

AE1501

PWM BUCK DC/DC CONVERTER

AE1501

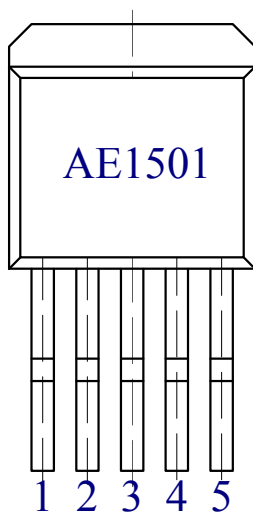
● Features

3.3V, 5V, two fixed output versions
TO-263 package
Output load current 3A
Input voltage range up to 40V
Requires only 4 external components
150 kHz fixed frequency internal oscillator
TTL shutdown capability
Low power standby mode,
 I_Q typically 85 μ A
High efficiency
Thermal shutdown and current limit protection

● Application

Simple high-efficiency step-down (buck) regulator
LCD switching regulators

● Pin Configuration



5-Lead TO-263 (S)

● General Description

The AE1501 series of regulators are monolithic integrated circuits that provide all the active functions for a step-down (buck) switching regulator, capable of driving a 3A load with excellent line and load regulation. These devices are available in fixed output voltages of 3.3V, 5V version.

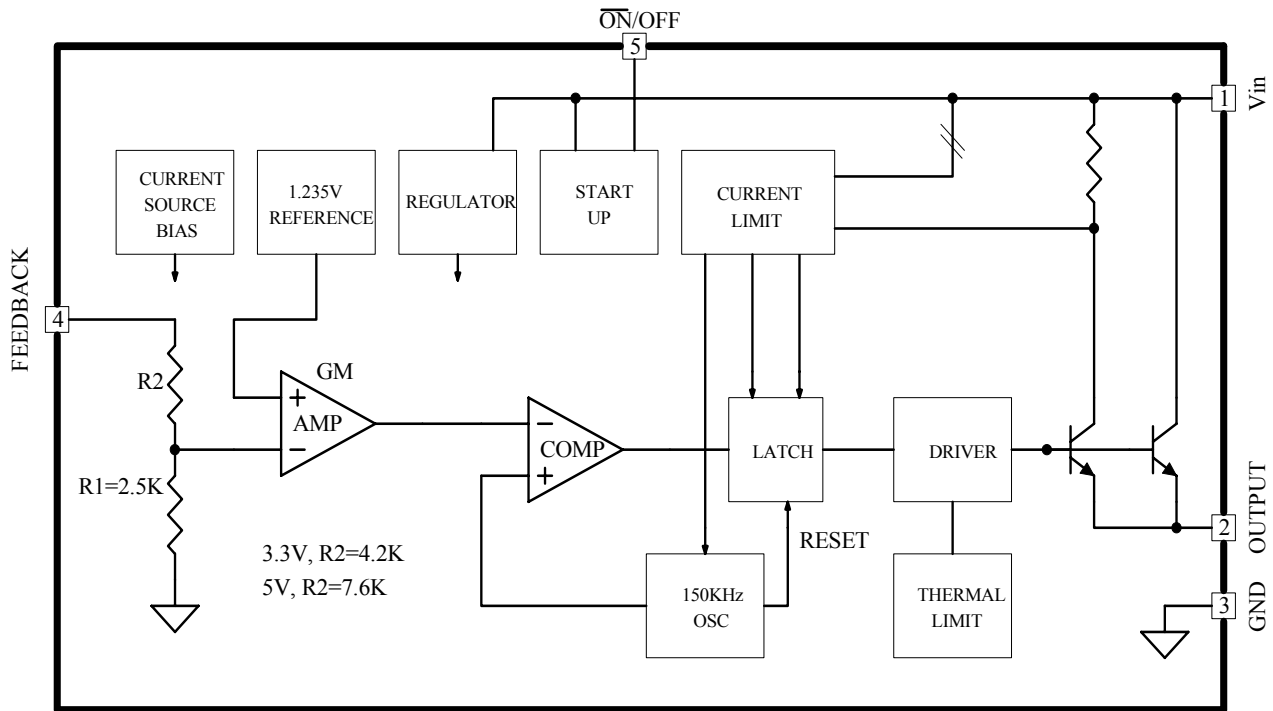
Requiring a minimum number of external components, these regulators are simple to use and include internal frequency compensation, and a fixed frequency oscillator.

The AE1501 series operates at a switching frequency of 150 kHz thus allowing smaller sized filter components than what would be needed with lower frequency switching regulators. Available in a 5-lead TO-263 surface mount package.

Other features include a guaranteed $\pm 5\%$ tolerance on output voltage under specified input voltage and output load conditions, and $\pm 15\%$ on the oscillator frequency. External shutdown is included, featuring typically 85 μ A standby current. Selfprotection features include a two stage frequency reducing current limit for the output switch and an over temperature shutdown for complete protection under fault conditions.

Pin No.	Symbol	Parameter
1	V_{IN}	DC Input
2	V_{OUT}	DC Output
3	GND	Ground
4	Feedback	Feedback signal
5	\overline{ON}/OFF	Standby control

● Block Diagram



● Absolute Maximum Ratings(note1)

Parameter		Rating	Unit
Maximum Supply Voltage		40	V
$\overline{\text{ON/OFF}}$ Pin Input Voltage		-0.3 ~ 25	V
Feedback Pin Voltage		-0.3 ~ 25	V
Power Dissipation		Internally limited	--
Storage Temperature Range		-65 ~ 150	
Conditions	Maximum Junction Temperature	150	
	Temperature Range	-40 ~ 125	
	Supply Voltage	5 ~ 36	V

Electrical Characteristics

V_O=3.3V						
Symbol	Parameter	Conditions	Min (Note 4)	Typ (Note 3)	Max (Note4)	Units
V _{OUT}	Output Voltage	5V V _{IN} 36V 0.2A I _{LOAD} 3A	3.15	3.30	3.40	V
	Efficiency	V _{IN} =12V , I _{LOAD} =3A	--	72	--	%
V_O=5V						
V _{OUT}	Output Voltage	7V V _{IN} 36V 0.2A I _{LOAD} 3A	4.80	5.0	5.15	V
	Efficiency	V _{IN} =12V , I _{LOAD} =3A	--	79	--	%

● All Output Voltage Versions Electrical Characteristics (otherwise specified, V_{IN} = 12V, I_{LOAD} = 500 mA)

Note 1: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but do not guarantee specific performance limits. For guaranteed specifications and test conditions, see the Electrical Characteristics.

Note 2: The human body model is a 100 pF capacitor discharged through a 1.5k resistor into each pin.

Note 3: Typical numbers are at 25 °C and represent the most likely norm.

Note4: All limits guaranteed at room temperature (standard type face) and at temperature extremes (bold type face). All room temperature limits are 100% production tested. All limits at temperature extremes are guaranteed via correlation using standard Statistical Quality Control (SQC) methods. All limits are used to calculate Average Outgoing Quality Level (AOQL).

Note5: External components such as the catch diode, inductor, input and output capacitors can affect switching regulator system performance.

Note6: The switching frequency is reduced when the second stage current limit is activated.

Note7: No diode, inductor and capacitor connected to output pin.

Note8: Feedback pin removed from output and connected to 0V to force the output transistor switch ON.

Note9: Feedback pin removed from output and connected to 12V for the 3.3V, 5V version, to force the output transistor switch OFF.

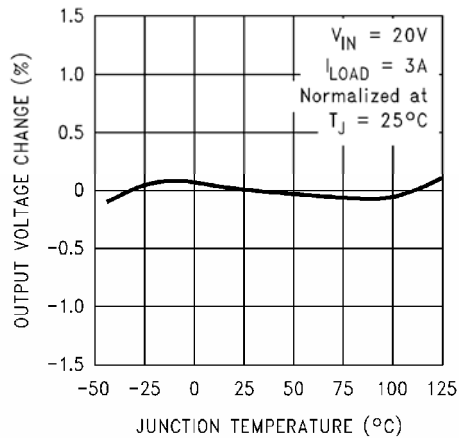
Note10: V_{IN} = 36V.

Note11: Junction to ambient thermal resistance (no external heat sink) for the TO-263 package mounted vertically, with the leads soldered to a printed circuit board with (1 oz.) copper area of approximately 1 in².

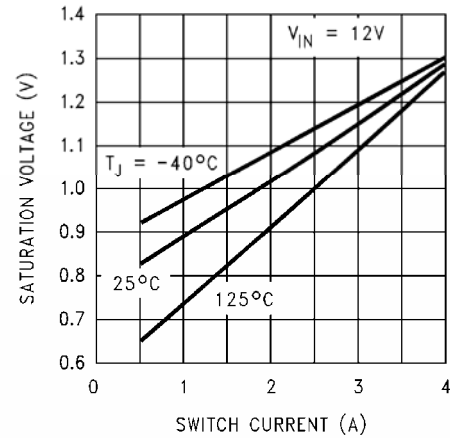
• Typical Performance Characteristics

Symbol	Parameter	Conditions	AE1501 - XX			Units
			Min (Note 4)	Typ (Note 3)	Max (Note)	
f_O	Oscillator Frequency	(Note 6)	127	150	173	kHz
V_{SAT}	VSAT Saturation Voltage	$I_{OUT}=3A$ (Notes 7, 8)	--	1.36	1.60	V
DC	Max Duty Cycle	\overline{ON} (Note 8)	--	100	--	%
	Min Duty Cycle	OFF (Note 9)	--	0	--	%
I_{CL}	Current Limit	Peak Current (Notes 7, 8)	4.1	4.90	5.60	A
I_{SC}	Output Short Current	$R_{LOAD}=0$	5.20	5.50	6.40	A
I_L	Output Leakage Current	Output = 0V (Notes 7, 9)	--	--	60	μA
		Output = -1V (Notes 10)	--	5	30	mA
I_Q	Quiescent Current	(Note 9)	--	7.80	12	mA
I_{STBY}	Standby Quiescent Current	\overline{ON}/OFF pin = 5V (OFF) (Note 10)	--	85	190	μA
J_A	Thermal Resistance	TO-263	--	30	--	/W
\overline{ON}/OFF CONTROL						
V_{IH}	\overline{ON}/OFF Pin Logic Input	Low (Regulator on)	2.0	1.4	--	V
	Threshold Voltage	High (Regulator off)		--	--	V
V_{IL}			--	--	0.9	V
I_H	\overline{ON}/OFF Pin Input Current	$V_{LOGIC}=2.5V$ (Regulator OFF)	--	6	15	μA
I_L		$V_{LOGIC}=0.5V$ (Regulator ON)	--	0.02	2	μA

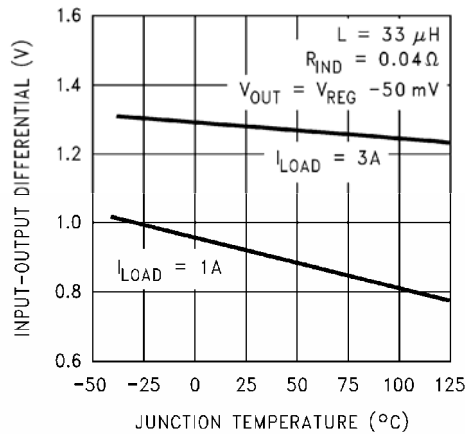
Normalized Output Voltage



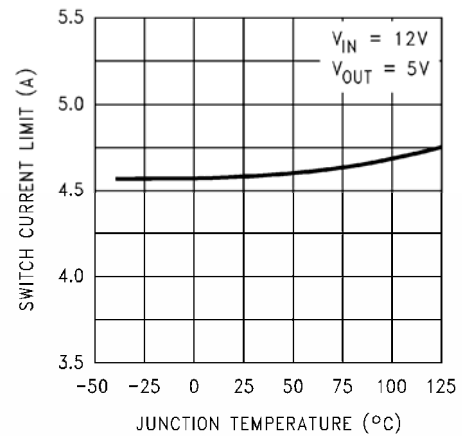
Switch Saturation Voltage



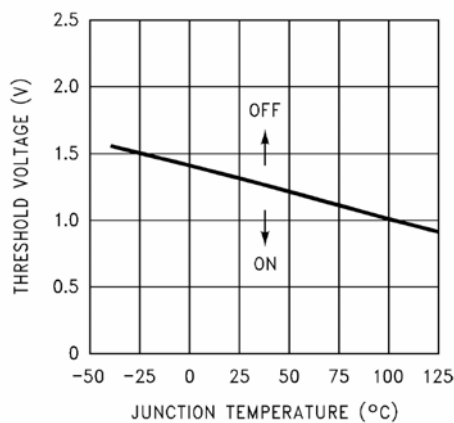
Dropout Voltage



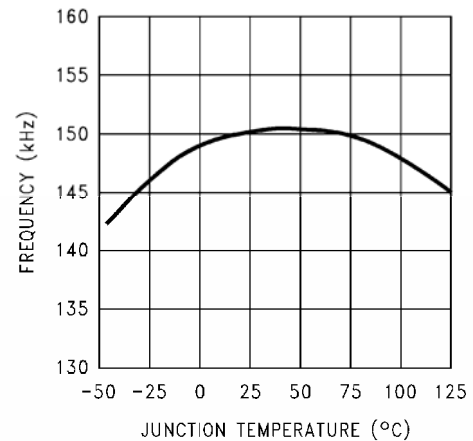
Switch Current Limit



ON /OFF Threshold Voltage

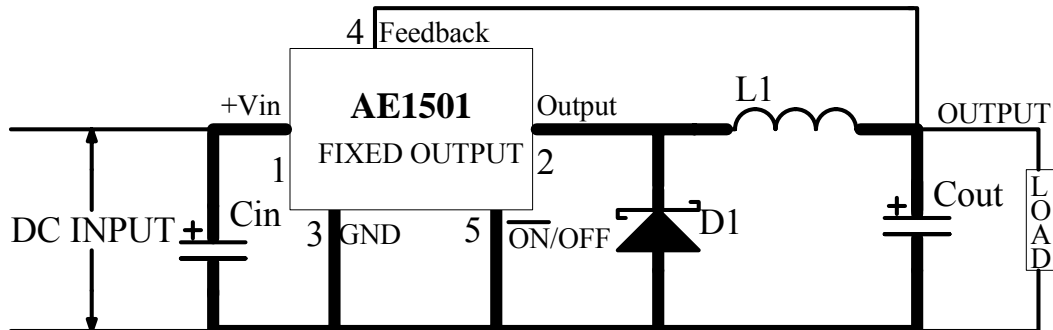


Switching Frequency



Testing Circuit

Fixed Output Voltage Versions



C_{IN} —470 μF , 50V, Aluminum Electrolytic Nichicon “PL Series”

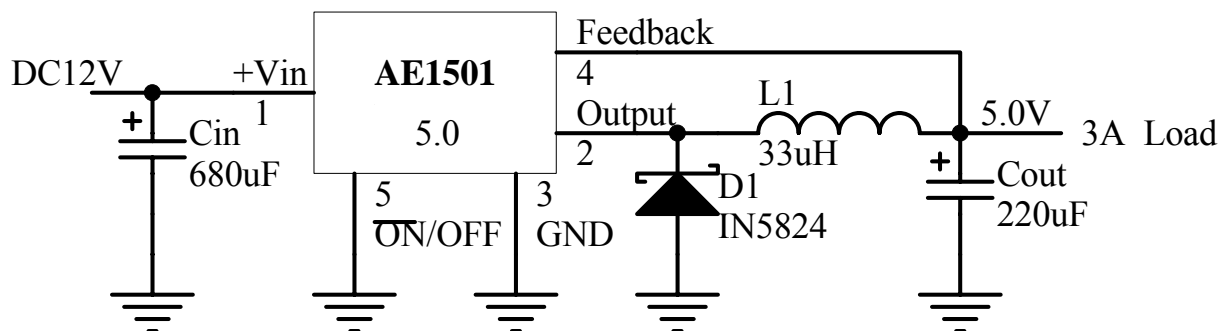
C_{OUT} —220 μF , 25V Aluminum Electrolytic, Nichicon “PL Series”

D1 —5A, 40V Schottky Rectifier, 1N5825

L1 —68 μH , L38

Note: Keep Feedback wiring away from inductor flux and heavy line must be kept short and use ground plane construction or best results.

• Typical Application circuit



• Pin Functions

+V_{IN}

This is the positive input supply for the IC switching regulator. A suitable input bypass capacitor must be present at this pin to minimize voltage transients and to supply the switching currents needed by the regulator.

Ground

Circuit ground.

Output

Sep. 2006 V2.0

Chengdu Chip-Rail Tech. Co., Ltd.

AE1501

Internal switch. The voltage at this pin switches between $(+V_{IN}-V_{SAT})$ and approximately $-0.5V$, with a duty cycle of approximately V_{OUT} / V_{IN} . To minimize coupling to sensitive circuitry, the PC board copper area connected to this pin should be kept a minimum.

Feedback

Senses the regulated output voltage to complete the feedback loop.

 \overline{ON}/OFF

Allows the switching regulator circuit to be shutdown using logic level signals thus dropping the total input supply current to approximately 150uA. Pulling this pin below a threshold voltage of approximately 1.3V turns the regulator on, and pulling this pin above 1.3V (up to a maximum of 25V) shuts the regulator down. If this shutdown feature is not needed, the \overline{ON}/OFF pin can be wired to the ground pin or it can be left open, in either case the regulator will be in the ON condition.

● External Components

INPUT CAPACITOR C_{IN} —A low ESR aluminum or tantalum bypass capacitor is needed between the input pin and ground pin. It must be located near the regulator using short leads. This capacitor prevents large voltage transients from appearing at the input, and provides the instantaneous current needed each time the switch turns on. Selecting an input capacitor requires consulting the manufacturers data sheet for maximum allowable RMS ripple current. For a maximum ambient temperature of 40°C, a general guideline would be to select a capacitor with a ripple current rating of approximately 50% of the DC load current. For ambient temperatures up to 70°C, a current rating of 75% of the DC load current would be a good choice for a conservative design. The capacitor voltage rating must be at least 1.25 times greater than the maximum input voltage, and often a much higher voltage capacitor is needed to satisfy the RMS current requirements.

OUTPUT CAPACITOR C_{OUT} —An output capacitor is required to filter the output and provide regulator loop stability. Low impedance or low ESR Electrolytic or solid tantalum capacitors designed for switching regulator applications must be used. When selecting an output capacitor, the important capacitor parameters are; the 100 kHz Equivalent Series esistance (ESR), the RMS ripple current rating, voltage rating, and capacitance value. For the output capacitor, the ESR value is the most important parameter. The output capacitor requires an ESR value that has an upper and lower limit. For low output ripple voltage, a low ESR value is needed. This value is determined by the maximum allowable output ripple voltage, typically 1% to 2% of the output voltage. But if the selected capacitor's ESR is extremely low, there is a possibility of an unstable feedback loop, resulting in an oscillation at the output.

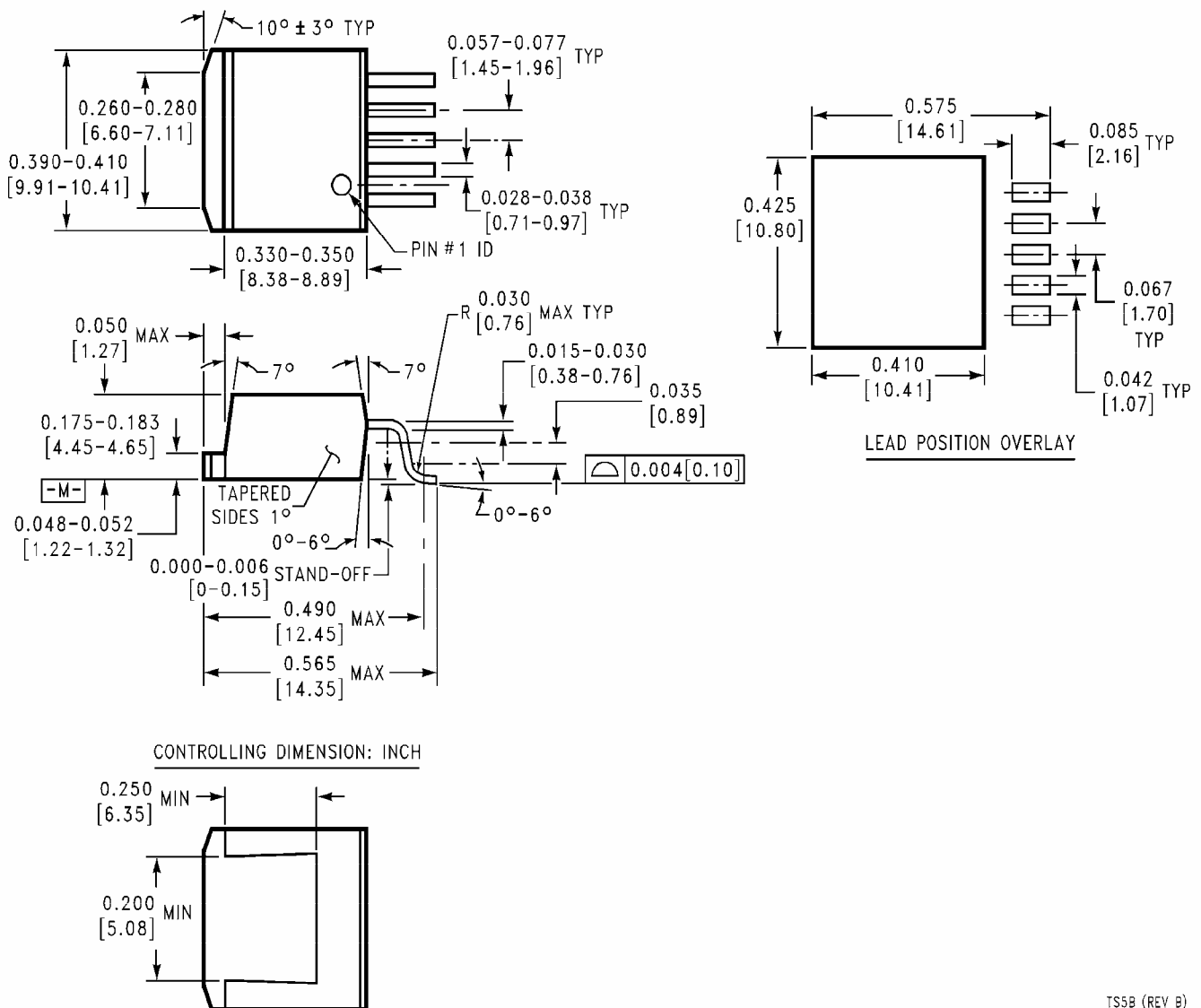
CATCH DIODE D—Buck regulators require a diode to provide a return path for the inductor current when the switch turns off. This must be a fast diode and must be located close to the AE1501 using short leads and short printed circuit traces. Because of their very fast switching speed and low forward voltage drop, Schottky diodes provide the best performance, especially in low output voltage applications (5V and lower). Ultra fast recovery, or High-Efficiency rectifiers are also a good choice, but some types with an abrupt turnoff characteristic may cause instability or EMI problems.

AE1501

INDUCTOR SELECTION L----All switching regulators have two basic modes of operation; continuous and discontinuous. The difference between the two types relates to the inductor current, whether it is flowing continuously, or if it drops to zero for a period of time in the normal switching cycle. Each mode has distinctively different operating characteristics, which can affect the regulators performance and requirements. Most switcher designs will operate in the discontinuous mode when the load current is low. The AE1501 (or any of the Simple Switcher family) can be used for both continuous and discontinuous modes of operation. There is a formula for general applications:

$$L=(5 \sim 10) \frac{V_o}{300I_o} (1-\frac{V_o}{V_{IN}}) \text{mH}$$

● Package Information



TSSB (REV B)

5-Lead To-263 Surface Mount Package(s)