

# Single/Dual/Quad 220MHz, 1500V/ $\mu$ s Operational Amplifiers with Programmable Supply Current

## FEATURES

- 220MHz Gain-Bandwidth Product
- 1500V/ $\mu$ s Slew Rate
- 6.5mA Supply Current per Amplifier
- Space Saving MSOP and SSOP Packages
- Ultra Small SOT-23 and Leadless DFN Packages
- Programmable Current Option
- 6nV/ $\sqrt{\text{Hz}}$  Input Noise Voltage
- Unity-Gain Stable
- 1.5mV Maximum Input Offset Voltage
- 8 $\mu$ A Maximum Input Bias Current
- 800nA Maximum Input Offset Current
- 50mA Minimum Output Current,  $V_{\text{OUT}} = \pm 3\text{V}$
- $\pm 3.5\text{V}$  Minimum Input CMR,  $V_{\text{S}} = \pm 5\text{V}$
- Specified at  $\pm 5\text{V}$ , Single 5V Supplies
- Operating Temperature Range:  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$

## APPLICATIONS

- Wideband Amplifiers
- Buffers
- Active Filters
- Video and RF Amplification
- Communication Receivers
- Cable Drivers
- Data Acquisition Systems

## DESCRIPTION

The LT<sup>®</sup>1815/LT1816/LT1817 are low power, high speed, very high slew rate operational amplifiers with excellent DC performance. The LT1815/LT1816/LT1817 feature higher bandwidth and slew rate, much lower input offset voltage and lower noise and distortion than other devices with comparable supply current. A programmable current option (LT1815 and LT1816A) allows power savings and flexibility by operating at reduced supply current and speed. The circuit topology is a voltage feedback amplifier with the slewing characteristics of a current feedback amplifier.

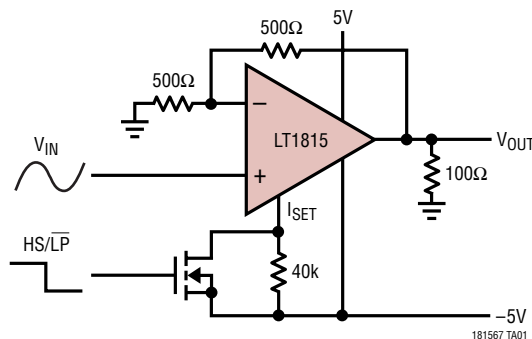
The output drives a 100 $\Omega$  load to  $\pm 3.8\text{V}$  with  $\pm 5\text{V}$  supplies. On a single 5V supply, the output swings from 1V to 4V with a 100 $\Omega$  load connected to 2.5V. Harmonic distortion is  $-70\text{dB}$  for a 5MHz, 2V<sub>p-p</sub> output driving a 100 $\Omega$  load in a gain of  $-1$ .

The LT1815/LT1816/LT1817 are manufactured on Linear Technology's advanced low voltage complementary bipolar process and are available in a variety of SOT-23, SO, MSOP, SSOP and leadless DFN packages.

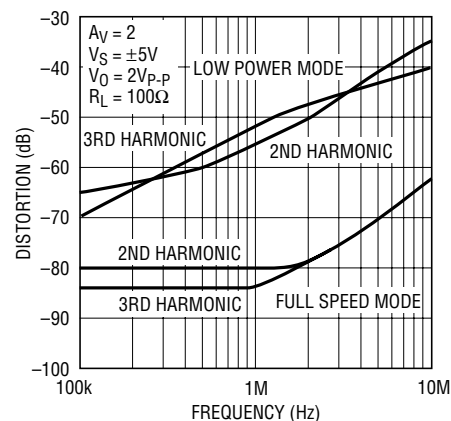
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## TYPICAL APPLICATION

Programmable Current Amplifier Switches  
from Low Power Mode to Full Speed Mode



Distortion vs Frequency

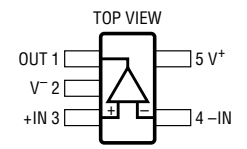
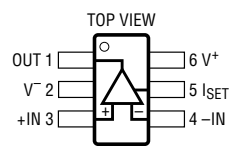
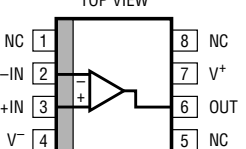
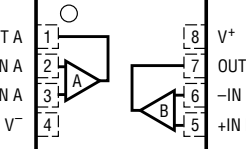
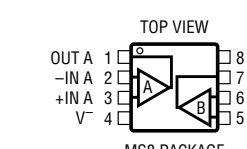
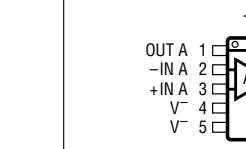
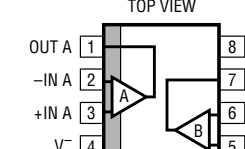
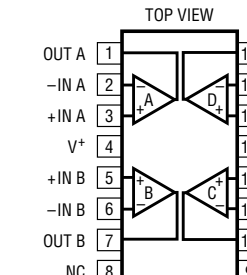
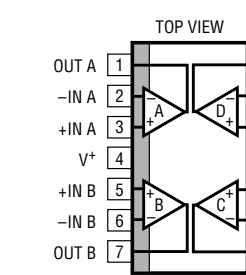


# LT1815 LT1816/LT1817

## ABSOLUTE MAXIMUM RATINGS (Note 1)

Total Supply Voltage ( $V^+$ to $V^-$ ) .....	12.6V	Specified Temperature Range (Note 8) ...	$-40^\circ\text{C}$ to $85^\circ\text{C}$
Differential Input Voltage (Transient Only, Note 2) .....	$\pm 6\text{V}$	Maximum Junction Temperature .....	$150^\circ\text{C}$
Input Voltage .....	$\pm V_S$	(DD Package) .....	$125^\circ\text{C}$
Output Short-Circuit Duration (Note 3) .....	Indefinite	Storage Temperature Range .....	$-65^\circ\text{C}$ to $150^\circ\text{C}$
Operating Temperature Range .....	$-40^\circ\text{C}$ to $85^\circ\text{C}$	(DD Package) .....	$-65^\circ\text{C}$ to $125^\circ\text{C}$
		Lead Temperature (Soldering, 10 sec) .....	$300^\circ\text{C}$

## PACKAGE/ORDER INFORMATION

 <p>TOP VIEW</p> <p>OUT 1 5 <math>V^+</math></p> <p><math>V^-</math> 2</p> <p>+IN 3 4 -IN</p> <p>S5 PACKAGE 5-LEAD PLASTIC SOT-23 <math>T_{JMAX} = 150^\circ\text{C}</math>, <math>\theta_{JA} = 250^\circ\text{C/W}</math> (NOTE 9)</p>		 <p>TOP VIEW</p> <p>OUT 1 6 <math>V^+</math></p> <p><math>V^-</math> 2</p> <p>+IN 3 4 -IN</p> <p>5 ISET</p> <p>S6 PACKAGE 6-LEAD PLASTIC SOT-23 <math>T_{JMAX} = 150^\circ\text{C}</math>, <math>\theta_{JA} = 230^\circ\text{C/W}</math> (NOTE 9)</p>		 <p>TOP VIEW</p> <p>NC 1 8 NC</p> <p>-IN 2 7 <math>V^+</math></p> <p>+IN 3 6 OUT</p> <p><math>V^-</math> 4 5 NC</p> <p>S8 PACKAGE 8-LEAD PLASTIC SO <math>T_{JMAX} = 150^\circ\text{C}</math>, <math>\theta_{JA} = 150^\circ\text{C/W}</math> (NOTE 9)</p>		 <p>TOP VIEW</p> <p>OUT A 1 8 <math>V^+</math></p> <p>-IN A 2 7 OUT B</p> <p>+IN A 3 6 -IN B</p> <p><math>V^-</math> 4 5 +IN B</p> <p>DD PACKAGE 8-LEAD (3mm x 3mm) PLASTIC DFN <math>T_{JMAX} = 125^\circ\text{C}</math>, <math>\theta_{JA} = 160^\circ\text{C/W}</math> (NOTE 9) UNDERSIDE METAL INTERNALLY CONNECTED TO <math>V^-</math></p>	
ORDER PART NUMBER	S5 PART MARKING	ORDER PART NUMBER	S6 PART MARKING	ORDER PART NUMBER	S8 PART MARKING	ORDER PART NUMBER	DD PART MARKING*
LT1815CS5 LT1815IS5	LTUP LTVC	LT1815CS6 LT1815IS6	LTUL LTVD	LT1815CS8 LT1815IS8	1815 1815I	LT1816CDD LT1816IDD	LAAR
 <p>TOP VIEW</p> <p>OUT A 1 8 <math>V^+</math></p> <p>-IN A 2 7 OUT B</p> <p>+IN A 3 6 -IN B</p> <p><math>V^-</math> 4 5 +IN B</p> <p>MS8 PACKAGE 8-LEAD PLASTIC MSOP <math>T_{JMAX} = 150^\circ\text{C}</math>, <math>\theta_{JA} = 250^\circ\text{C/W}</math> (NOTE 9)</p>		 <p>TOP VIEW</p> <p>OUT A 1 10 <math>V^+</math></p> <p>-IN A 2 9 OUT B</p> <p>+IN A 3 8 -IN B</p> <p><math>V^-</math> 4 7 +IN B</p> <p>5 ISET</p> <p>MS10 PACKAGE 10-LEAD PLASTIC MSOP <math>T_{JMAX} = 150^\circ\text{C}</math>, <math>\theta_{JA} = 250^\circ\text{C/W}</math> (NOTE 9)</p>		 <p>TOP VIEW</p> <p>OUT A 1 8 <math>V^+</math></p> <p>-IN A 2 7 OUT B</p> <p>+IN A 3 6 -IN B</p> <p><math>V^-</math> 4 5 +IN B</p> <p>S8 PACKAGE 8-LEAD PLASTIC SO <math>T_{JMAX} = 150^\circ\text{C}</math>, <math>\theta_{JA} = 150^\circ\text{C/W}</math> (NOTE 9)</p>			
ORDER PART NUMBER	MS8 PART MARKING	ORDER PART NUMBER	MS10 PART MARKING	ORDER PART NUMBER	S8 PART MARKING		
LT1816CMS8 LT1816IMS8	LTWA LTNQ	LT1816ACMS LT1816AIMS	LTYA LTXX	LT1816CS8 LT1816IS8	1816 1816I		
 <p>TOP VIEW</p> <p>OUT A 1 16 OUT D</p> <p>-IN A 2 15 -IN D</p> <p>+IN A 3 14 +IN D</p> <p><math>V^+</math> 4 13 <math>V^-</math></p> <p>+IN B 5 12 +IN C</p> <p>-IN B 6 11 -IN C</p> <p>OUT B 7 10 OUT C</p> <p>NC 8 9 NC</p> <p>GN PACKAGE 16-LEAD PLASTIC SSOP <math>T_{JMAX} = 150^\circ\text{C}</math>, <math>\theta_{JA} = 135^\circ\text{C/W}</math></p>		ORDER PART NUMBER	 <p>TOP VIEW</p> <p>OUT A 1 14 OUT D</p> <p>-IN A 2 13 -IN D</p> <p>+IN A 3 12 +IN D</p> <p><math>V^+</math> 4 11 <math>V^-</math></p> <p>+IN B 5 10 +IN C</p> <p>-IN B 6 9 -IN C</p> <p>OUT B 7 8 OUT C</p> <p>S PACKAGE 14-LEAD PLASTIC SO <math>T_{JMAX} = 150^\circ\text{C}</math>, <math>\theta_{JA} = 100^\circ\text{C/W}</math></p>		ORDER PART NUMBER		
		LT1817CGN LT1817IGN			LT1817CS LT1817IS		
		GN PART MARKING					
		1817 1817I					

Consult LTC Marketing for parts specified with wider operating temperature ranges.

\*The temperature grades are identified by a label on the shipping container.

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**ELECTRICAL CHARACTERISTICS** The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at  $T_A = 25^\circ\text{C}$  (Note 8).  $V_S = \pm 5\text{V}$ ,  $V_{CM} = 0\text{V}$  unless otherwise noted. For the programmable current option (LT1815S6 or LT1816A), the  $I_{SET}$  pin must be connected to  $V^-$  through  $75\Omega$  or less, unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
$V_{OS}$	Input Offset Voltage	(Note 4) $T_A = 0^\circ\text{C to } 70^\circ\text{C}$ $T_A = -40^\circ\text{C to } 85^\circ\text{C}$	●	0.2	1.5	mV
		●		2.0	mV	
$\frac{\Delta V_{OS}}{\Delta T}$	Input Offset Voltage Drift	$T_A = 0^\circ\text{C to } 70^\circ\text{C}$ (Note 7) $T_A = -40^\circ\text{C to } 85^\circ\text{C}$ (Note 7)	●	10	15	$\mu\text{V}/^\circ\text{C}$
			●	10	30	$\mu\text{V}/^\circ\text{C}$
			●			
$I_{OS}$	Input Offset Current	$T_A = 0^\circ\text{C to } 70^\circ\text{C}$ $T_A = -40^\circ\text{C to } 85^\circ\text{C}$	●	60	800	nA
			●		1000	nA
$I_B$	Input Bias Current	$T_A = 0^\circ\text{C to } 70^\circ\text{C}$ $T_A = -40^\circ\text{C to } 85^\circ\text{C}$	●	-2	$\pm 8$	$\mu\text{A}$
			●		$\pm 10$	$\mu\text{A}$
$e_n$	Input Noise Voltage Density	$f = 10\text{kHz}$		6		$\text{nV}/\sqrt{\text{Hz}}$
$i_n$	Input Noise Current Density	$f = 10\text{kHz}$		1.3		$\text{pA}/\sqrt{\text{Hz}}$
$R_{IN}$	Input Resistance	$V_{CM} = \pm 3.5\text{V}$ Differential		1.5	5	$\text{M}\Omega$
					750	$\text{k}\Omega$
$C_{IN}$	Input Capacitance			2		pF
$V_{CM}$	Input Voltage Range	Guaranteed by CMRR $T_A = -40^\circ\text{C to } 85^\circ\text{C}$	●	$\pm 3.5$	$\pm 4.2$	V
				$\pm 3.5$		V
CMRR	Common Mode Rejection Ratio	$V_{CM} = \pm 3.5\text{V}$ $T_A = 0^\circ\text{C to } 70^\circ\text{C}$ $T_A = -40^\circ\text{C to } 85^\circ\text{C}$	●	75	85	dB
			●	73		dB
			●	72		dB
PSRR	Power Supply Rejection Ratio	Guaranteed by PSRR $T_A = -40^\circ\text{C to } 85^\circ\text{C}$	●	$\pm 1.25$	$\pm 2$	V
			●		$\pm 2$	V
AVOL	Large-Signal Voltage Gain	$V_{OUT} = \pm 3\text{V}$ , $R_L = 500\Omega$ $T_A = 0^\circ\text{C to } 70^\circ\text{C}$ $T_A = -40^\circ\text{C to } 85^\circ\text{C}$	●	1.5	3	V/mV
			●	1.0		V/mV
			●	0.8		V/mV
V <sub>OUT</sub>	Maximum Output Swing	$R_L = \pm 3\text{V}$ , $R_L = 100\Omega$ $T_A = 0^\circ\text{C to } 70^\circ\text{C}$ $T_A = -40^\circ\text{C to } 85^\circ\text{C}$	●	0.7	2.5	V/mV
			●	0.5		V/mV
			●	0.4		V/mV
V <sub>OUT</sub>	Maximum Output Swing	$R_L = 500\Omega$ , 30mV Overdrive $T_A = 0^\circ\text{C to } 70^\circ\text{C}$ $T_A = -40^\circ\text{C to } 85^\circ\text{C}$	●	$\pm 3.8$	$\pm 4.1$	V
			●	$\pm 3.7$		V
			●	$\pm 3.6$		V
V <sub>OUT</sub>	Maximum Output Swing	$R_L = 100\Omega$ , 30mV Overdrive $T_A = 0^\circ\text{C to } 70^\circ\text{C}$ $T_A = -40^\circ\text{C to } 85^\circ\text{C}$	●	$\pm 3.50$	$\pm 3.8$	V
			●	$\pm 3.25$		V
			●	$\pm 3.15$		V

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SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
$I_{OUT}$	Maximum Output Current	$V_{OUT} = \pm 3\text{V}$ , 30mV Overdrive $T_A = 0^\circ\text{C}$ to $70^\circ\text{C}$ $T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$	● ●	$\pm 50$ $\pm 45$ $\pm 40$	$\pm 80$	mA mA mA
	Maximum Output Current (Low Power Mode) (Note 10)	LT1815S6/LT1816A; 40k $\Omega$ Between $I_{SET}$ and $V^-$ ; $V_{OUT} = \pm 3\text{V}$ , 30mV Overdrive $T_A = 0^\circ\text{C}$ to $70^\circ\text{C}$ $T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$	● ●	$\pm 50$ $\pm 40$ $\pm 30$	$\pm 75$	mA mA mA
$I_{SC}$	Output Short-Circuit Current	$V_{OUT} = 0\text{V}$ , 1V Overdrive (Note 3) $T_A = 0^\circ\text{C}$ to $70^\circ\text{C}$ $T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$	● ●	$\pm 100$ $\pm 90$ $\pm 70$	$\pm 200$	mA mA mA
SR	Slew Rate	$A_V = -1$ (Note 5) $T_A = 0^\circ\text{C}$ to $70^\circ\text{C}$ $T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$	● ●	900 750 600	1500	V/ $\mu\text{s}$ V/ $\mu\text{s}$ V/ $\mu\text{s}$
FPBW	Full-Power Bandwidth	6V <sub>P-P</sub> (Note 6)		80		MHz
GBW	Gain-Bandwidth Product	$f = 200\text{kHz}$ , $R_L = 500\Omega$ , LT1815 $T_A = 0^\circ\text{C}$ to $70^\circ\text{C}$ $T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$	● ●	150 140 130	220	MHz MHz MHz
		$f = 200\text{kHz}$ , $R_L = 500\Omega$ , LT1816/LT1817 $T_A = 0^\circ\text{C}$ to $70^\circ\text{C}$ $T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$	● ●	140 130 120	220	MHz MHz MHz
	Gain-Bandwidth Product (Low Power Mode) (Note 10)	LT1815S6/LT1816A; 40k $\Omega$ Between $I_{SET}$ and $V^-$ ; $f = 200\text{kHz}$ , $R_L = 500\Omega$ $T_A = 0^\circ\text{C}$ to $70^\circ\text{C}$ $T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$	● ●	35 30 25	55	MHz MHz MHz
-3dB BW	-3dB Bandwidth	$A_V = 1$ , $R_L = 500\Omega$		350		MHz
$t_r$ , $t_f$	Rise Time, Fall Time	$A_V = 1$ , 10% to 90%, 0.1V, $R_L = 100\Omega$		1		ns
$t_{PD}$	Propagation Delay	$A_V = 1$ , 50% to 50%, 0.1V, $R_L = 100\Omega$		1.4		ns
OS	Overshoot	$A_V = 1$ , 0.1V; $R_L = 100\Omega$		25		%
$t_s$	Settling Time	$A_V = -1$ , 0.1%, 5V		15		ns
THD	Total Harmonic Distortion	$A_V = 2$ , $f = 5\text{MHz}$ , $V_{OUT} = 2V_{P-P}$ , $R_L = 500\Omega$		-70		dB
dG	Differential Gain	$A_V = 2$ , $V_{OUT} = 2V_{P-P}$ , $R_L = 150\Omega$		0.08		%
dP	Differential Phase	$A_V = 2$ , $V_{OUT} = 2V_{P-P}$ , $R_L = 150\Omega$		0.04		Deg
$R_{OUT}$	Output Resistance	$A_V = 1$ , $f = 1\text{MHz}$		0.20		$\Omega$
$I_S$	Supply Current	LT1815 $T_A = 0^\circ\text{C}$ to $70^\circ\text{C}$ $T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$	● ●	6.5 9 10	7	mA mA mA
		LT1816/LT1817, per Amplifier $T_A = 0^\circ\text{C}$ to $70^\circ\text{C}$ $T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$	● ●	6.5 10.5 11.5	7.8	mA mA mA
	Supply Current (Low Power Mode) (Note 10)	LT1815S6/LT1816A, 40k $\Omega$ Between $I_{SET}$ and $V^-$ , per Amplifier $T_A = 0^\circ\text{C}$ to $70^\circ\text{C}$ $T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$	● ●	1 1.8 2.0	1.5	mA mA mA
$I_{SET}$	$I_{SET}$ Pin Current (Note 10)	LT1815S6/LT1816A $T_A = 0^\circ\text{C}$ to $70^\circ\text{C}$ $T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$	● ●	-150 -175 -200	-100	$\mu\text{A}$ $\mu\text{A}$ $\mu\text{A}$

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SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS	
$V_{OS}$	Input Offset Voltage	(Note 4) $T_A = 0^\circ\text{C to } 70^\circ\text{C}$ $T_A = -40^\circ\text{C to } 85^\circ\text{C}$	● ●	0.4	2.0 2.5 3.5	mV mV mV	
	Input Offset Voltage (Low Power Mode) (Note 10)	LT1815S6/LT1816A, $40\text{k}\Omega$ Between $I_{SET}$ and $V^-$ $T_A = 0^\circ\text{C to } 70^\circ\text{C}$ $T_A = -40^\circ\text{C to } 85^\circ\text{C}$	● ●	2	7 9 10	mV mV mV	
$\frac{\Delta V_{OS}}{\Delta T}$	Input Offset Voltage Drift	$T_A = 0^\circ\text{C to } 70^\circ\text{C}$ (Note 7) $T_A = -40^\circ\text{C to } 85^\circ\text{C}$ (Note 7)	● ●	10 10	15 30	$\mu\text{V}/^\circ\text{C}$ $\mu\text{V}/^\circ\text{C}$	
$I_{OS}$	Input Offset Current	$T_A = 0^\circ\text{C to } 70^\circ\text{C}$ $T_A = -40^\circ\text{C to } 85^\circ\text{C}$	● ●	60	800 1000 1200	nA nA nA	
$I_B$	Input Bias Current	$T_A = 0^\circ\text{C to } 70^\circ\text{C}$ $T_A = -40^\circ\text{C to } 85^\circ\text{C}$	● ●	-2.4	$\pm 8$ $\pm 10$ $\pm 12$	$\mu\text{A}$ $\mu\text{A}$ $\mu\text{A}$	
$e_n$	Input Noise Voltage Density	$f = 10\text{kHz}$		6		$\text{nV}/\sqrt{\text{Hz}}$	
$i_n$	Input Noise Current Density	$f = 10\text{kHz}$		1.3		$\text{pA}/\sqrt{\text{Hz}}$	
$R_{IN}$	Input Resistance	$V_{CM} = 1.5\text{V to } 3.5\text{V}$ Differential		1.5 5 750		$\text{M}\Omega$ $\text{k}\Omega$	
$C_{IN}$	Input Capacitance			2		pF	
$V_{CM}$	Input Voltage Range (High)	Guaranteed by CMRR $T_A = -40^\circ\text{C to } 85^\circ\text{C}$	●	3.5 3.5	4.1	V V	
	Input Voltage Range (Low)	Guaranteed by CMRR $T_A = -40^\circ\text{C to } 85^\circ\text{C}$	●		0.9 1.5 1.5	V V V	
CMRR	Common Mode Rejection Ratio	$V_{CM} = 1.5\text{V to } 3.5\text{V}$ $T_A = 0^\circ\text{C to } 70^\circ\text{C}$ $T_A = -40^\circ\text{C to } 85^\circ\text{C}$	● ● ●	73 71 70	82	dB dB dB	
		Channel Separation	$V_{OUT} = 1.5\text{V to } 3.5\text{V}$ , $R_L = 100\Omega$ , LT1816/LT1817 $T_A = 0^\circ\text{C to } 70^\circ\text{C}$ $T_A = -40^\circ\text{C to } 85^\circ\text{C}$	● ● ●	81 80 79	100	dB dB dB
		Minimum Supply Voltage	Guaranteed by PSRR $T_A = -40^\circ\text{C to } 85^\circ\text{C}$	●		2.5 4 4	V V V
$A_{VOL}$	Large-Signal Voltage Gain	$V_{OUT} = 1.5\text{V to } 3.5\text{V}$ , $R_L = 500\Omega$ $T_A = 0^\circ\text{C to } 70^\circ\text{C}$ $T_A = -40^\circ\text{C to } 85^\circ\text{C}$	● ● ●	1.0 0.7 0.6	2	V/mV V/mV V/mV	
		$V_{OUT} = 1.5\text{V to } 3.5\text{V}$ , $R_L = 100\Omega$ $T_A = 0^\circ\text{C to } 70^\circ\text{C}$ $T_A = -40^\circ\text{C to } 85^\circ\text{C}$	● ● ●	0.7 0.5 0.4	1.5	V/mV V/mV V/mV	
$V_{OUT}$	Maximum Output Swing (High)	$R_L = 500\Omega$ , 30mV Overdrive $T_A = 0^\circ\text{C to } 70^\circ\text{C}$ $T_A = -40^\circ\text{C to } 85^\circ\text{C}$	● ● ●	3.9 3.8 3.7	4.2	V V V	
		$R_L = 100\Omega$ , 30mV Overdrive $T_A = 0^\circ\text{C to } 70^\circ\text{C}$ $T_A = -40^\circ\text{C to } 85^\circ\text{C}$	● ● ●	3.7 3.6 3.5	4	V V V	

**ELECTRICAL CHARACTERISTICS** The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at  $T_A = 25^\circ\text{C}$  (Note 8).  $V_S = 5\text{V}$ ,  $0\text{V}$ ;  $V_{\text{CM}} = 2.5\text{V}$ ,  $R_L$  to  $2.5\text{V}$  unless otherwise noted. For the programmable current option (LT1815S6 or LT1816A), the  $I_{\text{SET}}$  pin must be connected to  $V^-$  through  $75\Omega$  or less, unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
$V_{\text{OUT}}$	Maximum Output Swing (Low)	$R_L = 500\Omega$ , 30mV Overdrive $T_A = 0^\circ\text{C}$ to $70^\circ\text{C}$ $T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$	●	0.8	1.1	V
			●		1.2	V
		$R_L = 100\Omega$ , 30mV Overdrive $T_A = 0^\circ\text{C}$ to $70^\circ\text{C}$ $T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$	●	1	1.3	V
			●		1.4	V
$I_{\text{OUT}}$	Maximum Output Current	$V_{\text{OUT}} = 1.5\text{V}$ or $3.5\text{V}$ , 30mV Overdrive $T_A = 0^\circ\text{C}$ to $70^\circ\text{C}$ $T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$	●	$\pm 30$	$\pm 50$	mA
	Maximum Output Current (Low Power Mode) (Note 10)	LT1815S6/LT1816A; $40\text{k}\Omega$ Between $I_{\text{SET}}$ and $V^-$ ; $V_{\text{OUT}} = 1.5\text{V}$ or $3.5\text{V}$ , 30mV Overdrive $T_A = 0^\circ\text{C}$ to $70^\circ\text{C}$ $T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$	●	$\pm 25$	$\pm 50$	mA
$I_{\text{SC}}$	Output Short-Circuit Current	$V_{\text{OUT}} = 2.5\text{V}$ , 1V Overdrive (Note 3) $T_A = 0^\circ\text{C}$ to $70^\circ\text{C}$ $T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$	●	$\pm 80$	$\pm 140$	mA
			●	$\pm 70$		mA
SR	Slew Rate	$A_V = -1$ (Note 5) $T_A = 0^\circ\text{C}$ to $70^\circ\text{C}$ $T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$	●	450	750	V/ $\mu\text{s}$
			●	375		V/ $\mu\text{s}$
			●	300		V/ $\mu\text{s}$
FPBW	Full-Power Bandwidth	$2V_{\text{P-P}}$ (Note 6)		120		MHz
GBW	Gain-Bandwidth Product	$f = 200\text{kHz}$ , $R_L = 500\Omega$ , LT1815 $T_A = 0^\circ\text{C}$ to $70^\circ\text{C}$ $T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$	●	140	200	MHz
			●	130		MHz
			●	120		MHz
		$f = 200\text{kHz}$ , $R_L = 500\Omega$ , LT1816/LT1817 $T_A = 0^\circ\text{C}$ to $70^\circ\text{C}$ $T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$	●	130	200	MHz
			●	110		MHz
			●	100		MHz
	Gain-Bandwidth Product (Low Power Mode) (Note 10)	LT1815S6/LT1816A; $40\text{k}\Omega$ Between $I_{\text{SET}}$ and $V^-$ ; $f = 200\text{kHz}$ , $R_L = 500\Omega$ $T_A = 0^\circ\text{C}$ to $70^\circ\text{C}$ $T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$	●	30	50	MHz
			●	25		MHz
			●	20		MHz
-3dB BW	-3dB Bandwidth	$A_V = 1$ , $R_L = 500\Omega$		300		MHz
$t_r$ , $t_f$	Rise Time, Fall Time	$A_V = 1$ , 10% to 90%, 0.1V, $R_L = 100\Omega$		1.2		ns
$t_{\text{PD}}$	Propagation Delay	$A_V = 1$ , 50% to 50%, 0.1V, $R_L = 100\Omega$		1.5		ns
OS	Overshoot	$A_V = 1$ , 0.1V; $R_L = 100\Omega$		25		%
$t_s$	Settling Time	$A_V = -1$ , 0.1%, 2V		15		ns
THD	Total Harmonic Distortion	$A_V = 2$ , $f = 5\text{MHz}$ , $V_{\text{OUT}} = 2V_{\text{P-P}}$ , $R_L = 500\Omega$		-65		dB
dG	Differential Gain	$A_V = 2$ , $V_{\text{OUT}} = 2V_{\text{P-P}}$ , $R_L = 150\Omega$		0.08		%
dP	Differential Phase	$A_V = 2$ , $V_{\text{OUT}} = 2V_{\text{P-P}}$ , $R_L = 150\Omega$		0.13		Deg
$R_{\text{OUT}}$	Output Resistance	$A_V = 1$ , $f = 1\text{MHz}$		0.24		$\Omega$
$I_S$	Supply Current	LT1815 $T_A = 0^\circ\text{C}$ to $70^\circ\text{C}$ $T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$	●	6.3	8	mA
			●		10	mA
		LT1816/LT1817, per Amplifier $T_A = 0^\circ\text{C}$ to $70^\circ\text{C}$ $T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$	●	6.3	9	mA
			●		12	mA
			●		13	mA
	Supply Current (Low Power Mode) (Note 10)	LT1815S6/LT1816A, $40\text{k}\Omega$ Between $I_{\text{SET}}$ and $V^-$ , per Amplifier $T_A = 0^\circ\text{C}$ to $70^\circ\text{C}$ $T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$	●	0.9	1.5	mA
			●		1.8	mA
			●		2.0	mA

**ELECTRICAL CHARACTERISTICS** The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at  $T_A = 25^\circ\text{C}$  (Note 8).  $V_S = 5\text{V}$ ,  $0\text{V}$ ;  $V_{CM} = 2.5\text{V}$ ,  $R_L$  to  $2.5\text{V}$  unless otherwise noted. For the programmable current option (LT1815S6 or LT1816A), the  $I_{SET}$  pin must be connected to  $V^-$  through  $75\Omega$  or less, unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
$I_{SET}$	$I_{SET}$ Pin Current (Note 10)	LT1815S6/LT1816A $T_A = 0^\circ\text{C}$ to $70^\circ\text{C}$ $T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$	● -150 ● -175 ● -200	-100		$\mu\text{A}$ $\mu\text{A}$ $\mu\text{A}$

**Note 1:** Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

**Note 2:** Differential inputs of  $\pm 6\text{V}$  are appropriate for transient operation only, such as during slewing. Large sustained differential inputs can cause excessive power dissipation and may damage the part.

**Note 3:** A heat sink may be required to keep the junction temperature below absolute maximum when the output is shorted indefinitely.

**Note 4:** Input offset voltage is pulse tested and is exclusive of warm-up drift.

**Note 5:** Slew rate is measured between  $\pm 2\text{V}$  at the output with  $\pm 3\text{V}$  input for  $\pm 5\text{V}$  supplies and  $2V_{P-P}$  at the output with a  $3V_{P-P}$  input for single  $5\text{V}$  supplies.

**Note 6:** Full-power bandwidth is calculated from the slew rate:

$$FPBW = SR/2\pi V_P$$

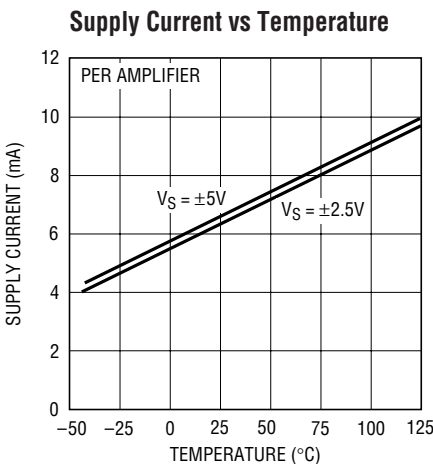
**Note 7:** This parameter is not 100% tested.

**Note 8:** The LT1815C/LT1816C/LT1817C are guaranteed to meet specified performance from  $0^\circ\text{C}$  to  $70^\circ\text{C}$  and are designed, characterized and expected to meet the extended temperature limits, but are not tested at  $-40^\circ\text{C}$  and  $85^\circ\text{C}$ . The LT1815I/LT1816I/LT1817I are guaranteed to meet the extended temperature limits.

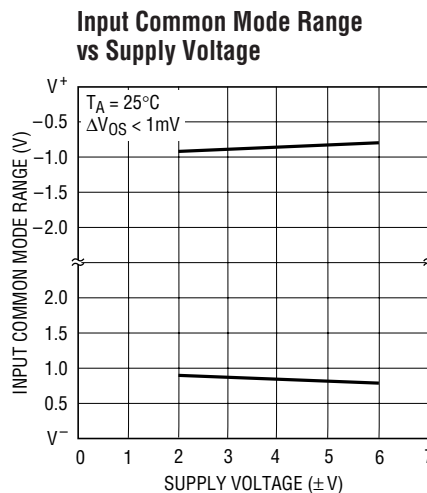
**Note 9:** Thermal resistance ( $\theta_{JA}$ ) varies with the amount of PC board metal connected to the package. The specified values are for short traces connected to the leads. If desired, the thermal resistance can be substantially reduced by connecting Pin 2 of the SOT-23, Pin 4 of the SO-8 and MS8, Pin 5 of the MS10 or the underside metal of the DD package to a large metal area.

**Note 10:** A resistor of  $40\text{k}$  or less is required between the  $I_{SET}$  and  $V^-$  pins of the LT1815S6 and the LT1816AMS. See the applications section for information on selecting a suitable resistor.

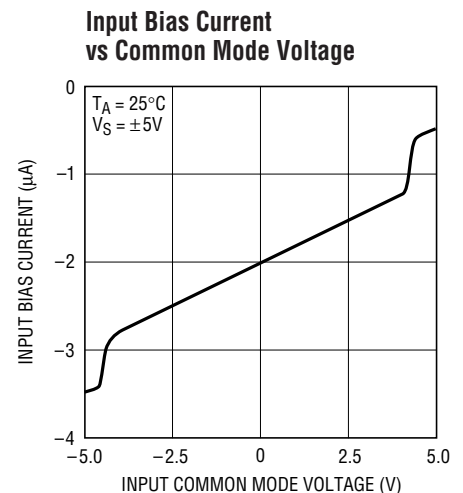
**TYPICAL PERFORMANCE CHARACTERISTICS**



181567 G01



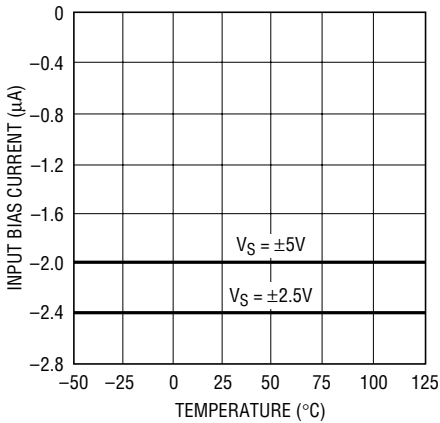
181567 G02



181567 G03

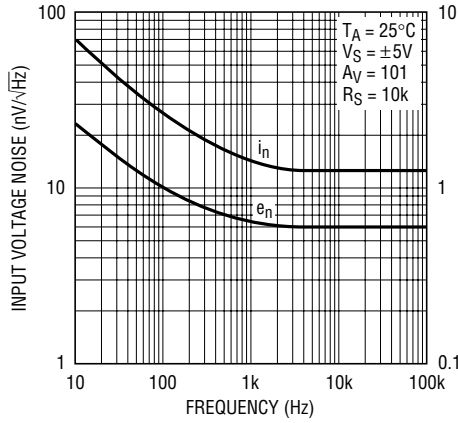
# TYPICAL PERFORMANCE CHARACTERISTICS

Input Bias Current vs Temperature



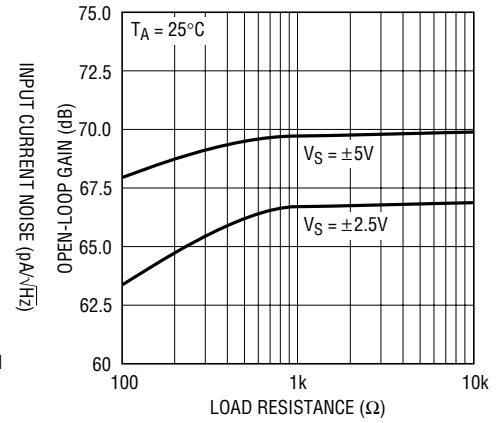
181567 G04

Input Noise Spectral Density



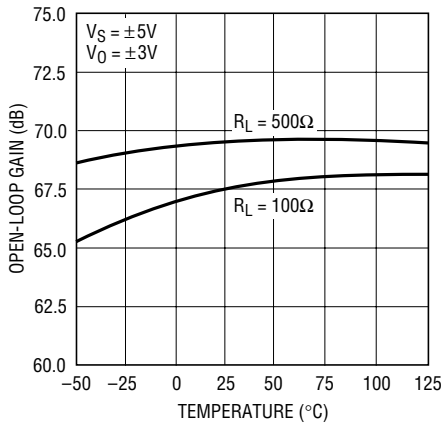
181567 G05

Open-Loop Gain vs Resistive Load



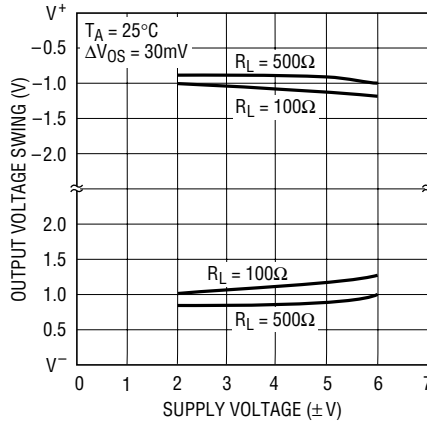
181567 G06

Open-Loop Gain vs Temperature



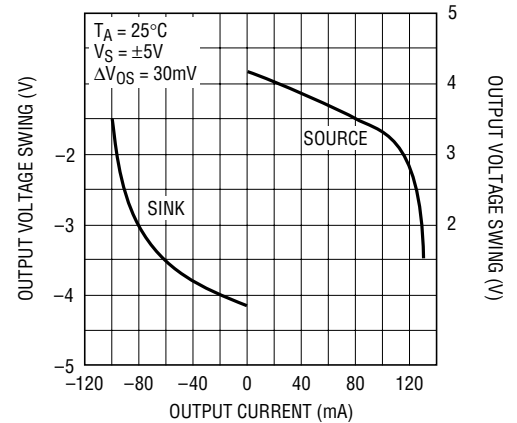
181567 G07

Output Voltage Swing vs Supply Voltage



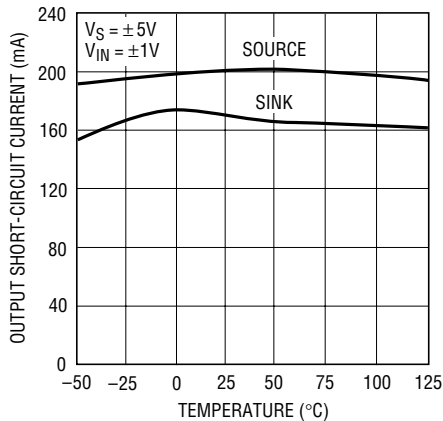
181567 G08

Output Voltage Swing vs Load Current



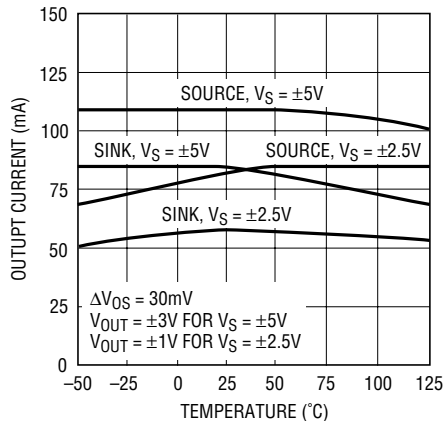
181567 G09

Output Short-Circuit Current vs Temperature



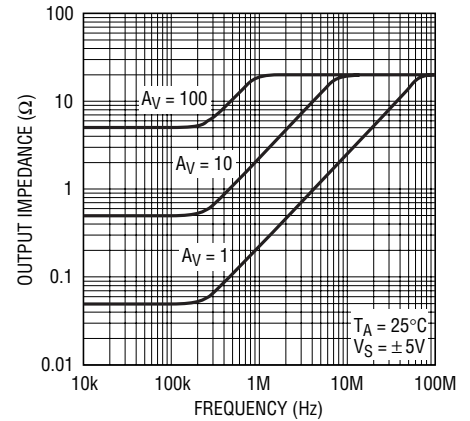
181567 G10

Output Current vs Temperature



181567 G11

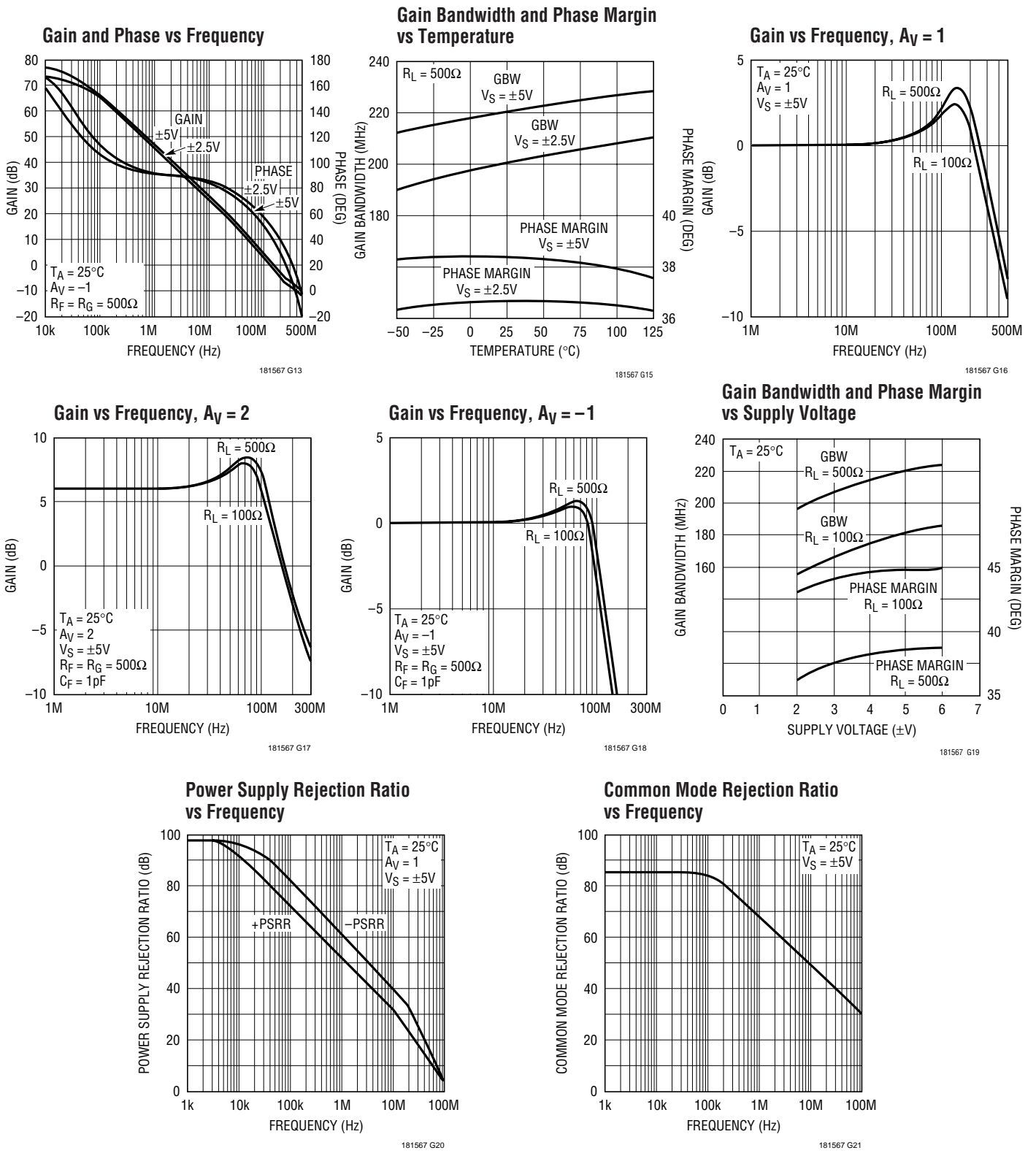
Output Impedance vs Frequency



181567 G12

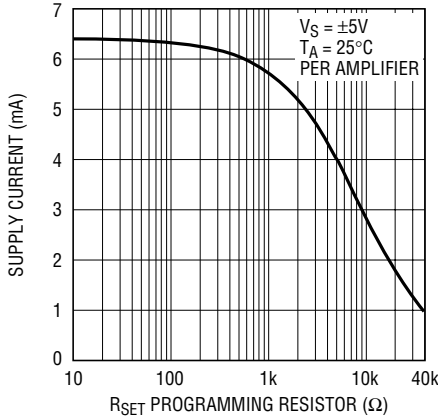


# TYPICAL PERFORMANCE CHARACTERISTICS



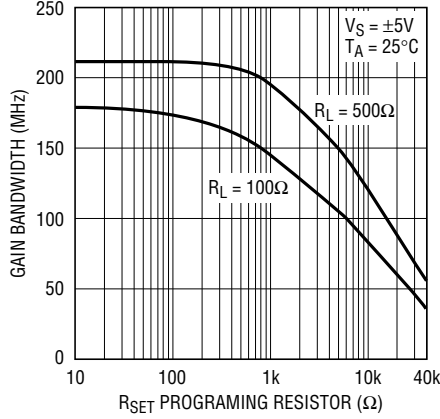
# TYPICAL PERFORMANCE CHARACTERISTICS

**Supply Current vs Programming Resistor**



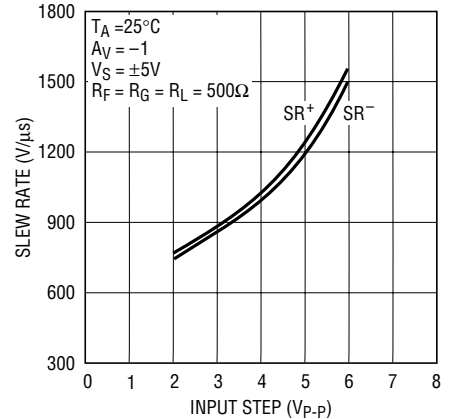
181567 F03

**Gain Bandwidth Product vs Programming Resistor**



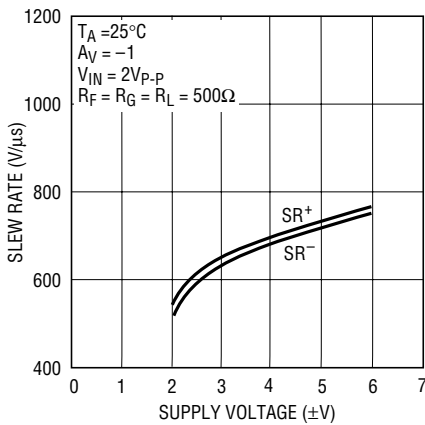
181567 F02

**Slew Rate vs Input Step**



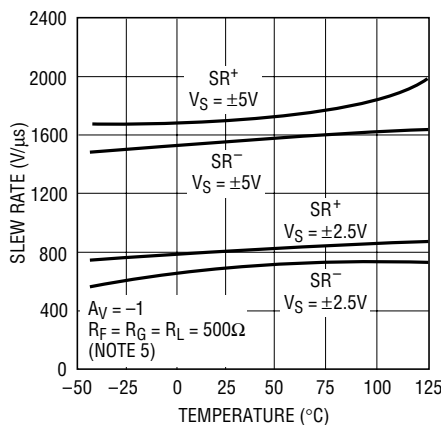
181567 G24

**Slew Rate vs Supply Voltage**



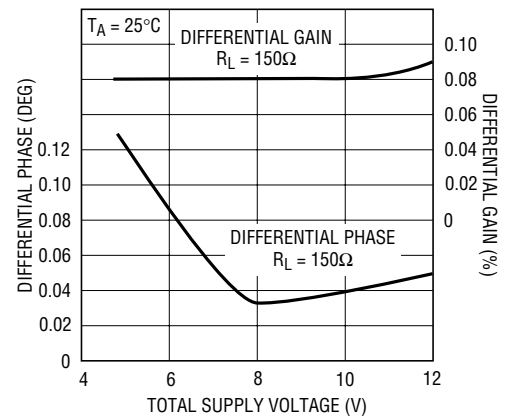
181567 G23

**Slew Rate vs Temperature**



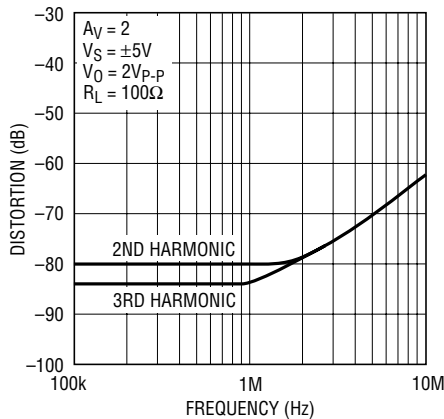
181567 G25

**Differential Gain and Phase vs Supply Voltage**



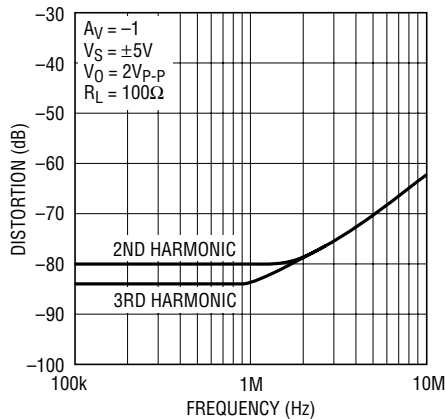
181567 G26

**Distortion vs Frequency, AV = 2**



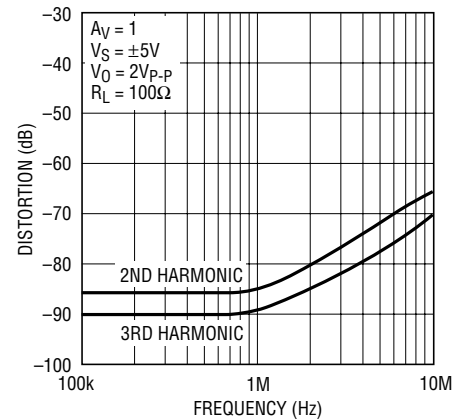
181567 G28

**Distortion vs Frequency, AV = -1**



181567 G29

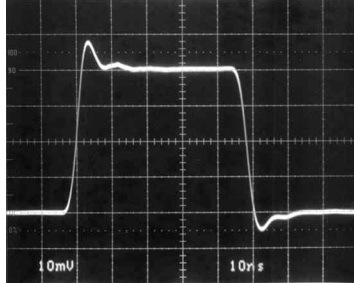
**Distortion vs Frequency, AV = 1**



181567 G30

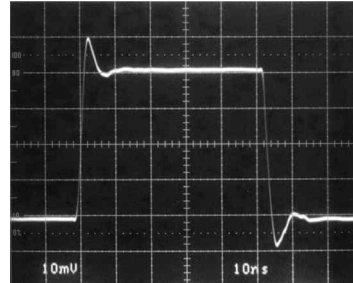
## TYPICAL PERFORMANCE CHARACTERISTICS

Small-Signal Transient,  
 $A_V = -1$



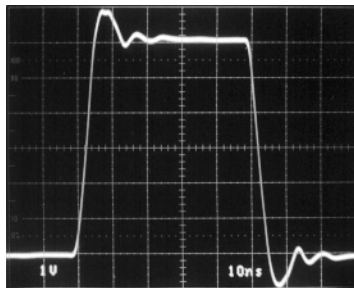
181567 G31

Small-Signal Transient,  
 $A_V = 1$



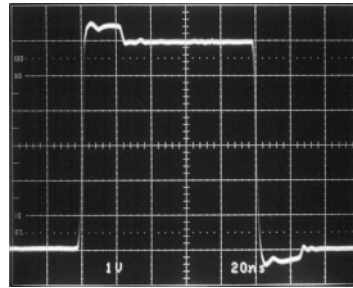
181567 G32

Large-Signal Transient,  
 $A_V = -1, V_S = \pm 5V$



181567 G33

Large-Signal Transient,  
 $A_V = 1, V_S = \pm 5V$



181567 G34

## APPLICATIONS INFORMATION

### Layout and Passive Components

As with all high speed amplifiers, the LT1815/LT1816/LT1817 require some attention to board layout. A ground plane is recommended and trace lengths should be minimized, especially on the negative input lead.

Low ESL/ESR bypass capacitors should be placed directly at the positive and negative supply (0.01 $\mu$ F ceramics are recommended). For high drive current applications, additional 1 $\mu$ F to 10 $\mu$ F tantalums should be added.

The parallel combination of the feedback resistor and gain setting resistor on the inverting input combine with the input capacitance to form a pole that can cause peaking or even oscillations. If feedback resistors greater than 1k are used, a parallel capacitor of value:

$$C_F > R_G \cdot C_{IN}/R_F$$

should be used to cancel the input pole and optimize dynamic performance. For applications where the DC noise gain is 1 and a large feedback resistor is used,  $C_F$  should be greater than or equal to  $C_{IN}$ . An example would be an I-to-V converter.

### Input Considerations

The inputs of the LT1815/LT1816/LT1817 amplifiers are connected to the base of an NPN and PNP bipolar transistor in parallel. The base currents are of opposite polarity and provide first-order bias current cancellation. Due to variation in the matching of NPN and PNP beta, the polarity of the input bias current can be positive or negative. The offset current, however, does not depend on beta matching and is tightly controlled. Therefore, the use of balanced source resistance at each input is recommended for applications where DC accuracy must be maximized. For example, with a 100 $\Omega$  source resistance at each input, the 800nA maximum offset current results in only 80 $\mu$ V of extra offset, while without balance the 8 $\mu$ A maximum input bias current could result in a 0.8mV offset contribution.

The inputs can withstand differential input voltages of up to 6V without damage and without needing clamping or series resistance for protection. This differential input voltage generates a large internal current (up to 80mA),

which results in the high slew rate. In normal transient closed-loop operation, this does not increase power dissipation significantly because of the low duty cycle of the transient inputs. Sustained differential inputs, however, will result in excessive power dissipation and therefore **this device should not be used as a comparator**.

### Capacitive Loading

The LT1815/LT1816/LT1817 are optimized for high bandwidth and low distortion applications. They can drive a capacitive load of 10pF in a unity-gain configuration and more with higher gain. When driving a larger capacitive load, a resistor of 10 $\Omega$  to 50 $\Omega$  should be connected between the output and the capacitive load to avoid ringing or oscillation. The feedback should still be taken from the output so that the resistor will isolate the capacitive load to ensure stability.

### Slew Rate

The slew rate of the LT1815/LT1816/LT1817 is proportional to the differential input voltage. Therefore, highest slew rates are seen in the lowest gain configurations. For example, a 5V output step in a gain of 10 has a 0.5V input step, whereas in unity gain there is a 5V input step. The LT1815/LT1816/LT1817 are tested for a slew rate in a gain of  $-1$ . Lower slew rates occur in higher gain configurations.

### Programmable Supply Current (LT1815/LT1816A)

In order to operate the LT1815S6 or LT1816A at full speed (and full supply current), connect the  $I_{SET}$  pin to the negative supply through a resistance of 75 $\Omega$  or less.

To adjust or program the supply current and speed of the LT1815S6 or LT1816A, connect an external resistor ( $R_{SET}$ ) between the  $I_{SET}$  pin and the negative supply as shown in Figure 1. The amplifiers are fully functional with  $0 \leq R_{SET} \leq 40k$ . Figures 2 and 3 show how the gain bandwidth and supply current vary with the value of the programming resistor  $R_{SET}$ . In addition, the Electrical Characteristics section of the data sheet specifies maximum supply current and offset voltage, as well as minimum gain bandwidth and output current at the maximum  $R_{SET}$  value of 40k.

## APPLICATIONS INFORMATION

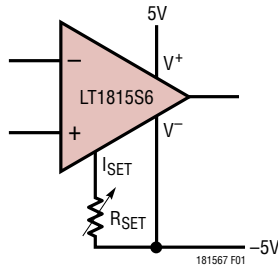


Figure 1. Programming Resistor Between ISET and V<sup>-</sup>

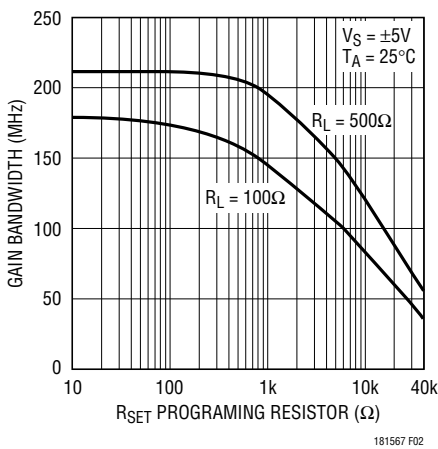


Figure 2. Gain Bandwidth Product vs R<sub>SET</sub> Programming Resistor

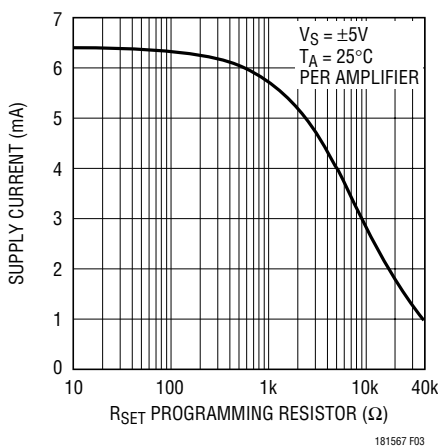


Figure 3. Supply Current vs R<sub>SET</sub> Programming Resistor

### Power Dissipation

The LT1815/LT1816/LT1817 combine high speed and large output drive in small packages. It is possible to exceed the maximum junction temperature specification (150°C) under certain conditions. Maximum junction temperature ( $T_J$ ) is calculated from the ambient temperature ( $T_A$ ), power dissipation per amplifier ( $P_D$ ) and number of amplifiers ( $n$ ) as follows:

$$T_J = T_A + (n \cdot P_D \cdot \theta_{JA})$$

Power dissipation is composed of two parts. The first is due to the quiescent supply current and the second is due to on-chip dissipation caused by the load current. The worst-case load induced power occurs when the output voltage is at 1/2 of either supply voltage (or the maximum swing if less than 1/2 the supply voltage). Therefore  $P_{D\text{MAX}}$  is:

$$P_{D\text{MAX}} = (V^+ - V^-) \cdot (I_{S\text{MAX}}) + (V^+/2)^2/R_L \text{ or}$$

$$P_{D\text{MAX}} = (V^+ - V^-) \cdot (I_{S\text{MAX}}) + (V^+ - V_{O\text{MAX}}) \cdot (V_{O\text{MAX}}/R_L)$$

Example: LT1816IS8 at 85°C,  $V_S = \pm 5V$ ,  $R_L = 100\Omega$

$$P_{D\text{MAX}} = (10V) \cdot (11.5mA) + (2.5V)^2/100\Omega = 178mW$$

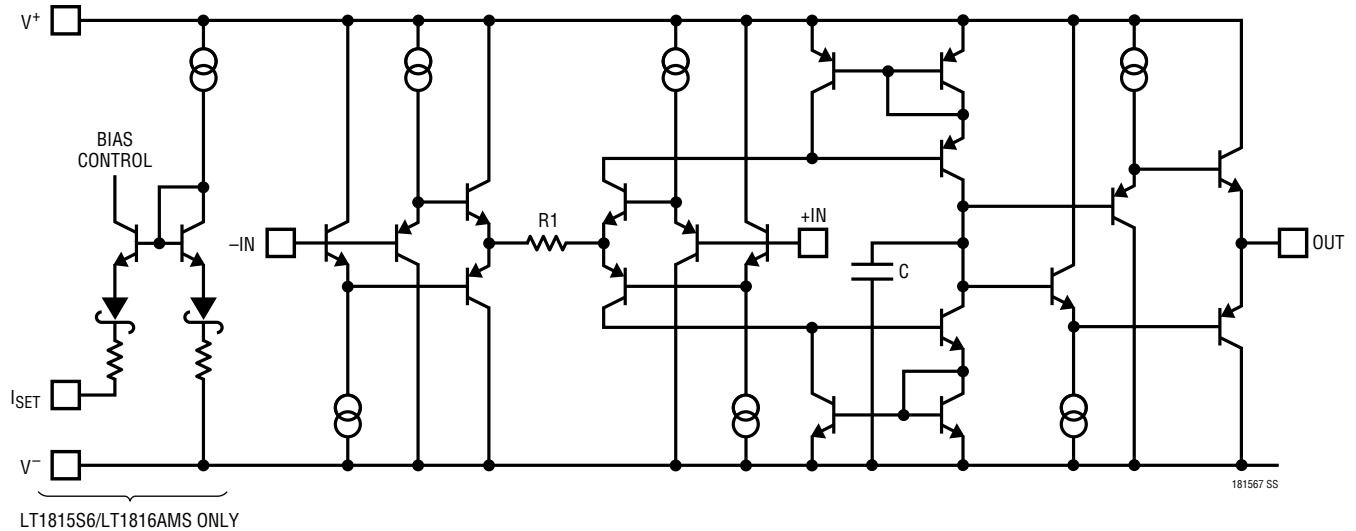
$$T_{J\text{MAX}} = 85^\circ\text{C} + (2 \cdot 178mW) \cdot (150^\circ\text{C/W}) = 138^\circ\text{C}$$

### Circuit Operation

The LT1815/LT1816/LT1817 circuit topology is a true voltage feedback amplifier that has the slewing behavior of a current feedback amplifier. The operation of the circuit can be understood by referring to the Simplified Schematic. Complementary NPN and PNP emitter followers buffer the inputs and drive an internal resistor. The input voltage appears across the resistor, generating current that is mirrored into the high impedance node.

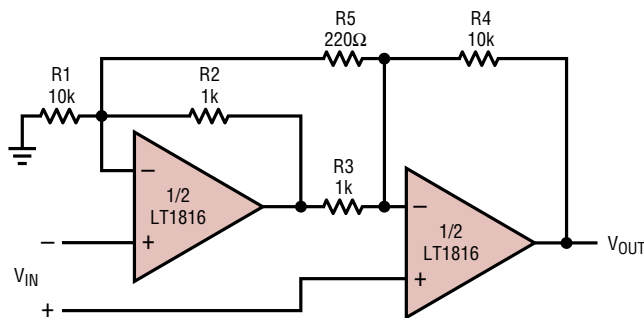
Complementary followers form an output stage that buffers the gain node from the load. The input resistor, input stage transconductance and the capacitor on the high impedance node determine the bandwidth. The slew rate is determined by the current available to charge the gain node capacitance. This current is the differential input voltage divided by  $R_1$ , so the slew rate is proportional to the input step. Highest slew rates are therefore seen in the lowest gain configurations.

**SIMPLIFIED SCHEMATIC** (one amplifier)



**TYPICAL APPLICATIONS**

Two Op Amp Instrumentation Amplifier



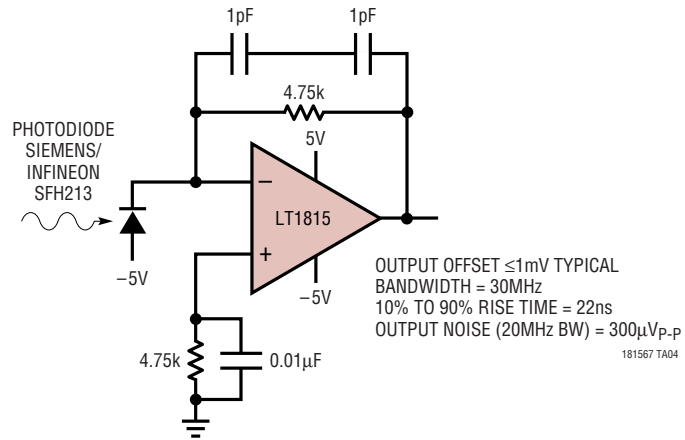
$$GAIN = \left[ \frac{R4}{R3} \right] \left[ 1 + \left( \frac{1}{2} \right) \left( \frac{R2}{R1} + \frac{R3}{R4} \right) + \frac{(R2 + R3)}{R5} \right] = 102$$

TRIM R5 FOR GAIN  
TRIM R1 FOR COMMON MODE REJECTION  
BW = 2MHz

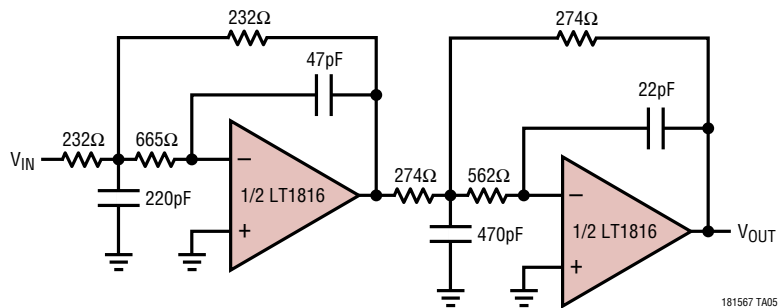
181567 TA03

## TYPICAL APPLICATIONS

### Photodiode Transimpedance Amplifier



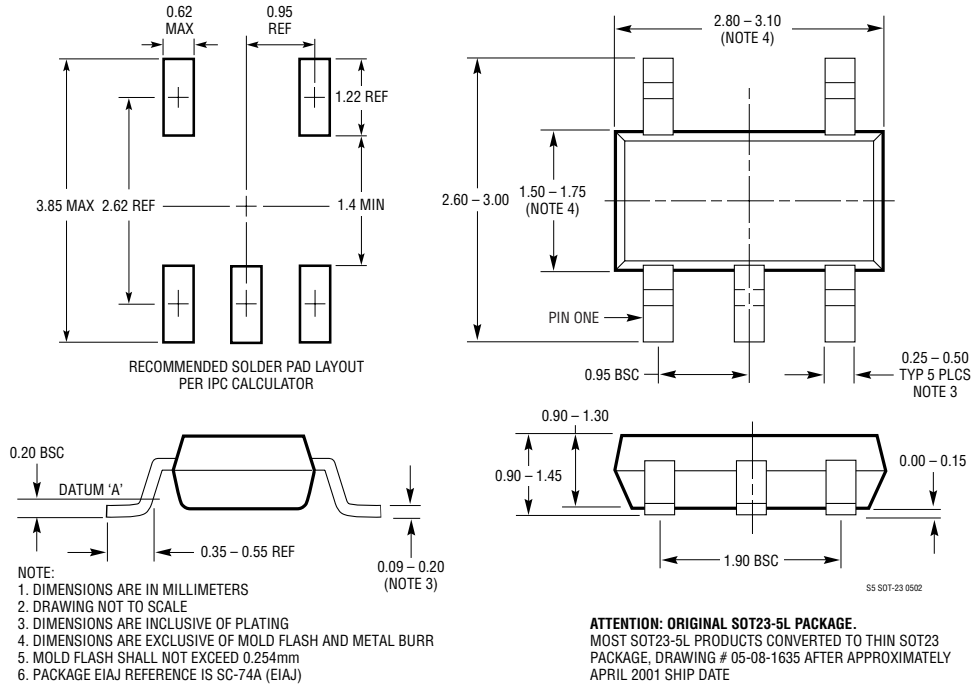
### 4MHz, 4th Order Butterworth Filter



# PACKAGE DESCRIPTION

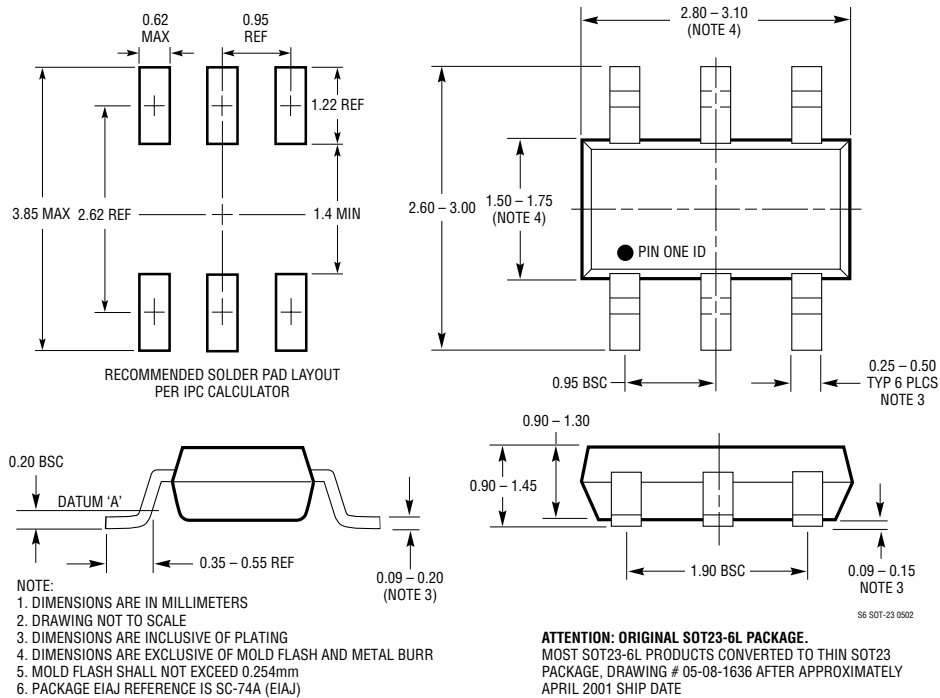
## S5 Package 5-Lead Plastic SOT-23

(Reference LTC DWG # 05-08-1633)  
 (Reference LTC DWG # 05-08-1635)



## S6 Package 6-Lead Plastic SOT-23

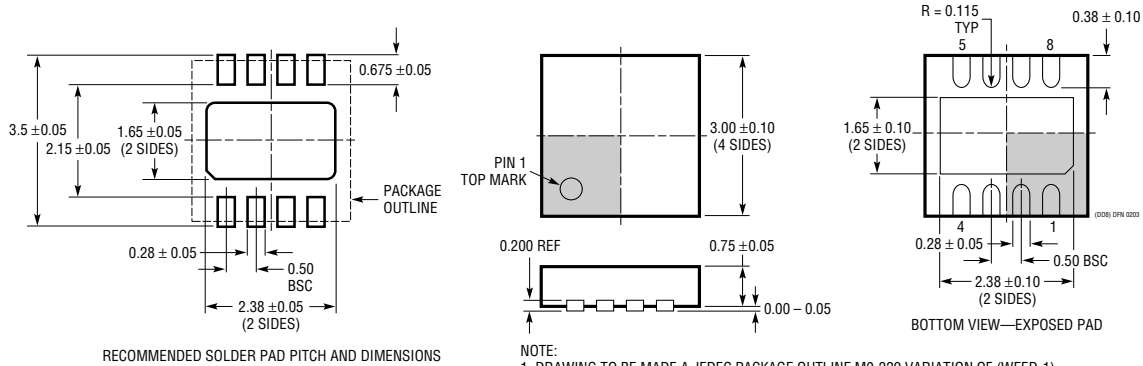
(Reference LTC DWG # 05-08-1634)  
 (Reference LTC DWG # 05-08-1636)



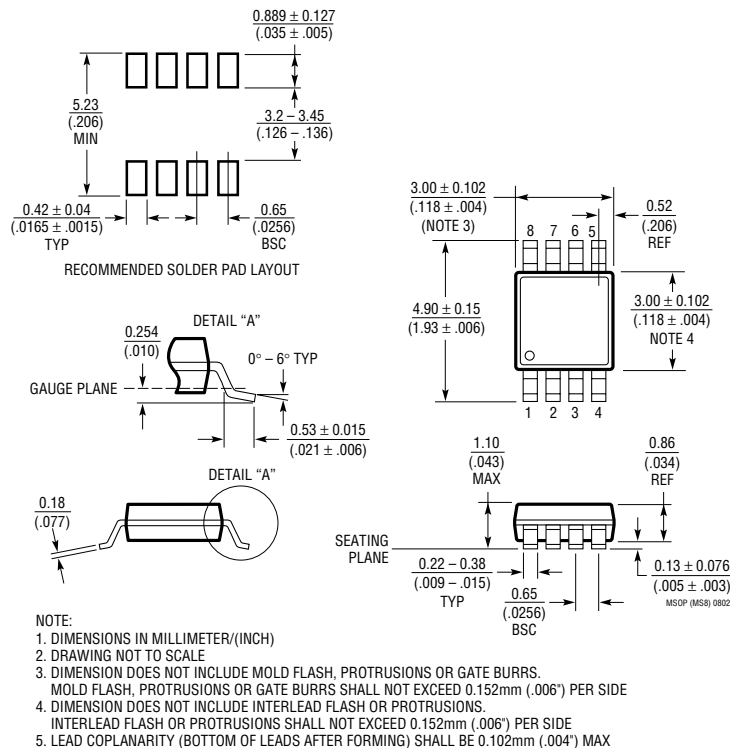


# PACKAGE DESCRIPTION

## DD Package 8-Lead Plastic DFN (3mm × 3mm) (Reference LTC DWG # 05-08-1698)



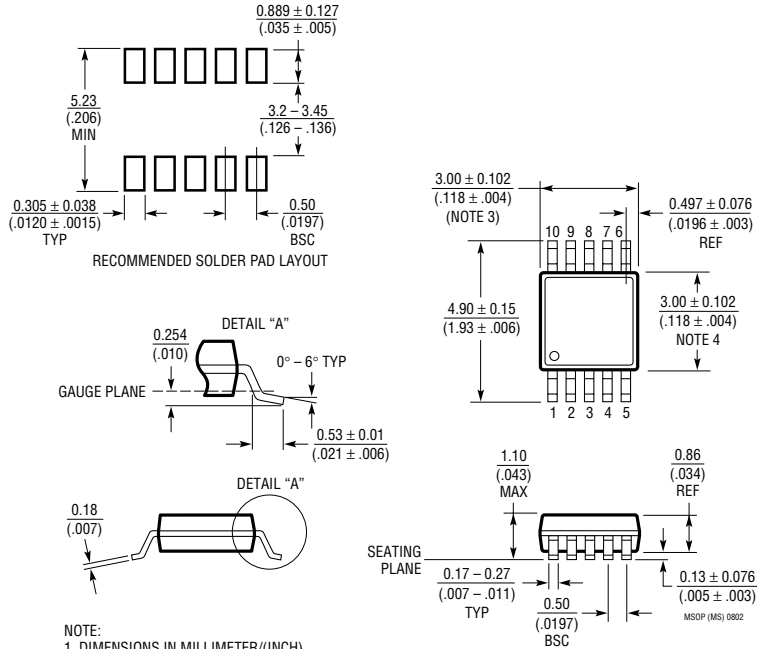
## MS8 Package 8-Lead Plastic MSOP (Reference LTC DWG # 05-08-1660)



## PACKAGE DESCRIPTION

### MS10 Package 10-Lead Plastic MSOP

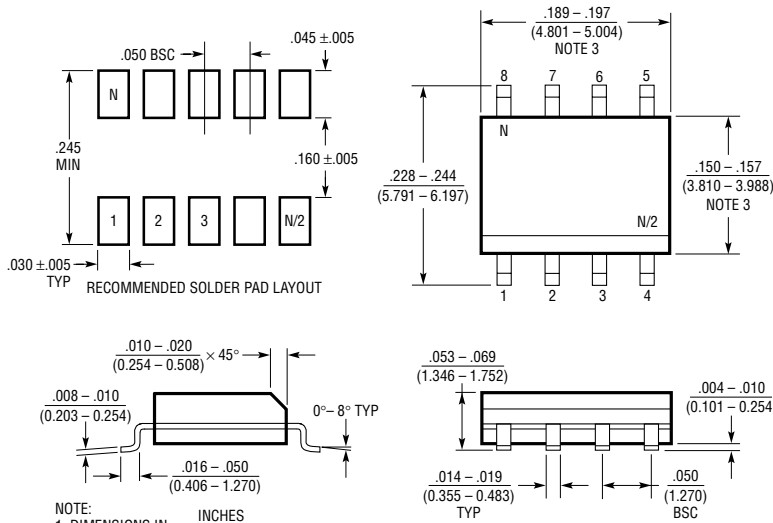
(Reference LTC DWG # 05-08-1661)



- NOTE:
1. DIMENSIONS IN MILLIMETER/(INCH)
  2. DRAWING NOT TO SCALE
  3. DIMENSION DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS.  
MOLD FLASH, PROTRUSIONS OR GATE BURRS SHALL NOT EXCEED 0.152mm (.006") PER SIDE
  4. DIMENSION DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSIONS.  
INTERLEAD FLASH OR PROTRUSIONS SHALL NOT EXCEED 0.152mm (.006") PER SIDE
  5. LEAD COPLANARITY (BOTTOM OF LEADS AFTER FORMING) SHALL BE 0.102mm (.004") MAX

### S8 Package 8-Lead Plastic Small Outline (Narrow .150 Inch)

(Reference LTC DWG # 05-08-1610)



- NOTE:
1. DIMENSIONS IN INCHES (MILLIMETERS)
  2. DRAWING NOT TO SCALE
  3. THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.  
MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED .006" (0.15mm)

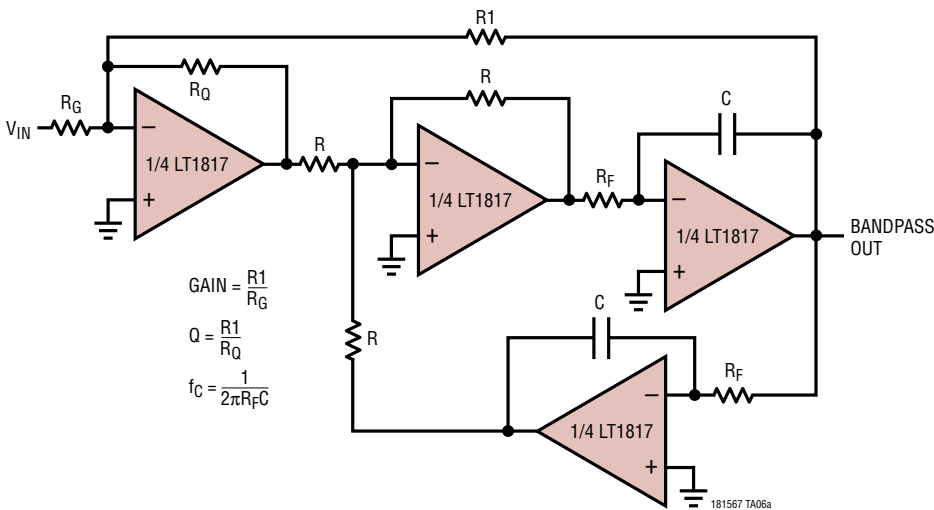
S08 0502

181567fa

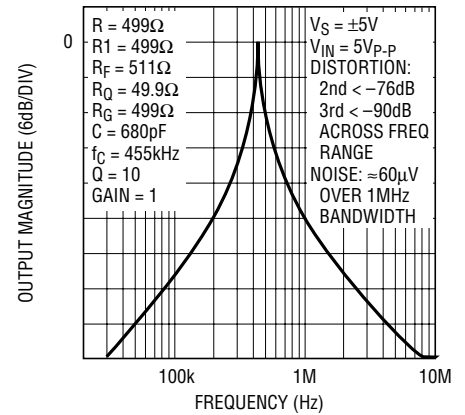


## TYPICAL APPLICATIONS

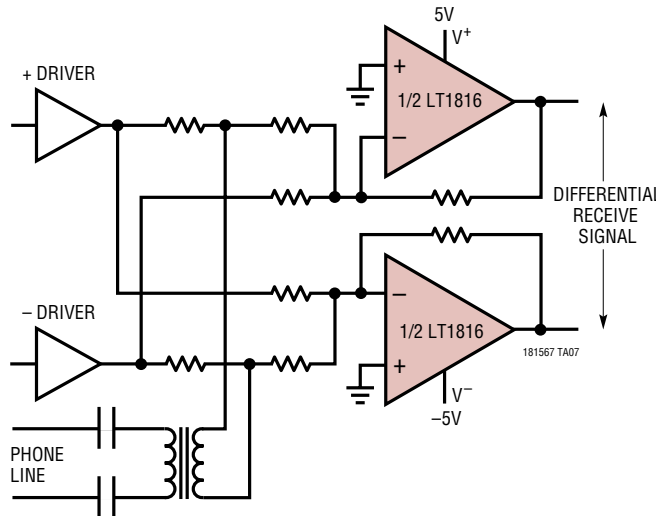
Bandpass Filter with Independently Settable Gain, Q and  $f_c$



455kHz Filter Frequency Response



Differential DSL Receiver



## RELATED PARTS

PART NUMBER	DESCRIPTION	COMMENTS
LT1363/LT1364/LT1365	Single/Dual/Quad 70MHz, 1V/ns, C-Load™ Op Amp	Wide Supply Range: $\pm 2.5V$ to $\pm 15V$
LT1395/LT1396/LT1397	Single/Dual/Quad 400MHz Current Feedback Amplifier	4.6mA Supply Current, 800V/ $\mu s$ , 80mA Output Current
LT1806/LT1807	Single/Dual 325MHz, 140V/ $\mu s$ Rail-to-Rail I/O Op Amp	Low Noise: 3.5nV/ $\sqrt{Hz}$
LT1809/LT1810	Single/Dual 180MHz, 350V/ $\mu s$ Rail-to-Rail I/O Op Amp	Low Distortion: 90dBc at 5MHz
LT1812/LT1813/LT1814	Single/Dual/Quad 3mA, 100MHz, 750V/ $\mu s$ Op Amp	Low Power: 3.6mA Max at $\pm 5V$

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