**GENERAL DESCRIPTION**

The AX3515A is a dual high-efficiency Pulse-Width-Modulated (PWM) step-down DC-DC converter. It is capable of delivering 1A output current over a wide input voltage range from 2.5V to 5.5V, the AX3515A is ideally suited for portable electronic devices that are powered from 1-cell Li-ion battery or from other power sources within the range such as cellular phones, PDAs and other handheld devices.

Two operational modes are available: PWM/Low-Dropout auto-switch and shutdown modes. Internal synchronous rectifier with low RDS(ON) dramatically reduces conduction loss at PWM mode. No external Schottky diode is required in practical application.

The AX3515A enters Low-Dropout mode when normal PWM cannot provide regulated output voltage by continuously turning on the upper PMOS. The AX3515A enters shutdown mode and consumes less than 0.1μA when EN pin is pulled low.

The switching ripple is easily smoothed-out by small package filtering elements due to a fixed operation frequency of 1.4MHz. This along with small TDFN-10L (3x3) package provides small PCB area application. Other features include soft start, lower internal reference voltage with 2% accuracy, over temperature protection, and over current protection.

**FEATURES**

- 2.5V to 5.5V Input Voltage Range
- Adjustable Output Voltage from 0.6V to VIN
- 1A Output Current/per channel
- High Efficiency: up to 95%
- No Schottky Diode Required
- 1.4MHz Fixed-Frequency PWM Operation
- Small 10-Lead TDFN Package
**BLOCK DIAGRAM**

- VIN1
  - FB
  - 0.6V
  - Soft-Star
- FB1
- EN1
- VIN2
  - FB
  - 0.6V
  - Soft-Star
- FB2
- EN2
- SW1
  - GND1
- SW2
  - GND2

Over-Temperature and Short-Circuit Protection

Enable Logic

PWM Logic

Non-Overlap Control

Reset

Set

Enable Logic
**PIN ASSIGNMENT**

The package of AX3515A is TDFN-10L; the pin assignment is given by:

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EN1</td>
<td>Chip Enable of Channel 1 (Active High). $V_{EN1} \leq V_{IN1}$.</td>
</tr>
<tr>
<td>FB1</td>
<td>Feedback of Channel 1.</td>
</tr>
<tr>
<td>VIN2</td>
<td>Power Input of Channel 2.</td>
</tr>
<tr>
<td>GND2</td>
<td>Ground. The exposed pad must be soldered to a large PCB and connected to GND for maximum power dissipation.</td>
</tr>
<tr>
<td>SW2</td>
<td>Pin for Switching of Channel 2.</td>
</tr>
<tr>
<td>EN2</td>
<td>Chip Enable of Channel 2 (Active High). $V_{EN2} \leq V_{IN2}$.</td>
</tr>
<tr>
<td>FB2</td>
<td>Feedback of Channel 2.</td>
</tr>
<tr>
<td>VIN1</td>
<td>Power Input of Channel 1.</td>
</tr>
<tr>
<td>SW1</td>
<td>Pin for Switching of Channel 1.</td>
</tr>
</tbody>
</table>

**ORDER/MARKING INFORMATION**

<table>
<thead>
<tr>
<th>Order Information</th>
<th>Top Marking</th>
</tr>
</thead>
<tbody>
<tr>
<td>AX3515A XXX X</td>
<td>3 5 1 5 A</td>
</tr>
<tr>
<td>Package Type</td>
<td>ID code: internal</td>
</tr>
<tr>
<td>J10: TDFN-10L (3*3)</td>
<td>WW: 01~52</td>
</tr>
<tr>
<td>Packing</td>
<td>Year: 10=2010</td>
</tr>
<tr>
<td>A : Taping</td>
<td>11=2011</td>
</tr>
</tbody>
</table>

**ABSOLUTE MAXIMUM RATINGS** (at $T_A=25°C$)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Symbol</th>
<th>Rating</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Input Voltage</td>
<td>$V_{IN1}$/$V_{IN2}$</td>
<td>-0.3 to 6.5</td>
<td>V</td>
</tr>
<tr>
<td>EN1, FB1, LX1, EN2, FB2 and LX2 Pin Voltage</td>
<td>$V_{IN}$</td>
<td>-0.3 to $V_{IN}$ + 0.3</td>
<td>V</td>
</tr>
<tr>
<td>Power Dissipation, PD @ $T_A=25°C$</td>
<td>PD</td>
<td>2.2</td>
<td>W</td>
</tr>
<tr>
<td>Lead Temperature (Soldering, 10 sec.)</td>
<td>$T_{ST}$</td>
<td>260</td>
<td>°C</td>
</tr>
<tr>
<td>Storage Temperature Range</td>
<td>$T_{ST}$</td>
<td>-65 to 150</td>
<td>°C</td>
</tr>
<tr>
<td>Junction Temperature</td>
<td>$T_J$</td>
<td>150</td>
<td>°C</td>
</tr>
<tr>
<td>Thermal Resistance from Junction to case</td>
<td>$\theta_{JC}$</td>
<td>15</td>
<td>°C/W</td>
</tr>
<tr>
<td>Thermal Resistance from Junction to ambient</td>
<td>$\theta_{JA}$</td>
<td>45</td>
<td>°C/W</td>
</tr>
</tbody>
</table>

Note: $\theta_{JA}$ is measured with the PCB copper area of approximately 1 in² (Multi-layer). That need connect to exposed pad.
**RECOMMENDED OPERATING CONDITIONS**

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Symbol</th>
<th>Rating</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Input Voltage</td>
<td>$V_{IN}$</td>
<td>2.5 to 5.5</td>
<td>V</td>
</tr>
<tr>
<td>Junction Temperature Range</td>
<td>$T_J$</td>
<td>-40 to 125</td>
<td>°C</td>
</tr>
<tr>
<td>Ambient Temperature Range</td>
<td>$T_A$</td>
<td>-40 to 85</td>
<td>°C</td>
</tr>
</tbody>
</table>

Note: The device is not guaranteed to function outside its operating conditions.

**ELECTRICAL CHARACTERISTICS**

$(V_{IN}=3.6V, V_{OUT}=2.5V, L=2.2uH, C_{IN}=4.7uF, C_{OUT}=10uF, T_A=25°C, I_{MAX}=1A unless otherwise specified)$

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Symbol</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel 1 and Channel 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input Voltage Range</td>
<td>$V_{IN}$</td>
<td></td>
<td>2.5</td>
<td>-</td>
<td>5.5</td>
<td>V</td>
</tr>
<tr>
<td>Under Voltage Lock Out threshold</td>
<td>UVLO</td>
<td></td>
<td>-</td>
<td>1.8</td>
<td>-</td>
<td>V</td>
</tr>
<tr>
<td>Hysteresis</td>
<td></td>
<td></td>
<td>-</td>
<td>0.1</td>
<td>-</td>
<td>V</td>
</tr>
<tr>
<td>Quiescent Current (per channel)</td>
<td>$I_Q$</td>
<td>$I_{OUT}=0mA, V_{FB}=1V$</td>
<td>-</td>
<td>250</td>
<td>350</td>
<td>μA</td>
</tr>
<tr>
<td>Shutdown Current</td>
<td>$I_{SD}$</td>
<td>$V_{EN1}=V_{EN2}=0V$</td>
<td>-</td>
<td>0.1</td>
<td>1</td>
<td>μA</td>
</tr>
<tr>
<td>Feedback Voltage</td>
<td>$V_{FB}$</td>
<td>For Adjustable Output Voltage</td>
<td>0.588</td>
<td>0.6</td>
<td>0.612</td>
<td>V</td>
</tr>
<tr>
<td>Output Voltage Accuracy</td>
<td>$\Delta V_{OUT}$</td>
<td>$V_{IN}=2.5V to 5.5V,\ A &lt; I_{OUT} &lt; 1A$</td>
<td>-3</td>
<td>-</td>
<td>+3</td>
<td>%</td>
</tr>
<tr>
<td>FB Input Current</td>
<td>$I_{FB}$</td>
<td>$V_{FB}=V_{IN}$</td>
<td>-50</td>
<td>-</td>
<td>50</td>
<td>nA</td>
</tr>
<tr>
<td>RDS(ON) of P-MOSFET</td>
<td>$R_{DS(ON)_P}$</td>
<td>$V_{FB}=0V, I_{OUT}=500mA$</td>
<td>-</td>
<td>0.35</td>
<td>-</td>
<td>Ω</td>
</tr>
<tr>
<td>RDS(ON) of N-MOSFET</td>
<td>$R_{DS(ON)_N}$</td>
<td>$I_{OUT}=500mA$ (Note 1)</td>
<td>-</td>
<td>0.3</td>
<td>-</td>
<td>Ω</td>
</tr>
<tr>
<td>P-Channel Current Limit</td>
<td>$I_{LIM,P}$</td>
<td></td>
<td>1.2</td>
<td>1.4</td>
<td>-</td>
<td>A</td>
</tr>
<tr>
<td>EN High-Level Input Voltage</td>
<td>$V_{EN,H}$</td>
<td></td>
<td>1.5</td>
<td>-</td>
<td>-</td>
<td>V</td>
</tr>
<tr>
<td>EN Low-Level Input Voltage</td>
<td>$V_{EN,L}$</td>
<td></td>
<td>-</td>
<td>-</td>
<td>0.4</td>
<td>V</td>
</tr>
<tr>
<td>Oscillator Frequency</td>
<td>$f_{OSC}$</td>
<td>SW Pin</td>
<td>1.1</td>
<td>1.4</td>
<td>1.7</td>
<td>MHz</td>
</tr>
<tr>
<td>Maximum Duty Cycle</td>
<td></td>
<td>$V_{FB}=0.5V$</td>
<td>100</td>
<td>-</td>
<td>-</td>
<td>%</td>
</tr>
<tr>
<td>SW Leakage Current</td>
<td>$I_{SW}$</td>
<td>$V_{IN}=3.6V, V_{SW}=0V$ or $V_{SW}=3.6V$</td>
<td>-1</td>
<td>-</td>
<td>1</td>
<td>μA</td>
</tr>
<tr>
<td>Thermal Shutdown Temperature</td>
<td>$T_{SD}$</td>
<td></td>
<td>-</td>
<td>140</td>
<td>-</td>
<td>°C</td>
</tr>
<tr>
<td>Thermal Shutdown Hysteresis</td>
<td>$T_{SH}$</td>
<td></td>
<td>-</td>
<td>30</td>
<td>-</td>
<td>°C</td>
</tr>
</tbody>
</table>

Note 1: Guarantee by design.
APPLICATION CIRCUIT
Adjustable Voltage Regulator

\[ V_{OUT1} = \text{V}_{FB1} \times \left(1 + \frac{R1}{R2}\right), V_{OUT2} = \text{V}_{FB2} \times \left(1 + \frac{R3}{R4}\right) \]

R2, R4: Rang = 50k ~ 330k

FUNCTION DESCRIPTIONS

Operation

AX3515A is a dual channel, 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 1A output current by each channel 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, \( I_{COMP} \), 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, beginning of the next clock cycle.
APPLICATION INFORMATION

Setting the Output Voltage

Application circuit item shows the basic application circuit with AX3515A adjustable output version. The external resistor sets the output voltage according to the following equation:

\[ V_{OUT1} = 0.6V \times \left(1 + \frac{R1}{R2}\right), \quad V_{OUT2} = 0.6V \times \left(1 + \frac{R3}{R4}\right) \]

Table 1 Resistor select for output voltage setting

<table>
<thead>
<tr>
<th>V_{OUT}</th>
<th>R2/R4</th>
<th>R1/R3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2V</td>
<td>300K</td>
<td>300K</td>
</tr>
<tr>
<td>1.5V</td>
<td>300K</td>
<td>450K</td>
</tr>
<tr>
<td>1.8V</td>
<td>300K</td>
<td>600K</td>
</tr>
<tr>
<td>2.5V</td>
<td>150K</td>
<td>470K</td>
</tr>
<tr>
<td>3.3V</td>
<td>120K</td>
<td>540K</td>
</tr>
</tbody>
</table>

Inductor Selection

For most designs, the AX3515A operates with inductors of 2.2\(\mu\)H to 3.3\(\mu\)H. 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 is inductor Ripple Current. Large value inductors lower ripple current and small value inductors result in high ripple currents. Choose inductor ripple current approximately 20% of the maximum load current 1000mA, \(\Delta I_L = 200mA\).

Table 2 Inductor select for output voltage setting \((V_{IN} = 3.6V)\)

<table>
<thead>
<tr>
<th>V_{OUT}</th>
<th>1.2V</th>
<th>1.5V</th>
<th>1.8V</th>
<th>2.5V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inductor</td>
<td>2.2(\mu)H</td>
<td>2.2(\mu)H</td>
<td>2.2(\mu)H</td>
<td>2.2(\mu)H</td>
</tr>
<tr>
<td>Part Number WE-TPC</td>
<td>7440430022</td>
<td>7440430022</td>
<td>7440430022</td>
<td>7440430022</td>
</tr>
</tbody>
</table>

Note: Part type MH or M (www.we-online.com)

For optimum voltage-positioning load transients, choose an inductor with DC series resistance in the 50m\(\Omega\) to 150m\(\Omega\) range. For higher efficiency at heavy loads (above 200mA), or minimal load regulation (but some transient overshoot), the resistance should be kept below 100m\(\Omega\). 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 (1000mA+100mA).
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 be 10uF 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.

Compensation Capacitor Selection

The compensation capacitors for increasing phase margin provide additional stability. It is required 15pF, Please refer to Demo Board Schematic to design.

Output Voltage Programming

The resistive divider allows the FB pin to sense a fraction of the output voltage as shown in setting the Output Voltage.

For adjustable voltage mode, the output voltage is set by an external resistive divider according to the following equation:

\[ V_{OUT1} = V_{FB1} \times (1+ R1/R2) \]
\[ V_{OUT2} = V_{FB2} \times (1+ R3/R4) \]

Where \( V_{FB} \) is the Feedback voltage (0.6V typical)
Thermal Considerations

The maximum power dissipation depends on the thermal resistance of IC package, PCB layout, the rate of surroundings airflow and temperature difference between junctions to ambient. The maximum power dissipation can be calculated by following formula:

$$P_{D(MAX)} = \frac{(T_{J(MAX)} - T_A)}{\theta_{JA}}$$

Where $T_{J(MAX)}$ is the maximum junction temperature, $T_A$ is the ambient temperature and the $\theta_{JA}$ is the junction to ambient thermal resistance. For recommended operating conditions specification of AX3515A DC/DC converter, where $T_{J(MAX)}$ is the maximum junction temperature of the die and $T_A$ is the ambient temperature. The junction to ambient thermal resistance $\theta_{JA}$ is layout dependent. For TDFN-10L (3x3) packages, the thermal resistance $\theta_{JA}$ is 45°C/W on the 1 in² Multi-layer PCB copper area (The IC exposed pad must be connected to the PCB Copper area) two-layers thermal test board. The maximum power dissipation at $T_A = 25°C$ can be calculated by following formula:

$$P_{D(MAX)} = \frac{(125°C - 25°C)}{(45°C/W)} = 2.22W$$ for TDFN-10L (3x3) package

The maximum power dissipation depends on operating ambient temperature for fixed $T_{J(MAX)}$ and thermal resistance $\theta_{JA}$.

Layout Guide
**TYPICAL CHARACTERISTICS**

- **1.2V OUT Efficiency**
- **1.8V OUT Efficiency**
- **2.5V OUT Efficiency**
- **3.3V OUT Efficiency**

- **Quiescent Current vs. Input Voltage**
- **Switch Frequency VS. Input Voltage**
TYPICAL CHARACTERISTICS (CONTINUOUS)
TYPICAL CHARACTERISTICS (CONTINUOUS)

- **Vin = 5V, Vout = 1.2V, Rload = No Load**
- **Vin = 5V, Vout = 1.2V, Rload = 1Ω**
- **Vin = 5V, Vout = 1.2V, Iout = 0.2A ↔ 1A**
- **Vin = 3.3V, Vout = 1.2V, Iout = 0.2A ↔ 1A**
### PACKAGE OUTLINES

**Top View**

**Bottom View**

**SIDE View**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Dimensions in Millimeters</th>
<th>Dimensions in Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Min. 0.70</td>
<td>Nom. 0.75</td>
</tr>
<tr>
<td>A1</td>
<td>Min. 0.00</td>
<td>Nom. 0.02</td>
</tr>
<tr>
<td>A3</td>
<td>Min. 0.20</td>
<td>Nom. REF.</td>
</tr>
<tr>
<td>b</td>
<td>Min. 0.18</td>
<td>Nom. 0.25</td>
</tr>
<tr>
<td>D</td>
<td>Min. 2.90</td>
<td>Nom. 3.00</td>
</tr>
<tr>
<td>D2</td>
<td>Min. 2.20</td>
<td>Nom. 2.40</td>
</tr>
<tr>
<td>E</td>
<td>Min. 2.90</td>
<td>Nom. 3.00</td>
</tr>
<tr>
<td>E2</td>
<td>Min. 1.50</td>
<td>Nom. 1.60</td>
</tr>
<tr>
<td>e</td>
<td>Min. 0.50</td>
<td>Nom. BSC.</td>
</tr>
<tr>
<td>L</td>
<td>Min. 0.30</td>
<td>Nom. 0.40</td>
</tr>
</tbody>
</table>