# ATI 2301 DC-DC Converter

Figure 1. Physical Photo of ATI2301

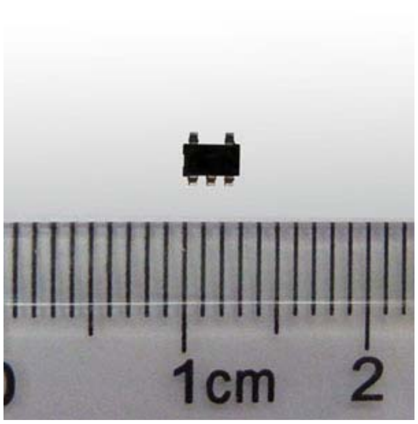



Figure 2. Physical Photo of ATI2301

## 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.

## Typical Application

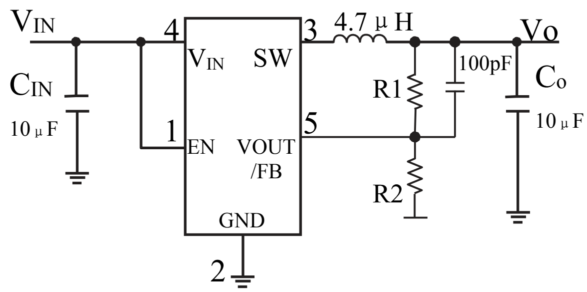



Figure 3. Adjustable Output Voltage

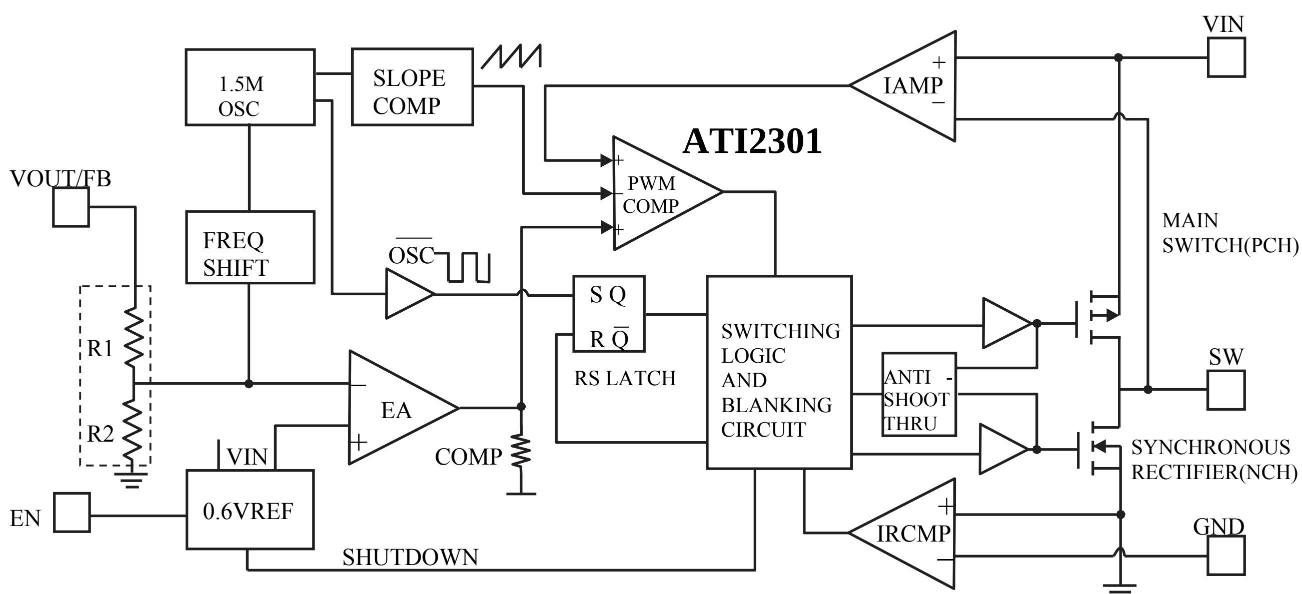
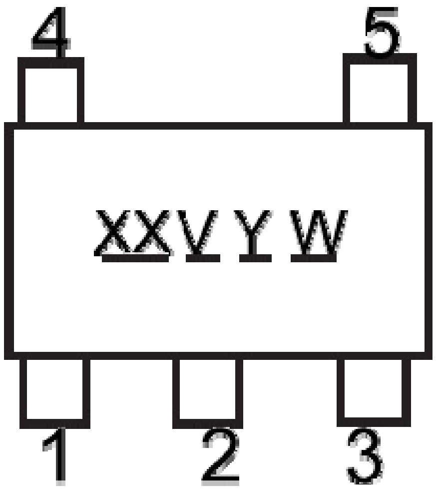



Figure 4. Block Diagram

## 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 | $\theta_{JC}$ | 130 | ℃/W |
| Thermal Resistance (Junction to Ambient) | | $\theta_{JA}$ | 250 | |
| Internal Power Dissipation | | $P_D$ | 400 | mW |

**Characteristics**

$T_A = 25℃$, $V_{IN} = 3.6V$, $V_O = 1.8V$, $C_{IN} = 10\ \mu F$, $L = 4.7\ \mu H$, 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 |
| $\Delta V_{FB}$ | 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 |
| | | | 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

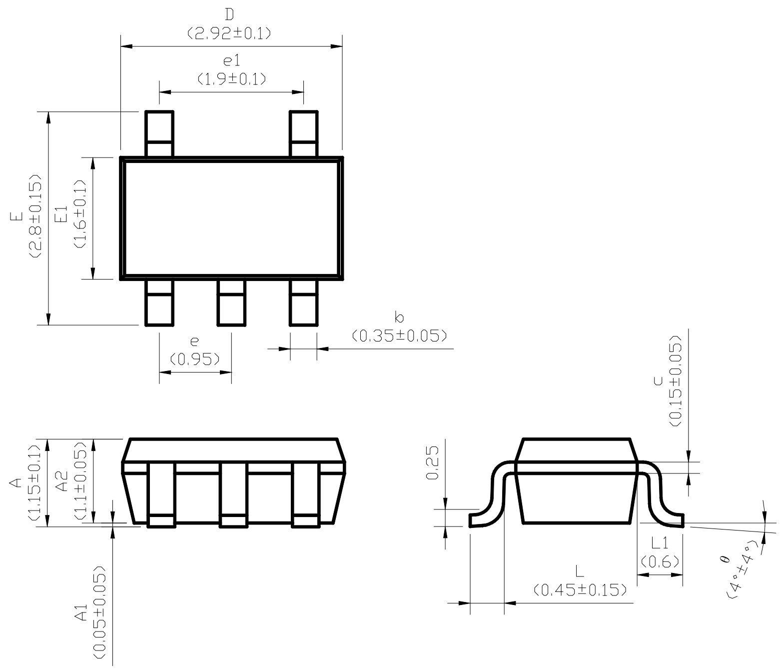



Figure 6. Top View and Side View of ATI2301 DC-DC Converter

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)

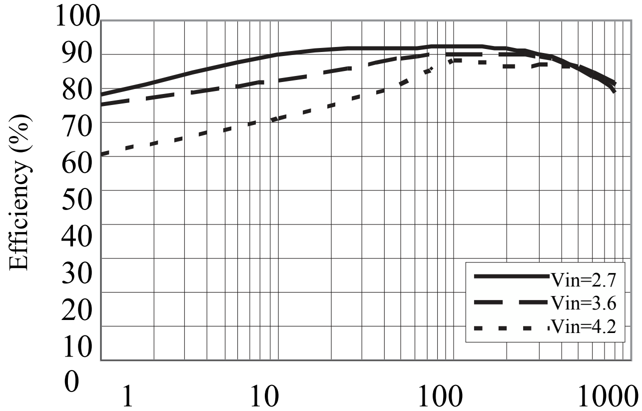



Figure 7. Output Current (mA)

Efficiency vs Output Current (Vo=1.5V)

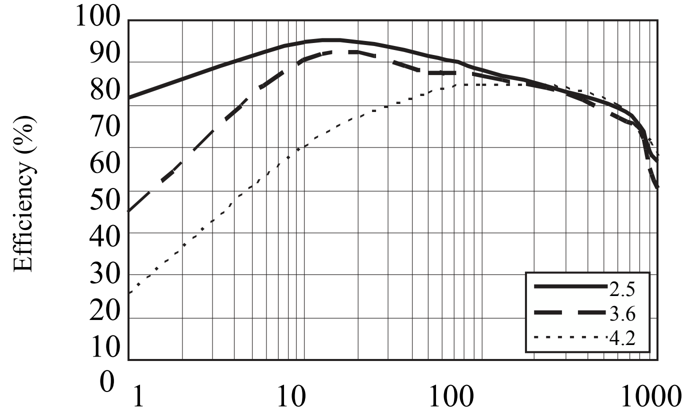



Figure 8. Output Current (mA)

Efficiency vs Output Current (Vo=1.8V)

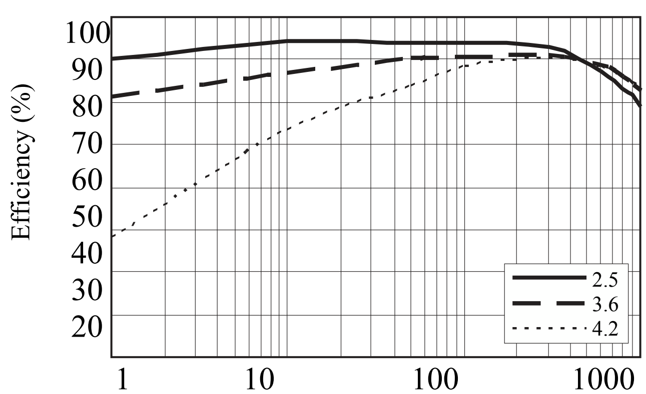



Figure 9. Output Current (mA)

Efficiency vs Output Current (Vo=2.5V)

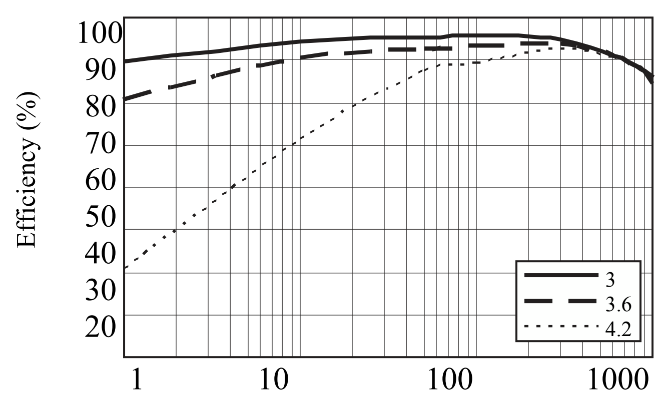



Figure 10. Output Current (mA)

Efficiency vs Output Current (Vo=2.8V)

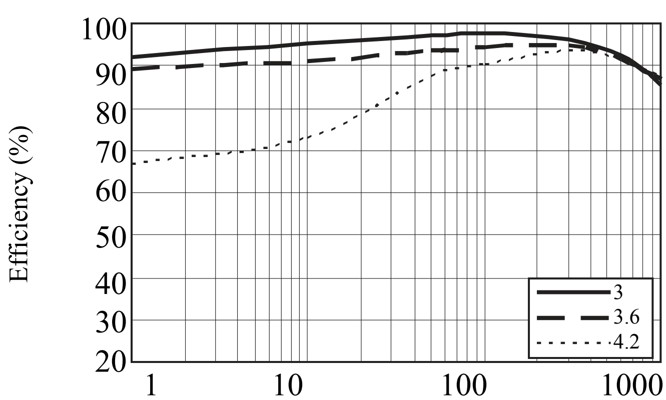



Figure 11. Output Current (mA)

Efficiency vs Output Current (Vo=3.3V)

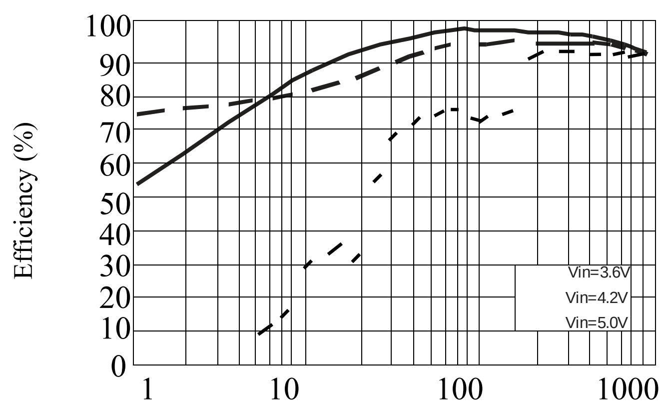



Figure 12. Output Current (mA)

Efficiency vs Input Voltage (Vo=1.2V)

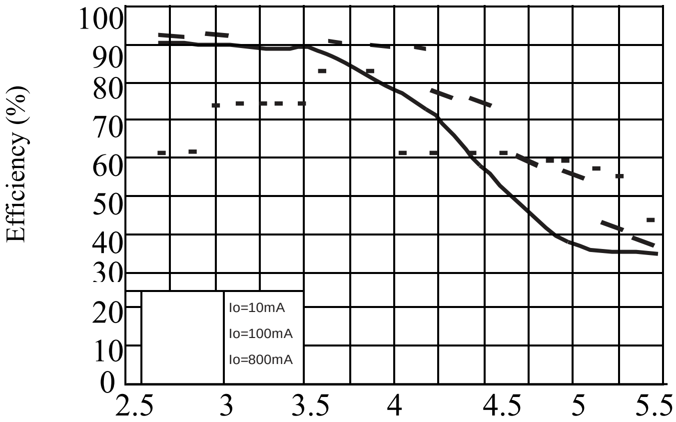



Figure 13. Input Voltage (V)

Efficiency vs Input Voltage (Vo=1.5V)

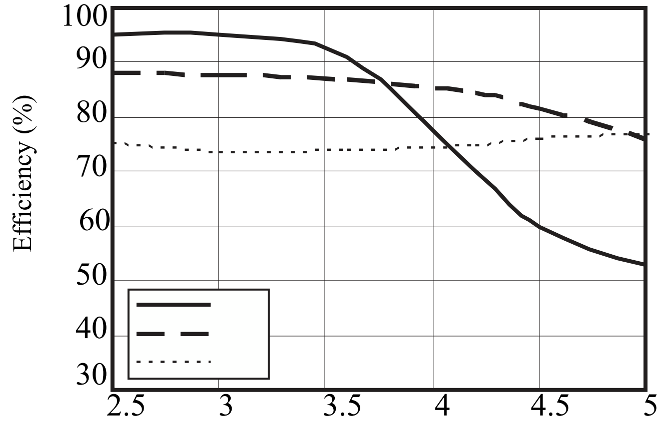



Figure 14. Input Voltage (V)

Efficiency vs Input Voltage (Vo=1.8V)

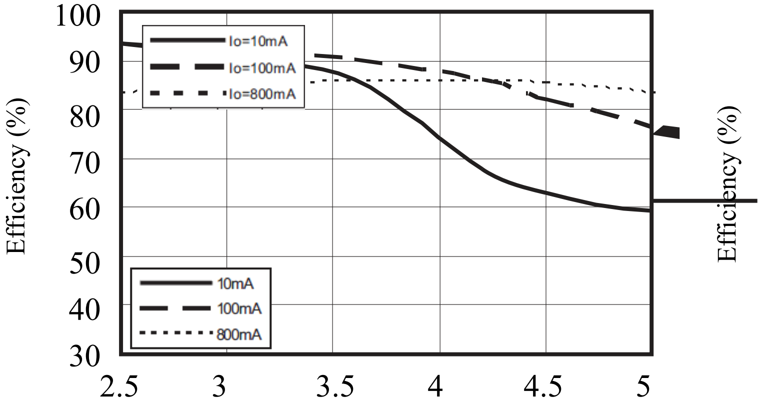



Figure 15. Input Voltage (V)

Efficiency vs Input Voltage (Vo=2.5V)

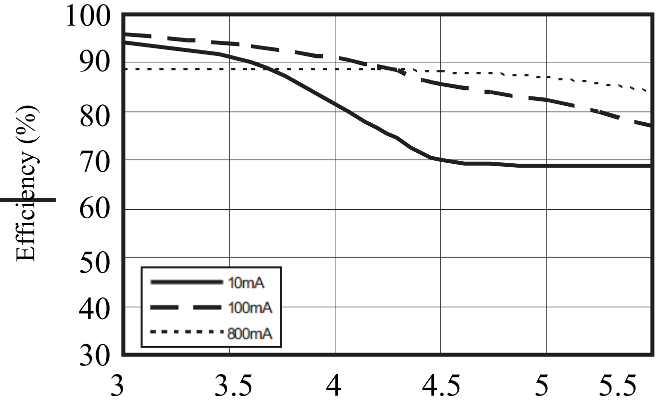



Figure 16. Input Voltage (V)

Efficiency vs Input Voltage (Vo=2.8V)

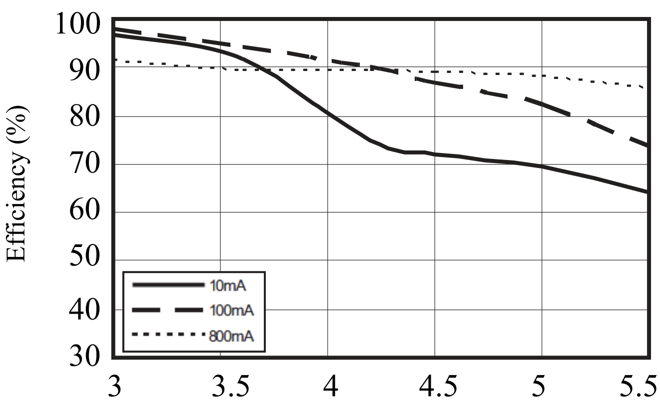



Figure 17. Input Voltage (V)

Efficiency vs Input Voltage (Vo=3.3V)

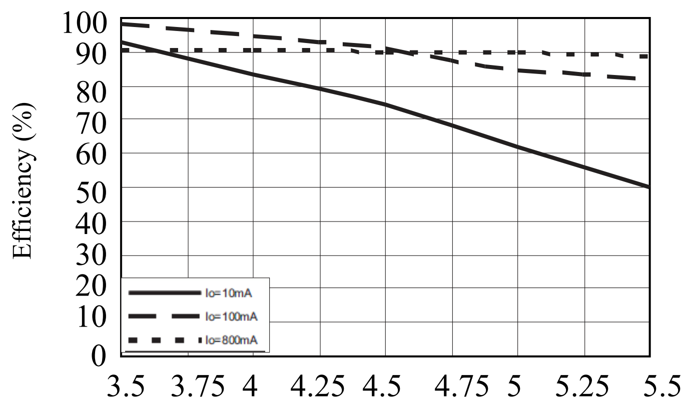



Figure 18. Input Voltage (V)

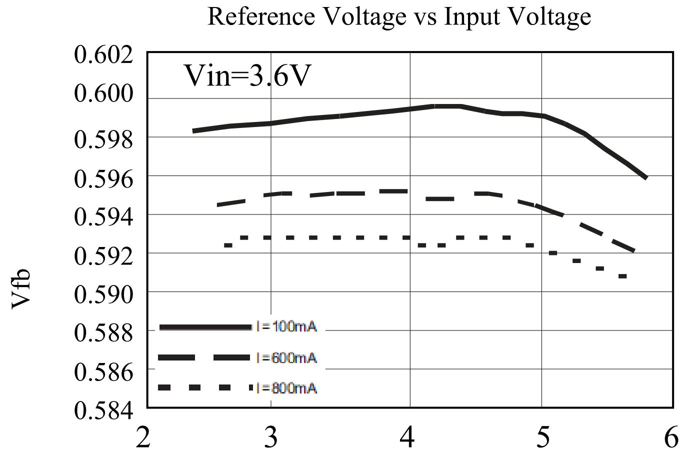



Figure 19. Input Voltage (V)

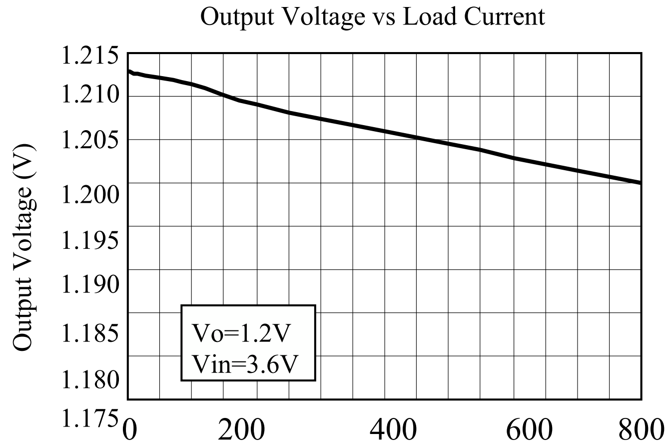



Figure 20. Load Current (mA)

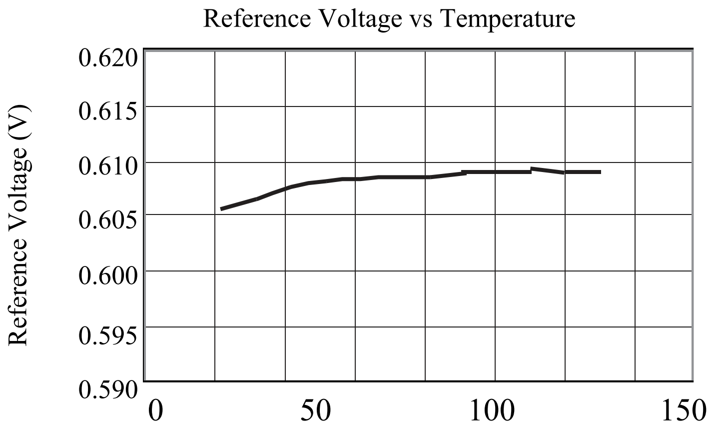



Figure 21. Temperature (℃)

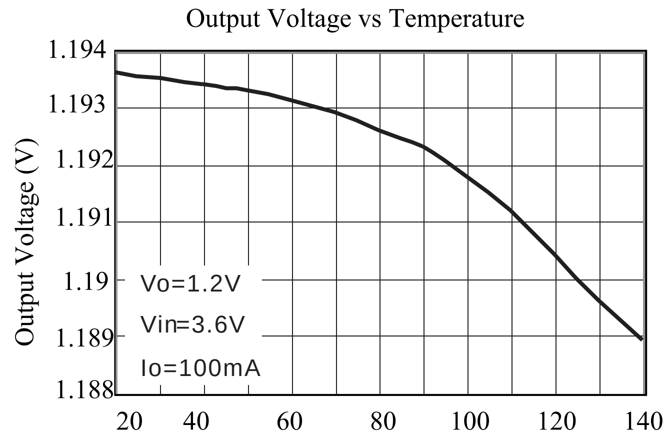



Figure 22. Temperature (℃)

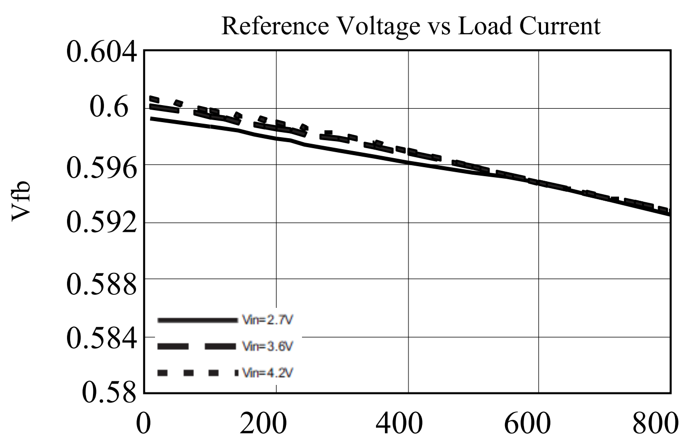



Figure 23. Load Current

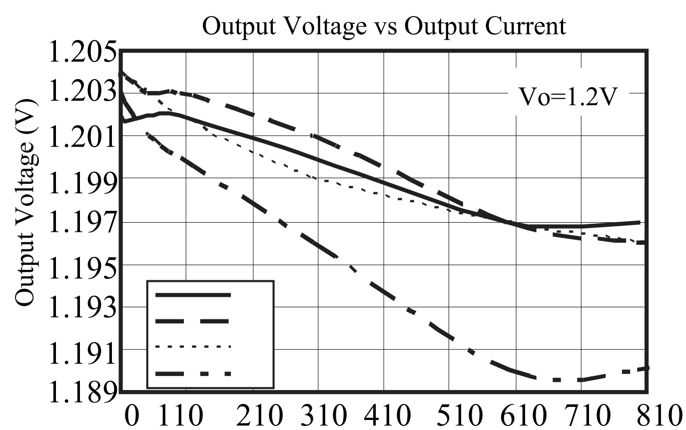



Figure 24. Output Current (mA)

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Email: staff@analogti.com/sales@analogti.com

Dynamic Supply Current vs Input Voltage

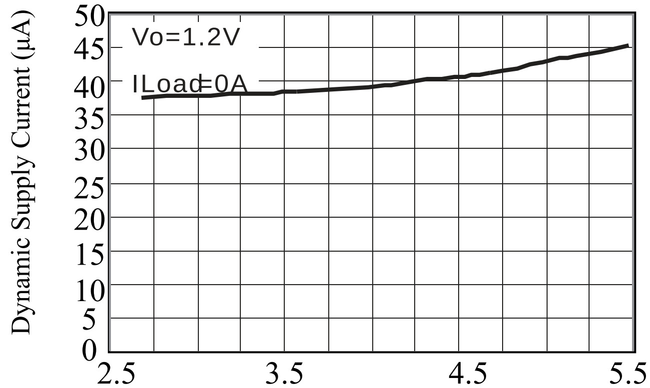



Figure 25. Input Voltage (V)

Dynamic Supply Current vs Temperature

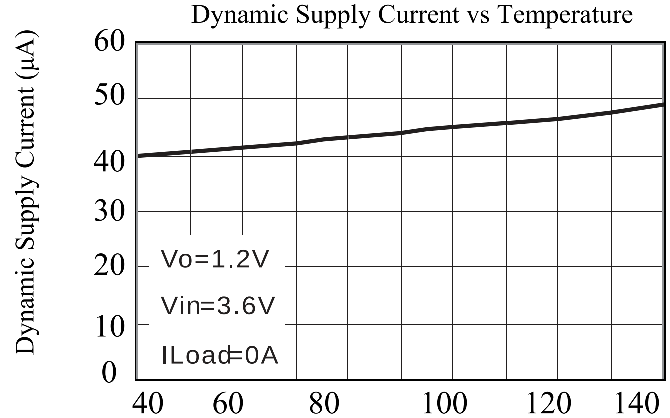



Figure 26. Temperature (℃)

Rdson vs Input Voltage

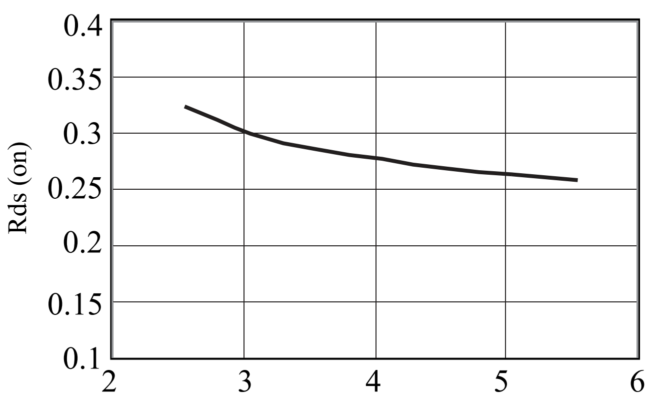



Figure 27. Input Voltage (V)

Rdson vs Temperature

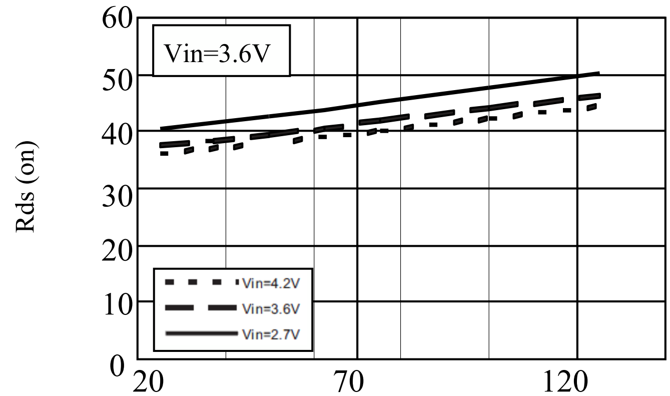



Figure 28. Temperature (℃)

Oscillator Frequency vs Supply Voltage

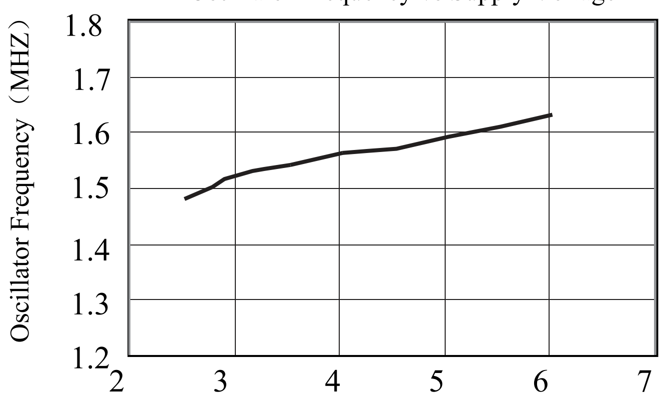



Figure 29. Supply Voltage (V)

Oscillator Frequency vs Temperature

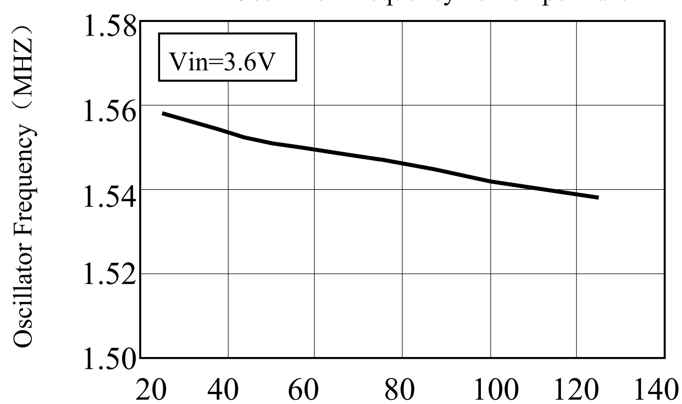



Figure 30. Temperature (℃)

## 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.

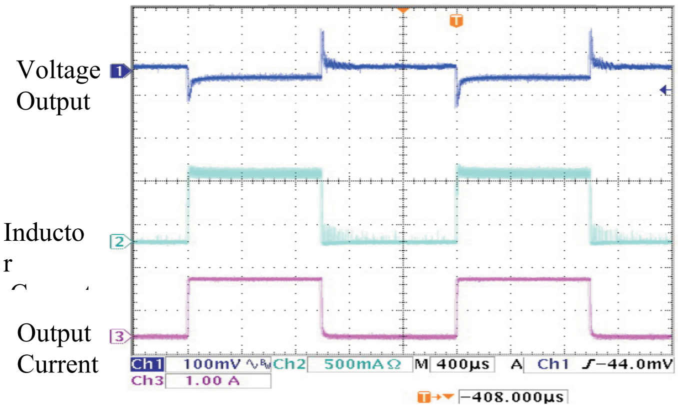



Figure 31. Load Transient
Io = 0-800 mA Vo = 1.8V $V_{IN}$ = 3.6V

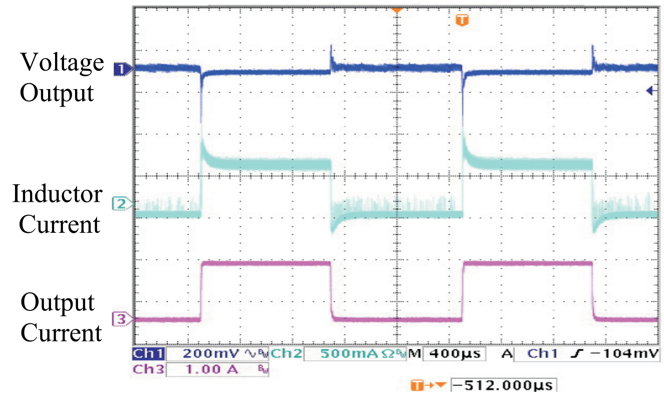



Figure 32. Load Transient
Io = 50-800 mA Vo = 1.8V $V_{IN}$ = 3.6V

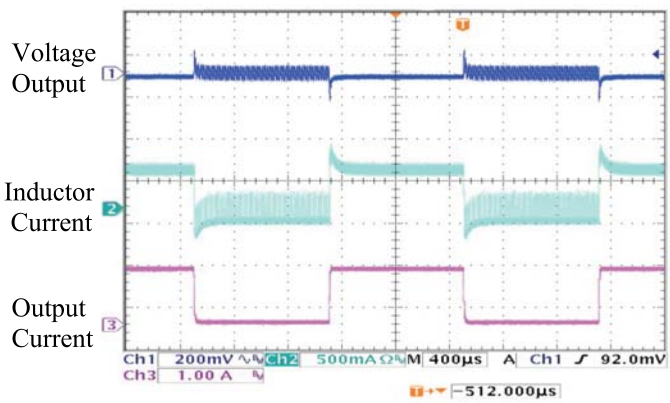



Figure 33. Load Transient
Io = 200-800 mA $V_O$= 1.8V $V_{IN}$ 3.6V

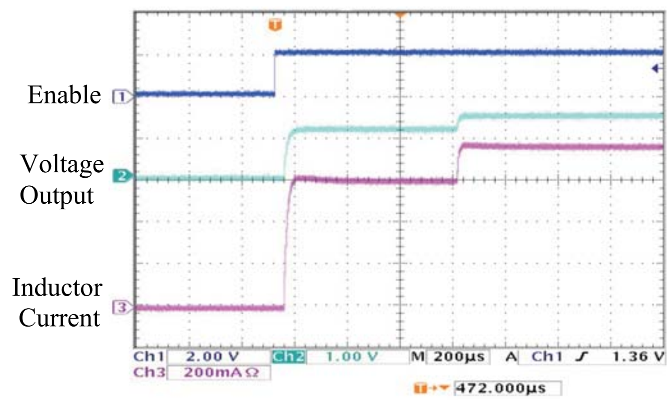



Figure 34. Start-up from Shutdown
$V_O$ =1.8V $V_{IN}$= 3.6V

## 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:

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

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.

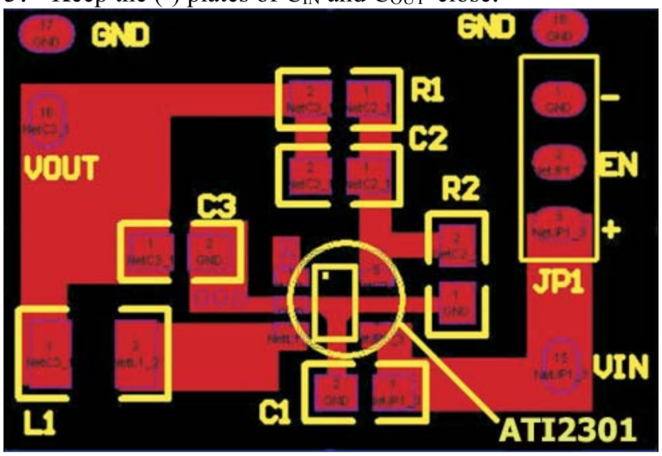
### Thermal Shutdown

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

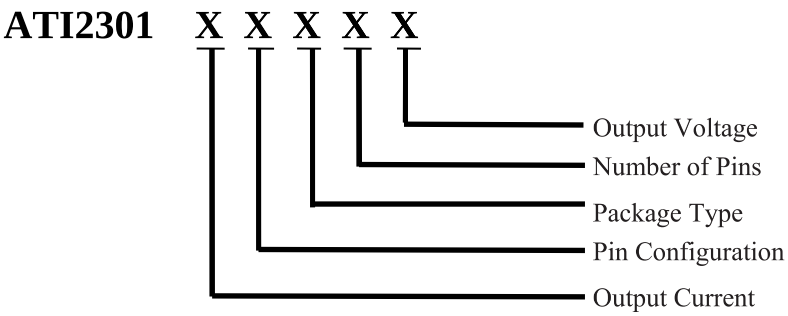



Table 7.

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

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