DESCRIPTION

The A7116 is a high efficiency monolithic synchronous buck regulator using a constant frequency, current mode architecture. The device is available in an adjustable version. Supply current with no load is 40μA and drops to <1uA in shutdown. The 2.5V to 6.8V input voltage range makes the A7116 ideally suited for single Li-Ion, two to four AA battery-powered applications. 100% duty cycle provides low dropout operation, extending battery life in portable systems. In power saving mode, 40μA quiescent current is very suitable for DSP/MCU in standby operation; and in PWM mode, low output ripple voltage is good enough for noise sensitive applications. The two modes can be automatically switched according to the load current.

Switching frequency is internally set at 1.5MHz, allowing the use of small surface mount inductors and capacitors. The internal synchronous switch increases efficiency and eliminates the need for an external Schottky diode. Low output voltages are easily supported with the 0.6V feedback reference voltage. The A7116 is available in a SOT-25 package.

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ORDER INFORMATION

Package Type	Part Number	
SOT-25 SPQ: 3,000pcs/Reel	E5	A7116E5R-ADJZ
		A7116E5VR-ADJZ
Note	XX: Output Voltage ADJ=Adjustable Z: Pin Type A or B V: Halogen free Package R: Tape & Reel	
AiT provides all RoHS products		

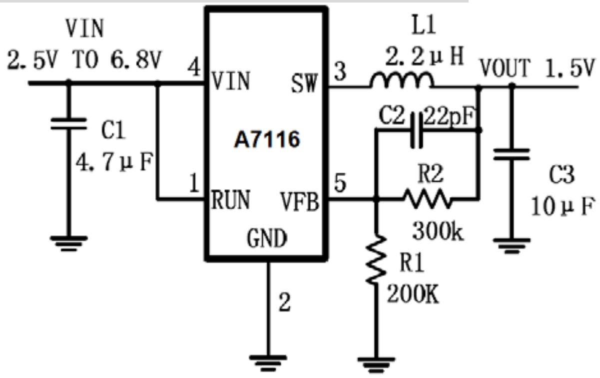
FEATURES

- High Efficiency: Up to 96%
- 1.5MHz Constant Switching Frequency
- 700mA Output Current at V_{IN}=3.6V
- Integrated Main switch and synchronous rectifier. No Schottky Diode Required
- 2.5V to 6.8V Input Voltage Range
- Output Voltage as Low as 0.6V
- 100% Duty Cycle in Dropout
- Quiescent Current: 40μA(input < 4.2V)
- Slope Compensated Current Mode Control for Excellent Line and Load Transient Response
- Short Circuit Protection
- <1uA Shutdown Current
- Available in SOT-25 package

APPLICATION

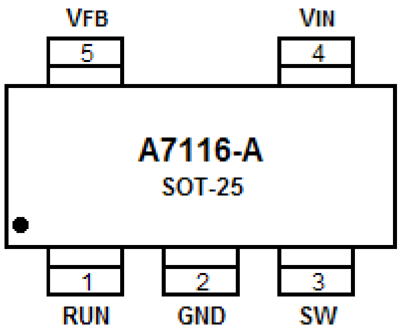
- Cellular and Smart Phones
- Microprocessors and DSP Core Supplies
- Wireless and DSL Modems
- PDAs
- MP3 / MP4 /PMP Player
- Digital Still and Video Cameras
- Portable Instruments

TYPICAL APPLICATION CIRCUIT

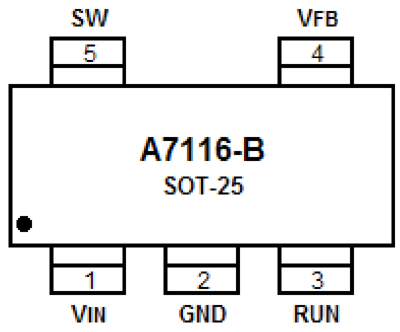


Basic Application Circuit with A7116 Adjustable version

PIN DESCRIPTION



Top View



Top View

Pin #		Symbol	Function
A	B		
1	3	RUN	Regulator Enable control input. Drive RUN above 1.5V to turn on the part. Drive RUN below 0.6V to turn it off. In shutdown, all functions are disabled drawing <1μA supply current. Do not leave RUN floating.
2	2	GND	Ground
3	5	SW	Power Switch Output. It is the Switch note connection to Inductor. This pin connects to the drains of the internal P-CH and N-CH MOSFET switches.
4	1	V_{IN}	Supply Input Pin. Must be closely decoupled to GND, Pin 2, with a 2.2μF or greater ceramic capacitor.
5	4	V_{FB}	V_{FB} (Adjustable): Feedback Input Pin. Connect FB to the center point of the external resistor divider. The feedback threshold voltage is 0.6V.

ABSOLUTE MAXIMUM RATINGS

Input Supply Voltage	-0.3V ~ +7V
RUN, V_{FB} Voltages	0.3V ~ V_{IN} +0.3V
SW Voltages	-0.3V ~ V_{IN}+0.3V
P-Channel Switch Source Current (DC)	1000mA
N-Channel Switch Sink Current (DC)	1000mA
Peak SW Sink and Source Current	1.5A
Package Thermal Resistance NOTE1	
θ_{JA}	220°C/W
θ_{JC}	110°C/W
Operating Temperature Range	-40°C ~ +85°C
Junction Temperature NOTE2	+125°C
Storage Temperature Range	-65°C ~ +150°C
Lead Temperature (Soldering, 10s)	+260°C
ESD Susceptibility (HBM Mode)	3KV (CLASS2)
Humidity	85% (CLASS1)

Stresses above may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the Electrical Characteristics is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

NOTE1: Thermal Resistance is specified with approximately 1 square of 1 Oz copper.

NOTE2: T_J is calculated from the ambient temperature T_A and power dissipation P_D according to the following formula:

$T_J = T_A + (P_D)x(220°C/W)$

ELECTRICAL CHARACTERISTICS[NOTE3]

V_{IN}=V_{RUN}= 3.6V, T_A = 25°C, unless otherwise noted.

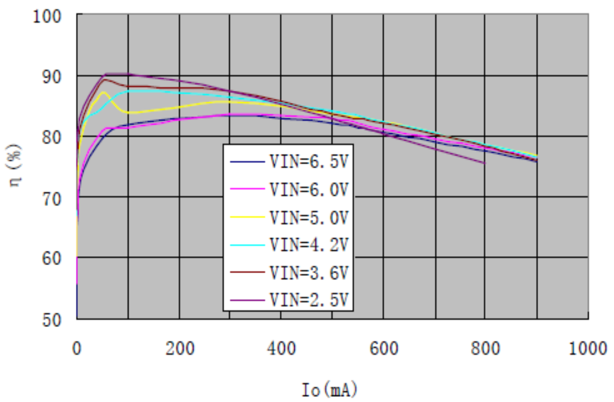
Parameter	Conditions	MIN	TYP	MAX	unit
Input Voltage Range		2.5	-	6.8	V
Input DC Supply Current PWM Mode Power Saving Mode Shutdown Mode	 V_{FB}=0.5V or V_{OUT}=90% V_{FB}=0.63V V_{FB}=0V, V_{IN}=4.2V	-	 300 40 0.1	 400 50 1.0	 μA μA μA
Regulated Feedback Voltage	T_A= +25°C	0.5880	0.6000	0.6120	V
	T_A= 0°C ≤ T_A ≤ 85°C	0.5865	0.6000	0.6135	V
	T_A= -40°C ≤ T_A ≤ 85°C	0.5820	0.6000	0.6180	V
V_{FB} Input Bias Current	V_{FB} = 0.65V	-	-	±30	nA
Reference Voltage Line Regulation	V_{IN} = 2.5V to 5.5V	-	0.4	0.80	%
Output Voltage Line Regulation	V_{IN}= 2.5V to 5.5V	-	0.4	0.80	%
Output Voltage Load Regulation	In Power Saving Mode	-	0.5	-	%
Peak Inductor Current	V_{IN}=3V, V_{FB}=0.5V or V_{OUT}=90% Duty Cycle <35%	0.75	1.00	1.25	A
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	-	0.40	0.50	Ω
$R_{DS(ON)}$of N-CH MOSFET	I_{SW} = -300mA	-	0.35	0.45	Ω
SW Leakage	V_{RUN} = 0V, V_{SW} = 0V or 5V, V_{IN} = 5V	-	±0.01	±1	μA
RUN Threshold Low	-40°C ≤ T_A ≤ 85°C	-	-	0.6	V
RUN Threshold High		1.5		-	
RUN Leakage Current		-	±0.01	±1	μA
Thermal Shutdown		-	165	-	°C

NOTE3: 100% production test at +25°C. Specifications over the temperature range are guaranteed by design and characterization.

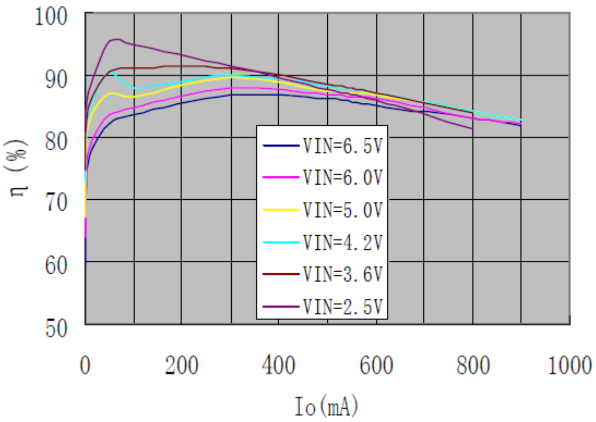
TYPICAL PERFORMANCE CHARACTERISTICS

Test Figure 1 above unless otherwise specified

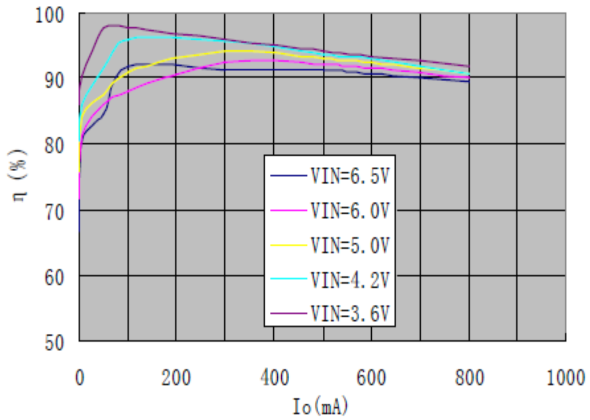
1. η vs. Io (V_{OUT}=1.2V)



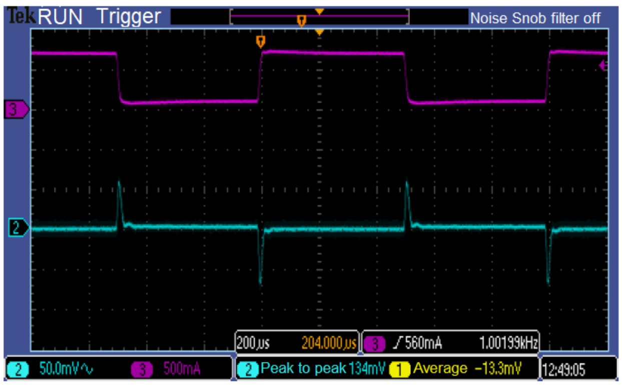
2. η vs. Io (V_{OUT}=1.8V)



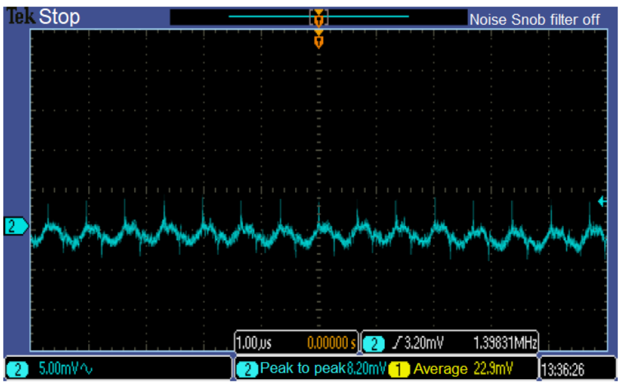
3. η vs. Io (V_{OUT}=3.3V)



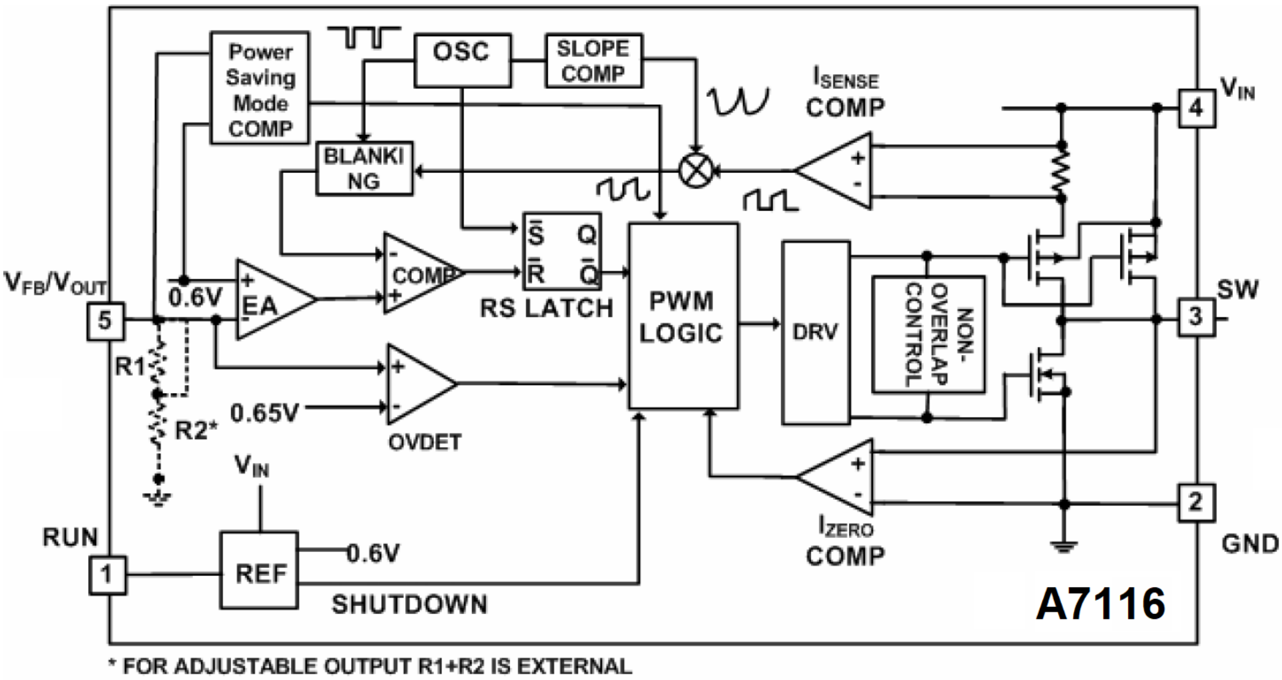
4. Load Transient Response
V_{IN}=3.6V,V_{OUT}=1.8V,Io=0.1-0.7A



5. Output Ripple
V_{IN}=3.6V,V_{OUT}=1.8V,Io=0.7A



BLOCK DIAGRAM



DETAILED INFORMATION

Operation

A7116 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 700mA output current at V_{OUT} = 1.8V with input voltage range from 2.5V to 6.8V.

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, as indicated by the current reversal comparator, I_{ZERO}, 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.

Power Saving Mode Operation

At very light loads, the A7116 automatically enters Power Saving Mode. In power saving mode at light load, a control circuit puts most of the circuit into sleep in order to reduce quiescent current and improve efficiency at light load. When the output voltage drops to certain threshold, the control circuit turns back on the oscillator and the PWM control loop, boosting output backup. When an upper threshold is reached, the control circuit again puts most of circuit into sleep, reducing quiescent current. During Power Saving Mode operation, the converter positions the output voltage slightly higher than the nominal output voltage during PWM operation, allowing additional headroom for voltage drop during a load transient from light to heavy load. While the power saving mode improves light load efficiency, however, with the turning on and off, the noise or ripple voltage is larger than that in the PWM Mode.

Dropout Operation

When the input voltage decreases toward the value of the output voltage, the A7116 allows the main switch to remain on for more than one switching cycle and increases the duty cycle (NOTE4) 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.

NOTE4: 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).

Maximum Load Current

The A7116 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 PCB board, the following suggestions should be taken to ensure proper operation of the A7116. These items are also illustrated graphically in Figure 1 & Figure 2.

1. The power traces, including the GND trace, the SW trace and the V_{IN} 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 C_{OUT} 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.

LAYOUT & APPLICATION SUGGESTION

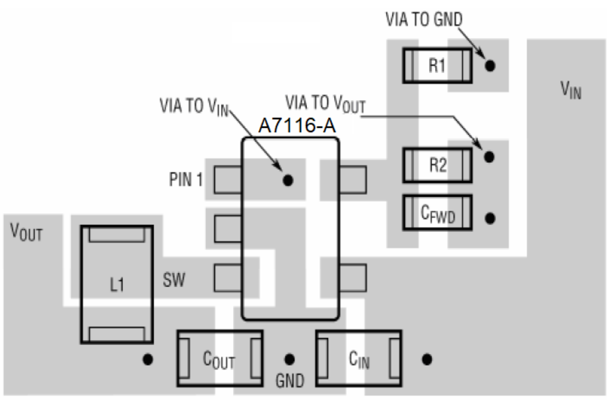


Figure 1. A7116-ADJA

Adjustable Output Suggested Layout

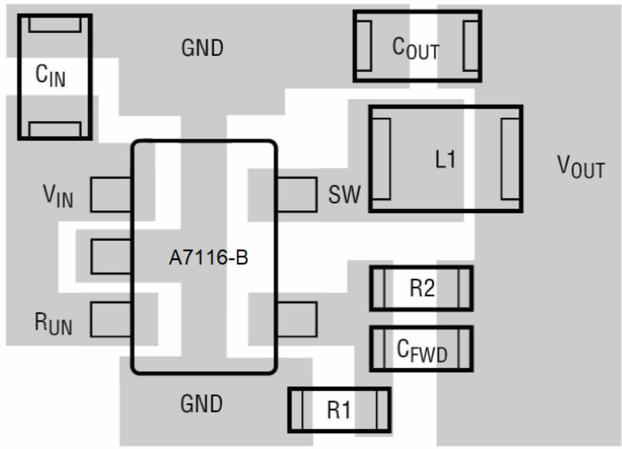


Figure 2. A7116-ADJB

Adjustable Output Suggested Layout

Application Information

A7116 is adjustable output version. The adjustable output version output voltage can be setting by two divided resistors R1 and R2.

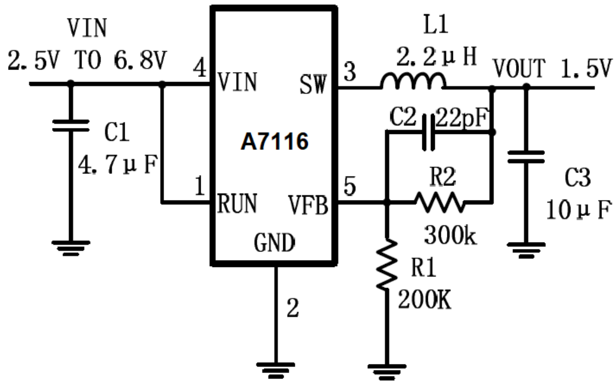


Figure 3. Circuit of Adjustable Output Version

Setting the Output Voltage

Figure 3 above shows the basic application circuit with A7116 adjustable output version. The external resistor sets the output voltage according to the following equation:

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

R1= 200kΩ for all outputs; R2= 200kΩ for V_{OUT}=1.2V, R2=300kΩ for V_{OUT} =1.5V, R2=400kΩ for V_{OUT} =1.8V, and R2=900kΩ for V_{OUT} =3.3V.

Inductor Selection

For most designs, the A7116 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 700mA, or ΔI_L =245mA.

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 (700mA+122.5mA). Table 1 lists some typical surface mount inductors that meet target applications for the A7116.

Part #	L (μH)	Max DCR (mΩ)	Rated D.C. Current (A)	Size W x L x H (mm)
Sumida CR43	1.4 2.2 3.3 4.7	56.2 71.2 86.2 108.7	2.52 1.75 1.44 1.15	4.5x4.0x3.5
Sumida CDRH4D18	1.5 2.2 3.3 4.7	 75 110 162	 1.32 1.04 0.84	4.7x4.7x2.0
Toko D312C	1.5 2.2 3.3 4.7	120 140 180 240	1.29 1.14 0.98 0.79	3.6x3.6x1.2

Table 1. Typical Surface Mount Inductors

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.

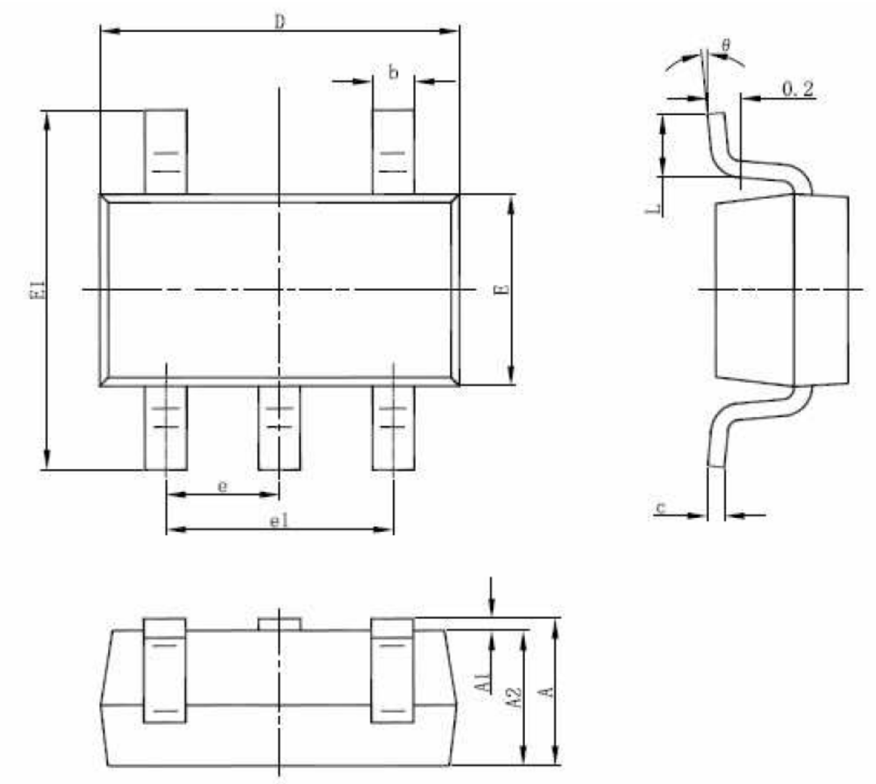
Output Capacitor Selection

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:

$$\Delta V_{OUT} \leq \frac{V_{OUT} \text{ x } (V_{IN} - V_{OUT})}{V_{IN} \text{ x } f_{OSC} \text{ x } L} \text{ x } \left(ESR + \frac{1}{8 \text{ x } f_{OSC} \text{ x } C3} \right)$$

PACKAGE INFORMATION

Dimension in SOT-25 (Unit: mm)



Symbol	Millimeters		Inches	
	Min	Max	Min	Max
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950(BSC)		0.037(BSC)	
e1	1.800	2.000	0.071	0.079
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

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