

1.5 MHz, 600mA Synchronous Step-Down Converter With Low Quiescent Current

Product Description

GS5571 is a 1.5MHz constant frequency, slope compensated current mode PWM step-down converter. The device integrates a main switch and a synchronous rectifier for high efficiency without an external Schottky diode. It is ideal for powering portable equipment that runs from a single cell lithium-Ion (Li+) battery.

The GS5571 can supply 600mA of load current from a 2.5V to 5.5V input voltage. The output voltage can be regulated as low as 0.6V. The GS5571 can also run at 100% duty cycle for low dropout operation, extending battery life in portable system. Idle mode operation at light loads provides very low output ripple voltage for noise sensitive applications.

The GS5571 is offered in a low profile (1mm) 5-pin, thin SOT package, and is available in an adjustable version and fixed output voltage of 1.2V, 1.5V and 1.8V

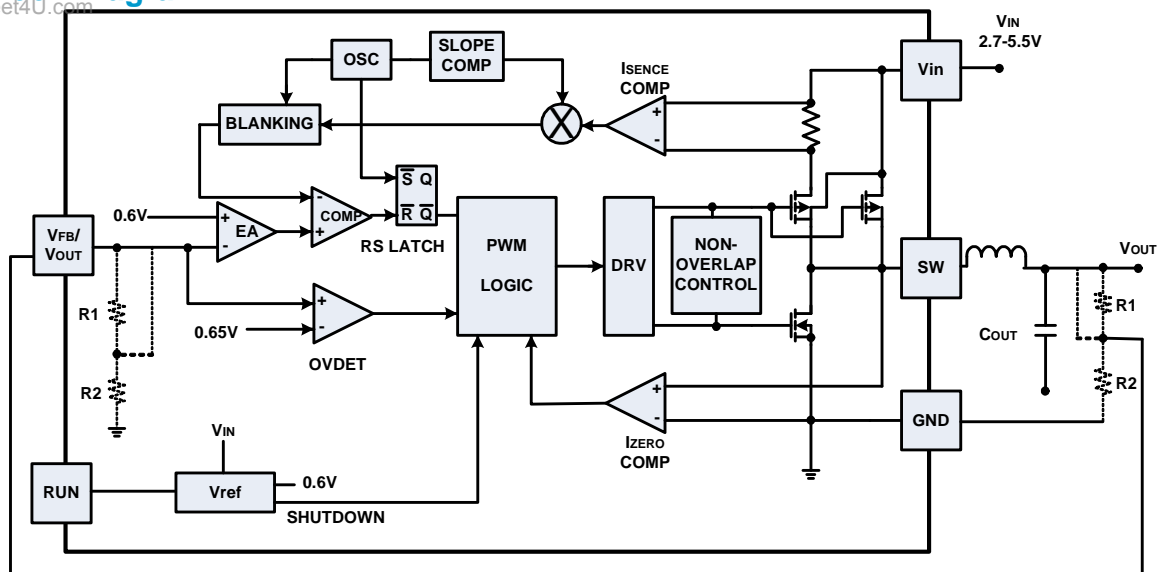
Features

- High Efficiency: Up to 96%.
- 1.5MHz Constant Switching Frequency.
- 600mA Output Current at $V_{IN}=3.0V$.
- Integrated Main switch and synchronous rectifier.
- No Schottky Diode Required.
- 2.5V to 5.5V Input Voltage Range.
- Output Voltage as Low as 0.6V.
- 100% Duty Cycle in Dropout.
- Low Quiescent Current: 30 μ A.
- <1 μ A Shutdown Current.
- Slope Compensated Current Mode Control for Excellent Line and Load Transient Response.
- Short Circuit and Thermal Fault Protection
- Space Saving 5-Pin Thin SOT23 package.

Applications

- Cellular and Smart Phones
- PDAs
- MP3 Player
- DSP Core Supplies
- Digital Still Cameras
- Portable instruments

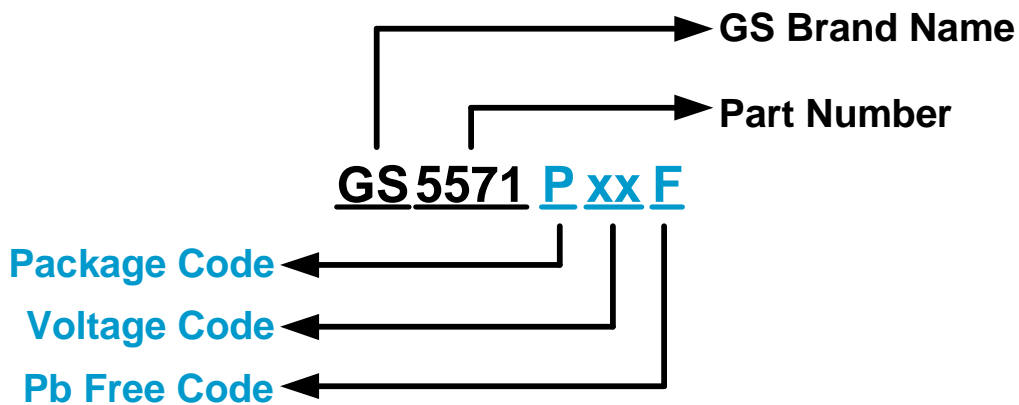
Block Diagram



Packages & Pin Assignments

Adjustable Version	Pin No.	Fixed Version	Pin No.	Symbol	Description
	1		1	RUN	Enable (Active High)
	2		2	GND	Ground
	3		3	SW	Switch
	4		4	V _{IN}	Input
	5		-	FB	Feedback
	-		5	V _{OUT}	Output

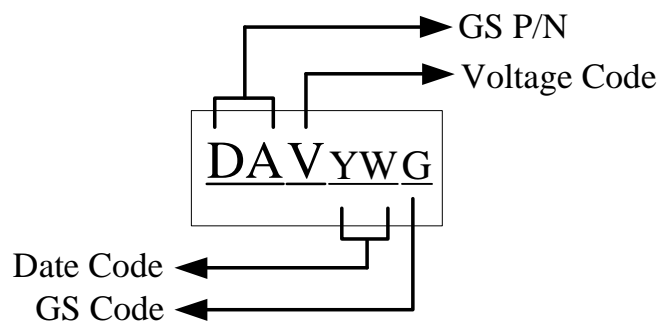
Ordering Information



GS Complete P/N	Voltage	Package	Marking	Q'ty / Reel
GS5571LF	Adjustable	SOT-23-5L	DAA _{YWG}	3000 Pcs
GS5571L12F	1.2V	SOT-23-5L	DAD _{YWG}	3000 Pcs
GS5571L15F	1.5V	SOT-23-5L	DAG _{YWG}	3000 Pcs
GS5571L18F	1.8V	SOT-23-5L	DAF _{YWG}	3000 Pcs

Adjustable Version need not Voltage Code.

Marking Information



Absolute Maximum Ratings

Exceeding the specifications below may result in permanent damage to the device, or device malfunction. Operation outside of the parameters specified in the Electrical Characteristics section is not implied.

Parameter	Symbol	Max	Units
Input Supply Voltage	V_{IN}	-0.3V to 6	V
Enable, Feedback Voltages	V_{RUN}, V_{FB}	-.0.3 to $V_{IN}+0.3$	V
SW Voltages	V_{SW}	-0.3 to $V_{IN}+0.3$	V
Peak SW Sink and Source Current	I_{PSW}	1.5	A
Operating Temperature Range (Note 2)	T_A	-40 to +85	°C
Operating Junction Temperature Range	T_J	+125	°C
Storage Temperature Range	T_{STG}	-65 to +150	°C
Lead Temperature (Soldering) 10 Sec.	T_{LEAD}	300	°C
ESD Rating (Human Body Model)	ESD	2	kV

Note 1: Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

Note 2: T_J is calculated from the ambient temperature T_A and power dissipation P_D according to the following formula: $T_J = T_A + P_D \times \theta_{JA}$

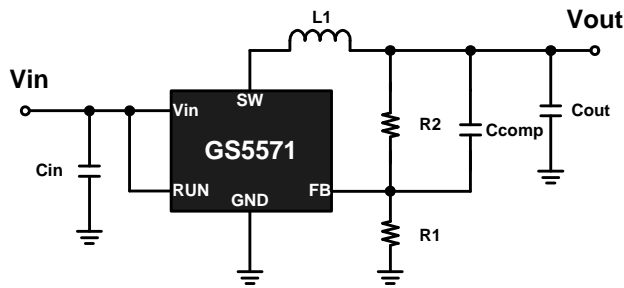
Electrical Characteristics (Note 3)

($V_{IN} = V_{RUN} = 3.6V$, $T_A = 25^\circ C$, unless otherwise noted)

Parameter	Conditions	MIN	TYP	MAX	unit
Input Voltage Range		2.5		5.5	V
Input DC Supply Current	$V_{FB} = 0.5V$		270	400	μA
Active Mode Shutdown Mode	$V_{FB} = 0V, V_{IN} = 4.2V$	-	0.08	1.0	μA
Regulated Feedback Voltage	$T_A = +25^\circ C$	0.5880	0.6000	0.6120	V
	$T_A = 0^\circ C \leq T_A \leq 85^\circ C$	0.5865	0.6000	0.6135	V
	$T_A = -40^\circ C \leq T_A \leq 85^\circ C$	0.5850	0.6000	0.6150	V
V_{FB} Input Bias Current	$V_{FB} = 0.65V$	-	-	± 30	nA
Reference Voltage Line Regulation	$V_{IN} = 2.5V$ to $5.5V, V_{OUT} = V_{FB} (R2=0)$	-	0.11	0.40	%/V
Regulated Output Voltage	GS5571-1.2, $-40^\circ C \leq T_A \leq 85^\circ C$	1.164	1.200	1.236	V
	GS5571-1.5, $-40^\circ C \leq T_A \leq 85^\circ C$	1.455	1.500	1.545	V
	GS5571-1.8, $-40^\circ C \leq T_A \leq 85^\circ C$	1.746	1.800	1.854	V
Output Voltage Line Regulation	$V_{IN} = 2.5V$ to $5.5V, I_{OUT} = 10mA$	-	0.11	0.40	%/V
Output Voltage Load Regulation	I_{OUT} from 0 to 600mA	-	0.0015	-	%/mA
Maximum Output Current	$V_{IN} = 3.0V$	600	-	-	mA
Oscillator Frequency	$V_{FB} = 0.6V$ or $V_{OUT} = 100\%$	1.2	1.5	1.8	MHz
$R_{DS(ON)}$ of P-CH MOSFET	$I_{SW} = 300mA$	-	0.30	0.50	Ω
$R_{DS(ON)}$ of N-CH MOSFET	$I_{SW} = -300mA$	-	0.20	0.45	Ω
Peak Inductor Current	$V_{IN} = 3V, V_{FB} = 0.5V$ or $V_{OUT} = 90\%$ Duty Cycle < 35%	-	1.20		A
SW Leakage	$V_{RUN} = 0V, V_{SW} = 0V$ or $5V, V_{IN} = 5V$	-	± 0.01	± 1	μA
Output over voltage lockout	$\Delta V_{OVL} = V_{OVL} - V_{FB}$	-	60		mV
RUN Threshold	$-40^\circ C \leq T_A \leq 85^\circ C$	0.3	0.45	1.30	V
RUN Leakage Current			± 0.1	± 1	μA

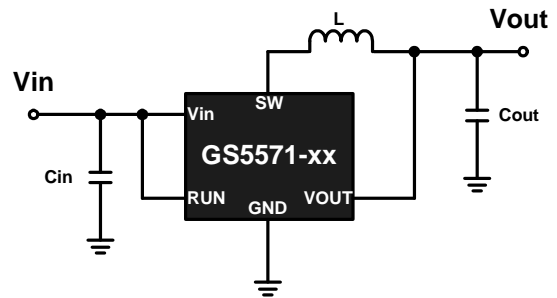
Note 3: 100% production test at +25°C. Specifications over the temperature range are guaranteed by design and characterization.

Typical Applications



$$V_{OUT} = V_{REF} \times (1 + R2/R1)$$

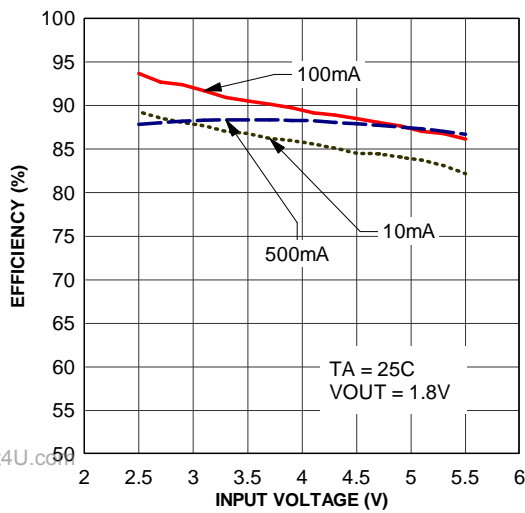
Adjustable Voltage Version



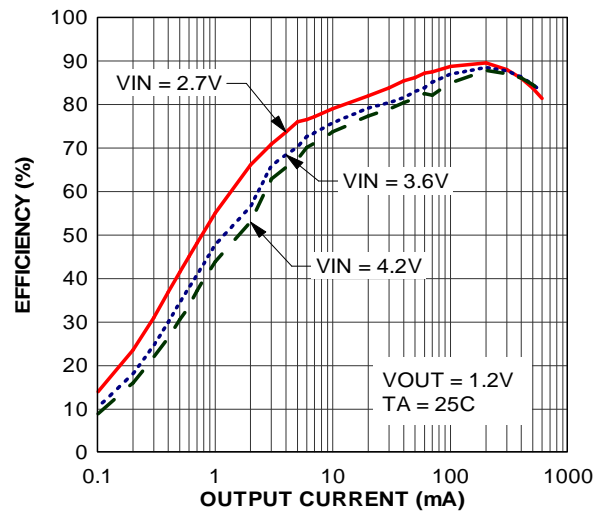
Fixed Voltage Version

Typical Performance Characteristics

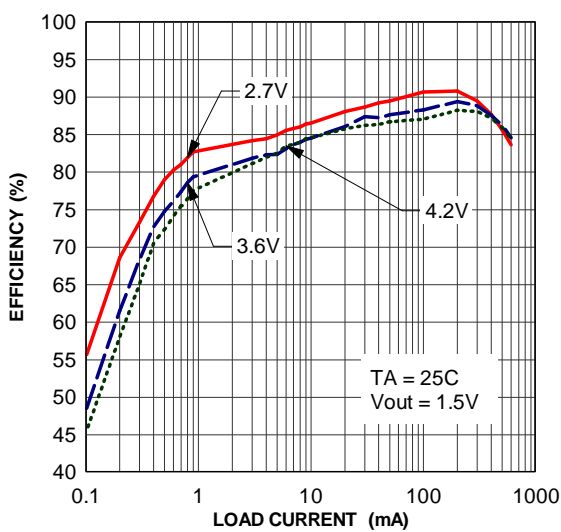
Efficiency vs Input Voltage



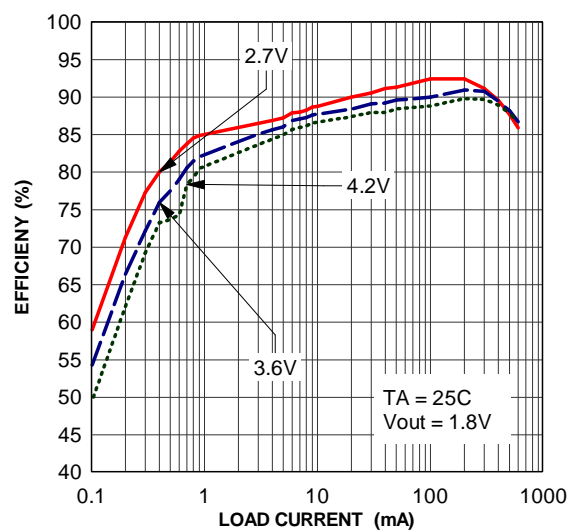
Efficiency vs Output Current



Efficiency vs Load Current



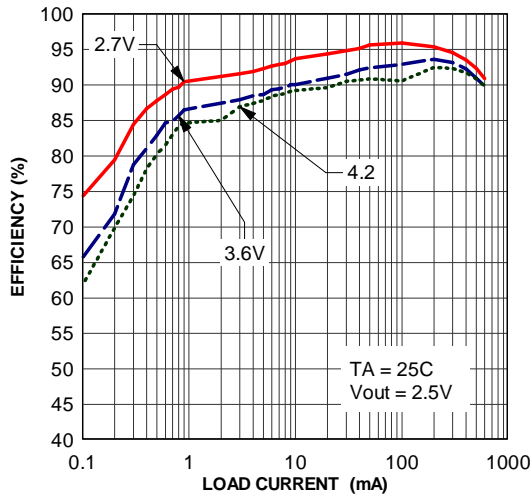
Efficiency vs Load Current



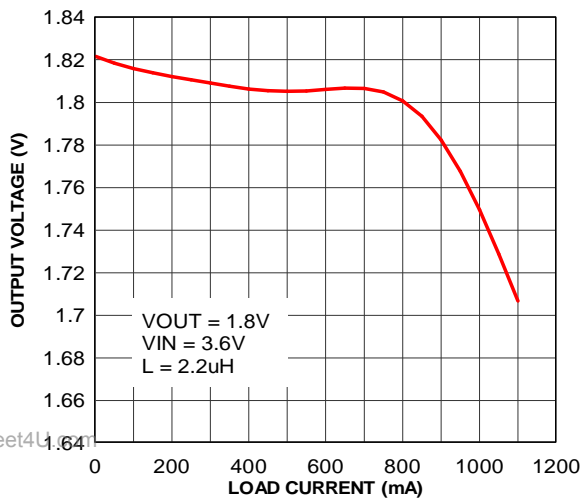
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Typical Performance Characteristics (Continue)

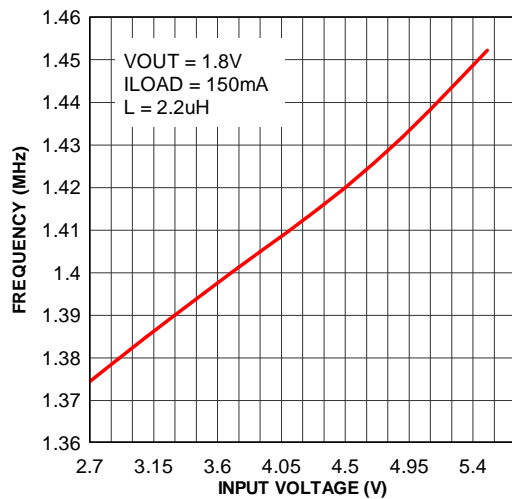
Efficiency vs Load Current



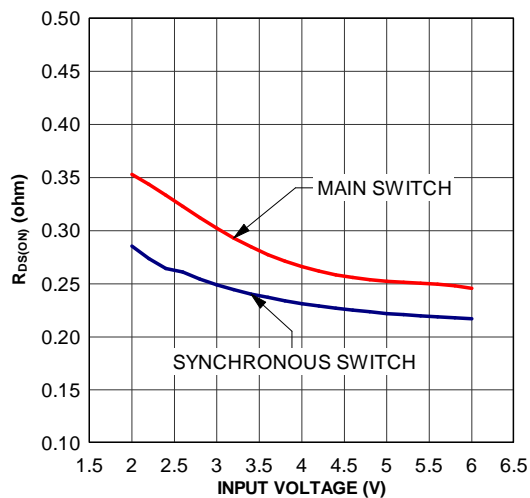
Output Voltage vs Load Current



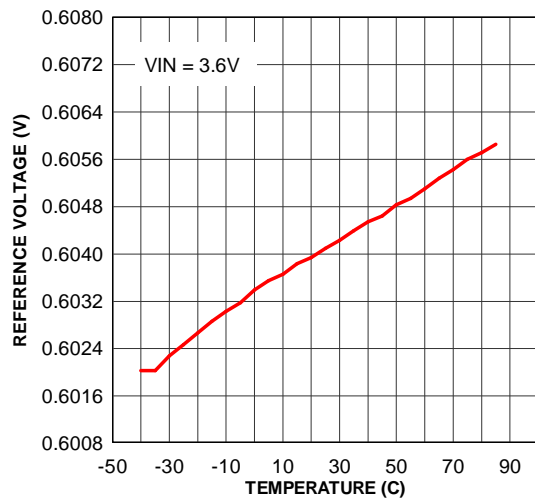
Frequency vs Input Voltage



R_{DS(ON)} vs Input Voltage



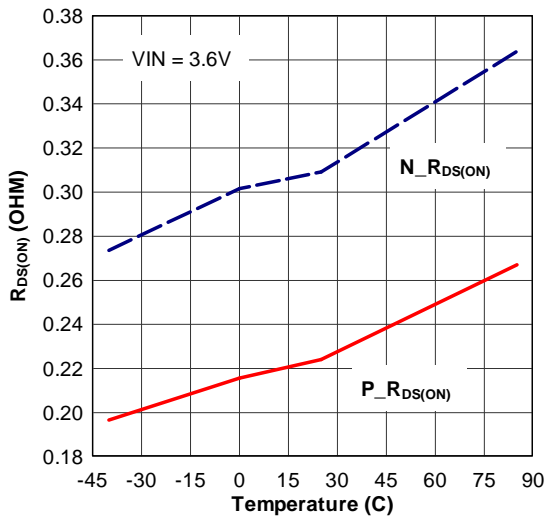
Reference Voltage vs Temperature



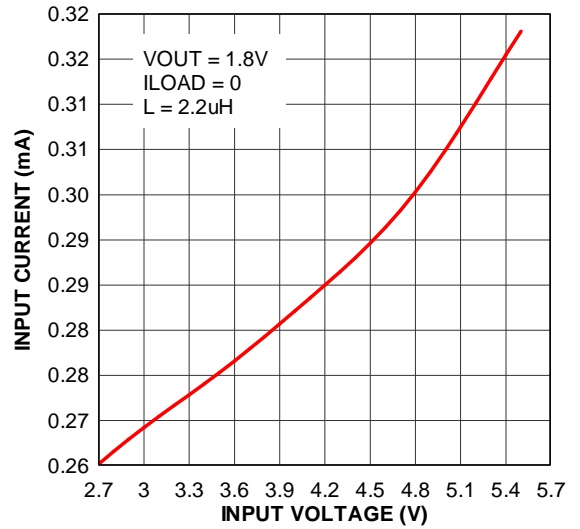
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Typical Performance Characteristics (Continue)

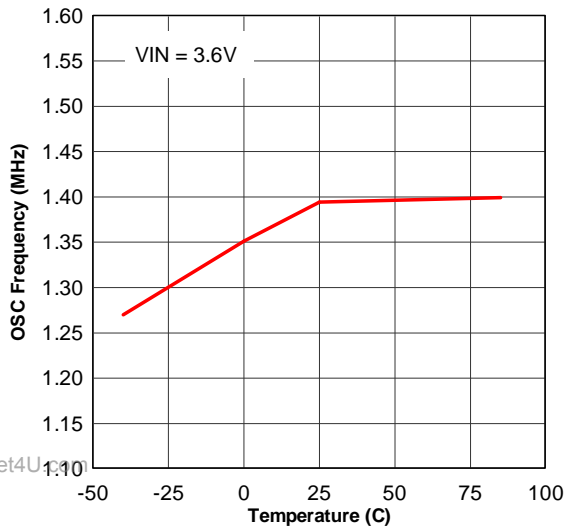
$R_{DS(ON)}$ vs Temperature



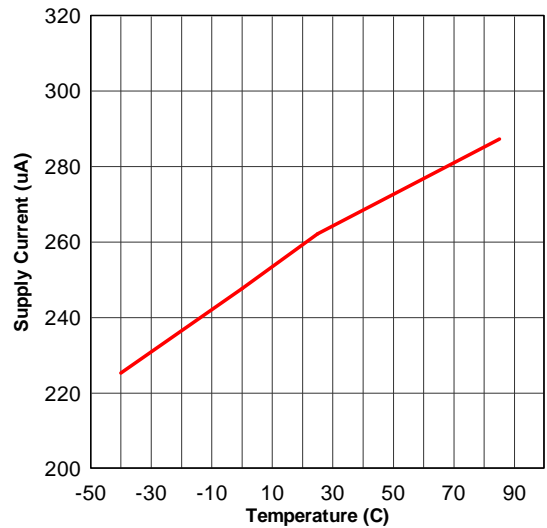
Input Voltage vs Input Current



Frequency vs Temperature



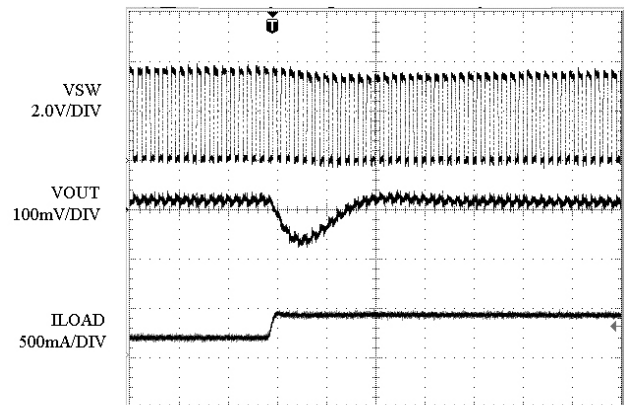
Supply Current vs Temperature



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Iload = 26 mA TO 400 mA, Power Saving Mode to PWM Mode
L=2.2uH, Cin=10uF, Cout=10uF, Vin=3.6V, Vout=1.8V



Iload = 180 mA TO 400 mA
L=2.2uH, Cin=10uF, Cout=10uF, Vin=3.6V, Vout=1.8V

Operation

GS5571 is a monolithic switching mode Step-Down DC-DC converter. It utilizes internal MOSFETs to achieve high efficiency and can generate very low output voltage by using internal reference at 0.6V. It operates at a fixed switching frequency, and uses the slope compensated current mode architecture. This Step-Down DC-DC Converter supplies 600mA output current at $V_{IN} = 3V$ with input voltage range from 2.5V to 5.5V.

Current Mode PWM Control

Slope compensated current mode PWM control provides stable switching and cycle-by-cycle current limit for excellent load and line responses and protection of the internal main switch (P-Ch MOSFET) and synchronous rectifier (N-Ch MOSFET). During normal operation, the internal P-Ch MOSFET is turned on for a certain time to ramp the inductor current at each rising edge of the internal oscillator, and switched off when the peak inductor current is above the error voltage. The current comparator, ICOMP, limits the peak inductor current. When the main switch is off, the synchronous rectifier will be turned on immediately and stay on until either the inductor current starts to reverse, as indicated by the current reversal comparator, IZERO, or the beginning of the next clock cycle. The OVDET comparator controls output transient overshoots by turning the main switch off and keeping it off until the fault is no longer present.

Idle Mode Operation

At very light loads, the GS5571 automatically enters Idle Mode. In the Idle Mode, the inductor current may reach zero or reverse on each pulse. The PWM control loop will automatically skip pulses to maintain output regulation. The bottom MOSFET is turned off by the current reversal comparator, IZERO, and the switch voltage will ring. This is discontinuous mode operation, and is normal behavior for the switching regulator.

Dropout Operation

When the input voltage decreases toward the value of the output voltage, the GS5571 allows the main switch to remain on for more than one switching cycle and increases the duty cycle ^(Note 5) until it reaches 100%. The output voltage then is the input voltage minus the voltage drop across the main switch and the inductor. At low input supply voltage, the $R_{DS(ON)}$ of the P-Channel MOSFET increases, and the efficiency of the converter decreases. Caution must be exercised to ensure the heat dissipated not to exceed the maximum junction temperature of the IC.

Note 5: The duty cycle D of a step-down converter is defined as:

$$D = T_{ON} \times f_{OSC} \times 100\% \approx \frac{V_{OUT}}{V_{IN}} \times 100\%$$

Where T_{ON} is the main switch ON time, and f_{OSC} is the oscillator frequency (1.5Mhz). The output voltage then is the input voltage minus the voltage drop across the main switch and the inductor. At low input supply voltage, the $R_{DS(ON)}$ of the P-Channel MOSFET increases, and the efficiency of the converter decreases. Caution must be exercised to ensure the heat dissipated not to exceed the maximum junction temperature of the IC.

Maximum Load Current

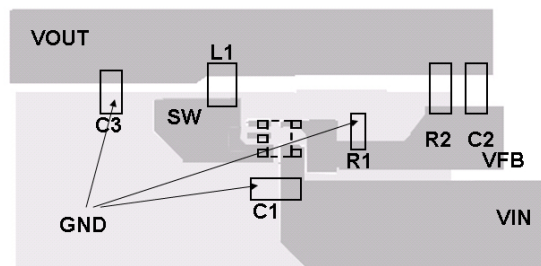
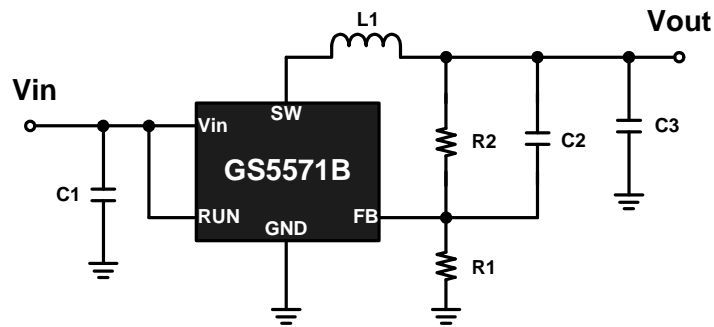
The GS5571 will operate with input supply voltage as low as 2.5V, however, the maximum load current decreases at lower input due to large IR drop on the main switch and synchronous rectifier. The slope compensation signal reduces the peak inductor current as a function of the duty cycle to prevent sub-harmonic oscillations at duty cycles greater than 50%. Conversely the current limit increases as the duty cycle decreases.

Layout Guidance

When laying out the PC board, the following suggestions should be taken to ensure proper operation of the GS5571. These items are also illustrated graphically in Figure 3.

1. The power traces, including the GND trace, the SW trace and the VIN trace should be kept short, direct and wide.
2. The V_{FB} pin should be connected directly to the feedback resistor. The resistive divider R1/R2 must be connected between the (+) plate of C3 and ground.
3. Connect the (+) plate of C1 to the V_{IN} pin as closely as possible. This capacitor provides the AC current to internal power MOSFET.
4. Keep the switching node, SW, away from the sensitive V_{FB} node.
5. Keep the (-) plates of C1 and C3 as close as possible.

Operation (Continue)



GS5571 Layout Example

Setting the Output Voltage

Figure 1 shows the basic application circuit with GS5571 adjustable output version. The external resistor sets the output voltage according to the following equation:

$$V_{OUT} = 0.6V \times \left(1 + \frac{R2}{R1}\right)$$

V _{OUT}	R1	R2
1.2V	316k	316k
1.5V	316k	470k
1.8V	316k	634k
2.5V	316k	1000k

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Table 1. Resistor select for output voltage setting

Inductor Selection

For most designs, the GS5571 operates with inductors of 1μH to 4.7μH. Low inductance values are physically smaller but require faster switching, which results in some efficiency loss. The inductor value can be derived from the following equation:

$$L = \frac{V_{OUT} \times (V_{IN} - V_{OUT})}{V_{IN} \times \Delta I_L \times f_{OSC}}$$

Where ΔI_L is inductor Ripple Current. Large value inductors lower ripple current and small value inductors result in high ripple currents. Choose inductor ripple current approximately 35% of the maximum load current 600mA, or $\Delta I_L = 210mA$.

For output voltages above 2.0V, when light-load efficiency is important, the minimum recommended inductor is 2.2μH. For optimum voltage-positioning load transients, choose an inductor with DC series resistance in the 50mΩ to 150mΩ range. For higher efficiency at heavy loads (above 200mA), or minimal load regulation (but some transient overshoot), the resistance should be kept below 100mΩ. The DC current rating of the inductor should be at least equal to the maximum load current plus half the ripple current to prevent core saturation (600mA+105mA).

Operation (Continue)

Input Capacitor Selection

The input capacitor reduces the surge current drawn from the input and switching noise from the device. The input capacitor impedance at the switching frequency shall be less than input source impedance to prevent high frequency switching current passing to the input. A low ESR input capacitor sized for maximum RMS current must be used. Ceramic capacitors with X5R or X7R dielectrics are highly recommended because of their low ESR and small temperature coefficients. A 4.7μF ceramic capacitor for most applications is sufficient.

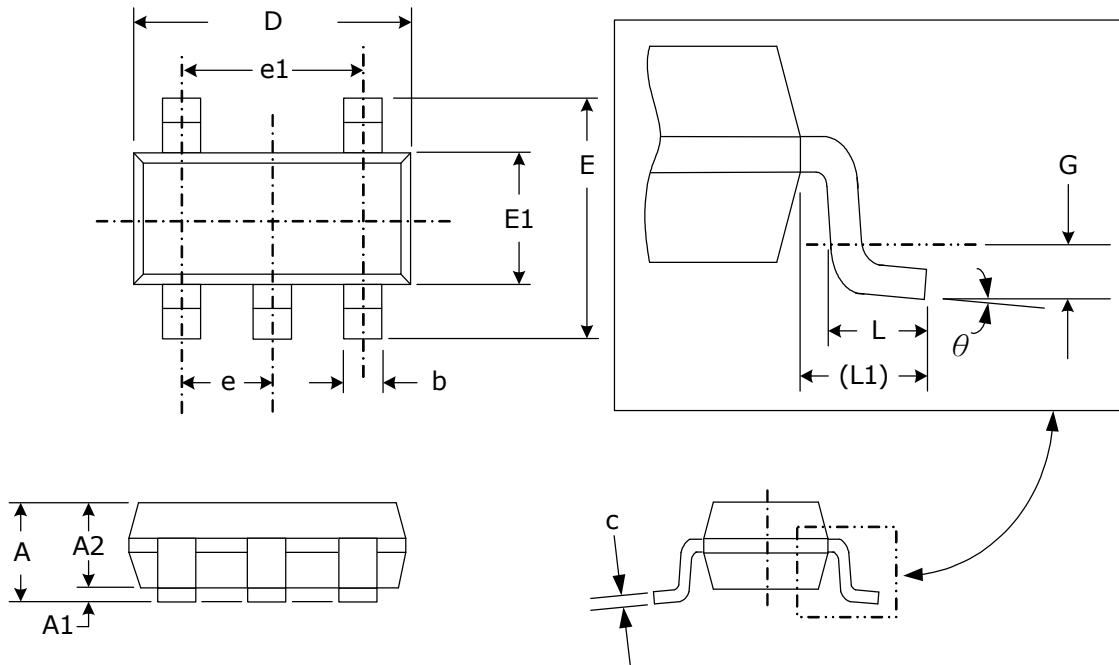
Output Capacitor Selection

The output capacitor is required to keep the output voltage ripple small and to ensure regulation loop stability. The output capacitor must have low impedance at the switching frequency. Ceramic capacitors with X5R or X7R dielectrics are recommended due to their low ESR and high ripple current. The output ripple V_{OUT} is determined by:

$$\Delta V_{OUT} = \frac{V_{OUT} \times (V_{IN} - V_{OUT})}{V_{IN} \times L \times f_{osc}} \times \left(ESR + \frac{1}{8 \times C \times f_{osc}} \right)$$

Package Dimension

SOT-23-5L PLASTIC PACKAGE



Dimensions				
SYMBOL	Millimeters		Inches	
	MIN	MAX	MIN	MAX
A	0.95	1.45	.037	.057
A1	0.05	0.15	.002	.006
A2	0.90	1.30	.035	.051
b	0.30	0.50	.012	.020
c	0.08	0.20	.003	.008
D	2.80	3.00	.110	.118
E	2.60	3.00	.102	.118
E1	1.50	1.70	.059	.067
e	0.95 (TYP)		.037 (TYP)	
e1	1.90 (TYP)		.075 (TYP)	
L	0.35	0.55	.014	.022
L1	0.60 (TYP)		.024 (TYP)	
G	0.25 (TYP)		.010 (TYP)	
theta	0°	8°	0°	8°

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