

FAMILY OF MICROPOWER RAIL-TO-RAIL INPUT AND OUTPUT OPERATIONAL AMPLIFIERS

FEATURES

- **BiMOS Rail-to-Rail Input/Output**
- **Input Bias Current . . . 1 pA**
- **High Wide Bandwidth . . . 160 kHz**
- **High Slew Rate . . . 0.1 V/μs**
- **Supply Current . . . 7 μA (per channel)**
- **Input Noise Voltage . . . 90 nV/√Hz**
- **Supply Voltage Range . . . 2.7 V to 16 V**
- **Specified Temperature Range**
 - –40°C to 125°C . . . Industrial Grade
- **Ultra-Small Packaging**
 - 5 Pin SOT-23 (TLV2381)

APPLICATIONS

- **Portable Medical**
- **Power Monitoring**
- **Low Power Security Detection Systems**
- **Smoke Detectors**

DESCRIPTION

The TLV238x single supply operational amplifiers provide rail-to-rail input and output capability. The TLV238x takes the minimum operating supply voltage down to 2.7 V over the extended industrial temperature range, while adding the rail-to-rail output swing feature. The TLV238x also provides 160-kHz bandwidth from only 7 μA. The maximum recommended supply voltage is 16 V, which allows the devices to be operated from (±8 V supplies down to ±1.35 V) two rechargeable cells.

The combination of rail-to-rail inputs and outputs make them good upgrades for the TLC27Lx family—offering more bandwidth at a lower quiescent current. The offset voltage is lower than the TLC27LxA variant.

To maintain cost effectiveness the TLV2381/2 are only available in the extended industrial temperature range. This means that one device can be used in a wide range of applications that include PDAs as well as automotive sensor interface.

All members are available in SOIC, with the singles in the small SOT-23 package, duals in the MSOP.

SELECTION GUIDE

DEVICE	V _S [V]	I _Q /ch [μA]	V _{ICR} [V]	V _{IO} [mV]	I _{IB} [pA]	GBW [MHz]	SLEW RATE [V/μs]	V _n , 1 kHz [nV/√Hz]
TLV238x	2.7 to 16	10	–0.2 to V _S + 0.2	4.5	60	0.16	0.06	100
TLV27Lx	2.7 to 16	11	–0.2 to V _S – 1.2	5	60	0.16	0.06	100
TLC27Lx	4 to 16	17	–0.2 to V _S – 1.5	10/5/2	60	0.085	0.03	68
OPAx349	1.8 to 5.5	2	–0.2 to V _S + 0.2	10	10	0.070	0.02	300
OPAx347	2.3 to 5.5	34	–0.2 to V _S + 0.2	6	10	0.35	0.01	60
TLC225x	2.7 to 16	62.5	0 to V _S – 1.5	1.5/0.85	60	0.200	0.02	19

NOTE: All dc specs are maximums while ac specs are typicals.



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

PACKAGE/ORDERING INFORMATION

PRODUCT	PACKAGE	PACKAGE CODE	SYMBOL	SPECIFIED TEMPERATURE RANGE	ORDER NUMBER	TRANSPORT MEDIA
TLV2381ID	SOIC-8	D	2381I	-40°C to 125°C	TLV2381ID	Tube
					TLV2381IDR	Tape and Reel
TLV2381IDBV	SOT-23	DBV	VBKI		TLV2381IDBVR	Tape and Reel
					TLV2381IDBVT	
TLV2382ID	SOIC-8	D	2382I		TLV2382ID	Tube
					TLV2382IDR	Tape and Reel

absolute maximum ratings over operating free-air temperature (unless otherwise noted)†

Supply voltage, V_S	16.5 V
Input voltage, V_I (see Notes 1 and 2)	$V_S + 0.2 V$
Output current, I_O	100 mA
Differential input voltage, V_{ID}	V_S
Continuous total power dissipation	See Dissipation Rating Table
Maximum junction temperature, T_J	150°C
Operating free-air temperature range, T_A : I suffix	-40°C to 125°C
Storage temperature range, T_{stg}	-65°C to 125°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	300°C

† Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

- NOTES: 1. Relative to GND pin.
2. Maximum is 16.5 V or $V_S+0.2 V$ whichever is the lesser value.

DISSIPATION RATING TABLE

PACKAGE	θ_{JC} (°C/W)	θ_{JA} (°C/W)	$T_A \leq 25^\circ\text{C}$ POWER RATING	$T_A = 85^\circ\text{C}$ POWER RATING
D (8)	38.3	176	710 mW	370 mW
DBV (5)	55	324.1	385 mW	201 mW
DBV (6)	55	294.3	425 mW	221 mW

recommended operating conditions

		MIN	MAX	UNIT
Supply voltage, (V _S)	Dual supply	±1.35	±8	V
	Single supply	2.7	16	
Input common-mode voltage range		-0.2	V _S +0.2	V
Operating free air temperature, T _A	I-suffix	-40	125	°C

electrical characteristics at recommended operating conditions, V_S = 2.7 V, 5 V, and 15 V (unless otherwise noted)

dc performance

PARAMETER		TEST CONDITIONS		T _A †	MIN	TYP	MAX	UNIT		
V _{IO}	Input offset voltage	V _{IC} = V _S /2, R _L = 100 kΩ	V _O = V _S /2 R _S = 50 Ω	25°C	0.5	4.5	6.5	mV		
				Full range						
α _{VIO}	Offset voltage drift			25°C	1.1			μV/°C		
CMRR	Common-mode rejection ratio	V _{IC} = 0 V to V _S , R _S = 50 Ω	V _S = 2.7 V	25°C	54	69	70	dB		
				Full range						
				25°C	71	86			70	dB
				Full range						
		V _{IC} = 0 V to V _S , R _S = 50 Ω	V _S = 5 V	25°C	58	74	70	dB		
				Full range						
				25°C	72	88			70	dB
				Full range						
		V _{IC} = 0 V to V _S , R _S = 50 Ω	V _S = 15 V	25°C	65	80	70	dB		
				Full range						
				25°C	72	90			70	dB
				Full range						
A _{VD}	Large-signal differential voltage amplification	V _{O(PP)} = V _S /2, R _L = 100 kΩ	V _S = 2.7 V	25°C	80	100	77	dB		
				Full range						
			V _S = 5 V	25°C	80	100	77		dB	
				Full range						
			V _S = 15 V	25°C	77	83	74		dB	
				Full range						

† Full range is -40°C to 125°C.

input characteristics

PARAMETER		TEST CONDITIONS		T _A	MIN	TYP	MAX	UNIT
I _{IO}	Input offset current	V _{IC} = V _S /2, R _L = 100 kΩ ,	V _O = V _S /2, R _S = 50 Ω	≤25°C	1		60	pA
				≤70°C			100	
				≤125°C			1000	
				≤25°C	1		60	
I _{IB}	Input bias current			≤25°C	1		60	pA
				≤70°C			200	
				≤125°C			1000	
r _{i(d)}	Differential input resistance			25°C	1000		GΩ	
C _{IC}	Common-mode input capacitance	f = 1 kHz		25°C	8		pF	

electrical characteristics at recommended operating conditions, $V_S = 2.7\text{ V}$, 5 V , and 15 V (unless otherwise noted) (continued)

power supply

PARAMETER		TEST CONDITIONS	T_A^\dagger	MIN	TYP	MAX	UNIT
I_{DD}	Supply current (per channel)	$V_O = V_S/2$	25°C	7	10		μA
			Full range			15	
PSRR	Power supply rejection ratio ($\Delta V_S/\Delta V_{IO}$)	$V_S = 2.7\text{ V to }16\text{ V}$, $V_{IC} = V_S/2\text{ V}$	25°C	74	82		dB
			Full range	70			

\dagger Full range is -40°C to 125°C for I suffix.

output characteristics

PARAMETER		TEST CONDITIONS		T_A^\dagger	MIN	TYP	MAX	UNIT
V_O	Output voltage swing from rail	$V_{IC} = V_S/2$, $I_O = 100\ \mu\text{A}$	$V_S = 2.7\text{ V}$	25°C	200	160		mV
				Full range	220			
			$V_S = 5\text{ V}$	25°C	120	85		
				Full range	200			
		$V_S = 15\text{ V}$	25°C	120	50			
			Full range	150				
		$V_{IC} = V_S/2$, $I_O = 500\ \mu\text{A}$	$V_S = 5\text{ V}$	25°C	800	420		mV
				Full range	900			
$V_S = 15\text{ V}$	25°C		400	200				
	Full range		500					
I_O	Output current	$V_O = 0.5\text{ V}$ from rail	$V_S = 2.7\text{ V}$	25°C	400		μA	

\dagger Full range is -40°C to 125°C for I suffix.

dynamic performance

PARAMETER		TEST CONDITIONS	T_A	MIN	TYP	MAX	UNIT
GBP	Gain bandwidth product	$R_L = 100\ \text{k}\Omega$, $C_L = 10\ \text{pF}$, $f = 1\ \text{kHz}$	25°C		160		kHz
SR	Slew rate at unity gain	$V_{O(pp)} = 2\ \text{V}$, $R_L = 100\ \text{k}\Omega$, $C_L = 10\ \text{pF}$	25°C		0.06		$\text{V}/\mu\text{s}$
			-40°C		0.05		
			125°C		0.08		
ϕ_M	Phase margin	$R_L = 100\ \text{k}\Omega$, $C_L = 50\ \text{pF}$	25°C		62		$^\circ$
	Gain margin		25°C		6.7		dB
t_s	Settling time (0.1%)	$V_{(\text{STEP})pp} = 1\ \text{V}$, $A_V = -1$, $C_L = 10\ \text{pF}$, $R_L = 100\ \text{k}\Omega$	25°C	Rise	31		μs
				Fall	61		

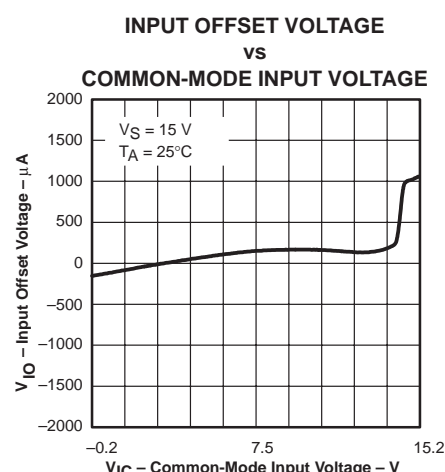
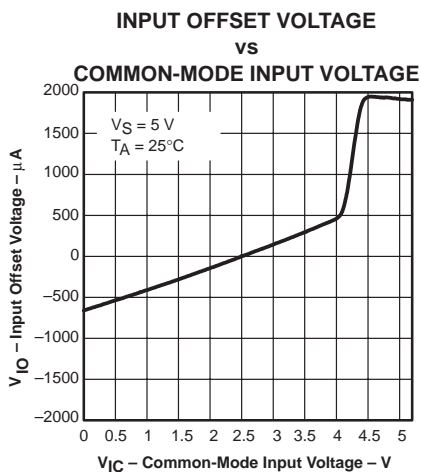
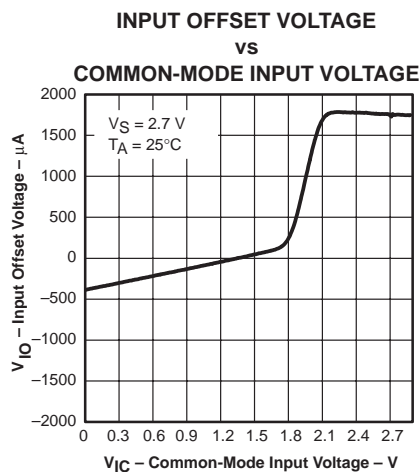
noise/distortion performance

PARAMETER		TEST CONDITIONS	T_A	MIN	TYP	MAX	UNIT
V_n	Equivalent input noise voltage	$f = 1\ \text{kHz}$	25°C		90		$\text{nV}/\sqrt{\text{Hz}}$

TYPICAL CHARACTERISTICS

Table of Graphs

			FIGURE
V_{IO}	Input offset voltage	vs Common-mode input voltage	1, 2, 3
I_{IB}/I_{IO}	Input bias and offset current	vs Free-air temperature	4
V_{OH}	High-level output voltage	vs High-level output current	5, 7, 9
V_{OL}	Low-level output voltage	vs Low-level output current	6, 8, 10
I_Q	Quiescent current	vs Supply voltage	11
		vs Free-air temperature	12
	Supply voltage and supply current ramp up		13
A_{VD}	Differential voltage gain and phase shift	vs Frequency	14
GBP	Gain-bandwidth product	vs Free-air temperature	15
ϕ_m	Phase margin	vs Load capacitance	16
CMRR	Common-mode rejection ratio	vs Frequency	17
PSRR	Power supply rejection ratio	vs Frequency	18
	Input referred noise voltage	vs Frequency	19
SR	Slew rate	vs Free-air temperature	20
$V_{O(PP)}$	Peak-to-peak output voltage	vs Frequency	21
	Inverting small-signal response		22
	Inverting large-signal response		23
	Crosstalk	vs Frequency	24



TYPICAL CHARACTERISTICS

INPUT BIAS AND INPUT
OFFSET CURRENT
VS
FREE-AIR TEMPERATURE

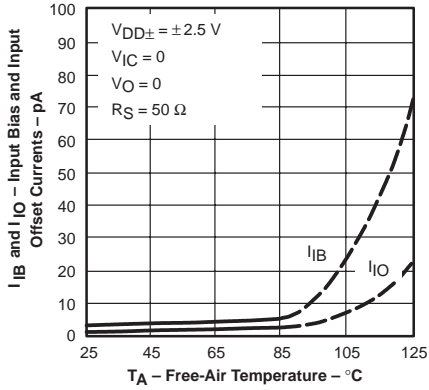


Figure 4

HIGH-LEVEL OUTPUT VOLTAGE
VS
HIGH-LEVEL OUTPUT CURRENT

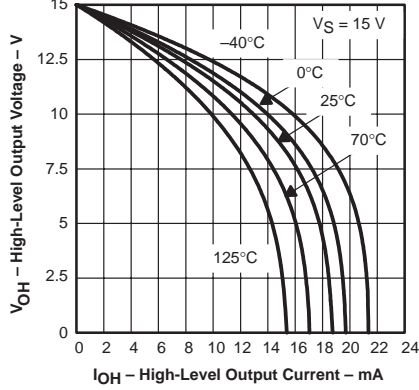


Figure 5

LOW-LEVEL OUTPUT VOLTAGE
VS
LOW-LEVEL OUTPUT CURRENT

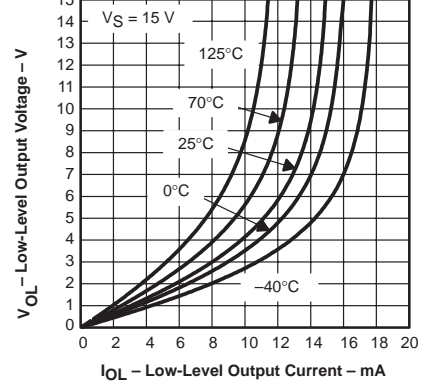


Figure 6

HIGH-LEVEL OUTPUT VOLTAGE
VS
HIGH-LEVEL OUTPUT CURRENT

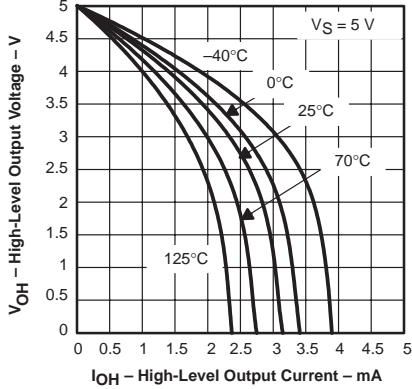


Figure 7

LOW-LEVEL OUTPUT VOLTAGE
VS
LOW-LEVEL OUTPUT CURRENT

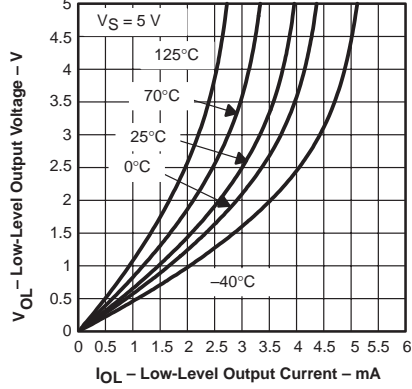


Figure 8

HIGH-LEVEL OUTPUT VOLTAGE
VS
HIGH-LEVEL OUTPUT CURRENT

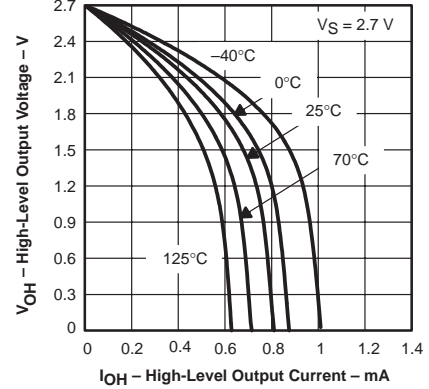


Figure 9

LOW-LEVEL OUTPUT VOLTAGE
VS
LOW-LEVEL OUTPUT CURRENT

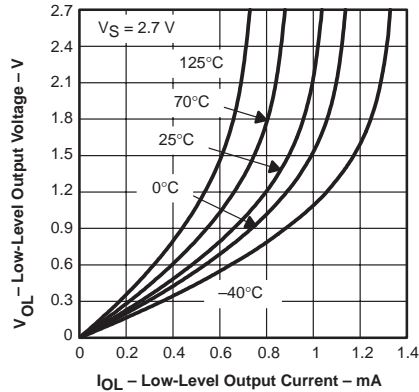


Figure 10

QUIESCENT CURRENT
VS
SUPPLY VOLTAGE

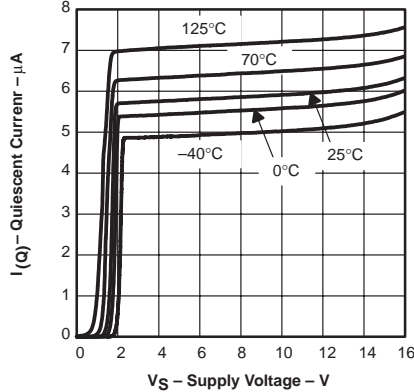


Figure 11

QUIESCENT CURRENT
VS
FREE-AIR TEMPERATURE

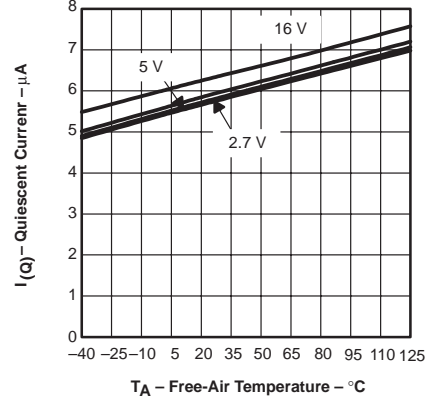


Figure 12

TYPICAL CHARACTERISTICS

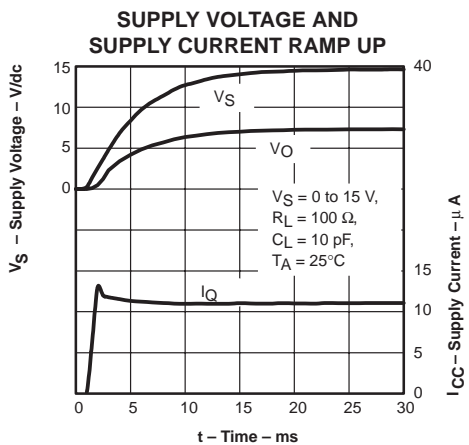


Figure 13

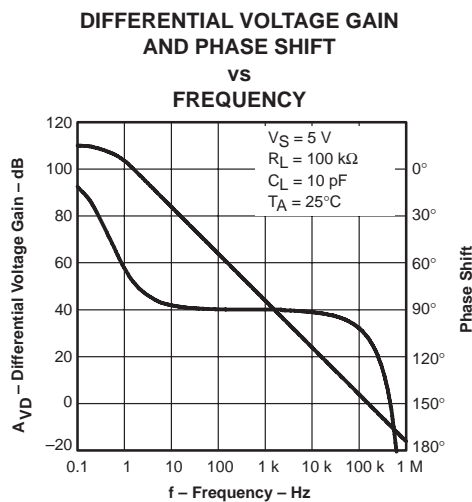


Figure 14

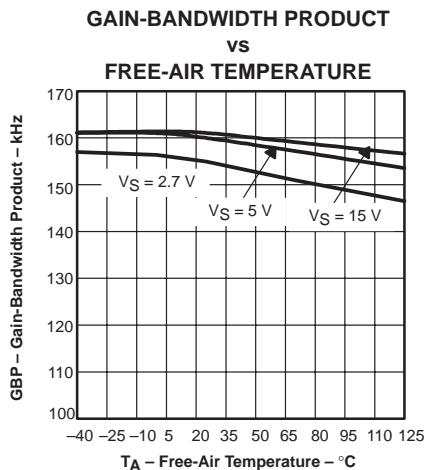


Figure 15

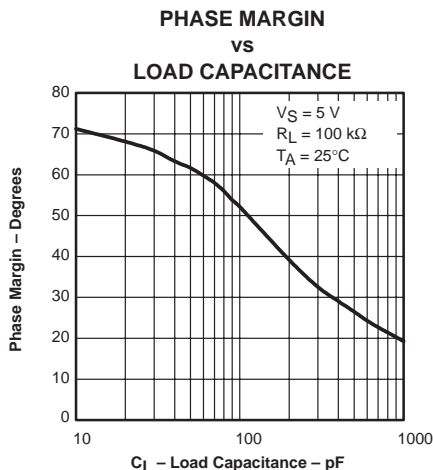


Figure 16

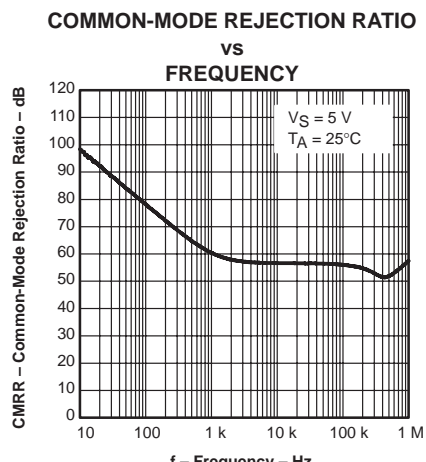


Figure 17

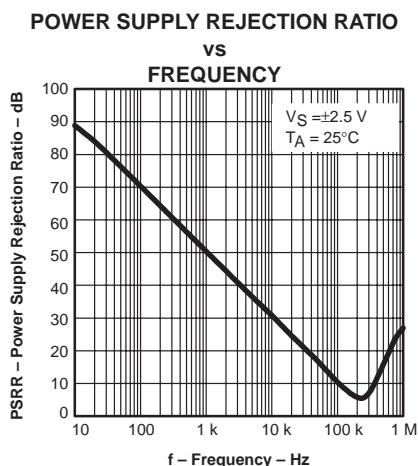


Figure 18

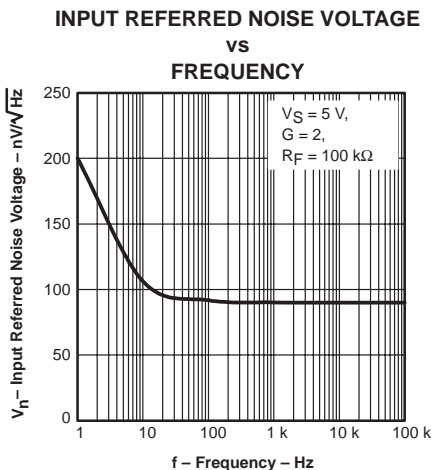


Figure 19

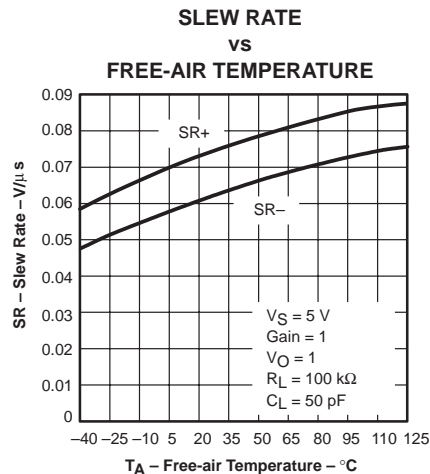
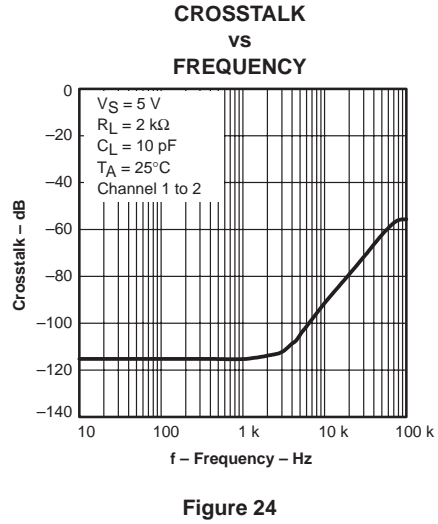
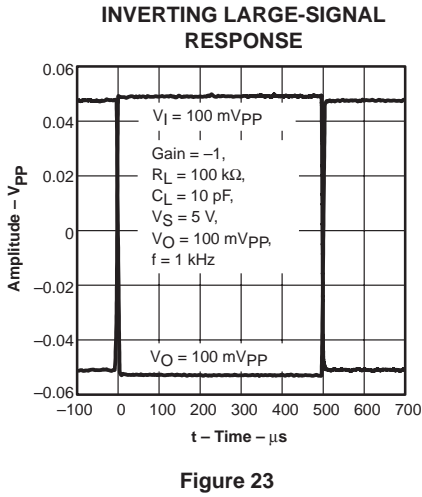
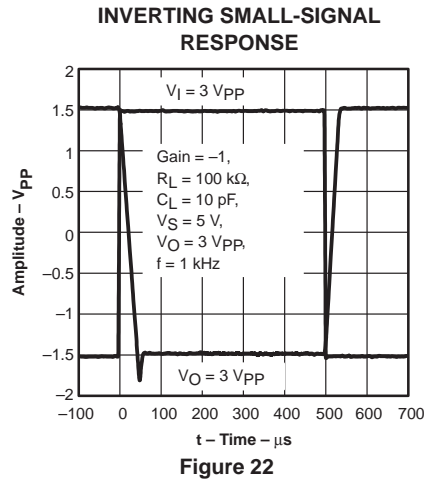
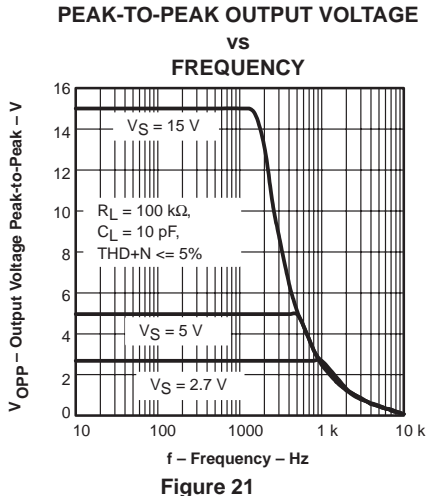


Figure 20

TYPICAL CHARACTERISTICS



APPLICATION INFORMATION

offset voltage

The output offset voltage (V_{OO}) is the sum of the input offset voltage (V_{IO}) and both input bias currents (I_{IB}) times the corresponding gains. The following schematic and formula can be used to calculate the output offset voltage:

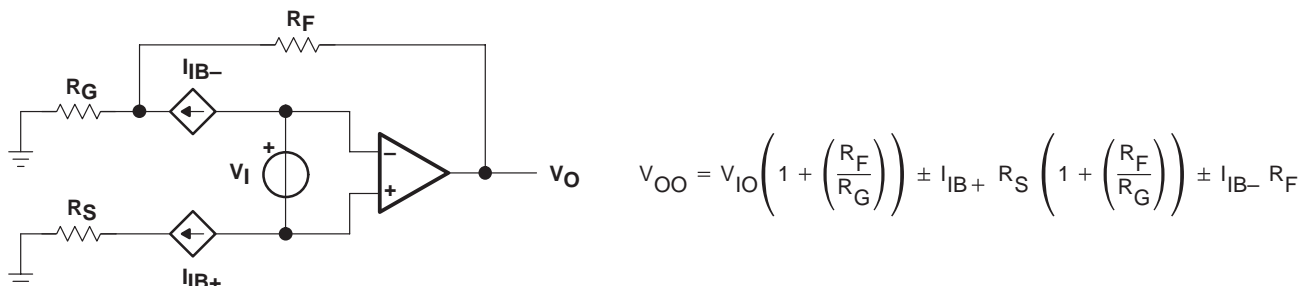


Figure 25. Output Offset Voltage Model

general configurations

When receiving low-level signals, limiting the bandwidth of the incoming signals into the system is often required. The simplest way to accomplish this is to place an RC filter at the noninverting terminal of the amplifier (see Figure 26).

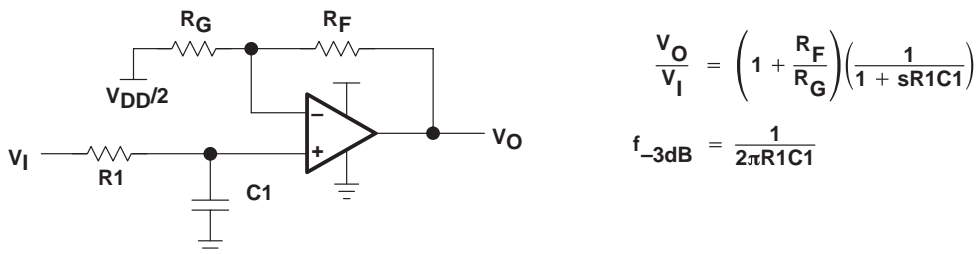


Figure 26. Single-Pole Low-Pass Filter

If even more attenuation is needed, a multiple pole filter is required. The Sallen-Key filter can be used for this task. For best results, the amplifier should have a bandwidth that is 8 to 10 times the filter frequency bandwidth. Failure to do this can result in phase shift of the amplifier.

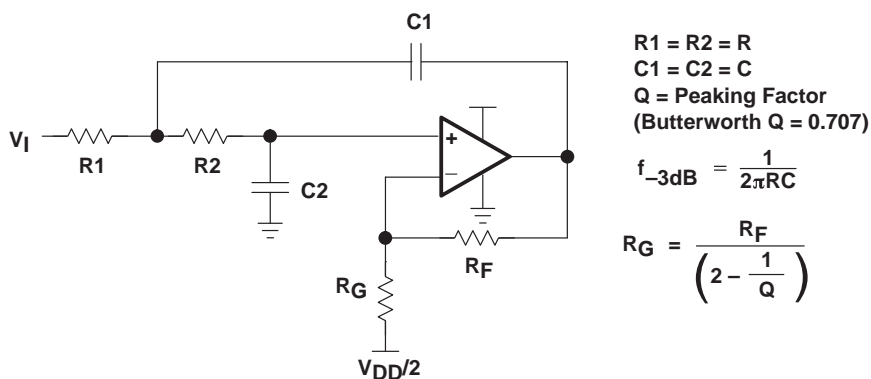


Figure 27. 2-Pole Low-Pass Sallen-Key Filter

APPLICATION INFORMATION

circuit layout considerations

To achieve the levels of high performance of the TLV238x, follow proper printed-circuit board design techniques. A general set of guidelines is given in the following.

- Ground planes—It is highly recommended that a ground plane be used on the board to provide all components with a low inductive ground connection. However, in the areas of the amplifier inputs and output, the ground plane can be removed to minimize the stray capacitance.
- Proper power supply decoupling—Use a 6.8- μ F tantalum capacitor in parallel with a 0.1- μ F ceramic capacitor on each supply terminal. It may be possible to share the tantalum among several amplifiers depending on the application, but a 0.1- μ F ceramic capacitor should always be used on the supply terminal of every amplifier. In addition, the 0.1- μ F capacitor should be placed as close as possible to the supply terminal. As this distance increases, the inductance in the connecting trace makes the capacitor less effective. The designer should strive for distances of less than 0.1 inches between the device power terminals and the ceramic capacitors.
- Sockets—Sockets can be used but are not recommended. The additional lead inductance in the socket pins will often lead to stability problems. Surface-mount packages soldered directly to the printed-circuit board is the best implementation.
- Short trace runs/compact part placements—Optimum high performance is achieved when stray series inductance has been minimized. To realize this, the circuit layout should be made as compact as possible, thereby minimizing the length of all trace runs. Particular attention should be paid to the inverting input of the amplifier. Its length should be kept as short as possible. This will help to minimize stray capacitance at the input of the amplifier.
- Surface-mount passive components—Using surface-mount passive components is recommended for high performance amplifier circuits for several reasons. First, because of the extremely low lead inductance of surface-mount components, the problem with stray series inductance is greatly reduced. Second, the small size of surface-mount components naturally leads to a more compact layout thereby minimizing both stray inductance and capacitance. If leaded components are used, it is recommended that the lead lengths be kept as short as possible.

APPLICATION INFORMATION

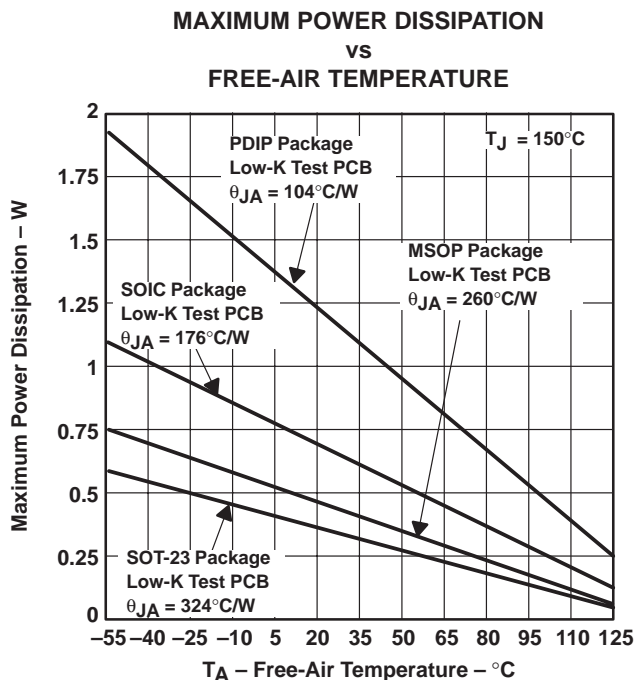
general power dissipation considerations

For a given θ_{JA} , the maximum power dissipation is shown in Figure 28 and is calculated by the following formula:

$$P_D = \left(\frac{T_{MAX} - T_A}{\theta_{JA}} \right)$$

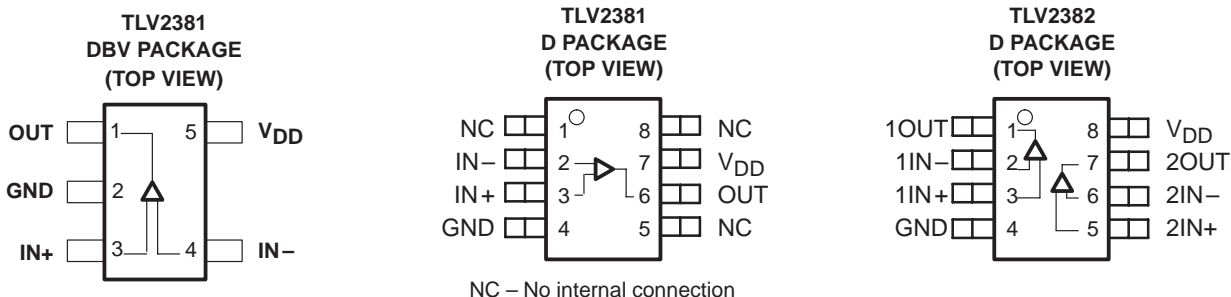
Where:

- P_D = Maximum power dissipation of TLV238x IC (watts)
- T_{MAX} = Absolute maximum junction temperature (150°C)
- T_A = Free-ambient air temperature (°C)
- $\theta_{JA} = \theta_{JC} + \theta_{CA}$
- θ_{JC} = Thermal coefficient from junction to case
- θ_{CA} = Thermal coefficient from case to ambient air (°C/W)



NOTE A: Results are with no air flow and using JEDEC Standard Low-K test PCB.

Figure 28. Maximum Power Dissipation vs Free-Air Temperature



IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products		Applications	
Amplifiers	amplifier.ti.com	Audio	www.ti.com/audio
Data Converters	dataconverter.ti.com	Automotive	www.ti.com/automotive
DSP	dsp.ti.com	Broadband	www.ti.com/broadband
Interface	interface.ti.com	Digital Control	www.ti.com/digitalcontrol
Logic	logic.ti.com	Military	www.ti.com/military
Power Mgmt	power.ti.com	Optical Networking	www.ti.com/opticalnetwork
Microcontrollers	microcontroller.ti.com	Security	www.ti.com/security
		Telephony	www.ti.com/telephony
		Video & Imaging	www.ti.com/video
		Wireless	www.ti.com/wireless

Mailing Address: Texas Instruments
Post Office Box 655303 Dallas, Texas 75265

Copyright © 2003, Texas Instruments Incorporated