency of the cross over frequency.

$$Ccomp = \frac{1}{2\pi Rcomp \times \frac{1}{40} \times fs} \tag{5}$$

STEP 3: If the output capacitors' ESR is high enough to cause a zero at lower than 4 times the cross frequency, an additional compensation capacitor Ccomp2 is required, and the proper value is

$$Ccomp2 = \frac{CoutR_{ESR}}{Rcomp} \tag{6}$$

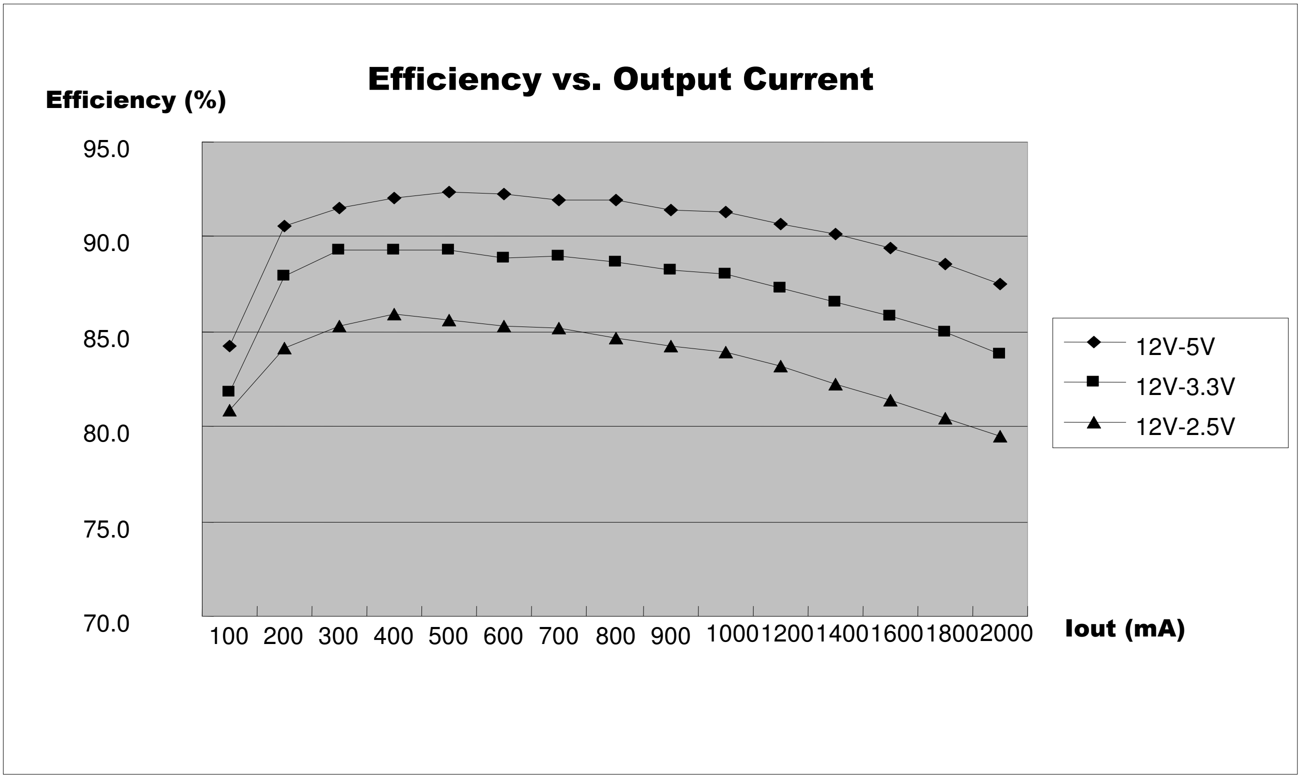


Figure 5. Efficiency vs. Load Current

8. Electrical Characteristics

8.1 Absolute Maximum Ratings

Condition	Min	Max
Supply Voltage (V_{IN})	-0.3V	28V
Switch Voltage (V_{SW})	-1.0V	V_{IN}+1V
Bootstrap Voltage (V_{BST})	V_{SW}-0.3V	Vsw+6V
Feedback Voltage (V_{FB})	-0.3V	6V
Enable Voltage (V_{EN})	-0.3V	6V
Comp Voltage (V_{COMP})	-0.3V	6V
OSC Voltage (V_{OSC})	-0.3V	6V
Operating Junction Temperature	-40℃	150℃
Storage Temperature	-55℃	150℃
Lead Temperature	-	300℃

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 conditions outside those indicated in the operational sections of this specification are not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

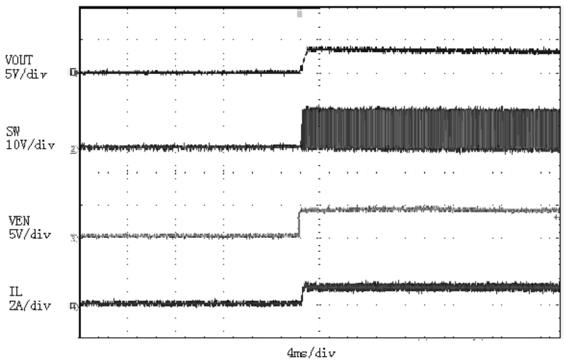
8.2 Electrical Characteristics

Electrical Characteristics (V_{IN}=12V, T_A=25℃ unless otherwise specified)

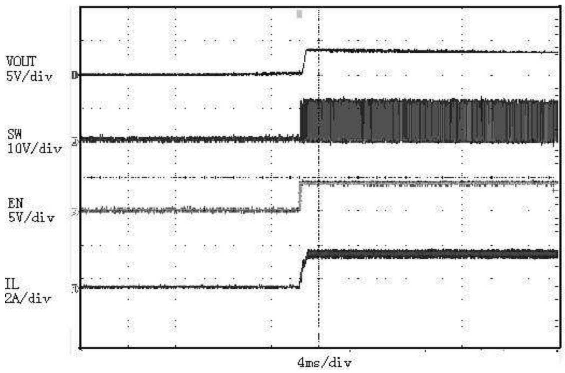
Parameter	Symbol	Conditions	Min.	Typ.	Max.	Units
Input Voltage Range	V_{IN}		4.5	-	24	V
Supply Quiescent Current	I_Q	V_{IN}=12V	-	1.0	-	mA
Supply Shutdown Current	I_{SHDN}	V_{EN}=0V	-	10	20	μA
Feedback Voltage	V_{FB}	$4.75 \le V_{IN} \le 18V$, $V_{COMP}<2V$	1.23	1.25	1.27	V
HS Switch On Resistance	R_{ONH}	I_{SW}=100mA	-	0.2	-	Ω
LS Switch On Resistance	R_{ONL}	I_{SW}=50mA	-	10	-	Ω
Internal Switch Leakage	I_{LEAK}	V_{EN}=0, V_{DS}=23V	-	-	10	μA
Current Limit	I_{LIM}		2.5	2.9	3.3	A
COMP to Current Sense Transconductance	G_{CS}		-	2.5	-	A/V
Error Amplifier DC Gain	A_{VEA}		-	4000	-	V/V
Error Amplifier Transconductance	G_{EA}	$\Delta I_{COMP}=\pm 10\mu A$	-	800	-	μA/V
Switching Frequency	f_{SW}		-	380	-	kHz
Switching Frequency	f_{SW_SET}	R_{OSC}=80kΩ	1125	1250	1375	kHz
Short Circuit Frequency		V_{FB}=0V	-	$f_{SW}/8$	-	kHz
Maximum Duty Cycle	D_{MAX}	V_{FB}=1.0V	-	90	-	%
Minimum on Time	$t_{ON(MIN)}$		-	150	-	ns
Enable Threshold Voltages	V_{IH}		0.6	0.85	1.2	V
Under Voltage Lockout Threshold Rising	V_{UVLO}		2.4	2.5	2.6	V
Under Voltage Lockout Threshold Hysteresis	V_{UVL_TH}		-	150	-	mV
Thermal Shutdown Temperature	T_{SHDN}		-	160	-	℃
Thermal Shutdown Temperature Hysteresis			-	40	-	℃

8.3 Typical characteristics

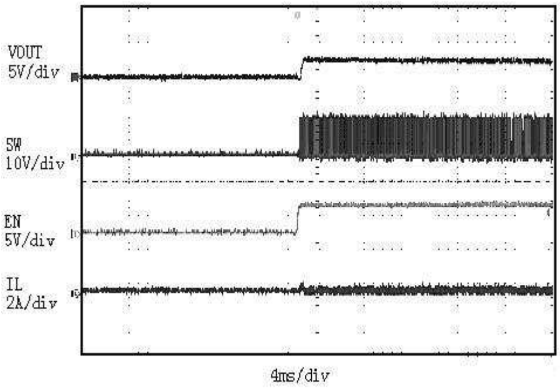
Start up through Enable at 1A Load



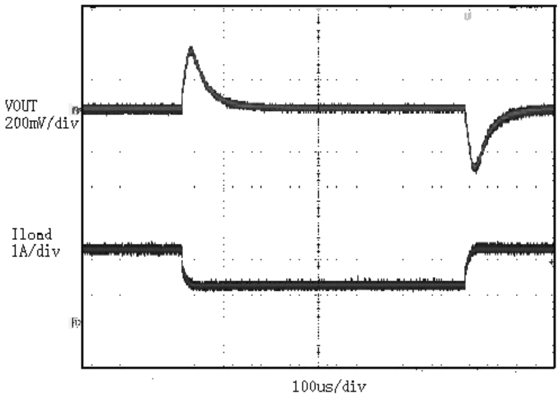
Start up through Enable at 2A Load



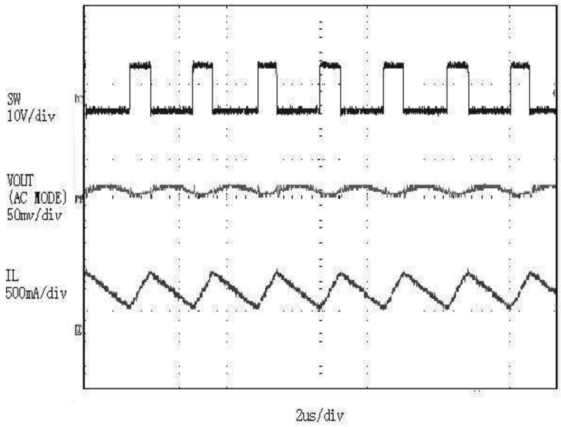
Start up through Enable without Load



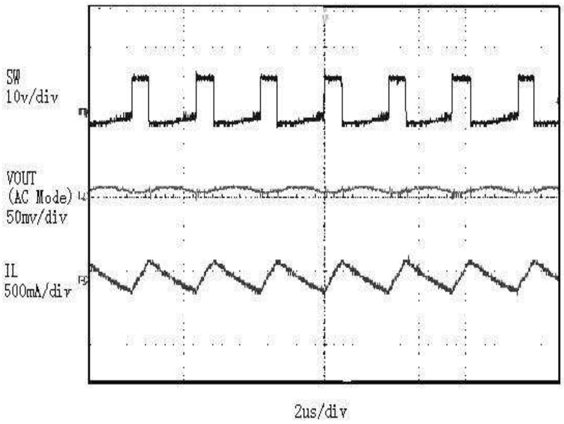
Load Transition(1A to 2A)



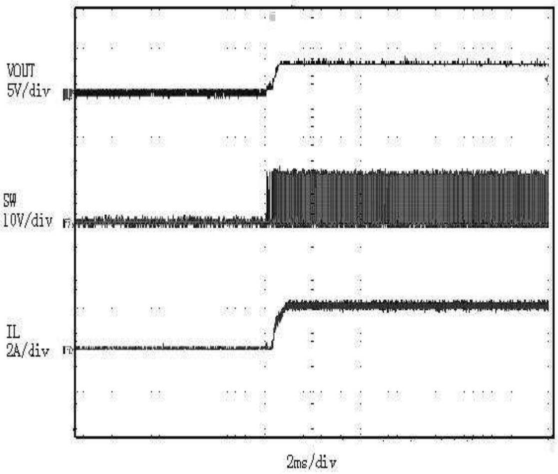
Full Load Operation



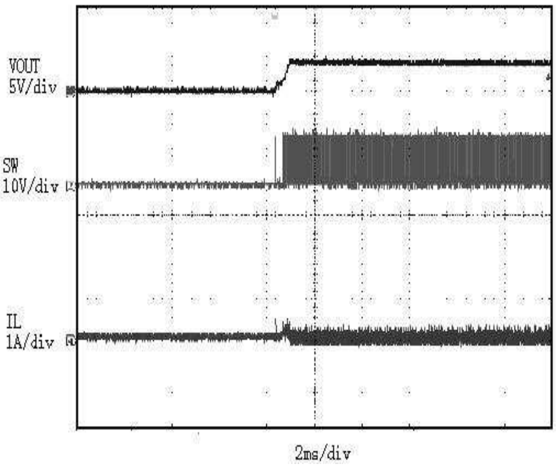
Operation without Load



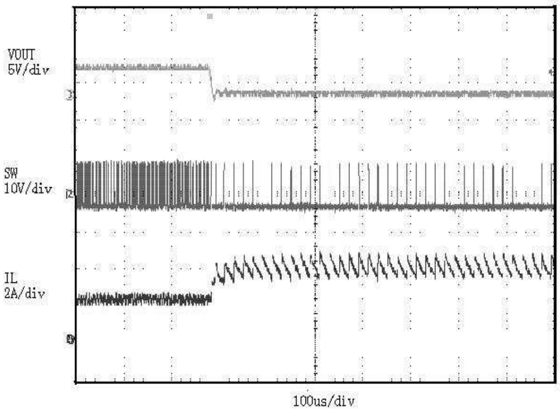
Soft-start at 2A Load



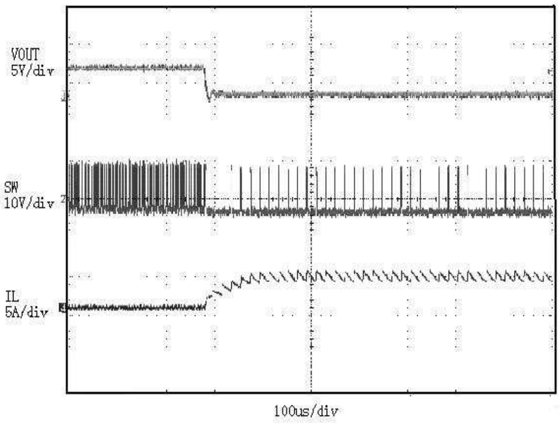
Soft-start without Load



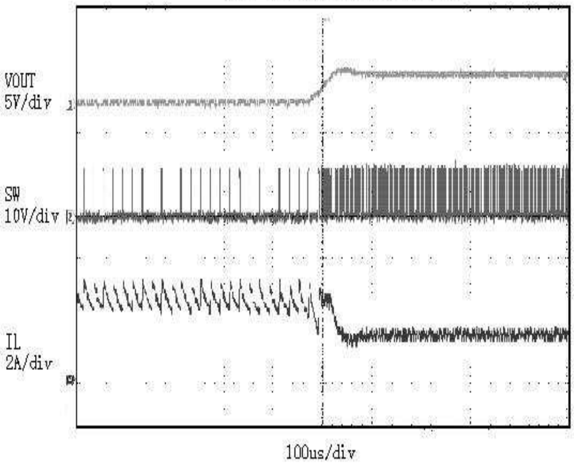
Vout Short to GND at 2A Load



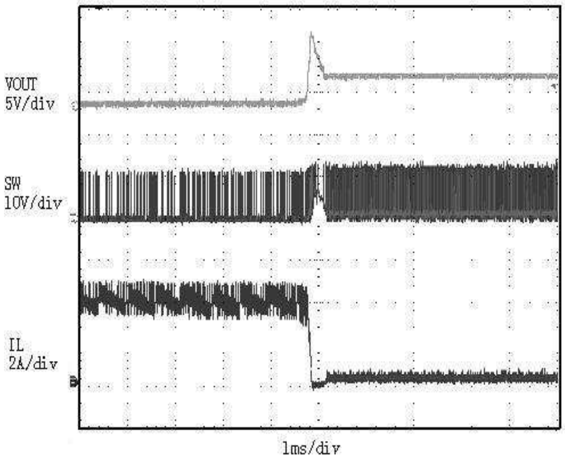
Vout Short to GND without Load



Vout Short Recovery at 2A Load

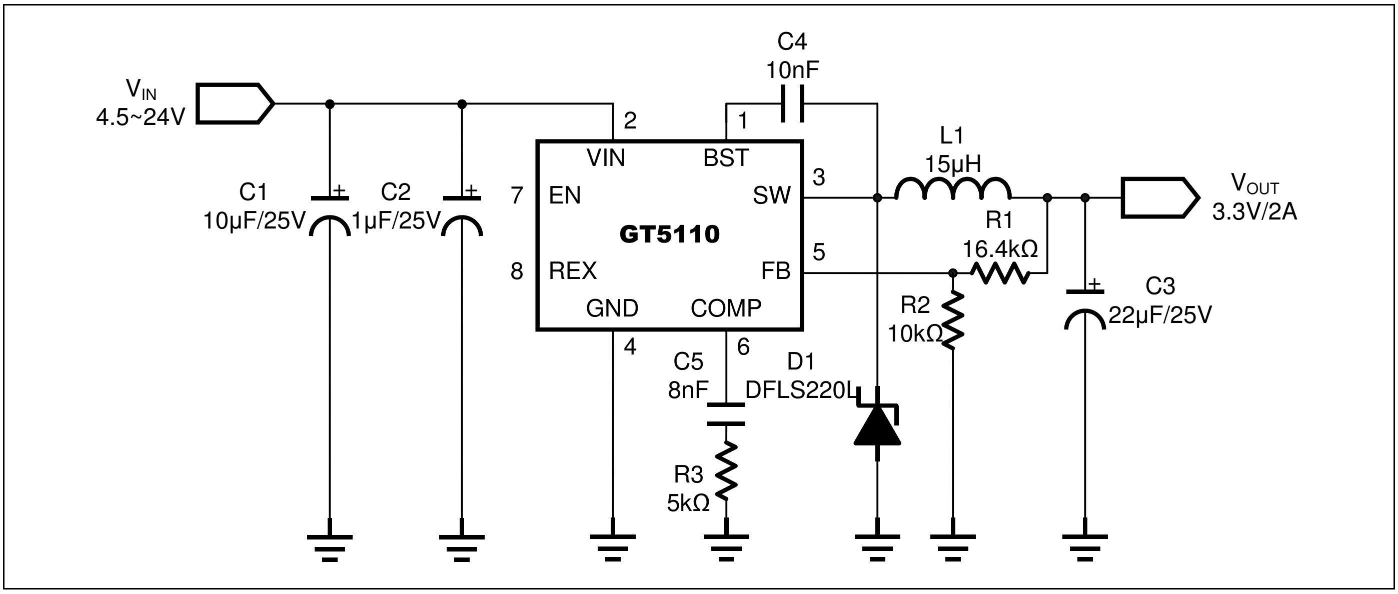


Vout Short Recovery without Load

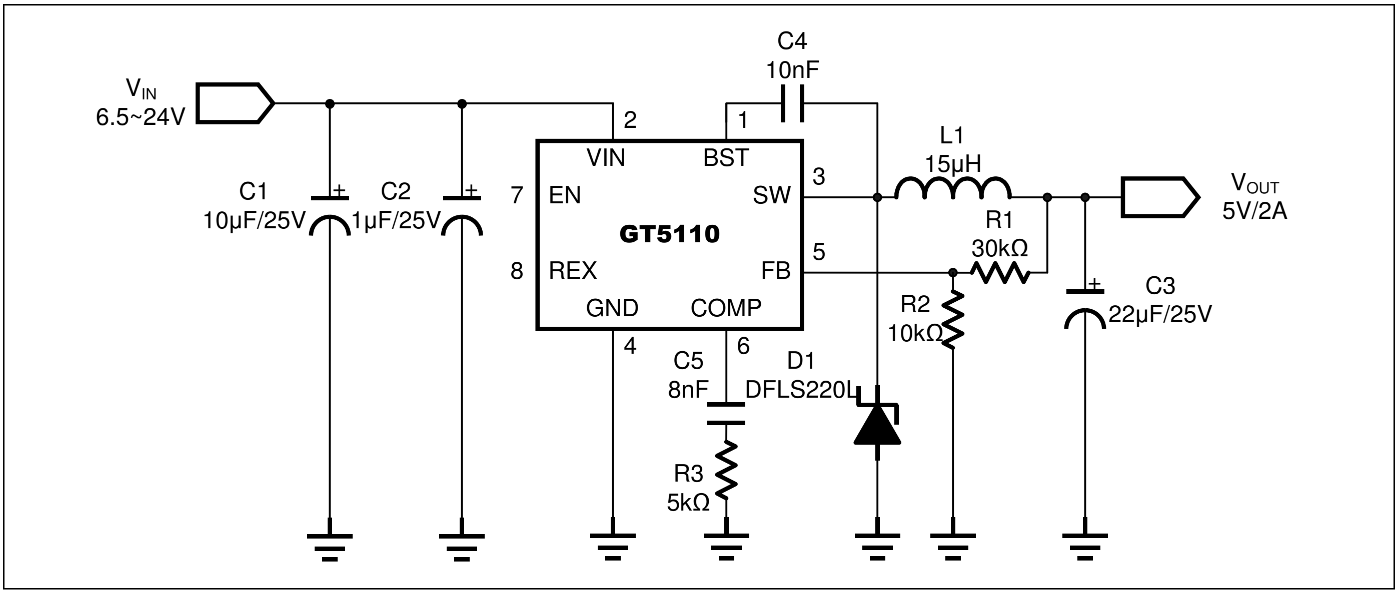


9. Typical Application Circuits

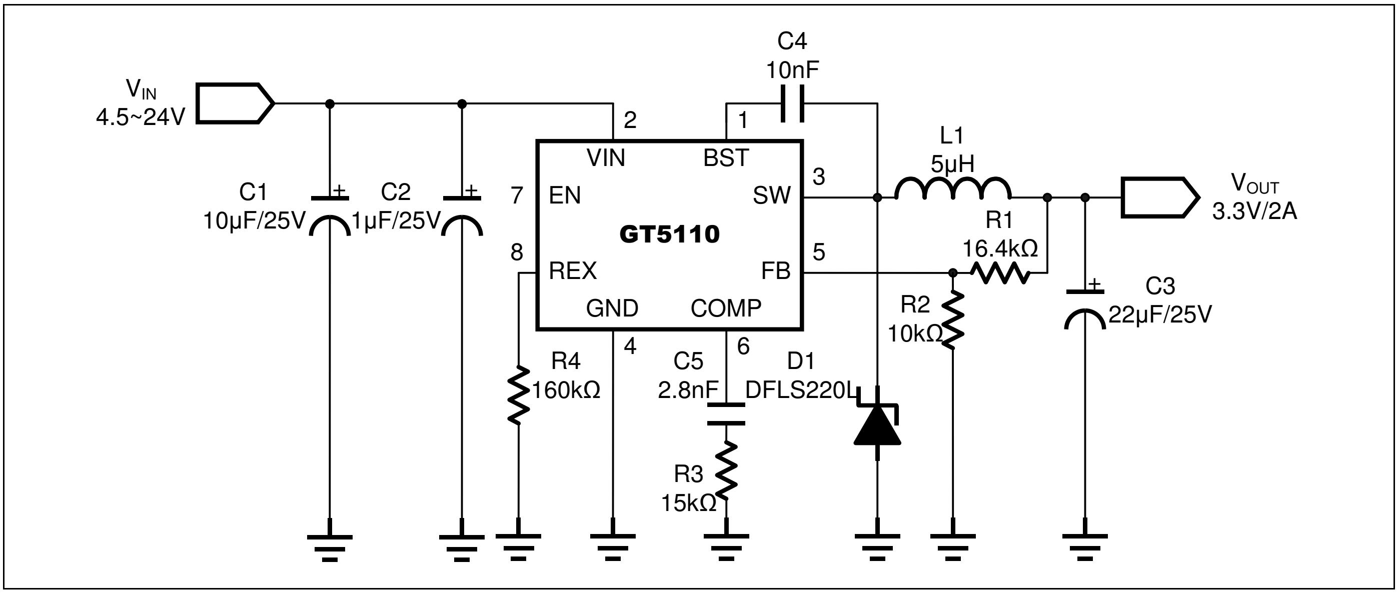
9.1 V_{OUT}=3.3V, I_{LOAD}=2A, f_{SW}=380kHz



9.2 V_{OUT}=5V, I_{LOAD}=2A, f_{SW} =380kHz



9.3 V_{OUT}=3.3V, I_{LOAD}=2A, f_{SW} =1MHz



10. Ordering Information

GT XX XX - XX X X

Temperature Range

Bank	Commercial: 0℃~70℃
I	Industrial: -40℃~85℃

Pb Status

G	GREEN

Package Type:

G	SOP
H	HSOP

Part Number

Production Family

51	Power Management Product; DC-DC

Giantec Prefix

GT	Giantec

Order Number	Package Description	Package Option
GT5110-GGI-TR	5.1 x 4 mm SOP8	Tape and Reel 4000
GT5110-HGI-TR	5.1 x 4 mm HSOP8	Tape and Reel 4000

11. Part Markings

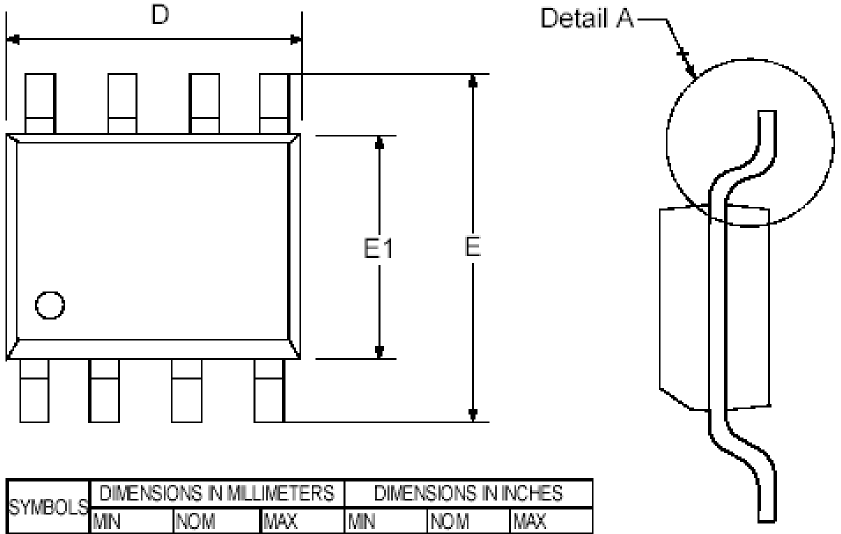
11.1 GT5110-GGI (Top View)

G	T	5	1	1	0	G	G	I
				Lot Number				
●		Y	Y	W	W	S	V	

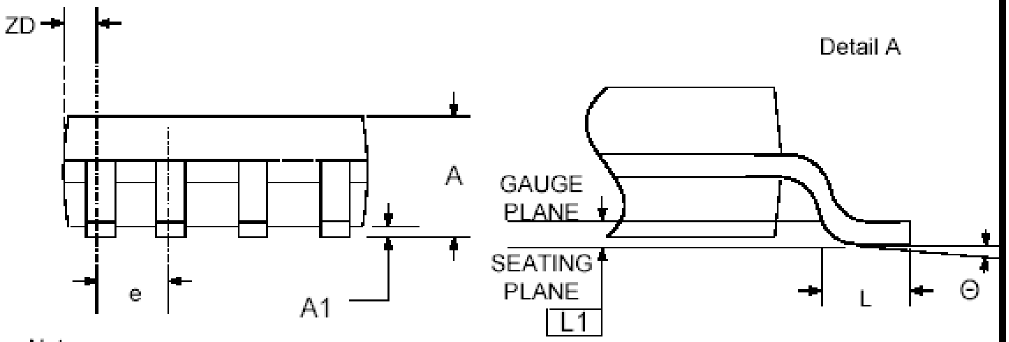
GT5110GGI	
Lot Number	States the last 9 characters of the wafer lot information
●	Pin 1 Indicator
YY	Seal Year
	00 = 2000
	01 = 2001
	99 = 2099
WW	Seal Week
	01 = Week 1
	02 = Week 2
	.
	.
	.
	51 = Week 51
	52 = Week 52
S	Subcon Code
	J = ASESH
	L = ASEKS
V	Die Version

12. Package Information

12.1 SOP8



SYMBOLS	DIMENSIONS IN MILLIMETERS			DIMENSIONS IN INCHES		
	MIN	NOM	MAX	MIN	NOM	MAX
A	1.35	--	1.75	0.053	--	0.069
A1	0.10	--	0.25	0.004	--	0.010
b	0.33	--	0.51	0.013	--	0.020
D	4.80	--	5.00	0.189	--	0.197
E	5.80	--	6.20	0.228	--	0.244
E1	3.80	--	4.00	0.150	--	0.157
e	1.27 BSC.			0.050 BSC.		
L	0.38	--	1.27	0.015		0.050
L1	0.25 BSC.			0.010 BSC.		
ZD	0.545 REF.			0.021 REF.		
Θ	0	--	8°	0	--	8°



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 MS-012
5. Drawing is not to scale

TITLE	8L 150mil SOP Package Outline	Rev.	A	DATE	01/13/2010	

13. Revision History

Revision	Date	Descriptions
A0	Aug., 2010	Initial Version