

LMV358-Q1 DUAL, LMV324-Q1 QUAD LOW-VOLTAGE RAIL-TO-RAIL OUTPUT OPERATIONAL AMPLIFIERS

SLOS415B – JUNE 2003 – REVISED OCTOBER 2003

- Qualification in Accordance With AEC-Q100†
- Qualified for Automotive Applications
- Customer-Specific Configuration Control Can Be Supported Along With Major-Change Approval
- 2.7-V and 5-V Performance
- No Crossover Distortion
- Low Supply Current:
LMV358 . . . 210 μ A Typ
LMV324 . . . 410 μ A Typ
- Rail-to-Rail Output Swing

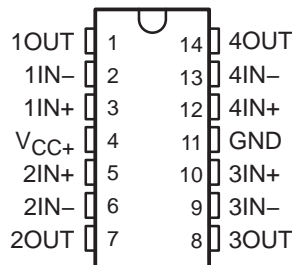
†Contact factory for details. Q100 qualification data available on request.

description/ordering information

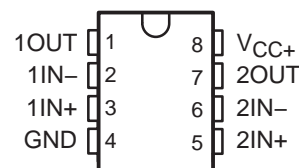
The LMV358 and LMV324 are dual and quad low-voltage (2.7 V to 5.5 V) operational amplifiers with rail-to-rail output swing.

The LMV358 and LMV324 are the most cost-effective solution for applications where low-voltage operation, space saving, and low price are needed. These amplifiers were designed specifically for low-voltage (2.7 V to 5 V) operation, with performance specifications meeting or exceeding the venerable LM358 and LM324 devices that operate from 5 V to 30 V. Additional features of the LMV3xx devices are a common-mode input voltage range that includes ground, 1-MHz unity-gain bandwidth, and 1-V/ μ s slew rate.

LMV324 . . . D OR PW PACKAGE
(TOP VIEW)



LMV358 . . . D OR PW PACKAGE
(TOP VIEW)



ORDERING INFORMATION

T _A		PACKAGE‡		ORDERABLE PART NUMBER	TOP-SIDE MARKING
–40°C to 85°C	Dual	SOIC (D)	Tube of 75	LMV358IDQ1	358IQ1
			Reel of 2500	LMV358IDRQ1	
		TSSOP (PW)	Reel of 2000	LMV358IPWRQ1	358IQ1
–40°C to 85°C	Quad	SOIC (D)	Tube of 50	LMV324IDQ1	LMV324IQ1
			Reel of 2500	LMV324IDRQ1	
		TSSOP (PW)	Reel of 2000	LMV324IPWRQ1	V324IQ1
–40°C to 125°C	Dual	SOIC (D)	Tube of 75	LMV358QDQ1	V358Q1
			Reel of 2500	LMV358QDRQ1	
		TSSOP (PW)	Reel of 2000	LMV358QPWRQ1	V358Q1
–40°C to 125°C	Quad	SOIC (D)	Tube of 50	LMV324QDQ1	LMV324Q1
			Reel of 2500	LMV324QDRQ1	
		TSSOP (PW)	Reel of 2000	LMV324QPWRQ1	MV324Q1

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



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.

PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

 **TEXAS
INSTRUMENTS**

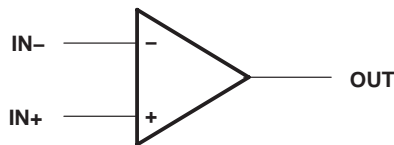
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symbol (each amplifier)



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

Supply voltage, V_{CC} (see Note 1)	5.5 V
Differential input voltage, V_{ID} (see Note 2)	± 5.5 V
Input voltage, V_I (either input)	0 to 5.5 V
Duration of output short circuit (one amplifier) to ground at (or below) $T_A = 25^\circ\text{C}$, $V_{CC} \leq 5.5$ V (see Note 3)	Unlimited
Package thermal impedance, θ_{JA} (see Notes 4 and 5):	
D (8-pin) package	97°C/W
D (14-pin) package	86°C/W
PW (8-pin) package	149°C/W
PW (14-pin) package	113°C/W
Operating virtual junction temperature, T_J	150°C
Storage temperature range, T_{stg}	-65 to 150°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:
- All voltage values (except differential voltages and V_{CC} specified for the measurement of I_{OS}) are with respect to the network GND.
 - Differential voltages are at $IN+$ with respect to $IN-$.
 - Short circuits from outputs to V_{CC} can cause excessive heating and eventual destruction.
 - Maximum power dissipation is a function of $T_{J(max)}$, θ_{JA} , and T_A . The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_{J(max)} - T_A)/\theta_{JA}$. Selecting the maximum of 150°C can affect reliability.
 - The package thermal impedance is calculated in accordance with JESD 51-7.

recommended operating conditions (see Note 6)

		MIN	MAX	UNIT	
V_{CC}	Supply voltage (single-supply operation)	2.7	5.5	V	
V_{IH}	Amplifier turn-on voltage level	$V_{CC} = 2.7$ V	1.7	V	
		$V_{CC} = 5$ V	3.5		
V_{IL}	Amplifier turn-off voltage level	$V_{CC} = 2.7$ V	0.7	V	
		$V_{CC} = 5$ V	1.5		
T_A	Operating free-air temperature	I suffix	-40	85	°C
		Q suffix	-40	125	

NOTE 6: All unused control inputs of the device must be held at V_{CC} or GND to ensure proper device operation. Refer to the TI application report, *Implications of Slow or Floating CMOS Inputs*, literature number SCBA004.

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electrical characteristics at $T_A = 25^\circ\text{C}$ and $V_{CC+} = 2.7\text{ V}$ (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{IO}	Input offset voltage			1.7	7	mV
$\alpha_{V_{IO}}$	Average temperature coefficient of input offset voltage			5		$\mu\text{V}/^\circ\text{C}$
I_{IB}	Input bias current			11	250	nA
I_{IO}	Input offset current			5	50	nA
CMRR	Common-mode rejection ratio	$V_{CM} = 0$ to 1.7 V	50	63		dB
k_{SVR}	Supply-voltage rejection ratio	$V_{CC} = 2.7\text{ V}$ to 5 V , $V_O = 1\text{ V}$	50	60		dB
V_{ICR}	Common-mode input voltage range	CMRR $\geq 50\text{ dB}$	0 to 1.7	-0.2 to 1.9		V
	Output swing	$R_L = 10\text{ k}\Omega$ to 1.35 V	High level	$V_{CC}-100$	$V_{CC}-10$	mV
			Low level		60	
I_{CC}	Supply current	LMV358 (both amplifiers)		140	340	μA
		LMV324 (all four amplifiers)		260	680	
B_1	Unity-gain bandwidth	$C_L = 200\text{ pF}$		1		MHz
ϕ_m	Phase margin			60		deg
G_m	Gain margin			10		dB
V_n	Equivalent input noise voltage	$f = 1\text{ kHz}$		46		$\text{nV}/\sqrt{\text{Hz}}$
I_n	Equivalent input noise current	$f = 1\text{ kHz}$		0.17		$\text{pA}/\sqrt{\text{Hz}}$

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

PARAMETER		TEST CONDITIONS	T_A †	MIN	TYP	MAX	UNIT	
V_{IO}	Input offset voltage		25°C		1.7	7	mV	
			Full range			9		
$\alpha_{V_{IO}}$	Average temperature coefficient of input offset voltage		25°C		5		$\mu\text{V}/^\circ\text{C}$	
I_{IB}	Input bias current		25°C		15	250	nA	
			Full range			500		
I_{IO}	Input offset current		25°C		5	50	nA	
			Full range			150		
CMRR	Common-mode rejection ratio	$V_{CM} = 0\text{ to }4\text{ V}$	25°C	50	65		dB	
k_{SVR}	Supply-voltage rejection ratio	$V_{CC} = 2.7\text{ V to }5\text{ V}$, $V_O = 1\text{ V}$, $V_{CM} = 1\text{ V}$	25°C	50	60		dB	
V_{ICR}	Common-mode input voltage range	$CMMR \geq 50\text{ dB}$	25°C	0 to 4	-0.2 to 4.2		V	
Output swing		$R_L = 2\text{ k}\Omega\text{ to }2.5\text{ V}$	High level	25°C	$V_{CC}-300$	$V_{CC}-40$	mV	
				Full range	$V_{CC}-400$			
			Low level	25°C		120		300
				Full range				400
		$R_L = 10\text{ k}\Omega\text{ to }2.5\text{ V}$	High level	25°C	$V_{CC}-100$	$V_{CC}-10$		
				Full range	$V_{CC}-200$			
			Low level	25°C		65		180
				Full range				280
A_{VD}	Large-signal differential voltage gain	$R_L = 2\text{ k}\Omega$	25°C	15	100	V/mV		
			Full range	10				
I_{OS}	Output short-circuit current	Sourcing, $V_O = 0\text{ V}$	25°C	5	60	mA		
		Sinking, $V_O = 5\text{ V}$		10	160			
I_{CC}	Supply current	LMV358 (both amplifiers)	25°C		210	440	μA	
			Full range			615		
		LMV324 (all four amplifiers)	25°C		410	830		
			Full range			1160		
B_1	Unity-gain bandwidth	$C_L = 200\text{ pF}$	25°C		1	MHz		
ϕ_m	Phase margin		25°C		60	deg		
G_m	Gain margin		25°C		10	dB		
V_n	Equivalent input noise voltage	$f = 1\text{ kHz}$	25°C		39	$\text{nV}/\sqrt{\text{Hz}}$		
I_n	Equivalent input noise current	$f = 1\text{ kHz}$	25°C		0.21	$\text{pA}/\sqrt{\text{Hz}}$		
SR	Slew rate		25°C		1	$\text{V}/\mu\text{s}$		

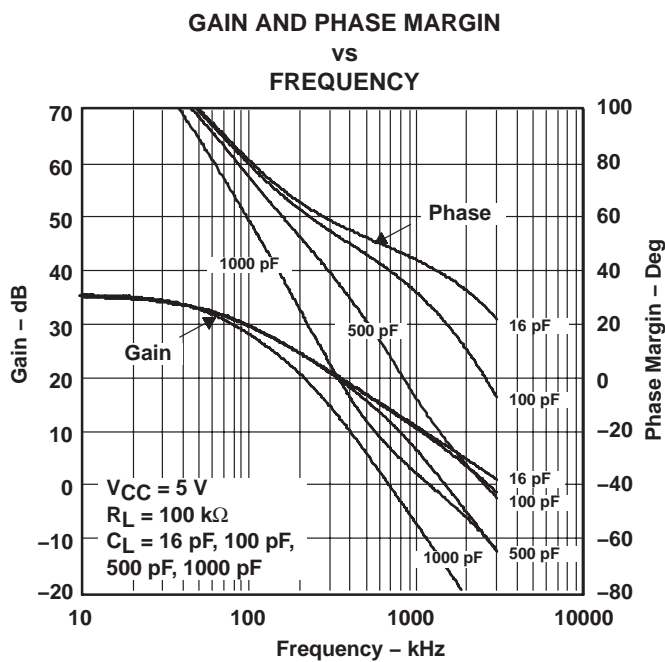
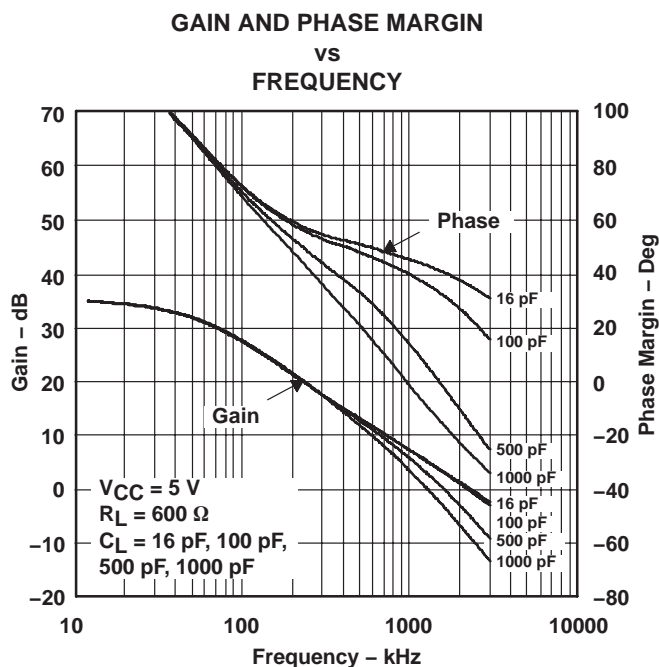
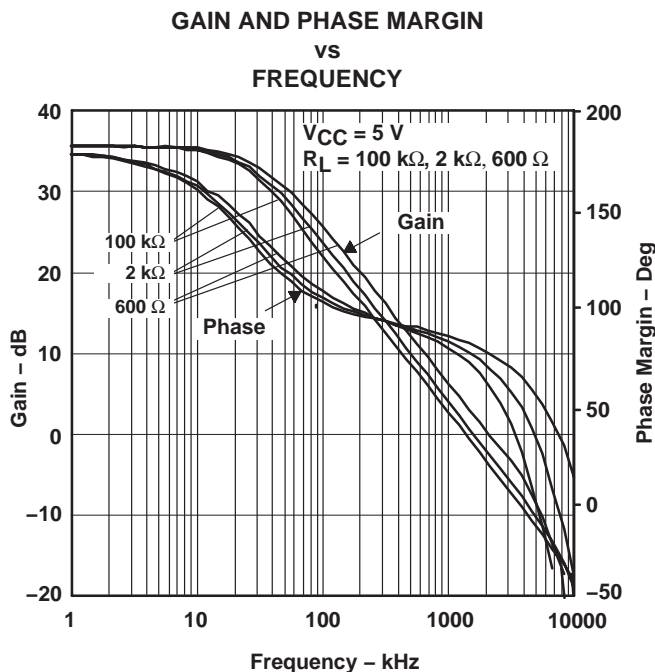
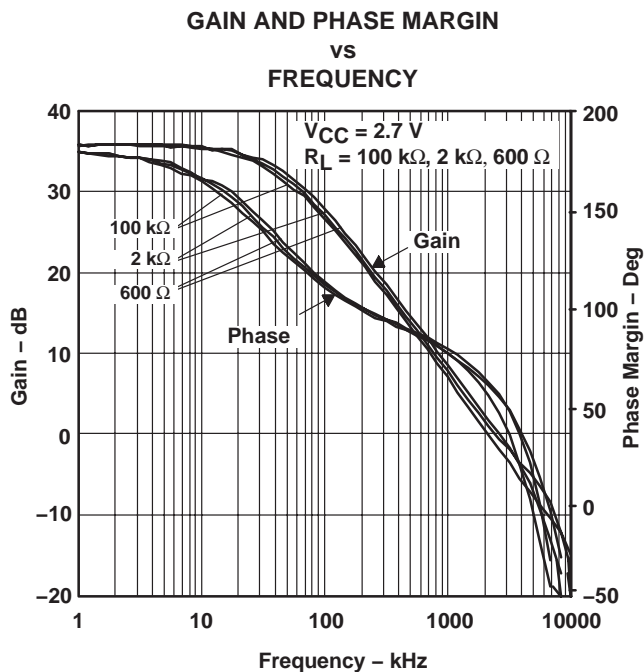
† Full range is -40°C to 85°C for I level part, -40°C to 125°C for Q level part.



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TYPICAL CHARACTERISTICS



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TYPICAL CHARACTERISTICS

**GAIN AND PHASE MARGIN
VS
FREQUENCY**

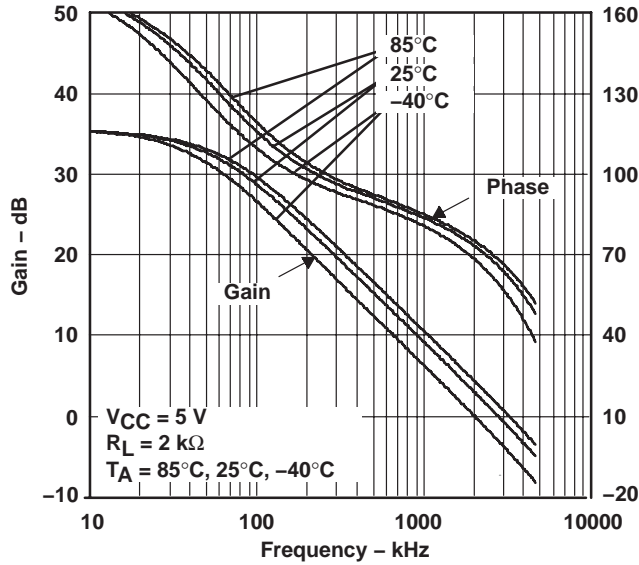


Figure 5

**STABILITY
VS
CAPACITIVE LOAD**

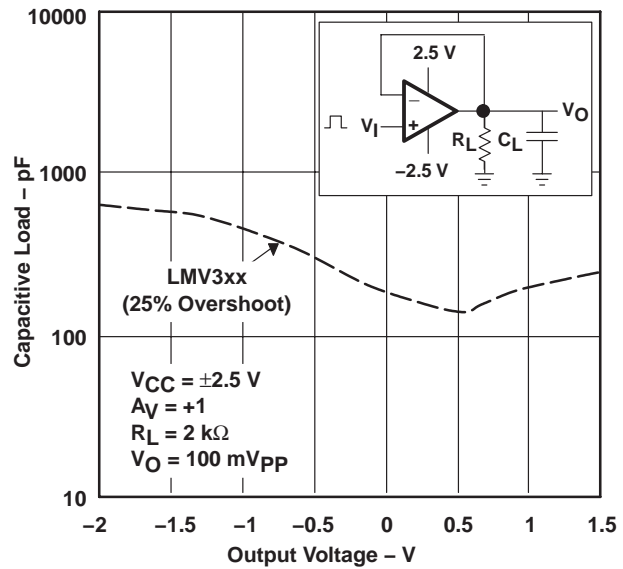


Figure 6

**STABILITY
VS
CAPACITIVE LOAD**

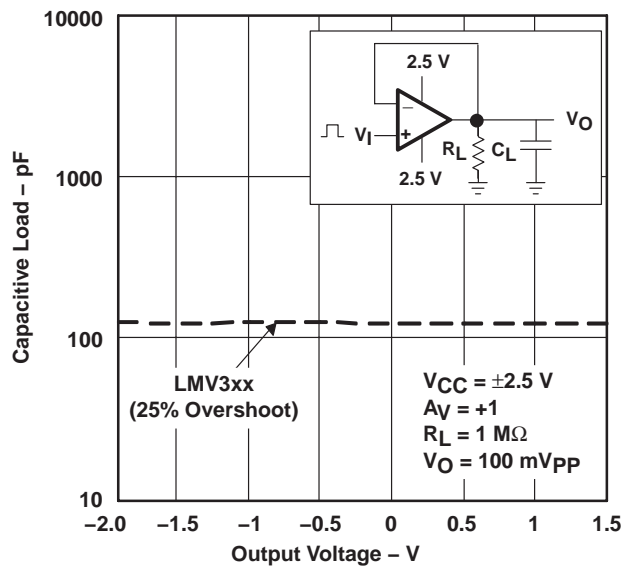


Figure 7

**STABILITY
VS
CAPACITIVE LOAD**

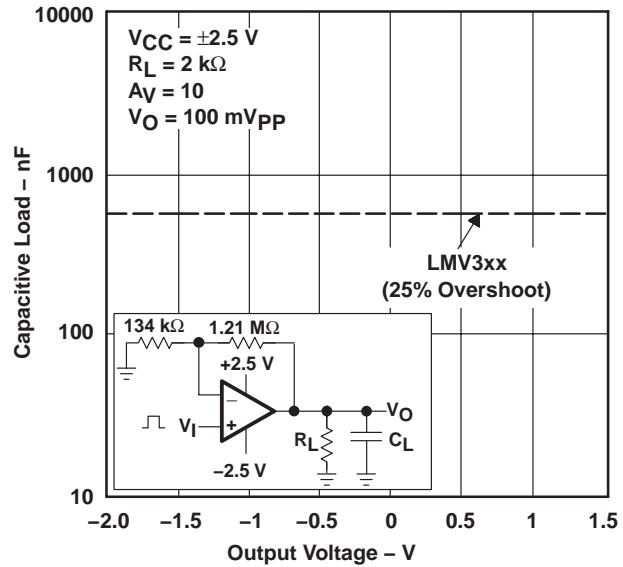


Figure 8

TYPICAL CHARACTERISTICS

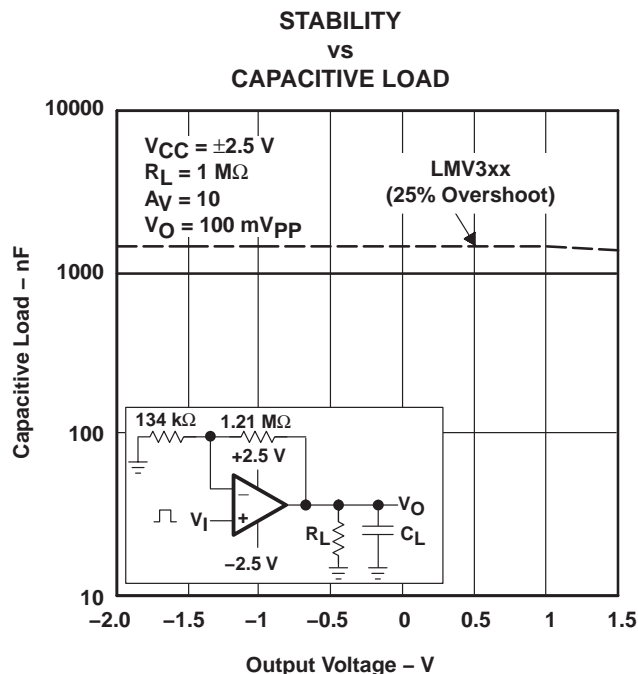


Figure 9

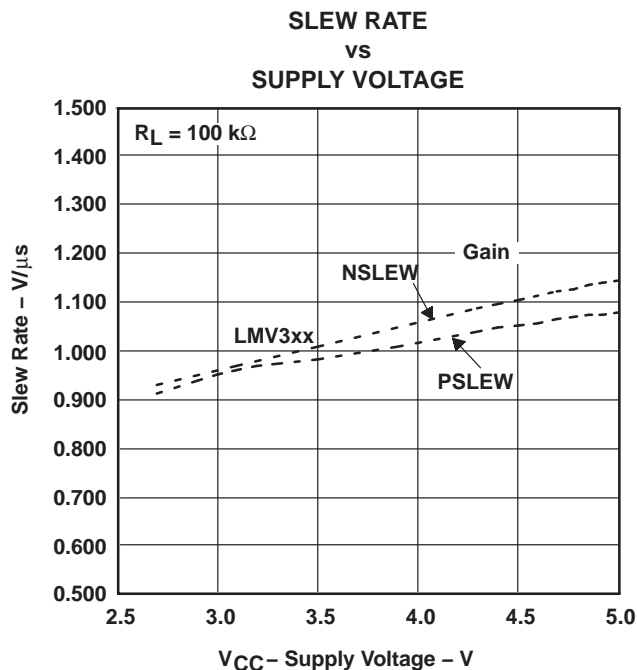


Figure 10

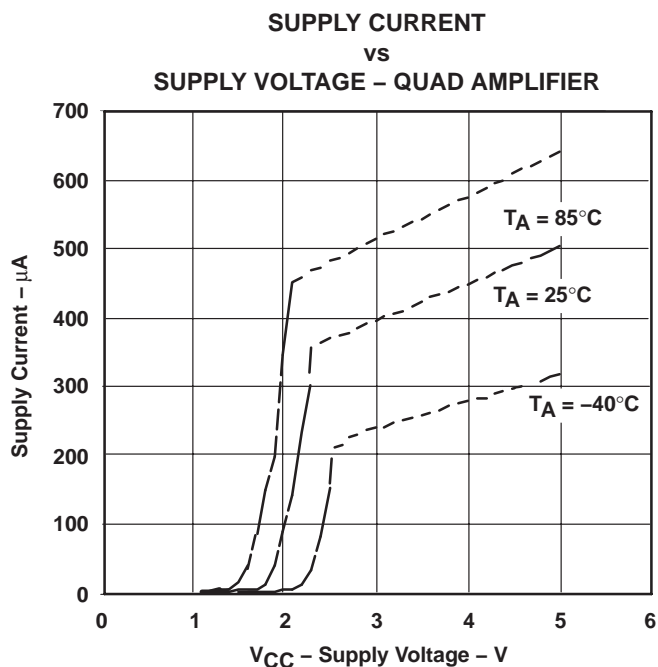


Figure 11

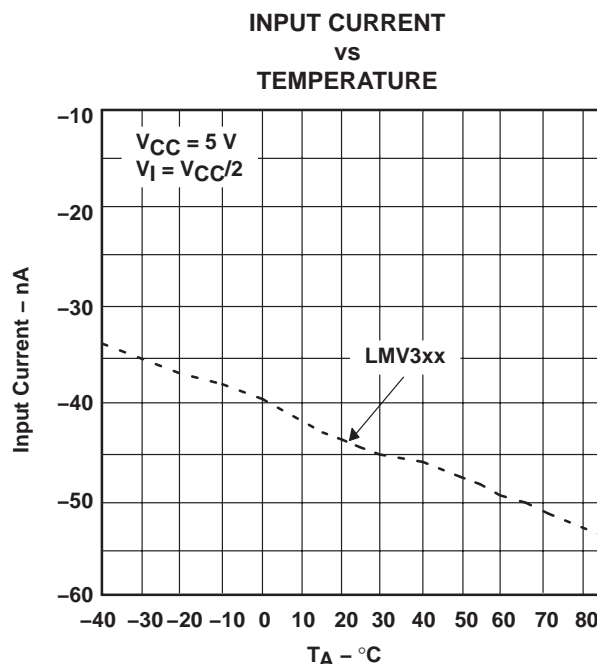


Figure 12

LMV358-Q1 DUAL, LMV324-Q1 QUAD LOW-VOLTAGE RAIL-TO-RAIL OUTPUT OPERATIONAL AMPLIFIERS

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TYPICAL CHARACTERISTICS

**SOURCE CURRENT
vs
OUTPUT VOLTAGE**

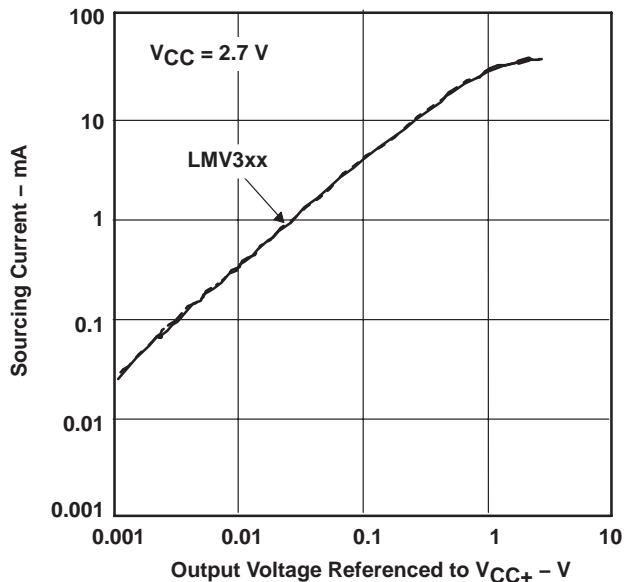


Figure 13

**SOURCE CURRENT
vs
OUTPUT VOLTAGE**

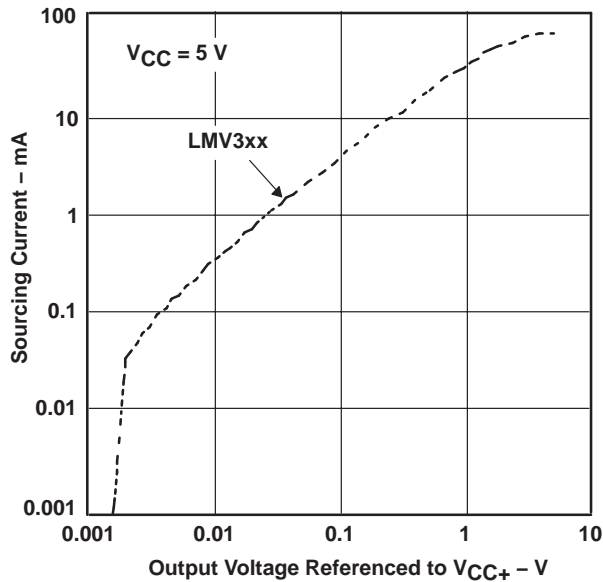


Figure 14

**SINKING CURRENT
vs
OUTPUT VOLTAGE**

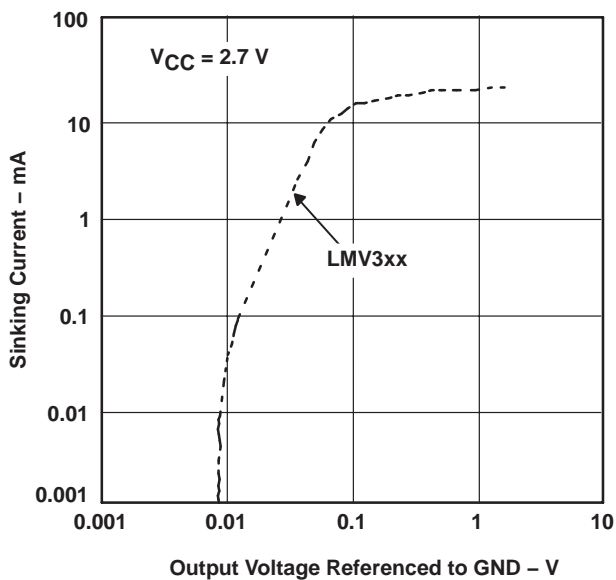


Figure 15

**SINKING CURRENT
vs
OUTPUT VOLTAGE**

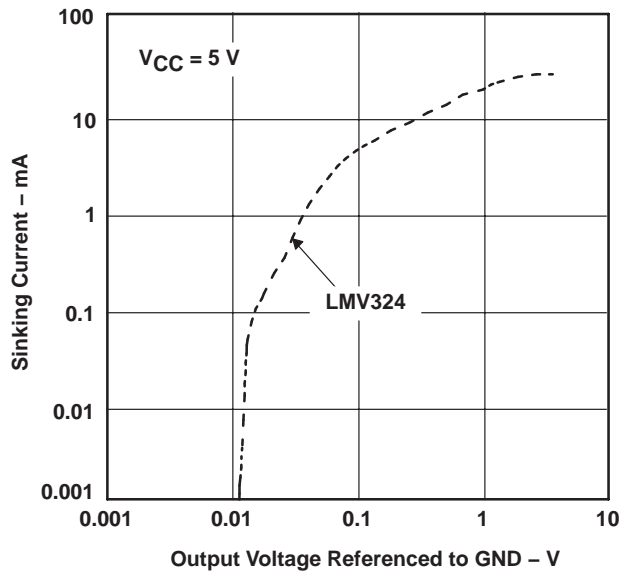


Figure 16

TYPICAL CHARACTERISTICS

SHORT-CIRCUIT CURRENT
 vs
 TEMPERATURE

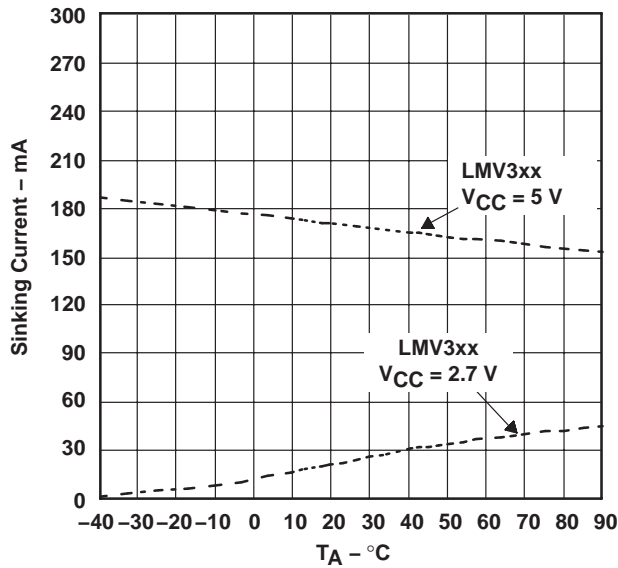


Figure 17

SHORT-CIRCUIT CURRENT
 vs
 TEMPERATURE

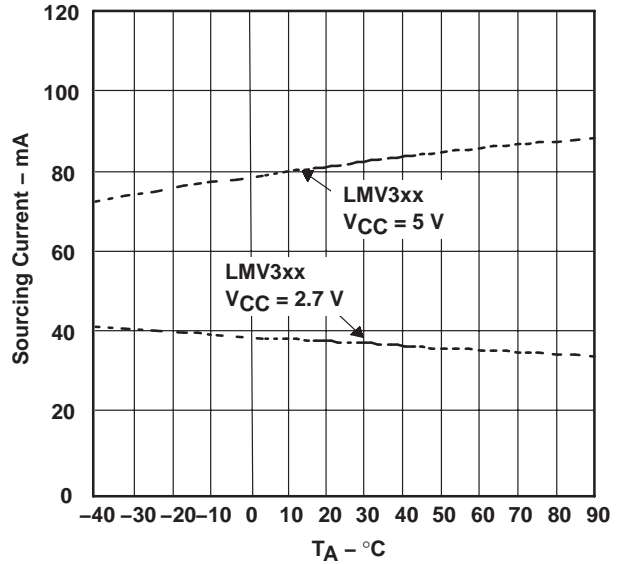


Figure 18

-k_{SVR}
 vs
 FREQUENCY

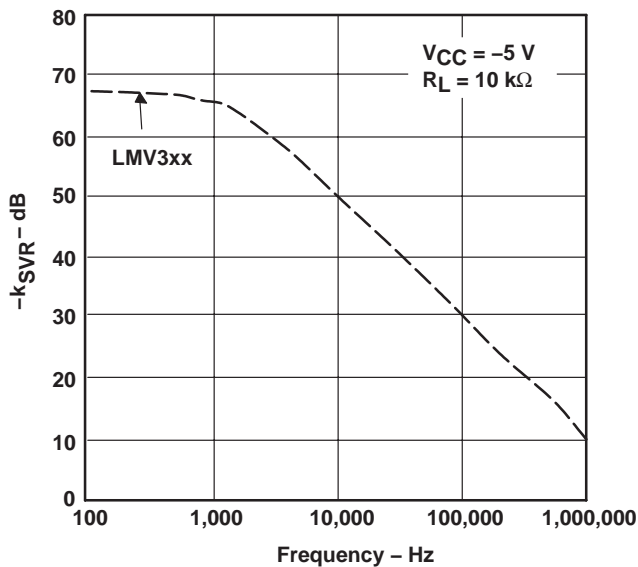


Figure 19

+k_{SVR}
 vs
 FREQUENCY

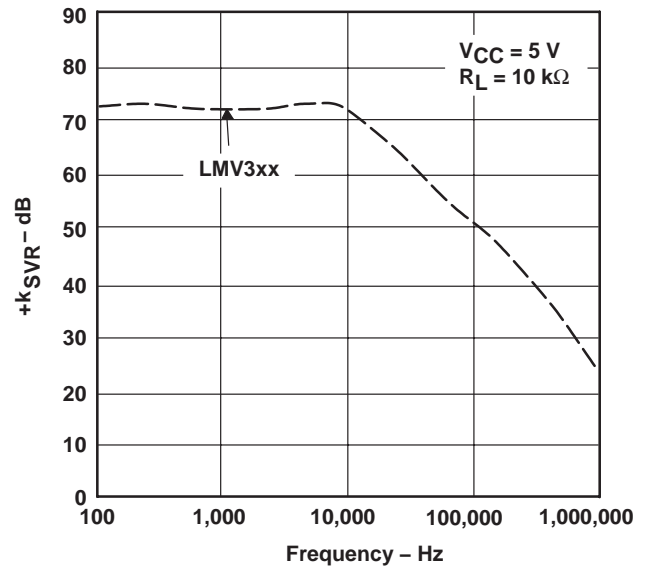


Figure 20

**LMV358-Q1 DUAL, LMV324-Q1 QUAD
LOW-VOLTAGE RAIL-TO-RAIL OUTPUT
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TYPICAL CHARACTERISTICS

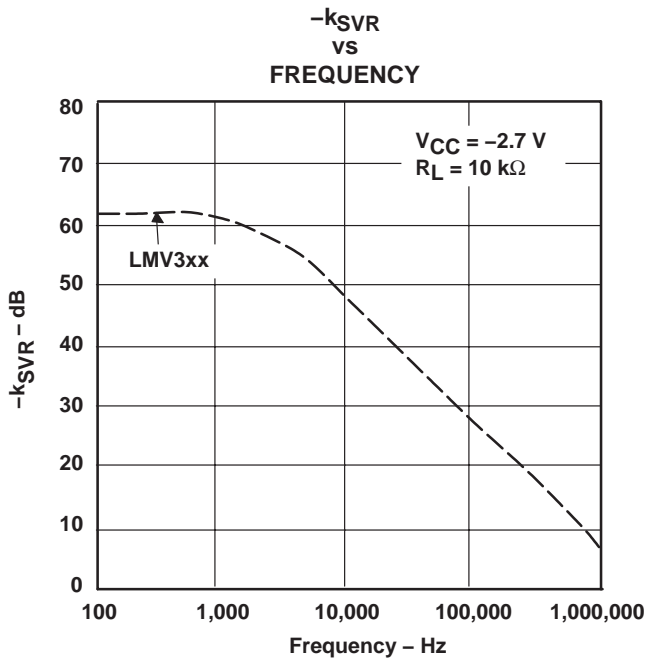


Figure 21

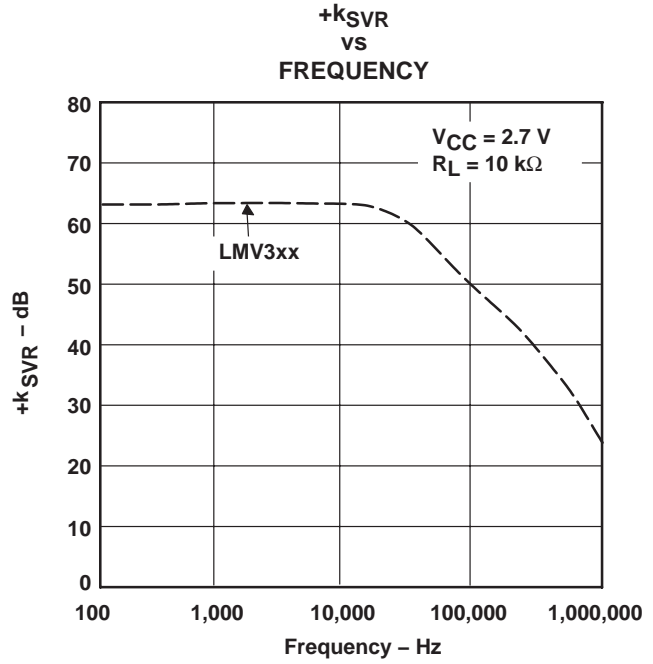


Figure 22

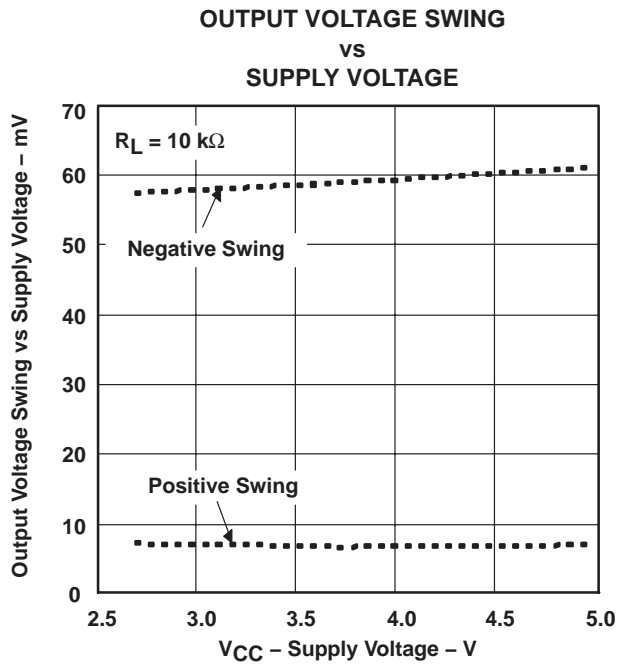


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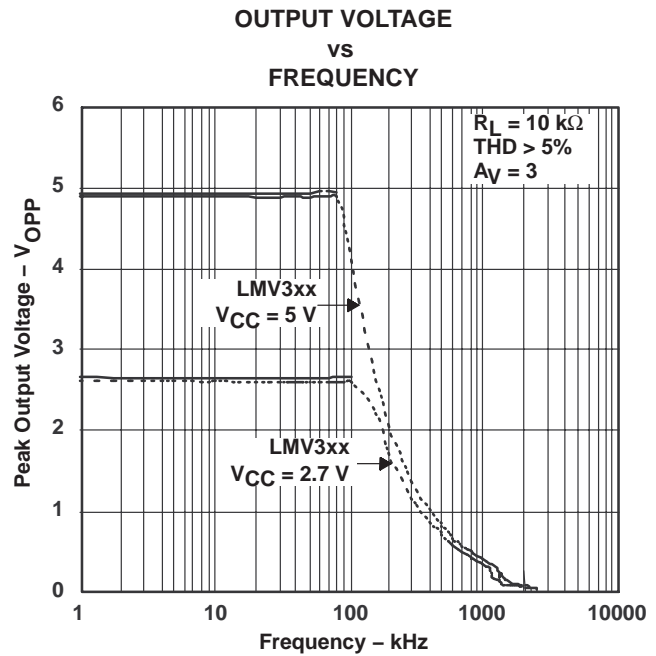


Figure 24



TYPICAL CHARACTERISTICS

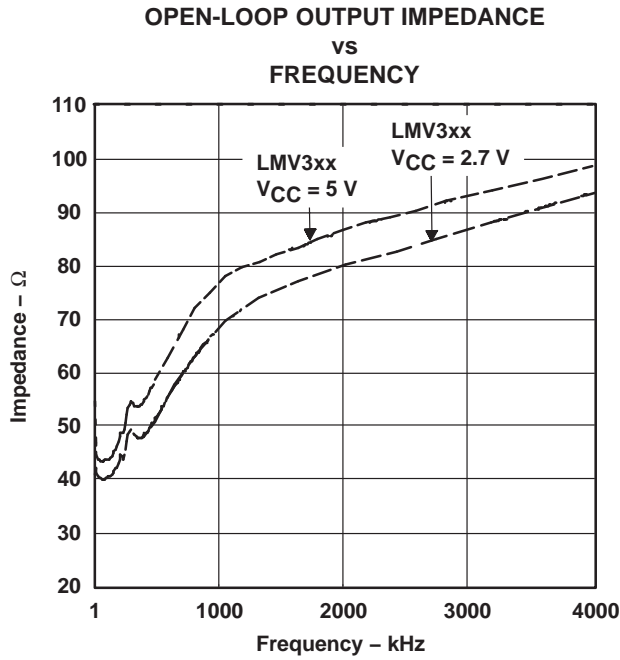


Figure 25

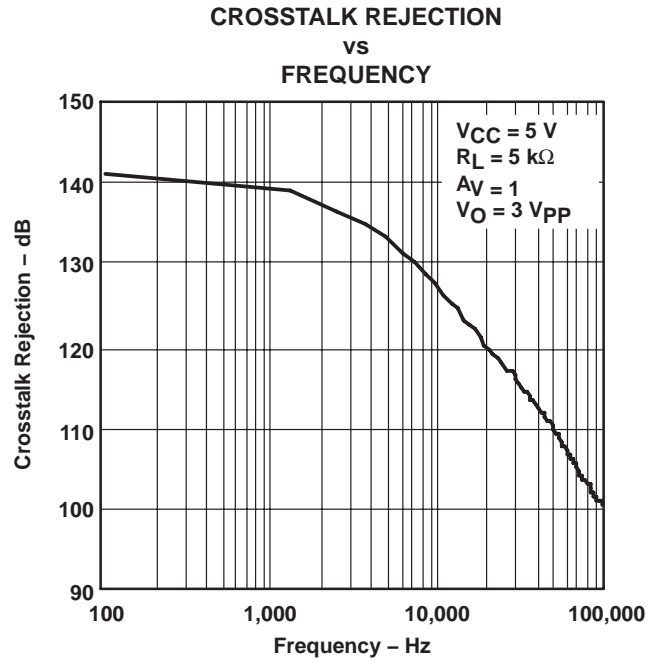


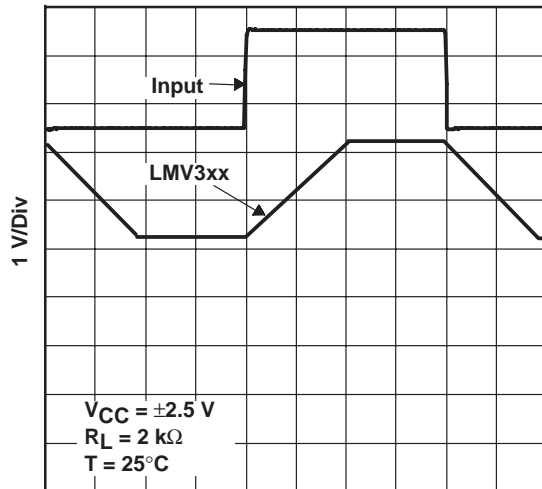
Figure 26

LMV358-Q1 DUAL, LMV324-Q1 QUAD LOW-VOLTAGE RAIL-TO-RAIL OUTPUT OPERATIONAL AMPLIFIERS

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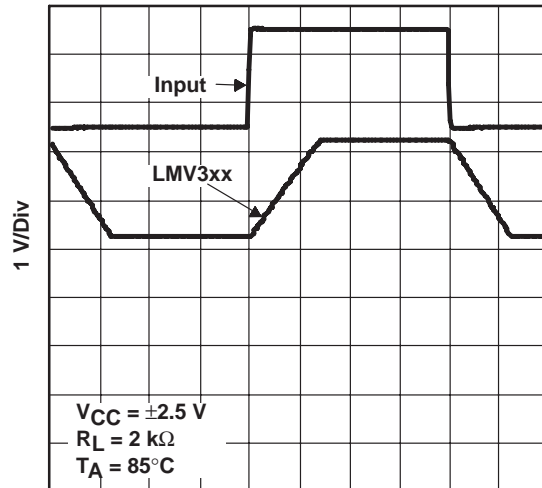
TYPICAL CHARACTERISTICS

NONINVERTING LARGE-SIGNAL PULSE RESPONSE



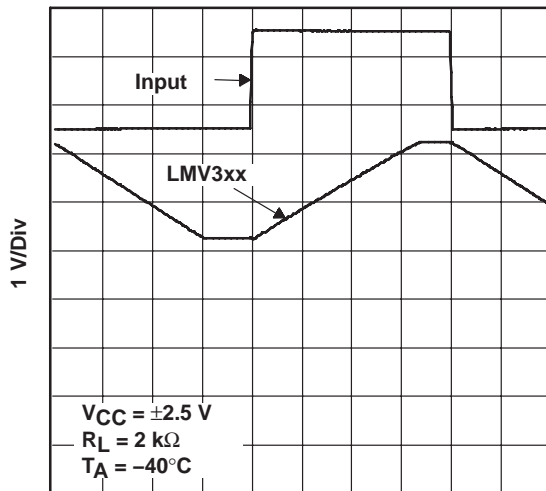
1 $\mu\text{s}/\text{Div}$
Figure 27

NONINVERTING LARGE-SIGNAL PULSE RESPONSE



1 $\mu\text{s}/\text{Div}$
Figure 28

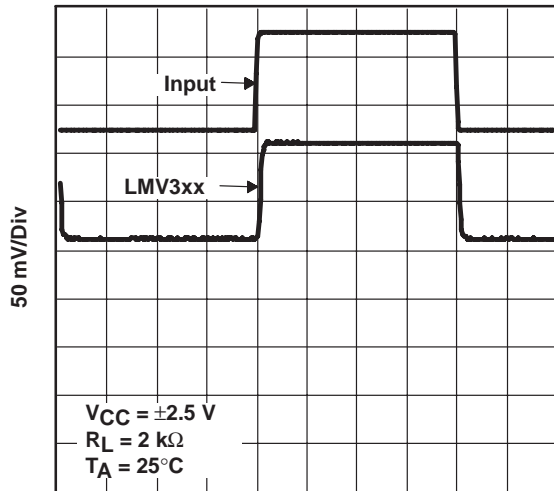
NONINVERTING LARGE-SIGNAL PULSE RESPONSE



1 $\mu\text{s}/\text{Div}$
Figure 29

TYPICAL CHARACTERISTICS

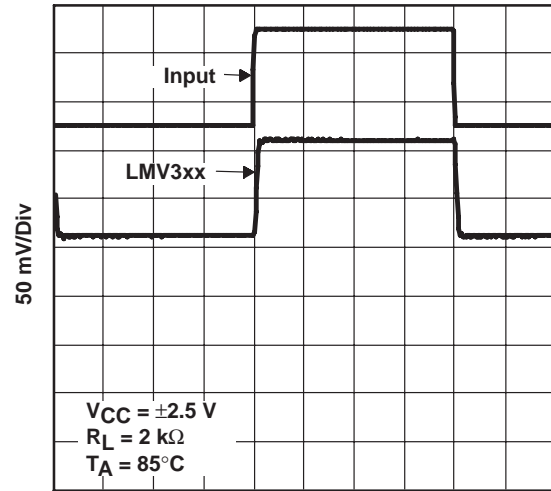
NONINVERTING SMALL-SIGNAL
PULSE RESPONSE



1 $\mu\text{s}/\text{Div}$

Figure 30

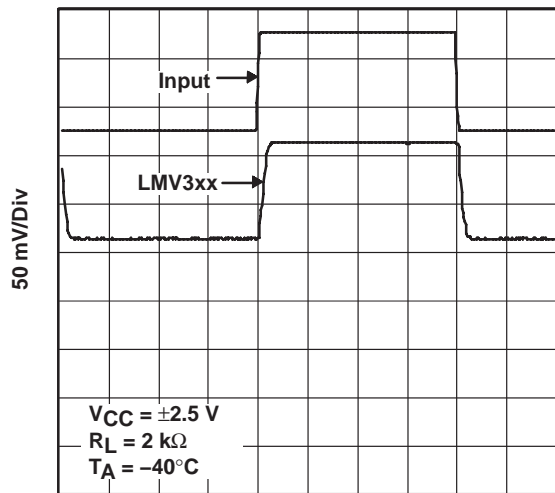
NONINVERTING SMALL-SIGNAL
PULSE RESPONSE



1 $\mu\text{s}/\text{Div}$

Figure 31

NONINVERTING SMALL-SIGNAL
PULSE RESPONSE



1 $\mu\text{s}/\text{Div}$

Figure 32

LMV358-Q1 DUAL, LMV324-Q1 QUAD LOW-VOLTAGE RAIL-TO-RAIL OUTPUT OPERATIONAL AMPLIFIERS

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TYPICAL CHARACTERISTICS

INVERTING LARGE-SIGNAL PULSE RESPONSE

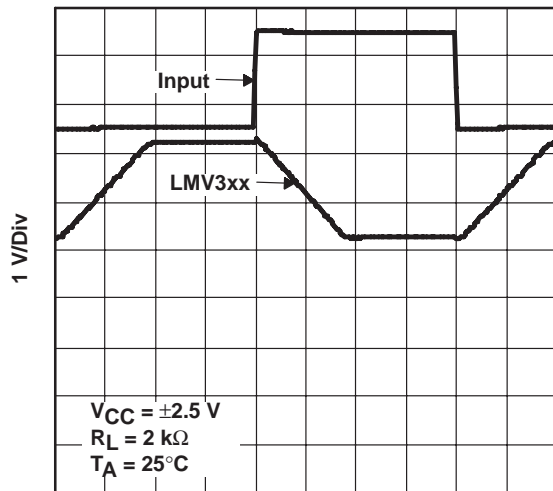


Figure 33

INVERTING LARGE-SIGNAL PULSE RESPONSE

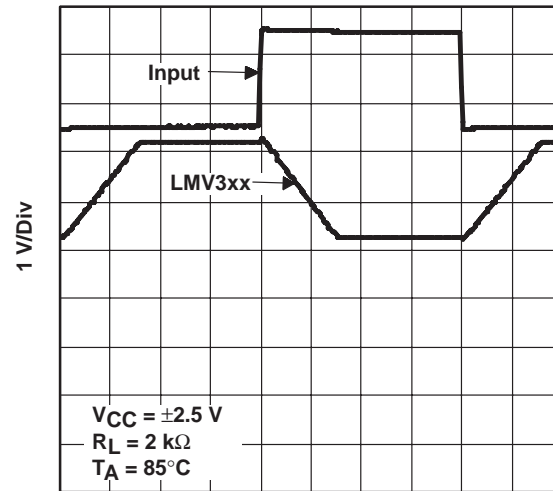


Figure 34

INVERTING LARGE-SIGNAL PULSE RESPONSE

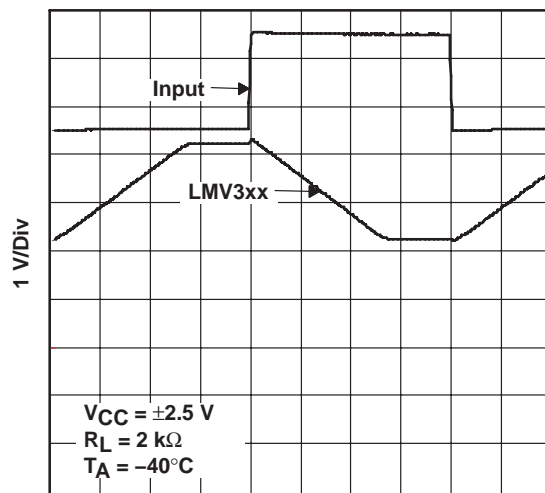
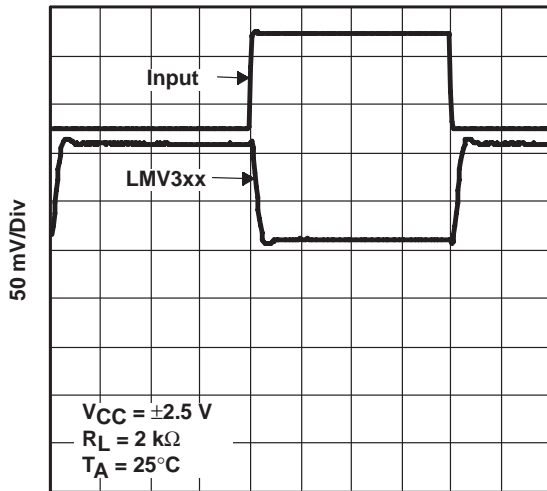


Figure 35

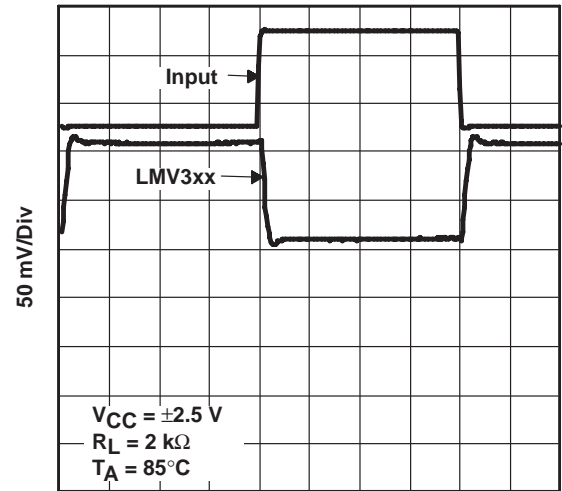
TYPICAL CHARACTERISTICS

INVERTING SMALL-SIGNAL
PULSE RESPONSE



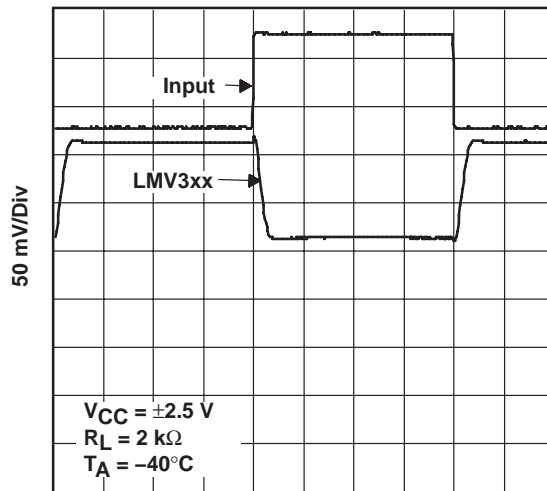
1 $\mu\text{s/Div}$
Figure 36

INVERTING SMALL-SIGNAL
PULSE RESPONSE



1 $\mu\text{s/Div}$
Figure 37

INVERTING SMALL-SIGNAL
PULSE RESPONSE



1 $\mu\text{s/Div}$
Figure 38

**LMV358-Q1 DUAL, LMV324-Q1 QUAD
LOW-VOLTAGE RAIL-TO-RAIL OUTPUT
OPERATIONAL AMPLIFIERS**

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TYPICAL CHARACTERISTICS

**INPUT CURRENT NOISE
vs
FREQUENCY**

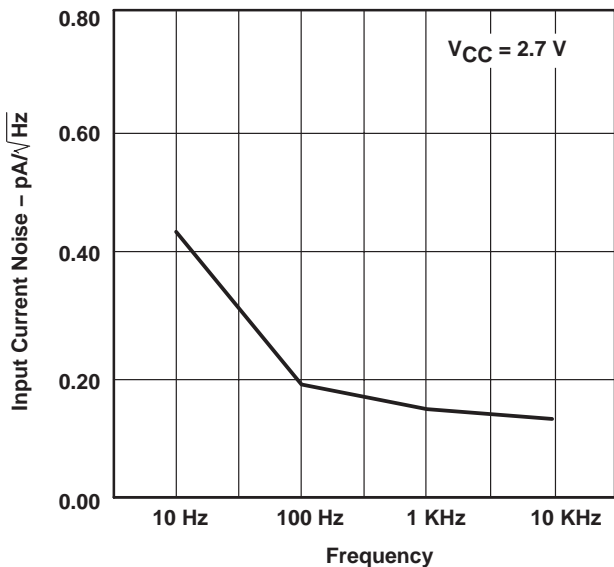


Figure 39

**INPUT CURRENT NOISE
vs
FREQUENCY**

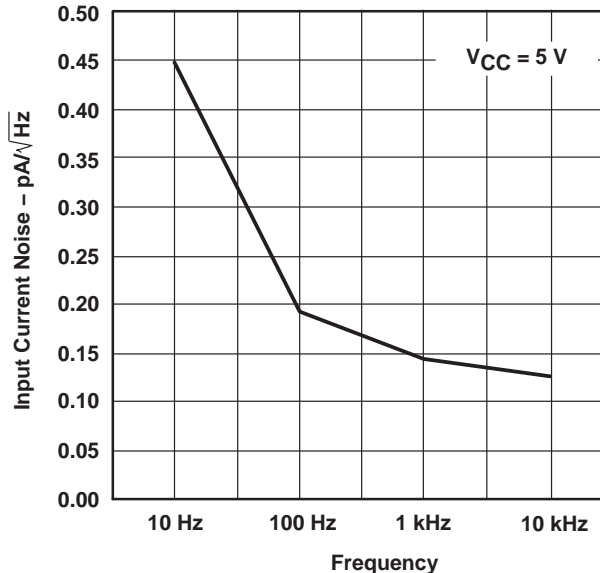


Figure 40

**INPUT VOLTAGE NOISE
vs
FREQUENCY**

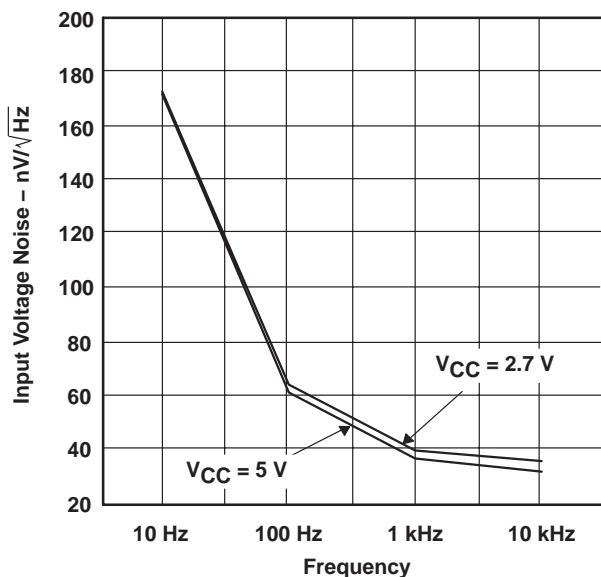


Figure 41



TYPICAL CHARACTERISTICS

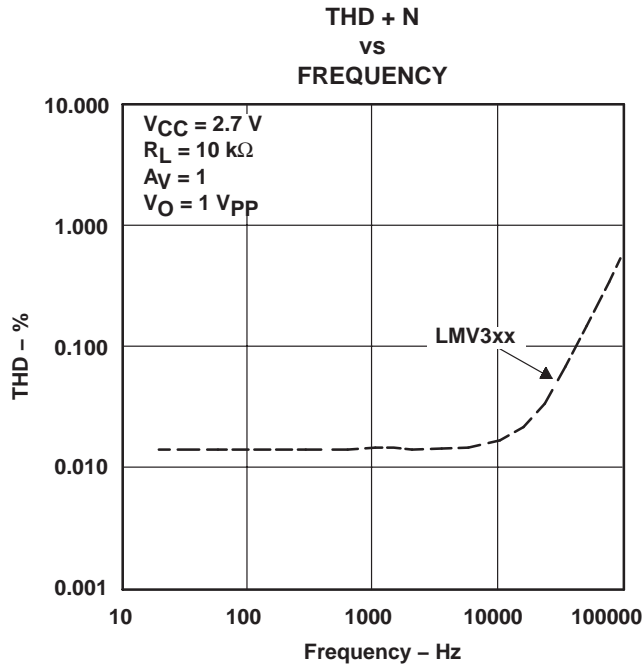


Figure 42

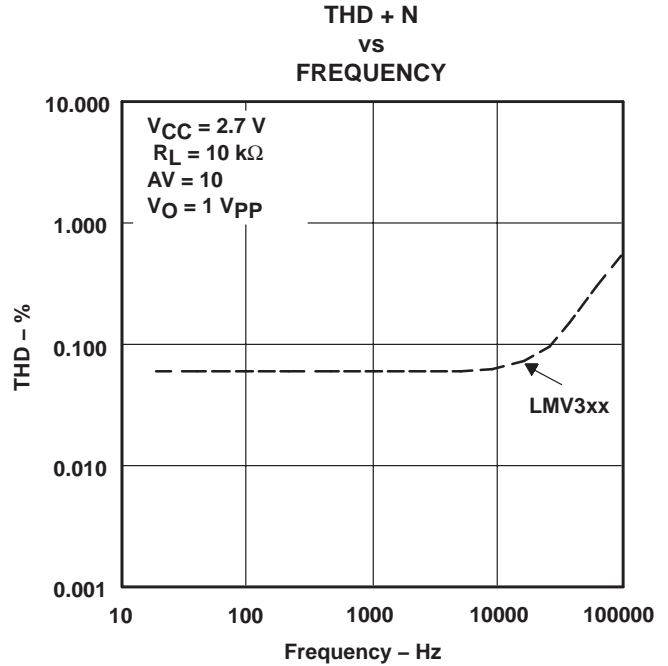


Figure 43

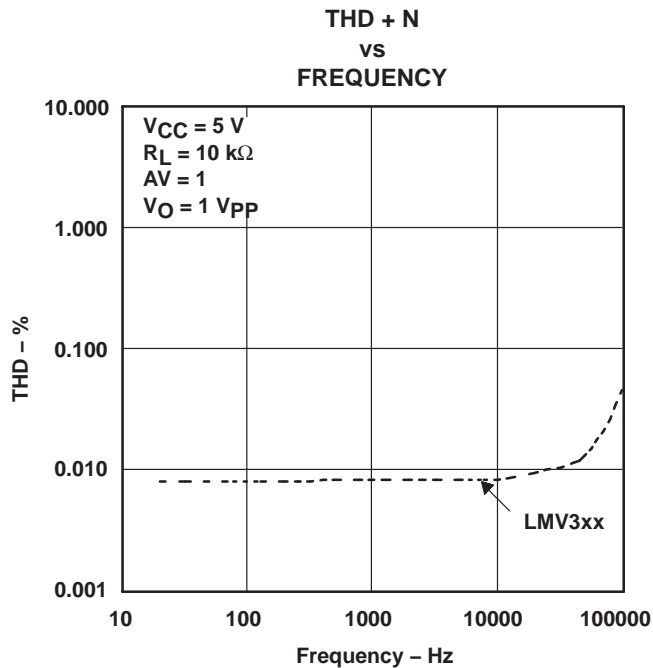


Figure 44

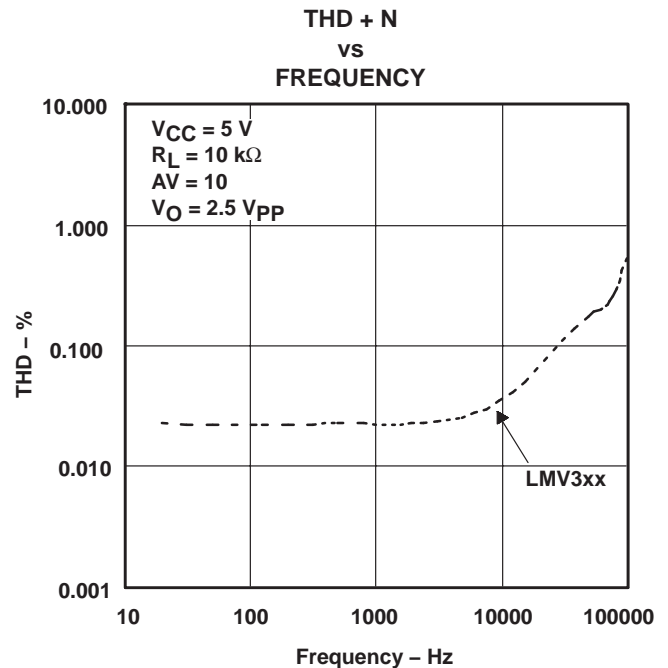


Figure 45

PW (R-PDSO-G**)

PLASTIC SMALL-OUTLINE PACKAGE

14 PINS SHOWN



4040064/F 01/97

- 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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