

1.25MHz, 2A Synchronous Step-Down Converter

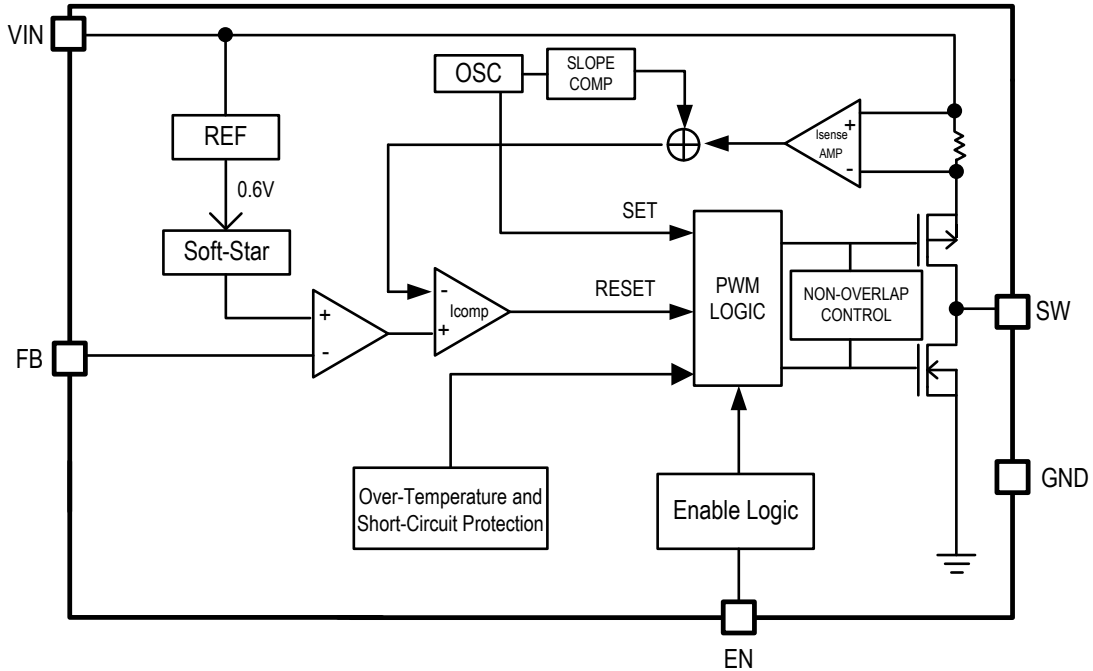
❖ GENERAL DESCRIPTION

AX3531 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 200uA and drops to <1uA in shutdown. The 2.8V to 5.5V input voltage range makes AX3531 ideally suited for single Li-Ion, two to three AA battery-powered applications. 100% duty cycle provides low dropout operation, extending battery life in portable systems. Switching frequency is internally set at 1.25MHz, allowing the use of small surface mount inductors and capacitors. The internal synchronous switch increases efficiency and decreases need of an external schottky diode. Low output voltages are easily supported with the 0.6V feedback reference voltage. AX3531 is available in small TSOT-23-6L package.

❖ FEATURES

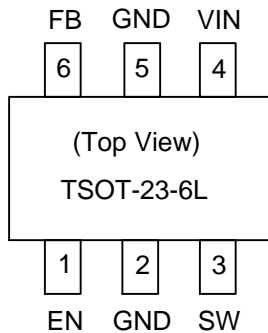
- 2.8V to 5.5V Input Voltage Range
- Output Voltage from 0.6V to VIN
- High Efficiency: Up to 96%
- 1.25MHz Constant Frequency Operation
- Up to 2A Output Current
- Quiescent Current: 200uA (Typical)
- No Schottky Diode Required
- Current Mode Operation for Excellent Line and Load Transient Response
- Current limit, Enable function
- Short Circuit Protect (SCP)
- Build in soft start function
- $\leq 1\mu\text{A}$ Shutdown Current
- TSOT-23-6L Pb-Free package

❖ **BLOCK DIAGRAM**



❖ **PIN ASSIGNMENT**

The package of AX3531 is TSOT-23-6L; the pin assignment is given by:



Name	Description
EN	Enable pin H : normal operation L : Shut down
VIN	Power Supply Input Pin
SW	Switch output pin. Connect external inductor here. Minimize trace area at this pin to reduce EMI.
GND	Ground Pin
FB	Output Feedback pin

❖ **ORDER/MARKING INFORMATION**

Order Information	Top Marking (TSOT-23-6L)
<p>AX3531 XX X</p> <p>Package Type: CT: TSOT-23-6L</p> <p>Packing: Blank : Bag, A : Taping</p>	<p>GG Y W X</p> <p>AX3531</p> <p>→ ID code: internal</p> <p>→ WW: 01~26(A~Z), 27~52(a~z)</p> <p>→ Year: A=2010, 1=2011, ..., 9=2019</p>

❖ ABSOLUTE MAXIMUM RATINGS (at $T_A=25^{\circ}\text{C}$)

Characteristics	Symbol	Rating	Unit
VIN Pin Voltage	V_{IN}	$V_{SS} - 0.3$ to $V_{SS} + 6.5$	V
Feedback Pin Voltage	V_{FB}	$V_{SS} - 0.3$ to $V_{IN} + 0.3$	V
EN Pin Voltage	V_{EN}	$V_{SS} - 0.3$ to $V_{IN} + 0.3$	V
Switch Pin Voltage	V_{SW}	$V_{SS} - 0.3$ to $V_{IN} + 0.3$	V
Power Dissipation	PD	$(T_J - T_A) / \theta_{JA}$	mW
Storage Temperature Range	T_{ST}	-40 to +150	$^{\circ}\text{C}$
Operating Temperature Range	T_{OP}	-40 to +85	$^{\circ}\text{C}$
Junction Temperature	T_J	+125	$^{\circ}\text{C}$
Thermal Resistance from Junction to case	TSOT-23-6L θ_{JC}	50	$^{\circ}\text{C}/\text{W}$
Thermal Resistance from Junction to ambient	TSOT-23-6L θ_{JA}	100	$^{\circ}\text{C}/\text{W}$

Note: θ_{JA} is measured with the PCB copper area of approximately 1 in²(Multi-layer).

❖ ELECTRICAL CHARACTERISTICS

($V_{IN} = V_{EN} = 3.6\text{V}$, $T_A = 25^{\circ}\text{C}$, unless otherwise specified)

Characteristics	Symbol	Conditions	Min	Typ	Max	Units
Input Voltage Range	V_{IN}		2.8	-	5.5	V
V_{IN} UVLO Threshold	V_{IN}		-	2.2	-	V
V_{IN} UVLO Hysteresis	$V_{IN(hys)}$		-	0.35	-	V
Feedback Voltage	V_{FB}	$T_A = +25^{\circ}\text{C}$	0.588	0.600	0.612	V
Feedback Bias Current	I_{FB}	$V_{FB} = 0.65\text{V}$	-	-	± 30	nA
Quiescent Current	I_{CCQ}	$V_{FB} = 1\text{V}$	-	200	350	μA
Shutdown Supply Current	I_{SD}	$V_{EN} = 0\text{V}$	-	0.1	1	μA
Switching Current Limit	I_{LIMIT}		2.2	3	-	A
Line Regulation	$\Delta V_{OUT}/V_{OUT}$	$V_{IN} = 2.5\text{V}$ to 5.5V	-	0.4	-	%/V
Load Regulation	$\Delta V_{OUT}/V_{OUT}$	$I_{OUT} = 0.01$ to 2A	-	1	-	%
Oscillation Frequency	F_{OSC}	$I_{OUT} = 300\text{mA}$	1.0	1.25	1.5	MHz
$R_{DS(ON)}$ of P-CH MOSFET	$R_{DS(ON)}$	$V_{IN} = 5\text{V}$	-	120	-	m Ω

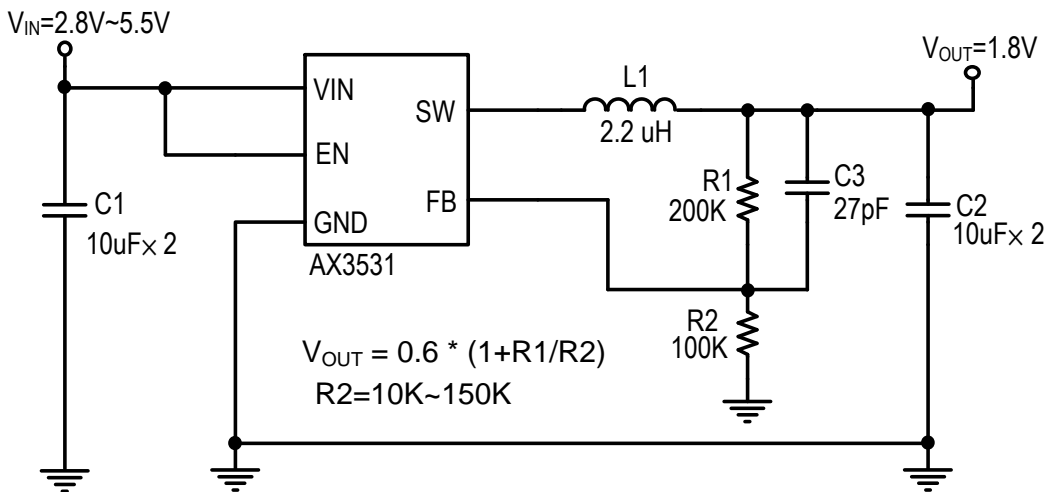
❖ **ELECTRICAL CHARACTERISTICS (COUNTINOUS)**

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

Characteristics	Symbol	Conditions	Min	Typ	Max	Units
$R_{DS(ON)}$ of N-CH MOSFET	$R_{DS(ON)}$	$V_{IN} = 5V$ (Note 1)	-	100	-	mΩ
EN pin logic input threshold voltage	V_{ENL}		-	-	0.4	V
	V_{ENH}		1.2	-	-	
EN Pin Input Current	I_{EN}		-	±0.1	±1	uA
Efficiency	EFFI	$V_{IN}=5V$, $V_{OUT}=3.3V$, $I_{OUT}=0.5A$	-	94	-	%
Thermal shutdown	T_{DS}		-	150	-	°C
Thermal shutdown Hysteresis	T_{SH}		-	30	-	°C

Note 1: Guaranteed by design.

❖ **APPLICATION CIRCUIT**



❖ **FUNCTION DESCRIPTIONS**

Operation

AX3531 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 minimum 2000mA output current at input voltage range from 2.8V 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 transient 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.

❖ APPLICATION INFORMATION

Setting the Output Voltage

Application circuit item shows the basic application circuit with AX3531 adjustable output version. The external resistor sets the output voltage according to the following equation:

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

Table 1 Resistor select for output voltage setting

V_{OUT}	R2	R1
1.2V	100K	100K
1.5V	100K	150K
1.8V	100K	200K
2.5V	150K	470K
3.3V	120K	540K

Inductor Selection

For most designs, the AX3531 operates with inductors of 2.2 μ H to 3.3 μ 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 2000mA, $\Delta I_L=400$ mA.

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

V_{OUT}	1.2V	1.5V	1.8V	2.5V
Inductor	2.2uH	2.2uH	2.2uH	2.2uH
Part Number WE-TPC	7440430022	7440430022	7440430022	7440430022

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 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 (2000mA+200mA).

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 10μF ceramic capacitor for most applications is sufficient.

Output Capacitor Selection

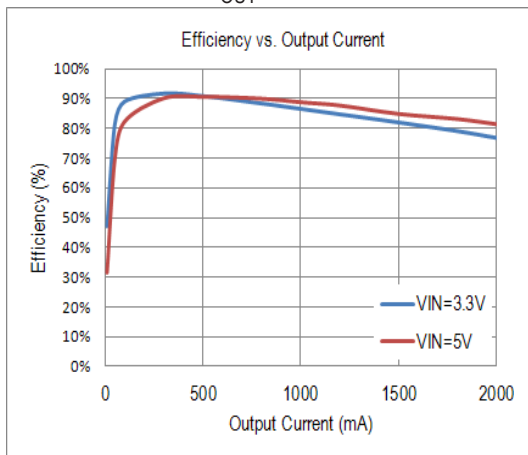
The output capacitor is required to be 10uF×2 to keep the output voltage ripple small and to ensure regulation loop stability. The output capacitor must have low impedance at the switching frequency. Ceramic capacitors with X5R or X7R dielectrics are recommended due to their low ESR and high ripple current.

Compensation Capacitor Selection

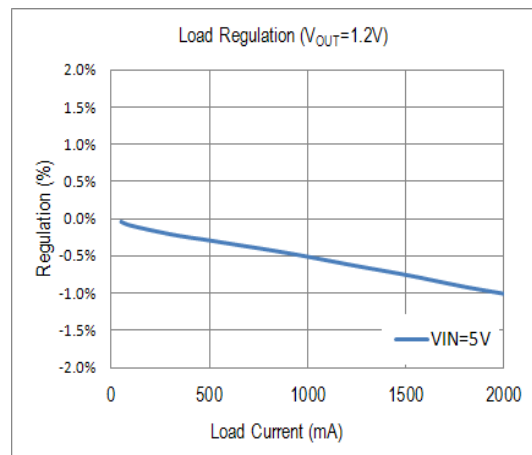
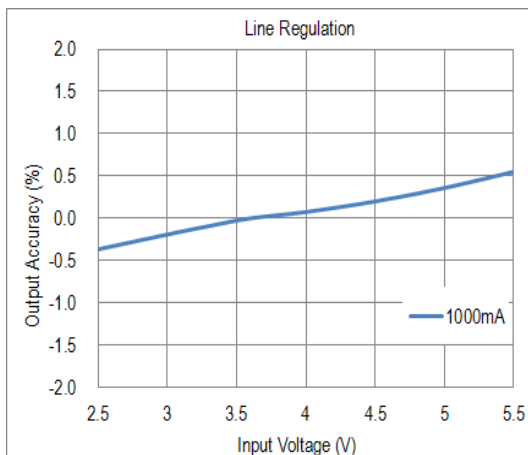
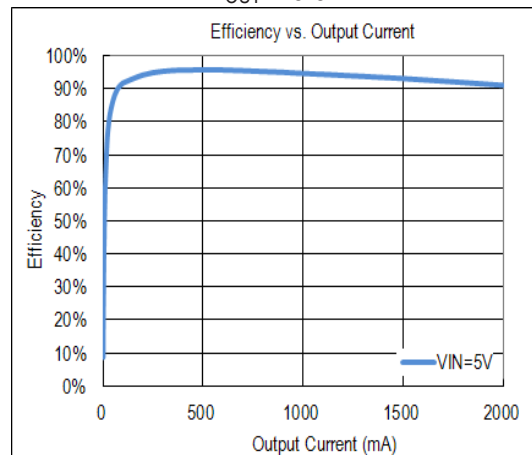
The compensation capacitors for increasing phase margin provide additional stability. It is required 27pF, Please refer to Demo Board Schematic to design.

❖ TYPICAL CHARACTERISTICS

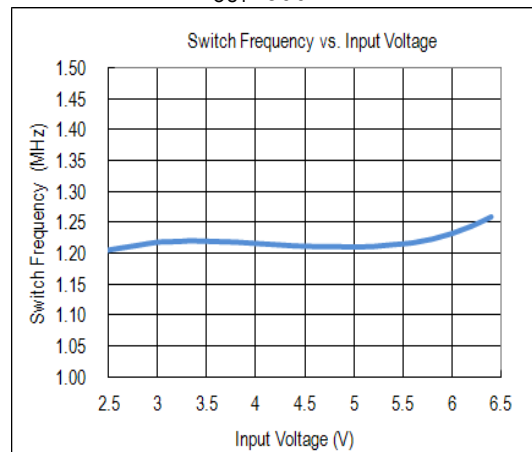
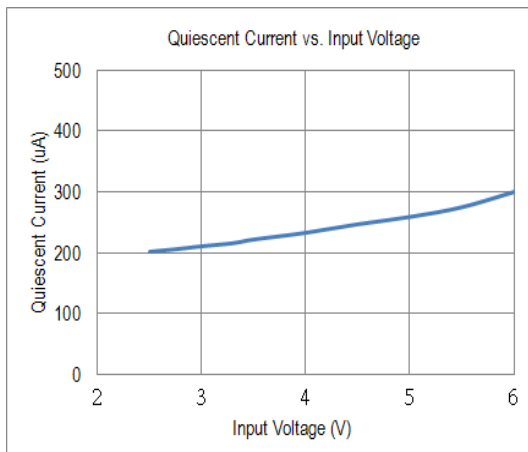
$V_{OUT} = 1.2V$



$V_{OUT} = 3.3V$

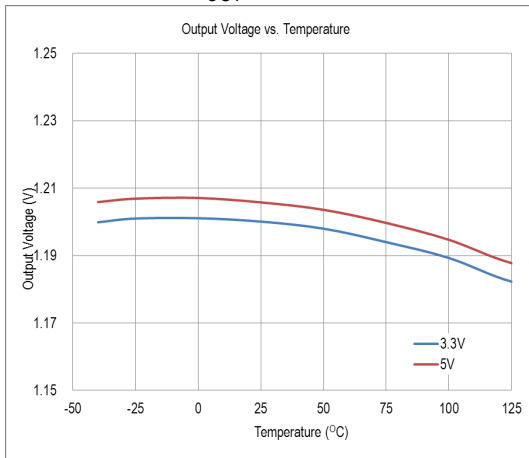


$I_{OUT} = 500mA$

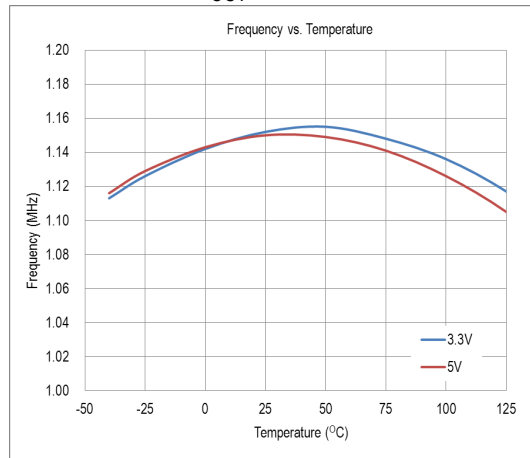


❖ TYPICAL CHARACTERISTICS (COUNTINOUS)

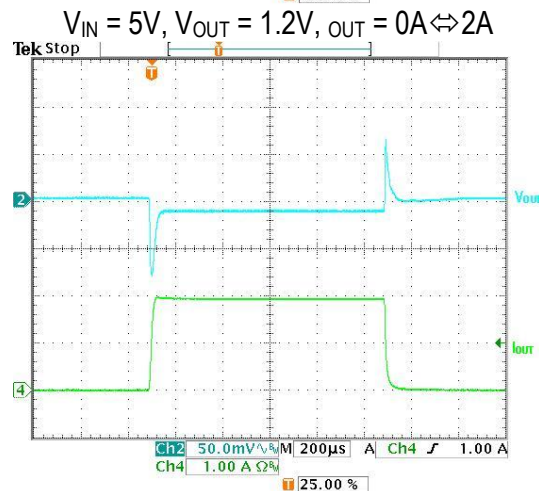
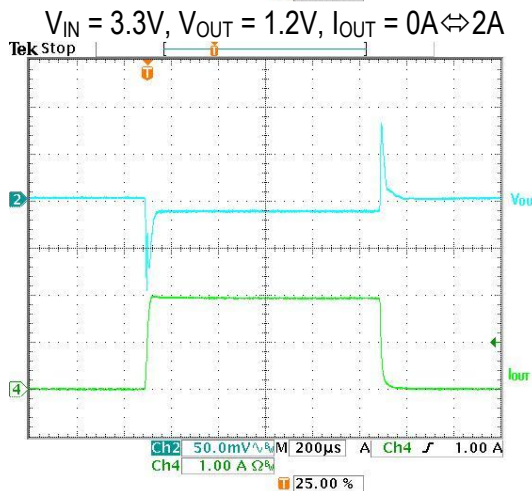
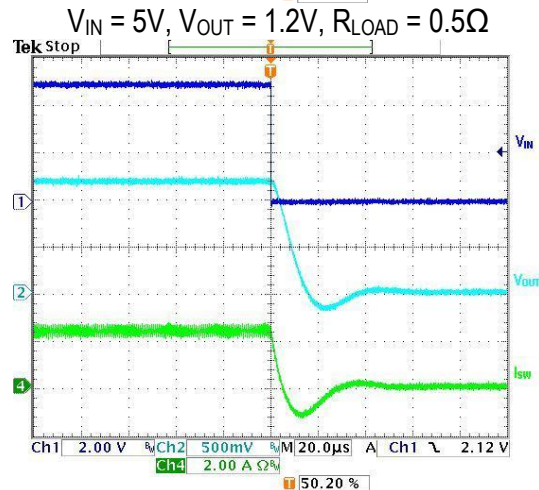
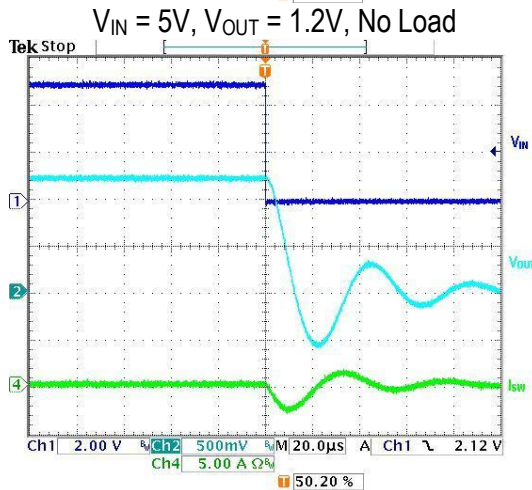
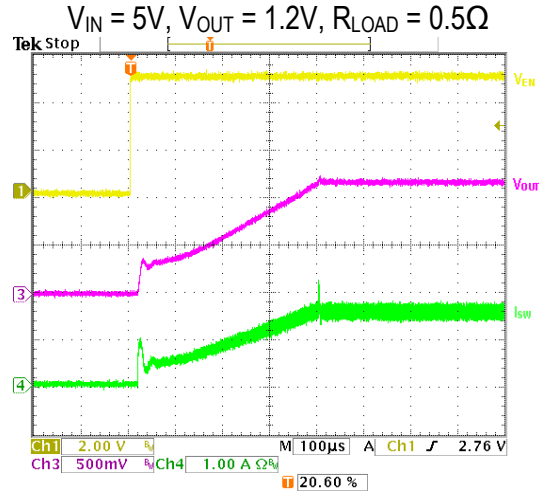
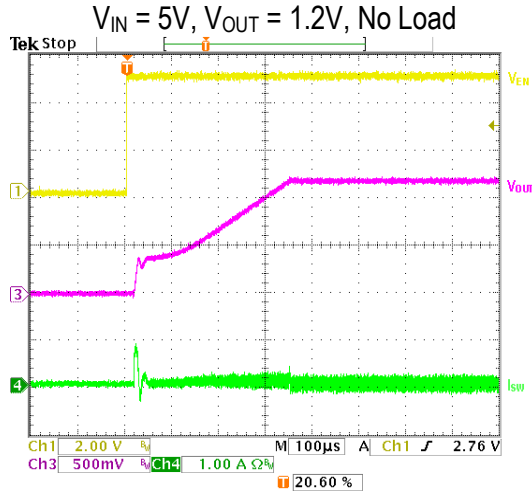
$I_{OUT}=500mA$



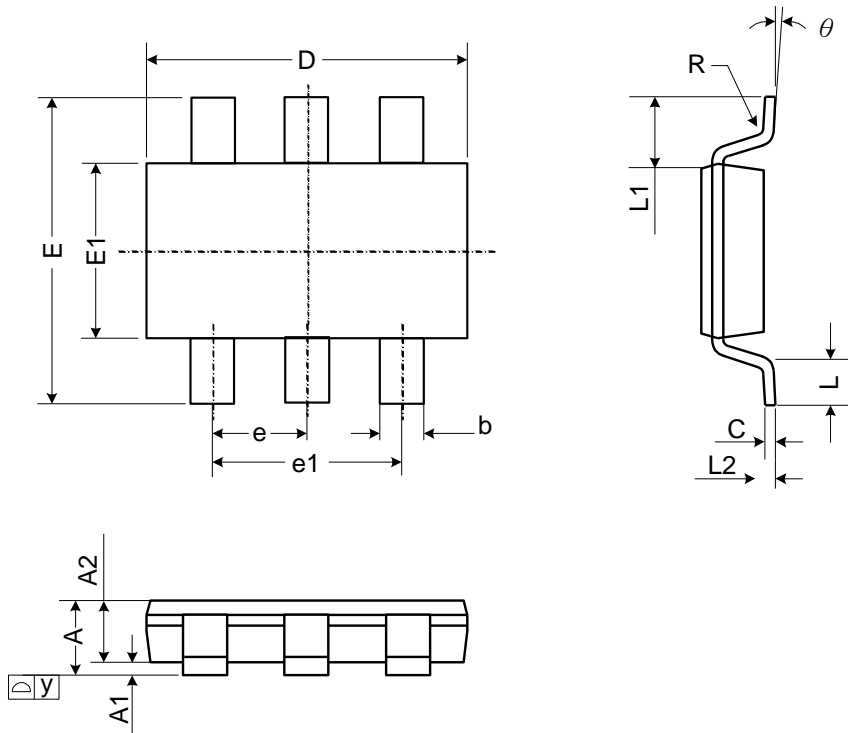
$I_{OUT}=500mA$



❖ TYPICAL CHARACTERISTICS (COUNTINOUS)



❖ PACKAGE OUTLINES



Symbol	Dimensions in Millimeters			Dimensions in Inches		
	Min.	Nom.	Max.	Min.	Nom.	Max.
A	-	-	1.10	-	-	0.043
A1	0.00	-	0.10	0	-	0.004
A2	0.70	0.90	1.00	0.028	0.035	0.039
b	0.30	0.40	0.50	0.012	0.016	0.020
C	0.08	0.14	0.20	0.003	0.006	0.008
D	2.80	2.90	3.00	0.110	0.114	0.118
E	2.60	2.80	3.00	0.102	0.110	0.118
E1	1.50	1.60	1.70	0.059	0.063	0.067
e	0.95 BSC.			0.037 BSC.		
e1	1.90 BSC.			0.075 BSC.		
L	0.30	0.45	0.60	0.012	0.018	0.024
L1	0.60 REF.			0.024 REF.		
L2	0.25 BSC.			0.010 BSC.		
y	-	-	0.10	-	-	0.004
R	0.10	-	-	0.004	-	-
θ	0°	-	8°	0°	-	8°

JEDEC outline: MO-193 AA