ATI 2301 DC-DC Converter

Figure 1. Physical Photo of ATI2301

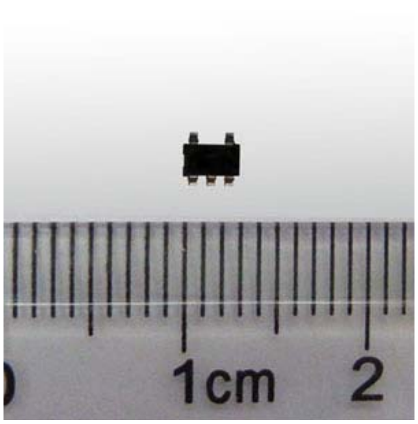

Figure 2. Physical Photo of ATI2301

FEATURES

- High Efficiency: up to 96%
- Internal Synchronous Rectifier
- Low Quiescent Current: 40µA
- Output current: up to 800mA
- High Switching Frequency: 1.5MHz
- Under-Voltage Lockout
- Soft Start
- Short Circuit Protection
- Small SOT23-5 Package
- Pb-Free

APPLICATIONS

This IC is widely used in various applications, such as cellular phone, portable electronics, wireless devices, cordless phone, computer Peripherals, Battery Powered Widgets, Electronic Scales, Digital Frame, etc.

DESCRIPTION

The ATI2301 is a step-down current-mode, DC-DC converter. At heavy load, it works at the constant frequency PWM mode which has good stability and transient response. To ensure the longest battery life under light load in portable applications, the ATI2301 features a power-saving pulse-skipping modulation (PSM) mode, which reduces quiescent current to save power.

It comes with an internal power switch and a synchronous rectifier minimizing the external part count with high efficiency. During shutdown, the input is disconnected from the output and the shutdown current is less than 0.1 uA. To prevent battery from being over discharged, it has a under-voltage lockout circuit, to shut down the converter upon detecting the input voltage below a preset value.

The ATI2301 has an input voltage from 2.5V to 5.5V, allowing the use of a single Li+/Li-polymer cell battery, multiple Alkaline/NiMH cell battery, USB port power, and other 2.7 to 5V standard power sources. The output voltage can be set from 0.6V to the input voltage, while the part number suffix ATI2301-XX indicates a pre-set output voltage versions: adjustable. The maximum output current limit is 800mA.

The ATI2301 is available in a compact and easy soldering SOT23-5 package**.**

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Typical Application

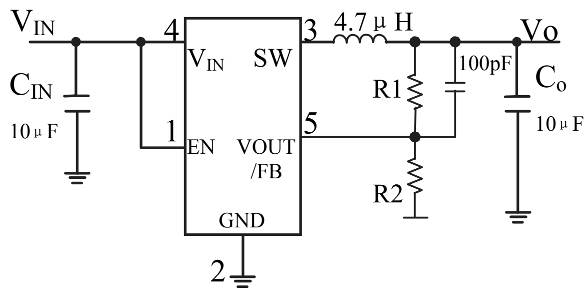


Figure 3. Adjustable Output Voltage

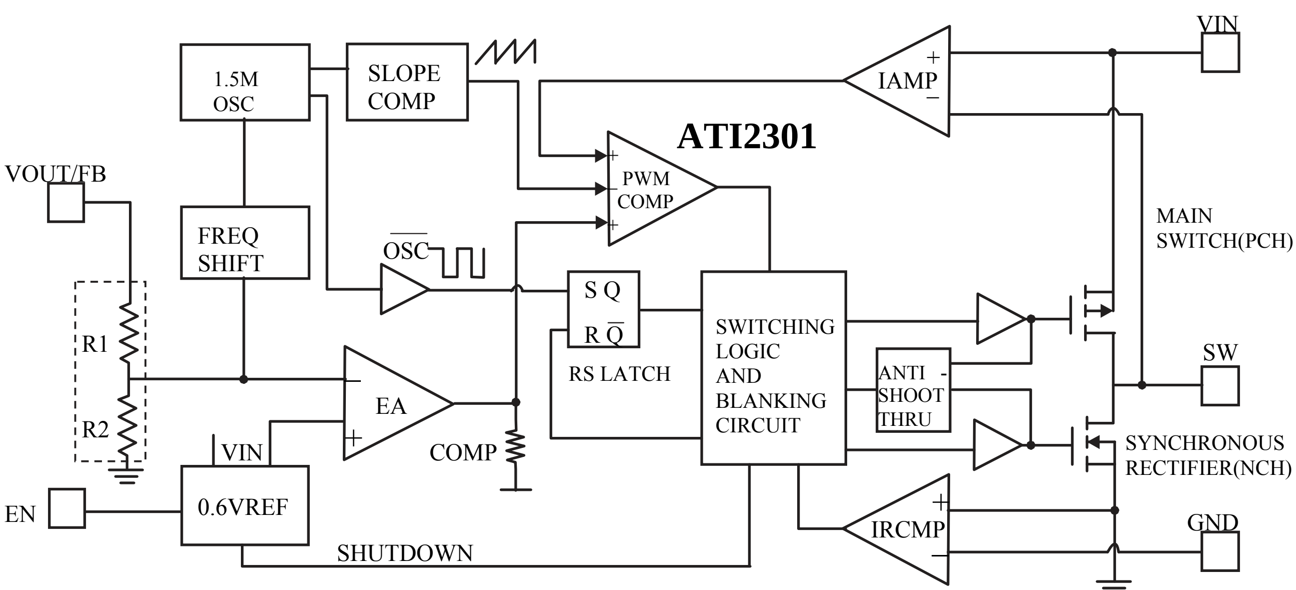
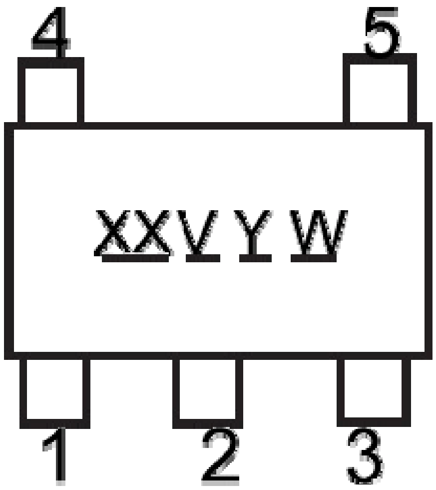


Figure 4. Block Diagram

Pin Configuration & Marking Information



X X: Product Code of ATI2301
V: Output Voltage
Y: Year
W: Week

Figure 5. Top View SOT-23-5

Pin Description

Table 1.

Pin Number	Name	Function
1	EN	Enable control input. Force this pin voltage above 1.5V, enables the chip, and below 0.3V shuts down the device.
2	GND	Ground
3	SW	The drains of the internal main and synchronous power MOSFET.
4	VIN	Chip main power supply pin
5	VOUT/FB	VOUT: Output voltage feedback pin, an internal resistive divider divides the output voltage down for comparison to the internal reference voltage. FB: Feedback voltage to internal error amplifier, the threshold voltage is 0.6V.

Absolute Maximum Ratings

These are stress ratings only and functional operation is not implied. Exposure to absolute maximum ratings for prolonged time periods may affect device reliability all voltages are with respect to ground.

Input Voltage.......................................-0.3V to 6.0V
EN, FB Pin Voltage..............................-0.3V to V_{IN}
SW Pin Voltage.......................-0.3V to （V_{IN}+0.3V）
Junction Temperature..150℃
Storage Temperature Range..........................-65℃ to 150℃
Soldering Temperature......................................300℃, 5 sec

Recommended Operating Conditions

Supply Voltage..............................2.5V to 5.5V
Junction Temperature Range........-40℃ to 125℃
Operating Temperature Range……………....-40℃ to 85 ℃

Thermal Information

Table 2.

Parameter	Package	Symbol	Maximum	Unit
Thermal Resistance (Junction to Case)	SOT-23-5	θ_{JC}	130	℃/W
Thermal Resistance (Junction to Ambient)		θ_{JA}	250	
Internal Power Dissipation		P_D	400	mW

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Characteristics

T_A = 25℃， V_{IN} = 3.6V , V_O = 1.8V , C_{IN} = 10 μF , L = 4.7 μH , unless otherwise noted.

Table 3.

SYMBOL	PARAMETER	Test Conditions	MIN	TYP	MAX	UNITS
V_{IN}	Input Voltage Range		2.5		5.5	V
V_{FB}	Regulated Feedback Voltage		0.588	0.6	0.612	V
ΔV_{FB}	Reference Voltage Line Regulation			0.3		%/V
V_O	Regulated Output Voltage Accuracy	I_O=100mA	-3		+3	%
I_{PK}	Peak Inductor Current	V_{IN}=3V, V_{FB}=0.5V or V_O=90%		1.2		A
LNR	Output Voltage Line Regulation	V_{IN}=2.5V to 5V,I_O=10mA		0.2	0.5	%/V
LDR	Output Voltage Load Regulation	I_O=1mA to 800mA		0.5	1.5	%
I_Q	Quiescent Current	No load		40	70	µA
I_{SD}	Shutdown Current	V_{EN}=0V		0.1	1	µA
F_{OSC}	Oscillator Frequency	V_O=100%	1.2	1.5	1.8	MHz
		V_{FB}=0V or V_O=0V		500		KHz
$R_{DS}(_{ON})$	Drain-Source On-State Resistance	I_{DS}=100mA, P MOSFET		0.3	0.45	Ω
		I_{DS}=100mA, N MOSFET		0.35	0.5	Ω
I_{LSW}	SW Leakage Current			±0.01	1	µA
V_{EH}	EN Threshold High		1.5			V
V_{EL}	EN Threshold Low				0.3	V
I_{EL}	EN Leakage Current			±0.01		µA
η	High Efficiency			96		%
OTP	Over Temperature Protection			150		°C
OTH	OTP Hysteresis			30		°C

Purchasing Information

Table 4.

Part Number	Output Voltage	Output Current	Marking	Standard Package
ATI2301AAABADJ	Adjustable	800mA	BAAYW	3000Units/Tape&Reel

Dimensions

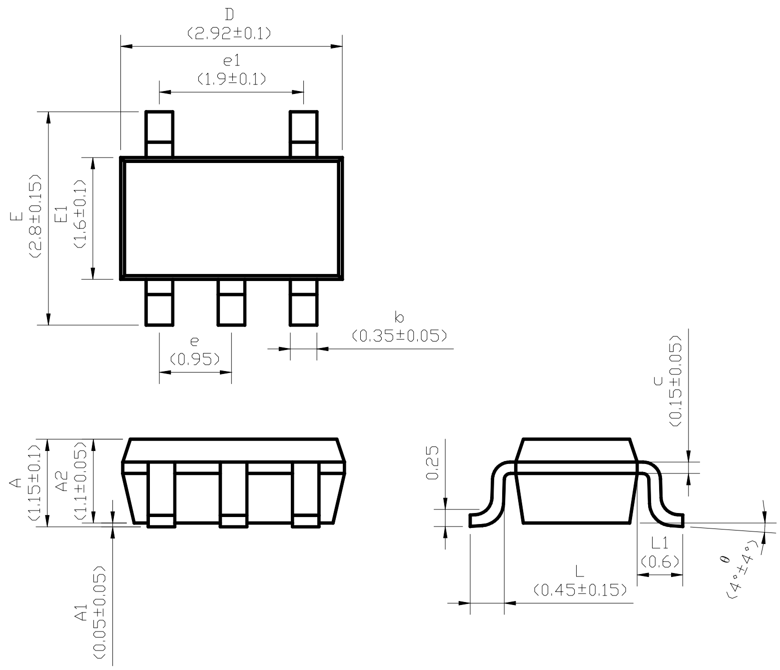


Figure 6. Top View and Side View of ATI2301 DC-DC Converter

Table 5.

Symbol	A	A1	A2	b	c	D	E
Spec	1.15±0.1	0.05±0.05	1.10±0.05	0.35±0.05	0.15±0.05	2.92±0.1	1.6±0.1
Symbol	E1	e	e 1	L	L1	θ	
Spec	2.8±0.15	0.950TYP	1.90±0.1	0.60REF	0.45±0.15	4°±4°	

Typical Performance Characteristics

Unless specified otherwise, the following conditions apply: T_A =25℃, C_{IN} = 10μF, Co =10μF, L =4.7μH, for efficiency curves and waveforms.

Efficiency vs Output Current (Vo=1.2V)

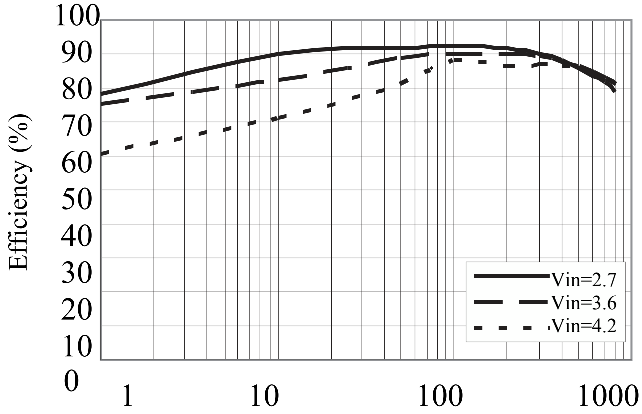


Figure 7. Output Current (mA)

Efficiency vs Output Current (Vo=1.5V)

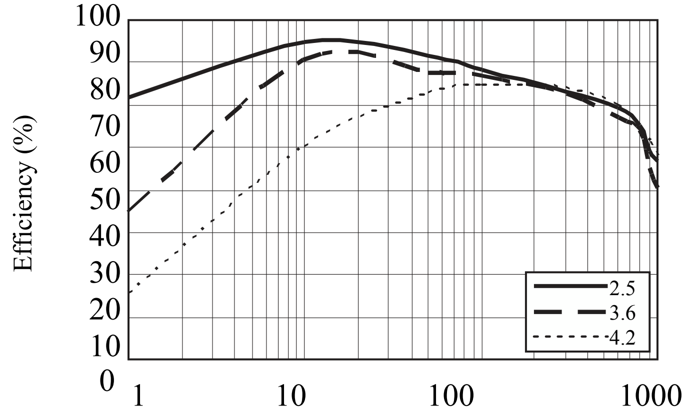


Figure 8. Output Current (mA)

Efficiency vs Output Current (Vo=1.8V)

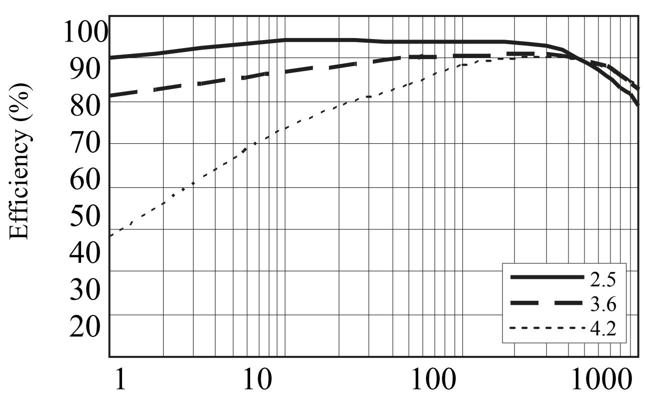


Figure 9. Output Current (mA)

Efficiency vs Output Current (Vo=2.5V)

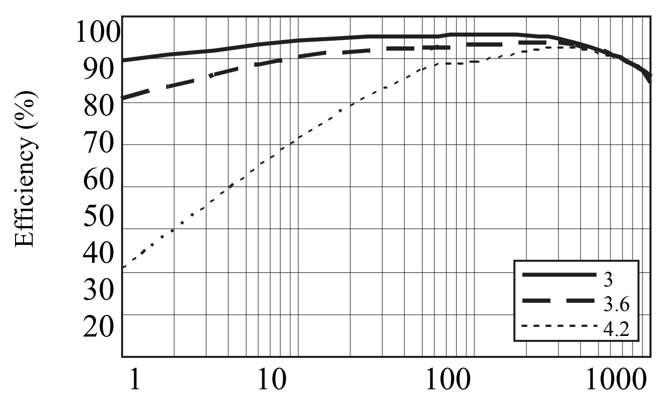


Figure 10. Output Current (mA)

Efficiency vs Output Current (Vo=2.8V)

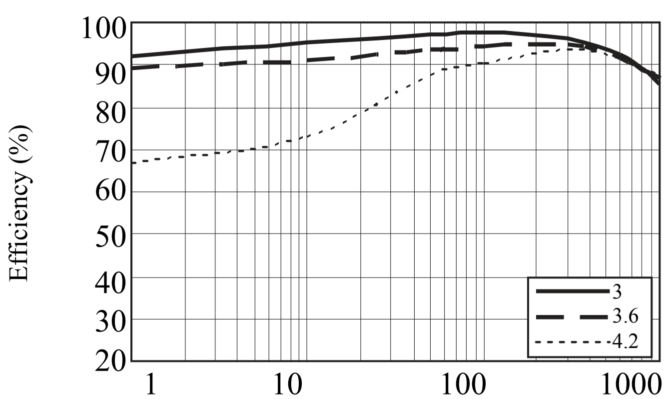


Figure 11. Output Current (mA)

Efficiency vs Output Current (Vo=3.3V)

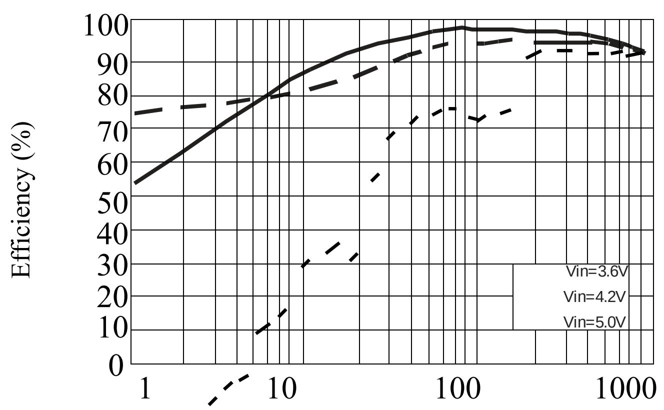


Figure 12. Output Current (mA)

Efficiency vs Input Voltage (Vo=1.2V)

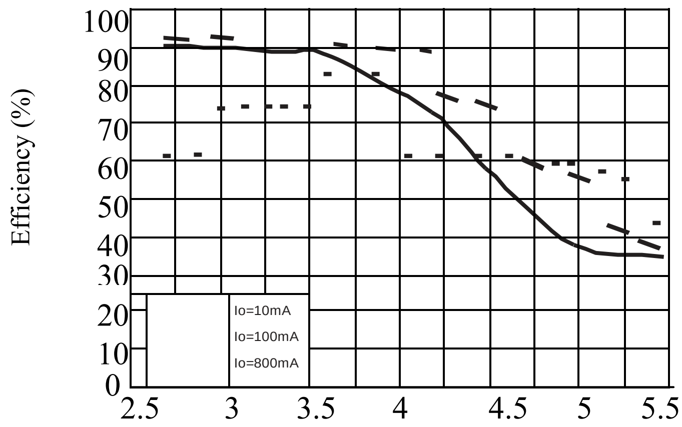


Figure 13. Input Voltage (V)

Efficiency vs Input Voltage (Vo=1.5V)

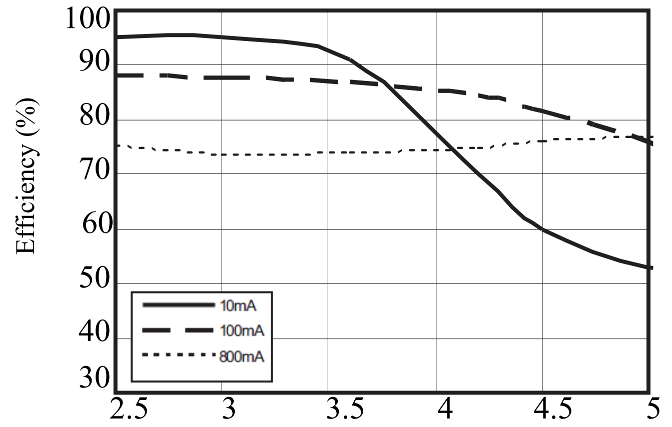


Figure 14. Input Voltage (V)

Efficiency vs Input Voltage (Vo=1.8V)

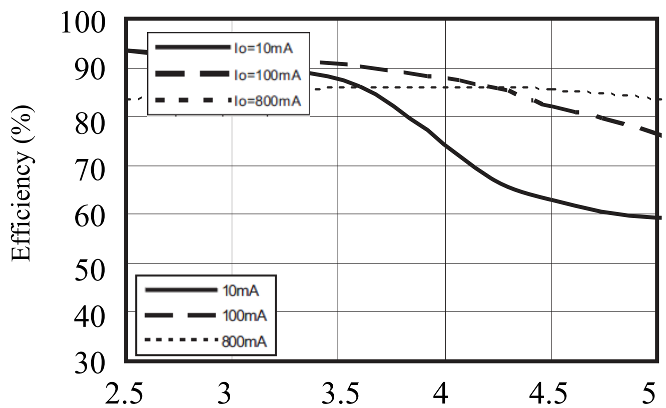


Figure 15. Input Voltage (V)

Efficiency vs Input Voltage (Vo=2.5V)

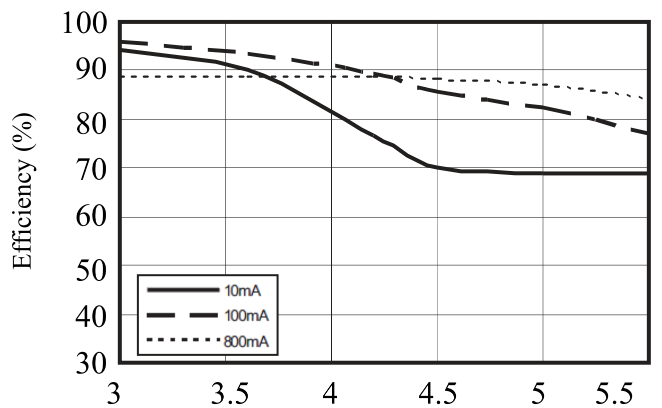


Figure 16. Input Voltage (V)

Efficiency vs Input Voltage (Vo=2.8V)

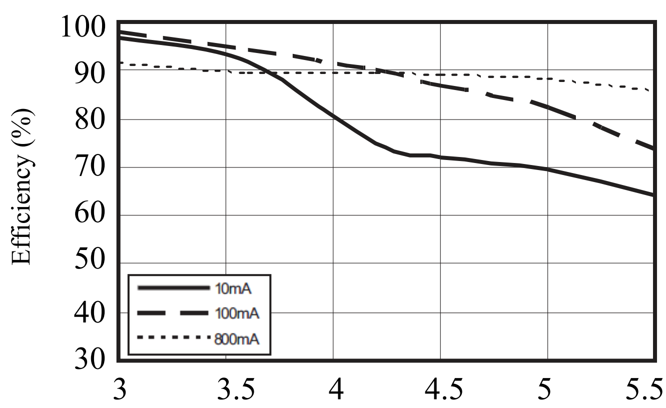


Figure 17. Input Voltage (V)

Efficiency vs Input Voltage (Vo=3.3V)

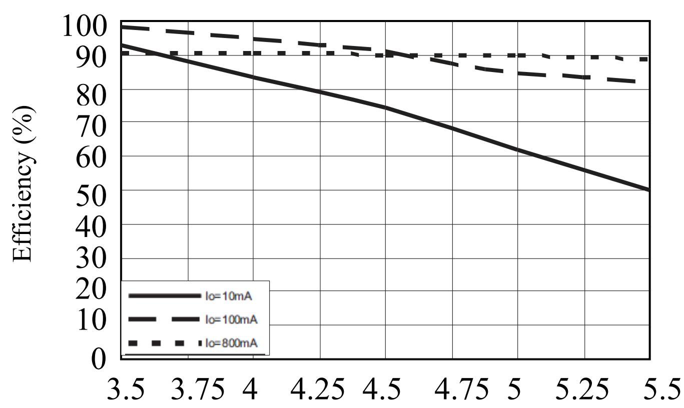


Figure 18. Input Voltage (V)

Reference Voltage vs Input Voltage

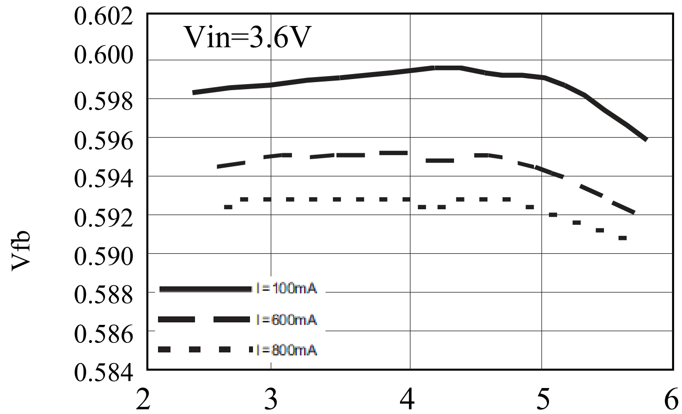


Figure 19. Input Voltage (V)

Output Voltage vs Load Current

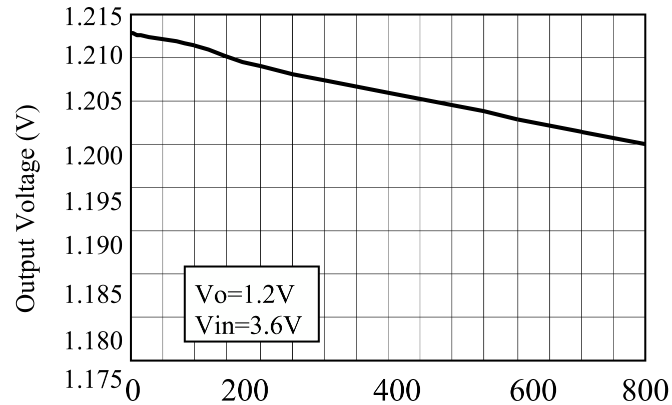


Figure 20. Load Current (mA)

Reference Voltage vs Temperature

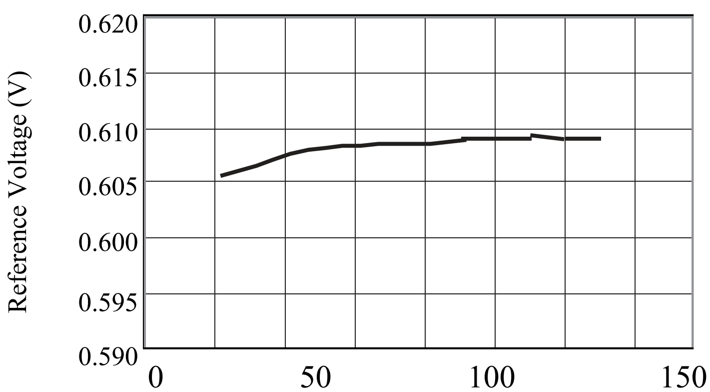


Figure 21. Temperature (℃)

Output Voltage vs Temperature

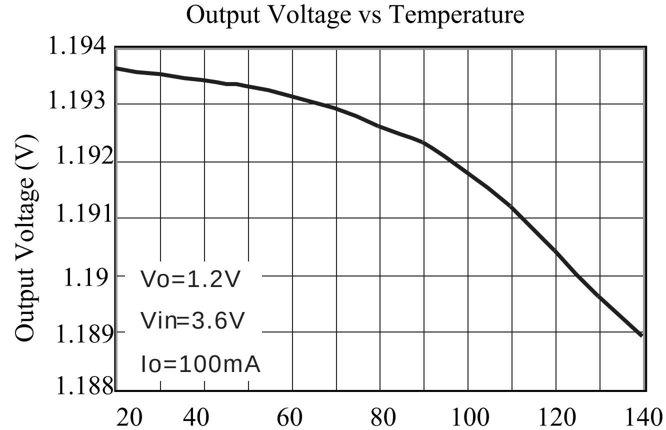


Figure 22. Temperature (℃)

Reference Voltage vs Load Current

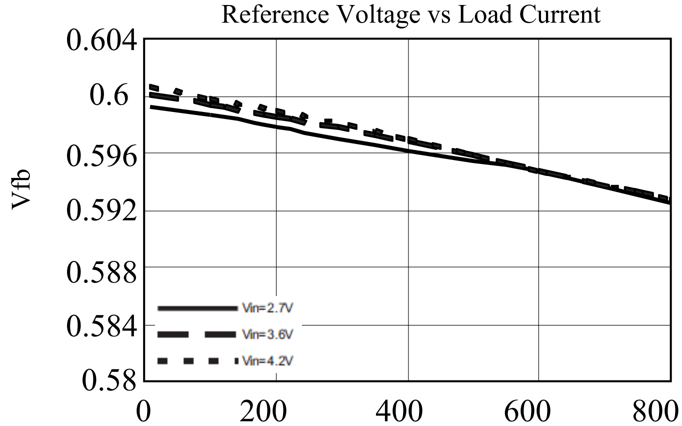


Figure 23. Load Current

Output Voltage vs Output Current

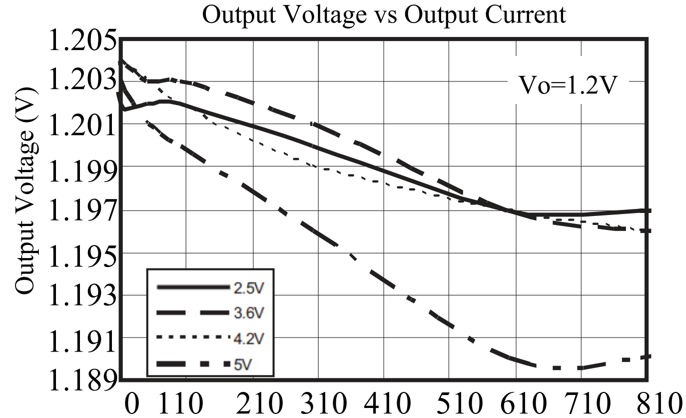


Figure 24. Output Current (mA)

Dynamic Supply Current vs Input Voltage

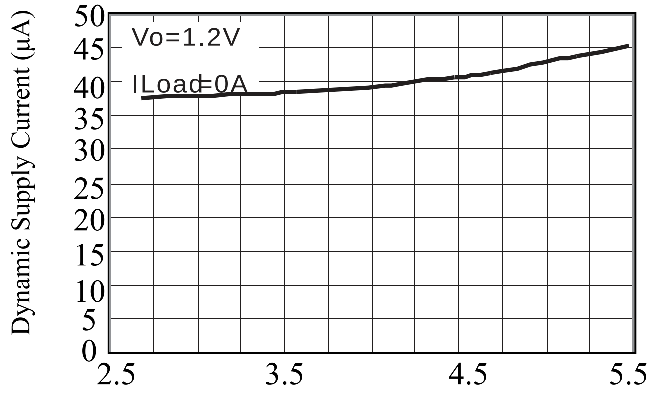


Figure 25. Input Voltage (V)

Dynamic Supply Current vs Temperature

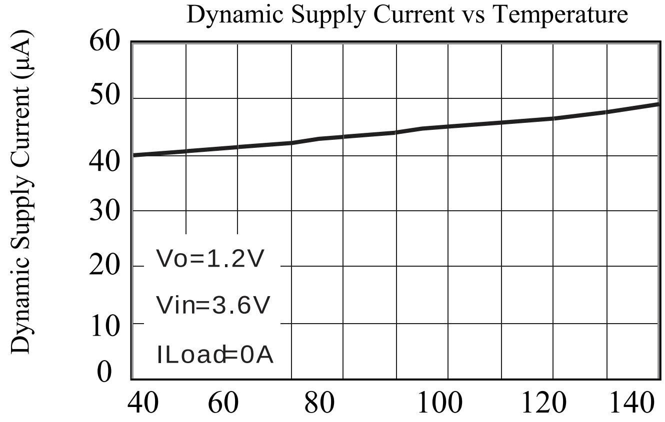


Figure 26. Temperature (℃)

Rdson vs Input Voltage

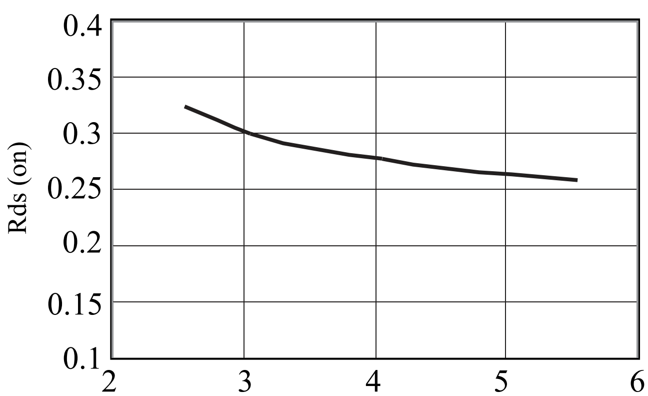


Figure 27. Input Voltage (V)

Rdson vs Temperature

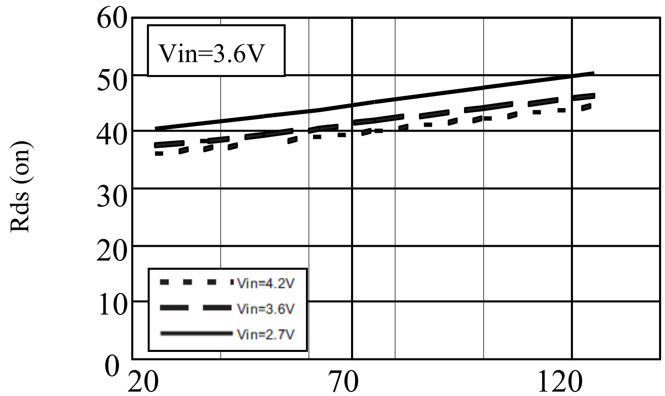


Figure 28. Temperature (℃)

Oscillator Frequency vs Supply Voltage

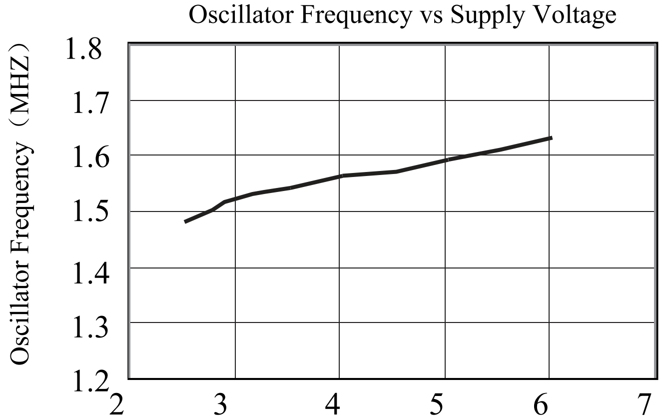


Figure 29. Supply Voltage (V)

Oscillator Frequency vs Temperature

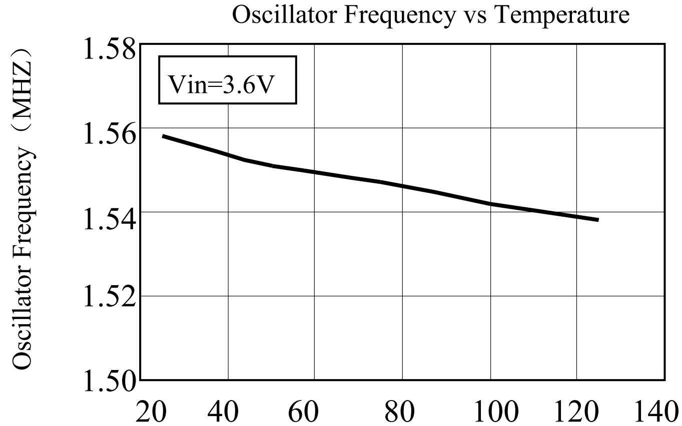


Figure 30. Temperature (℃)

Typical Performance Characteristics

Unless otherwise specified, the following conditions apply: T_A =25℃, C_{IN} = 10µF, Co = 10µF, L = 4.7µH for efficiency curves and waveforms.

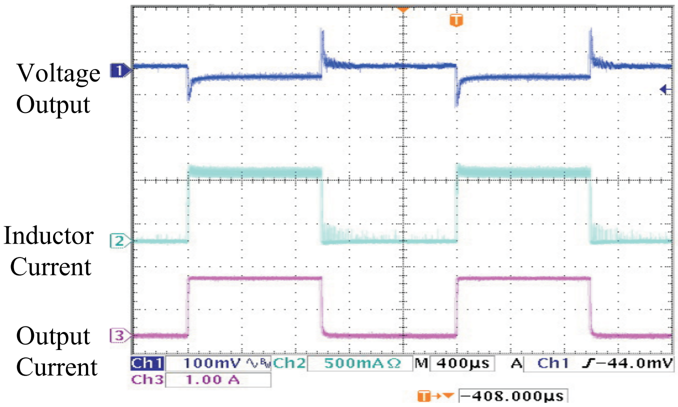


Figure 31. Load Transient
Io = 0-800 mA Vo = 1.8V V_{IN} = 3.6V

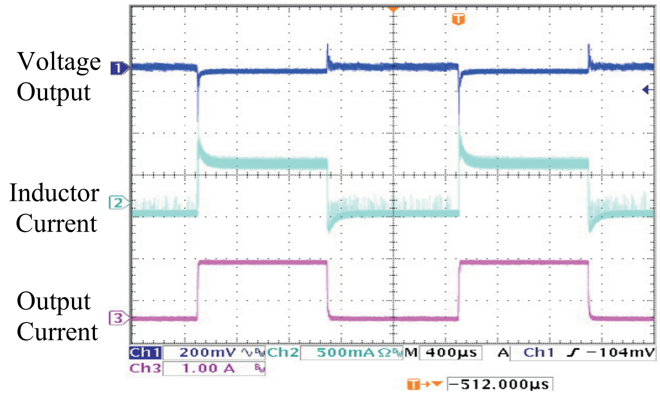


Figure 32. Load Transient
Io = 50-800 mA Vo = 1.8V V_{IN} = 3.6V

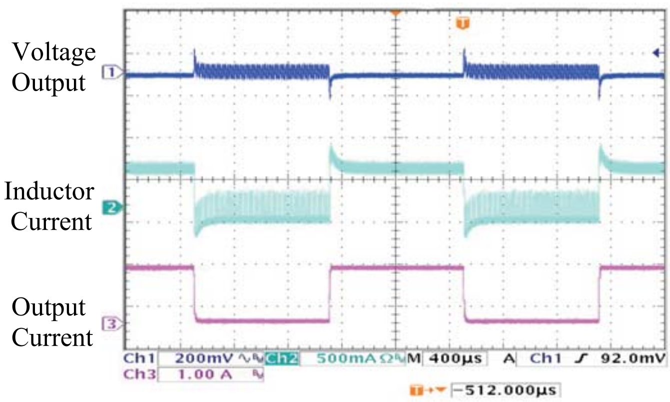


Figure 33. Load Transient
Io = 200-800 mA V_O= 1.8V V_{IN} 3.6V

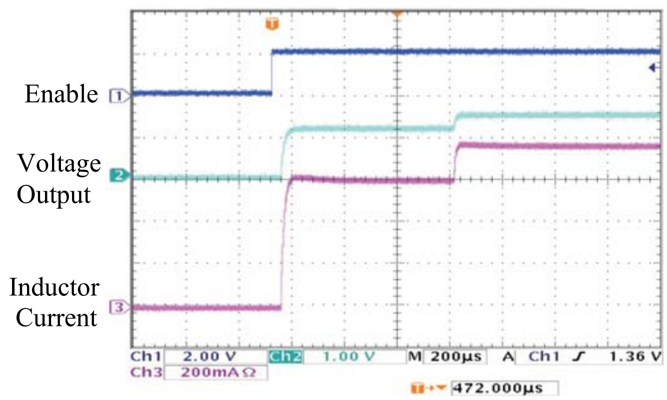


Figure 34. Start-up from Shutdown
V_O =1.8V V_{IN}= 3.6V

Application Information

The basic ATI2301 application circuit is shown in Page 2. External component selection is determined by the load requirement, selecting L first and then C_{IN} and C_{OUT}.

Inductor Selection

For most applications, the value of the inductor will fall in the range of 1μH to 4.7μH, which is chosen according to the desired ripple current. Large value inductors lead to higher ripple currents. Higher V_{IN} or V_{OUT} also increases the ripple current as shown in equation 1. For set ripple current, this is a reasonable starting point $\triangle I_L$=320Ma(40% of 800mA)

$$\Delta I_L = \frac{1}{(f)(L)} Vout\left(1-\frac{Vout}{V_{IN}}\right)$$

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. Thus, a 1120mA rated inductor is enough for most applications (800mA + 320mA). For higher efficiency, low DC-resistance inductor is an option.

C_{IN} and C_{OUT} Selection

In continuous mode, the source current of the top MOSFET is a square wave of duty cycle V_{OUT}/V_{IN}. A low ESR input capacitor sized for the maximum RMS current should be used to prevent large voltage transients. The maximum RMS capacitor current is:

C_{IN} required $$I_{RMS} \cong I_{OMAX} \frac{\sqrt{[V_{OUT}(V_{IN}-V_{OUT})]}}{V_{IN}}$$

The formula has a maximum at V_{IN} = 2Vout, where I_{RMS}=Iout/2. This condition is commonly used because even significant deviations do not offer much relief. The capacitor manufacturer's ripple current ratings are often based on 2000 hours of life. This makes it advisable to further derate the capacitor, or choose a capacitor rated at a higher temperature than required.

The selection of C_{OUT} is driven by the required effective series resistance (ESR).

Usually, when the ESR requirement for C_{OUT} has been met, the RMS current rating will exceed the I_{RIPPLE} (P-P) requirement. The output ripple $\triangle V_{OUT}$ is determined by:

$$VV_{OUT} \cong VI_L\left(ESR+\frac{1}{8fC_{OUT}}\right)$$

Where f = operating frequency, C_{OUT}=output capacitance and $\triangle I_L$ = ripple current in the inductor. For a fixed output voltage, the output ripple is highest at maximum input voltage since $\triangle I_L$ increases with input voltage.

Using Ceramic Input and Output Capacitors

Higher values, lower cost ceramic capacitors come in smaller case sizes now. They are ideal for switching regulator applications due to their high ripple current, high voltage rating and low ESR. By using ceramic capacitors, low output ripple and small circuit size can be achieved.

When choosing the input and output ceramic capacitors, choose the X5R or X7R dielectric formulations， for they have the best temperature and voltage characteristics of all the ceramics for a given value and size.

Setting the Output Voltage

The internal reference is 0.6V (Typical). The output voltage is calculated as below:

$$V_0 = 0.6\times\left(1+\frac{R1}{R2}\right)$$

The output voltage is shown Table 1 below.

Table 6. Resistor selection for output voltage setting.

V_O	R1	R2
1.2V	100K	100K
1.5V	150K	100K
1.8V	200K	100K
2.5V	380K	120K
3.3V	540K	120K

As the input voltage approaches the output voltage, the converter turns the P-channel transistor continuously on. In this mode, the output voltage equals to the input voltage minus the voltage drop across the P- channel transistor:

$$V_{OUT} = V_{IN} - I_{LOAD}\times(R_{dson}+R_L)$$

Where R_{dson} = P-channel switch ON resistance, I_{LOAD} = Output current, R_L = Inductor DC resistance.

UVLO and Soft-Start

The reference and the circuit will remain reset until the VIN crosses its UVLO threshold.

The ATI2301 comes with an internal soft-start circuit. The soft-start functions like a digital circuit to increase the switch current in several steps to the P-channel current limit (1500mA).

Short Circuit Protection

The switch peak current is limited cycle-by-cycle to a typical value of 1500mA. In the event of an output voltage short circuit, the device will operate with a frequency of 400 kHz and minimum duty cycle, therefore the average input current is typically 200mA.

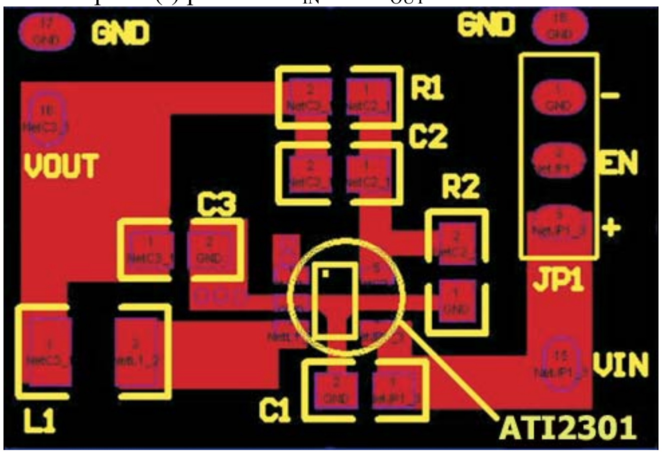
Thermal Shutdown

When the die temperature exceeds 150ºC, the system will reset and the process remains till the temperature decrease to 120ºC, at which time the circuit can be restarted.

PCB Layout Check List

In order to ensure correct operation of this product, the following checklist should be used when laying out the PCBs. These items are also illustrated graphically in Figure 1. Check the following in your layout:

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



Order Information

ATI2301 X X X X X

- Output Voltage
- Number of Pins
- Package Type
- Pin Configuration
- Output Current

Table 7.

Output Current	Pin Configuration	Package Type	Number of Pins	Output Voltage
A: 800mA	A: Type 1. EN 2. GND 3. SW 4. VIN 5. VOUT /FB	A: SOT-23	B: 5	330: 3.3V 280: 2.8V 250: 2.5V 180: 1.8V 150: 1.5V 120: 1.2V ADJ: adj

ORDERING INFORMATION

Table 8. Unit Price

Quantity	10-24	25-99	100-249	250-499	500-999	≥1000
ATI2301	$2.70	$2.25	$2.00	$1.85	$1.60	$1.35

NOTICE

1. ATI warrants performance of its products for one year to the specifications applicable at the time of sale, except for those being damaged by excessive abuse. Products found not meeting the specifications within one year from the date of sale can be exchanged free of charge.
2. ATI reserves the right to make changes to its products or to discontinue any product or service without notice, and advise customers to obtain the latest version of relevant information to verify, before placing orders, that information being relied on is current and complete.
3. All products are sold subject to the terms and conditions of sale supplied at the time of order acknowledgment, including those pertaining to warranty, patent infringement, and limitation of liability. Testing and other quality control techniques are utilized to the extent ATI deems necessary to support this warranty. Specific testing of all parameters of each device is not necessarily performed, except those mandated by government requirements.
4. Customers are responsible for their applications using ATI components. In order to minimize risks associated with the customers' applications, adequate design and operating safeguards must be provided by the customers to minimize inherent or procedural hazards. ATI assumes no liability for applications assistance or customer product design.
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