Micropower, Over-The-Top SOT-23, Rail-to-Rail Input and Output Op Amp

FEATURES

- **Operates with Inputs Above V⁺**
- **Rail-to-Rail Input and Output**
- **Micropower: 55μA Supply Current Max**
- Operating Temperature Range: −40°C to 125°C
- Low Profile (1mm) ThinSOT™ Package
- Low Input Offset Voltage: 800μV Max
- Single Supply Input Range: 0V to 18V
- High Output Current: 18mA Min
- Specified on 3V, 5V and ±5V Supplies
- Output Shutdown on 6-Lead Version
- Reverse Battery Protection to 18V
- High Voltage Gain: 1500V/mV
- Gain Bandwidth Product: 200kHz
- Slew Rate: 0.07V/μs

APPLICATIONS

- Portable Instrumentation
- Battery- or Solar-Powered Systems
- Sensor Conditioning
- Supply Current Sensing
- Battery Monitoring
- MUX Amplifiers
- 4mA to 20mA Transmitters

DESCRIPTION

The LT®1782 is a 200kHz op amp available in the small SOT-23 package that operates on all single and split supplies with a total voltage of 2.5V to 18V. The amplifier draws less than 55μA of quiescent current and has reverse battery protection, drawing negligible current for reverse supply voltages up to 18V.

The input range of the LT1782 includes ground, and a unique feature of this device is its Over-The-Top™ operation capability with either or both of its inputs above the positive rail. The inputs handle 18V both differential and common mode, independent of supply voltage. The input stage incorporates phase reversal protection to prevent false outputs from occurring even when the inputs are 9V below the negative supply.

The LT1782 can drive loads up to 18mA and still maintain rail-to-rail capability. A shutdown feature on the 6-lead version can disable the part, making the output high impedance and reducing quiescent current to 5μA. The LT1782 op amp is available in the 5- and 6-lead SOT-23 packages. For applications requiring higher speed, refer to the LT1783.
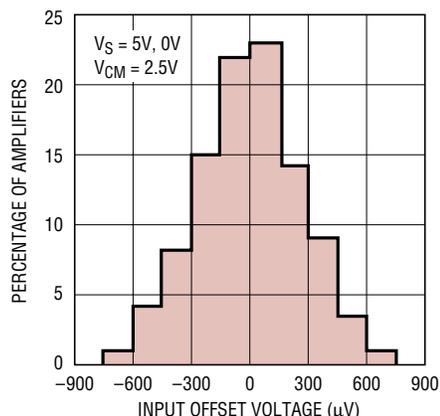
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TYPICAL APPLICATION

Positive Supply Rail Current Sense

$V_{OUT} = 2\Omega(I_{LOAD})$
0V TO 4.3V

1782 TA01
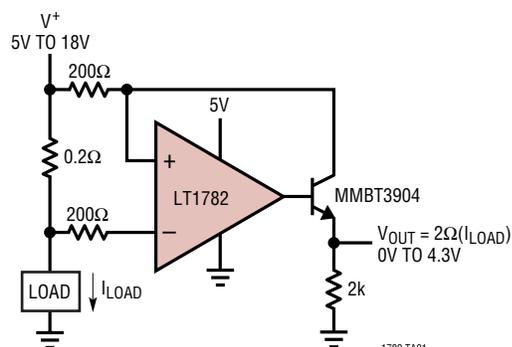
Distribution of Input Offset Voltage

$V_S = 5V, 0V$
$V_{CM} = 2.5V$

1782 TA01a

LT1782

ABSOLUTE MAXIMUM RATINGS (Note 1)

Total Supply Voltage (V$^+$ to V$^-$) 18V
Input Differential Voltage 18V
Input Pin Voltage to V$^-$ .... +24V/−10V
Shutdown Pin Voltage Above V$^-$ 18V
Shutdown Pin Current .... ±10mA
Output Short-Circuit Duration (Note 2) .... Indefinite
Operating Temperature Range (Note 3)
   LT1782C .... −40°C to 85°C
   LT1782I .... −40°C to 85°C
   LT1782H .... −40°C to 125°C

Specified Temperature Range (Note 4)
   LT1782C .... −40°C to 85°C
   LT1782I .... −40°C to 85°C
   LT1782H .... −40°C to 125°C
Junction Temperature .... 150°C
Storage Temperature Range .... −65°C to 150°C
Lead Temperature (Soldering, 10 sec) .... 300°C

PACKAGE/ORDER INFORMATION

	ORDER PART NUMBER
TOP VIEW OUT 1 5 V$^+$ V$^-$ 2 +IN 3 4 −IN S5 PACKAGE 5-LEAD PLASTIC SOT-23 T$_{JMAX}$ = 150°C, θ$_{JA}$ = 250°C/W	LT1782CS5 LT1782IS5 LT1782HS5
	S5 PART MARKING
	LTLD LTLE LTXK

	ORDER PART NUMBER
TOP VIEW OUT 1 6 V$^+$ V$^-$ 2 5 SHDN +IN 3 4 −IN S6 PACKAGE 6-LEAD PLASTIC SOT-23 T$_{JMAX}$ = 150°C, θ$_{JA}$ = 230°C/W	LT1782CS6 LT1782IS6 LT1782HS6
	S6 PART MARKING
	LTIS LTIT LTXL

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

ELECTRICAL CHARACTERISTICS

The ● denotes specifications which apply over the specified temperature range, otherwise specifications are T$_A$ = 25°C.
V$_S$ = 3V, 0V; V$_S$ = 5V, 0V, V$_{CM}$ = V$_{OUT}$ = half supply, for the 6-lead part V$_{PIN5}$ = 0V, pulse power tested unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS		LT1782C/LT1782I MIN	TYP	MAX	UNITS
V$_{OS}$	Input Offset Voltage	T$_A$ = 25°C			400	800	μV
		0°C ≤ T$_A$ ≤ 70°C	●			950	μV
		−40°C ≤ T$_A$ ≤ 85°C	●			1100	μV
ΔV$_{OS}$/ΔT	Input Offset Voltage Drift (Note 7)		●		2	5	μV/°C
I$_{OS}$	Input Offset Current		●		0.7	2	nA
		V$_{CM}$ = 18V (Note 5)	●			1	μA
I$_B$	Input Bias Current		●		8	15	nA
		V$_{CM}$ = 18 (Note 5)	●		6	12	μA
		SHDN or V$_S$ = 0V, V$_{CM}$ = 0V to 18V			0.1		nA
	Input Bias Current Drift	−40°C ≤ T$_A$ ≤ 85°C	●		0.01		nA/°C
	Input Noise Voltage	0.1Hz to 10Hz			1		μV$_{P-P}$
e$_n$	Input Noise Voltage Density	f = 1kHz			50		nV/√Hz
i$_n$	Input Noise Current Density	f = 1kHz			0.05		pA/√Hz

ELECTRICAL CHARACTERISTICS

The ● denotes specifications which apply over the specified temperature range, otherwise specifications are $T_A = 25°C$.
$V_S = 3V$, $0V$; $V_S = 5V$, $0V$, $V_{CM} = V_{OUT}$ = half supply, for the 6-lead part $V_{PIN5} = 0V$, pulse power tested unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS		LT1782C/LT1782I MIN	TYP	MAX	UNITS
R_{IN}	Input Resistance	Differential	●	3.4	6.5		MΩ
		Common Mode, $V_{CM} = 0V$ to $(V_{CC} - 1V)$			5		GΩ
		Common Mode, $V_{CM} = 0V$ to 18V	●	1.5	3		MΩ
C_{IN}	Input Capacitance				5		pF
	Input Voltage Range		●	0		18	V
CMRR	Common Mode Rejection Ratio (Note 5)	$V_{CM} = 0V$ to $V_{CC} - 1V$	●	90	100		dB
		$V_{CM} = 0V$ to 18V (Note 8)	●	68	80		dB
PSRR	Power Supply Rejection Ratio	$V_S = 3V$ to 12.5V, $V_{CM} = V_O = 1V$	●	90	100		dB
A_{VOL}	Large-Signal Voltage Gain	$V_S = 3V$, $V_O = 500mV$ to 2.5V, $R_L = 10k$		200	1500		V/mV
		$V_S = 3V$, $0°C \leq T_A \leq 70°C$	●	133			V/mV
		$V_S = 3V$, $-40°C \leq T_A \leq 85°C$	●	100			V/mV
		$V_S = 5V$, $V_O = 500mV$ to 4.5V, $R_L = 10k$		400	1500		V/mV
		$V_S = 5V$, $0°C \leq T_A \leq 70°C$	●	250			V/mV
		$V_S = 5V$, $-40°C \leq T_A \leq 85°C$	●	200			V/mV
V_{OL}	Output Voltage Swing LOW	No Load	●		3	8	mV
		$I_{SINK} = 5mA$	●		200	500	mV
		$V_S = 5V$, $I_{SINK} = 10mA$	●		400	800	mV
V_{OH}	Output Voltage Swing HIGH	$V_S = 3V$, No Load	●	2.91	2.94		V
		$V_S = 3V$, $I_{SOURCE} = 5mA$	●	2.6	2.8		V
		$V_S = 5V$, No Load	●	4.91	4.94		V
		$V_S = 5V$, $I_{SOURCE} = 10mA$	●	4.5	4.74		V
I_{SC}	Short-Circuit Current (Note 2)	$V_S = 3V$, Short to GND		5	10		mA
		$V_S = 3V$, Short to V_{CC}		15	30		mA
		$V_S = 5V$, Short to GND		15	30		mA
		$V_S = 5V$, Short to V_{CC}		20	40		mA
	Minimum Supply Voltage		●	2.7			V
	Reverse Supply Voltage	$I_S = -100\mu A$	●	18			V
I_S	Supply Current (Note 6)				40	55	μA
		$0°C \leq T_A \leq 70°C$	●			60	μA
		$-40°C \leq T_A \leq 85°C$	●			65	μA
	Supply Current, SHDN	$V_{PIN5} = 2V$, No Load (Note 10)	●		5	15	μA
I_{SHDN}	Shutdown Pin Current	$V_{PIN5} = 0.3V$, No load (Note 10)	●		0.5		nA
		$V_{PIN5} = 2V$, No Load (Note 10)	●		2	8	μA
		$V_{PIN5} = 5V$, No Load (Note 10)	●		5		μA
	Shutdown Output Leakage Current	$V_{PIN5} = 2V$, No Load (Note 10)	●		0.05	1	μA
	Maximum Shutdown Pin Current	$V_{PIN5} = 18V$, No Load (Note 10)	●		10	30	μA
V_L	Shutdown Pin Input Low Voltage	(Note 10)	●			0.3	V
V_H	Shutdown Pin Input High Voltage	(Note 10)	●	2			V
t_{ON}	Turn-On Time	$V_{PIN5} = 5V$ to $0V$, $R_L = 10k$ (Note 10)			100		μs
t_{OFF}	Turn-Off Time	$V_{PIN5} = 0V$ to $5V$, $R_L = 10k$ (Note 10)			6		μs
GBW	Gain Bandwidth Product (Note 5)	$f = 5kHz$		110	200		kHz
		$0°C \leq T_A \leq 70°C$	●	100			kHz
		$-40°C \leq T_A \leq 85°C$	●	90			kHz

ELECTRICAL CHARACTERISTICS

The ● denotes specifications which apply over the specified temperature range, otherwise specifications are T$_A$ = 25°C.
V$_S$ = 3V, 0V; V$_S$ = 5V, 0V, V$_{CM}$ = V$_{OUT}$ = half supply, for the 6-lead part V$_{PIN5}$ = 0V, pulse power tested unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS		LT1782C/LT1782I MIN	TYP	MAX	UNITS
SR	Slew Rate (Note 5)	A$_V$ = −1, R$_L$ = ∞ 0°C ≤ T$_A$ ≤ 70°C −40°C ≤ T$_A$ ≤ 85°C	 ● ●	0.035 0.031 0.028	0.07		V/µs V/µs V/µs
t$_S$	Settling Time	V$_S$ = 5V, ΔV$_{OUT}$ = 2V to 0.1%, A$_V$ = −1			45		µs
THD	Distortion	V$_S$ = 3V, V$_O$ = 2V$_{P–P}$, A$_V$ = 1, R$_L$ = 10k, f =1kHz			0.003		%
FPBW	Full-Power Bandwidth (Note 9)	V$_{OUT}$ = 2V$_{P–P}$			11		kHz

The ● denotes specifications which apply over the specified temperature range, otherwise specifications are T$_A$ = 25°C.
V$_S$ = ±5V, V$_{CM}$ = 0V, V$_{OUT}$ = 0V, for the 6-lead part V$_{PIN5}$ = V$^-$, pulse power tested unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS		LT1782C/LT1782I MIN	TYP	MAX	UNITS
V$_{OS}$	Input Offset Voltage	T$_A$ = 25°C 0°C ≤ T$_A$ ≤ 70°C −40°C ≤ T$_A$ ≤ 85°C	 ● ●		500	900 1050 1200	µV µV µV
ΔV$_{OS}$/ΔT	Input Offset Voltage Drift (Note 7)		●		2	5	µV/°C
I$_{OS}$	Input Offset Current		●		0.7	2	nA
I$_B$	Input Bias Current		●		8	15	nA
	Input Bias Current Drift		●		0.01		nA/°C
	Input Noise Voltage	0.1Hz to 10Hz			1		µV$_{P-P}$
e$_n$	Input Noise Voltage Density	f = 1kHz			50		nV/√Hz
i$_n$	Input Noise Current Density	f = 1kHz			0.05		pA/√Hz
R$_{IN}$	Input Resistance	Differential Common Mode, V$_{CM}$ = −5V to 13V	● ●	3.4 1.5	6.5 3		MΩ MΩ
C$_{IN}$	Input Capacitance				5		pF
	Input Voltage Range		●	−5		13	V
CMRR	Common Mode Rejection Ratio	V$_{CM}$ = −5V to 13V	●	68	80		dB
A$_{VOL}$	Large-Signal Voltage Gain	V$_O$ = ±4V, R$_L$= 10k 0°C ≤ T$_A$ ≤ 70°C −40°C ≤ T$_A$ ≤ 85°C	 ● ●	55 40 30	150		V/mV V/mV V/mV
V$_{OL}$	Output Voltage Swing LOW	No Load I$_{SINK}$ = 5mA I$_{SINK}$ = 10mA	● ● ●		−4.997 −4.8 −4.6	−4.992 −4.5 −4.2	V V V
V$_{OH}$	Output Voltage Swing HIGH	No Load I$_{SOURCE}$ = 5mA I$_{SOURCE}$ = 10mA	● ● ●	4.91 4.6 4.5	4.94 4.8 4.74		V V V
I$_{SC}$	Short-Circuit Current (Note 2)	Short to GND 0°C ≤ T$_A$ ≤ 70°C	 ●	18 15	30		mA mA
PSRR	Power Supply Rejection Ratio	V$_S$ = ±1.5V to ±9V	●	90	100		dB
I$_S$	Supply Current	 0°C ≤ T$_A$ ≤ 70°C −40°C ≤ T$_A$ ≤ 85°C	 ● ●		45	60 65 70	µA µA µA
	Supply Current, SHDN	V$_{PIN5}$ = −3V, V$_S$ = ±5V, No Load (Note 10)	●		6	20	µA
I$_{SHDN}$	Shutdown Pin Current	V$_{PIN5}$ = −4.7V, V$_S$ = ±5V, No load (Note 10) V$_{PIN5}$ = −3V, V$_S$ = ±5V, No Load (Note 10)	● ●		0.5 2	 8	nA µA

ELECTRICAL CHARACTERISTICS

The ● denotes specifications which apply over the specified temperature range, otherwise specifications are T_A = 25°C.
V_S = ±5V, V_{CM} = 0V, V_{OUT} = 0V, for the 6-lead part V_{PIN5} = V⁻, pulse power tested unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS		LT1782C/LT1782I MIN	TYP	MAX	UNITS
	Maximum Shutdown Pin Current	V_{PIN5} = 9V, V_S = ±9V (Note 10)	●		10	30	µA
	Shutdown Output Leakage Current	V_{PIN5} = −7V, V_S = ±9V, No Load (Note 10)	●		0.05	1	µA
V_L	Shutdown Pin Input Low Voltage	V_S = ±5V (Note 10)	●			−4.7	V
V_H	Shutdown Pin Input High Voltage	V_S = ±5V (Note 10)	●	−3			V
t_{ON}	Turn-On Time	V_{PIN5} = 0V to −5V, R_L = 10k (Note 10)	●		100		µs
t_{OFF}	Turn-Off Time	V_{PIN5} = −5V to 0V, R_L = 10k (Note 10)	●		6		µs
GBW	Gain Bandwidth Product	f = 5kHz 0°C ≤ T_A ≤ 70°C −40°C ≤ T_A ≤ 85°C	 ● ●	120 110 100	225		kHz kHz kHz
SR	Slew Rate	A_V = −1, R_L = ∞, V_O = ±4V, Measured at V_O = ±2V 0°C ≤ T_A ≤ 70°C −40°C ≤ T_A ≤ 85°C	 ● ●	0.0375 0.033 0.030	0.075		V/µs V/µs V/µs
t_S	Settling Time	ΔV_{OUT} = 4V to 0.1%, A_V = 1			50		µs
FPBW	Full-Power Bandwidth (Note 9)	V_{OUT} = 8$V_{P–P}$			3		kHz

The ● denotes specifications which apply over the full operating temperature range of −40°C ≤ T_A ≤ 125°C. V_S = 3V, 0V; V_S = 5V, 0V; V_{CM} = V_{OUT} = half supply, for the 6-lead part V_{PIN5} = 0V, pulse power tested unless otherwise specified. (Note 4)

SYMBOL	PARAMETER	CONDITIONS		LT1782H MIN	TYP	MAX	UNITS
V_{OS}	Input Offset Voltage		 ●		400	800 3	µV mV
$\Delta V_{OS}/\Delta T$	Input Offset Voltage Drift		●			15	µV/°C
I_{OS}	Input Offset Current	 V_{CM} = 18V (Note 5)	● ●			3 2	nA µA
I_B	Input Bias Current	 V_{CM} = 18V (Note 5)	● ●			30 25	nA µA
	Input Voltage Range		●	0.3		18	V
CMRR	Common Mode Rejection Ratio	V_{CM} = 0.3V to V_{CC} − 1V V_{CM} = 0.3V to 18V	● ●	76 60			dB dB
A_{VOL}	Large-Signal Voltage Gain	V_S = 3V, V_O = 500mV to 2.5V, R_L = 10k	 ●	200 50	1500		V/mV V/mV
		V_S = 5V, V_O = 500mV to 4.5V, R_L = 10k	 ●	400 80	1500		V/mV V/mV
V_{OL}	Output Voltage Swing LOW	No Load I_{SINK} = 5mA V_S = 5V, I_{SINK} = 10mA	● ● ●			15 900 1500	mV mV mV
V_{OH}	Output Voltage Swing HIGH	V_S = 3V, No Load V_S = 3V, I_{SOURCE} = 5mA	● ●	2.85 2.20			V V
		V_S = 5V, No Load V_S = 5V, I_{SOURCE} = 10mA	● ●	4.85 3.80			V V
PSRR	Power Supply Rejection Ratio	V_S = 3V to 12.5V, V_{CM} = V_O = 1V	●	80			dB
	Minimum Supply Voltage		●	2.7			V
	Reverse Supply Voltage	I_S = −100µA	●	18			V

ELECTRICAL CHARACTERISTICS

The ● denotes specifications which apply over the full operating temperature range of −40°C ≤ T_A ≤ 125°C. V_S = 3V, 0V; V_S = 5V, 0V; V_{CM} = V_{OUT} = half supply, for the 6-lead part V_{PIN5} = 0V, pulse power tested unless otherwise specified. (Note 4)

SYMBOL	PARAMETER	CONDITIONS		MIN	LT1782H TYP	MAX	UNITS
I_S	Supply Current				40	55	μA
			●			100	μA
	Supply Current, SHDN	V_{PIN5} = 2V, No Load (Note 10)	●			25	μA
I_{SHDN}	Shutdown Pin Current	V_{PIN5} = 0.3V, No load (Note 10)	●		0.5		nA
		V_{PIN5} = 2V, No Load (Note 10)	●			12	μA
	Output Leakage Current	V_{PIN5} = 2V, No Load (Note 10)	●			3	μA
	Maximum Shutdown Pin Current	V_{PIN5} = 18V, No Load	●			45	μA
V_L	Shutdown Pin Input Low Voltage	(Note 10)	●			0.3	V
V_H	Shutdown Pin Input High Voltage	(Note 10)	●	2			V
GBW	Gain Bandwidth Product	f = 10kHz (Note 5)		110	200		kHz
			●	65			kHz
SR	Slew Rate	A_V = −1, R_L = ∞ (Note 7)		0.035	0.07		V/μs
			●	0.020			V/μs

The ● denotes specifications which apply over the full operating temperature range of −40°C ≤ T_A ≤ 125°C. V_S = ±5V, V_{CM} = 0V, V_{OUT} = 0V, for the 6-lead part V_{PIN5} = V⁻, pulse power tested unless otherwise specified. (Note 4)

SYMBOL	PARAMETER	CONDITIONS		MIN	LT1782H TYP	MAX	UNITS
V_{OS}	Input Offset Voltage				500	900	μV
			●			3.2	mV
$\Delta V_{OS}/\Delta T$	Input Offset Voltage Drift (Note 9)		●			15	μV/°C
I_{OS}	Input Offset Current		●			3	nA
I_B	Input Bias Current		●			30	nA
CMRR	Common Mode Rejection Ratio	V_{CM} = −4.7V to 13V	●	60			dB
A_{VOL}	Large-Signal Voltage Gain	V_S = ±4V, R_L = 10k		55	150		V/mV
			●	20			V/mV
V_O	Output Voltage Swing	No Load	●	±4.85			V
		I_{SINK} = ±5mA	●	±4.10			V
		I_{SINK} = ±10mA	●	±3.50			V
PSRR	Power Supply Rejection Ratio	V_S = ±1.5V to ±9V	●	80			dB
	Minimum Supply Voltage		●	±1.35			V
I_S	Supply Current				45	60	μA
			●			110	μA
	Supply Current, SHDN	V_{PIN5} = −3V, V_S = ±5V, No Load (Note 10)	●			25	μA
I_{SHDN}	Shutdown Pin Current	V_{PIN5} = −4.7V, V_S = ±5V, No load (Note 10)	●		0.5		nA
		V_{PIN5} = −3V, V_S = ±5V, No Load (Note 10)	●			12	μA
	Maximum Shutdown Pin Current	V_{PIN5} = 9V, V_S = ±9V, No Load (Note 10)	●			45	μA
	Output Leakage Current	V_{PIN5} = −7V, V_S = ±9V, No Load	●			3	μA
V_L	Shutdown Pin Input Low Voltage	V_S = ±5V	●			−4.7	V
V_H	Shutdown Pin Input High Voltage	V_S = ±5V	●	−3			V
GBW	Gain Bandwidth Product	f = 5kHz		120	225		kHz
			●	70			kHz
SR	Slew Rate	A_V = −1, R_L = ∞, V_O = ±4V		0.0375	0.075		V/μs
		Measured at V_O = ±2V	●	0.0220			V/μs

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ELECTRICAL CHARACTERISTICS

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

Note 2: A heat sink may be required to keep the junction temperature below absolute maximum.

Note 3: The LT1782C and LT1782I are guaranteed functional over the operating temperature range of −40°C to 85°C. The LT1782H is guaranteed functional over the operating temperature range of −40°C to 125°C.

Note 4: The LT1782C is guaranteed to meet specified performance from 0°C to 70°C. The LT1782C is designed, characterized and expected to meet specified performance from −40°C to 85°C but is not tested or QA sampled at these temperatures. The LT1782I is guaranteed to meet specified performance from −40°C to 85°C. The LT1782H is guaranteed to meet specified performance from −40°C to 125°C.

Note 5: V_S = 5V limits are guaranteed by correlation to V_S = 3V and V_S = ±5V or V_S = ±9V tests.

Note 6: V_S = 3V limits are guaranteed by correlation to V_S = 5V and V_S = ±5V or V_S = ±9V tests.

Note 7: Guaranteed by correlation to slew rate at V_S = ±5V, and GBW at V_S = 3V and V_S = ±5V tests.

Note 8: This specification implies a typical input offset voltage of 1.8mV at V_{CM} = 18V and a maximum input offset voltage of 7.2mV at V_{CM} = 18V.

Note 9: This parameter is not 100% tested.

Note 10: Specifications apply to 6-lead SOT-23 with shutdown.

Note 11: Full-power bandwidth is calculated for the slew rate. FPBW = $SR/2\pi V_P$.

TYPICAL PERFORMANCE CHARACTERISTICS

Supply Current vs Supply Voltage
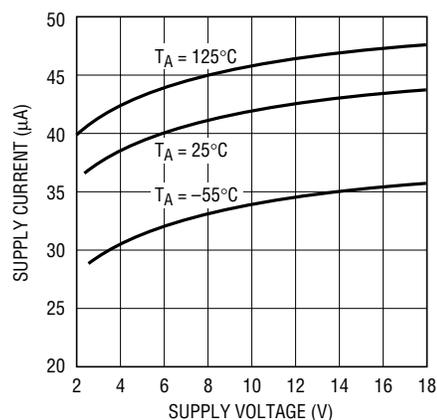
1782 G01

Minimum Supply Voltage
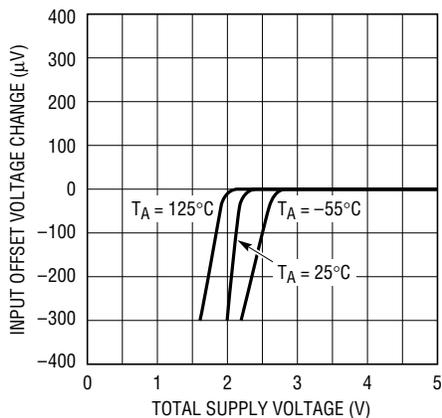
1782 G02

Output Voltage vs Large Input Voltage
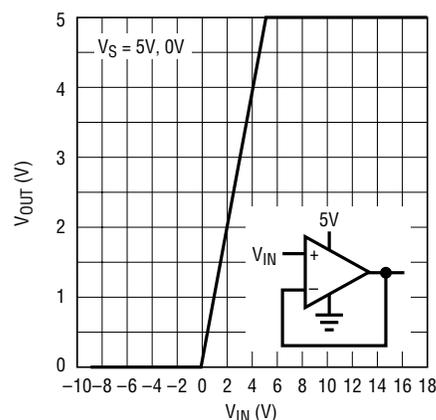
1782 G02a

TYPICAL PERFORMANCE CHARACTERISTICS

Input Bias Current vs Common Mode Voltage

$V_S = 5V, 0V$
$T_A = 125°C$
$T_A = 25°C$
$T_A = -55°C$
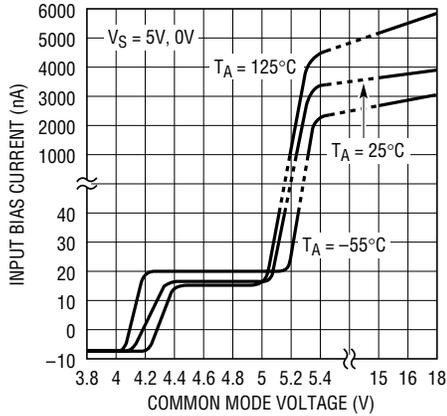
1782 G03

Output Saturation Voltage vs Load Current (Output High)

$V_S = ±2.5V$
$V_{OD} = 30mV$
$T_A = 125°C$
$T_A = 25°C$
$T_A = -55°C$
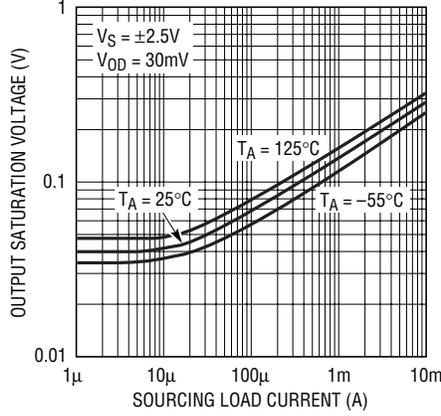
1782 G04

Output Saturation Voltage vs Load Current (Output Low)

$V_S = ±2.5V$
$V_{OD} = 30mV$
$T_A = 125°C$
$T_A = 25°C$
$T_A = -55°C$
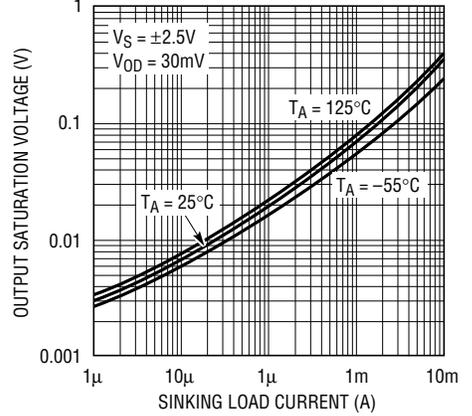
1782 G05

Output Saturation Voltage vs Input Overdrive

OUTPUT HIGH
OUTPUT LOW
$V_S = ±2.5V$
NO LOAD
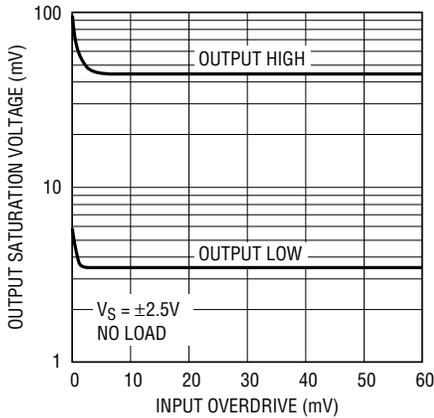
1782 G06

Output Short-Circuit Current vs Temperature

$V_S = ±5V$
SINKING CURRENT
SOURCING CURRENT
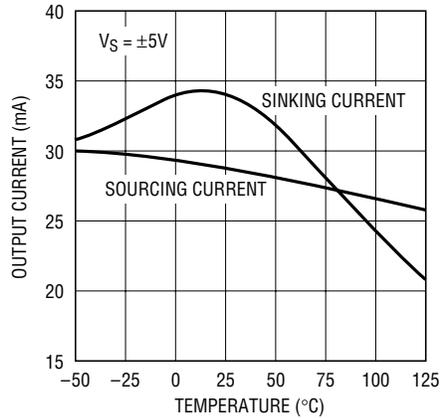
1782 G06a

0.1Hz to 10Hz Noise Voltage

$V_S = ±2.5V$
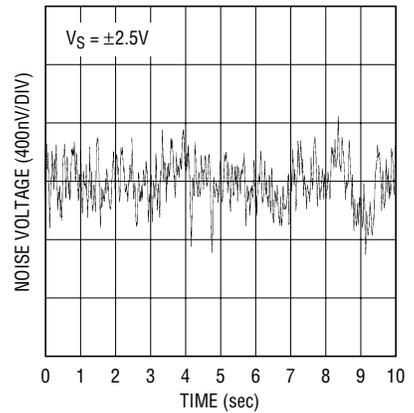
1782 G07

Noise Voltage Density vs Frequency
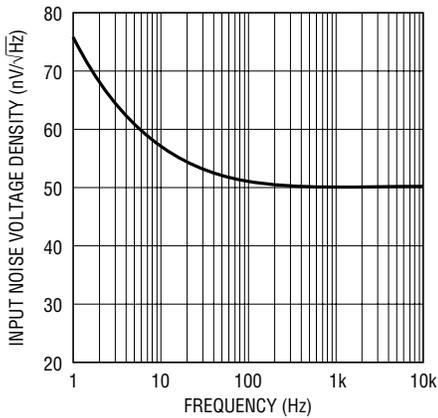
1782 G08

Input Noise Current vs Frequency

$V_S = ±2.5V$
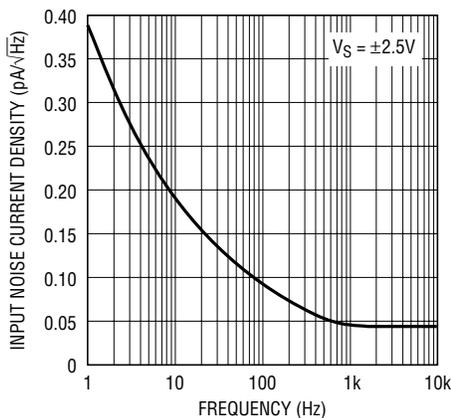
1782 G09

Gain and Phase Shift vs Frequency

$V_S = ±2.5V$
PHASE
GAIN
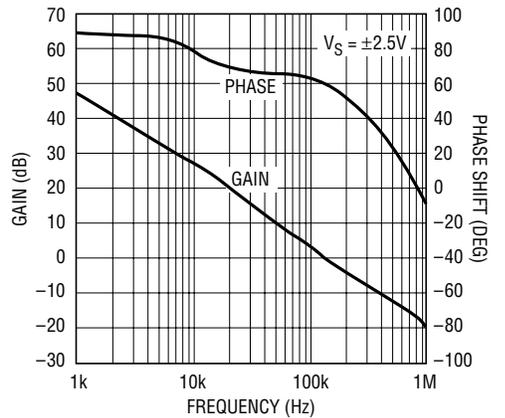
1782 G10

TYPICAL PERFORMANCE CHARACTERISTICS

Gain Bandwidth Product vs Temperature
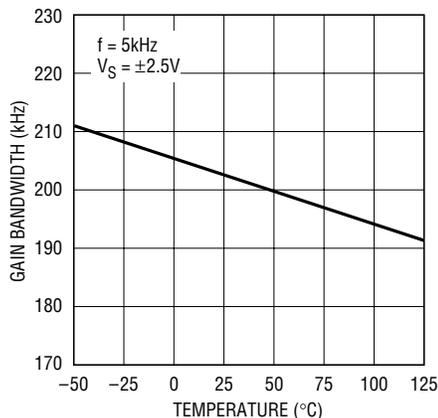
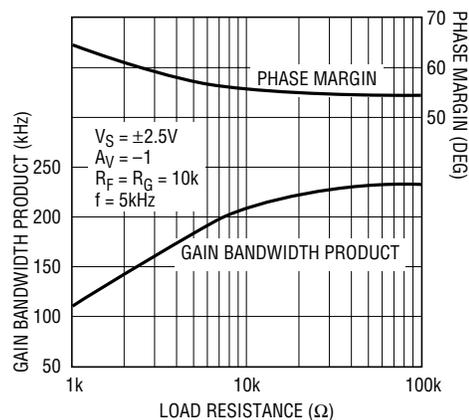1782 G11

Slew Rate vs Temperature
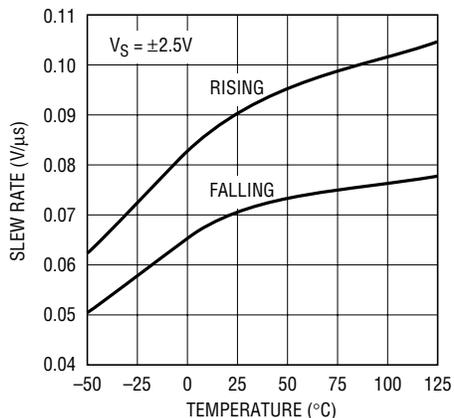
1782 G12

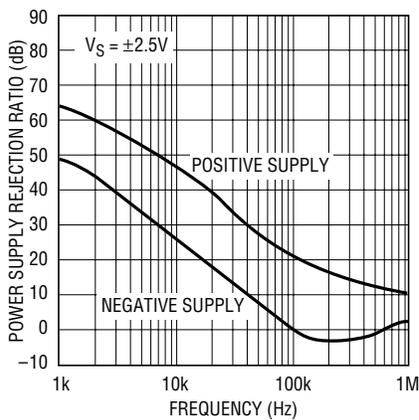### Gain Bandwidth Product and Phase Margin vs Supply Voltage
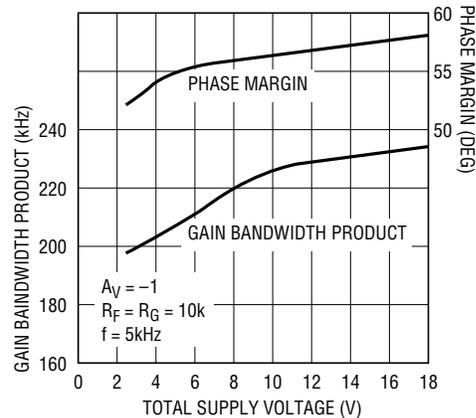
1782 G13

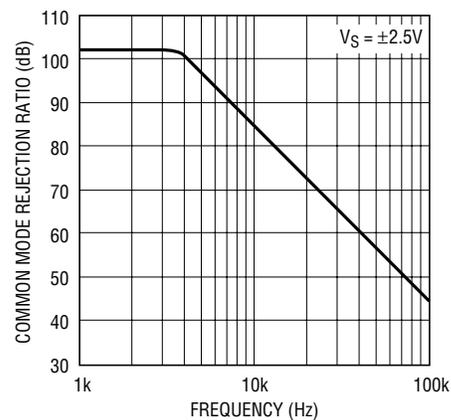### Gain Bandwidth Product and Phase Margin vs Load Resistance
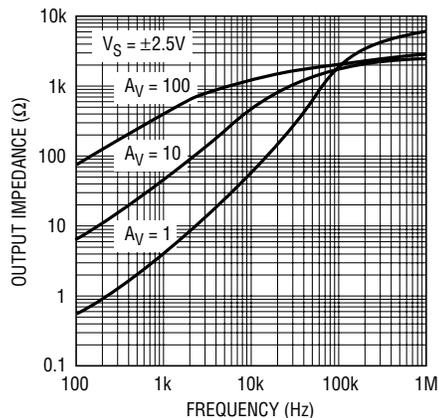

1782 G14

PSRR vs Frequency

1782 G15

CMRR vs Frequency

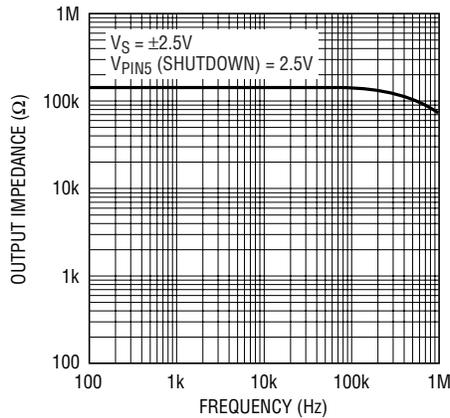

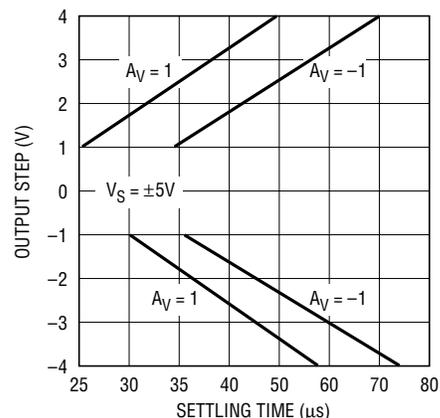1782 G16

Output Impedance vs Frequency

1782 G17

Disabled Output Impedance vs Frequency (Note 8)

1782 G17a

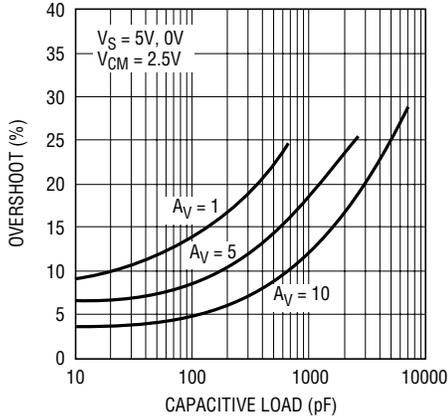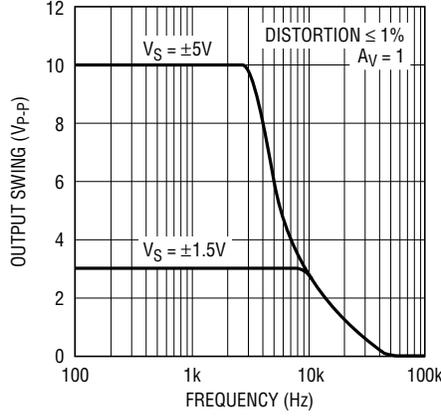### Settling Time to 0.1% vs Output Step

1782 G18

9

TYPICAL PERFORMANCE CHARACTERISTICS
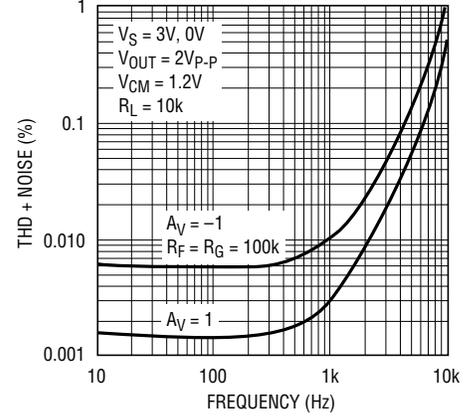
Capacitive Load Handling Overshoot vs Capacitive Load

$V_S = 5V, 0V$
$V_{CM} = 2.5V$

$A_V = 1$
$A_V = 5$
$A_V = 10$

1782 G19

Undistorted Output Swing vs Frequency

DISTORTION ≤ 1%
$A_V = 1$
$V_S = ±5V$
$V_S = ±1.5V$

1782 G20

Total Harmonic Distortion + Noise vs Frequency

$V_S = 3V, 0V$
$V_{OUT} = 2V_{P-P}$
$V_{CM} = 1.2V$
$R_L = 10k$

$A_V = -1$
$R_F = R_G = 100k$

$A_V = 1$

1782 G21

Total Harmonic Distortion + Noise vs Load Resistance

$V_S = 3V$ TOTAL
$A_V = 1$
$V_{IN} = 2V_{P-P}$ AT 1kHz

$V_S = ±1.5V$
$V_{IN} = ±1V$

$V_S = 3V, 0V$
$V_{IN} = 0.5V$ TO 2.5V

$V_S = 3V, 0V$
$V_{IN} = 0.2V$ TO 2.2V
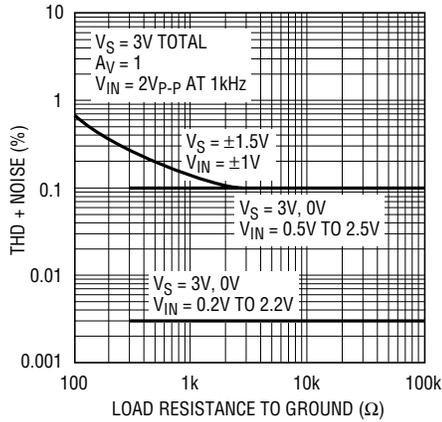
1782 G22

Total Harmonic Distortion + Noise vs Output Voltage Amplitude

f = 1kHz, $R_L = 10k$

$A_V = 1$
$V_S = ±1.5V$
$V_{CM} = 0V$

$A_V = -1$, $R_F = R_G = 100k$
$V_S = ±1.5V$
$V_{CM} = 0V$

$A_V = 1$
$V_S = 3V, 0V$
$V_{CM} = 1.5V$

$A_V = -1$, $R_F = R_G = 100k$
$V_S = 3V, 0V$
$V_{CM} = 1.5V$
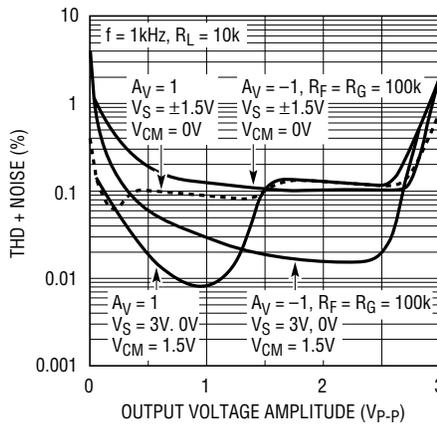
1782 G23

Open-Loop Gain

$V_S = ±5V$

$R_L = 10k$
$R_L = 50k$
$R_L = 2k$
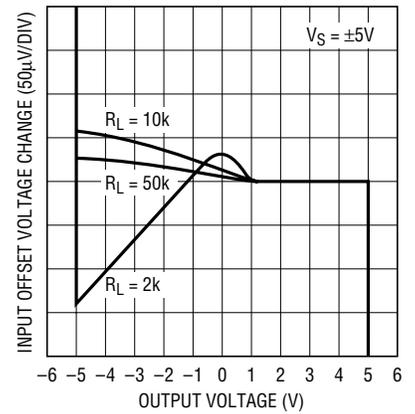
1782 G24

Supply Current vs Shutdown Voltage

$T_A = 125°C$
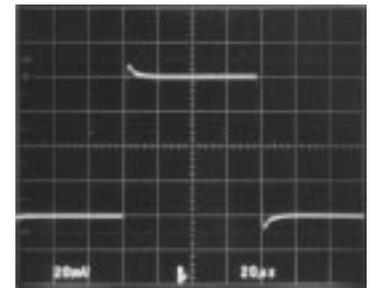$V_S = 5V, 0V$
$T_A = 25°C$
$T_A = -55°C$
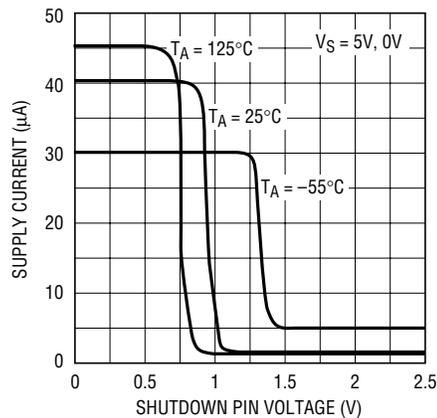
1782 G25

Large-Signal Response
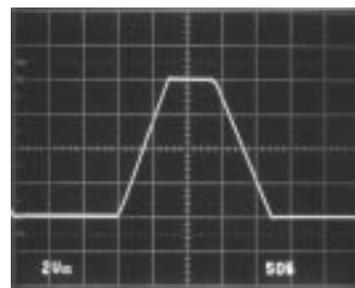
$V_S = ±5V$
$A_V = 1$
$C_L = 15pF$

1782 G26

Small-Signal Response

$V_S = ±5V$
$A_V = 1$
$C_L = 15pF$

1782 G27

APPLICATIONS INFORMATION

Supply Voltage

The positive supply pin of the LT1782 should be bypassed with a small capacitor (typically 0.1µF) within an inch of the pin. When driving heavy loads, an additional 4.7µF electrolytic capacitor should be used. When using split supplies, the same is true for the negative supply pin.

The LT1782 is protected against reverse battery voltages up to 18V. In the event a reverse battery condition occurs, the supply current is typically less than 1nA.

Inputs

The LT1782 has two input stages, NPN and PNP (see the Simplified Schematic), resulting in three distinct operating regions as shown in the Input Bias Current vs Common Mode typical performance curve.

For input voltages about 0.8V or more below V^+, the PNP input stage is active and the input bias current is typically –8nA. When the input common mode voltage is within 0.5V of the positive rail, the NPN stage is operating and the input bias current is typically 15nA. Increases in temperature will cause the voltage at which operation switches from the PNP input stage to the NPN input stage to move towards V^+. The input offset voltage of the NPN stage is untrimmed and is typically 1.8mV.

A Schottky diode in the collector of the input NPN transistors, along with special geometries for these NPN transistors, allows the LT1782 to operate with either or both of its inputs above V^+. At about 0.3V above V^+, the NPN input transistor is fully saturated and the input bias current is typically 4µA at room temperature. The input offset voltage is typically 1.8mV when operating above V^+. The LT1782 will operate with its inputs 18V above V^- regardless of V^+.

The inputs are protected against excursions as much as 10V below V^- by an internal 6k resistor in series with each input and a diode from the input to the negative supply. The input stage of the LT1782 incorporates phase reversal protection to prevent the output from phase reversing for inputs up to 9V below V^-. There are no clamping diodes between the inputs and the maximum differential input voltage is 18V.

Output

The output of the LT1782 can swing to within 60mV of the positive rail with no load and within 3mV of the negative rail with no load. When monitoring voltages within 60mV of the positive rail or within 3mV of the negative rail, gain should be taken to keep the output from clipping. The LT1782 can sink and source over 30mA at ±5V supplies, sourcing current is reduced to 10mA at 3V total supplies as noted in the Electrical Characteristics.

The LT1782 is internally compensated to drive at least 600pF of capacitance under any output loading conditions. A 0.22µF capacitor in series with a 150Ω resistor between the output and ground will compensate these amplifiers for larger capacitive loads, up to 10,000pF, at all output currents.

Distortion

There are two main contributors to distortion in op amps: output crossover distortion as the output transitions from sourcing to sinking current, and distortion caused by nonlinear common mode rejection. If the op amp is operating inverting, there is no common mode induced distortion. If the op amp is operating in the PNP input stage (input is not within 0.8V of V^+), the CMRR is very good,

APPLICATIONS INFORMATION

typically 100dB. When the LT1782 switches between input stages, there is significant nonlinearity in the CMRR. Lower load resistance increases the output crossover distortion but has no effect on the input stage transition distortion. For lowest distortion, the LT1782 should be operated single supply, with the output always sourcing current and with the input voltage swing between ground and $(V^+ - 0.8V)$. See the Typical Performance Characteristics curves, "Total Harmonic Distortion + Noise vs Ouput Voltage Amplitude."
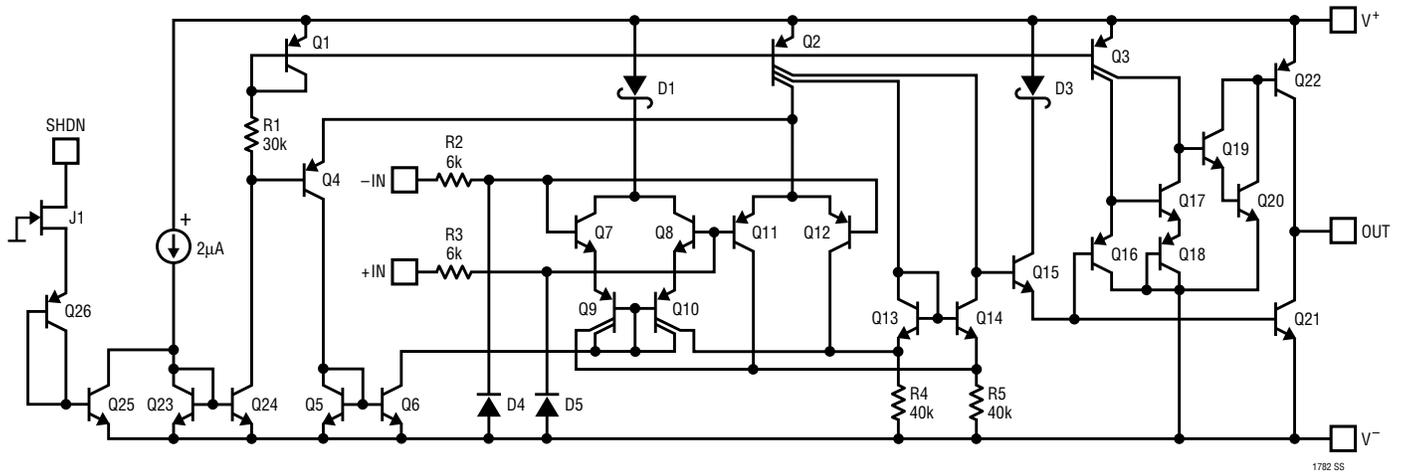
Gain

The open-loop gain is almost independent of load when the output is sourcing current. This optimizes perfor-mance in single supply applications where the load is returned to ground. The typical performance curve of open-loop gain for various loads shows the details.
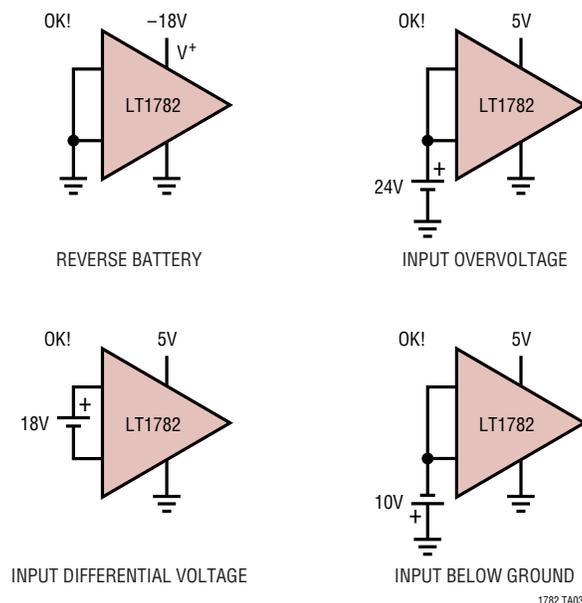
Shutdown

The 6-lead part includes a shutdown feature that disables the part, reducing quiescent current and making the output high impedance. The part can be shut down by bringing the SHDN pin 1.2V or more above V^-. When shut down, the supply current is about $5\mu A$ and the output leakage current is less than $1\mu A$ ($V^- \leq V_{OUT} \leq V^+$). In normal operation, the SHDN pin can be tied to V^- or left floating. See the Typical Performance Characteristics curves, "Supply Current vs Shutdown Pin Voltage."
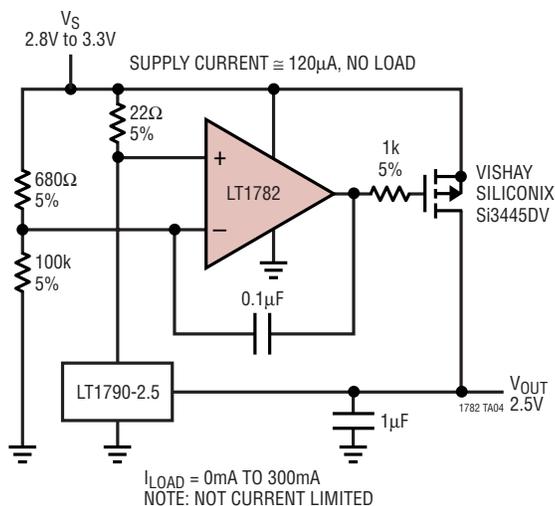
SIMPLIFIED SCHEMATIC

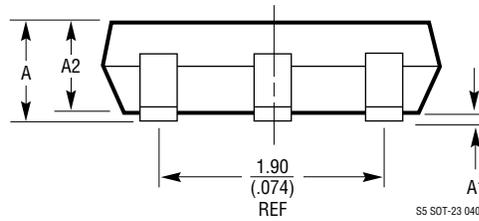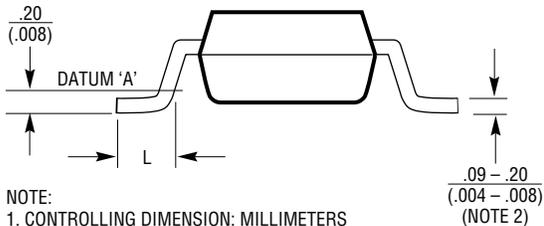1782 SS

TYPICAL APPLICATIONS

Protected Fault Conditions

REVERSE BATTERY

INPUT OVERVOLTAGE

INPUT DIFFERENTIAL VOLTAGE

INPUT BELOW GROUND

1782 TA03

Compact, High Output Current, Low Dropout, Precision 2.5V Supply

V_S
2.8V to 3.3V

SUPPLY CURRENT ≅ 120µA, NO LOAD

22Ω 5%

680Ω 5%

100k 5%

LT1782

1k 5%

VISHAY SILICONIX Si3445DV

0.1µF

LT1790-2.5

1µF

V_{OUT} 2.5V

1782 TA04

I_{LOAD} = 0mA TO 300mA
NOTE: NOT CURRENT LIMITED

PACKAGE DESCRIPTION

S5 Package
5-Lead Plastic SOT-23
(LTC DWG # 05-08-1633)
(LTC DWG # 05-08-1635)

	SOT-23 (Original)	SOT-23 (ThinSOT)
A	.90 – 1.45 (.035 – .057)	1.00 MAX (.039 MAX)
A1	.00 – .15 (.00 – .006)	.01 – .10 (.0004 – .004)
A2	.90 – 1.30 (.035 – .051)	.80 – .90 (.031 – .035)
L	.35 – .55 (.014 – .021)	.30 – .50 REF (.012 – .019 REF)
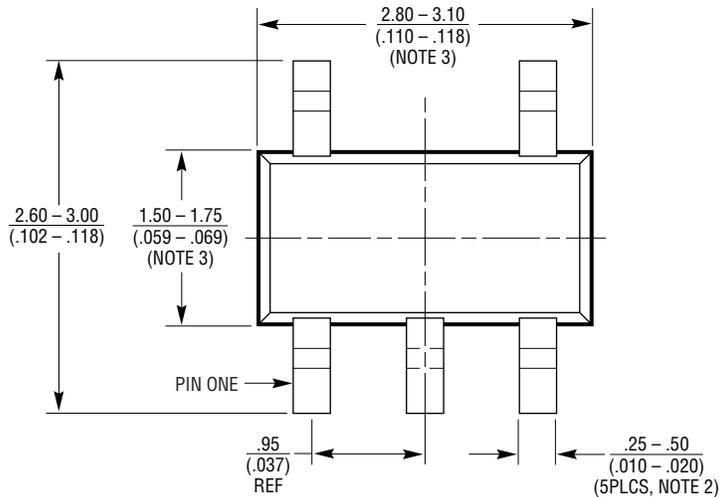
2.80 – 3.10
(.110 – .118)
(NOTE 3)

2.60 – 3.00
(.102 – .118)

1.50 – 1.75
(.059 – .069)
(NOTE 3)

PIN ONE

.95
(.037)
REF

.25 – .50
(.010 – .020)
(5PLCS, NOTE 2)

.20
(.008)

DATUM 'A'

L

.09 – .20
(.004 – .008)
(NOTE 2)

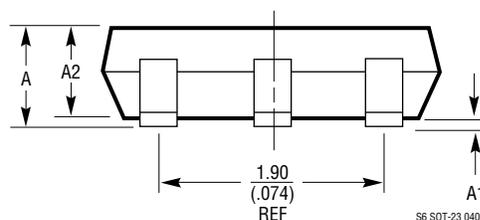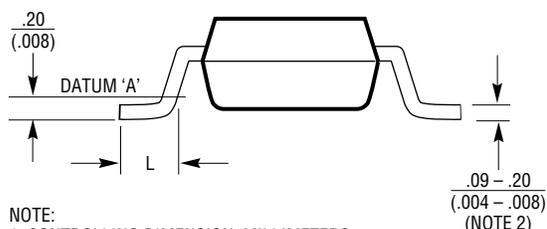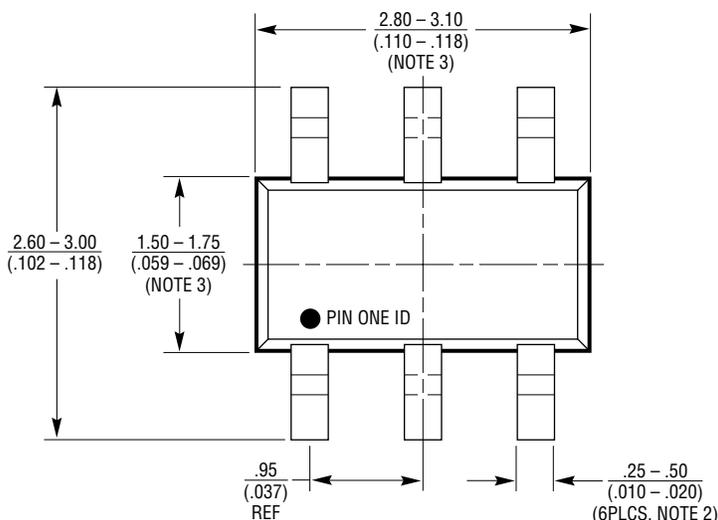A

A2

1.90
(.074)
REF

A1

S5 SOT-23 0401

NOTE:
1. CONTROLLING DIMENSION: MILLIMETERS

2. DIMENSIONS ARE IN $\dfrac{\text{MILLIMETERS}}{\text{(INCHES)}}$

3. DRAWING NOT TO SCALE
4. DIMENSIONS ARE INCLUSIVE OF PLATING
5. DIMENSIONS ARE EXCLUSIVE OF MOLD FLASH AND METAL BURR
6. MOLD FLASH SHALL NOT EXCEED .254mm
7. PACKAGE EIAJ REFERENCE IS:
   SC-74A (EIAJ) FOR ORIGINAL
   JEDEL MO-193 FOR THIN

PACKAGE DESCRIPTION

**S6 Package
6-Lead Plastic SOT-23**
(LTC DWG # 05-08-1634)
(LTC DWG # 05-08-1636)

	SOT-23 (Original)	SOT-23 (ThinSOT)
A	.90 – 1.45 (.035 – .057)	1.00 MAX (.039 MAX)
A1	.00 – 0.15 (.00 – .006)	.01 – .10 (.0004 – .004)
A2	.90 – 1.30 (.035 – .051)	.80 – .90 (.031 – .035)
L	.35 – .55 (.014 – .021)	.30 – .50 REF (.012 – .019 REF)

2.80 – 3.10
(.110 – .118)
(NOTE 3)

2.60 – 3.00
(.102 – .118)

1.50 – 1.75
(.059 – .069)
(NOTE 3)

PIN ONE ID

.95
(.037)
REF

.25 – .50
(.010 – .020)
(6PLCS, NOTE 2)

.20
(.008)

DATUM 'A'

L

.09 – .20
(.004 – .008)
(NOTE 2)

A

A2

1.90
(.074)
REF

A1

S6 SOT-23 0401

NOTE:
1. CONTROLLING DIMENSION: MILLIMETERS
2. DIMENSIONS ARE IN $\frac{MILLIMETERS}{(INCHES)}$
3. DRAWING NOT TO SCALE
4. DIMENSIONS ARE INCLUSIVE OF PLATING
5. DIMENSIONS ARE EXCLUSIVE OF MOLD FLASH AND METAL BURR
6. MOLD FLASH SHALL NOT EXCEED .254mm
7. PACKAGE EIAJ REFERENCE IS:
   SC-74A (EIAJ) FOR ORIGINAL
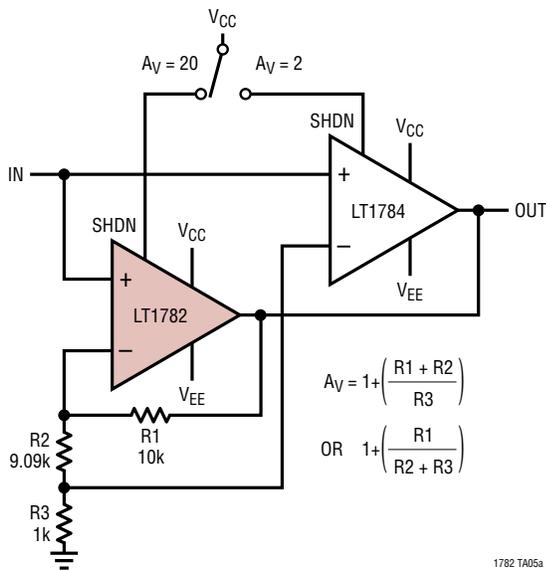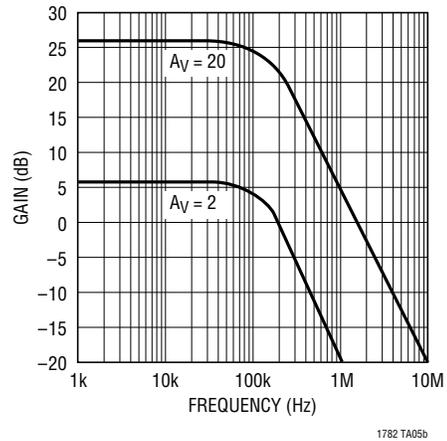   JEDEL MO-193 FOR THIN

TYPICAL APPLICATIONS

Current Source

$$I_{OUT} = \frac{1.25V}{R1}$$

1782 TA02
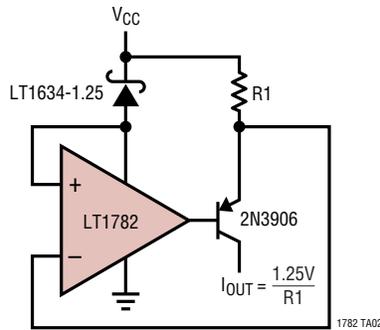
Programmable Gain, $A_V = 2$, $A_V = 20$, 100kHz Amplifier

$$A_V = 1 + \left(\frac{R1 + R2}{R3}\right)$$

$$\text{OR} \quad 1 + \left(\frac{R1}{R2 + R3}\right)$$

1782 TA05a

Programmable Gain Amplifier Frequency Response

1782 TA05b

RELATED PARTS

PART NUMBER	DESCRIPTION	COMMENTS
LT1783	Micropower Over-The-Top SOT-23 Rail-to-Rail Input and Output Op Amp	SOT-23 Package, Micropower 210μA per Amplifier, Rail-to-Rail Input and Output , 1.25MHz GBW
LT1490/LT1491	Dual/Quad Over-The-Top Micropower Rail-to-Rail Input and Output Op Amps	Single Supply Input Range: –0.4V to 44V, Micropower 50μA per Amplifier, Rail-to-Rail Input and Output , 200kHz GBW
LT1636	Single Over-The-Top Micropower Rail-to-Rail Input and Output Op Amp	55μA Supply Current, V_{CM} Extends 44V Above V_{EE}, Independent of V_{CC}, MSOP Package, Shutdown Function
LT1638/LT1639	Dual/Quad, 1.2MHz, 0.4V/μs, Over-The-Top Micropower Rail-to-Rail Input and Output Op Amps	170μA Supply Current, Single Supply Input Range: –0.4V to 44V, Rail-to-Rail Input and Output

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(408) 432-1900 • FAX: (408) 434-0507 • www.linear.com

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