

# FAN2534/FAN2535

## 150 mA CMOS LDO Regulator with Fast Start, Enable

### Features

- 70dB Ripple rejection (>45dB up to 1MHz)
- 150µsec Power On Time
- 150µsec Enable Time
- Low noise - 50µVrms
- Enable optimized for CDMA time slices
- 180 mV dropout voltage at 150 mA
- Enable/Shutdown Control
- Enable time independent of noise bypass capacitor value
- SOT23-5 package
- Thermal limiting
- 300 mA trimmed current limit

### Applications

- Cellular Phones and accessories
- PDAs
- Portable cameras and video recorders
- Laptop, notebook and palmtop computers

### Description

The FAN2534/FAN2535 family of micropower low-dropout voltage regulators utilize CMOS technology to offer a new level of cost-effective performance in GSM, TDMA, and CDMA cellular handsets, laptop and notebook computers, and other portable devices. Proprietary design technics ensure high ripple rejection. Other features include low noise, short circuit current limit, thermal shutdown circuit,

low dropout voltage, fast enable required in CDMA handset applications, exceptional loop stability to accommodate a wide variety of external capacitors, and a compact SOT23-5 surface-mount package. These products offer significant improvements over older Bipolar and CMOS designs and are pin-compatible with many popular devices.

The FAN2534 and FAN2535 devices are distinguished by the assignment of pin 4:

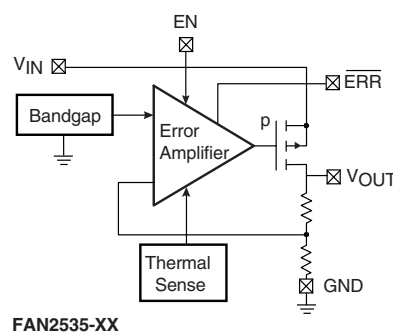
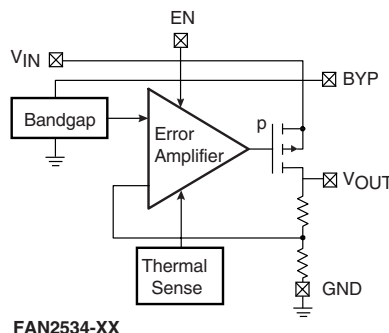
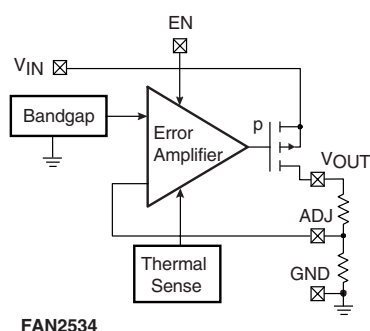
**FAN2534:** pin 4 – ADJ, allowing the user to adjust the output voltage over a wide range using an external voltage divider.

**FAN2534-XX:** pin 4 – BYP, to which a bypass capacitor may be connected for optimal noise performance. Output voltage is fixed, as specified by the suffix XX.

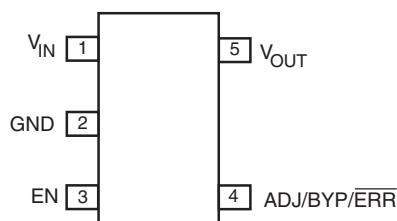
**FAN2535-XX:** pin 4 –  $\overline{\text{ERR}}$ , a flag which indicates that the output voltage has dropped below the specified minimum due to a fault condition.

The standard fixed output voltages available are 2.6V, 2.85V, and 3.0V. Custom output voltages are also available: please contact your local Fairchild Sales Office for information.

### Block Diagrams



## Pin Assignments



Pin No.	FAN2534	FAN2534-XX	FAN2535-XX
1.	V <sub>IN</sub>	V <sub>IN</sub>	V <sub>IN</sub>
2.	GND	GND	GND
3.	EN	EN	EN
4.	ADJ	BYP	$\overline{\text{ERR}}$
5.	V <sub>OUT</sub>	V <sub>OUT</sub>	V <sub>OUT</sub>

## Pin Descriptions

Pin Name	Pin No.	Type	Pin Function Description
ADJ	4	Input	<b>FAN2534 Adjust.</b> Ratio of potential divider from V <sub>OUT</sub> to ADJ determines output voltage.
BYP	4	Passive	<b>FAN2534-XX Bypass.</b> Connect 10 nF capacitor for noise reduction.
$\overline{\text{ERR}}$	4	Open drain	<b>FAN2535-XX Error.</b> Error flag output. LOW when V <sub>out</sub> < 95% of nominal; HIGH when V <sub>out</sub> > 95% of nominal.
EN	3	Digital Input	<b>Enable.</b> LOW in Shutdown Mode; HIGH in Enable Mode
V <sub>IN</sub>	1	Power in	<b>Voltage Input.</b> Supply voltage input.
V <sub>OUT</sub>	5	Power out	<b>Voltage Output.</b> Regulated output voltage.
GND	2	Power	<b>Ground.</b>

## Absolute Maximum Ratings (Note 1)

Parameter	Min.	Typ.	Max.	Unit
<b>Power Supply Voltages</b>				
V <sub>IN</sub> (Measured to GND); Enable Input (EN); $\overline{\text{ERR}}$ Output;	0		7	V
Power Dissipation	Internally limited			
Operating Junction Temperature	-65		150	°C
Lead Soldering (5 seconds)			260	°C
Storage	-65		150	°C
Electrostatic Discharge (Note 2)	4			kV

## Operating Conditions

Symbol	Parameter	Min.	Typ.	Max.	Units
$V_{IN}$	Input Voltage Range	$V_{OUT}+V_{DO}$		6.5	V
$V_{OUT}$	Output Voltage Range FAN2534-XX, FAN2535-XX (Note 3)	2.3		3.3	V
$V_{OUT}$	Output Voltage Range (FAN2534 only)	2.0		5.0	V
$V_{EN}$	Enable Input Voltage	0		$V_{IN}$	V
$V_{ERR}$	$\overline{ERR}$ Flag Voltage			$V_{IN}$	V
$T_J$	Junction Temperature	-40		+125	°C
$\theta_{JA}$	Thermal resistance		220		°C/W
$\theta_{JC}$	Thermal resistance		130		°C/W

## DC Electrical Characteristics (Notes 4, 5)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Units
<b>Regulator</b>						
$V_{DO}$	Drop Out Voltage (Note 6)	$I_{OUT} = 100 \mu A$		2.5	4	mV
		$I_{OUT} = 50 \text{ mA}$		50	75	mV
		$I_{OUT} = 100 \text{ mA}$		100	140	mV
		$I_{OUT} = 150 \text{ mA}$		180	220	mV
$\Delta V_O$	Output Voltage Accuracy (Note 7)	Initial Accuracy at no load	-1		1	%
		<b>Over Line, Load &amp; Temp</b>	<b>-3.7</b>		<b>2</b>	%
$I_{GND(NL)}$	Ground Pin Current	No Load		90		$\mu A$
$I_{GND(FL)}$	Ground Pin Current	$I_{OUT} = 150 \text{ mA}$		110		$\mu A$
<b>Protection</b>						
	Current Limit			300	<b>400</b>	mA
$I_{GSD}$	Shut-Down Current	EN = 0V			<b>1</b>	$\mu A$
$T_{SH}$	Thermal Shutdown Temperature Hysteresis			155		°C
				15		°C
$E_{TL}$	$\overline{ERR}$ Trip Level	FAN2535 only	90	93	96	%
<b>Enable Input</b>						
$V_{EL}$	Logic Low Voltage			0.4	1.2	V
$V_{EH}$	Logic High Voltage		1.4	2		V
$I_{EH}$	Input Current High				1	$\mu A$
$I_{EL}$	Input Current Low				1	$\mu A$

## Switching Characteristics (Notes 4, 5)

Parameter	Conditions	Min.	Typ.	Max.	Unit
Enable Response time (Note 8)	$C_L=10\mu\text{F}$ $C_{BP}=10\text{nF}$		150	<b>300</b>	$\mu\text{sec}$
Power "ON" Response time	$C_L=10\mu\text{F}$ $C_{BP}=10\text{nF}$ $V_{OUT} = 3.0\text{V}$		150	<b>500</b>	$\mu\text{sec}$
Error Flag Response time (FAN2535-XX only)				<b>3</b>	msec

## AC Performance Characteristics (Notes 4, 5)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Units
$\frac{\Delta V_{OUT}}{\Delta V_{IN}}$	Line regulation	$V_{IN} = (V_{OUT} + 1)$ to 6.5V, $I_L = 10\text{mA}$		0.05	0.2	%/V
$\frac{\Delta V_{OUT}}{V_{OUT}}$	Load regulation	$I_{OUT} = 0.1$ to 100mA		1.0	2.0	%
$e_N$	Output noise	BW: 300Hz–50KHz $C_{OUT} = 10\mu\text{F}$ , $C_{BYP} = 0.01\mu\text{F}$		50		$\mu\text{VRMS}$
PSRR	Power Supply Ripple Rejection	100 Hz, $C_{OUT} = 1\mu\text{F}$ , $C_{BYP} = 0.01\mu\text{F}$ $0\text{mA} < I_L < 150\text{mA}$		70		dB

### Notes:

- Functional operation under any of these conditions is NOT implied. Performance and reliability are guaranteed only if Operating Conditions are not exceeded.
- Using Mil Std. 883E, method 3015.7(Human Body Model), 400V when using JEDEC method A115-A (Machine Model).
- For specific output voltages of the fixed output voltage versions please refer to the table: "Output Voltage Options and Ordering Information" on Page 9. Custom fixed output voltages, not listed in the table, are also available.
- Unless otherwise stated,  $T_A = 25^\circ\text{C}$ ,  $V_{IN} = V_{OUT} + 1\text{V}$ ,  $I_{OUT} = 100\mu\text{A}$ ,  $V_{EH} > 2.0\text{V}$ .
- Bold values indicate  $-40 < T_J < 125^\circ\text{C}$ .
- Dropout Voltage is defined as the input to output differential at which the output voltage drops to 2% below the nominal value measured at 1V input - output differential.
- Adjustable version, has a bandgap reference voltage of 1.0V, trimmed to +/-1% initial accuracy.
- When using repeated cycling,  $F > 0.5\text{Hz}$ .

## Functional Description

Utilizing CMOS technology, the FAN2534/FAN2535 product family is optimized for use in compact battery powered systems, offering a unique combination of high ripple rejection, low noise, low power consumption, extremely low dropout voltages, high tolerance for a variety of output capacitors, and less than 1 $\mu$ A "OFF" current. In the circuit, a differential amplifier controls a series-pass P-Channel MOSFET, and a separate error amplifier compares the load voltage at the output with an onboard trimmed low voltage bandgap reference. The series resistance of the pass P-Channel MOSFET is approximately 1 Ohm, yielding an unusually low dropout voltage even under high load conditions.

Thermal shutdown and current limit circuits protect the device under extreme conditions. When the device temperature reaches 155°C, the output is disabled, until the device cooles down by 15°C, then re-enabled. The user can to shut down the device using the Enable control pin at any time. The current limit circuit is trimmed, which leads to consistent power on /enable delays, and provides safe short circuit current densities even in narrow traces of the PCB.

A carefully optimized control loop accommodates a wide range of ESR values in the output bypass capacitor, allowing the user to optimize space, cost, and performance requirements.

An Enable pin shuts down the regulator output to conserve power, reducing supply current to less than 1 $\mu$ A. The output can then be re-Enabled within 150 $\mu$ Sec, fulfilling the fast power-cycling needs of CDMA applications.

Depending on the device type selected, other control and status functions are available at pin 4. The fixed-voltage versions are available with either a noise-bypass pin or an Error flag pin option. The error flag can be used as a diagnostic function to indicate that the output voltage has dropped more than 5% below the nominal value.

The adjustable-voltage versions utilize pin 4 to connect to an external voltage divider which feeds back to the regulator error amplifier, thus setting the output voltage to the desired value.

## Applications Information

### External Capacitors – Selection

The FAN2534/FAN2535 allows the user to utilize a wide variety of capacitors compared to other LDO products. An innovative design approach offers significantly reduced sensitivity to ESR (Equivalent Series Resistance), which degrades regulator loop stability in older designs. While the improvements featured in the FAN2534/FAN2535 family greatly simplify the design task, capacitor quality still must be considered if the designer is to achieve optimal circuit performance. In general, ceramic capacitors offer superior ESR performance, and a smaller case size than tantalums.

### Input Capacitor

An input capacitor of 2.2 $\mu$ F (nominal value) or greater, connected between the Input pin and Ground, placed in close proximity to the device, will improve transient response and ripple rejection. Higher values will further improve ripple rejection and transient response. An input capacitor is recommended when the input source, either a battery or a regulated AC voltage, is located far from the device. Any good quality ceramic, tantalum, or metal film capacitor will give acceptable performance, however in extreme cases capacitor surge current ratings may have to be considered.

### Output Capacitor

An output capacitor is required to maintain regulator loop stability. Stable operation will be achieved with a wide variety of capacitors with ESR values ranging from 0m $\Omega$  up to 400m $\Omega$ . Multilayer ceramic, tantalum or aluminum electrolytic capacitors may be used. A nominal value of at least 1 $\mu$ F is recommended. Note that the choice of output capacitor effects load transient response, ripple rejection, and it has a slight effect on noise performance as well.

### Bypass Capacitor (FAN2534-XX Only)

In the fixed-voltage configuration, connecting a capacitor between the bypass pin and ground can significantly reduce output noise. Values ranging from 0pF to 47nF can be used, depending on the sensitivity to output noise in the application.

At the high-impedance Bypass pin, care must be taken in the PCB layout to minimize noise pickup, and capacitors must be selected to minimize current loading (leakage). Noise pickup from external sources can be considerable. Leakage currents into the Bypass pin will directly affect regulator accuracy and should be kept as low as possible; thus, high-quality ceramic and film types are recommended for their low leakage characteristics. Cost-sensitive applications not concerned with noise can omit this capacitor.

## Control Functions

### Enable Pin

Connecting 2.0V or greater to the Enable pin will enable the output, while 0.4V or less will disable it while reducing the quiescent current consumption to less than 1 $\mu$ A. If this shutdown function is not needed, the pin can simply be connected permanently to the V<sub>IN</sub> pin. Allowing this pin to float will cause erratic operation.

### Error Flag (FAN2535-XX Only)

Fault conditions such as input voltage dropout (low V<sub>IN</sub>), overheating, or overloading (excessive output current), will set an error flag: The  $\overline{\text{ERR}}$  pin which is an open-drain output, will go LOW when V<sub>OUT</sub> is less than 95% or the specified output voltage. When the voltage at V<sub>OUT</sub> is greater than 95% of the specified output voltage, the  $\overline{\text{ERR}}$  pin is HIGH. A logic pullup resistor of 100K Ohm is recommended at this output. The pin can be left disconnected if unused.

### Thermal Protection

The FAN2534/FAN2535 is designed to supply high peak output currents for brief periods, however sustained excessive output load at high input - output voltage difference will cause the device temperature to increase and exceed maximum ratings due to power dissipation. During output overload conditions, when the die temperature exceeds the shutdown limit temperature of 155°C, an onboard thermal protection will disable the output until the temperature drops approximately 15°C below the limit, at which point the output is re-enabled. During a thermal shutdown situation the user may assert the power-down function at the Enable pin, reducing power consumption to a minimum.

### Thermal Characteristics

The FAN2534/FAN2535 is designed to supply 150mA at the specified output voltage with an operating die (junction) temperature of up to 125°C. Once the power dissipation and thermal resistance is known, the maximum junction temperature of the device can be calculated. While the power dissipation is calculated from known electrical parameters, the actual thermal resistance depends on the thermal characteristics of the SOT23-5 surface-mount package and the surrounding PC Board copper to which it is mounted.

The power dissipation is equal to the product of the input-to-output voltage differential and the output current plus the ground current multiplied by the input voltage, or:

$$P_D = (V_{IN} - V_{OUT})I_{OUT} + V_{IN}I_{GND}$$

The ground pin current I<sub>GND</sub> can be found in the charts provided in the Electrical Characteristics section.

The relationship describing the thermal behavior of the package is:

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

where T<sub>J(max)</sub> is the maximum allowable junction temperature of the die, which is 125°C, and T<sub>A</sub> is the ambient operating temperature.  $\theta_{JA}$  is dependent on the surrounding PC board layout and can be empirically obtained. While the  $\theta_{JC}$  (junction-to-case) of the SOT23-5 package is specified at 130°C/W, the  $\theta_{JA}$  of the minimum PWB footprint will be at least 235°C/W. This can be improved upon by providing a heat sink of surrounding copper ground on the PWB. Depending on the size of the copper area, the resulting  $\theta_{JA}$  can range from approximately 180°C/W for one square inch to nearly 130°C/W for 4 square inches. The addition of backside copper with through-holes, stiffeners, and other enhancements can also aid in reducing thermal resistance. The heat contributed by the dissipation of other devices located nearby must be included in the design considerations. Once the limiting parameters in these two relationships have been determined, the design can be modified to ensure that the device remains within specified operating conditions. If overload conditions are not considered, it is possible for the device to enter a thermal cycling loop, in which the circuit enters a shutdown condition, cools, re-enables, and then again overheats and shuts down repeatedly due to an unmanaged fault condition.

### Adjustable Version

The FAN2534 adjustable version includes an input pin ADJ which allows the user to select an output voltage ranging from 2.5V to near V<sub>IN</sub>, using an external resistor divider. The voltage V<sub>ADJ</sub> presented to the ADJ pin is fed to the onboard error amplifier which adjusts the output voltage until V<sub>ADJ</sub> is equal to the onboard bandgap reference voltage of 1.00V(typ). The equation is:

$$V_{OUT} = 1.00V \times \left[ 1 + \frac{R_{upper}}{R_{lower}} \right]$$

Since the bandgap reference voltage is trimmed, 1% initial accuracy can be achieved. The total value of the resistor chain should not exceed 250K Ohm total to keep the error amplifier biased during no-load conditions. Programming output voltages very near V<sub>IN</sub> need to allow for the magnitude and variation of the dropout voltage V<sub>DO</sub> over load, supply, and temperature variations. Note that the low-leakage FET input to the CMOS Error Amplifier induces no bias current error to the calculation.

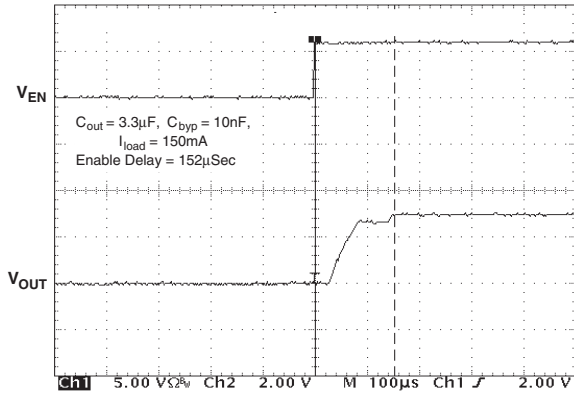
### General PWB Layout Considerations

For optimum device performance, careful circuit layout and grounding technics must be used. Establishing a small local ground, to which the GND pin, and the output and bypass capacitors are connected, is recommended, while the input capacitor should be grounded to the main ground plane.

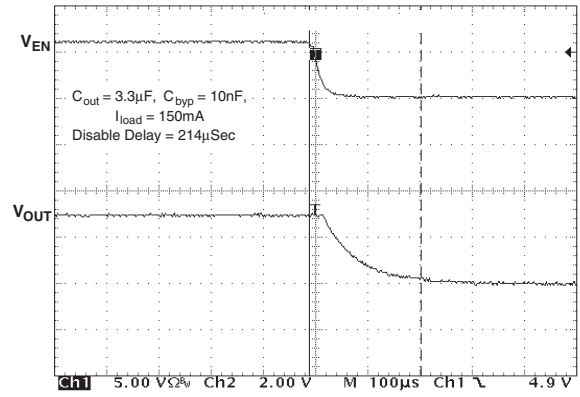
The quiet local ground is then routed back to the main ground plane using feedthrough vias. In general, the high-frequency compensation components (input, bypass, and output capacitors) should be located as close to the device as possible. The proximity of the output capacitor is especially important to achieve optimum performance, especially during high load conditions. A large copper area in the local ground serves as heat sink (as discussed above) when high power dissipation significantly increases device temperature. Component-side copper provides significantly better thermal performance. Added feedthrough connecting the device side ground plane to the back plane further reduces thermal resistance.

# Typical Performance Characteristics

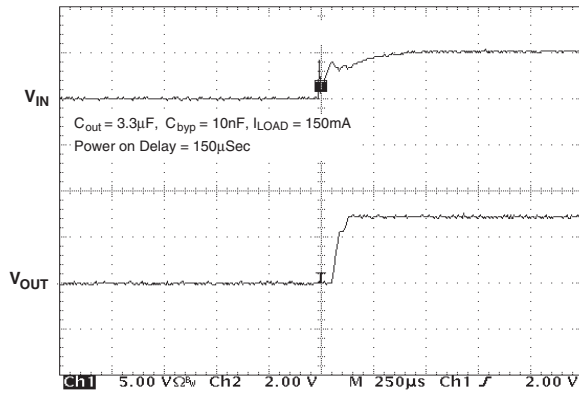
**Enable Delay**



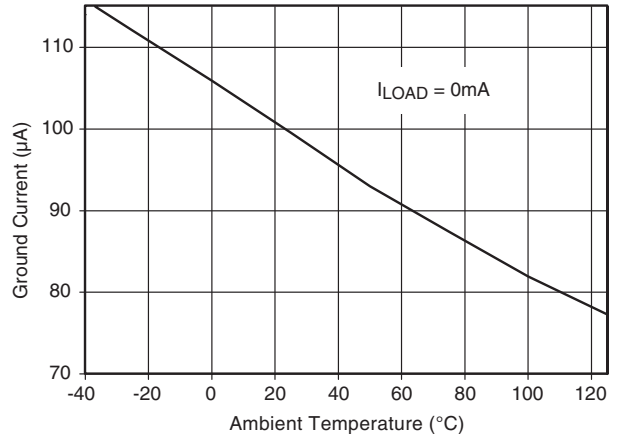
**Disable Delay**



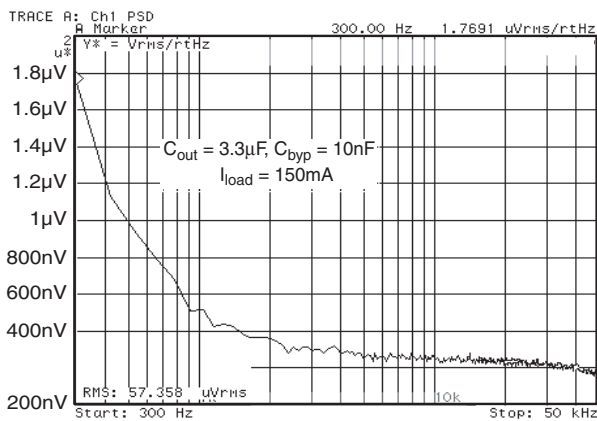
**Power on Delay**



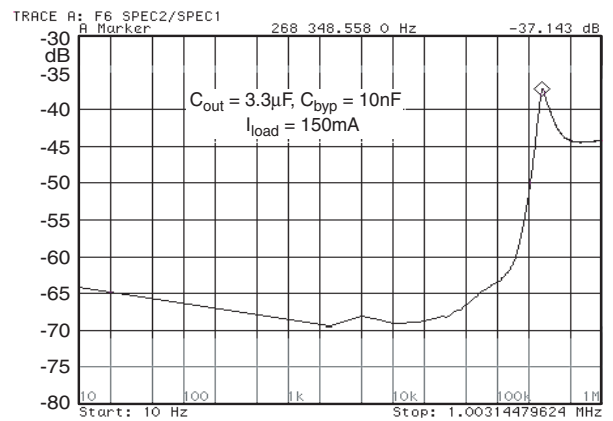
**Ground Current vs Ambient Temperature**



**Noise Plot**

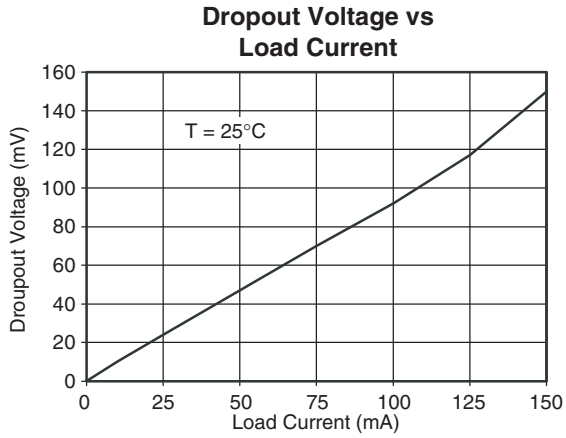
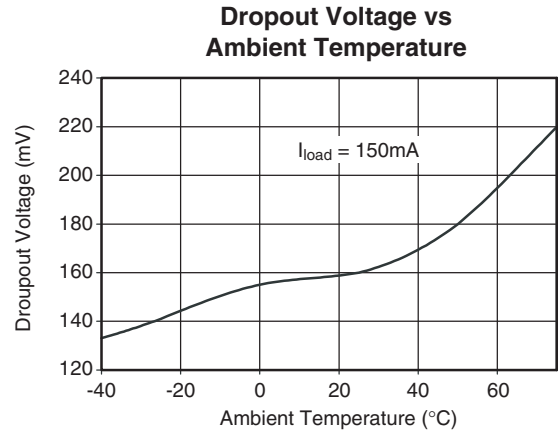
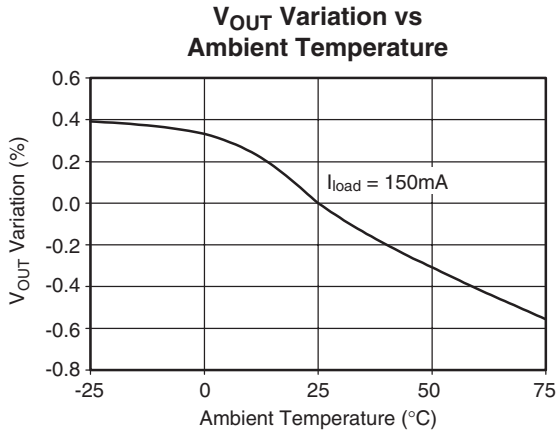


**Ripple Rejection Plot**



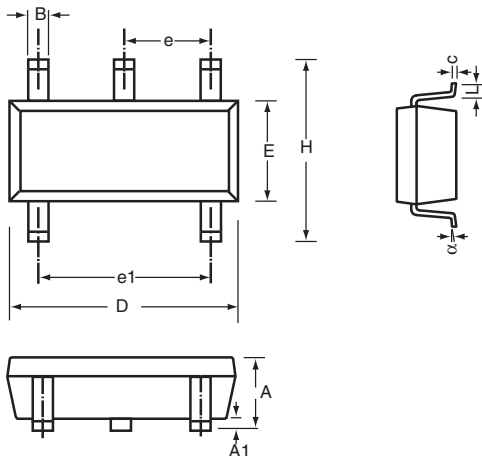


### Typical Performance Characteristics (Continued)



# Mechanical Dimensions

## 5-Lead SOT-23 Package



Symbol	Inches		Millimeters		Notes
	Min	Max	Min	Max	
A	.035	.057	.90	1.45	
A1	.000	.006	.00	.15	
B	.008	.020	.20	.50	
c	.003	.010	.08	.25	
D	.106	.122	2.70	3.10	
E	.059	.071	1.50	1.80	
e	.037 BSC		.95 BSC		
e1	.075 BSC		1.90 BSC		
H	.087	.126	2.20	3.20	
L	.004	.024	.10	.60	
α	0°	10°	0°	10°	

## Output Voltage Options and Ordering Information

Product Number	V <sub>OUT</sub>	Pin 4 Function	Package Marking
FAN2534SX	Adj.	Adjust	AJA
FAN2534S26X	2.6	Bypass	AJG
FAN2534S30X	3.0	Bypass	AJW
FAN2535S26X	2.6	Error output	AKG
FAN2535S285X	2.85	Error output	AKN

## Tape and Reel Information

Quantity	Reel Size	Width
3000	7"	8mm

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