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New Product

Description

The TLC27L1 operational amplifier combines a wide range of input offset-voltage grades with low offset-voltage drift and high input impedance. The TLC27L1 is a low-bias version of the TLC271 programmable amplifier.

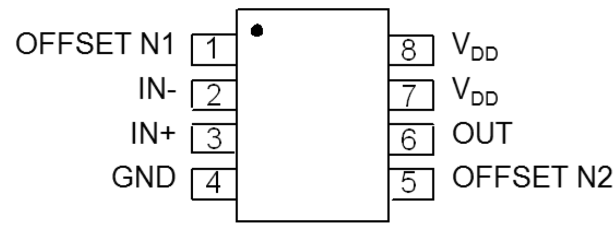
Three offset-voltage grades are available, ranging from the low-cost TLC27L1 (10mV) to the TLC27L1B (2mV) low-offset version. The devices are offered in both commercial and industrial operating temperature ranges.

The extremely high input impedance and low bias currents, in conjunction with good common-mode rejection and supply voltage rejection, make these devices a good choice for new state-of-the-art designs as well as for upgrading existing designs.

The devices also exhibit low-voltage single-supply operation, with a common-mode input-voltage range including the negative rail.

Pin Assignments

(Top View)



SO-8

Features

- Wide range of supply voltages over specified temperature range:
  - 0°C to +70°C . . . 3 V to 16 V
  - –40°C to +85°C . . . 4 V to 16 V
- Single-Supply Operation
- Common-Mode Input Voltage Range Extends Below the Negative Rail
- Low Noise:
  - 68nV/√Hz typical @ f = 1kHz
- Output Voltage Range Includes Negative Rail
- High Input Impedance
- Designed-In Latch-Up Immunity
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**

Applications

The TLC27L1 is the low power version of the TLC271. It offers low power for applications requiring long battery life. For applications that require more performance consider the TLC271.

The TLC27L1 is well suited to many consumer audio, industrial and other low power applications. Consider carefully the bandwidth and slew rate requirements for a specific application.

- Audio
  Microphone Preamplifier
  Filtering – Equalizers
  Signal Amplification
- Industrial
  Power Supply
  Instrumentation
  Metering
- Medical
  Portable Meters and Measurement
  Instrumentation

Notes: 1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS) & 2011/65/EU (RoHS 2) compliant.
2. See http://www.diodes.com/quality/lead_free.html for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
3. Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.

Ordering Information

Device	Package Code	Offset Voltage	Operating Temperature Range	Packaging (Note 4)	13" Tape and Reel	
					Quantity	Part Number Suffix
TLC27L1CS-13	S	10mV	0 to +70°C	SO-8	2500/Tape & Reel	-13
TLC27L1ACS-13	S	5mV	0 to +70°C	SO-8	2500/Tape & Reel	-13
TLC27L1BCS-13	S	2mV	0 to +70°C	SO-8	2500/Tape & Reel	-13
TLC27L1IS-13	S	10mV	-40 to +85°C	SO-8	2500/Tape & Reel	-13
TLC27L1AIS-13	S	5mV	-40 to +85°C	SO-8	2500/Tape & Reel	-13
TLC27L1BIS-13	S	2mV	-40 to +85°C	SO-8	2500/Tape & Reel	-13

Note: 4. Pad layout as shown on Diodes Inc. suggested pad layout document AP02001, which can be found on our website at http://www.diodes.com/datasheets/ap02001.pdf.

Pin Descriptions

Pin Name	Pin Number	Description
OFFSET N1	1	Offset Control Inverting Input
IN-	2	Inverting Input
IN+	3	Non-Inverting Input
GND	4	Ground
OFFSET N2	5	Offset Control Non-Inverting Input
OUT	6	Output
V_{DD}	7	Supply
V_{DD}	8	Supply

Absolute Maximum Ratings (Notes 5, 6, 7, 8, 9)

Symbol	Parameter		Rating	Unit
V_{DD}	Supply Voltage: (Note 6)		18	V
V_{ID}	Differential Input Voltage (Note 7)		$\pm V_{DD}$	V
V_{IN}	Input Voltage Range (either input)		-0.3 to V_{DD}	V
I_{IN}	Input Current		±5	mA
I_O	Output current		±30	mA
	Output Short-Circuit to GND (Note 8)		Continuous	—
P_D	Power Dissipation (Note 9)		1065	mW
T_A	Operating Temperature Range	C Grade	0 to +70	°C
		I Grade	-40 to +85	
T_J	Operating Junction Temperature		150	°C
T_{ST}	Storage Temperature Range		-65 to +150	°C
ESD HBM	Human Body Model ESD Protection (1.5kΩ in series with 100pF)		1.5	kV

Notes:
5. Stresses beyond those listed under absolute maximum ratings may cause permanent damage to the device. These are stress ratings only; 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.
6. All voltage values, except differential voltages, are with respect to ground.
7. Differential input voltages are at IN+ with respect to IN-.
8. The output may be shorted to either supply. Temperature and/or supply voltages must be limited to ensure that the maximum dissipation rating is not exceeded.
9. For operating at high temperatures, the TLC27L1 must be derated 8.5mW/°C to zero based on a +150°C maximum junction temperature and a thermal resistance of +117 °C/W when the device is soldered to a printed circuit board, operating in a still air ambient.

Recommended Operating Conditions

Symbol	Parameter		C grade		I grade		Unit
			Min	Max	Min	Max	—
V_{DD}	Supply Voltage		3	16	4	16	V
V_{IC}	Common Mode Input Voltage	V_{DD} = 5V	-0.2	3.5	-0.2	3.5	V
		V_{DD} = 10V	-0.2	8.5	-0.2	8.5	
T_A	Operating Free Air Temperature		0	+70	-40	+85	°C

Electrical Characteristics

Parameter			Conditions	T_A	TLC27L1C, TLC27L1AC, TLC27L1BC						Unit
					V_{DD} = 5V			V_{DD} = 10V			
					Min	Typ	Max	Min	Typ.	Max	
V_{IO}	Input Offset Voltage	TLC27L1C	V_O = 1.4V, V_{IC} = 0V, R_S = 50Ω, R_L = 1MΩ	+25°C	—	1.1	10	—	1.1	10	mV
				0 to +70°C	—	—	12	—	—	12	
		TLC27L1AC		+25°C	—	0.9	5	—	0.9	5	
				0 to +70°C	—	—	6.5	—	—	6.5	
		TLC27L1BC		+25°C	—	0.24	2	—	0.26	2	
				0 to +70°C	—	—	3	—	—	3	
α_{VIO}	Average Temperature Coefficient of Input Offset Voltage		—	+25 to +70°C	1.1			1			µV/°C
I_{IO}	Input Offset Current (Note 10)		$V_O = V_{DD}/2$, $V_{IC} = V_{DD}/2$	+25°C	—	0.1	60	—	0.1	60	pA
				+70°C	—	7	300	—	8	300	
I_{IB}	Input Bias Current (Note 10)		$V_O = V_{DD}/2$, $V_{IC} = V_{DD}/2$	+25°C	—	0.6	60	—	0.7	60	pA
				+70°C	—	40	600	—	50	600	
V_{ICR}	Common Mode Input Voltage (Note 11)		—	+25°C	-0.2 to 4	-0.3 to 4.2	—	-0.2 to 9	-0.3 to 9.2	—	V
				0°C to +70°C	-0.2 to 3.5	—	—	-0.2 to 8.5	—	—	V
V_{OH}	High Level Output Voltage		V_{ID} = 100mV, R_L = 1MΩ	+25°C	3.2	4.1	—	8	8.9	—	V
				0°C	3	4.1	—	7.8	8.9	—	
				+70°C	3	4.2	—	7.8	8.9	—	
V_{OL}	Low Level Output Voltage		V_{ID} = -100mV, I_{OL} = 0	+25°C	—	0	50	—	0	50	mV
				0°C	—	0	50	—	0	50	
				+70°C	—	0	50	—	0	50	
A_{VD}	Large Signal Differential Voltage Gain		R_L = 1MΩ (Note 12)	+25°C	50	520	—	50	870	—	V/mV
				0°C	50	700	—	50	1030	—	
				+70°C	50	380	—	50	660	—	
CMRR	Common Mode Rejection Ratio		$V_{IC} = V_{ICRmin}$	+25°C	65	94	—	65	97	—	dB
				0°C	60	95	—	60	97	—	
				+70°C	60	95	—	60	97	—	
k_{SVR}	Supply Voltage Rejection Ratio ($\Delta V_{DD}/\Delta V_{IO}$)		V_{DD} = 5V to 10V, V_O = 1.4V	+25°C	70	97	—	70	97	—	dB
				0°C	60	97	—	60	97	—	
				+70°C	60	98	—	60	98	—	
I_{DD}	Supply Current		$V_O = V_{DD}/2$, $V_{IC} = V_{DD}/2$, No Load	+25°C	—	10	17	—	14	23	µA
				0°C	—	12	21	—	18	33	
				+70°C	—	8	14	—	11	20	

Notes:
10. The typical values of input bias current and input offset current below 5pA were calculated.
11. This range also applies to each input individually.
12. At V_{DD} = 5V, V_O = 0.25V to 2V; at V_{DD} = 10V, V_O = 1V to 6V.

Electrical Characteristics

Parameter			Conditions	T_A	TLC27L1I, TLC27L1AI, TLC27L1BI						Unit
					V_{DD} = 5V			V_{DD} = 10V			
					Min	Typ	Max	Min	Typ.	Max	
V_{IO}	Input Offset Voltage	TLC27L1I	V_O = 1.4V V_{IC} = 0V R_S = 50Ω R_L = 1MΩ	+25°C	—	1.1	10	—	1.1	10	mV
				-40° to 85°C	—	—	13	—	—	13	
		TLC27L1AI		+25°C	—	0.9	5	—	0.9	5	
				-40° to +85°C	—	—	7	—	—	7	
		TLC27L1BI		+25°C	—	0.24	2		0.26	2	
				-40° to +85°C	—	—	3.5	—	—	3.5	
α_{VIO}	Average Temperature Coefficient of Input Offset Voltage		—	+25°C to +85°C		1.1			1		µV/°C
I_{IO}	Input Offset Current (Note 13)		$V_O = V_{DD}/2$ $V_{IC} = V_{DD}/2$	+25°C	—	0.1	60	—	0.1	60	pA
				+85°C	—	24	1000	—	26	1000	
I_{IB}	Input Bias Current (Note 13)		$V_O = V_{DD}/2$ $V_{IC} = V_{DD}/2$	+25°C	—	0.6	60	—	0.7	60	pA
				+85°C	—	200	2000	—	220	2000	
V_{ICR}	Common Mode Input Voltage (Note 14)		—	+25°C	-0.2 to 4	-0.3 to 4.2	—	-0.2 to 9	-0.3 to 9.2	—	V
				-40° to +85°C	-0.2 to 3.5	—	—	-0.2 to 8.5	—	—	V
V_{OH}	High Level Output Voltage		V_{ID} = 100mV, R_L = 1MΩ	+25°C	3	4.1	—	8	8.9	—	V
				-40°C	3	4.1	—	7.8	8.9	—	
				+85°C	3	4.2	—	7.8	8.9	—	
V_{OL}	Low Level Output Voltage		V_{ID} = -100mV, I_{OL} = 0	+25°C	—	0	50	—	0	50	mV
				-40°C	—	0	50	—	0	50	
				+85°C	—	0	50	—	0	50	
A_{VD}	Large Signal Differential Voltage Gain		R_L = 1MΩ (Note 15)	+25°C	50	520	—	50	870	—	V/mV
				-40°C	50	900	—	50	1550	—	
				+85°C	50	330	—	50	585	—	
CMRR	Common Mode Rejection Ratio		$V_{IC} = V_{ICRmin}$	+25°C	65	94	—	65	97	—	dB
				-40°C	60	95	—	60	97	—	
				+85°C	60	95	—	60	98	—	
k_{SVR}	Supply Voltage Rejection Ratio ($\Delta V_{DD}/\Delta V_{IO}$)		V_{DD} = 5V to 10V V_O = 1.4V	+25°C	70	97	—	70	97	—	dB
				-40°C	60	97	—	60	97	—	
				+85°C	60	98	—	60	98	—	
I_{DD}	Supply Current		$V_O = V_{DD}/2$ $V_{IC} = V_{DD}/2$ No load	+25°C	—	10	17	—	14	23	µA
				-40°C	—	16	27	—	25	43	
				+85°C	—	17	13	—	10	18	

Notes: 13. The typical values of input bias current and input offset current below 5pA were calculated.
14. This range also applies to each input individually.
15. At V_{DD} = 5V, V_O = 0.25V to 2V; at V_{DD} = 10V, V_O = 1V to 6V.

Electrical Characteristics

V_{DD} = 5V

Parameter		Conditions		T_A	TLC27L1C, TLC27L1AC, TLC27L1BC Min	Typ	Max	Unit
SR	Slew Rate at Unity Gain	R_L = 1MΩ C_L = 20pF See Figure 31	$V_{I(PP)}$ = 1V	+25°C	—	0.03	—	V/µs
				0°C	—	0.04	—	
				+70°C	—	0.03	—	
			$V_{I(PP)}$ = 2.5V	+25°C	—	0.03	—	
				0°C	—	0.03	—	
				+70°C	—	0.02	—	
V_n	Equivalent Input Noise Voltage	F = 1kHz, R_S = 20Ω See Figure 32		+25°C	—	68	—	nV/√Hz
B_{OM}	Maximum Output Swing Bandwidth	V_O = V_{OH}, C_L = 20pF, R_L = 1MΩ See Figure 31		+25°C	—	5	—	kHz
				0°C	—	6	—	
				+70°C	—	4.5	—	
B_1	Unity Gain Bandwidth	V_I = 10mV, C_L = 20pF See Figure 33		+25°C	—	85	—	MHz
				0°C	—	100	—	
				+70°C	—	65	—	
ϕ_m	Phase Margin	F = B_1, V_I = 10mV, C_L = 20pF See Figure 33		+25°C	—	34°	—	—
				0°C	—	36°	—	
				+70°C	—	30°	—	

V_{DD} = 10V

Parameter		Conditions		T_A	TLC27L1C, TLC27L1AC, TLC27L1BC Min	Typ	Max	Unit
SR	Slew Rate at Unity Gain	R_L = 1MΩ, C_L = 20pF See Figure 31	$V_{I(PP)}$ = 1V	+25°C	—	0.05	—	V/µs
				0°C	—	0.05	—	
				+70°C	—	0.04	—	
			$V_{I(PP)}$ = 5.5V	+25°C	—	0.04	—	
				0°C	—	0.05	—	
				+70°C	—	0.04	—	
V_n	Equivalent Input Noise Voltage	F = 1kHz, R_S = 20Ω See Figure 32		+25°C	—	68	—	nV/√Hz
B_{OM}	Maximum Output Swing Bandwidth	V_O = V_{OH}, C_L = 20pF, R_L = 1MΩ See Figure 31		+25°C	—	1	—	kHz
				0°C	—	1.3	—	
				+70°C	—	0.9	—	
B_1	Unity Gain Bandwidth	V_I = 10mV, C_L = 20pF See Figure 33		+25°C	—	110	—	MHz
				0°C	—	125	—	
				+70°C	—	90	—	
ϕ_m	Phase Margin	F = B_1, V_I = 10mV, C_L = 20pF See Figure 33		+25°C	—	38°	—	—
				0°C	—	40°	—	
				+70°C	—	34°	—	

Electrical Characteristics

V_{DD} = 5V

	Parameter	Conditions		T_A	TLC27L1I, TLC27L1AI, TLC27L1BI Min	Typ	Max	Unit
SR	Slew Rate at Unity Gain	R_L = 1MΩ, C_L = 20pF, See Figure 31	$V_{I(PP)}$ = 1V	+25°C	—	0.03	—	V/µs
				-40°	—	0.04	—	
				+85°C	—	0.03	—	
			$V_{I(PP)}$ = 2.5V	+25°C	—	0.03	—	
				-40°	—	0.04	—	
				+85°C	—	0.02	—	
V_n	Equivalent Input Noise Voltage	F = 1kHz, R_S = 20Ω See Figure 32		+25°C	—	68	—	nV/√Hz
B_{OM}	Maximum Output Swing Bandwidth	V_O = V_{OH}, C_L = 20pF, R_L = 1MΩ See Figure 31		+25°C	—	5	—	kHz
				-40°	—	7	—	
				+85°C	—	4	—	
B_1	Unity Gain Bandwidth	V_I = 10mV, C_L = 20pF See Figure 33		+25°C	—	85	—	MHz
				-40°	—	130	—	
				+85°C	—	55	—	
ϕ_m	Phase Margin	F = B_1, V_I = 10mV, C_L = 20pF See Figure 33		+25°C	—	34°	—	—
				-40°	—	38°	—	
				+85°C	—	28°	—	

V_{DD} = 10V

	Parameter	Conditions		T_A	TLC27L1I, TLC27L1AI, TLC27L1BI Min	Typ	Max	Unit
SR	Slew Rate at Unity Gain	R_L = 1MΩ, C_L = 20pF, See Figure 31	$V_{I(PP)}$ = 1V	+25°C	—	0.05	—	V/µs
				-40°	—	0.06	—	
				+85°C	—	0.03	—	
			$V_{I(PP)}$ = 5.5V	+25°C	—	0.04	—	
				-40°	—	0.05	—	
				+85°C	—	0.03	—	
V_n	Equivalent Input Noise Voltage	F = 1kHz, R_S = 20Ω See Figure 32		+25°C	—	68	—	nV/√Hz
B_{OM}	Maximum Output Swing Bandwidth	V_O = V_{OH}, C_L = 20pF, R_L = 1MΩ See Figure 31		+25°C	—	1	—	kHz
				-40°	—	1.4	—	
				+85°C	—	0.8	—	
B_1	Unity Gain Bandwidth	V_I = 10mV, C_L = 20pF See Figure 33		+25°C	—	110	—	MHz
				-40°	—	155	—	
				+85°C	—	80	—	
ϕ_m	Phase Margin	F = B_1, V_I = 10mV, C_L = 20pF See Figure 33		+25°C	—	38°	—	—
				-40°	—	42°	—	
				+85°C	—	32°	—	

Typical Performance Characteristics   Table Index of Graphs

			Figure
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		vs. Free Air Temperature	6
V_{OL}	Low Level Output Voltage	vs. Common Mode Input Voltage	7,8
		vs. Differential Input Voltage	9
		vs. Free Air Temperature	10
		vs. Low Level Output Current	11,12
A_{VD}	Large Signal Differential Voltage Gain	vs. Supply Voltage	13
		vs. Free Air Temperature	14
I_{IB}	Input Bias Current	vs. Free Air Temperature	15
I_{IO}	Input Offset Current	vs. Free Air Temperature	15
V_{IC}	Common Mode Input Voltage	vs. Supply Voltage	16
I_{DD}	Supply Current	vs. Supply Voltage	17
		vs. Free Air Temperature	18
SR	Slew Rate	vs. Supply Voltage	19
		vs. Free Air Temperature	20
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$V_{O(OPP)}$	Maximum Peak to Peak Output Voltage	vs. Frequency	22
B_1	Unity Gain Bandwidth	vs. Free Air Temperature	23
		vs. Supply Voltage	24
A_{VD}	Large Signal Differential Voltage Gain	vs. Frequency	29,30
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Typical Performance Characteristics

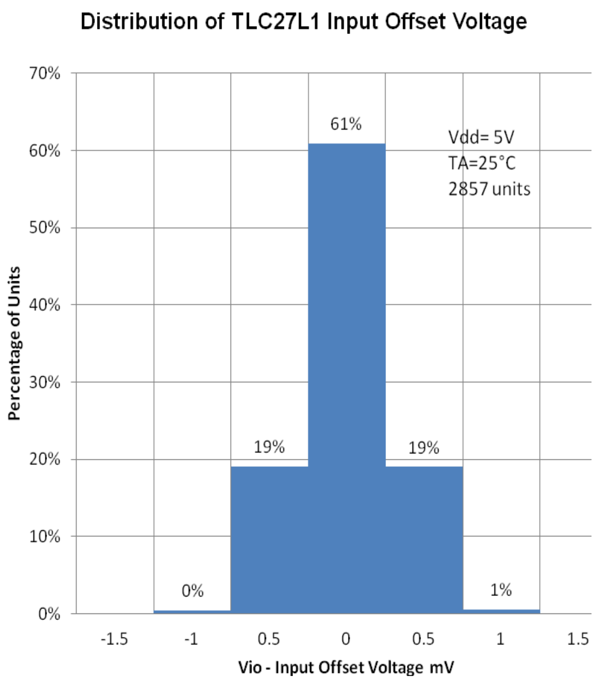


Figure 1

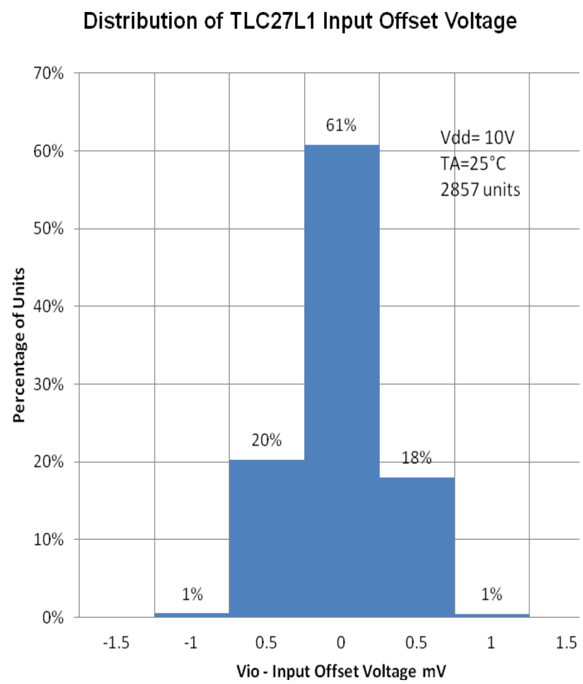


Figure 2

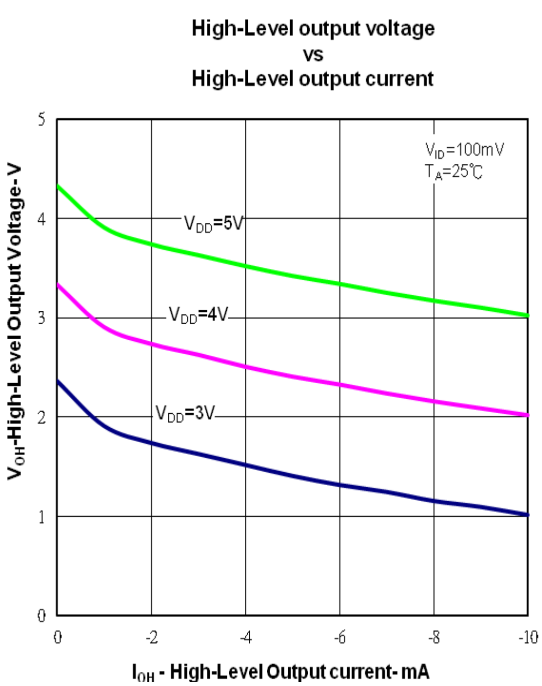


Figure 3

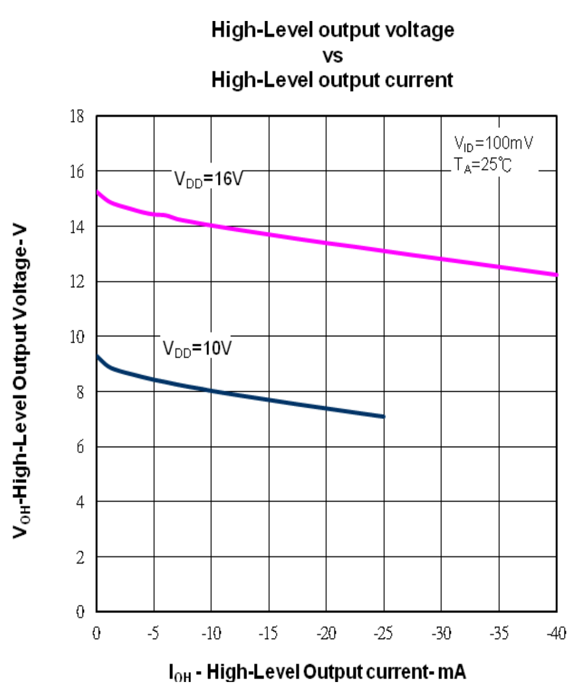


Figure 4

Typical Performance Characteristics

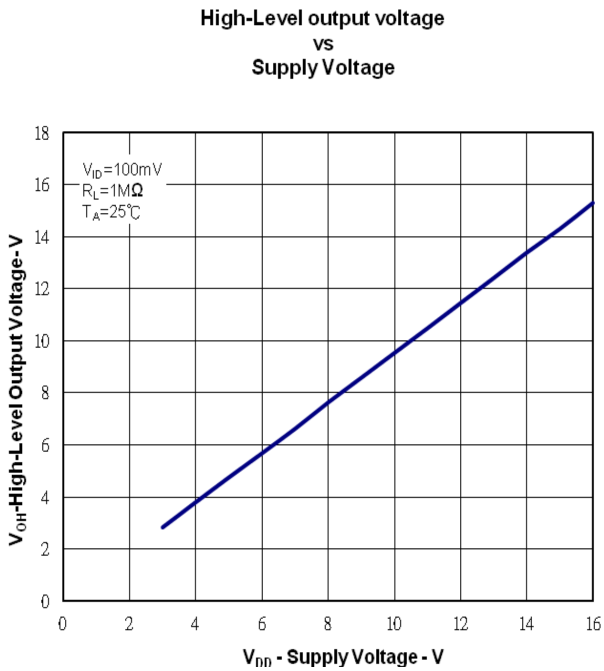


Figure 5

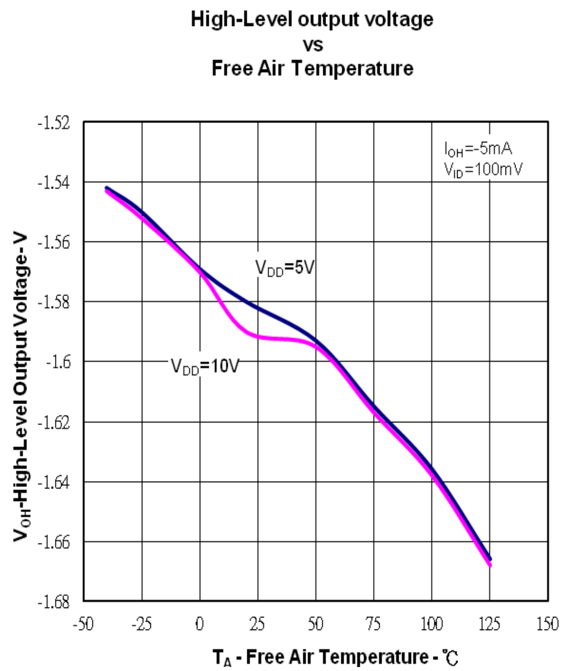


Figure 6

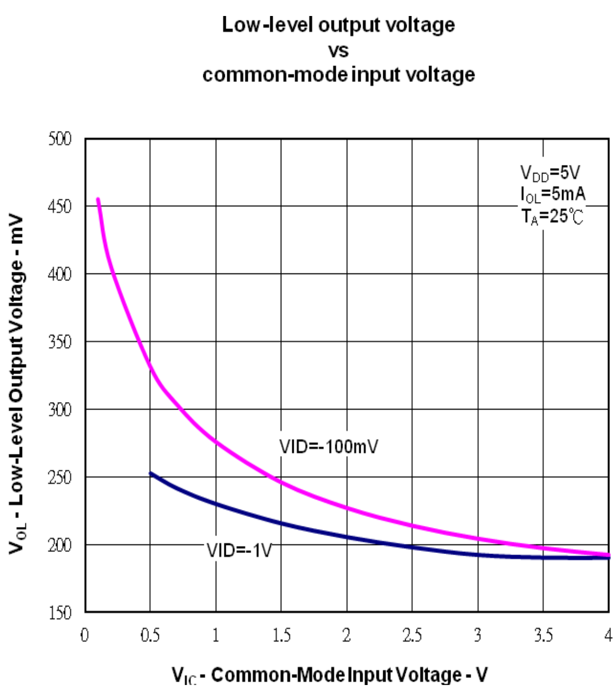


Figure 7

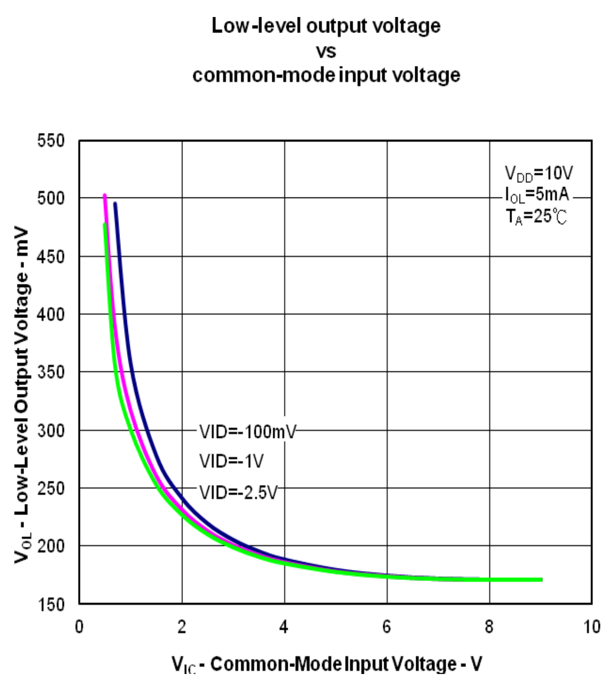


Figure 8

Typical Performance Characteristics

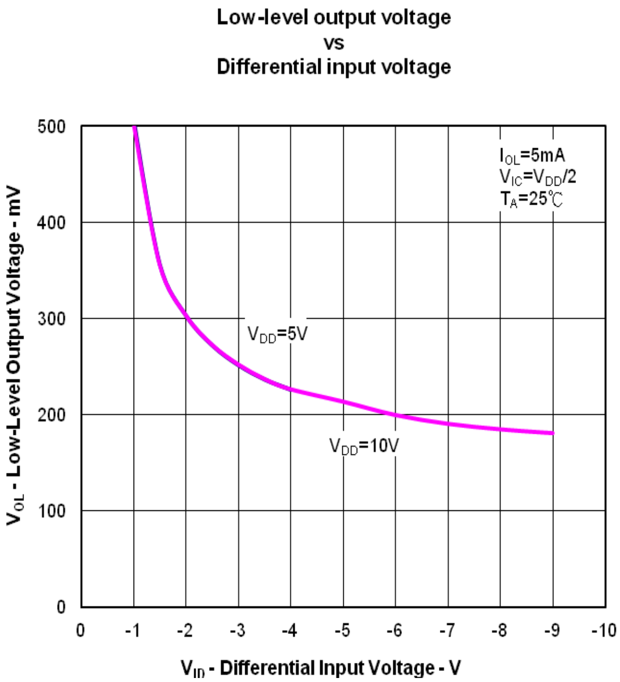
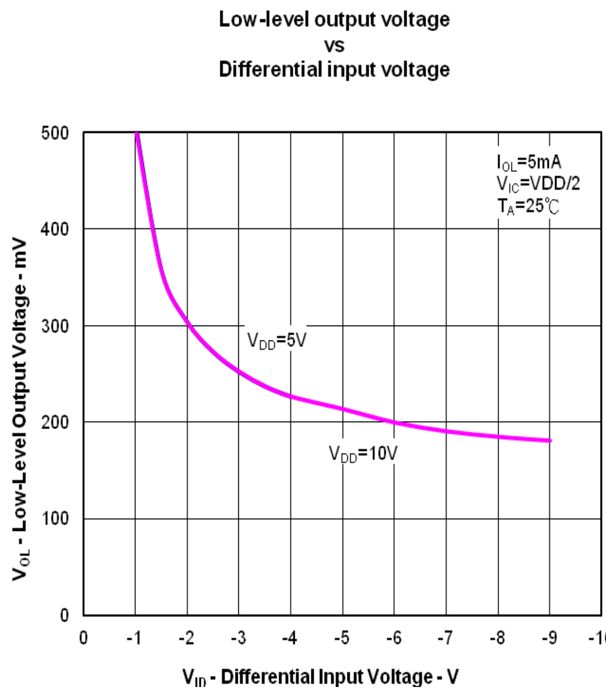


Figure 9



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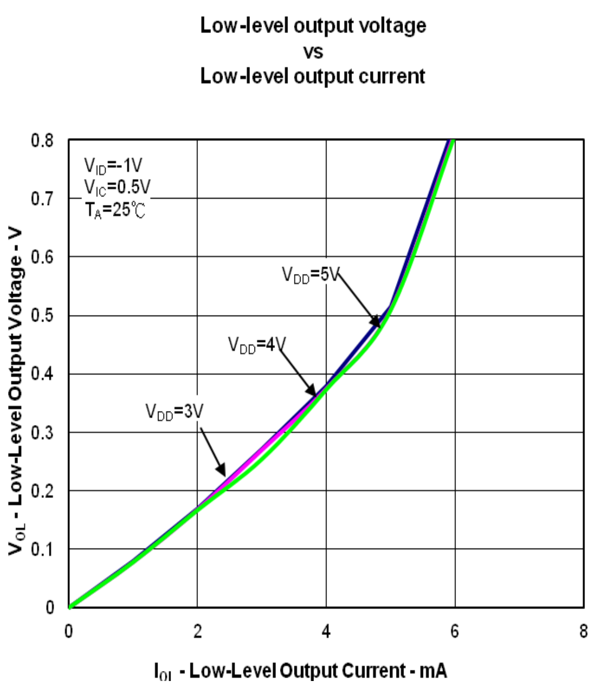

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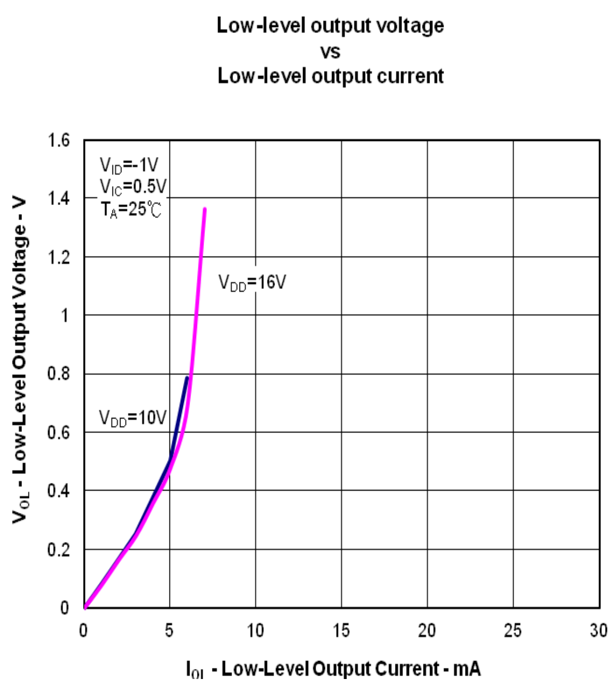


Figure 12

Typical Performance Characteristics

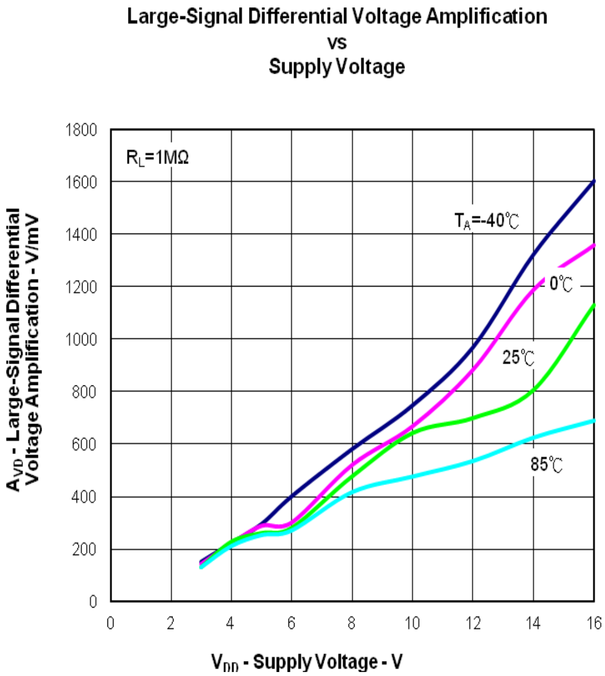


Figure 13

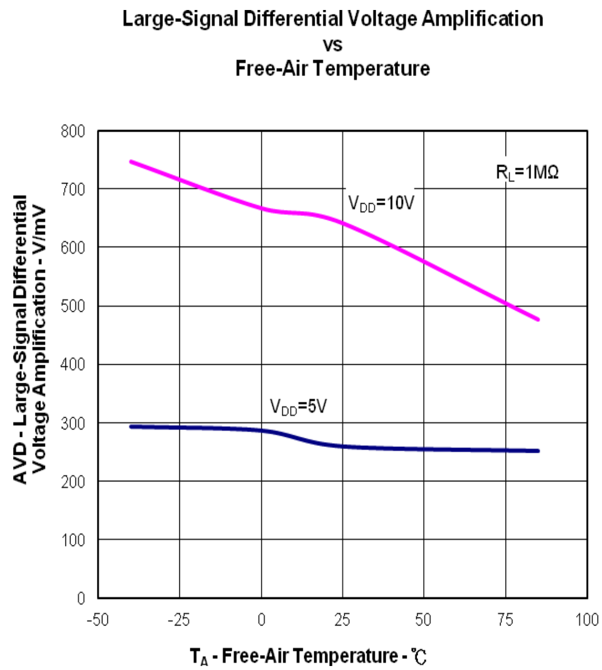


Figure 14

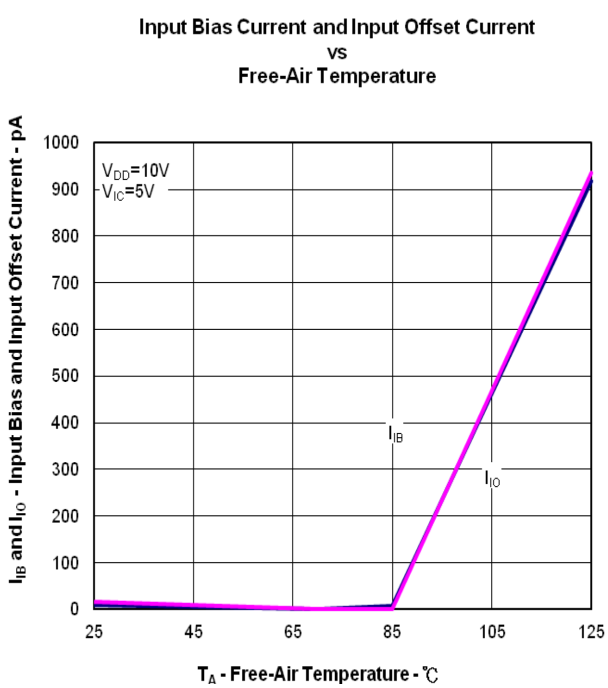


Figure 15

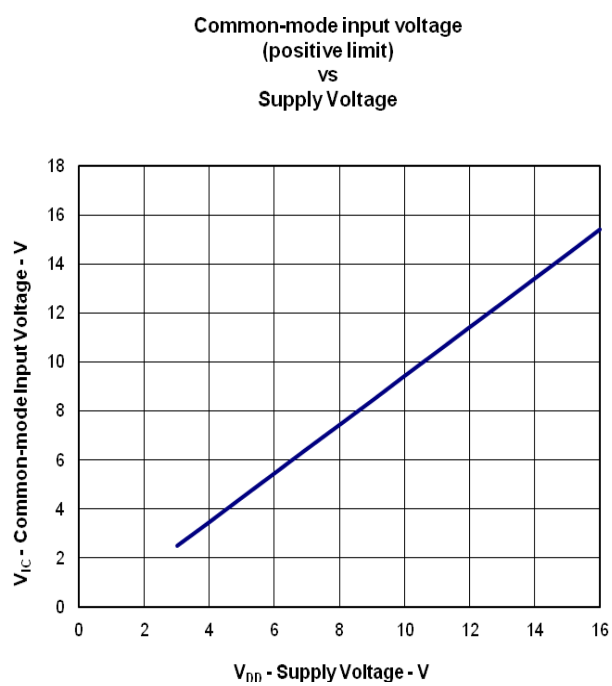


Figure 16

Typical Performance Characteristics

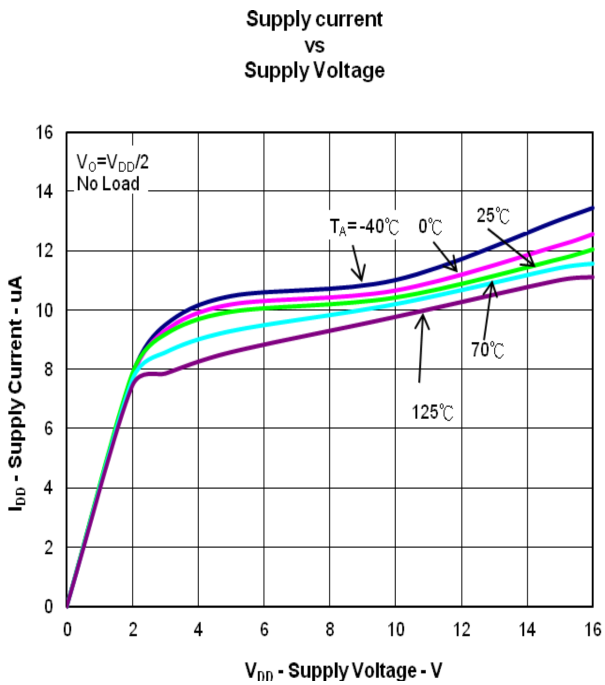


Figure 17

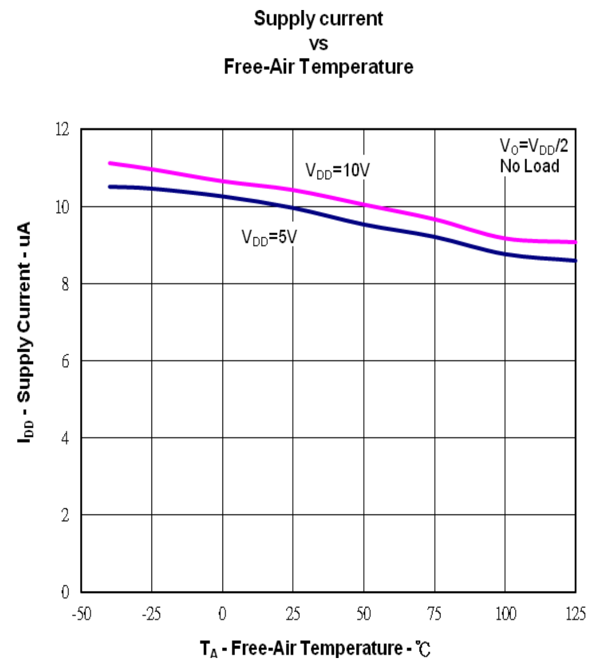


Figure 18

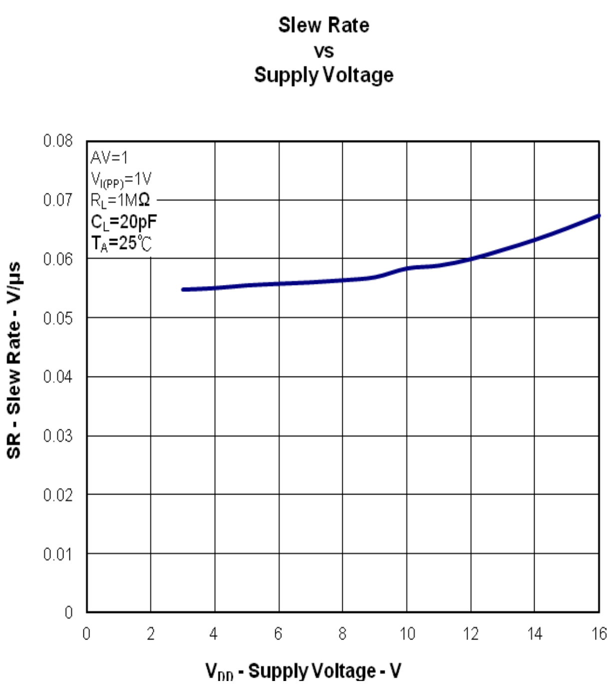


Figure 19

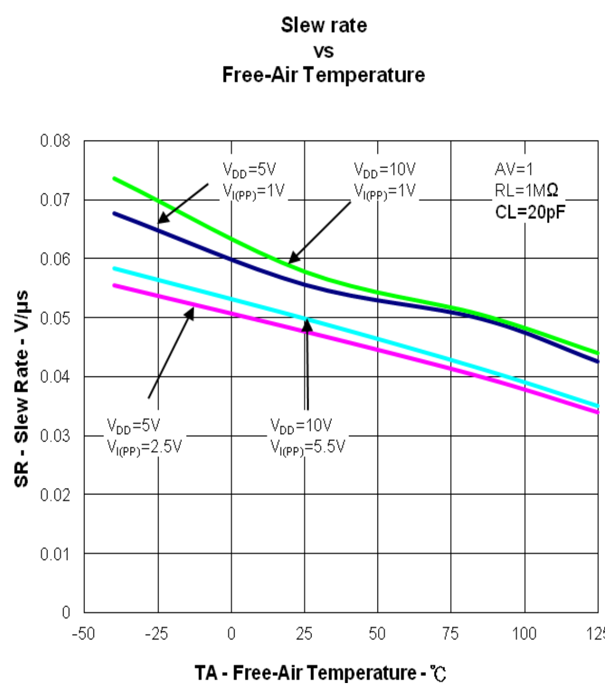


Figure 20

Typical Performance Characteristics

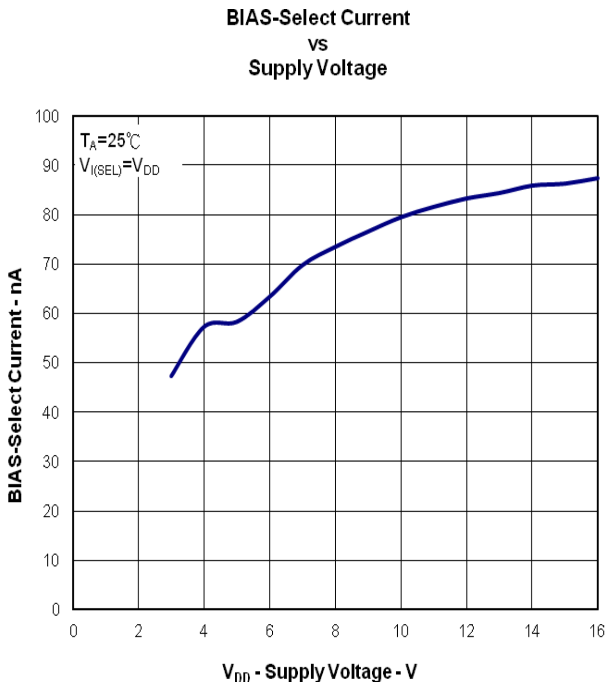


Figure 21

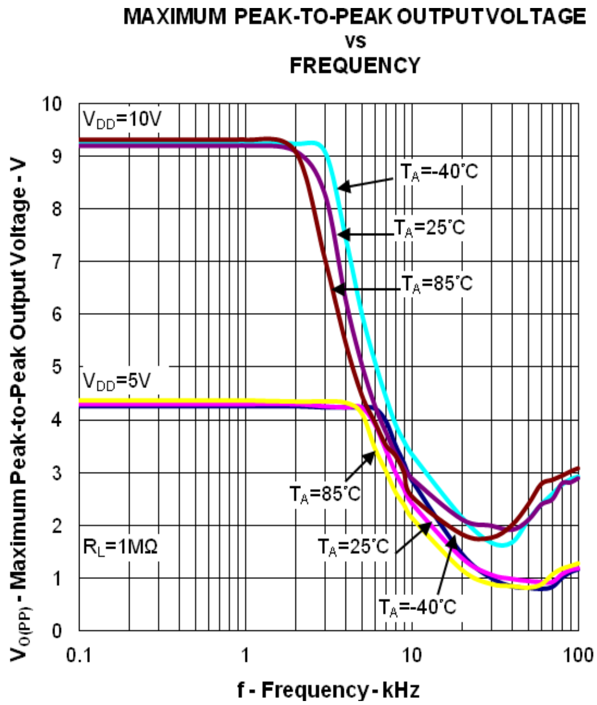


Figure 22

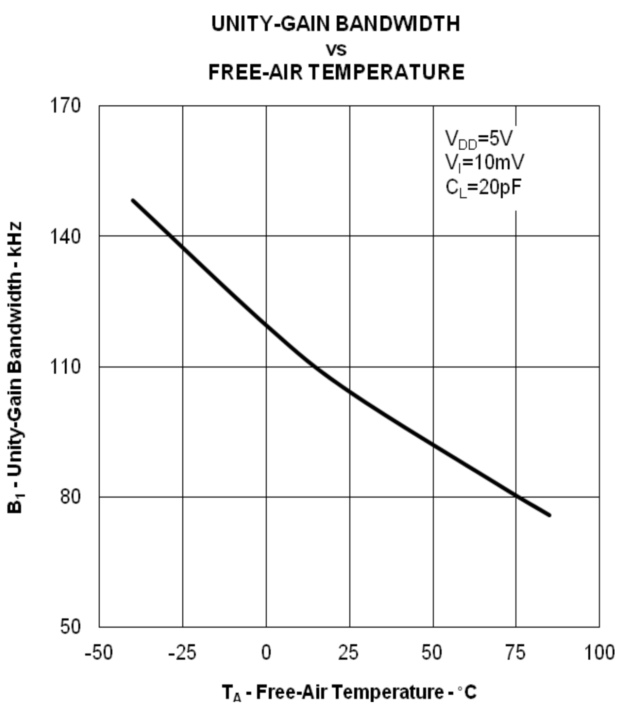


Figure 23

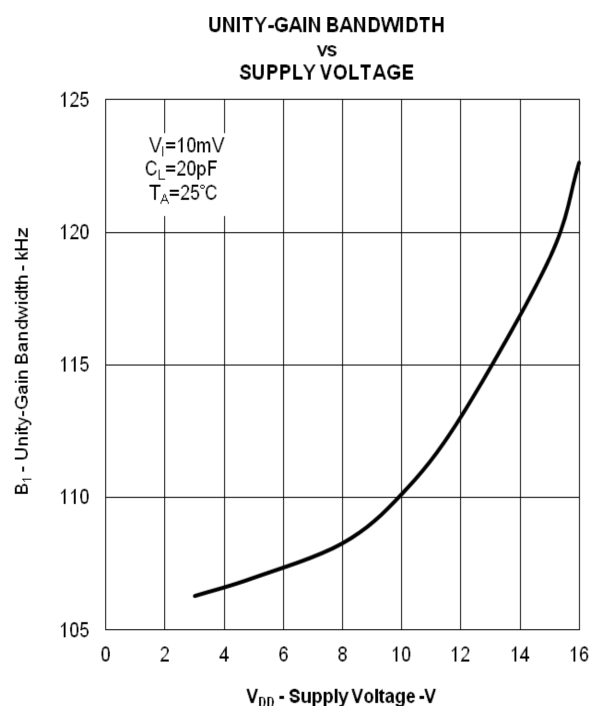


Figure 24

Typical Performance Characteristics

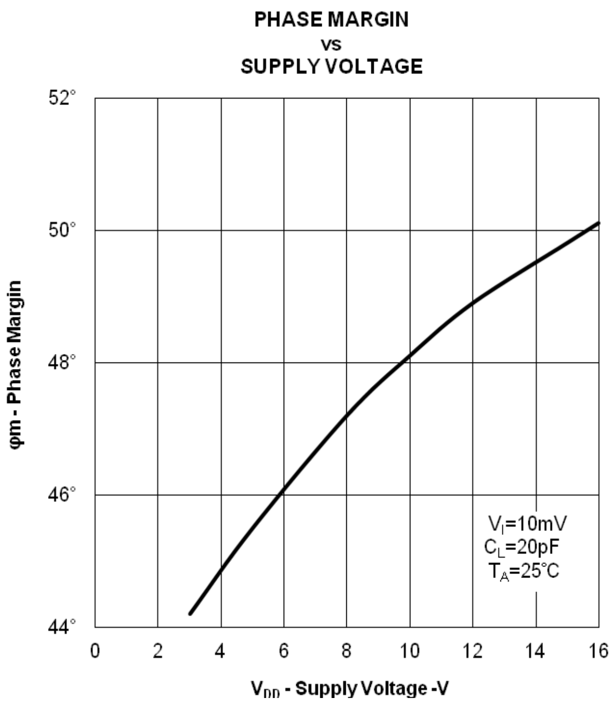


Figure 25

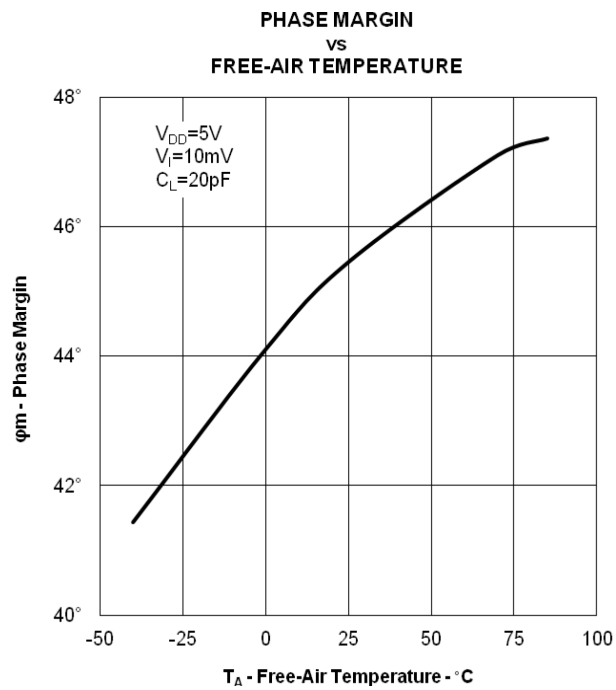


Figure 26

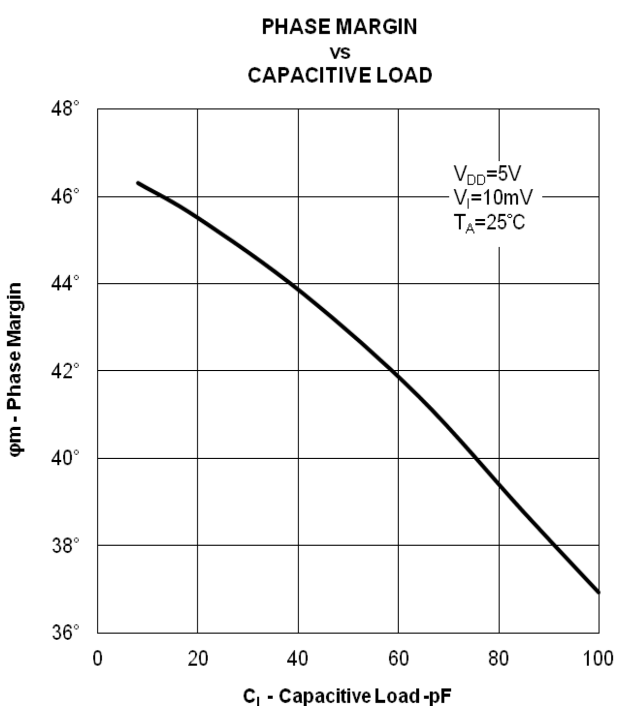


Figure 27

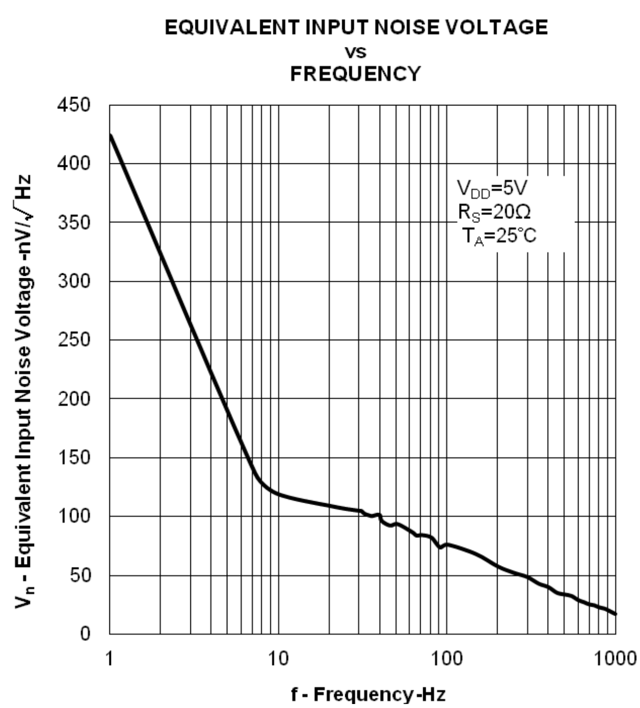


Figure 28

Typical Performance Characteristics

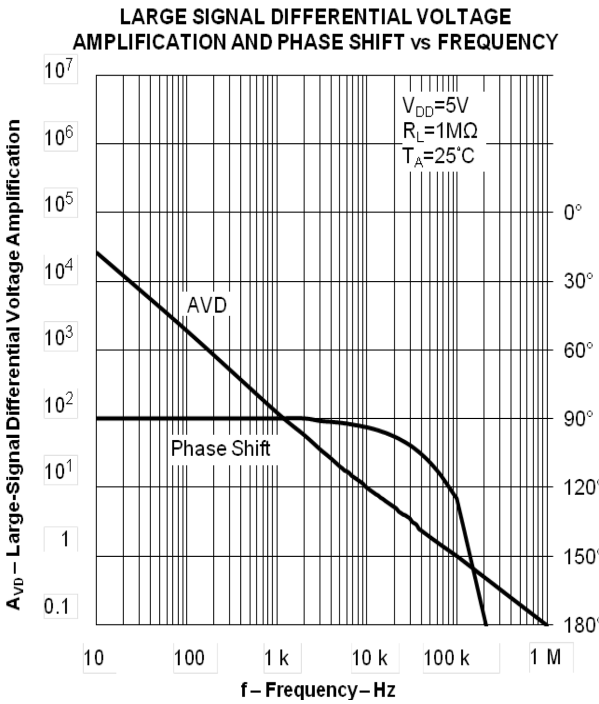


Figure 29

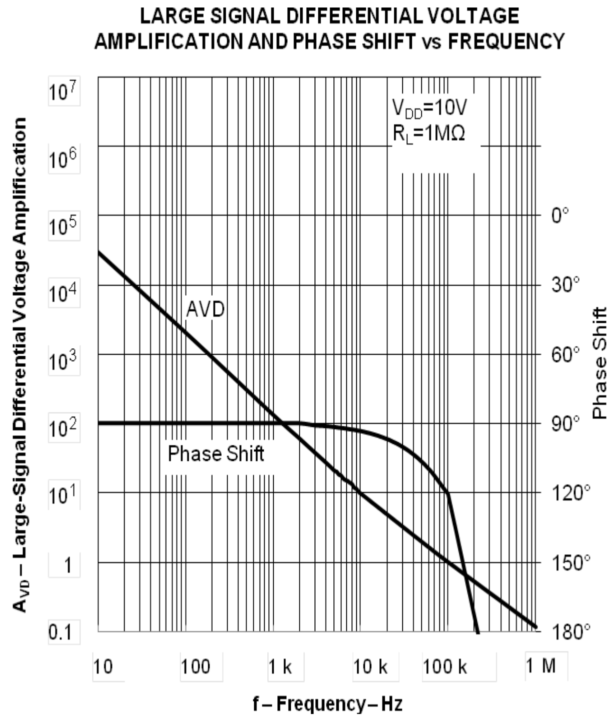
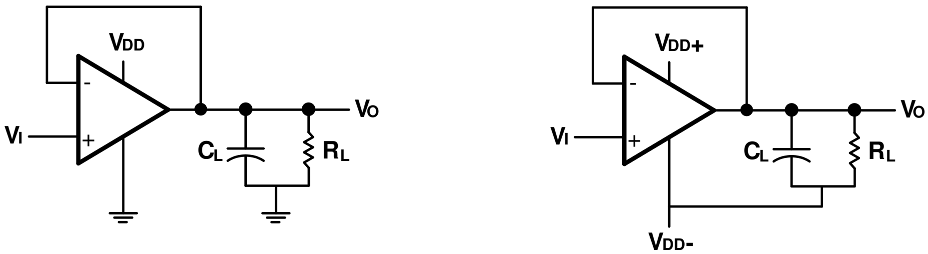


Figure 30

Application Information

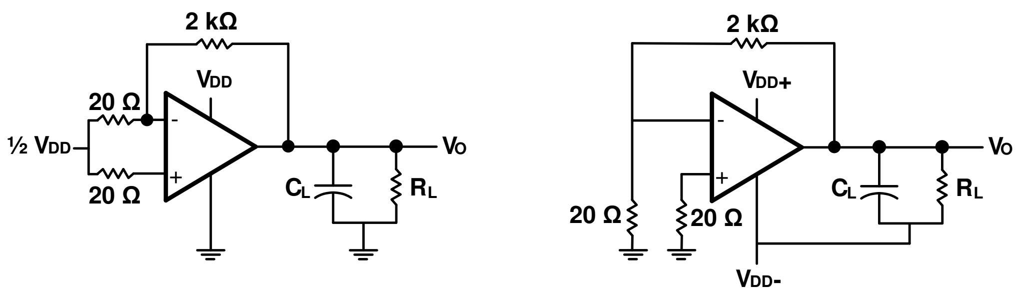
Parameter measurement circuits

Because the TLC271 is optimized for single-supply operation, circuit configurations used for the various tests can present some difficulties since the input signal must be offset from ground. This issue can be avoided by testing the device with split supplies and the output load tied to the negative rail. Example circuits are shown below.



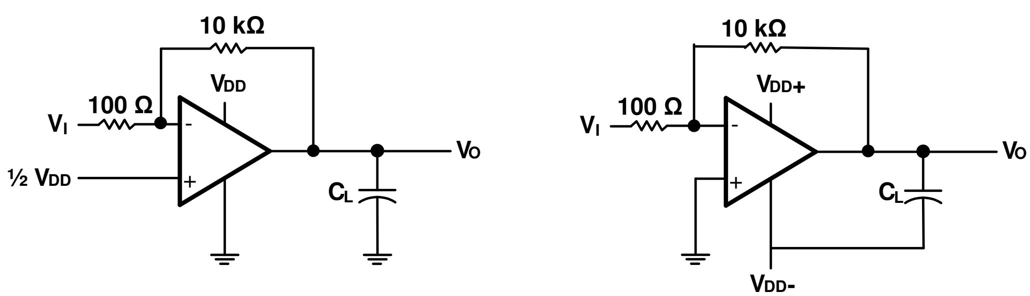
(a) Single Supply (b) Split Supply

Figure 31 Measurement circuit with either single or split supply



(a) Single Supply (b) Split Supply

Fig 32 Noise measurement with single or split supply



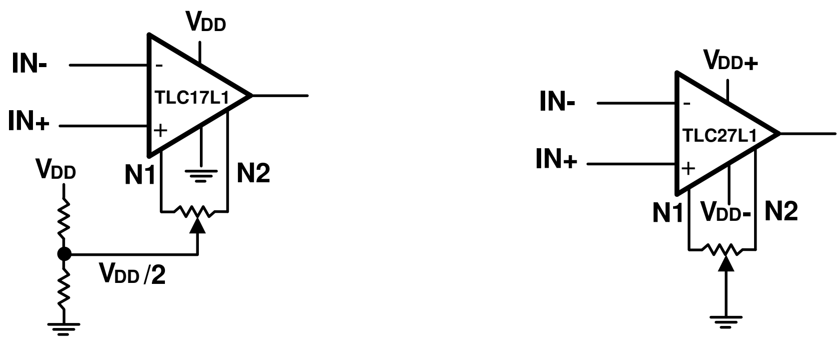
(a) Single Supply (b) Split Supply

Figure 33 Gain of 100 with single or split supply

Application Notes

Offset Voltage Nulling Circuit

The TLC27L1 offers external input offset null control. Nulling of the input off set voltage may be achieved by adjusting a 100-kΩ potentiometer connected between the offset null terminals with the wiper connected as shown in Figure 31.



(a) Single Supply (b) Split Supply

Figure 31 Offset Nulling Circuits

Input Bias Current – Error Protection

The TLC27L1 has an extremely high input impedance. To use the inputs as a high impedance node, for example, greater than100K, or to accurately measure bias current, it is necessary to place a guard ring around the input pins and drive the ring to a potential equivalent to the common mode input voltage. In many cases this common mode potential may exist as a part of the feedback circuit and can be obtained from one of the appropriate nodes. In the case for the SO8 package, pin 4 is connected to ground or Vdd-. Input pins 2 and 3 are normally well above the voltage on pin 4, so a large potential voltage on the order of several volts is likely between pins 3 and 4. To prevent interference with a 1 pA bias current, the board resistance will need to be in the order of gigaohms to have a minimum impact. The goal is to have the common mode potential on the guard ring, therefore reducing the stray voltage near the input pins to millivolts in normal applications. Any solder flux residue, excess moisture, humidity or board contamination will be detrimental to using the device in a high impedance input mode.

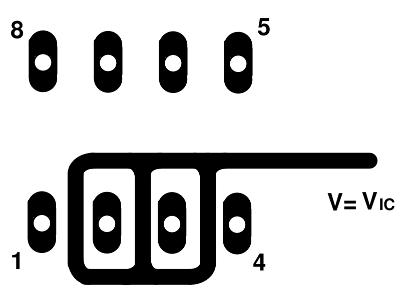


Figure 32 Bias Current Guarding for High Input Impedance Applications

Typical Application Circuits

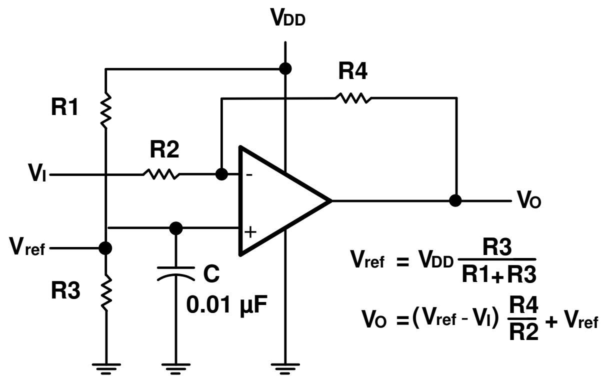


Figure 33 Inverting Amplifier With Voltage Reference

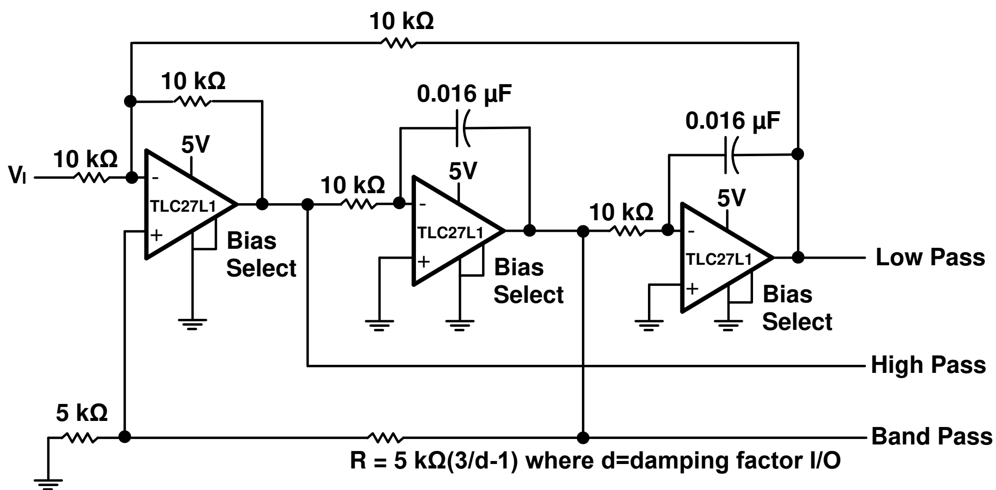


Figure 34 State Variable Filter

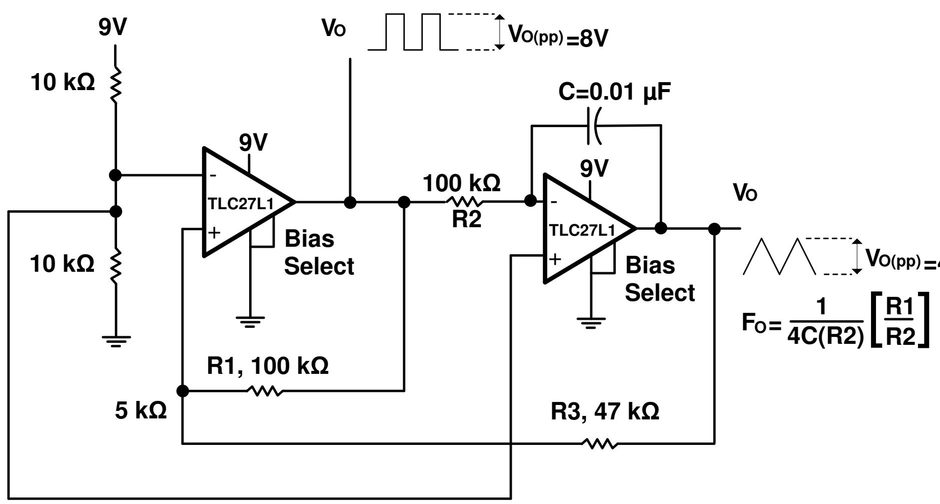


Figure 35 Single Supply Function Generator

Typical Application Circuits (cont.)

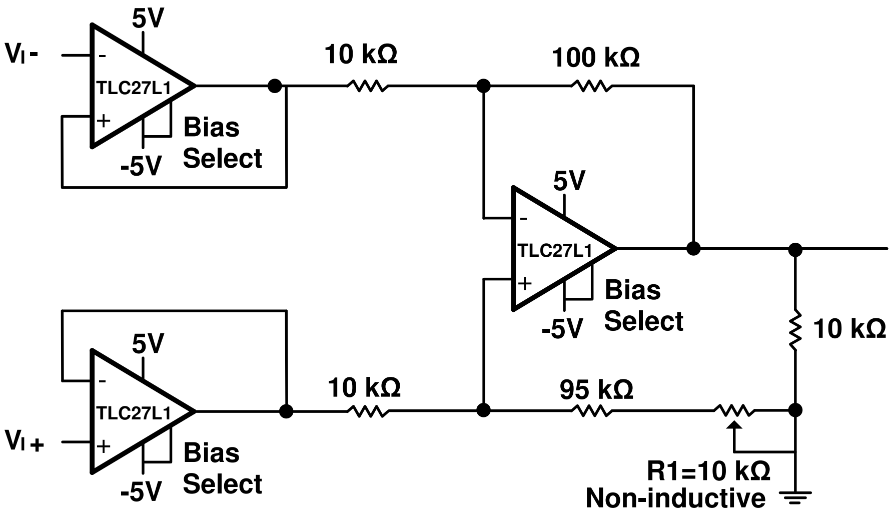


Figure 36 Low Power Instrumentation Amplifier

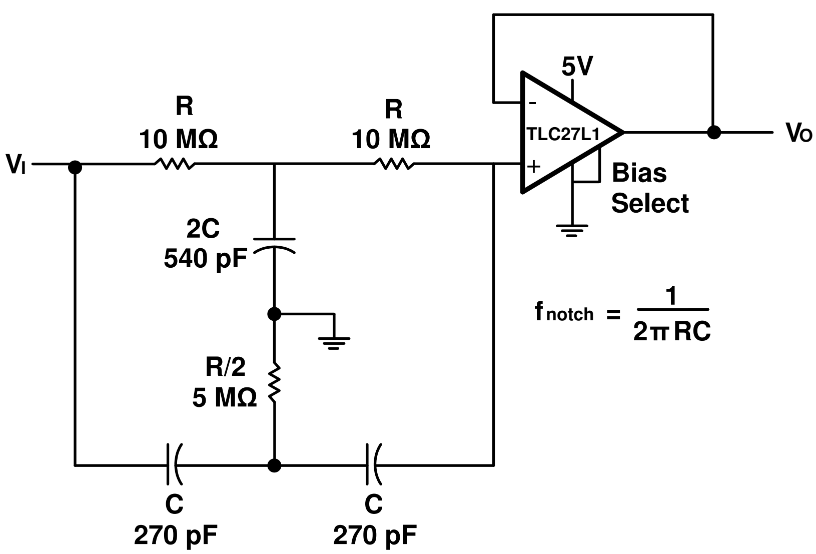


Figure 37 Single Supply Twin-T Notch Filter

Typical Application Circuits (cont.)

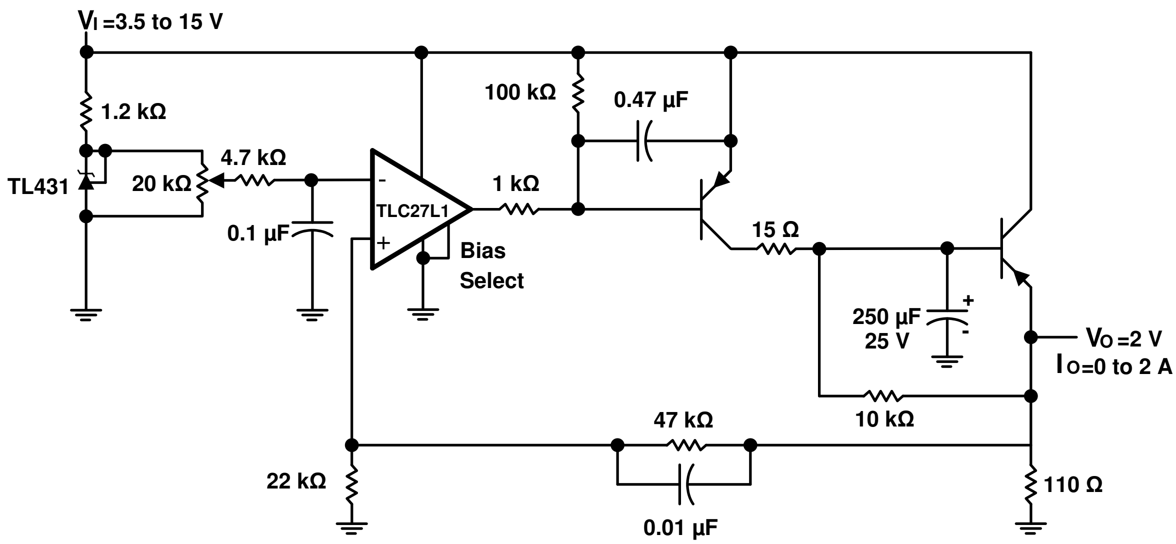


Figure 38 Power Supply

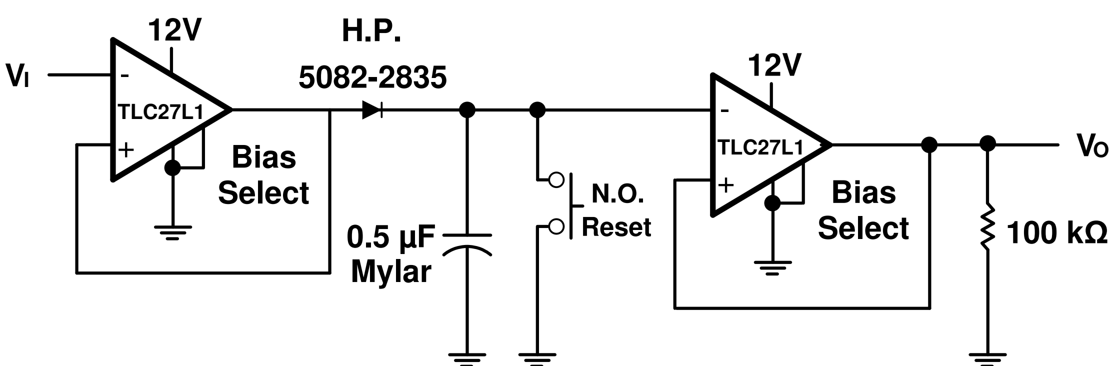


Figure 39 Positive Peak Detector

Typical Application Circuits (cont.)

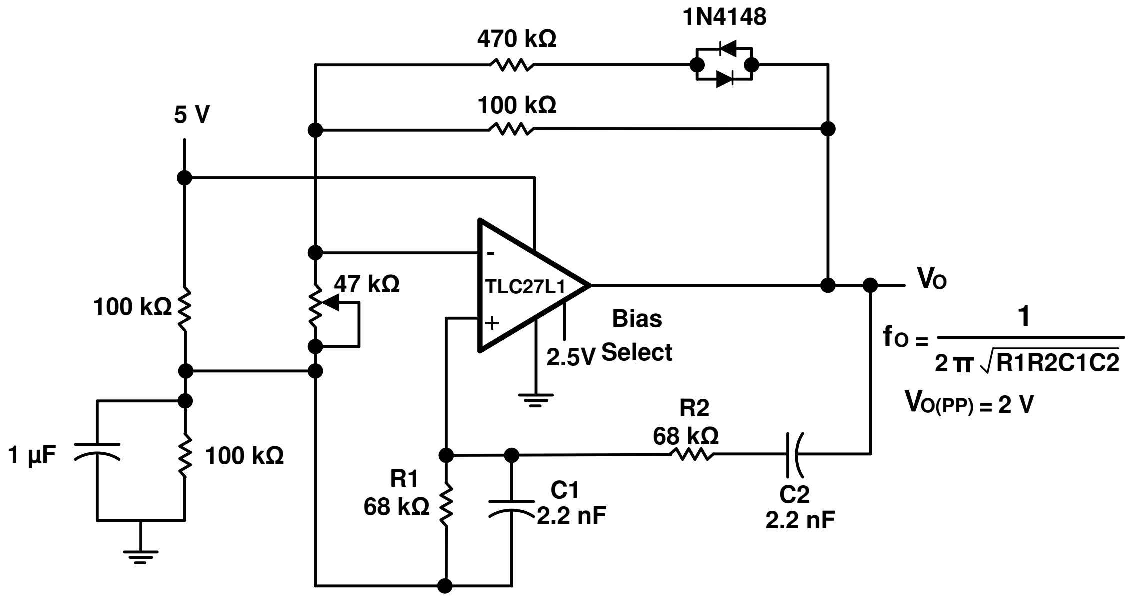


Figure 40 Wein Oscillator

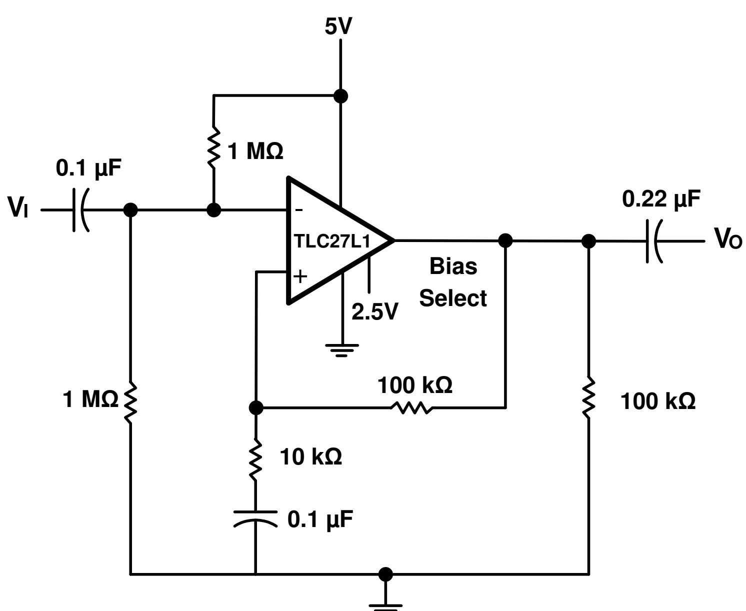


Figure 41 Single-Supply AC Amplifier

Typical Application Circuits (cont.)

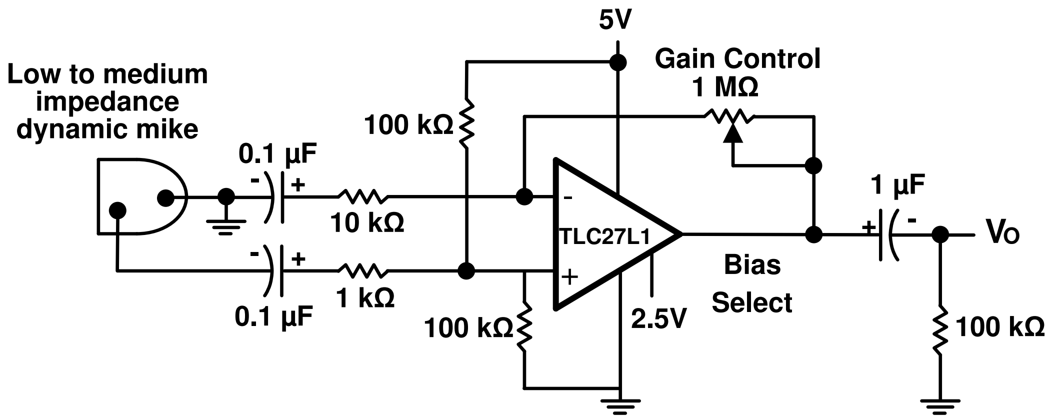


Figure 42 Microphone Preamplifier

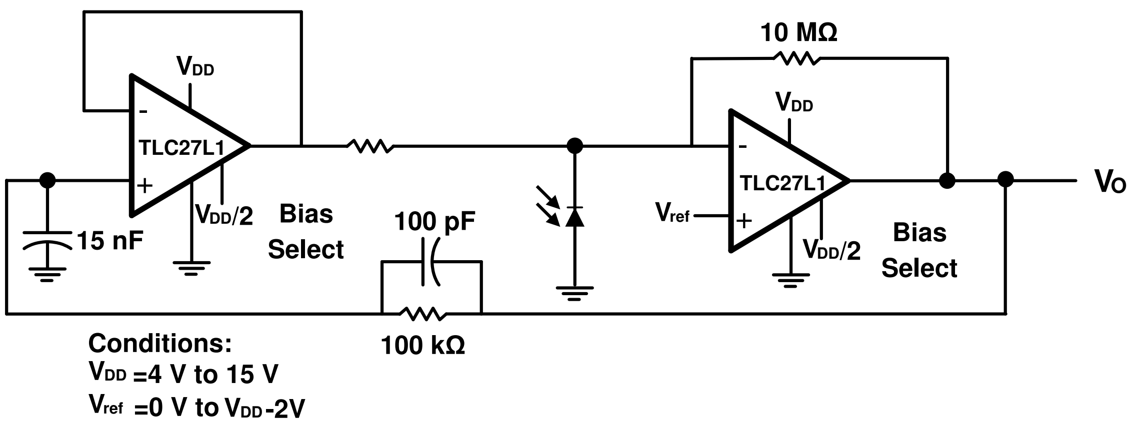


Figure 43 Photo-Diode Amplifier With Ambient Light Rejection

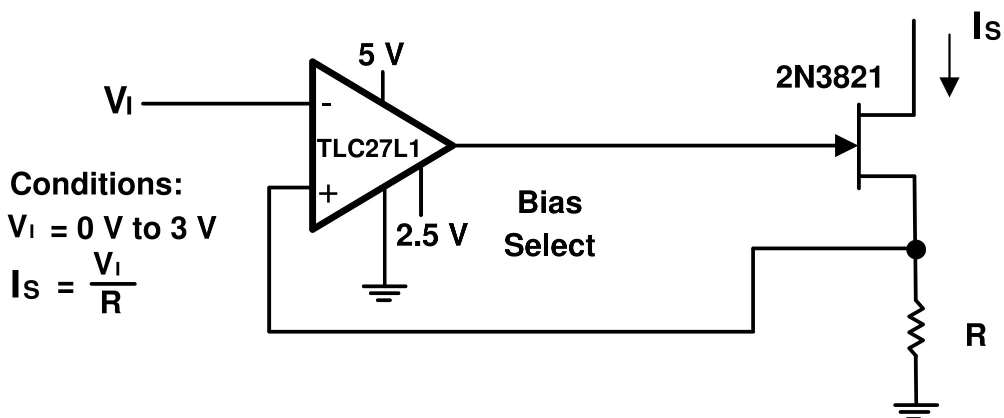


Figure 44 Precision Low-Current Sink

Typical Application Circuits (cont.)

Select	S1	S2
A_V	10	100

V_{DD} =5 V to 12 V

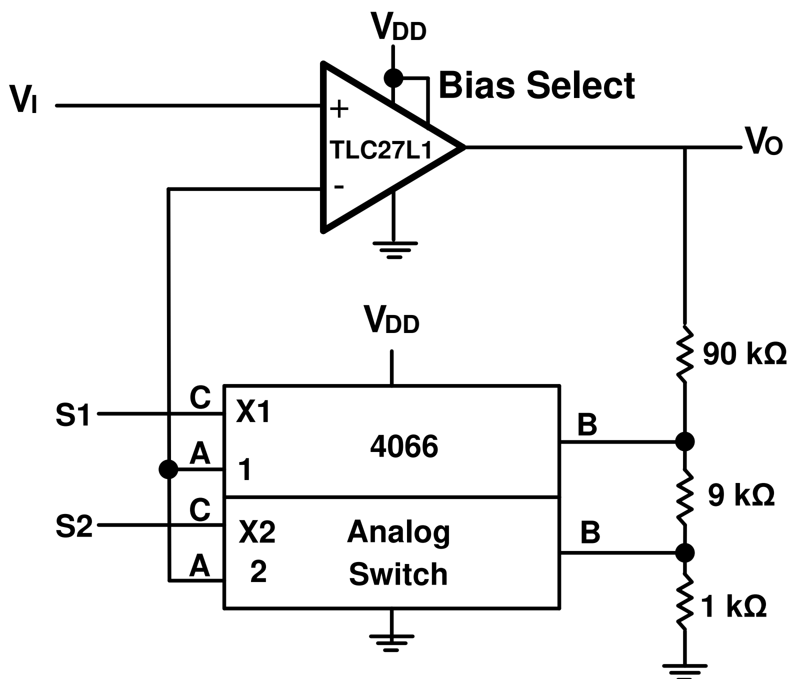


Figure 45 Amplifier With Digital Gain Selection

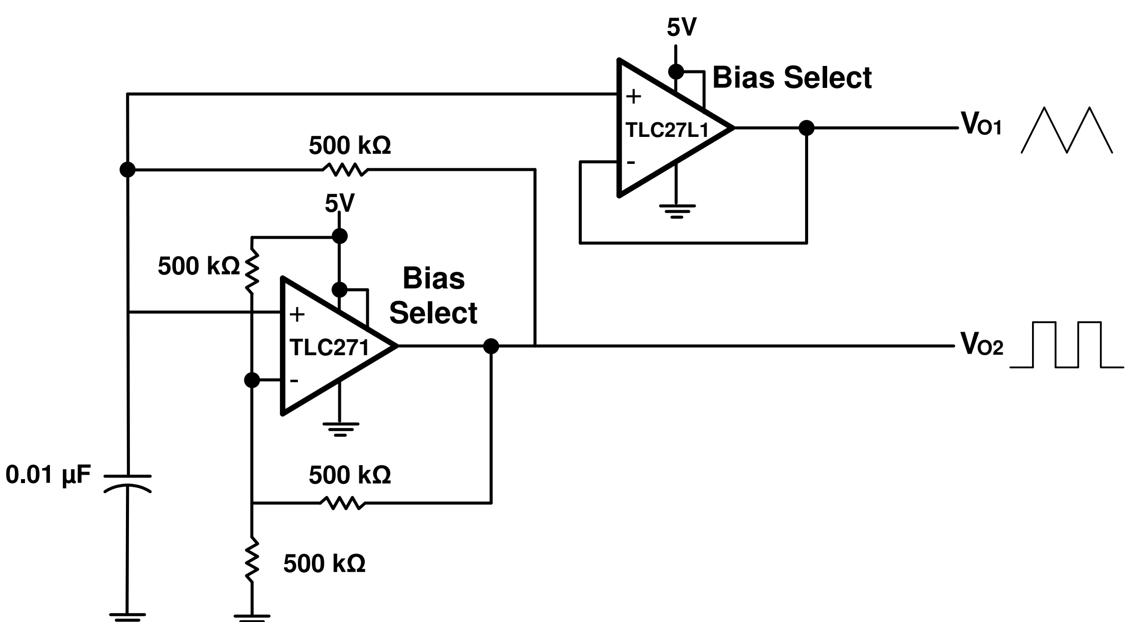


Figure 46 Multivibrator

Typical Application Circuits (cont.)

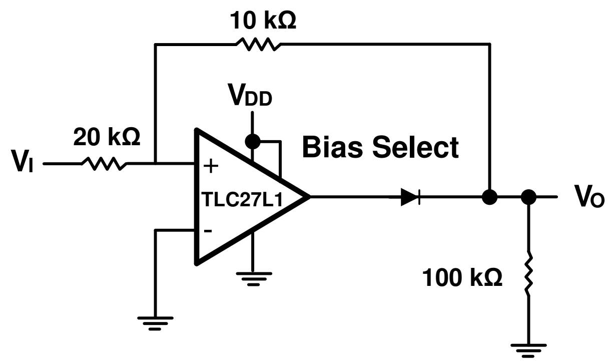


Figure 47 Full Wave Rectifier

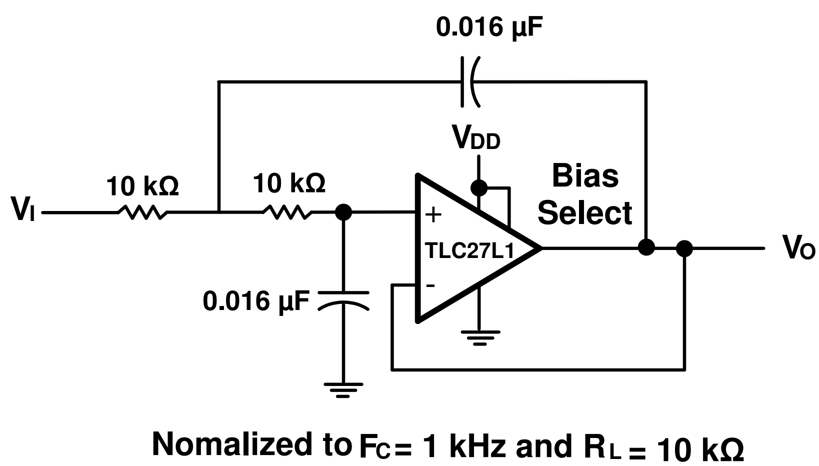


Figure 48 Two-Pole Low-Pass Butterworth Filter