KP1503A

125Khz, 2A PWM Buck Switching Regulator+OPERATIONAL AMPLIFIER

■ General Description

The KP1503A is a monolithic integrated circuit that provide all the active functions for a step-down switching regulator with an additional operational amplifier to precisely control ON/OFF function, capable of driving a 2A load without additional transistor component. Requiring a minimum number of external component, the board space can be saved easily. The external shutdown function can be controlled by TTL logic level and then come into standby mode. The internal compensation makes feedback control have good line and load regulation without external design. Regarding protected function, thermal shutdown is to prevent over temperature operating from damage, and current limit is against over current operating of the output switch. The KP1503A operates at a switching frequency of 125Khz thus allowing smaller sized filter components than what would be needed with lower frequency switching regulators. Other features include a guaranteed ±4% tolerance on output voltage under specified input voltage and output load conditions, and ±15% on the oscillator frequency. The output version included fixed 3.3V, 5V, 12V, and an adjustable type. The packages are available in a standard 8-lead SOP8.

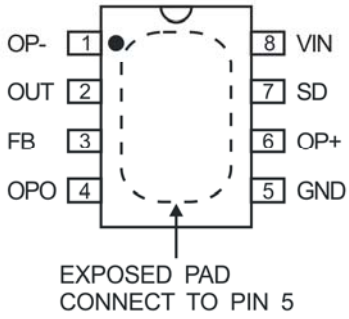
■ Features

- 3.3V, 5V, 12V and adjustable output versions
- Adjustable version output voltage range, 1.23V to 37V ±4% max over line and load condiction
- SOP-8L packages
- Voltage mode non-synchronous PWM control
- Thermal-shutdown and current-limit protection
- ON/OFF shutdown control input
- Input voltage range up to 40V
- Output load current: 2A
- 125 kHz fixed frequency internal oscillator
- Low power standby mode
- Built-in switching transistor on chip

■ Applications

- Simple High-efficiency step-down(buck) regulator
- Efficient preregulator for linear regulators
- On-card switching regulators
- Positive to negative converter
- Battery Charger

■ Pin Assignments



■ Pin Descriptions

Name	Description
V_{IN}	Operating voltage input.
Out	Switching output.
Gnd	Ground.
FB	Output voltage feedback control.
SD	$\overline{\textbf{ON}}$/OFF , Low:Active ; High:Shutdown
OPO	Operational Amplifier Output.
OP-	Operational Amplifier Negative Input
OP+	Operational Amplifier Positive Input
EXPOSED PAD	Pad for heatsinking purposes.Connect to groung plane using multiple vias.

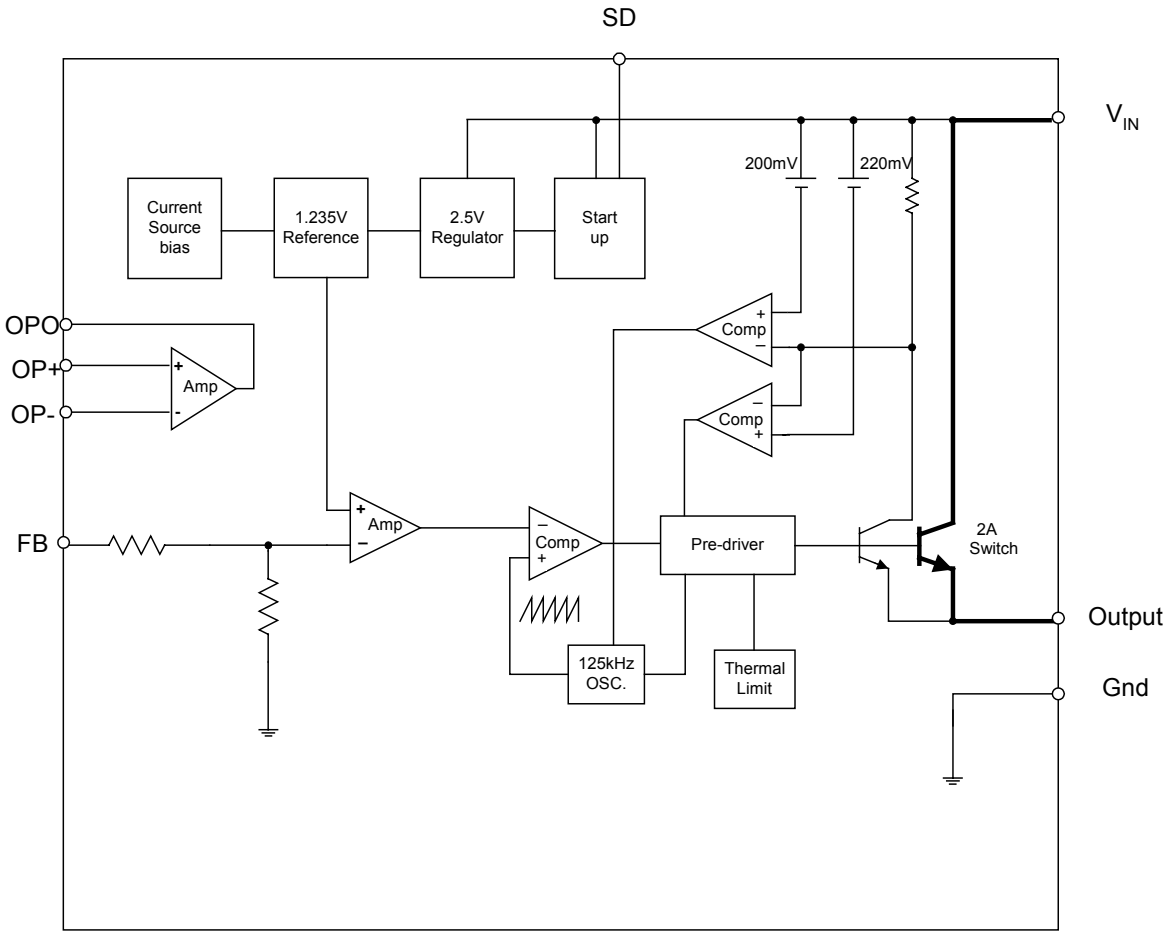
125Khz, 2A PWM Buck Switching
Regulator+OPERATIONAL AMPLIFIER

■ Ordering Information

KP1503A XX X X

Output version	Package	Packing
Blank : Adjustable	Blank : SOP-8L	Blank : Taping
-3.3 : 3.3V		A : Tube
-5.0 : 5.0V		
-12 : 12v		

■ Block Diagram



■ Absolute Maximum Ratings

Symbol	Parameter	Rating	Unit
V_{CC}	Supply Voltage	+45	V
V_{SD}	ON/OFF Pin input voltage	-0.3 to +25	V
V_{FB}	Feedback Pin voltage	-0.3 to +25	V
V_{OUT}	Output voltage to Ground	-1	V
P_D	Power dissipation	Internally limited	W
T_{ST}	Storage temperature	-65 to +125	°C
T_{OP}	Operating temperature	-40 to +125	°C
V_{OP}	Operating voltage	+4.5 to +25	V

■ Electrical Characteristics for Switching Regulator

Unless otherwise specified, V_{IN}=12V for 3.3V, 5V, adjustable version and V_{IN}=24V for the 12V version. I_{LOAD} = 0.3A

Symbol	Parameter		Conditions	Min.	Typ.	Max.	Unit
I_B	Feedback bias current		V_{FB}=1.3V (Adjustable version only)		-10	-50 -100	nA
F_{OSC}	oscillator frequency			105 **100**	125	140 **150**	Khz
Fscp	Oscillator frequency of short circuit protect		When current limit occurred and V_{FB} <0.55V		40		Khz
V_{SAT}	saturation voltage		I_{OUT}=1.5A no outside circuit V_{FB}=0V force driver on		1.20	1.4 **1.5**	V
DC	Max. Duty Cycle(ON)		V_{FB}=0V force driver on		100		%
	Min. Duty cycle(OFF)		V_{FB}=12V force driver off		0		
I_{CL}	current limit		peak current no outside circuit V_{FB}=0 force driver on		2.2	2.8 **3.6**	A
I_L	Output = 0V	Output leakage current	no outside circuit V_{FB}=12 force driver off			-200	uA
	Output = -1V		V_{IN}=24V		-5		mA
I_Q	Quiescent Current		V_{FB}=12 force driver off		5	10	mA
I_{STBY}	Standby Quiescent Current		ON/OFF pin=5V V_{IN}=24V		70	125 **200**	uA
V_{IL}	ON/OFF pin logic input threshold voltage		Low (regulator ON)	-	1.3	0.6	V
V_{IH}			High (regulator OFF)	2.0		-	
I_H	ON/OFF pin logic input current		V_{LOGIC}=2.5V (OFF)			-0.01	uA
I_L	ON/OFF pin input current		V_{LOGIC}=0.5V (ON)		-0.1	-1	
Ts	Over temperature shutdown threshold		Tj increasing		165		℃
			Tj decreasing		145		

■ Electrical Characteristics for Operational Amplifier(Continued)

Electrical characteristics at specified free-air temperature, VIN=5V(unless otherwise noted)

Parameter	Test Conditions		LM358			Unit
			Min.	Typ.	Max.	
V_{IO} Input offset Voltage	V_{IN}=5V to MAX V_{IC}= V_{ICR}MIN V_{OPO}=1.4V	25℃		3	7	mV
		Full Range			9	
αVIO Average Temperrature Coffcient of Input Offset Voltage		Full Range		**7**		μV/℃
I_{IO} Input offset Current	V_{OPO}=1.4V	25℃		2	50	nA
		Full Range			125	
αIIo Average Temperature Coefficient of Input Offset Voltage		Full Range		10		pA/℃
I_{IB} Input bias Current	V_{OPO}=1.4V	25℃		-20	-250	nA
		Full Range			-500	
V_{ICR} Common-Mode Input Voltage Range	V_{IN}=5V to MAX	25℃	0to $V_{CC}^{-1.5}$			
		Full Range	0to V_{CC}^{-2}			
V_{OH} High-LevelOutput Voltage	$R_L \geqq 2^{K\Omega}$	25℃	0to $V_{CC}^{-1.5}$			V
	V_{IN}=MAX R_L=$2^{K\Omega}$	Full Range	26			
	V_{IN}=MAX $R_L \geqq 10^{K\Omega}$	Full Range	27	28		
V_{OL} Low-Level Output Voltage	$R_L \geqq 10^{K\Omega}$	Full Range		5	20	mv
A_{VD} Large-Signal Differential Voltage Amplification	V_{IN}=15V V_{OPO}=1V to 11V $R_L \geqq 2^{K\Omega}$	25℃	25	100		V/mv
		Full Range	15			
CMRR Common-Mode Rejection Ratio	V_{IN}=5V to MAX V_{IC}=V_{ICR}MIN	25℃	65	80		dB
K_{SVR} Supply voltage Rejection Ration(△V_{IN}/△V_{IO})	V_{IN}=5V to MAX	25℃	65	100		dB
I_O Output Current	V_{IN}=15V V_{ID}=1V, V_{OPO}=0	25℃	-20	-30		mA
		Full Range	-10			
	V_{IN}=15V V_{ID}=-1V,V_{OPO}=15V	25℃	10	20		
		Full Range	5			
	V_{ID}= -1V, V_{OPO}=200mv	25℃	12	30		μA
I_{OS} Short-Circuit Output Current	V_{IN} at 5V	25℃		±40	±60	mA
	GND at -5V , V_O=0					
I_{CC} Supply Current (Only for Amplifiers)	V_O-2.5V,No Load	Full Range		0.7	1.2	mA
	V_{IN}=MAX V_{OPO}=0.5V_{IN}, No Load	Full Range		1	2	

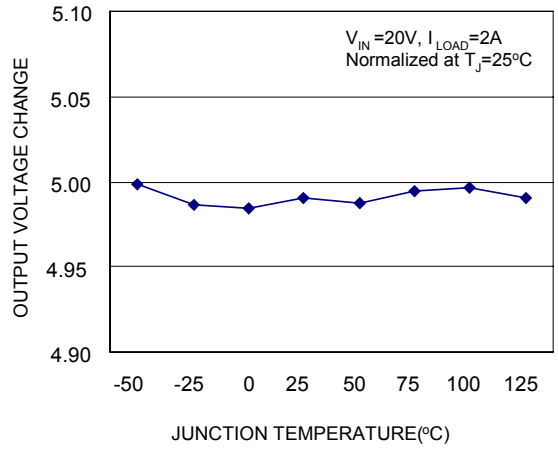
■ Electrical Characteristics (Continued)

	Symbol	Parameter	Conditions	Typ.	Limit	Unit
KP1503A-ADJ	V_{FB}	Output Feedback	$5V \le V_{IN} \le 40V$ $0.2A \le I_{LOAD} \le 2A$ V_{OUT} programmed for 3V	1.235	1.193/**1.18** 1.267/**1.28**	V V_{MIN} V_{MAX}
	η	Efficiency	V_{IN} = 12V, I_{LOAD}=2A	75		%
KP1503A-3.3V	V_{OUT}	Output voltage	$5.5V \le V_{IN} \le 40V$ $0.2A \le I_{LOAD} \le 2A$	3.3	3.168/**3.135** 3.432/**3.465**	V V_{MIN} V_{MAX}
	η	Efficiency	V_{IN} = 12V, I_{LOAD}=2A	75		%
KP1503A-5V	V_{OUT}	Output voltage	$8V \le V_{IN} \le 40V$ $0.2A \le I_{LOAD} \le 2A$	5	4.8/**4.75** 5.2/**5.25**	V V_{MIN} V_{MAX}
	η	Efficiency	V_{IN} = 12V, I_{LOAD}=2A	80		%
KP1503A-12V	V_{OUT}	Output voltage	$15V \le V_{IN} \le 40V$ $0.2A \le I_{LOAD} \le 2A$	12	11.52/**11.4** 12.48/**12.6**	V V_{MIN} V_{MAX}
	η	Efficiency	V_{IN} = 15V, I_{LOAD} = 2A	90		%

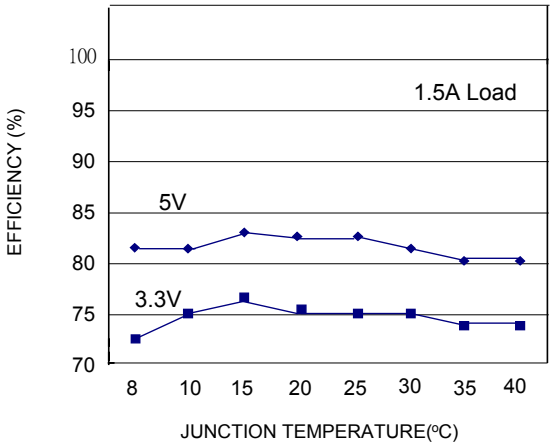
Specifications with **boldface type** are for full operating temperature range, the other type are for T_J=25ºC.

■ Typical Performance Characteristics

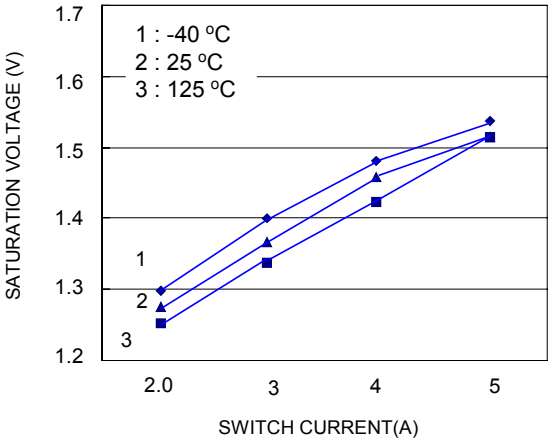
Typical Performance Characteristics
Normalized Output Voltage



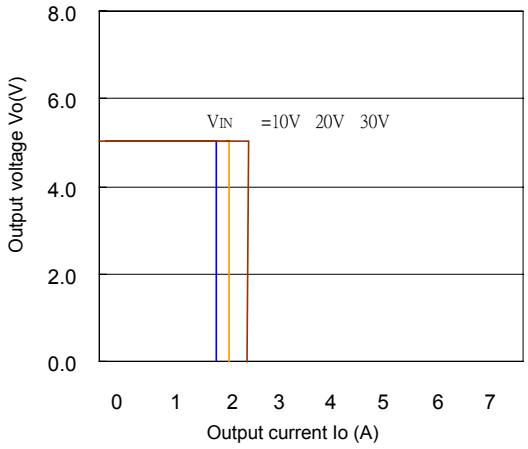
Efficiency



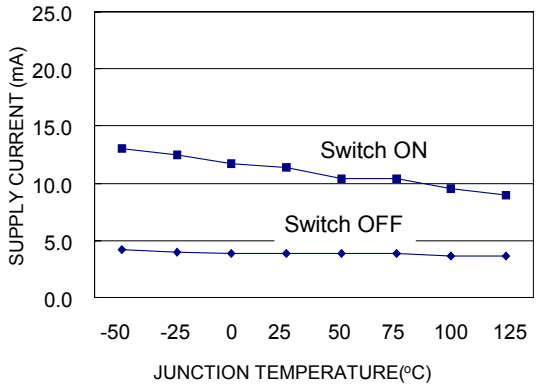
Switch Saturation Voltage



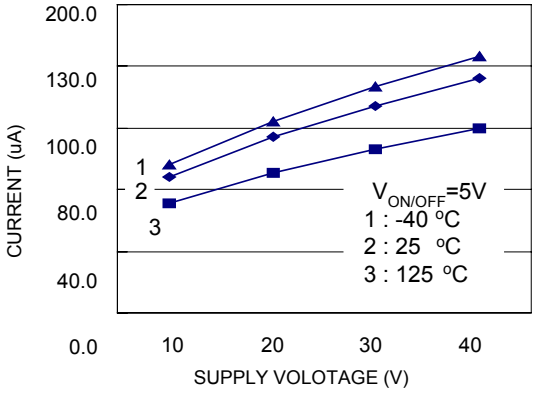
Switch Current Limit



Operating Quiescent Current

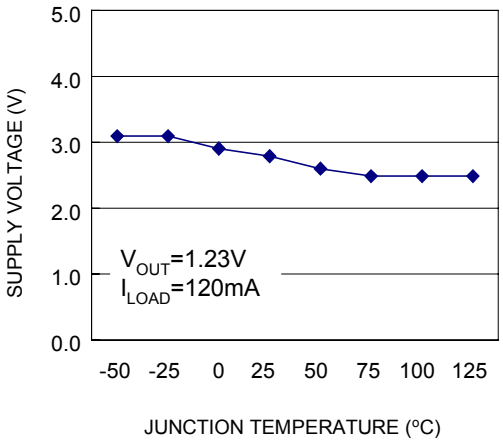


Shutdown Quiescent Current

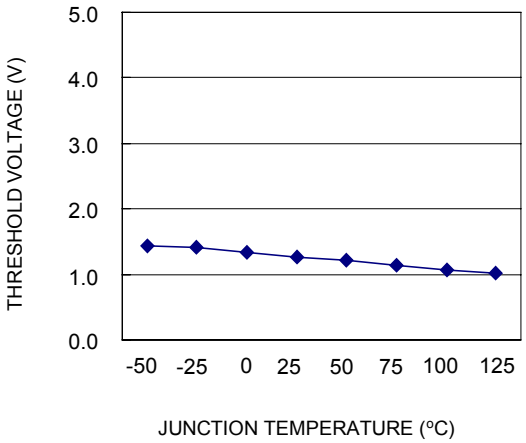


■ Typical Performance Characteristics (Continued)

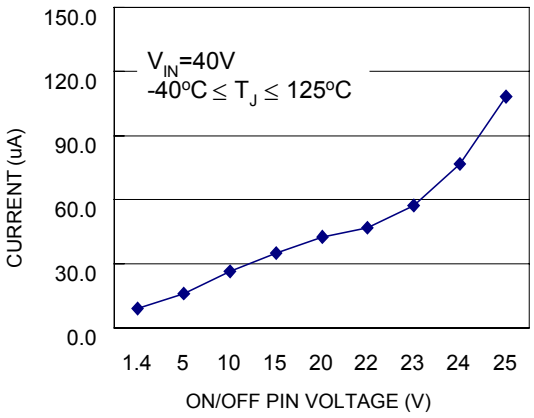
Minimum Operating Supply Voltage



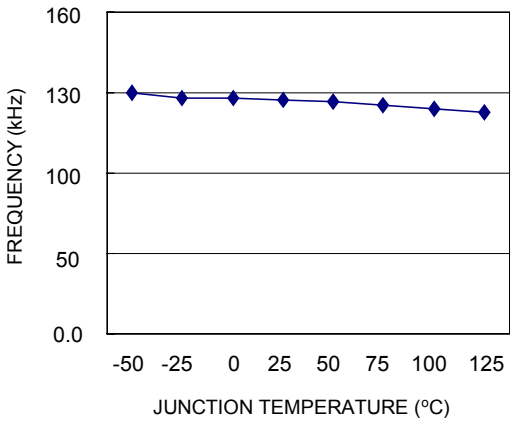
ON/OFF Threshold Voltage



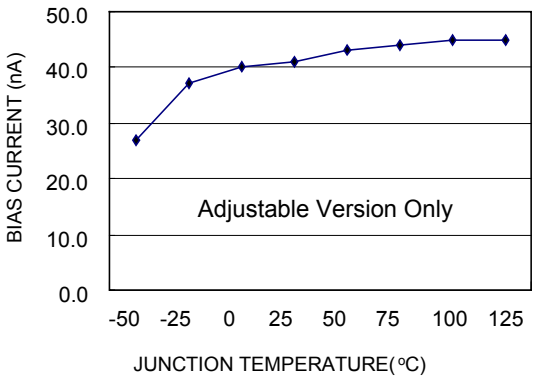
ON/OFF Pin Current (Sinking)



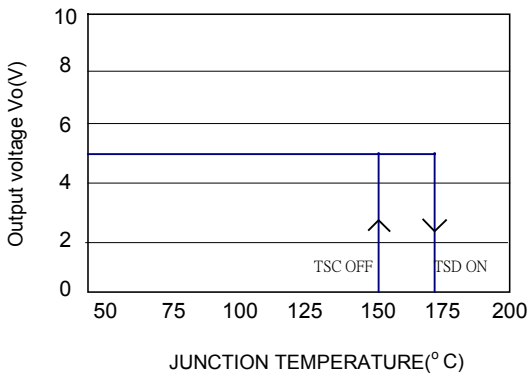
Switch Frequency



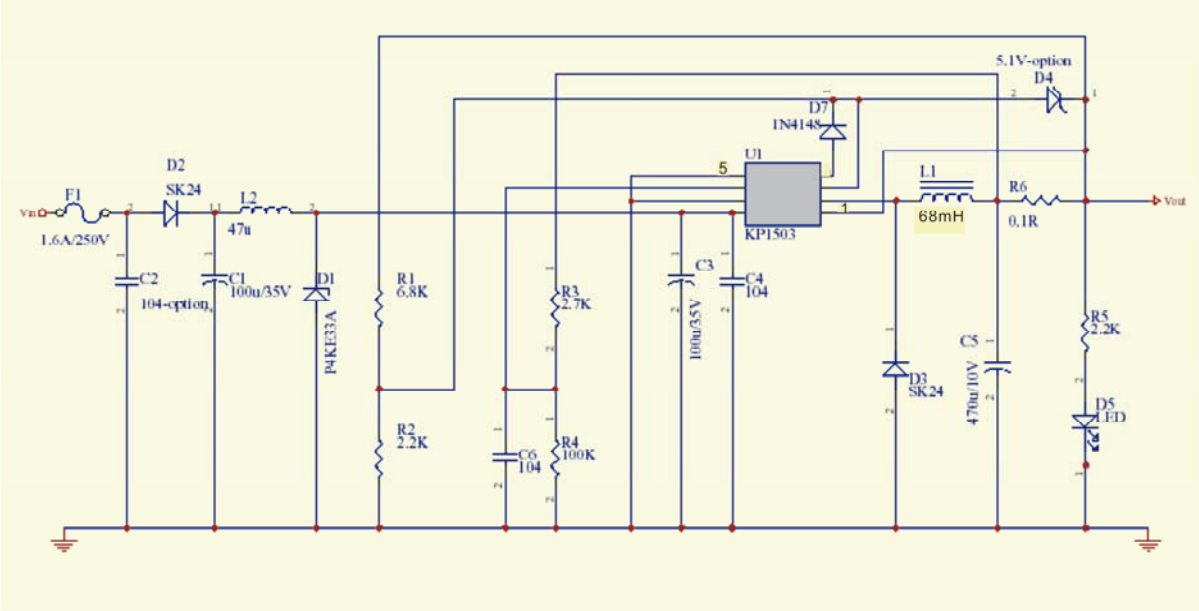
Feedback Pin Bias Current



Thermal protection



■ Typical Application Circuit(1A Battery Charger with Precisely current limit)



Some standard value of R_1 and R_2 for most commonly used output voltage are listed below.

VIN(V) /Vo (V)	R_1 (KΩ)	R_2 (KΩ)	L_1 Minimum
24/12	17.6	2	68uH
12/5.0	6	2	33uH
12/3.3	3.3	2	33uH
12/2.5	2	2	27uH
12/1.8	0.91	2	22uH
5.0/3.3	3.4	2	33uH
5.0/2.5	2.1	2	27uH
5.0/1.8	0.95	2	22uH

■ Function Description

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.

Out

Internal switch and power output. 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}. The PC board copper area connected to this pin should be kept a minimum in order to reduce the coupling sensitivity to the circuitry

Ground

Circuit ground.

Feedback
Complete the feedback loop by sensing the regulated output voltage

$\overline{\text{ON}}$/OFF
Allows the switching regulator circuit to be shutdown using logic level signals thus dropping the total input supply current to approximately 100uA. 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 $\overline{\text{ON}}$/OFF pin must be wired to the ground pin, in either case the regulator will be in the ON condition.

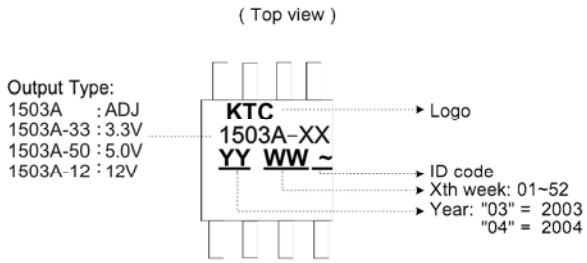
Thermal Considerations
The SOP-8 package needs a heat sink under most condictions . The size of the heatsink depends on the input voltage, the output voltage, the load current and the ambient temperature. The KP1503A junction temperature rises above ambient temperature for a 2A load and different input and output voltages. The data for these curves was taken with the KP1503A operating as a buck switching regulator in an ambient temperature of 25°C (still air). These temperature increments are all approximate and are affected by many factors. Some of these factors include board size, shape ,thickness ,position ,location, and even board temperature. Other factors are trace width, total printed circuit copper area, copper thickness , single or double-sided, multi-layer board and amount of solder on the board. Higher ambient temperatures require more heat sinking.

For the best thermal performance ,wide copper traces and generous amounts of printed circuit board copper should be used in the board layout. (One exception is the out(switch) pin, which should not have large areas of copper.) Large areas of copper provide the best transfer of heat(lower thermal resistance) to the surrounding air, and moving air lowers the thermal resistance even further.

The effectiveness of the PC board to dissipate heat also depends on the size, quantity and spacing of other components on the board , as well as whether the surrounding air is still or moving. Furthermore, some of these components such as the catch diode will add heat to the PC board and heat can vary as the input voltage changes. For the inductor, depending on the phical size, type of core material and the DC resistance, it could either act as a heat sink taking heat away from the board, or it could add heat to the board.

■ Marking Information

(1) SOP-8L



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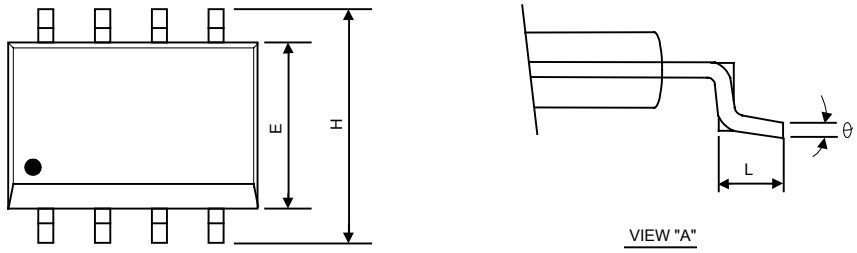
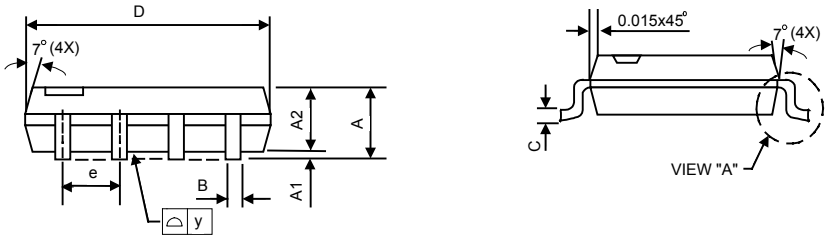
Regulator+OPERATIONAL AMPLIFIER

■ Package Information

(1) Package Type: SOP-8L





Symbol	Dimensions In Millimeters			Dimensions In Inches		
	Min.	Nom.	Max.	Min.	Nom.	Max.
A	1.40	1.60	1.75	0.055	0.063	0.069
A1	0.10	–	0.25	0.040	–	0.100
A2	1.30	1.45	1.50	0.051	0.057	0.059
B	0.33	0.41	0.51	0.013	0.016	0.020
C	0.19	0.20	0.25	0.0075	0.008	0.010
D	4.80	4.85	5.05	0.189	0.191	0.199
E	3.80	3.91	4.00	0.125	0.154	0.157
e	–	1.27	–	–	0.050	–
H	5.79	5.99	6.20	0.228	0.236	0.244
L	0.38	0.71	1.27	0.015	0.028	0.050
y	–	–	0.10	–	–	0.004
θ	0^O	–	8^O	0^O	–	8^O