

TLV277x-Q1, TLV277xA-Q1 FAMILY OF 2.7-V HIGH-SLEW-RATE RAIL-TO-RAIL OUTPUT OPERATIONAL AMPLIFIERS WITH SHUTDOWN

SGLS179 – SEPTEMBER 2003

- Qualification in Accordance With AEC-Q100[†]
- Qualified for Automotive Applications
- Customer-Specific Configuration Control Can Be Supported Along With Major-Change Approval
- ESD Protection Exceeds 2000 V Per MIL-STD-883, Method 3015; Exceeds 200 V Using Machine Model (C = 200 pF, R = 0)
- High Slew Rate . . . 10.5 V/ μ s Typ
- High-Gain Bandwidth . . . 5.1 MHz Typ
- Supply Voltage Range 2.5 V to 5.5 V
- Rail-to-Rail Output
- 360 μ V Input Offset Voltage
- Low Distortion Driving 600- Ω 0.005% THD+N
- 1 mA Supply Current (Per Channel)
- 17 nV/ $\sqrt{\text{Hz}}$ Input Noise Voltage
- 2 pA Input Bias Current
- Characterized From T_A = –55°C to 125°C
- Available in MSOP and SOT-23 Packages
- Micropower Shutdown Mode . . . I_{DD} < 1 μ A

[†] Contact factory for details. Q100 qualification data available on request.

description

The TLV277x CMOS operational amplifier family combines high slew rate and bandwidth, rail-to-rail output swing, high output drive, and excellent dc precision. The device provides 10.5 V/ μ s of slew rate and 5.1 MHz of bandwidth while only consuming 1 mA of supply current per channel. This ac performance is much higher than current competitive CMOS amplifiers. The rail-to-rail output swing and high output drive make these devices a good choice for driving the analog input or reference of analog-to-digital converters. These devices also have low distortion while driving a 600- Ω load for use in telecom systems.

These amplifiers have a 360- μ V input offset voltage, a 17 nV/ $\sqrt{\text{Hz}}$ input noise voltage, and a 2-pA input bias current for measurement, medical, and industrial applications. The TLV277x family is also specified across an extended temperature range (–40°C to 125°C), making it useful for automotive systems.

These devices operate from a 2.5-V to 5.5-V single supply voltage and are characterized at 2.7 V and 5 V. The single-supply operation and low power consumption make these devices a good solution for portable applications. The following table lists the packages available.

FAMILY PACKAGE TABLE

DEVICE	NUMBER OF CHANNELS	PACKAGE TYPES		SHUTDOWN	UNIVERSAL EVM BOARD
		SOIC	TSSOP		
TLV2770	1	8	—	Yes	Refer to the EVM Selection Guide (Lit# SLOU060)
TLV2771	1	8	—	—	
TLV2772	2	8	8	—	
TLV2773	2	14	—	Yes	
TLV2774	4	14	14	—	
TLV2775	4	16	16	Yes	



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A SELECTION OF SINGLE-SUPPLY OPERATIONAL AMPLIFIER PRODUCTS[†]

DEVICE	V _{DD} (V)	BW (MHz)	SLEW RATE (V/ μ s)	I _{DD} (per channel) (μ A)	RAIL-TO-RAIL
TLV277X	2.5 – 6.0	5.1	10.5	1000	O
TLV247X	2.7 – 6.0	2.8	1.5	600	I/O
TLV245X	2.7 – 6.0	0.22	0.11	23	I/O
TLV246X	2.7 – 6.0	6.4	1.6	550	I/O

[†] All specifications measured at 5 V.

ORDERING INFORMATION

T _A	V _{IO} max AT 25°C (mV)	PACKAGE [‡]		ORDERABLE PART NUMBER	TOP-SIDE MARKING
–40°C to 125°C	2.5	SOIC (D)	Tape and reel	TLV2770QDRQ1 [§]	
	1.6	SOIC (D)	Tape and reel	TLV2770AQDRQ1 [§]	
–40°C to 125°C	2.5	SOIC (D)	Tape and reel	TLV2771QDRQ1 [§]	
	1.6	SOIC (D)	Tape and reel	TLV2771AQDRQ1 [§]	
–40°C to 125°C	2.5	SOIC (D)	Tape and reel	TLV2772QDRQ1	TLV2772QI
		TSSOP (PW)	Tape and reel	TLV2772QPWRQ1	TLV2772QI
	1.6	SOIC (D)	Tape and reel	TLV2772AQDRQ1	TLV2772AQ
		TSSOP (PW)	Tape and reel	TLV2772AQPWRQ1	TLV2772AQ
–40°C to 125°C	2.5	SOIC (D)	Tape and reel	TLV2773QDRQ1 [§]	
	1.6	SOIC (D)	Tape and reel	TLV2773AQDRQ1 [§]	
–40°C to 125°C	2.7	SOIC (D)	Tape and reel	TLV2774QDRQ1 [§]	
		TSSOP (PW)	Tape and reel	TLV2774QPWRQ1 [§]	
	2.1	SOIC (D)	Tape and reel	TLV2774AQDRQ1 [§]	
		TSSOP (PW)	Tape and reel	TLV2774AQPWRQ1 [§]	
–40°C to 125°C	2.7	SOIC (D)	Tape and reel	TLV2775QDRQ1 [§]	
		TSSOP (PW)	Tape and reel	TLV2775QPWRQ1 [§]	
	2.1	SOIC (D)	Tape and reel	TLV2775AQDRQ1 [§]	
		TSSOP (PW)	Tape and reel	TLV2775AQPWRQ1 [§]	

[‡] Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.

[§] Product Preview

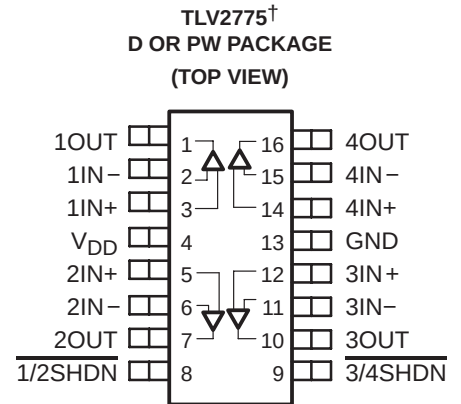
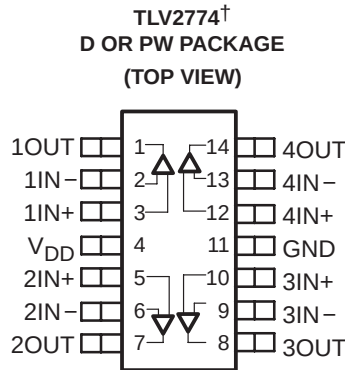
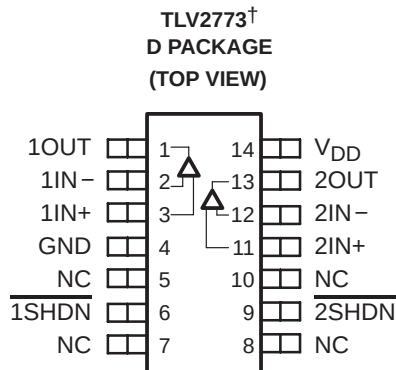
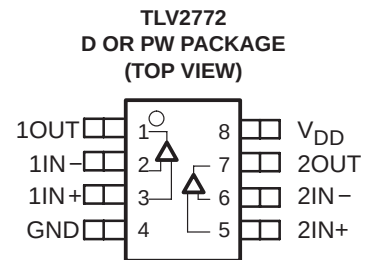
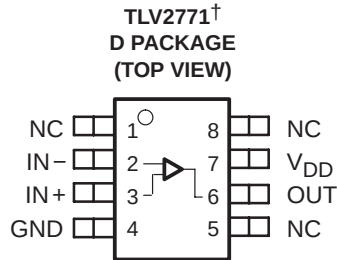
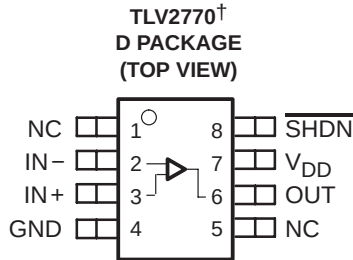


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TLV277x PACKAGE PINOUTS



NC – No internal connection

[†] This device is in the Product Preview stage of development. Please contact your local TI sales office for availability.

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

Supply voltage, V_{DD} (see Note 1)	7 V
Differential input voltage, V_{ID} (see Note 2)	$\pm V_{DD}$
Input voltage range, V_I (any input, see Note 1)	-0.3 V to V_{DD}
Input current, I_I (any input)	± 4 mA
Output current, I_O	± 50 mA
Total current into V_{DD+}	± 50 mA
Total current out of GND	± 50 mA
Duration of short-circuit current (at or below) 25°C (see Note 3)	unlimited
Continuous total power dissipation	See Dissipation Rating Table
Operating free-air temperature range, T_A : Q suffix	-40°C to 125°C
Storage temperature range, T_{stg}	-65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	260°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. All voltage values, except differential voltages, are with respect to GND.
 2. Differential voltages are at the noninverting input with respect to the inverting input. Excessive current flows when input is brought below GND - 0.3 V.
 3. 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.

DISSIPATION RATING TABLE

PACKAGE	$T_A \leq 25^\circ\text{C}$ POWER RATING	DERATING FACTOR ABOVE $T_A = 25^\circ\text{C}$	$T_A = 70^\circ\text{C}$ POWER RATING	$T_A = 85^\circ\text{C}$ POWER RATING	$T_A = 125^\circ\text{C}$ POWER RATING
D	725 mW	5.8 mW/°C	464 mW	377 mW	145 mW
PW	700 mW	5.6 mW/°C	448 mW	364 mW	140 mW

recommended operating conditions

	Q SUFFIX		UNIT
	MIN	MAX	
Supply voltage, V_{DD}	2.5	6	V
Input voltage range, V_I	GND	$V_{DD+} - 1.3$	V
Common-mode input voltage, V_{IC}	GND	$V_{DD+} - 1.3$	V
Operating free-air temperature, T_A	-40	125	°C



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electrical characteristics at specified free-air temperature, $V_{DD} = 2.7\text{ V}$ (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T _A [†]	TLV2772-Q1			TLV2772A-Q1			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
V _{IO}	Input offset voltage	V _{DD} = ±1.35 V, V _{IC} = 0, R _S = 50 Ω	25°C	0.44		2.5	0.44		1.6	mV
				0.47		2.7	0.47		1.9	
α _{VIO}	Temperature coefficient of input offset voltage		25°C to 125°C	2			2			μV/°C
I _{IO}	Input offset current		25°C	1		60	1		60	pA
			Full range	2		125	2		125	
I _{IB}	Input bias current		25°C	2		60	2		60	pA
			Full range	6		350	6		350	
V _{ICR}	Common-mode input voltage range	CMRR > 60 dB, R _S = 50 Ω	25°C	0 to 1.4	−0.3 to 1.7		0 to 1.4	−0.3 to 1.7	V	
			Full range	0 to 1.4	−0.3 to 1.7		0 to 1.4	−0.3 to 1.7		
V _{OH}	High-level output voltage	I _{OH} = −0.675 mA	25°C	2.6			2.6			V
			Full range	2.45			2.45			
		I _{OH} = −2.2 mA	25°C	2.4			2.4			
			Full range	2.1			2.1			
V _{OL}	Low-level output voltage	V _{IC} = 1.35 V, I _{OL} = 0.675 mA	25°C	0.1			0.1			V
			Full range	0.2			0.2			
		V _{IC} = 1.35 V, I _{OL} = 2.2 mA	25°C	0.21			0.21			
			Full range	0.6			0.6			
A _{VD}	Large-signal differential voltage amplification	V _{IC} = 1.35 V, V _O = 0.6 V to 2.1 V, R _L = 10 kΩ,‡	25°C	20	380		20	380	V/mV	
			Full range	13			13			
r _{i(d)}	Differential input resistance		25°C	10 ¹²			10 ¹²			Ω
c _{i(c)}	Common-mode input capacitance	f = 10 kHz,	25°C	8			8			pF
z _o	Closed-loop output impedance	f = 100 kHz, A _V = 10	25°C	25			25			Ω
CMRR	Common-mode rejection ratio	V _{IC} = V _{ICR} (min), R _S = 50 Ω, V _O = 1.5 V,	25°C	60	84		60	84	dB	
			Full range	60	82		60	82		
k _{SVR}	Supply voltage rejection ratio (ΔV _{DD} /ΔV _{IO})	V _{DD} = 2.7 V to 5 V, No load, V _{IC} = V _{DD} /2,	25°C	70	89		70	89	dB	
			Full range	70	84		70	84		
I _{DD}	Supply current (per channel)	V _O = 1.5 V, No load	25°C	1		2	1		2	mA
			Full range			2			2	

† Full range is -40°C to 125°C for Q level part.

‡ Referenced to 1.35 V

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OPERATIONAL AMPLIFIERS WITH SHUTDOWN

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operating characteristics at specified free-air temperature, $V_{DD} = 2.7\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T_A †	TLV2772-Q1			TLV2772A-Q1			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
SR	Slew rate at unity gain	$V_{O(PP)} = 0.8\text{ V}$, $C_L = 100\text{ pF}$, $R_L = 10\text{ k}\Omega$	25°C	5	9	5	9		V/ μs
			Full range	4.7	6	4.7	6		
V_n	Equivalent input noise voltage	$f = 1\text{ kHz}$	25°C	21		21			nV/ $\sqrt{\text{Hz}}$
		$f = 10\text{ kHz}$	25°C	17		17			
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ Hz to }1\text{ Hz}$	25°C	0.33		0.33			μV
		$f = 0.1\text{ Hz to }10\text{ Hz}$	25°C	0.86		0.86			μV
I_n	Equivalent input noise current	$f = 100\text{ Hz}$	25°C	0.6		0.6			fA/ $\sqrt{\text{Hz}}$
THD + N	Total harmonic distortion plus noise	$R_L = 600\text{ }\Omega$, $f = 1\text{ kHz}$	25°C	$A_V = 1$	0.0085%	0.0085%			
				$A_V = 10$	0.025%	0.025%			
				$A_V = 100$	0.12%	0.12%			
	Gain-bandwidth product	$f = 10\text{ kHz}$, $R_L = 600\text{ }\Omega$, $C_L = 100\text{ pF}$	25°C	4.8		4.8			MHz
t_s	Settling time	$A_V = -1$, Step = 0.85 V to 1.85 V, $R_L = 600\text{ }\Omega$, $C_L = 100\text{ pF}$	0.1%	25°C	0.186	0.186			μs
			0.01%	25°C	3.92	3.92			
ϕ_m	Phase margin at unity gain	$R_L = 600\text{ }\Omega$, $C_L = 100\text{ pF}$	25°C	46°		46°			
	Gain margin		25°C	12		12			dB

† Full range is -40°C to 125°C for Q level part.



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electrical characteristics at specified free-air temperature, $V_{DD} = 5\text{ V}$ (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T _A [†]	TLV2772-Q1			TLV2772A-Q1			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
V _{IO}	Input offset voltage	V _{DD} = ±2.5 V, V _{IC} = 0, V _O = 0, R _S = 50 Ω	25°C	0.36		2.5	0.36		1.6	mV
			Full range	0.4		2.7	0.4		1.9	
α _{VIO}	Temperature coefficient of input offset voltage		25°C to 125°C	2			2			μV/°C
I _{IO}	Input offset current		25°C	1		60	1		60	pA
			Full range	2		125	2		125	
I _{IB}	Input bias current		25°C	2		60	2		60	pA
			Full range	6		350	6		350	
V _{ICR}	Common-mode input voltage range	CMRR > 60 dB, R _S = 50 Ω	25°C	0 to 3.7	−0.3 to 3.8		0 to 3.7	−0.3 to 3.8		V
			Full range	0 to 3.7	−0.3 to 3.8		0 to 3.7	−0.3 to 3.8		
V _{OH}	High-level output voltage	I _{OH} = −1.3 mA	25°C	4.9			4.9			V
			Full range	4.8			4.8			
		I _{OH} = −4.2 mA	25°C	4.7			4.7			
			Full range	4.4			4.4			
V _{OL}	Low-level output voltage	V _{IC} = 2.5 V, I _{OL} = 1.3 mA	25°C	0.1			0.1			V
			Full range	0.2			0.2			
		V _{IC} = 2.5 V, I _{OL} = 4.2 mA	25°C	0.21			0.21			
			Full range	0.6			0.6			
A _{VD}	Large-signal differential voltage amplification	V _{IC} = 2.5 V, V _O = 1 V to 4 V R _L = 10 kΩ,‡	25°C	20	450		20	450		V/mV
			Full range	13			13			
r _{i(d)}	Differential input resistance		25°C	10 ¹²			10 ¹²			Ω
c _{i(c)}	Common-mode input capacitance	f = 10 kHz,	25°C	8			8			pF
z _o	Closed-loop output impedance	f = 100 kHz, A _V = 10	25°C	20			20			Ω
CMRR	Common-mode rejection ratio	V _{IC} = V _{ICR} (min), R _S = 50 Ω V _O = 3.7 V,	25°C	60	96		60	96		dB
			Full range	60	93		60	93		
k _{SVR}	Supply voltage rejection ratio (ΔV _{DD} /ΔV _{IO})	V _{DD} = 2.7 V to 5 V, No load V _{IC} = V _{DD} /2,	25°C	70	89		70	89		dB
			Full range	70	84		70	84		
I _{DD}	Supply current (per channel)	V _O = 1.5 V, No load	25°C	1		2	1		2	mA
			Full range	2			2			

† Full range is -40°C to 125°C for Q level part.

‡ Referenced to 2.5 V

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operating characteristics at specified free-air temperature, $V_{DD} = 5\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T_A †	TLV2772-Q1			TLV2772A-Q1			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
SR	Slew rate at unity gain	$V_{O(PP)} = 1.5\text{ V}$, $C_L = 100\text{ pF}$, $R_L = 10\text{ k}\Omega$	25°C	5	10.5	5	10.5		V/ μs
			Full range	4.7	6	4.7	6		
V_n	Equivalent input noise voltage	$f = 1\text{ kHz}$	25°C	17		17			nV/ $\sqrt{\text{Hz}}$
		$f = 10\text{ kHz}$	25°C	12		12			
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ Hz to }1\text{ Hz}$	25°C	0.33		0.33			μV
		$f = 0.1\text{ Hz to }10\text{ Hz}$	25°C	0.86		0.86			μV
I_n	Equivalent input noise current	$f = 100\text{ Hz}$	25°C	0.6		0.6			fA/ $\sqrt{\text{Hz}}$
THD + N	Total harmonic distortion plus noise	$R_L = 600\text{ }\Omega$, $f = 1\text{ kHz}$	25°C	$A_V = 1$	0.005%	0.005%			
				$A_V = 10$	0.016%	0.016%			
				$A_V = 100$	0.095%	0.095%			
	Gain-bandwidth product	$f = 10\text{ kHz}$, $R_L = 600\text{ }\Omega$, $C_L = 100\text{ pF}$	25°C	5.1		5.1			MHz
t_s	Settling time	$A_V = -1$, Step = 1.5 V to 3.5 V, $R_L = 600\text{ }\Omega$, $C_L = 100\text{ pF}$	0.1%	25°C	0.134	0.134			μs
			0.01%	25°C	1.97	1.97			
ϕ_m	Phase margin at unity gain	$R_L = 600\text{ }\Omega$, $C_L = 100\text{ pF}$	25°C	46°		46°			
	Gain margin		25°C	12		12			dB

† Full range is -40°C to 125°C for Q level part.

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TYPICAL CHARACTERISTICS

Table of Graphs

			FIGURE
V_{IO}	Input offset voltage	Distribution vs Common-mode input voltage Distribution	1,2 3,4 5,6
I_{IB}/I_{IO}	Input bias and input offset currents	vs Free-air temperature	7
V_{OH}	High-level output voltage	vs High-level output current	8,9
V_{OL}	Low-level output voltage	vs Low-level output current	10,11
$V_{O(PP)}$	Maximum peak-to-peak output voltage	vs Frequency	12,13
I_{OS}	Short-circuit output current	vs Supply voltage vs Free-air temperature	14 15
V_O	Output voltage	vs Differential input voltage	16
A_{VD}	Large-signal differential voltage amplification and phase margin	vs Frequency	17,18
A_{VD}	Differential voltage amplification	vs Load resistance vs Free-air temperature	19 20,21
z_o	Output impedance	vs Frequency	22,23
CMRR	Common-mode rejection ratio	vs Frequency vs Free-air temperature	24 25
k_{SVR}	Supply-voltage rejection ratio	vs Frequency	26,27
I_{DD}	Supply current (per channel)	vs Supply voltage	28
SR	Slew rate	vs Load capacitance vs Free-air temperature	29 30
V_O	Voltage-follower small-signal pulse response		31,32
V_O	Voltage-follower large-signal pulse response		33,34
V_O	Inverting small-signal pulse response		35,36
V_O	Inverting large-signal pulse response		37,38
V_n	Equivalent input noise voltage	vs Frequency	39,40
	Noise voltage (referred to input)	Over a 10-second period	41
THD + N	Total harmonic distortion plus noise	vs Frequency	42,43
	Gain-bandwidth product	vs Supply voltage	44
B_1	Unity-gain bandwidth	vs Load capacitance	45
ϕ_m	Phase margin	vs Load capacitance	46
	Gain margin	vs Load capacitance	47
	Amplifier with shutdown pulse turnon/off characteristics		48 – 50
	Supply current with shutdown pulse turnon/off characteristics		51 – 53
	Shutdown supply current	vs Free-air temperature	54
	Shutdown forward/reverse isolation	vs Frequency	55, 56



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TYPICAL CHARACTERISTICS

DISTRIBUTION OF TLV2772
INPUT OFFSET VOLTAGE

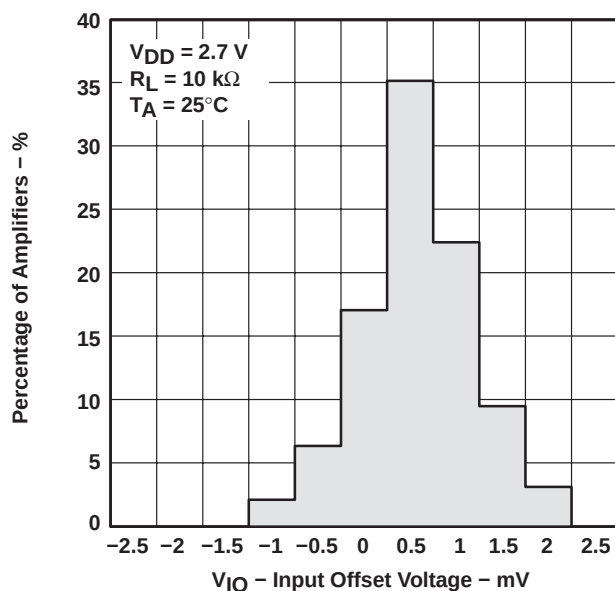


Figure 1

DISTRIBUTION OF TLV2772
INPUT OFFSET VOLTAGE

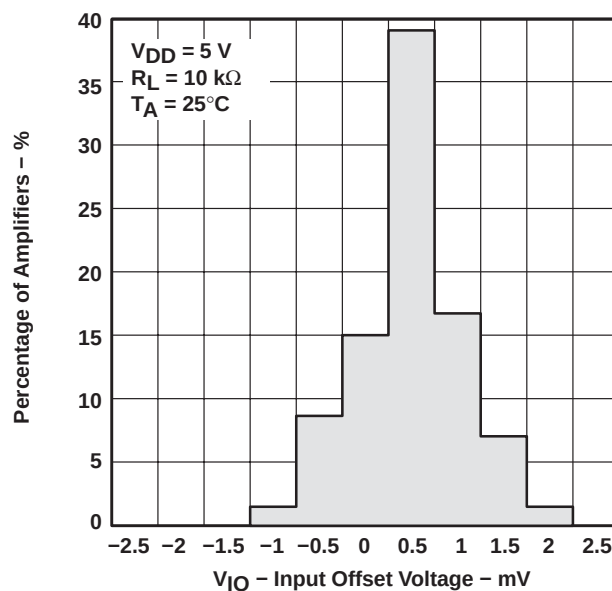


Figure 2

INPUT OFFSET VOLTAGE
vs
COMMON-MODE INPUT VOLTAGE

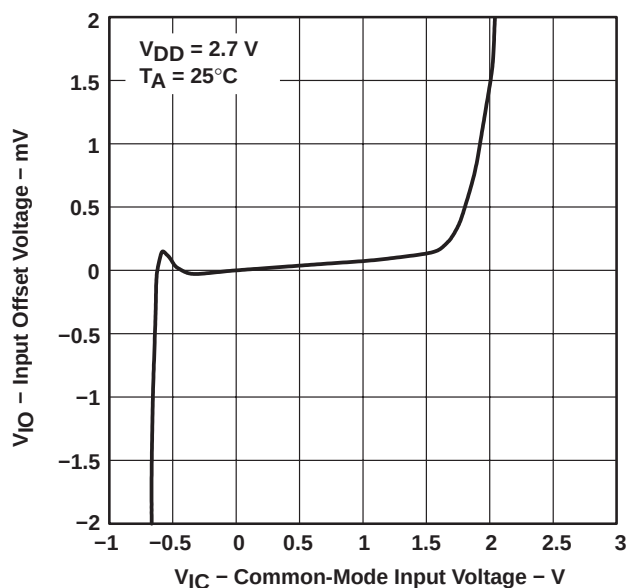


Figure 3

INPUT OFFSET VOLTAGE
vs
COMMON-MODE INPUT VOLTAGE

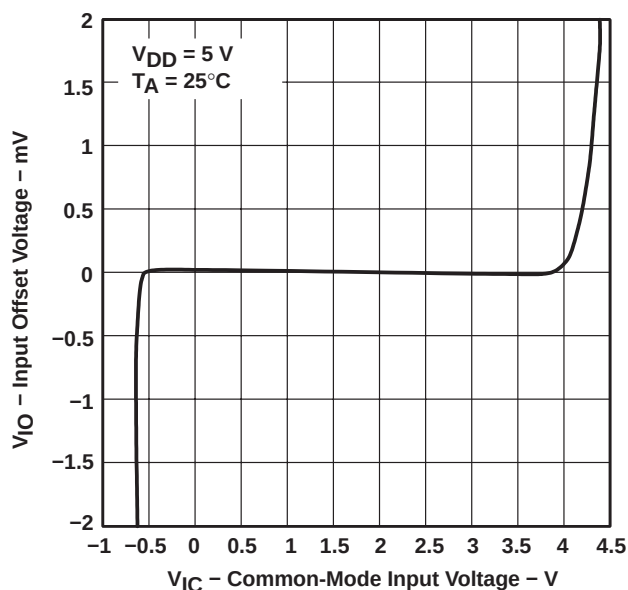


Figure 4

TYPICAL CHARACTERISTICS

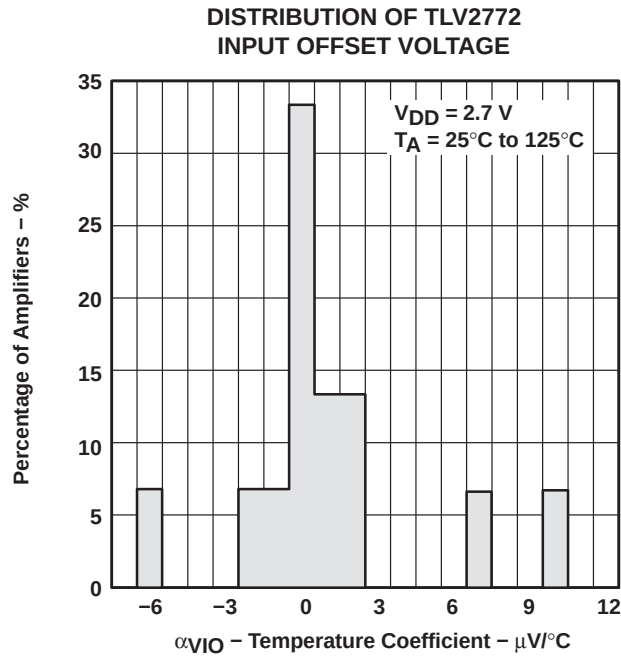


Figure 5

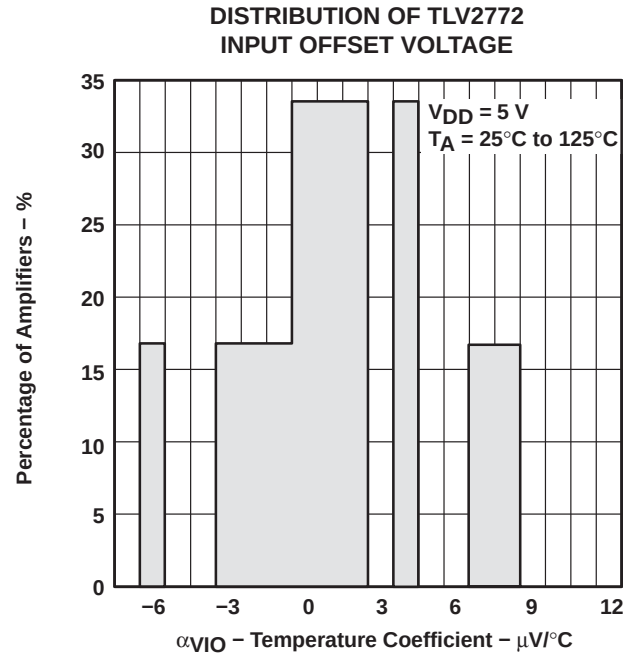


Figure 6

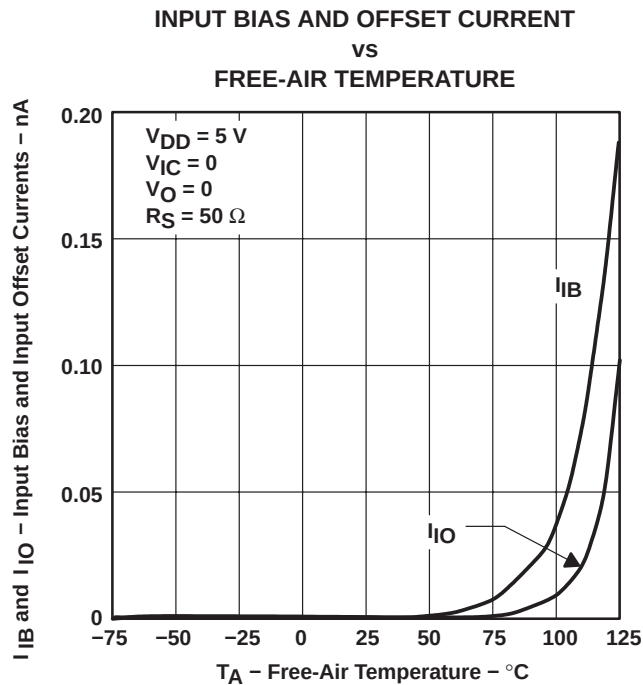


Figure 7

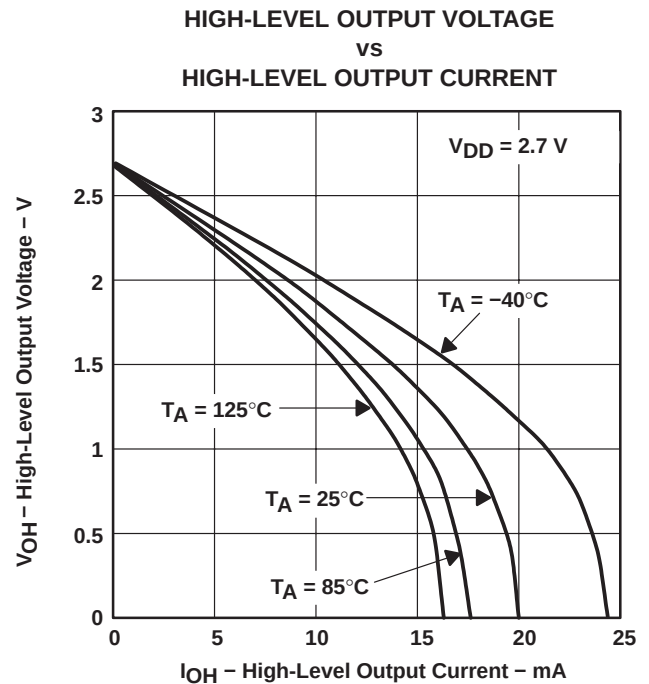


Figure 8

TLV277x-Q1, TLV277xA-Q1

FAMILY OF 2.7-V HIGH-SLEW-RATE RAIL-TO-RAIL OUTPUT OPERATIONAL AMPLIFIERS WITH SHUTDOWN

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TYPICAL CHARACTERISTICS

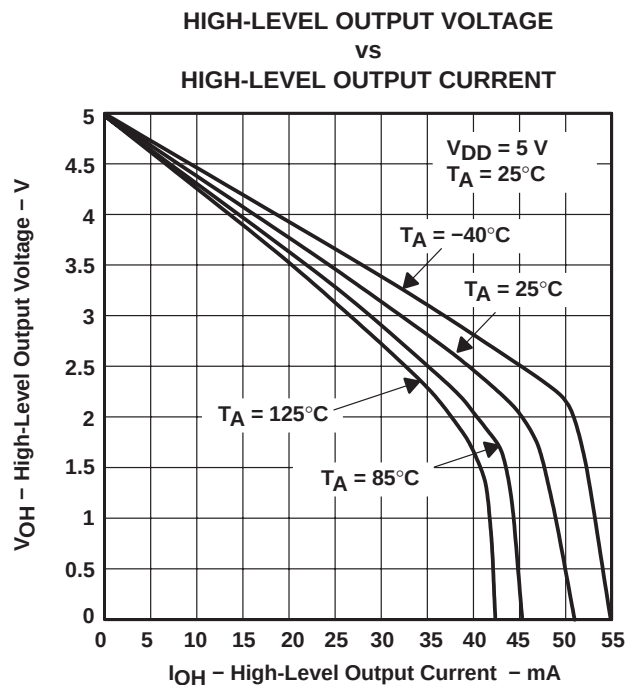


Figure 9

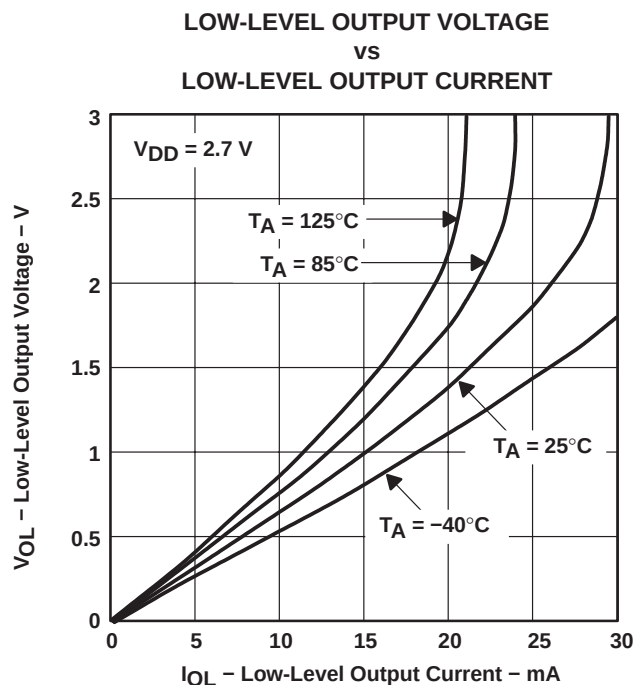


Figure 10

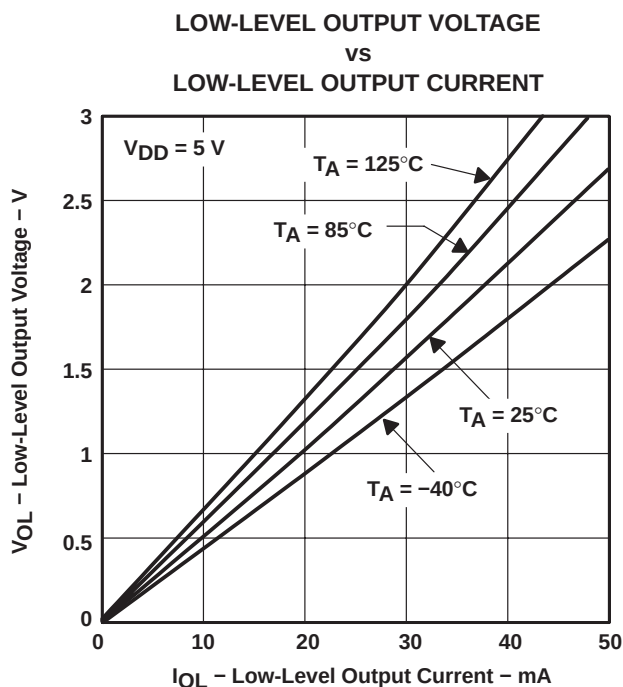


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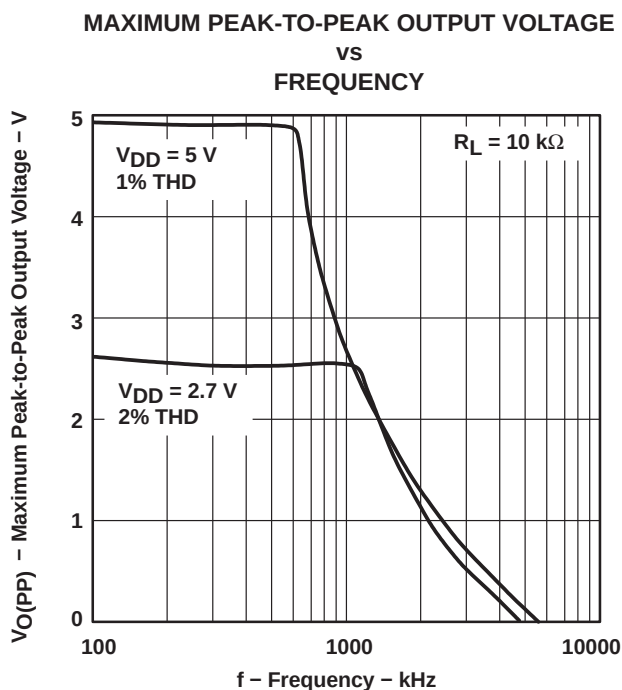


Figure 12

TLV277x-Q1, TLV277xA-Q1

FAMILY OF 2.7-V HIGH-SLEW-RATE RAIL-TO-RAIL OUTPUT OPERATIONAL AMPLIFIERS WITH SHUTDOWN

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TYPICAL CHARACTERISTICS

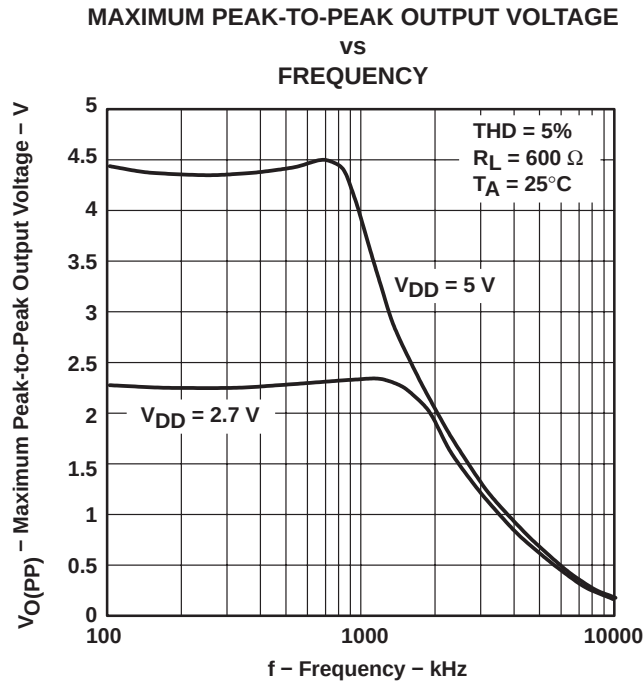


Figure 13

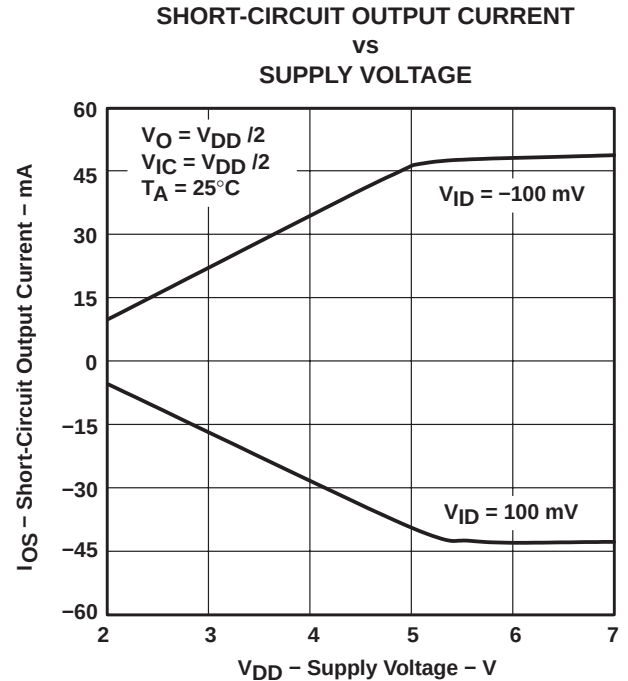


Figure 14

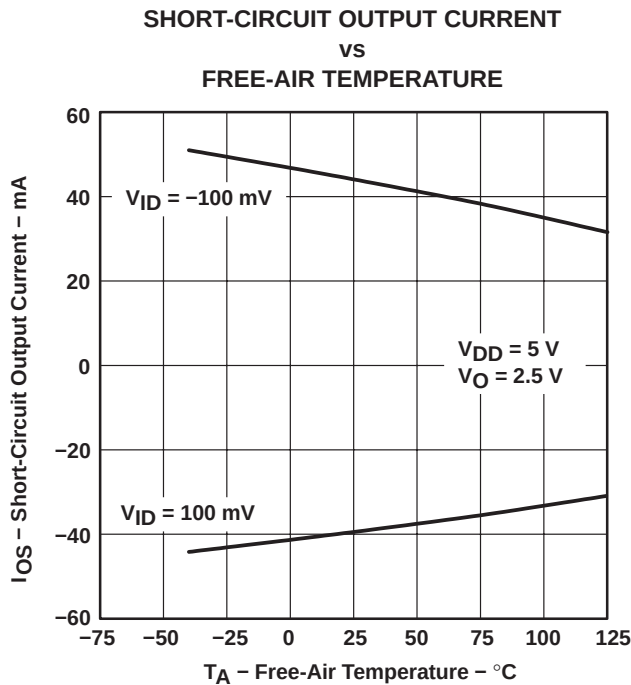


Figure 15

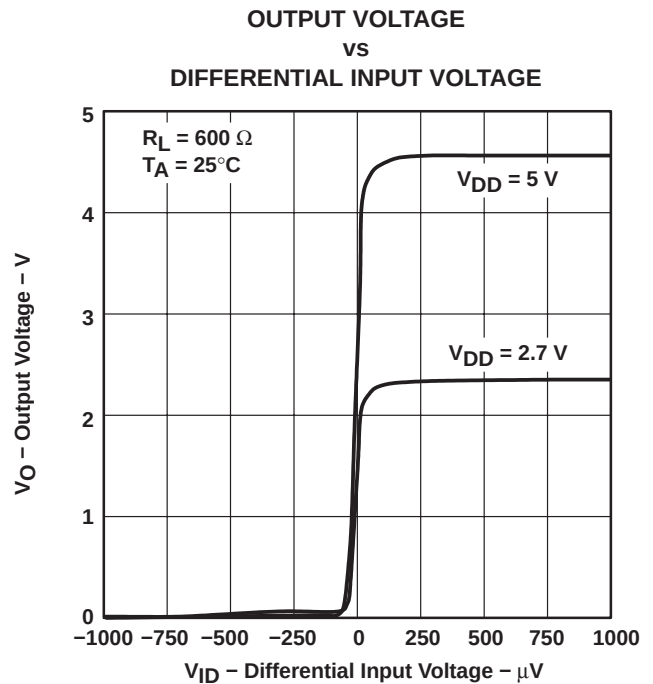


Figure 16

TLV277x-Q1, TLV277xA-Q1

FAMILY OF 2.7-V HIGH-SLEW-RATE RAIL-TO-RAIL OUTPUT OPERATIONAL AMPLIFIERS WITH SHUTDOWN

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TYPICAL CHARACTERISTICS

LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE MARGIN

VS
FREQUENCY

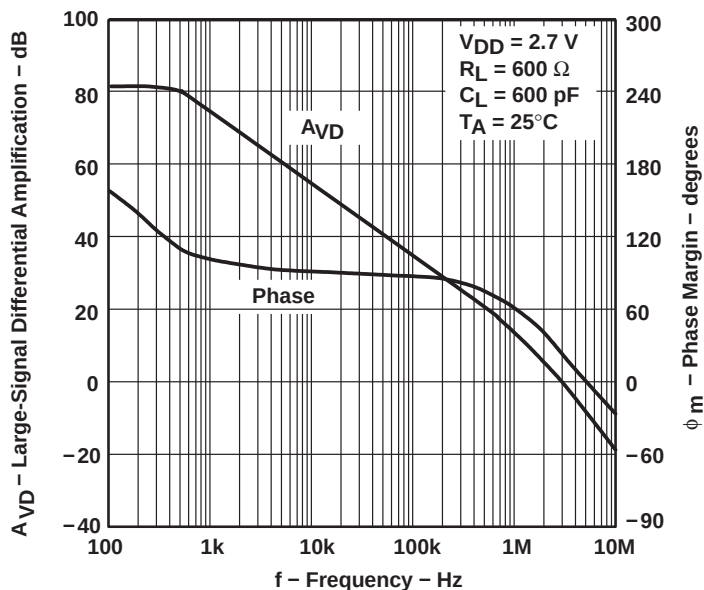


Figure 17

LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE MARGIN

VS
FREQUENCY

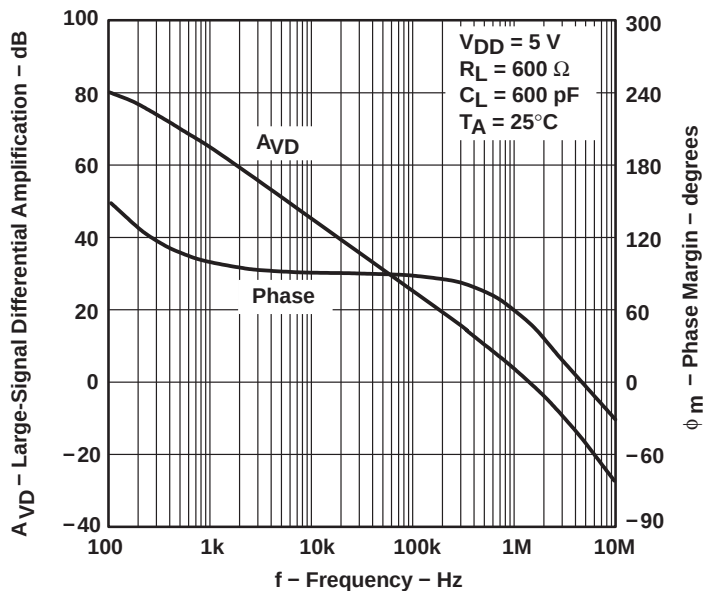


Figure 18



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TLV277x-Q1, TLV277xA-Q1

FAMILY OF 2.7-V HIGH-SLEW-RATE RAIL-TO-RAIL OUTPUT OPERATIONAL AMPLIFIERS WITH SHUTDOWN

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TYPICAL CHARACTERISTICS

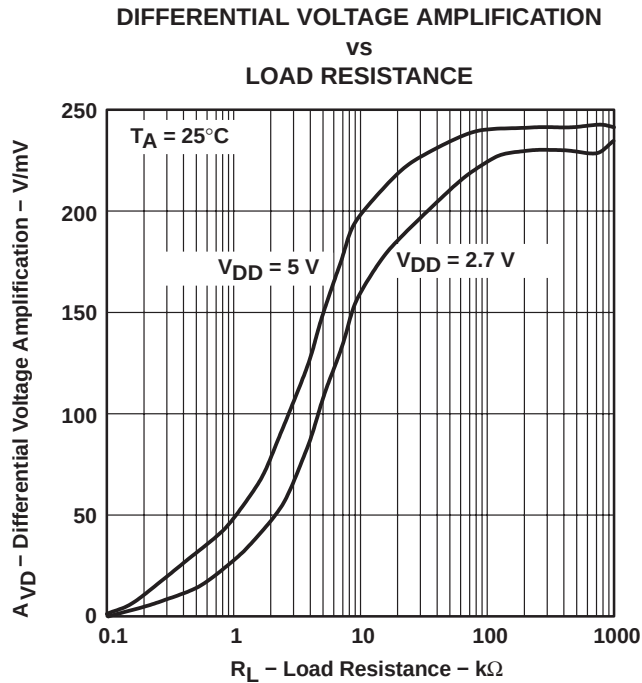


Figure 19

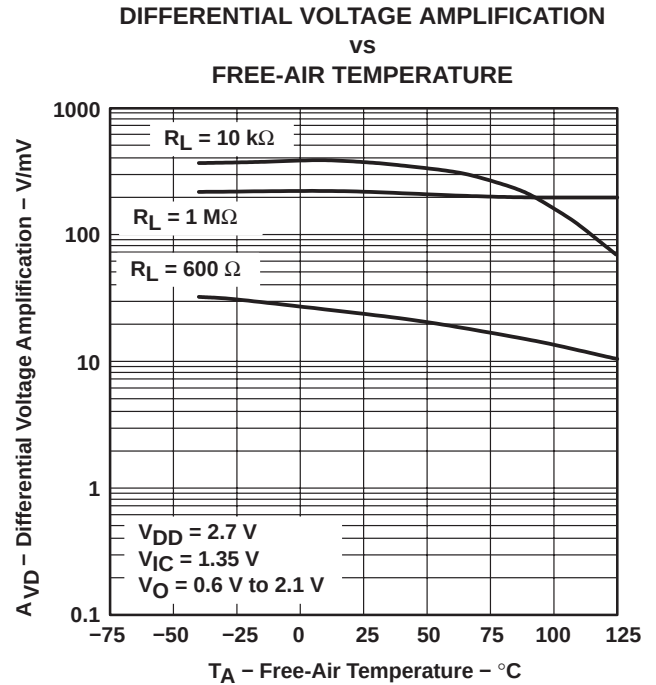


Figure 20

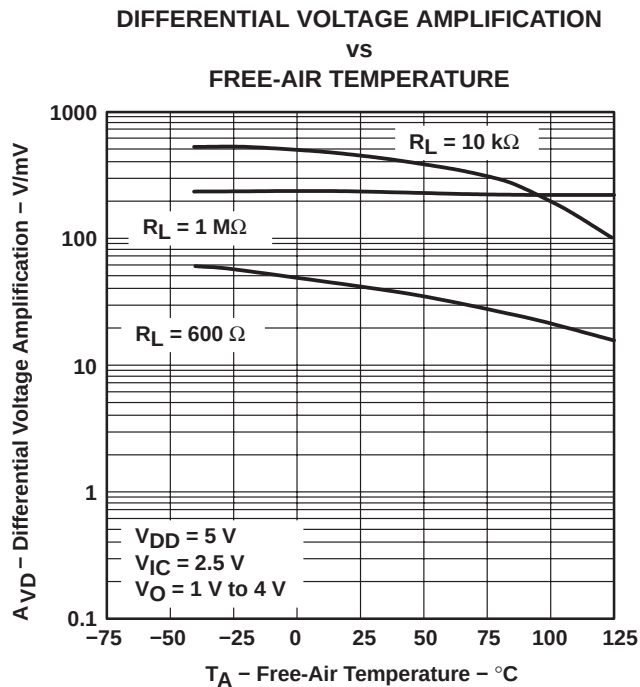


Figure 21

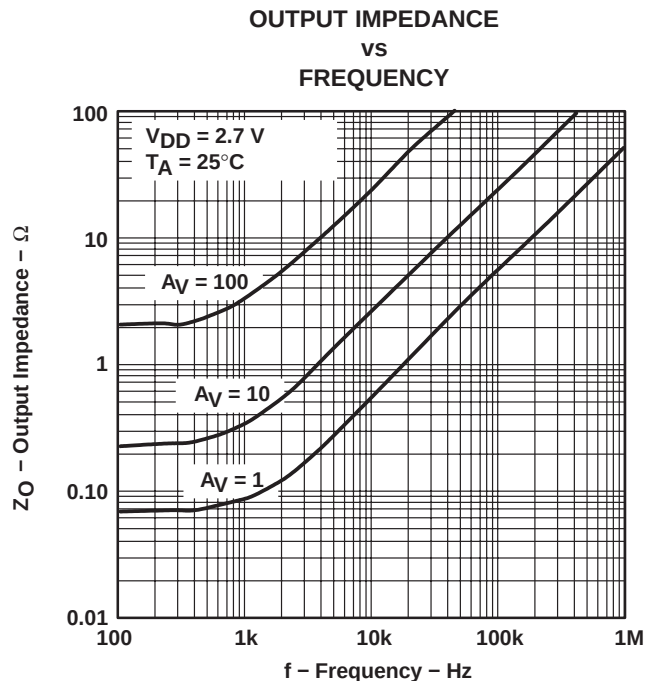


Figure 22

TLV277x-Q1, TLV277xA-Q1

FAMILY OF 2.7-V HIGH-SLEW-RATE RAIL-TO-RAIL OUTPUT OPERATIONAL AMPLIFIERS WITH SHUTDOWN

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TYPICAL CHARACTERISTICS

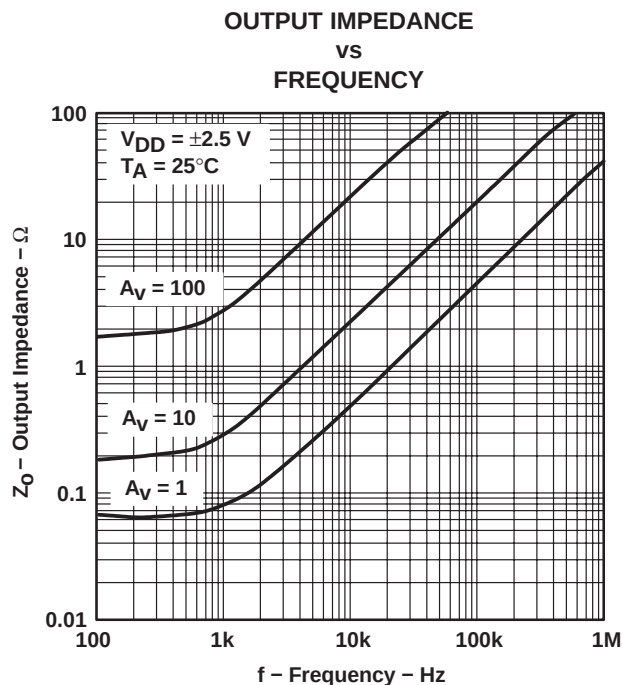


Figure 23

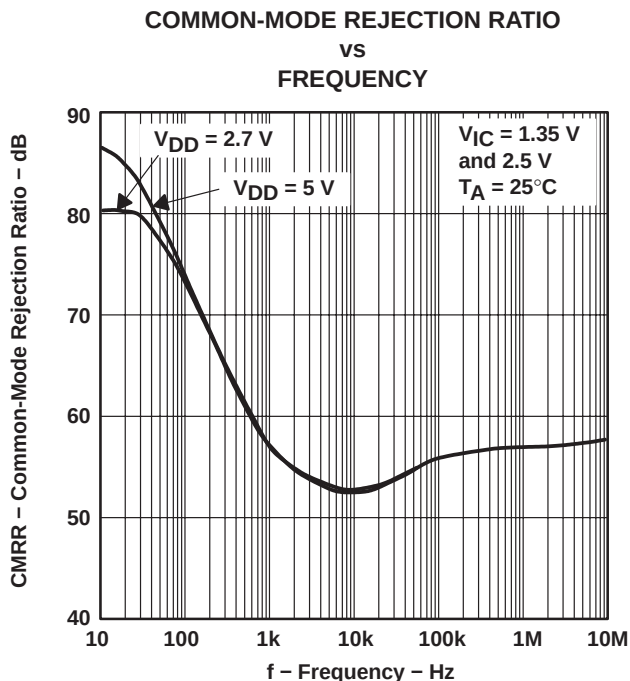


Figure 24

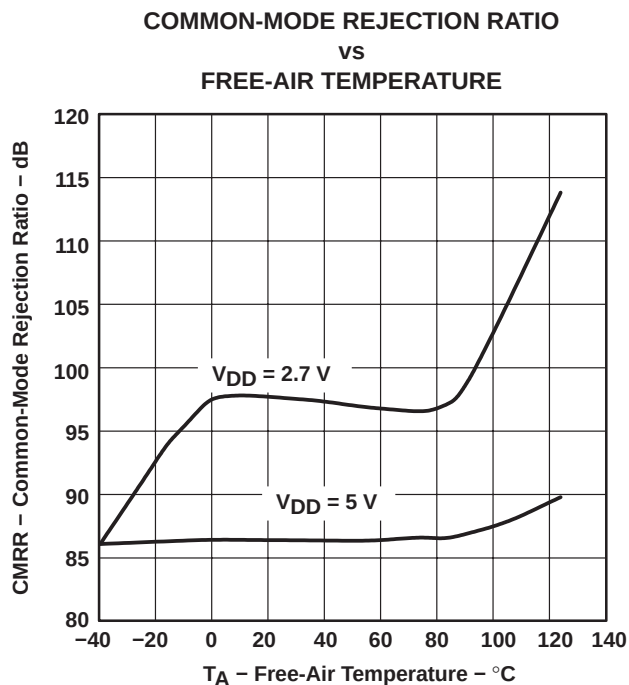


Figure 25

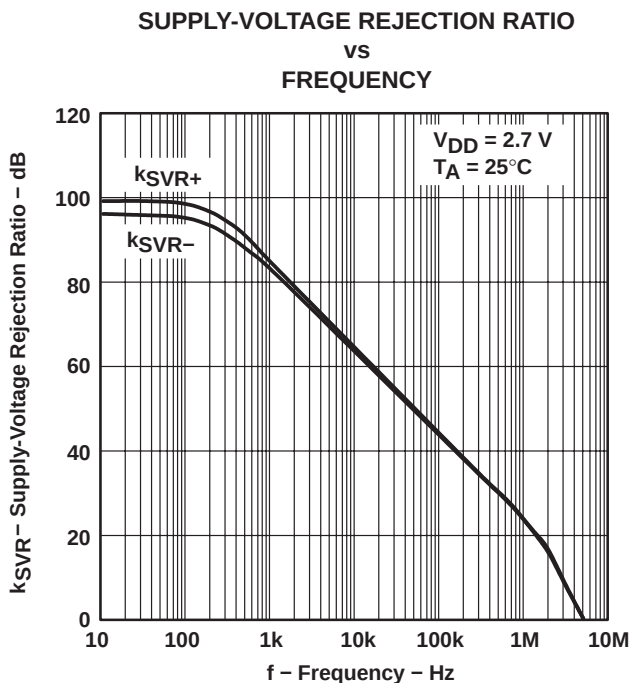


Figure 26

TLV277x-Q1, TLV277xA-Q1 FAMILY OF 2.7-V HIGH-SLEW-RATE RAIL-TO-RAIL OUTPUT OPERATIONAL AMPLIFIERS WITH SHUTDOWN

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TYPICAL CHARACTERISTICS

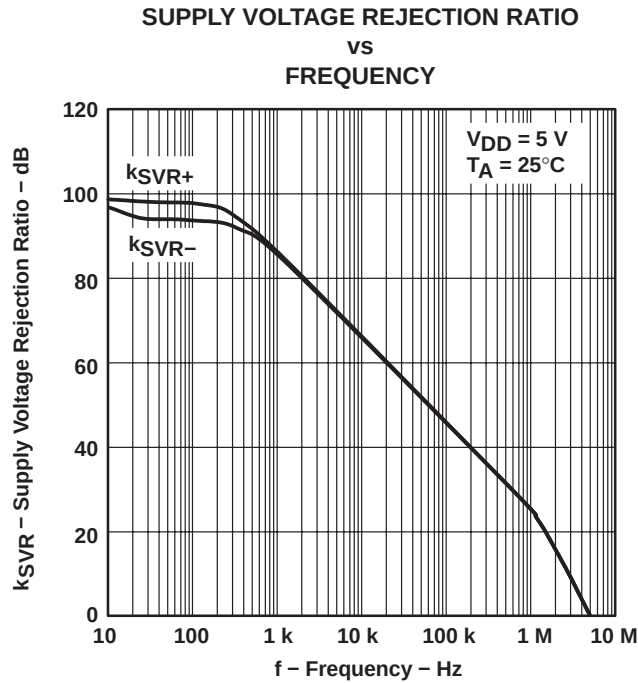


Figure 27

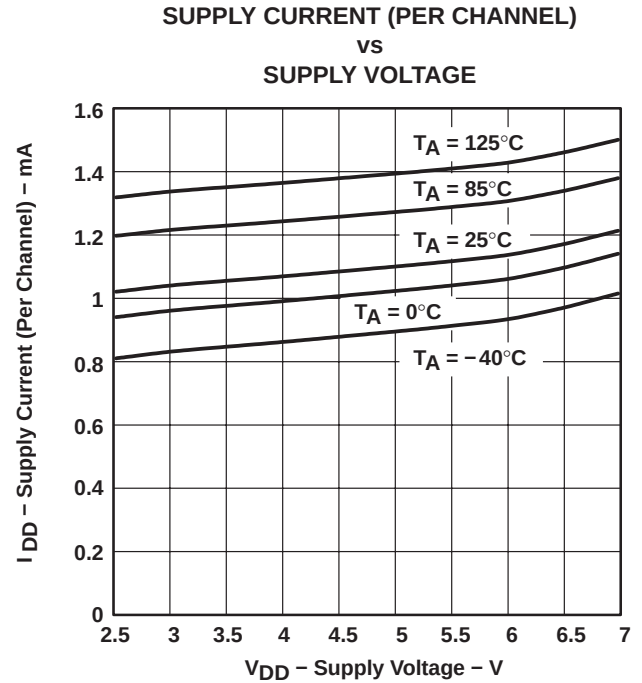


Figure 28

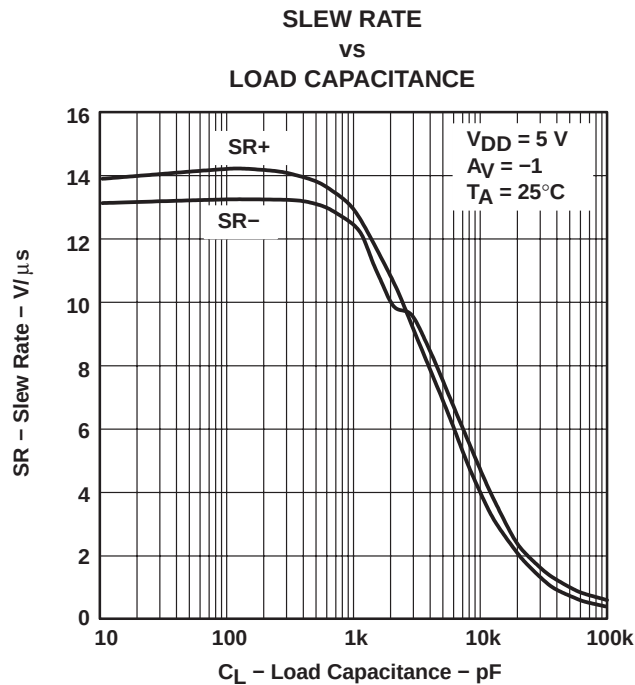


Figure 29

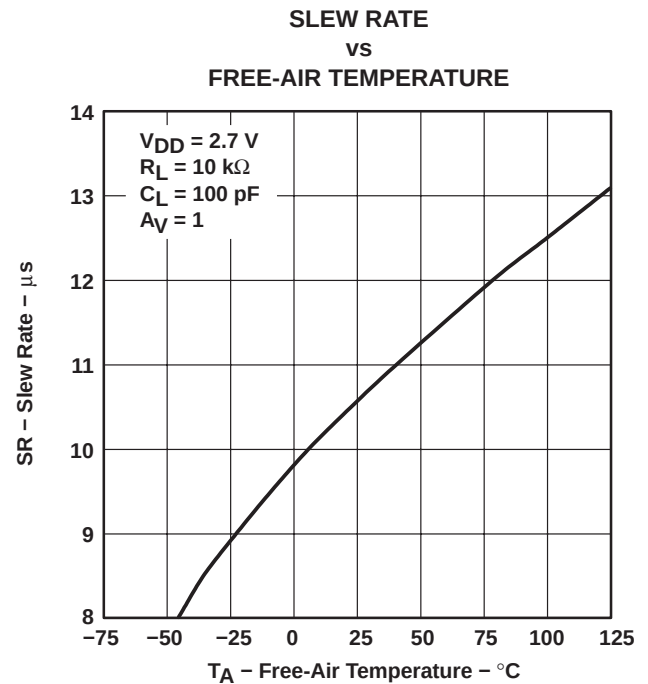


Figure 30

TLV277x-Q1, TLV277xA-Q1

FAMILY OF 2.7-V HIGH-SLEW-RATE RAIL-TO-RAIL OUTPUT OPERATIONAL AMPLIFIERS WITH SHUTDOWN

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TYPICAL CHARACTERISTICS

**VOLTAGE-FOLLOWER
SMALL-SIGNAL PULSE RESPONSE**

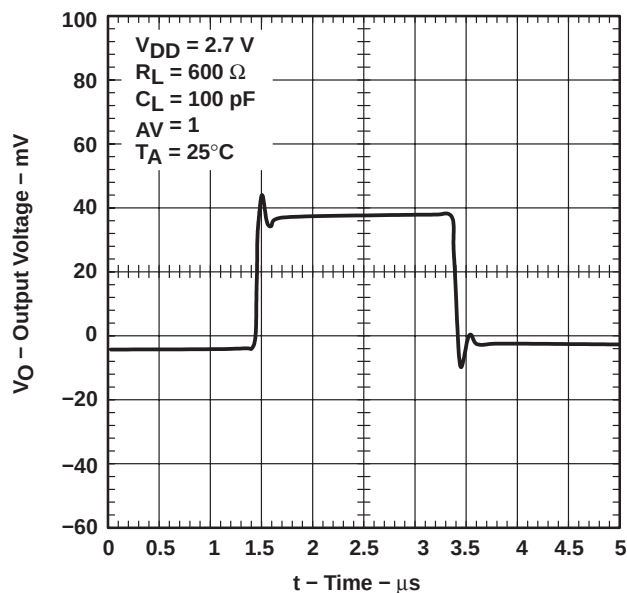


Figure 31

**VOLTAGE-FOLLOWER
SMALL-SIGNAL PULSE RESPONSE**

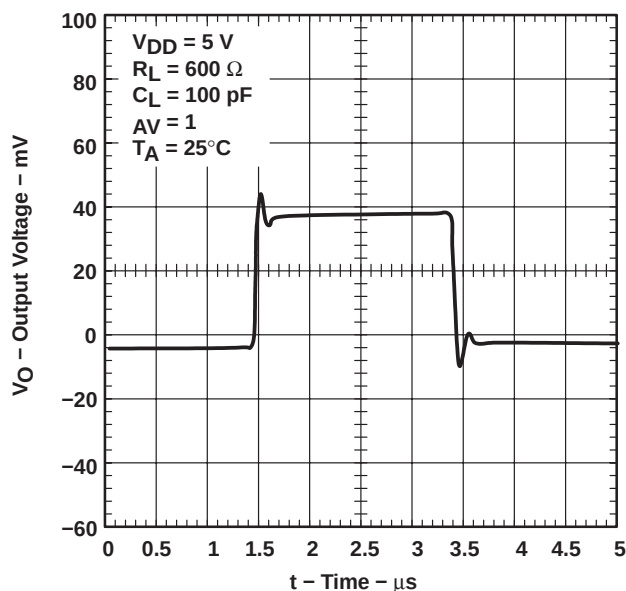


Figure 32

**VOLTAGE-FOLLOWER
LARGE-SIGNAL PULSE RESPONSE**

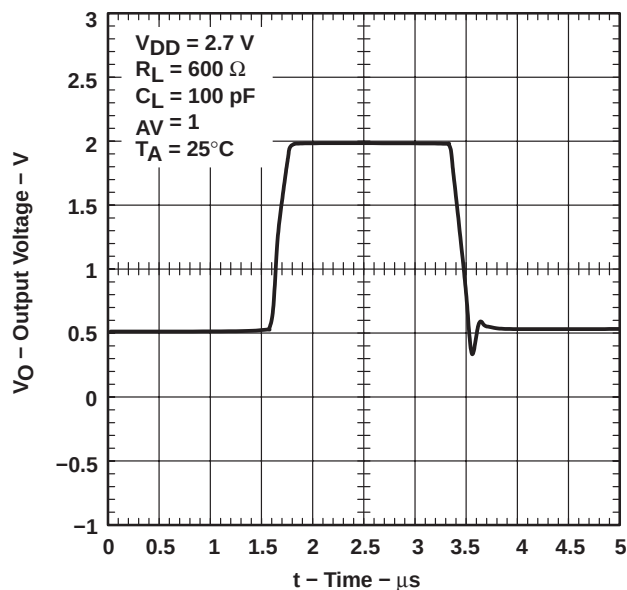


Figure 33

**VOLTAGE-FOLLOWER
LARGE-SIGNAL PULSE RESPONSE**

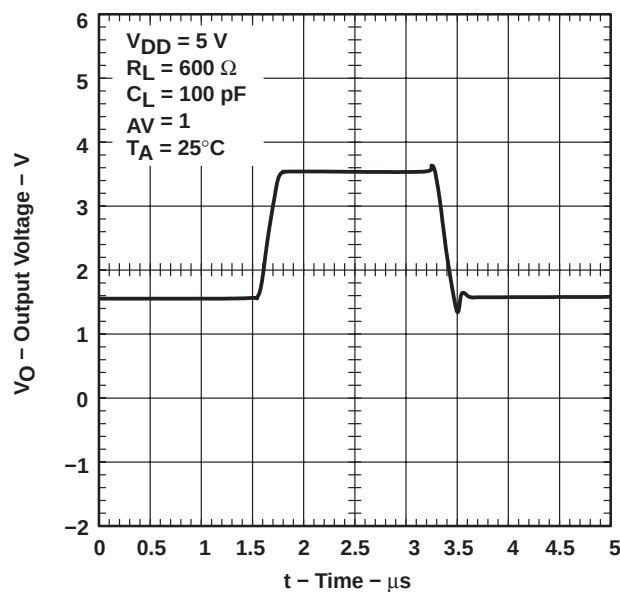


Figure 34

TLV277x-Q1, TLV277xA-Q1

FAMILY OF 2.7-V HIGH-SLEW-RATE RAIL-TO-RAIL OUTPUT OPERATIONAL AMPLIFIERS WITH SHUTDOWN

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TYPICAL CHARACTERISTICS

INVERTING SMALL-SIGNAL PULSE RESPONSE

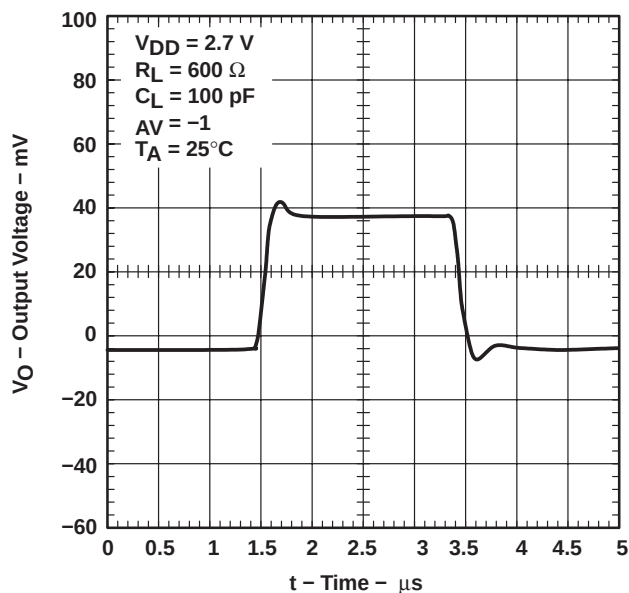


Figure 35

INVERTING SMALL-SIGNAL PULSE RESPONSE

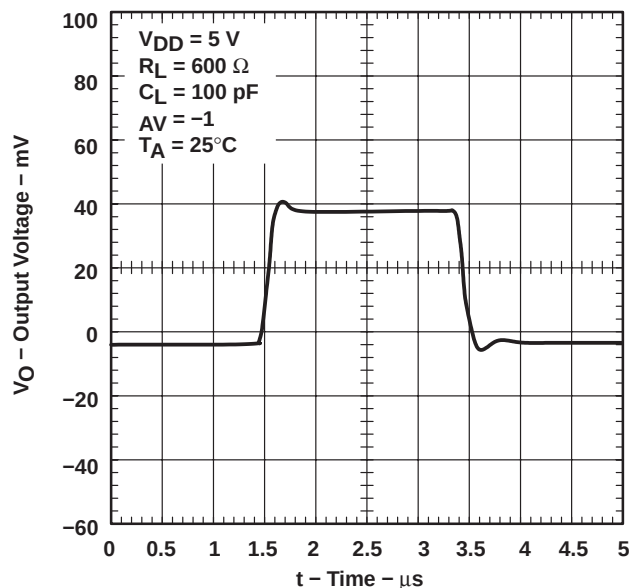


Figure 36

INVERTING LARGE-SIGNAL PULSE RESPONSE

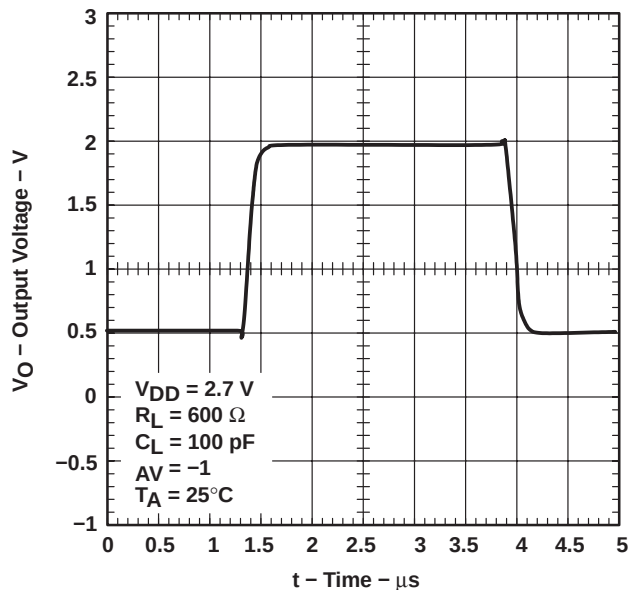


Figure 37

INVERTING LARGE-SIGNAL PULSE RESPONSE

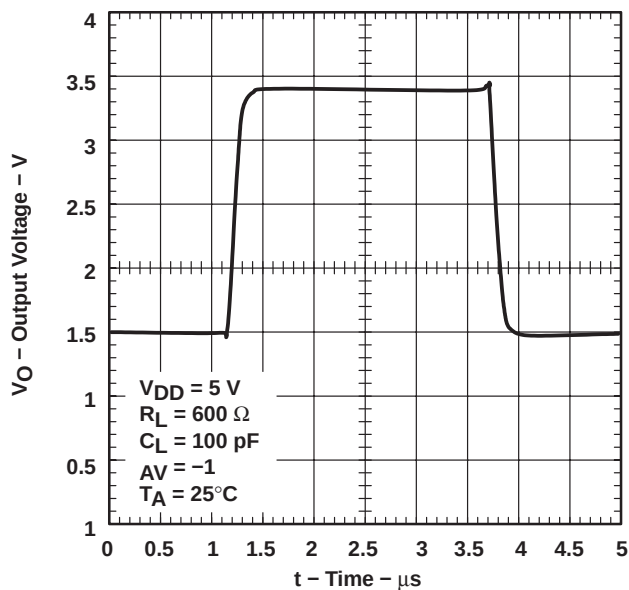


Figure 38

TYPICAL CHARACTERISTICS

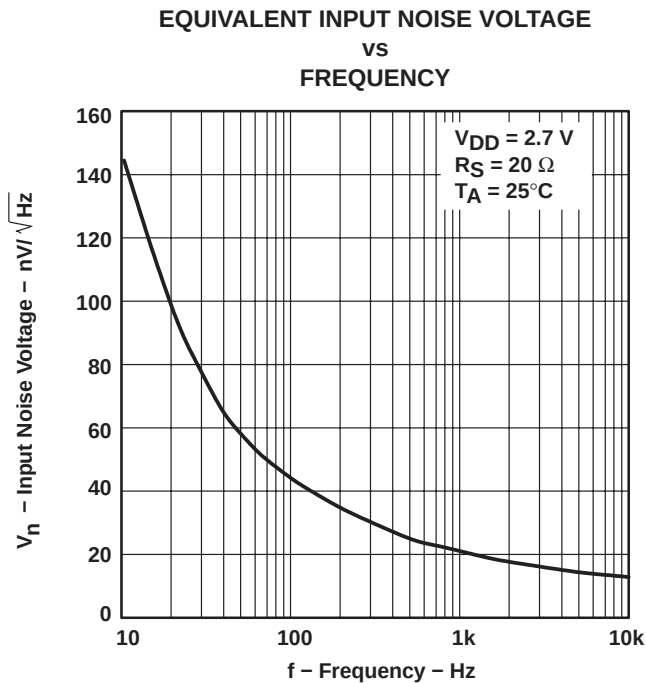


Figure 39

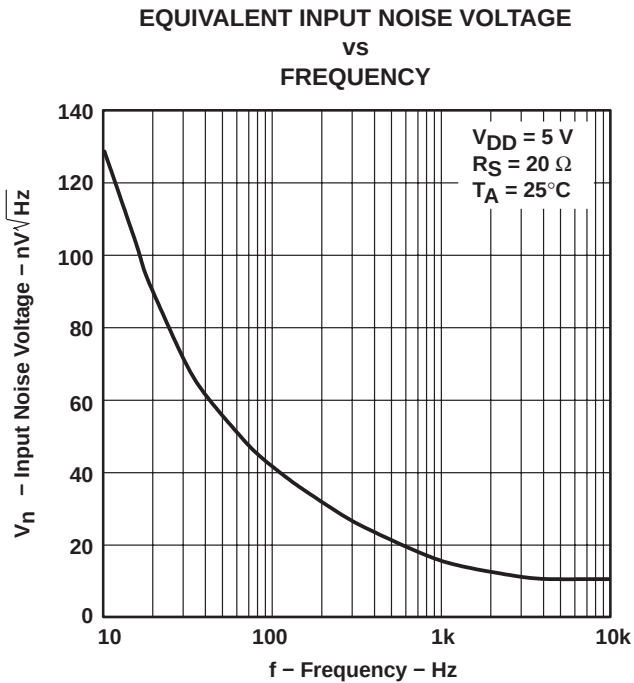


Figure 40

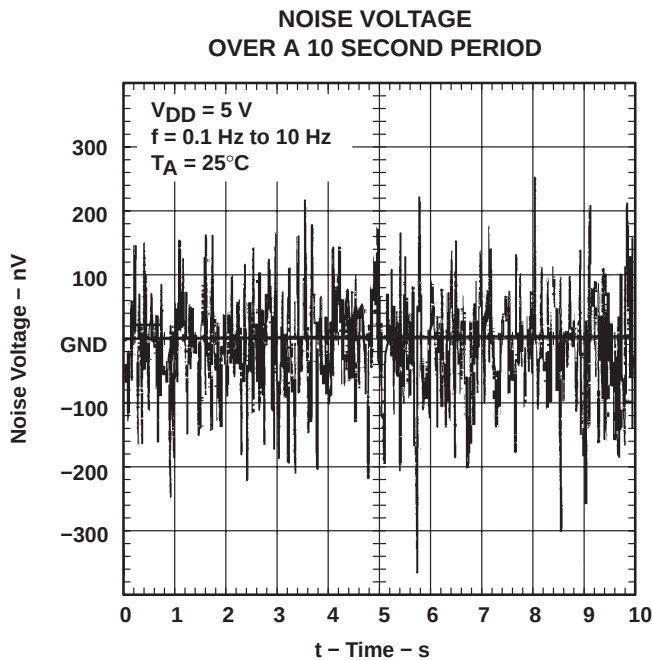


Figure 41

TLV277x-Q1, TLV277xA-Q1

FAMILY OF 2.7-V HIGH-SLEW-RATE RAIL-TO-RAIL OUTPUT OPERATIONAL AMPLIFIERS WITH SHUTDOWN

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TYPICAL CHARACTERISTICS

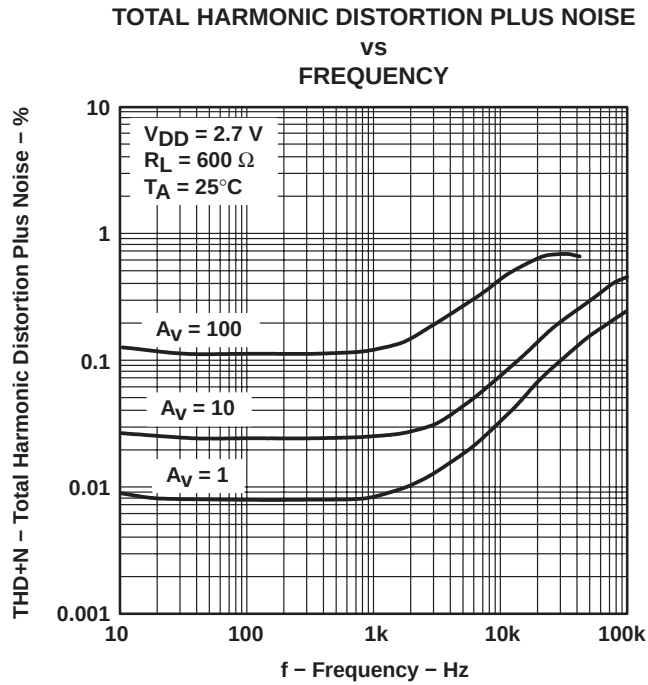


Figure 42

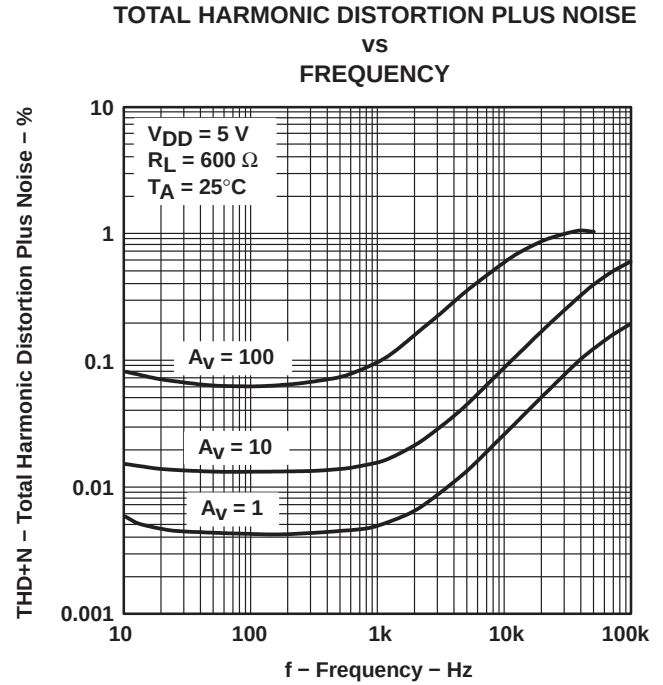


Figure 43

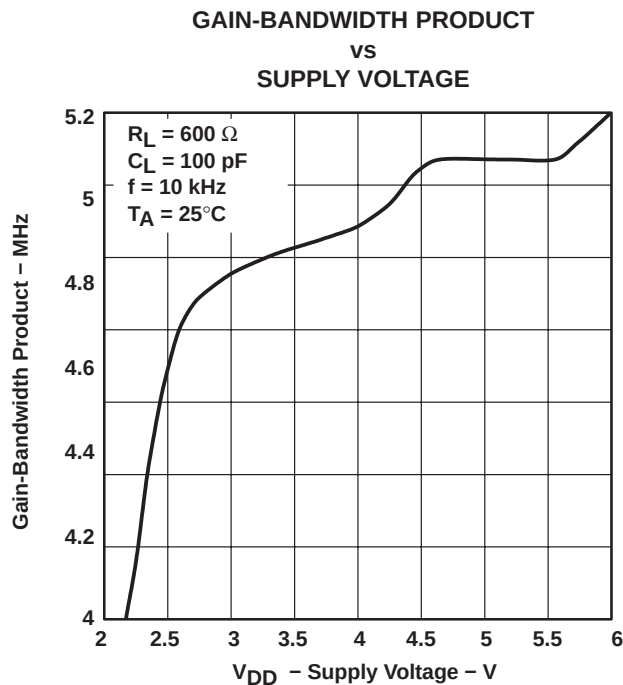


Figure 44

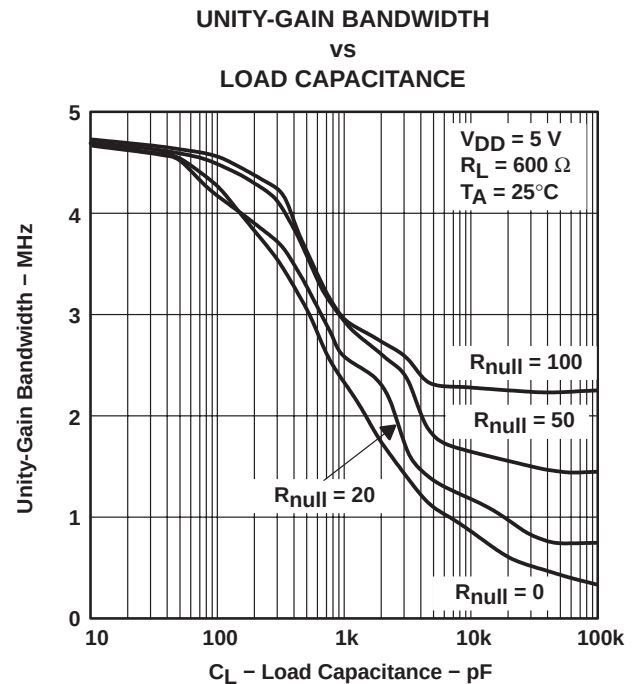


Figure 45

TLV277x-Q1, TLV277xA-Q1

FAMILY OF 2.7-V HIGH-SLEW-RATE RAIL-TO-RAIL OUTPUT OPERATIONAL AMPLIFIERS WITH SHUTDOWN

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TYPICAL CHARACTERISTICS

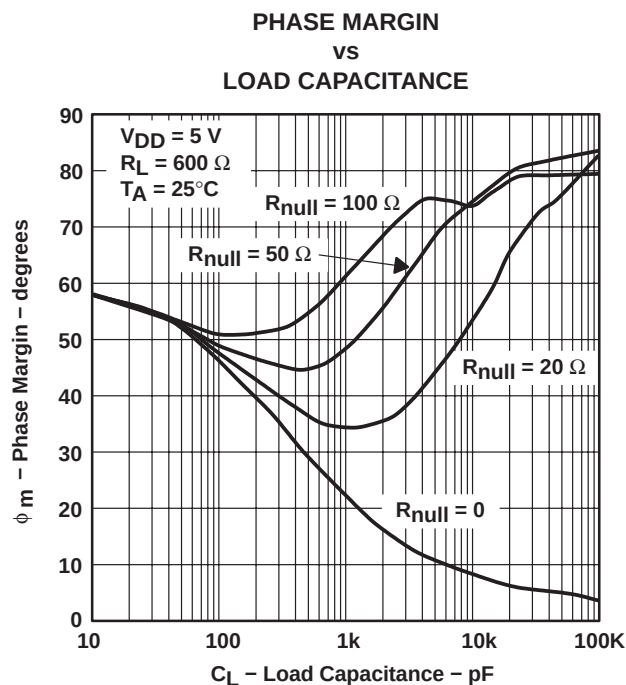


Figure 46

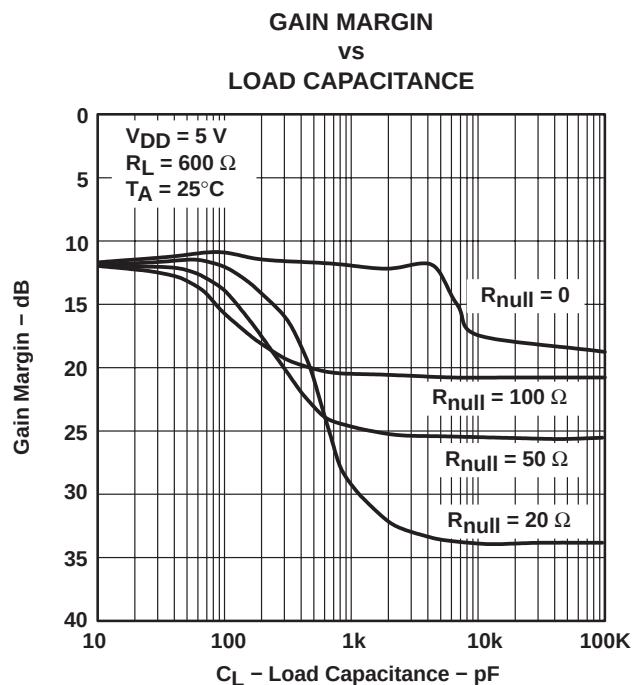


Figure 47

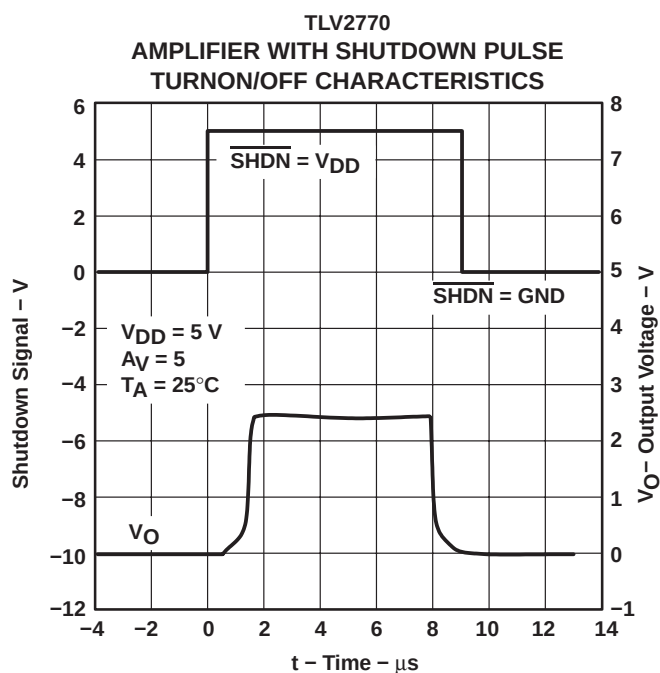


Figure 48

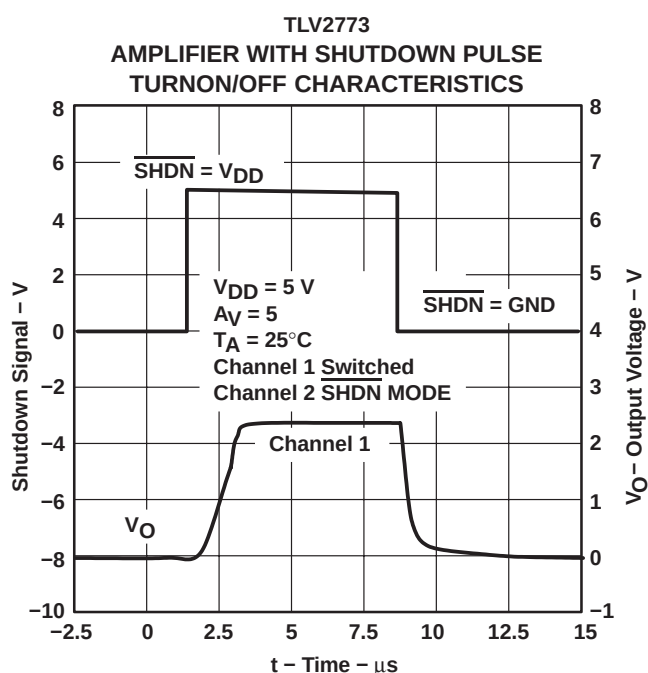


Figure 49

TLV277x-Q1, TLV277xA-Q1 FAMILY OF 2.7-V HIGH-SLEW-RATE RAIL-TO-RAIL OUTPUT OPERATIONAL AMPLIFIERS WITH SHUTDOWN

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TYPICAL CHARACTERISTICS

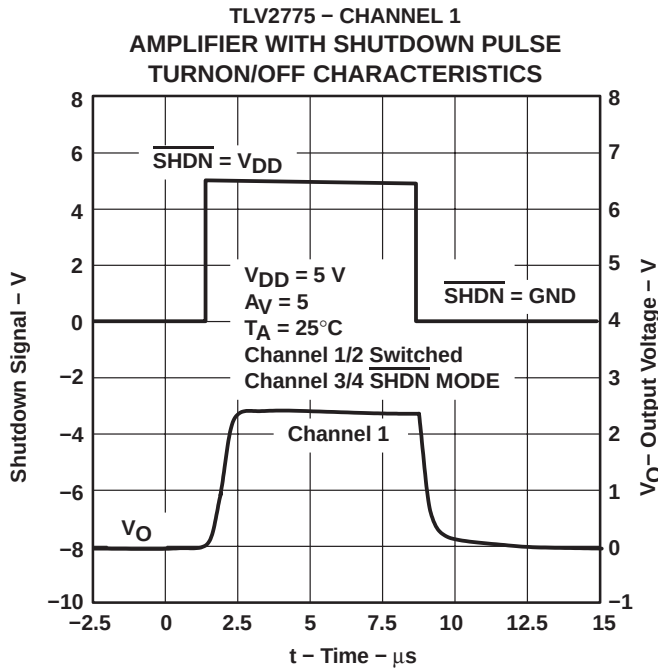


Figure 50

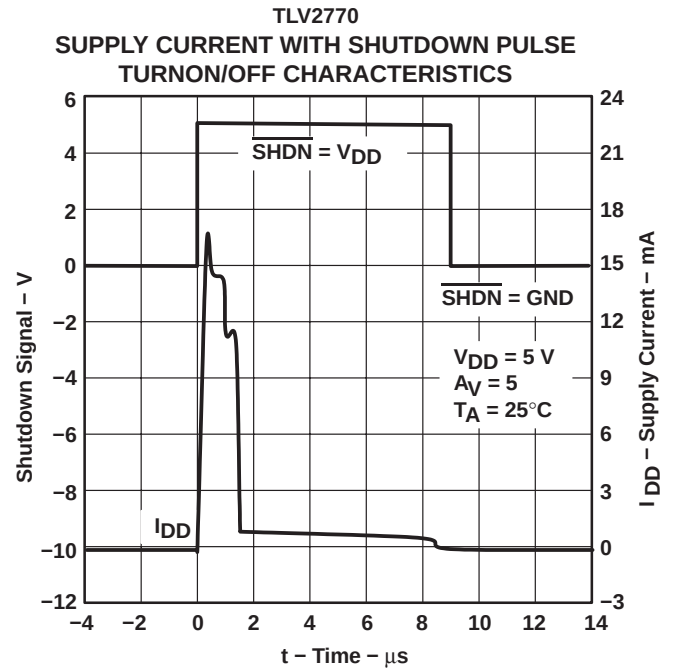


Figure 51

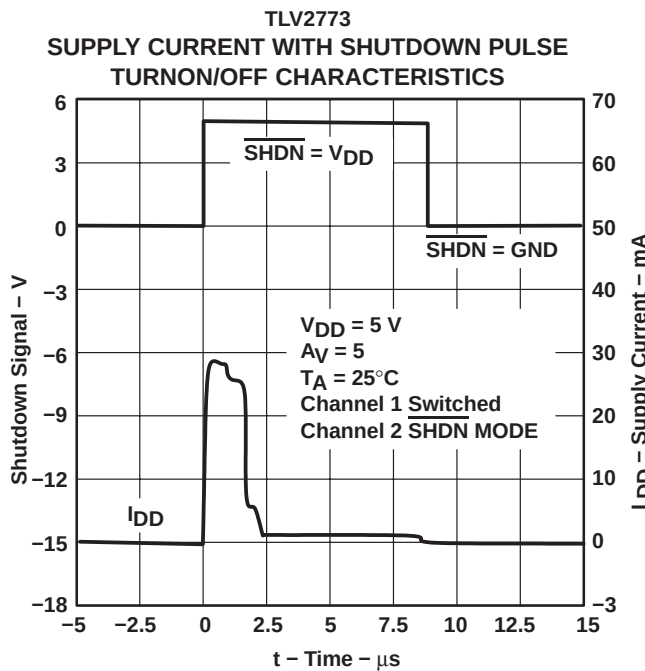


Figure 52

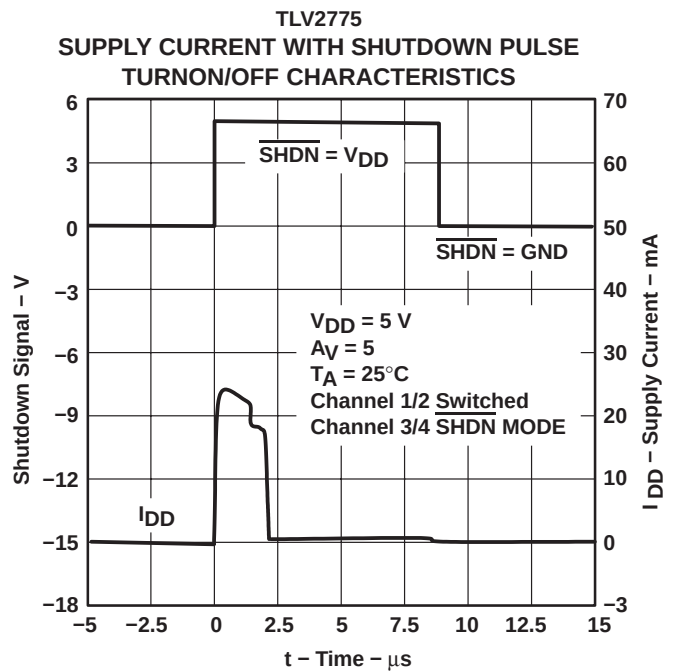


Figure 53

TLV277x-Q1, TLV277xA-Q1

FAMILY OF 2.7-V HIGH-SLEW-RATE RAIL-TO-RAIL OUTPUT OPERATIONAL AMPLIFIERS WITH SHUTDOWN

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TYPICAL CHARACTERISTICS

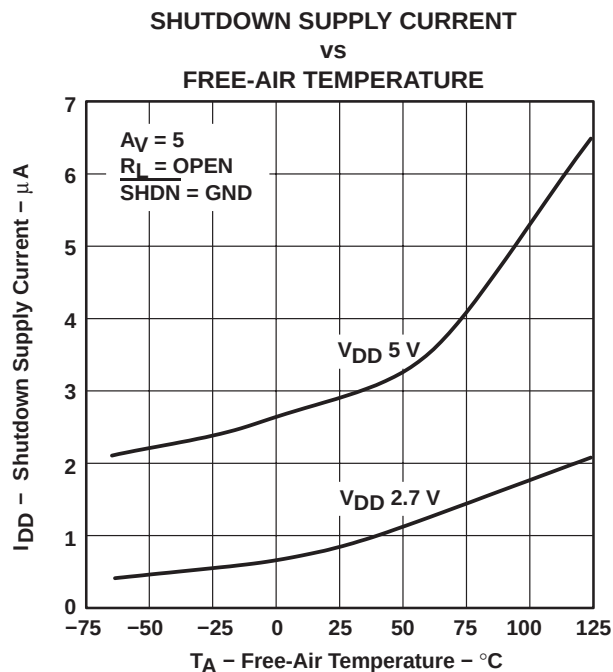


Figure 54

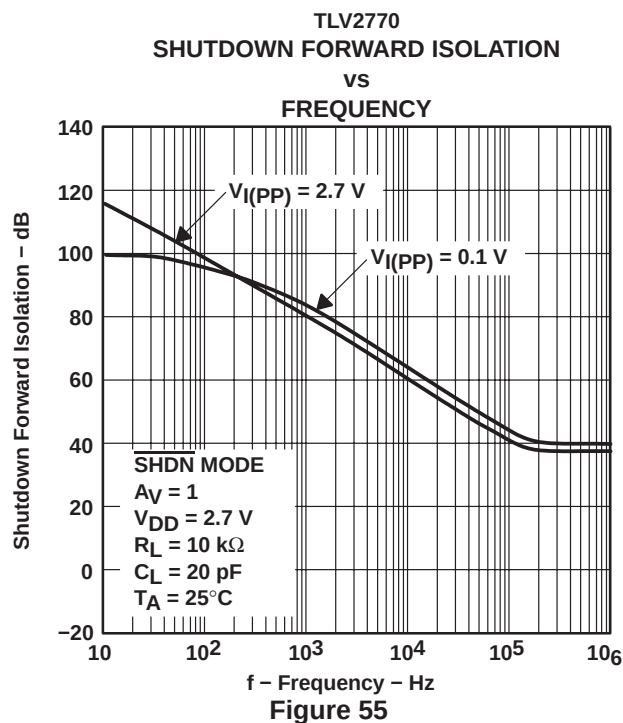


Figure 55

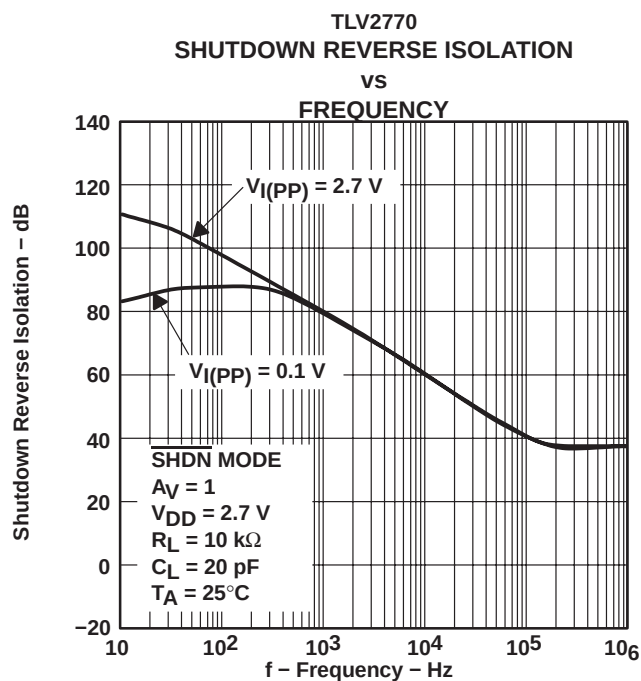


Figure 56

PARAMETER MEASUREMENT INFORMATION

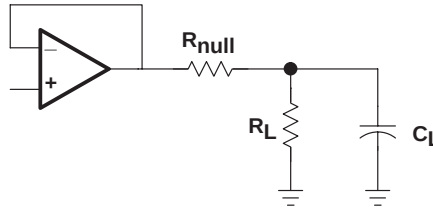


Figure 57

driving a capacitive load

When the amplifier is configured in this manner, capacitive loading directly on the output will decrease the device's phase margin leading to high frequency ringing or oscillations. Therefore, for capacitive loads of greater than 10 pF, it is recommended that a resistor be placed in series (R_{NULL}) with the output of the amplifier, as shown in Figure 58. A minimum value of 20 Ω should work well for most applications.

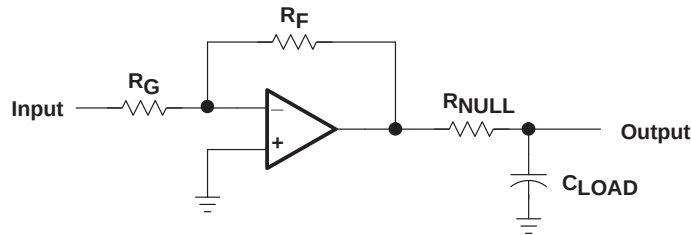


Figure 58. Driving a Capacitive Load

TLV277x-Q1, TLV277xA-Q1

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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:

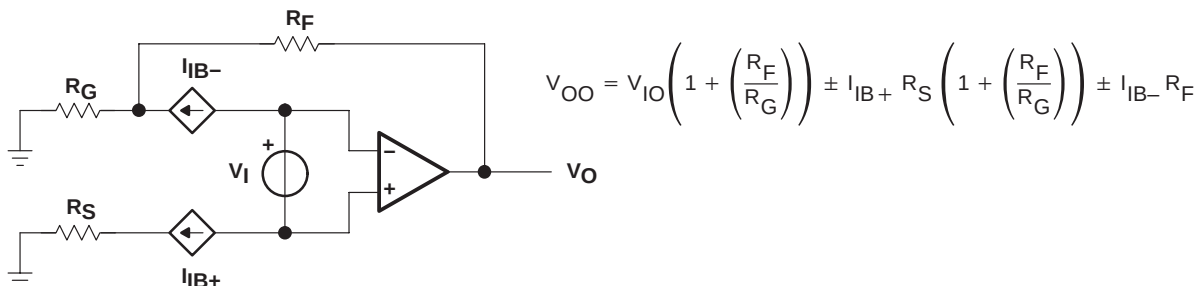


Figure 59. Output Offset Voltage Model

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 60).

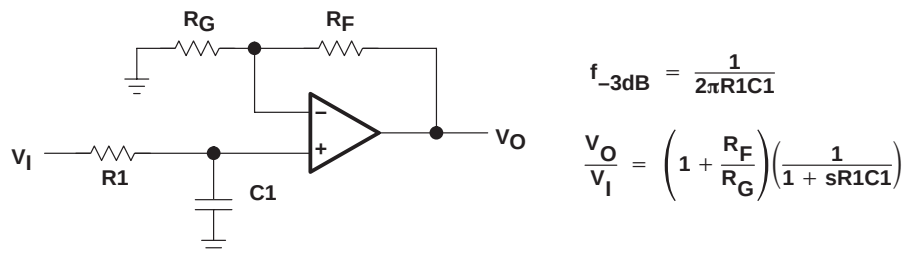


Figure 60. Single-Pole Low-Pass Filter

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.

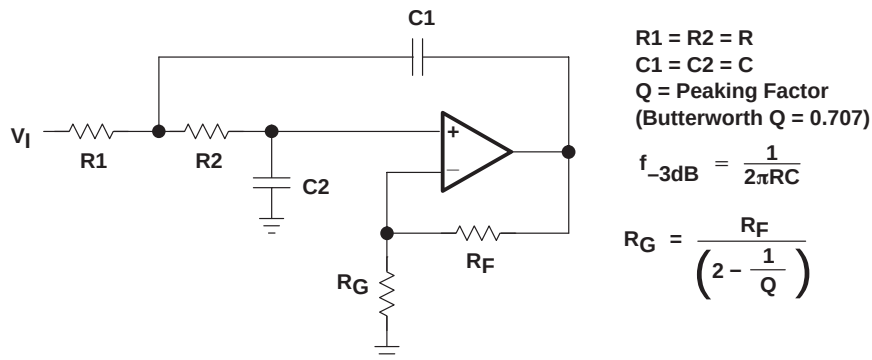


Figure 61. 2-Pole Low-Pass Sallen-Key Filter

APPLICATION INFORMATION

using the TLV2772 as an accelerometer interface

The schematic, shown in Figure 62, shows the ACH04-08-05 interfaced to the TLV1544 10-bit analog-to-digital converter (ADC).

The ACH04-08-05 is a shock sensor designed to convert mechanical acceleration into electrical signals. The sensor contains three piezoelectric sensing elements oriented to simultaneously measure acceleration in three orthogonal, linear axes (x, y, z). The operating frequency is 0.5 Hz to 5 kHz. The output is buffered with an internal JFET and has a typical output voltage of 1.80 mV/g for the x and y axis and 1.35 mV/g for the z axis.

Amplification and frequency shaping of the shock sensor output is done by the TLV2772 rail-to-rail operational amplifier. The TLV2772 is ideal for this application as it offers high input impedance, good slew rate, and excellent dc precision. The rail-to-rail output swing and high output drive are perfect for driving the analog input of the TLV1544 ADC.

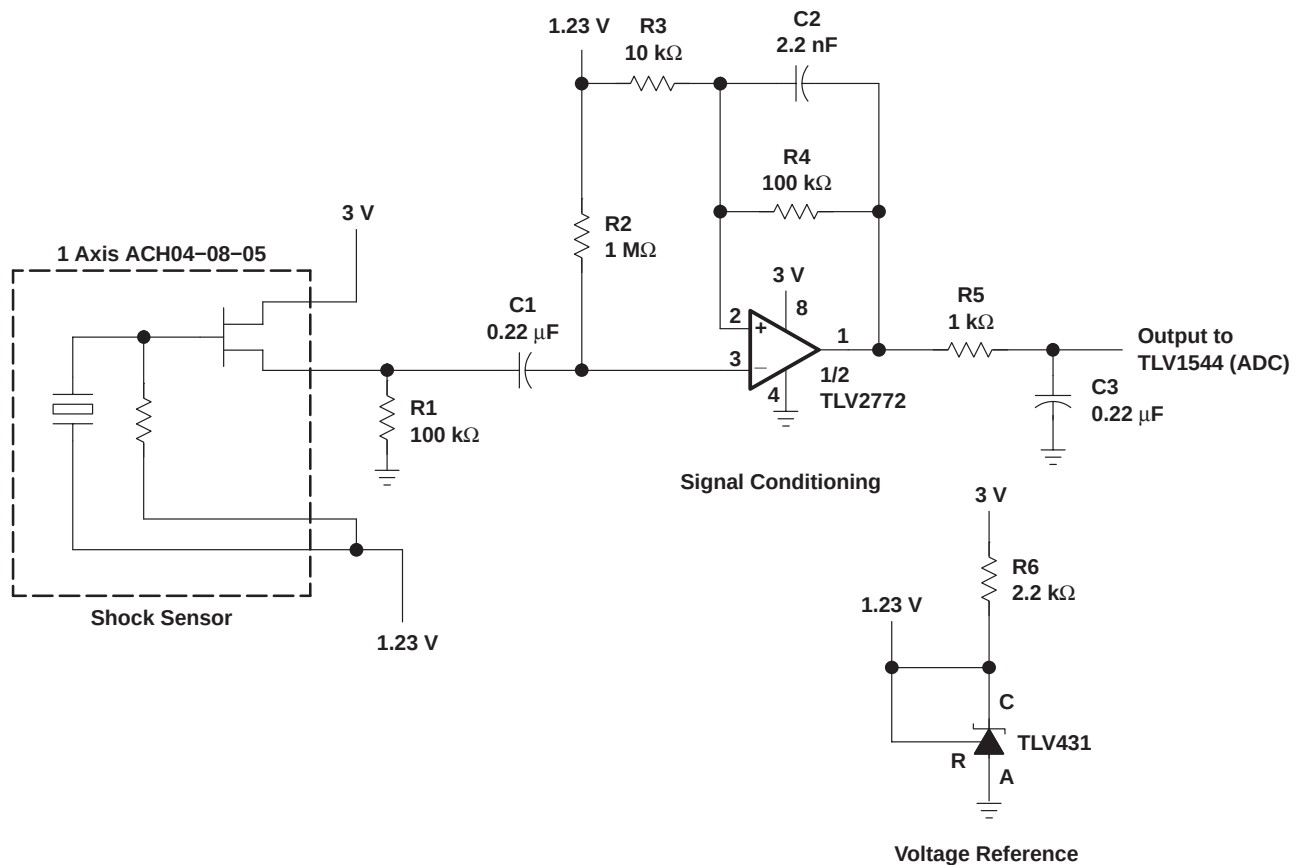


Figure 62. Accelerometer Interface Schematic

The sensor signal must be amplified and frequency-shaped to provide a signal the ADC can properly convert into the digital domain. Figure 62 shows the topology used in this application for one axis of the sensor. This system is powered from a single 3-V supply. Configuring the TLV431 with a 2.2-kΩ resistor produces a reference voltage of 1.23 V. This voltage is used to bias the operational amplifier and the internal JFETs in the shock sensor.

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APPLICATION INFORMATION

gain calculation

Since the TLV2772 is capable of rail-to-rail output using a 3-V supply, $V_O = 0$ (min) to 3 V (max). With no signal from the sensor, nominal $V_O =$ reference voltage = 1.23 V. Therefore, the maximum negative swing from nominal is $0\text{ V} - 1.23\text{ V} = -1.23\text{ V}$ and the maximum positive swing is $3\text{ V} - 1.23\text{ V} = 1.77\text{ V}$. By modeling the shock sensor as a low impedance voltage source with output of 2.25 mV/g (max) in the x and y axis and 1.70 mV/g (max) in the z axis, the gain of the circuit is calculated by equation 1.

$$\text{Gain} = \frac{\text{Output Swing}}{\text{Sensor Signal} \times \text{Acceleration}} \quad (1)$$

To avoid saturation of the operational amplifier, the gain calculations are based on the maximum negative swing of -1.23 V and the maximum sensor output of 2.25 mV/g (x and y axis) and 1.70 mV/g (z axis).

$$\text{Gain (x, y)} = \frac{-1.23\text{ V}}{2.25\text{ mV/g} \times -50\text{ g}} = 10.9 \quad (2)$$

and

$$\text{Gain (z)} = \frac{-1.23\text{ V}}{1.70\text{ mV/g} \times -50\text{ g}} = 14.5 \quad (3)$$

By selecting $R3 = 10\text{ k}\Omega$ and $R4 = 100\text{ k}\Omega$, in the x and y channels, a gain of 11 is realized. By selecting $R3 = 7.5\text{ k}\Omega$ and $R4 = 100\text{ k}\Omega$, in the z channel, a gain of 14.3 is realized. The schematic shows the configuration for either the x- or y-axis.

bandwidth calculation

To calculate the component values for the frequency shaping characteristics of the signal conditioning circuit, 1 Hz and 500 Hz are selected as the minimum required 3-dB bandwidth.

To minimize the value of the input capacitor (C1) required to set the lower cutoff frequency requires a large value resistor for R2 is required. A 1-M Ω resistor is used in this example. To set the lower cutoff frequency, the required capacitor value for C1 is:

$$C1 = \frac{1}{2\pi f_{\text{LOW}} R_2} = 0.159\text{ }\mu\text{F} \quad (4)$$

Using a value of 0.22 μF , a more common value of capacitor, the lower cutoff frequency is 0.724 Hz.

To minimize the phase shift in the feedback loop caused by the input capacitance of the TLV2772, it is best to minimize the value of the feedback resistor R4. However, to reduce the required capacitance in the feedback loop a large value for R4 is required. Therefore, a compromise for the value of R4 must be made. In this circuit, a value of 100 k Ω has been selected. To set the upper cutoff frequency, the required capacitor value for C2 is:

$$C2 = \frac{1}{2\pi f_{\text{HIGH}} R_4} = 3.18\text{ }\mu\text{F} \quad (5)$$

Using a 2.2-nF capacitor, the upper cutoff frequency is 724 Hz.

R5 and C3 also cause the signal response to roll off. Therefore, it is beneficial to design this roll-off point to begin at the upper cutoff frequency. Assuming a value of 1 k Ω for R5, the value for C3 is calculated to be 0.22 μF .

APPLICATION INFORMATION

circuit layout considerations

To achieve the levels of high performance of the TLV277x, 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.

TLV277x-Q1, TLV277xA-Q1

FAMILY OF 2.7-V HIGH-SLEW-RATE RAIL-TO-RAIL OUTPUT OPERATIONAL AMPLIFIERS WITH SHUTDOWN

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APPLICATION INFORMATION

general power dissipation considerations

For a given θ_{JA} , the maximum power dissipation is shown in Figure 63 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 TLV277x IC (watts)

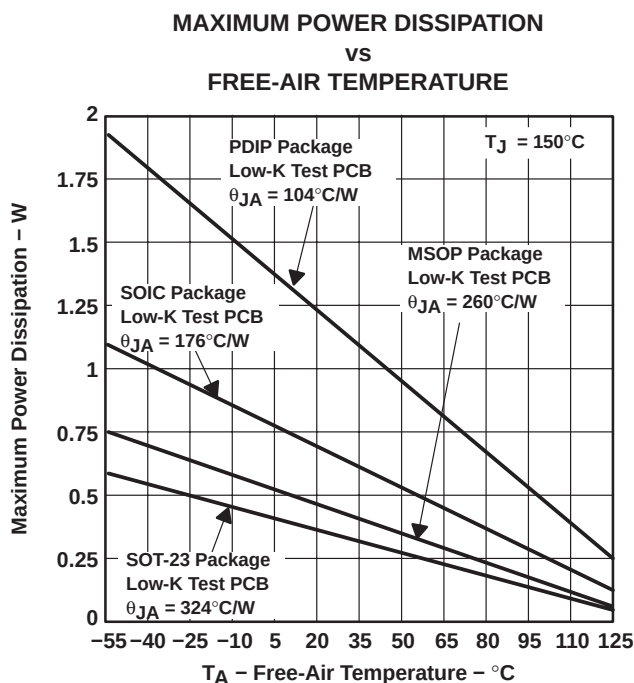
T_{MAX} = Absolute maximum junction temperature (150°C)

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 63. Maximum Power Dissipation vs Free-Air Temperature

APPLICATION INFORMATION

shutdown function

Three members of the TLV277x family (TLV2770/3/5) have a shutdown terminal for conserving battery life in portable applications. When the shutdown terminal is tied low, the supply current is reduced to 0.8 $\mu\text{A}/\text{channel}$, the amplifier is disabled, and the outputs are placed in a high impedance mode. To enable the amplifier, the shutdown terminal can either be left floating or pulled high. When the shutdown terminal is left floating, care needs to be taken to ensure that parasitic leakage current at the shutdown terminal does not inadvertently place the operational amplifier into shutdown. The shutdown terminal threshold is always referenced to $V_{DD}/2$. Therefore, when operating the device with split supply voltages (e.g. $\pm 2.5\text{ V}$), the shutdown terminal needs to be pulled to V_{DD-} (not GND) to disable the operational amplifier.

The amplifier's output with a shutdown pulse is shown in Figures 48, 49, and 50. The amplifier is powered with a single 5-V supply and configured as a noninverting configuration with a gain of 5. The amplifier turnon and turnoff times are measured from the 50% point of the shutdown pulse to the 50% point of the output waveform. The times for the single, dual, and quad are listed in the data tables. The *bump* on the rising edge of the TLV2770 output waveform is due to the start-up circuit on the bias generator. For the dual and quad (TLV2773/5), this *bump* is attributed to the bias generator's start-up circuit as well as the crosstalk between the other channel(s), which are in shutdown.

Figures 55 and 56 show the amplifier's forward and reverse isolation in shutdown. The operational amplifier is powered by $\pm 1.35\text{-V}$ supplies and configured as a voltage follower ($A_V = 1$). The isolation performance is plotted across frequency for both 0.1 V_{PP} and 2.7 V_{PP} input signals. During normal operation, the amplifier would not be able to handle a 2.7- V_{PP} input signal with a supply voltage of $\pm 1.35\text{ V}$ since it exceeds the common-mode input voltage range (V_{ICR}). However, this curve illustrates that the amplifier remains in shutdown even under a worst case scenario.

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PACKAGING INFORMATION

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/Ball Finish	MSL Peak Temp ⁽³⁾
TLV2772AQDRQ1	ACTIVE	SOIC	D	8	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-250C-1 YEAR/ Level-1-235C-UNLIM
TLV2772AQPWRQ1	ACTIVE	TSSOP	PW	8	2000	None	CU NIPDAU	Level-1-220C-UNLIM
TLV2772QDRQ1	ACTIVE	SOIC	D	8	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-250C-1 YEAR/ Level-1-235C-UNLIM
TLV2772QPWRQ1	ACTIVE	TSSOP	PW	8	2000	None	CU NIPDAU	Level-1-220C-UNLIM

⁽¹⁾ The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

OBSOLETE: TI has discontinued the production of the device.

⁽²⁾ Eco Plan - May not be currently available - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

None: Not yet available Lead (Pb-Free).

Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

Green (RoHS & no Sb/Br): TI defines "Green" to mean "Pb-Free" and in addition, uses package materials that do not contain halogens, including bromine (Br) or antimony (Sb) above 0.1% of total product weight.

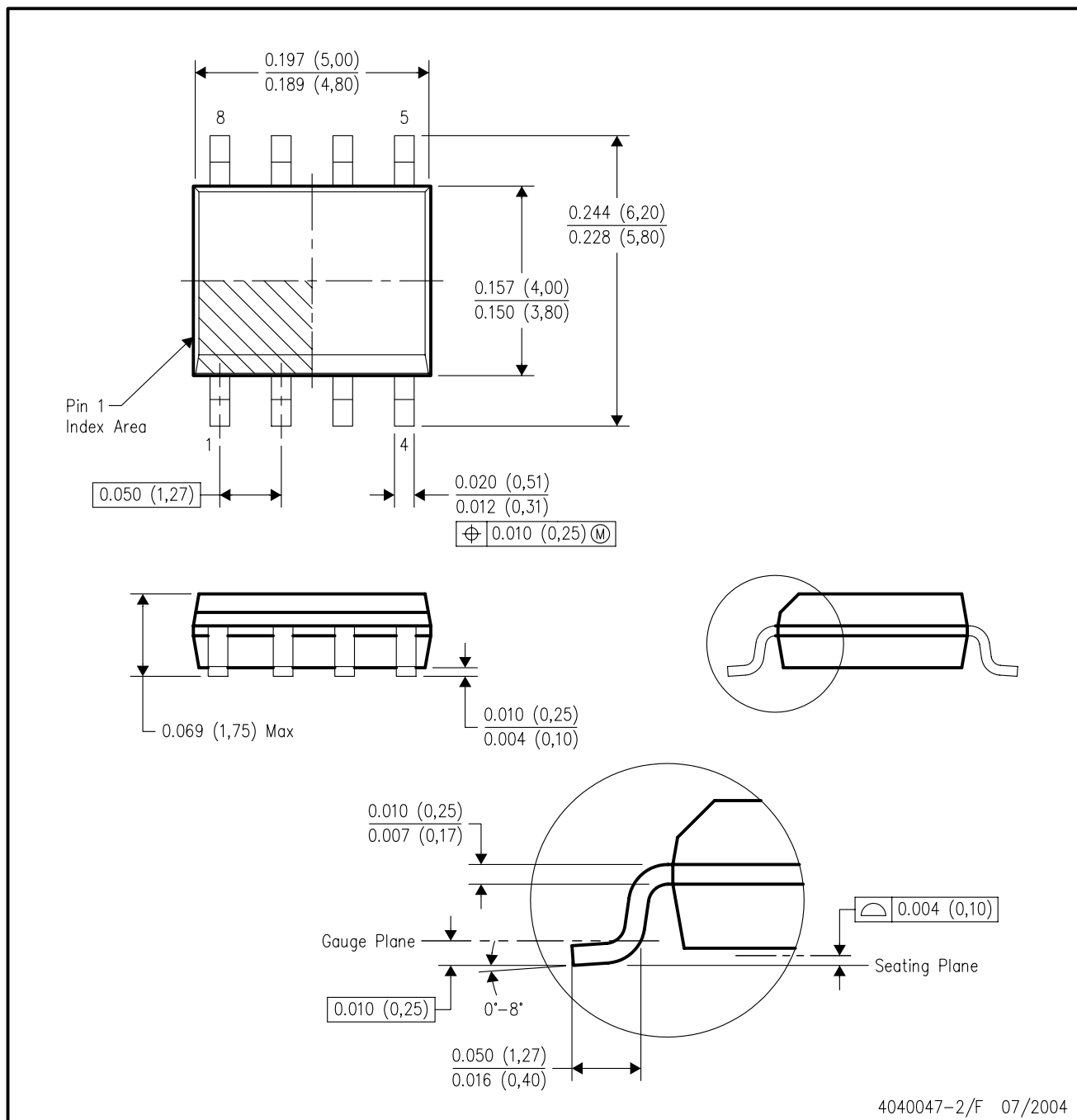
⁽³⁾ MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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D (R-PDSO-G8)

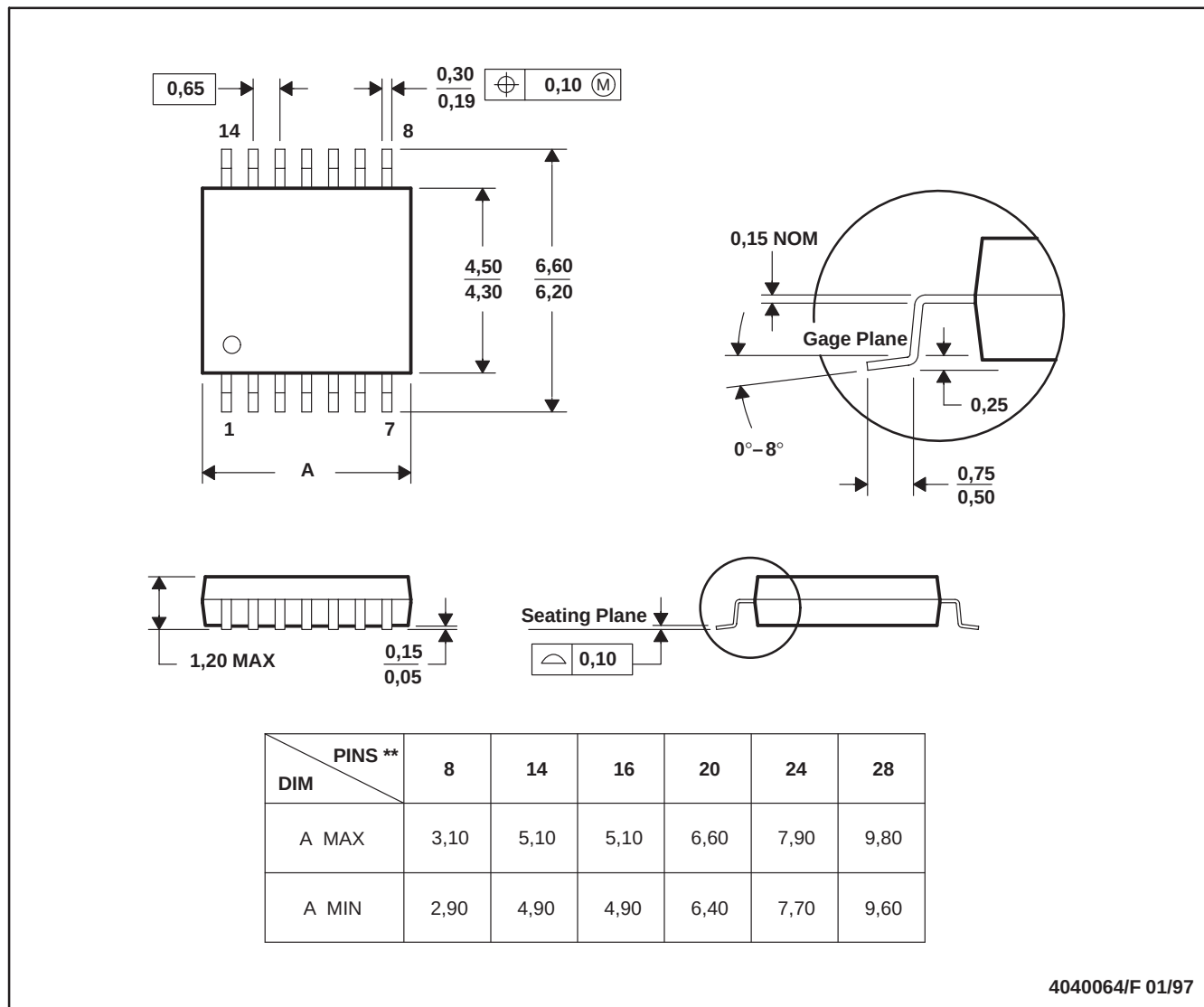
PLASTIC SMALL-OUTLINE PACKAGE



PW (R-PDSO-G**)

PLASTIC SMALL-OUTLINE PACKAGE

14 PINS SHOWN



- NOTES: A. All linear dimensions are in millimeters.
 B. This drawing is subject to change without notice.
 C. Body dimensions do not include mold flash or protrusion not to exceed 0,15.
 D. Falls within JEDEC MO-153

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