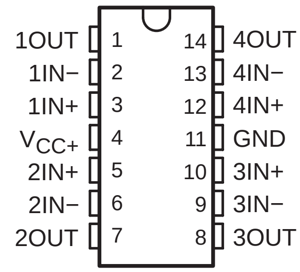
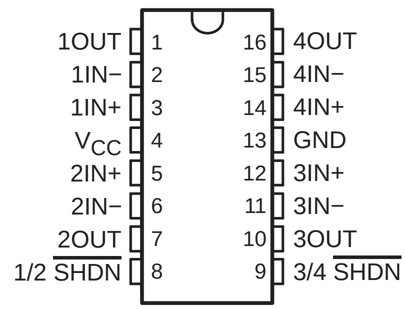
LMV321 SINGLE, LMV358 DUAL, LMV324 QUAD, LMV324S QUAD WITH SHUTDOWN LOW-VOLTAGE RAIL-TO-RAIL OUTPUT OPERATIONAL AMPLIFIERS

- **2.7-V and 5-V Performance**
- **−40°C to 125°C Operation**
- **Low-Power Shutdown Mode (LMV324S)**
- **No Crossover Distortion**
- **Low Supply Current**
  - **LMV321 . . . 130 μA Typ**
  - **LMV358 . . . 210 μA Typ**
  - **LMV324 . . . 410 μA Typ**
  - **LMV324S . . . 410 μA Typ**
- **Rail-to-Rail Output Swing**
- **ESD Protection Exceeds JESD 22**
  - **2000-V Human-Body Model (A114-A)**
  - **1000-V Charged-Device Model (C101)**

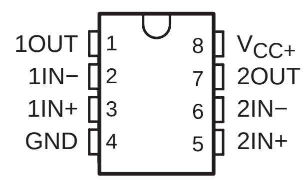
LMV324 . . . D (SOIC) OR PW (TSSOP) PACKAGE
(TOP VIEW)



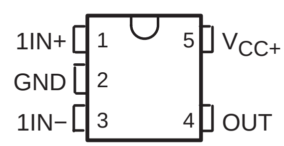
LMV324S . . . D (SOIC) OR PW (TSSOP) PACKAGE
(TOP VIEW)



LMV358 . . . D (SOIC), DDU (VSSOP), DGK (MSOP), OR PW (TSSOP PACKAGE
(TOP VIEW)



LMV321 . . . DBV (SOT-23) OR DCK (SC-70) PACKAGE
(TOP VIEW)



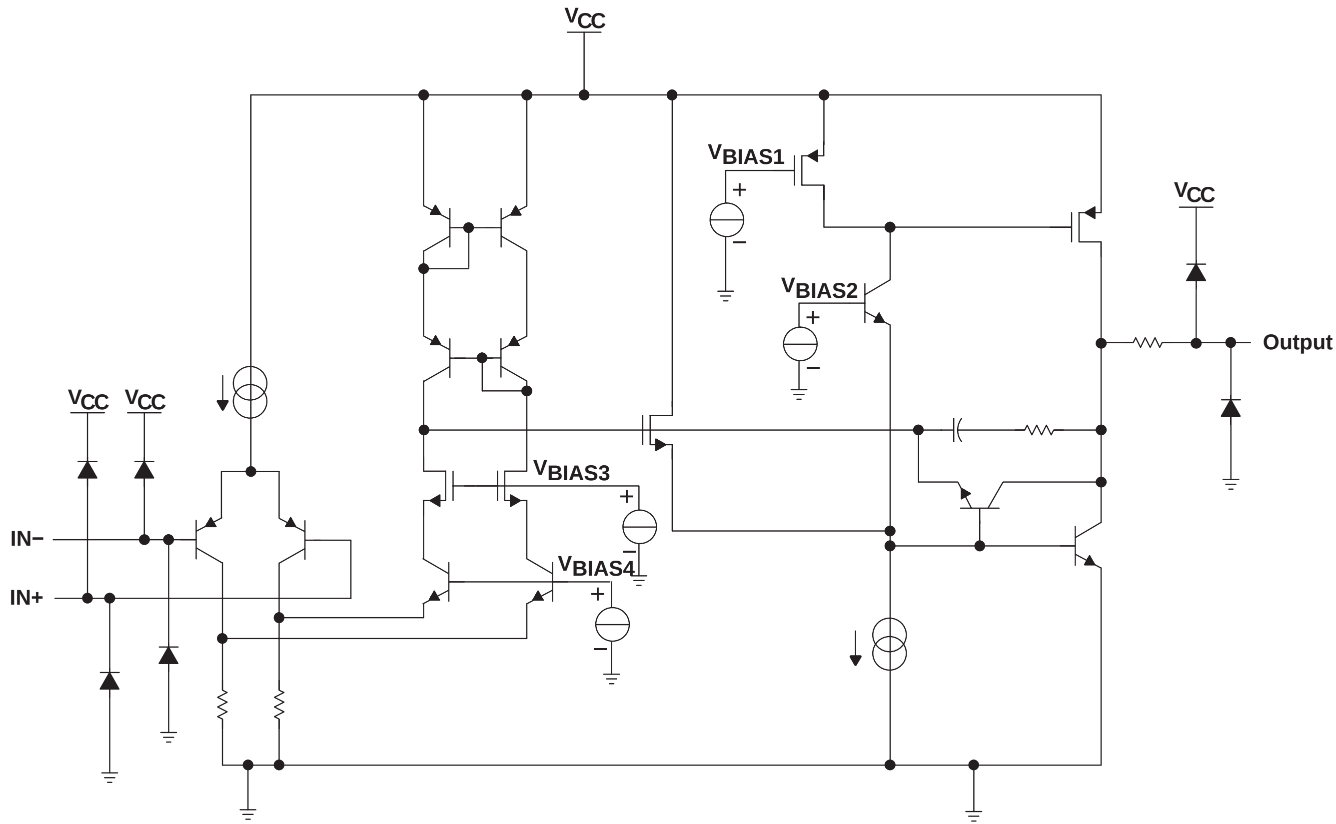
description

The LMV321, LMV358, and LMV324/LMV324S are single, dual, and quad low-voltage (2.7 V to 5.5 V), operational amplifiers with rail-to-rail output swing. The LMV324S, which is a variation of the standard LMV324, includes a power-saving shutdown feature that reduces supply current to a maximum of 5 μA per channel when the amplifiers are not needed. Channels 1 and 2 together are put in shutdown, as are channels 3 and 4. While in shutdown, the outputs actively are pulled low.

The LMV321, LMV358, LMV324, and LMV324S are the most cost-effective solutions for applications where low-voltage operation, space saving, and low cost are needed. These amplifiers were designed specifically for low-voltage (2.7 V to 5 V) operation, with performance specifications meeting or exceeding the 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/μs slew rate.

The LMV321 is available in the ultra-small DCK (SC-70) package, which is approximately one-half the size of the DBV (SOT-23) package. This package saves space on printed circuit boards and enables the design of small portable electronic devices. It also allows the designer to place the device closer to the signal source to reduce noise pickup and increase signal integrity.

LMV324 simplified schematic



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) $T_A = 25°C$, $V_{CC} \leq 5.5$ 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
	D (16-pin) package	73°C/W
	DBV (5-pin) package	206°C/W
	DCK (5-pin) package	252°C/W
	DDU (8-pin) package	TBD°C/W
	DGK (8-pin) package	172°C/W
	PW (8-pin) package	149°C/W
	PW (14-pin) package	113°C/W
	PW (16-pin) package	108°C/W
Operating virtual junction temperature, T_J		150°C
Storage temperature range, T_{stg}		−65°C 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:
1. All voltage values (except differential voltages and V_{CC} specified for the measurement of I_{OS}) are with respect to the network GND.
2. Differential voltages are at IN+ with respect to IN−.
3. Short circuits from outputs to V_{CC} can cause excessive heating and eventual destruction.
4. 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.
5. 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 turnon voltage level (LMV324S)‡	V_{CC} = 2.7 V	1.7		V
		V_{CC} = 5 V	3.5		
V_{IL}	Amplifier turnoff voltage level (LMV324S)	V_{CC} = 2.7 V		0.7	V
		V_{CC} = 5 V		1.5	
T_A	Operating free-air temperature	I-Temp	−40	85	°C
		Q-Temp	−40	125	

‡ V_{IH} should not be allowed to exceed V_{CC}.

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.

electrical characteristics at T_A = 25°C and V_{CC+} = 2.7 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		µV/°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 V to 5 V, V_O = 1 V		50	60		dB
V_{ICR}	Common-mode input voltage range	CMRR ≥ 50 dB		0 to 1.7	−0.2 to 1.9		V
	Output swing	R_L = 10 kΩ to 1.35 V	High level	V_{CC} − 100	V_{CC} − 10		mV
			Low level		60	180	
I_{CC}	Supply current	LMV321I			80	170	µA
		LMV358I (both amplifiers)			140	340	
		LMV324I/LMV324SI (all four amplifiers)			260	680	
B_1	Unity-gain bandwidth	C_L = 200 pF			1		MHz
Φ_m	Phase margin				60		deg
G_m	Gain margin				10		dB
V_n	Equivalent input noise voltage	f = 1 kHz			46		nV/√Hz
I_n	Equivalent input noise current	f = 1 kHz			0.17		pA/√Hz

shutdown characteristics (LMV324S) at T_A = 25°C and V_{CC+} = 2.7 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$I_{CC(SHDN)}$	Supply current in shutdown mode (per channel)	$\overline{SHDN}$ ≤ 0.6 V			5	µA
$t_{(on)}$	Amplifier turnon time	A_V = 1, R_L = Open (measured at 50% point)		2		µs
$t_{(off)}$	Amplifier turnoff time	A_V = 1, R_L = Open (measured at 50% point)		40		ns

electrical characteristics at specified free-air temperature range, V_{CC+} = 5 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		μV/°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 to 4 V		25°C	50	65		dB
k_{SVR}	Supply-voltage rejection ratio	V_{CC}= 2.7 V to 5 V, V_O = 1 V, V_{CM} = 1 V		25°C	50	60		dB
V_{ICR}	Common-mode input voltage range	CMMR ≥ 50 dB		25°C	0 to 4	−0.2 to 4.2		V
	Output swing	R_L = 2 kΩ to 2.5 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 kΩ to 2.5 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 kΩ		25°C	15	100		V/mV
				Full range	10			
I_{OS}	Output short-circuit current	Sourcing, V_O = 0 V		25°C	5	60		mA
		Sinking, V_O = 5 V			10	160		
I_{CC}	Supply current	LMV321I		25°C		130	250	μA
				Full range			350	
		LMV358I (both amplifiers)		25°C		210	440	
				Full range			615	
		LMV324I/LMV324SI (all four amplifiers)		25°C		410	830	
				Full range			1160	
B_1	Unity-gain bandwidth	C_L = 200 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 kHz		25°C		39		nV/√Hz
I_n	Equivalent input noise current	f = 1 kHz		25°C		0.21		pA/√Hz
SR	Slew rate			25°C		1		V/μs

† Full range: −40°C to 85°C for I-temp, −40°C to 125°C for Q-temp.

shutdown characteristics (LMV324S) at T_A = 25°C and V_{CC+} = 5 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A	MIN	TYP	MAX	UNIT
$I_{CC(SHDN)}$	Supply current in shutdown mode (per channel)	$\overline{SHDN}$ ≤ 0.6 V	−40°C to 85°C			5	μA
$t_{(on)}$	Amplifier turnon time	A_V = 1, R_L = Open (measured at 50% point)			2		μs
$t_{(off)}$	Amplifier turnoff time	A_V = 1, R_L = Open (measured at 50% point)			40		ns

TYPICAL CHARACTERISTICS

LMV321 FREQUENCY RESPONSE vs RESISTIVE LOAD

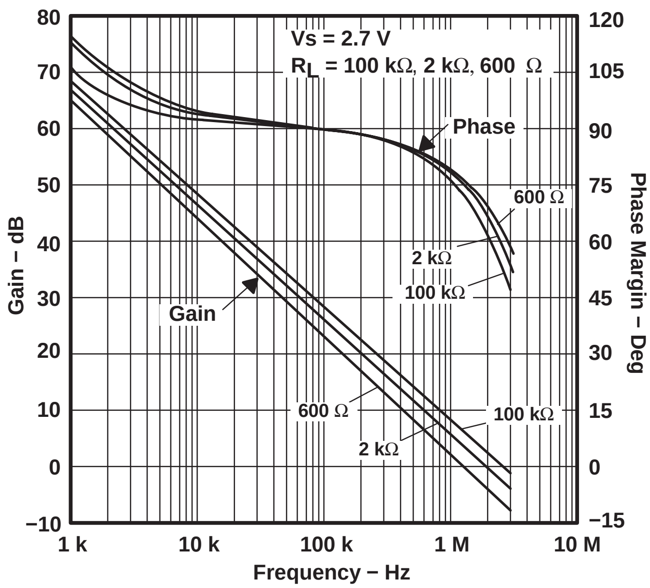


Figure 1

LMV321 FREQUENCY RESPONSE vs RESISTIVE LOAD

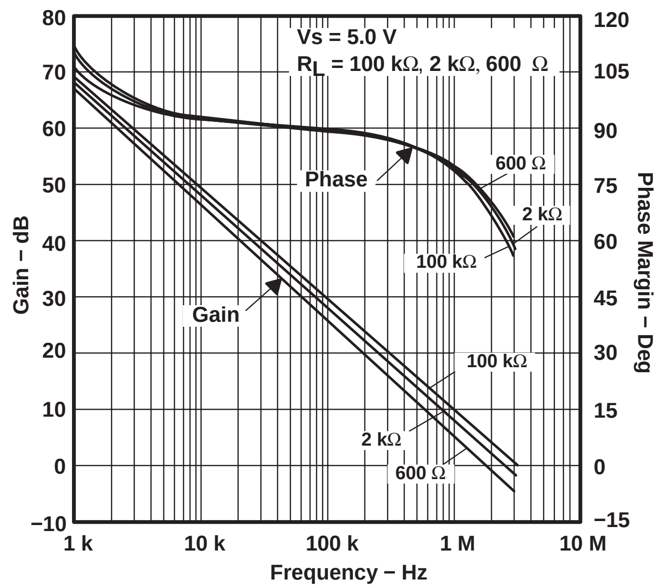


Figure 2

LMV321 FREQUENCY RESPONSE vs CAPACITIVE LOAD

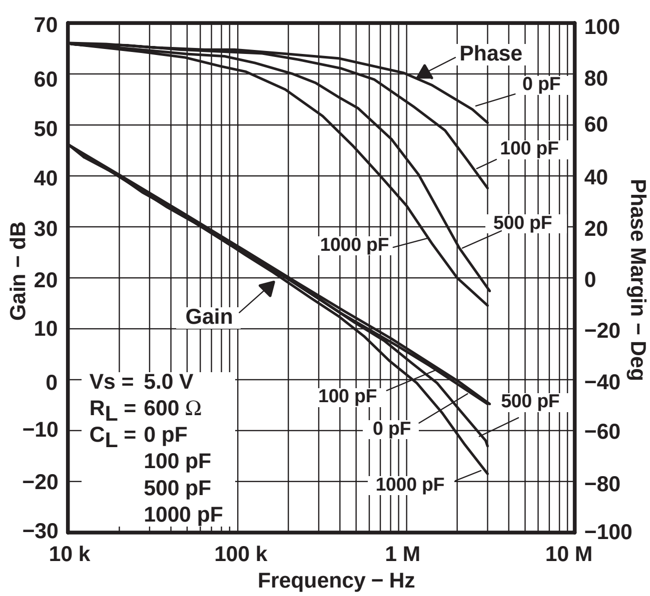


Figure 3

LMV321 FREQUENCY RESPONSE vs CAPACITIVE LOAD

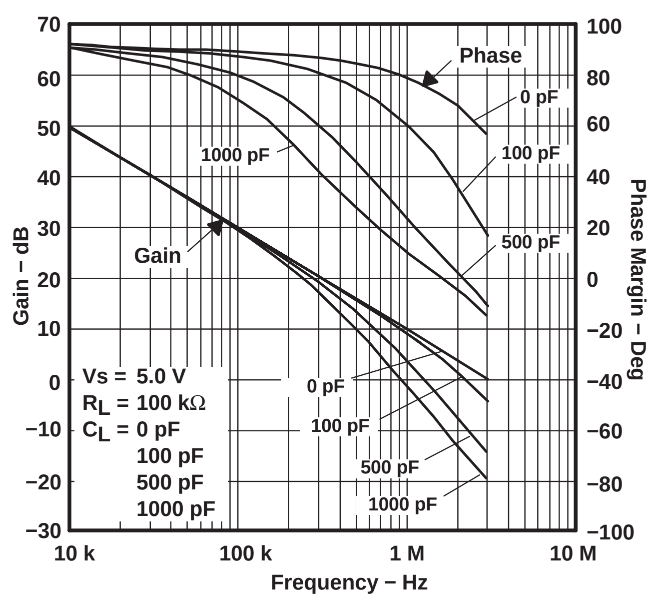


Figure 4

TYPICAL CHARACTERISTICS

LMV321 FREQUENCY RESPONSE
vs
TEMPERATURE

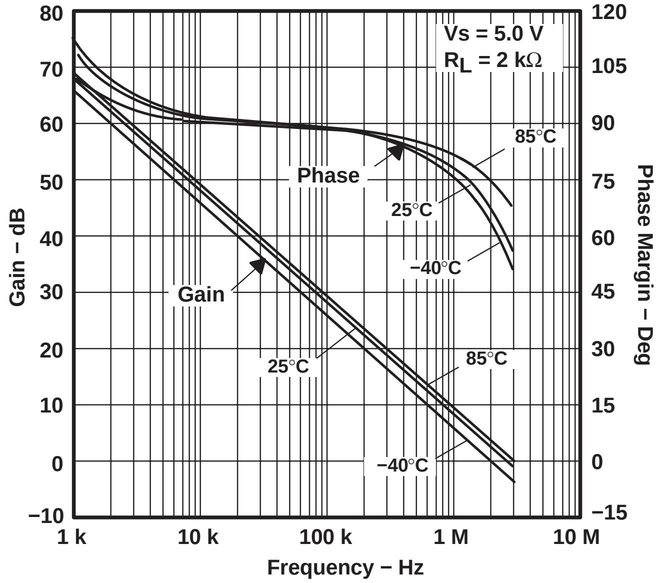


Figure 5

STABILITY
vs
CAPACITIVE LOAD

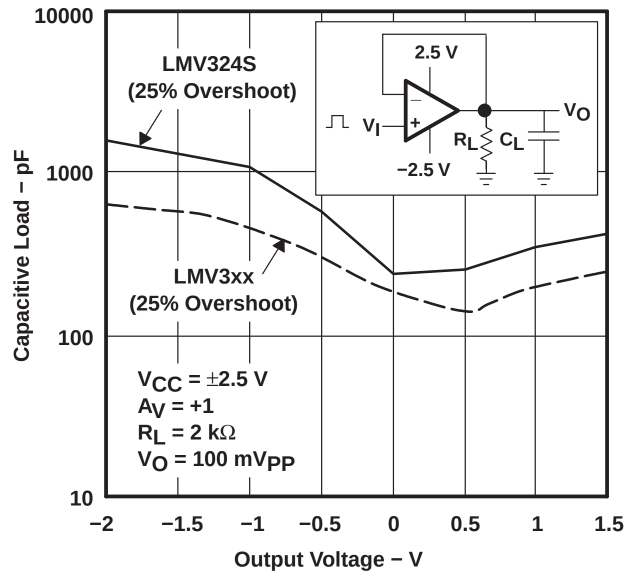


Figure 6

STABILITY
vs
CAPACITIVE LOAD

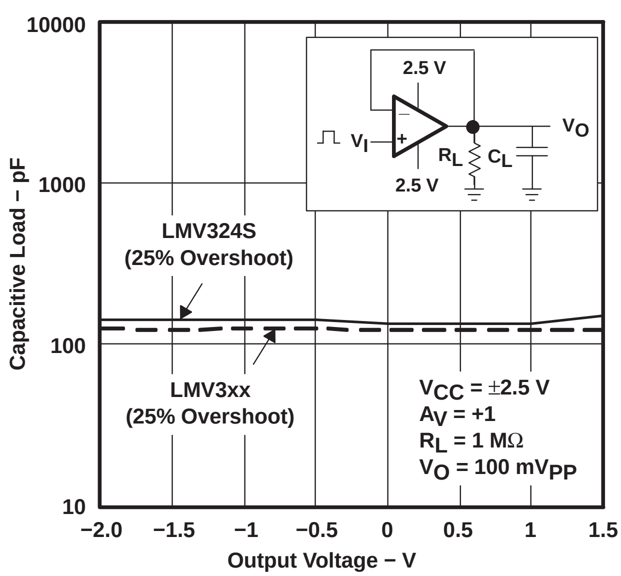


Figure 7

STABILITY
vs
CAPACITIVE LOAD

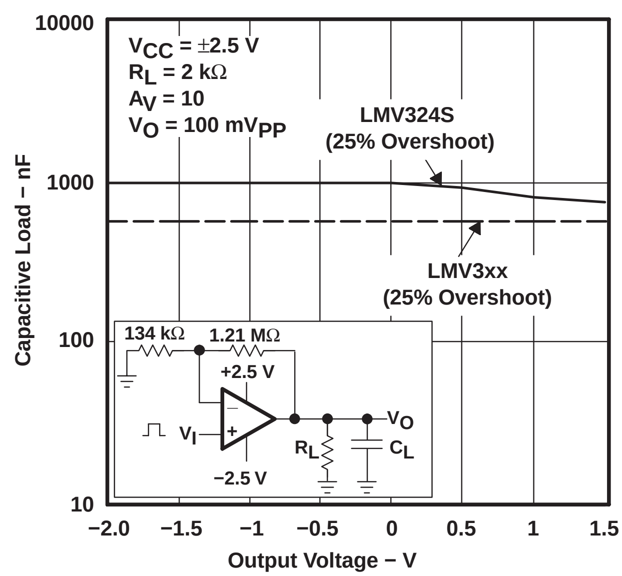


Figure 8

TYPICAL CHARACTERISTICS

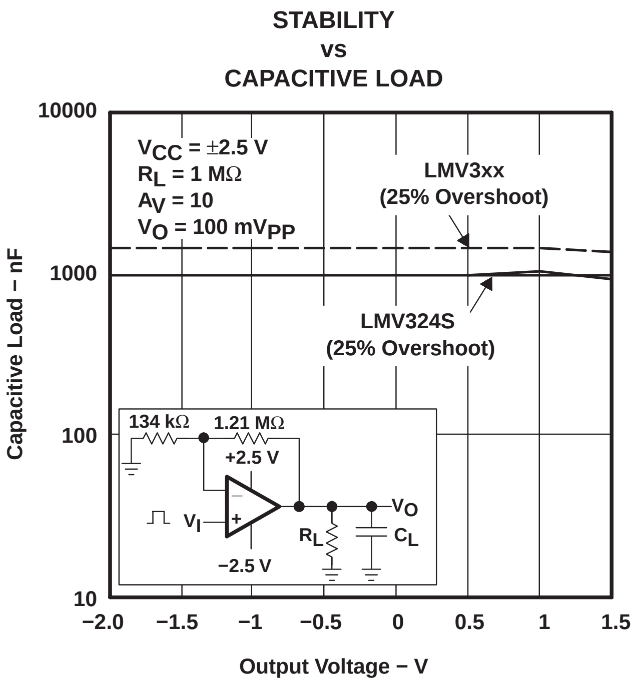


Figure 9

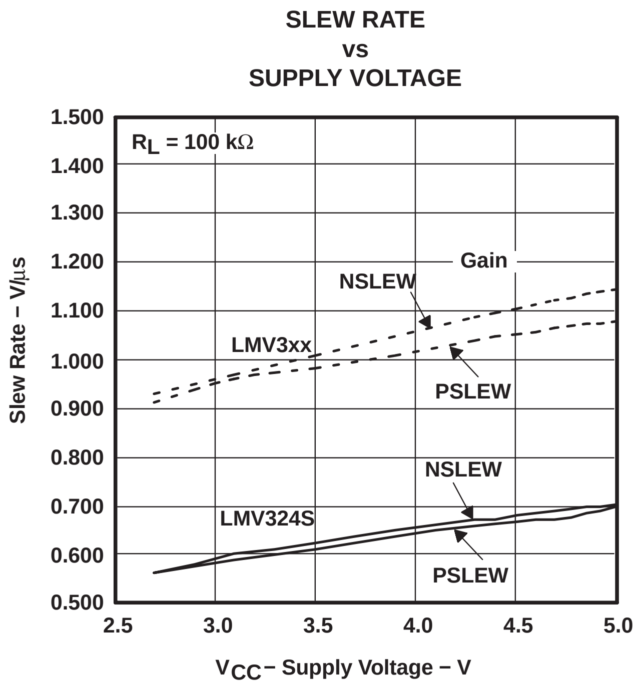


Figure 10

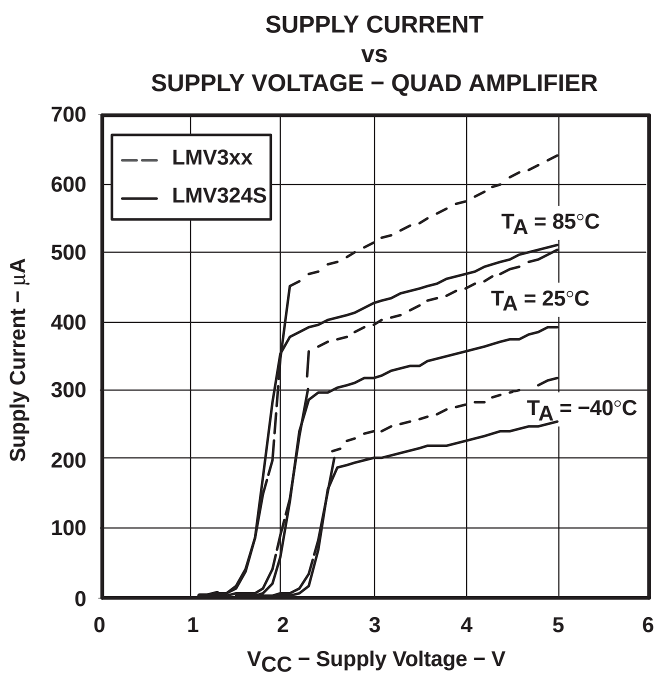


Figure 11

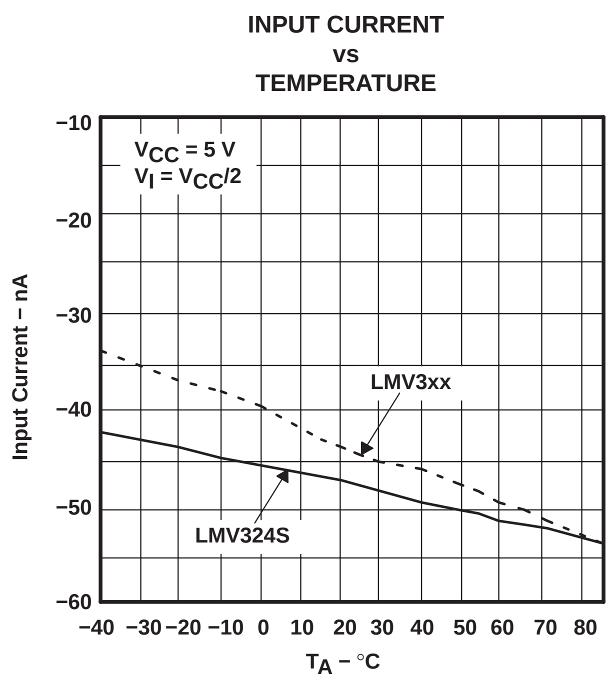


Figure 12

TYPICAL CHARACTERISTICS

SOURCE CURRENT
vs
OUTPUT VOLTAGE

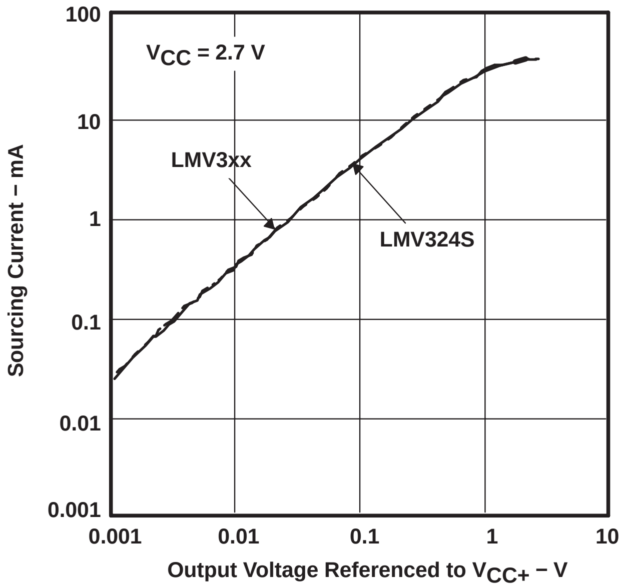


Figure 13

SOURCE CURRENT
vs
OUTPUT VOLTAGE

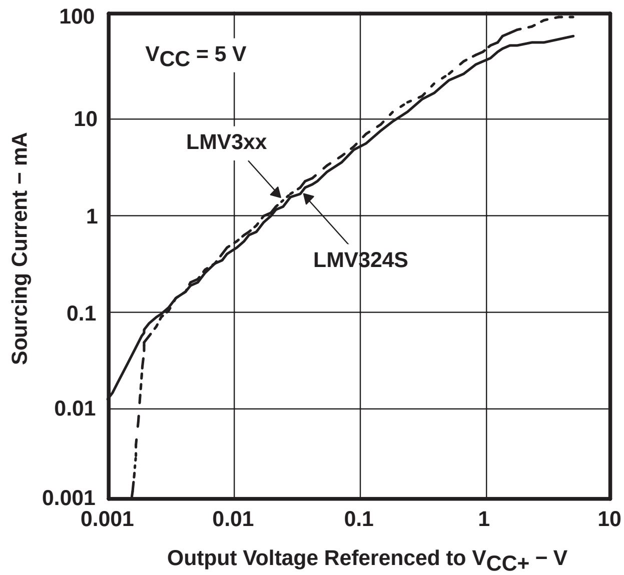


Figure 14

SINKING CURRENT
vs
OUTPUT VOLTAGE

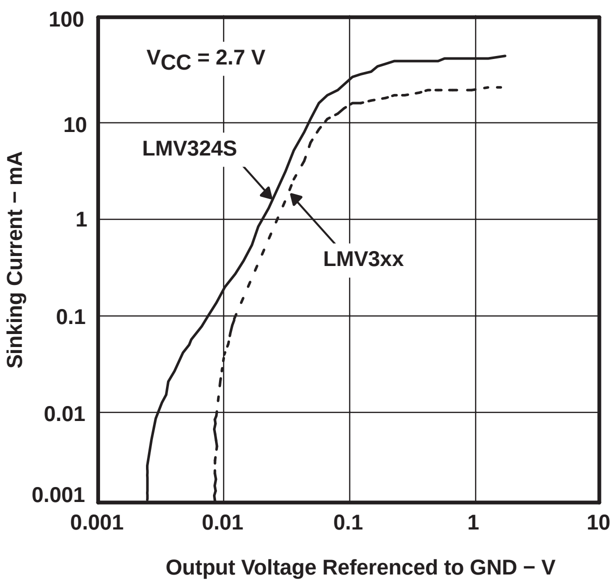


Figure 15

SINKING CURRENT
vs
OUTPUT VOLTAGE

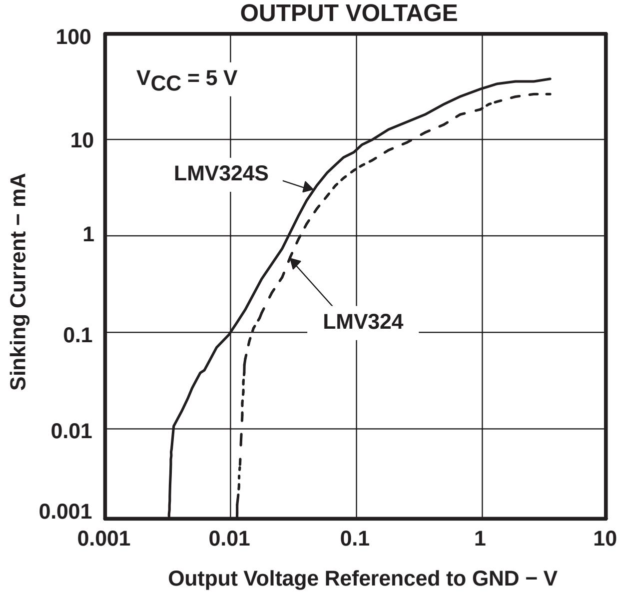


Figure 16

TYPICAL CHARACTERISTICS

SHORT-CIRCUIT CURRENT
vs
TEMPERATURE

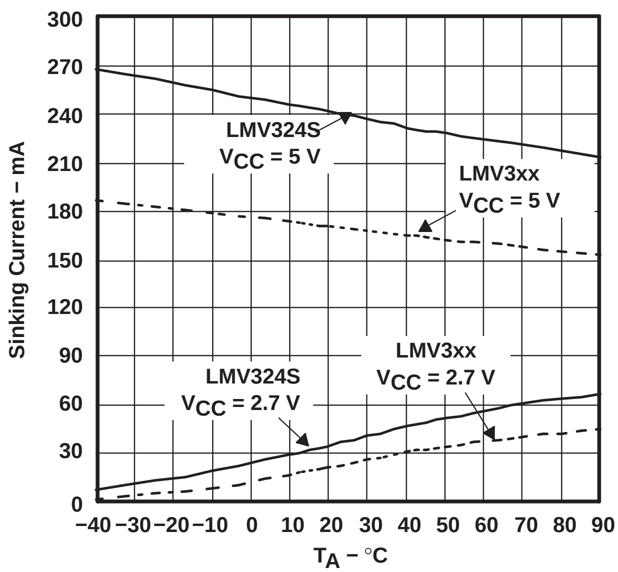


Figure 17

SHORT-CIRCUIT CURRENT
vs
TEMPERATURE

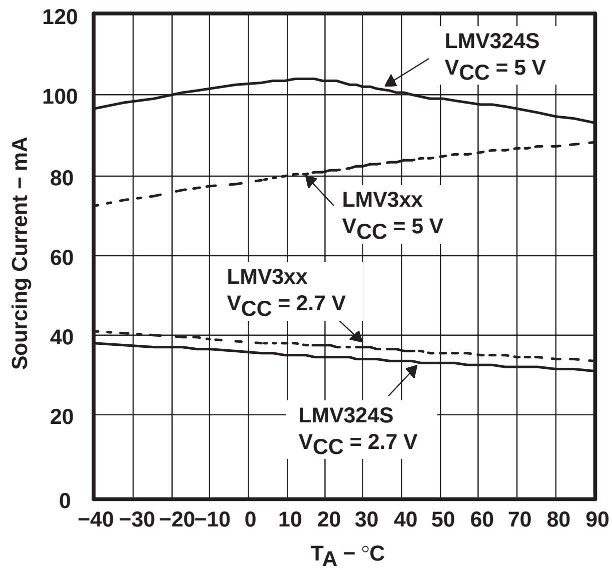


Figure 18

−k_{SVR}
vs
FREQUENCY

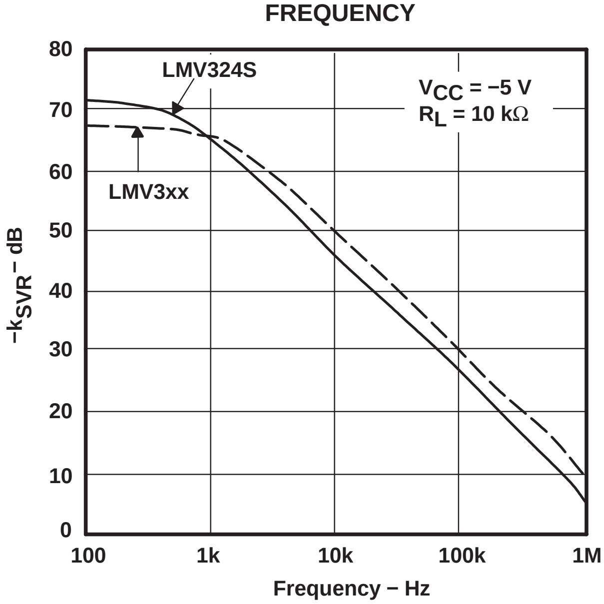


Figure 19

+k_{SVR}
vs
FREQUENCY

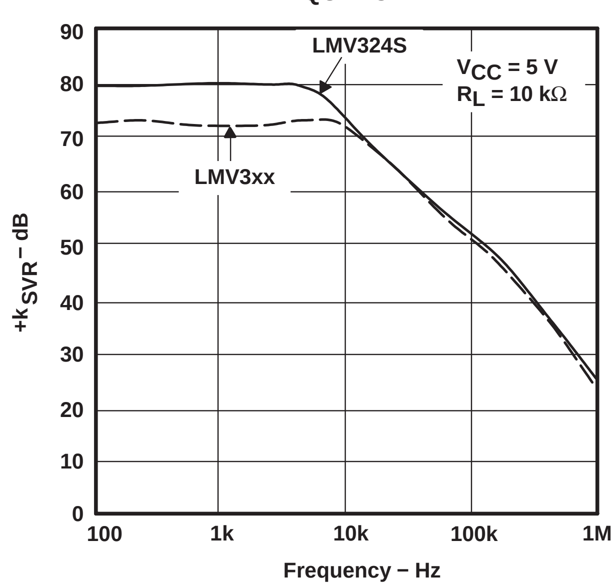


Figure 20

TYPICAL CHARACTERISTICS

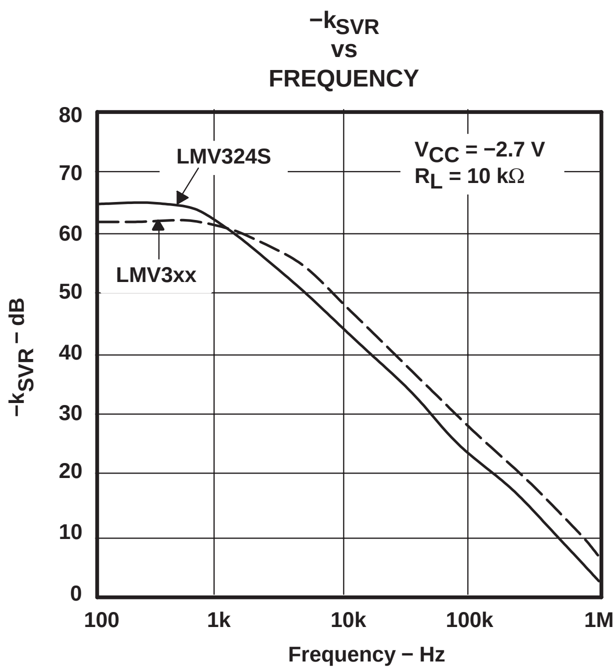


Figure 21

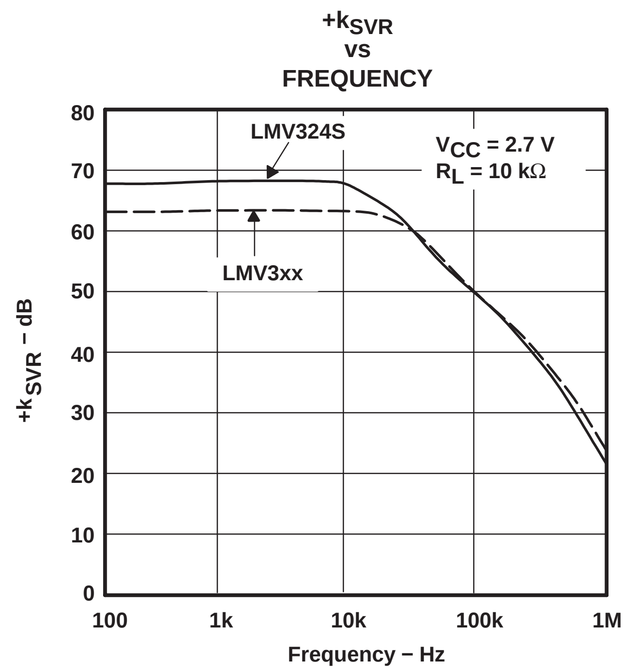


Figure 22

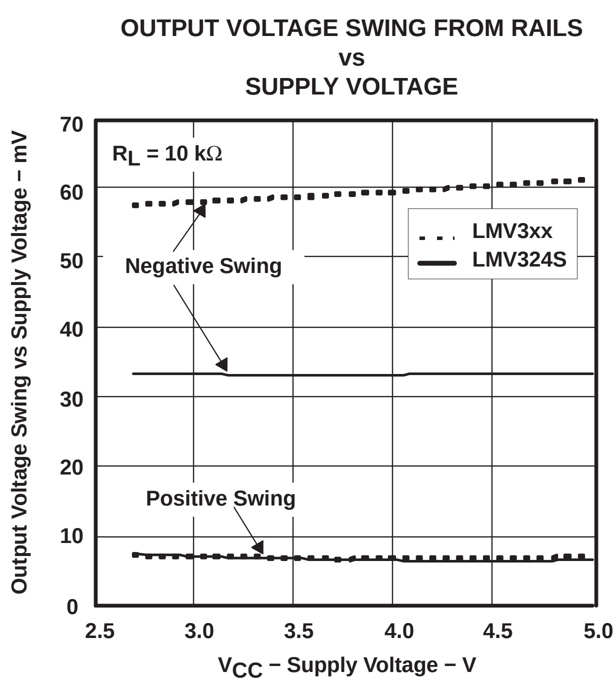


Figure 23

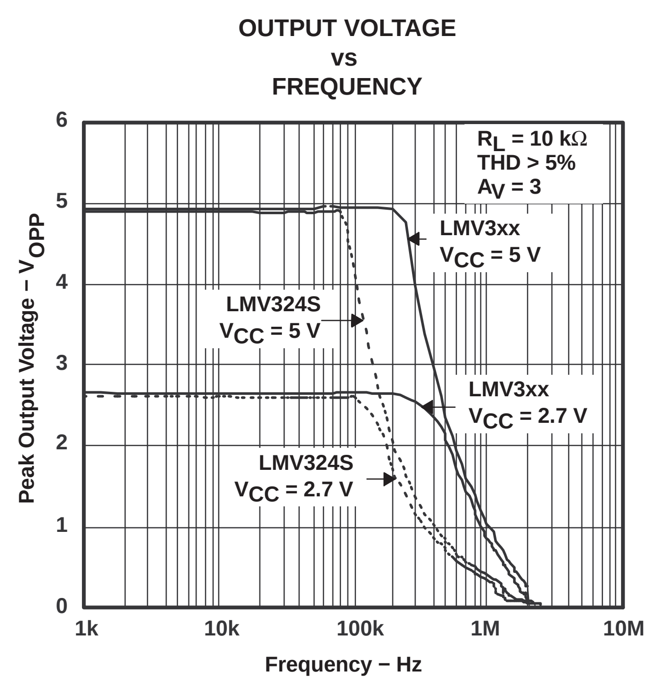


Figure 24

TYPICAL CHARACTERISTICS

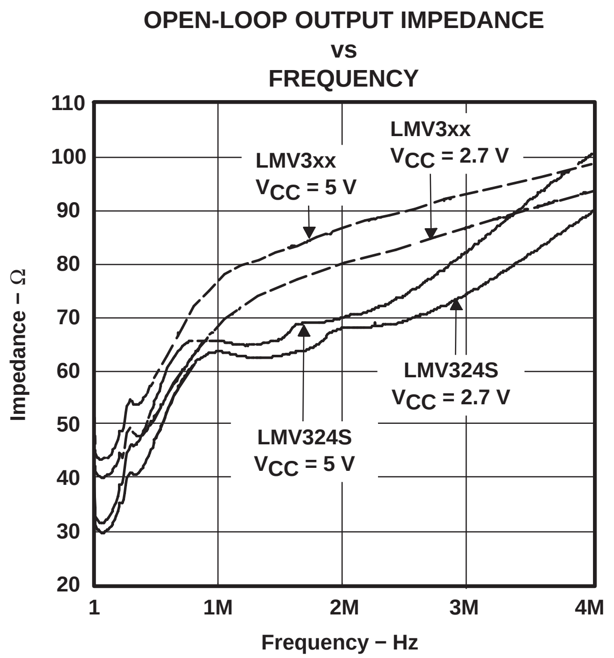


Figure 25

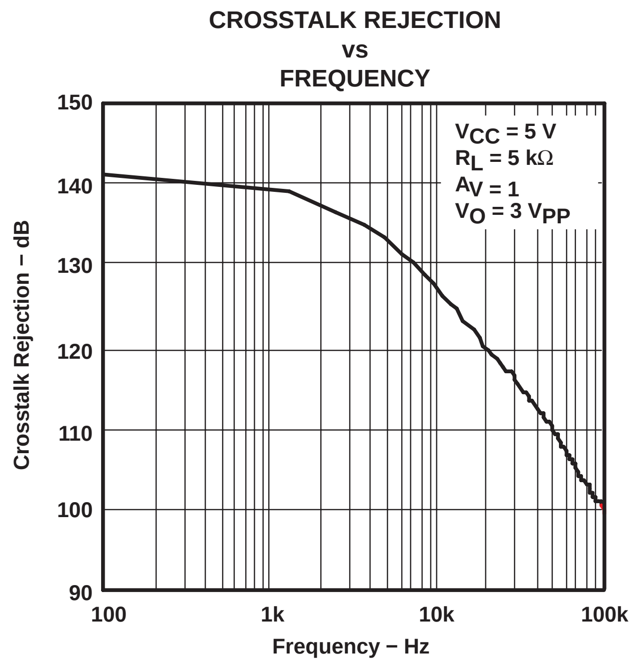


Figure 26

TYPICAL CHARACTERISTICS

NONINVERTING LARGE-SIGNAL
PULSE RESPONSE

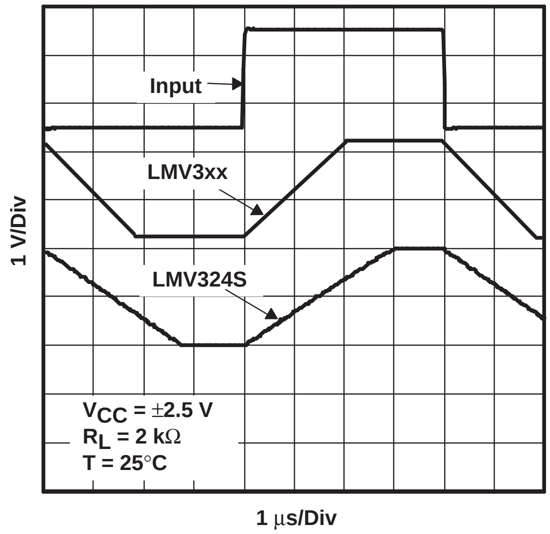


Figure 27

NONINVERTING LARGE-SIGNAL
PULSE RESPONSE

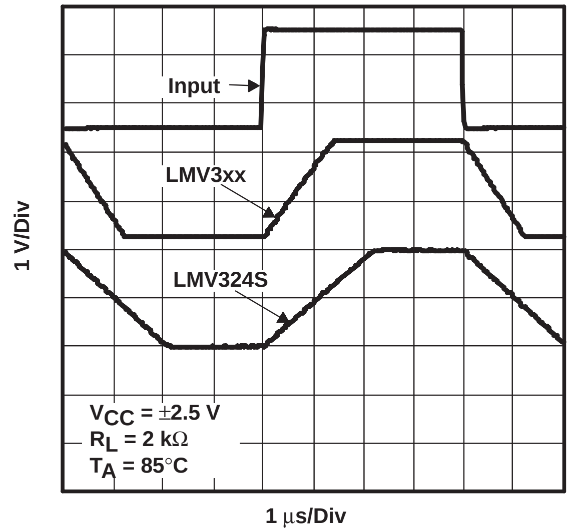


Figure 28

NONINVERTING LARGE-SIGNAL
PULSE RESPONSE

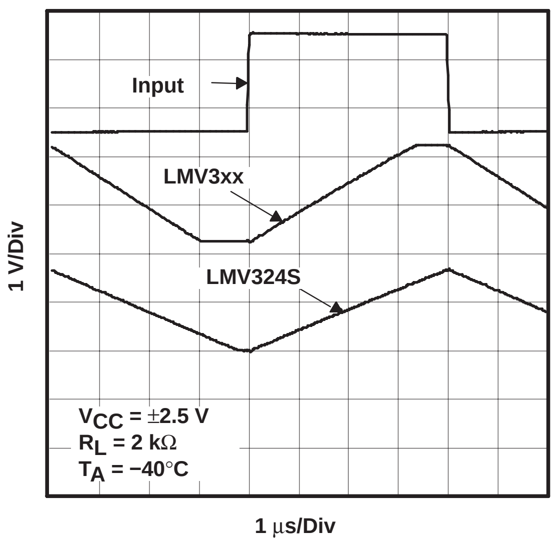


Figure 29

TYPICAL CHARACTERISTICS

NONINVERTING SMALL-SIGNAL PULSE RESPONSE

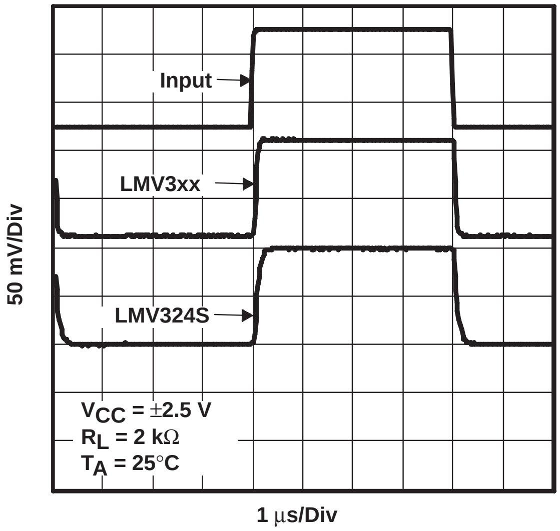


Figure 30

NONINVERTING SMALL-SIGNAL PULSE RESPONSE

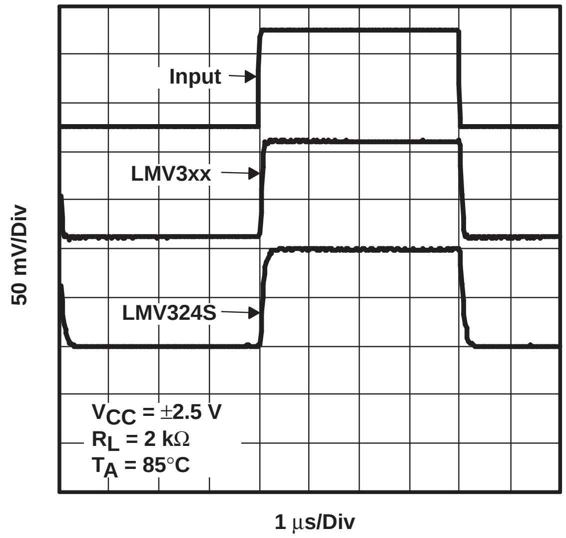


Figure 31

NONINVERTING SMALL-SIGNAL PULSE RESPONSE

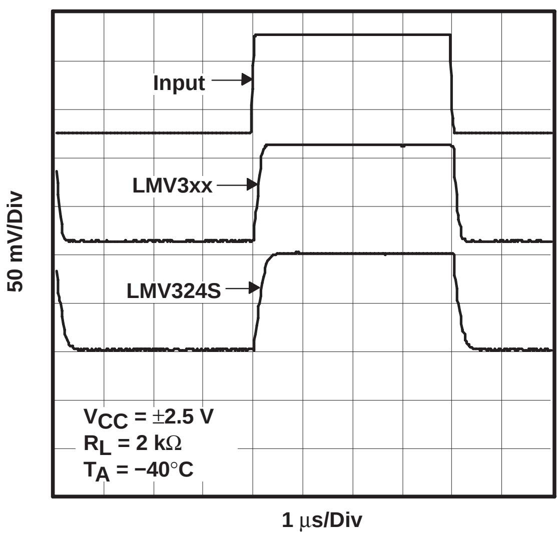


Figure 32

TYPICAL CHARACTERISTICS

INVERTING LARGE-SIGNAL PULSE RESPONSE

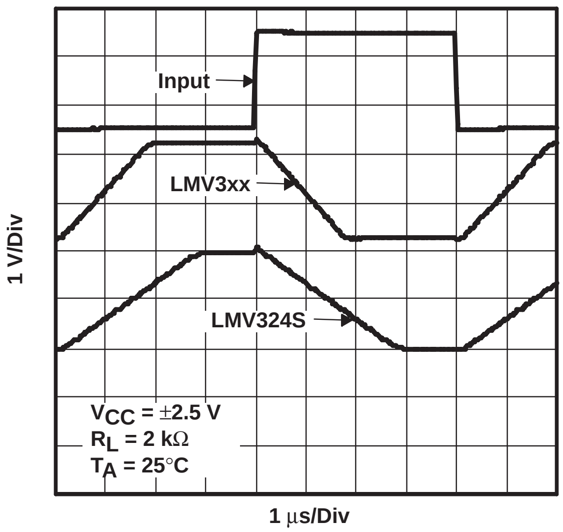


Figure 33

INVERTING LARGE-SIGNAL PULSE RESPONSE

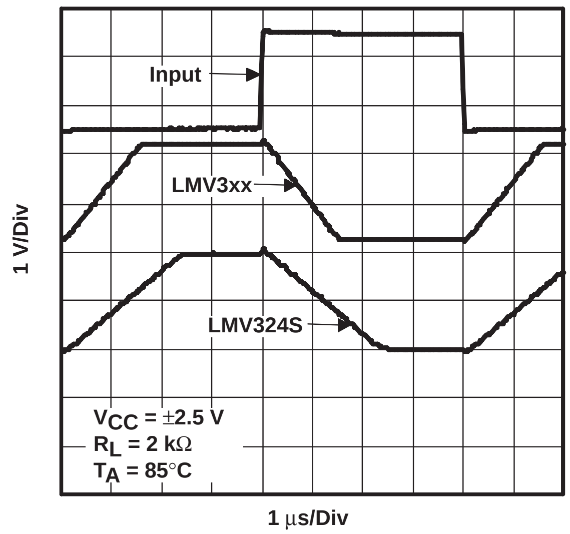


Figure 34

INVERTING LARGE-SIGNAL PULSE RESPONSE

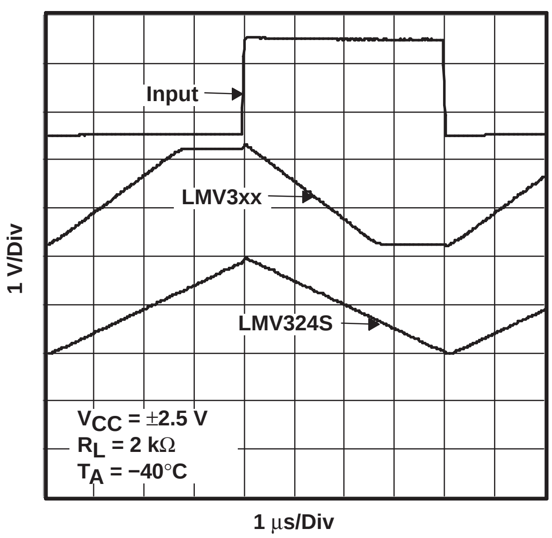


Figure 35

TYPICAL CHARACTERISTICS

INVERTING SMALL-SIGNAL PULSE RESPONSE

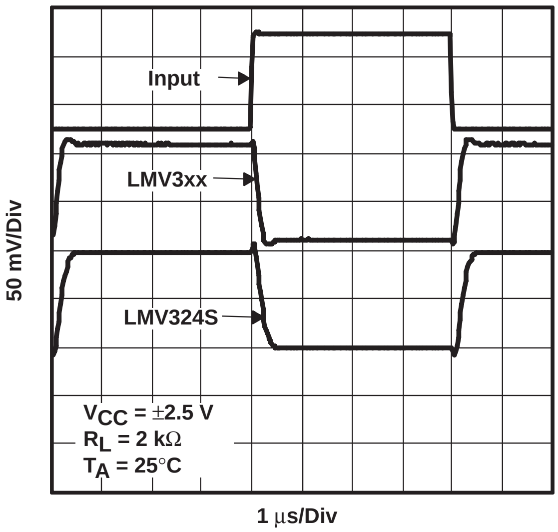


Figure 36

INVERTING SMALL-SIGNAL PULSE RESPONSE

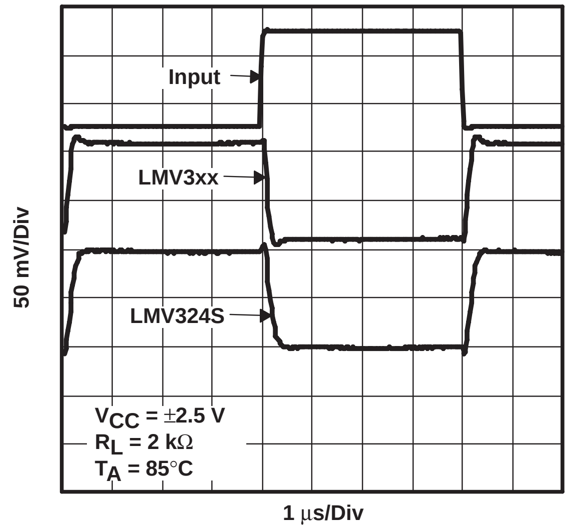


Figure 37

INVERTING SMALL-SIGNAL PULSE RESPONSE

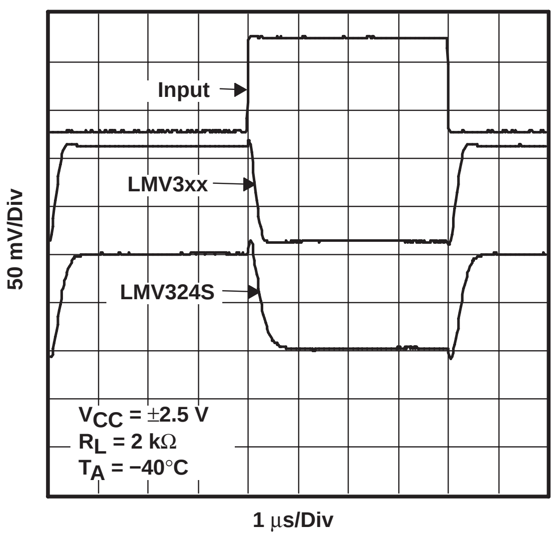


Figure 38

TYPICAL CHARACTERISTICS

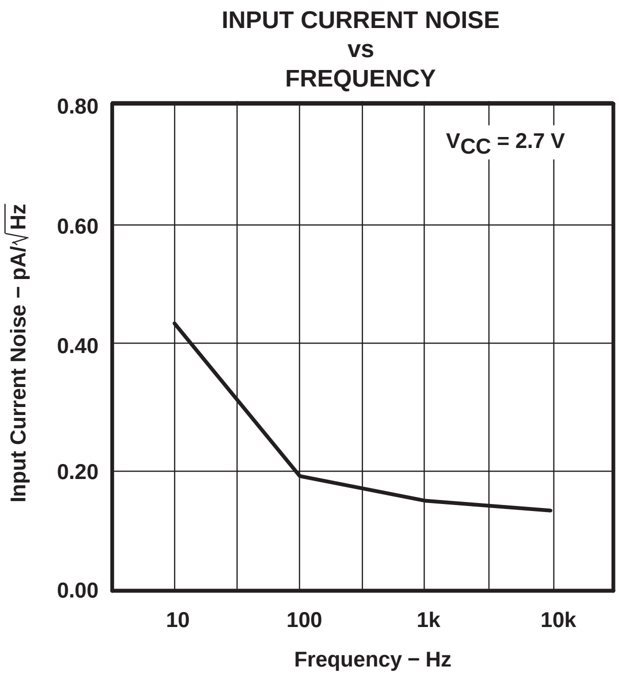


Figure 39

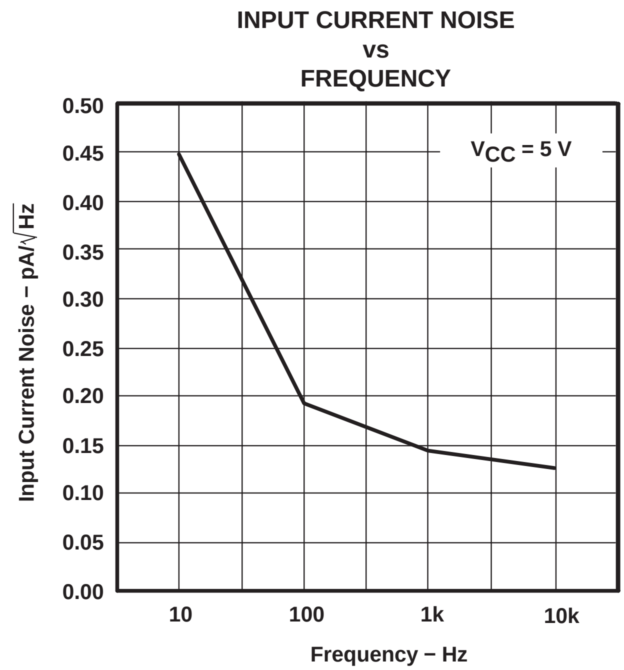


Figure 40

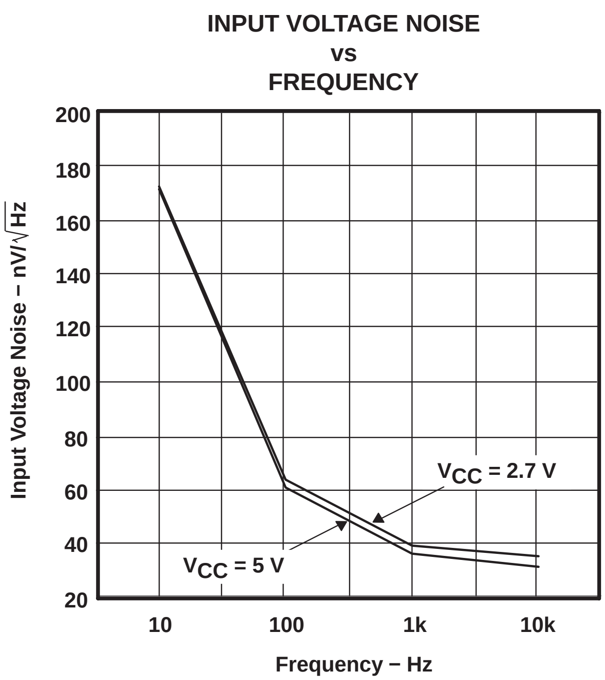


Figure 41

TYPICAL CHARACTERISTICS

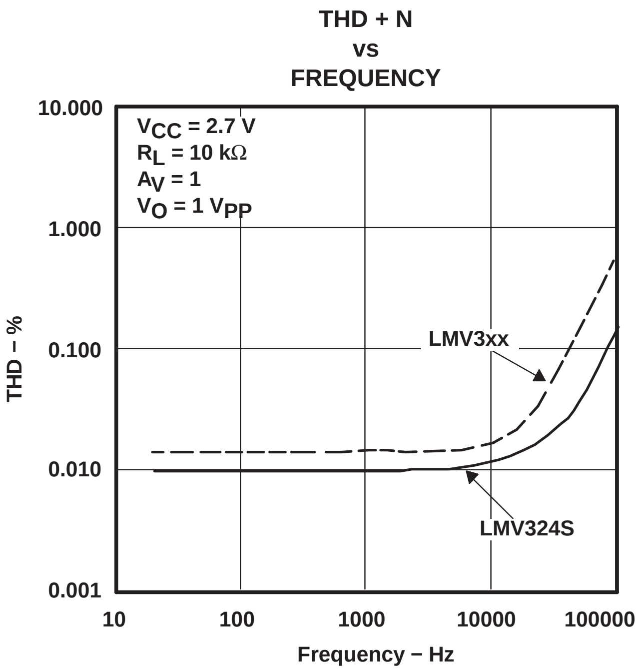


Figure 42

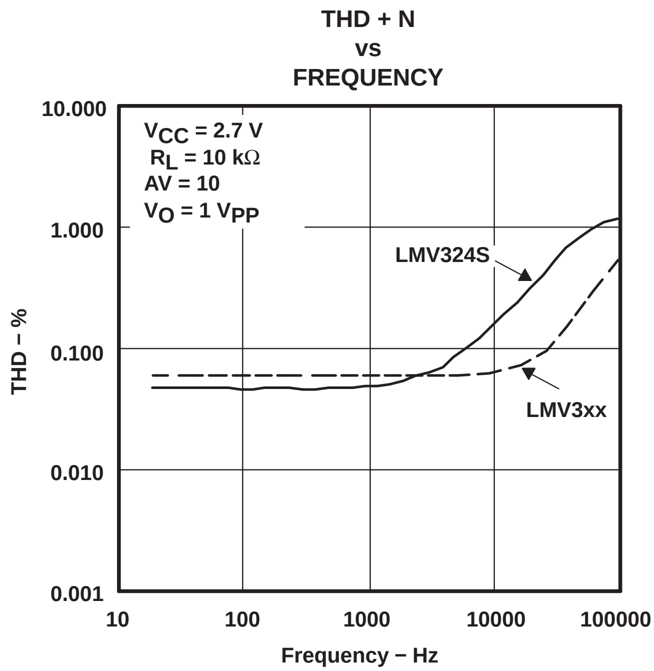


Figure 43

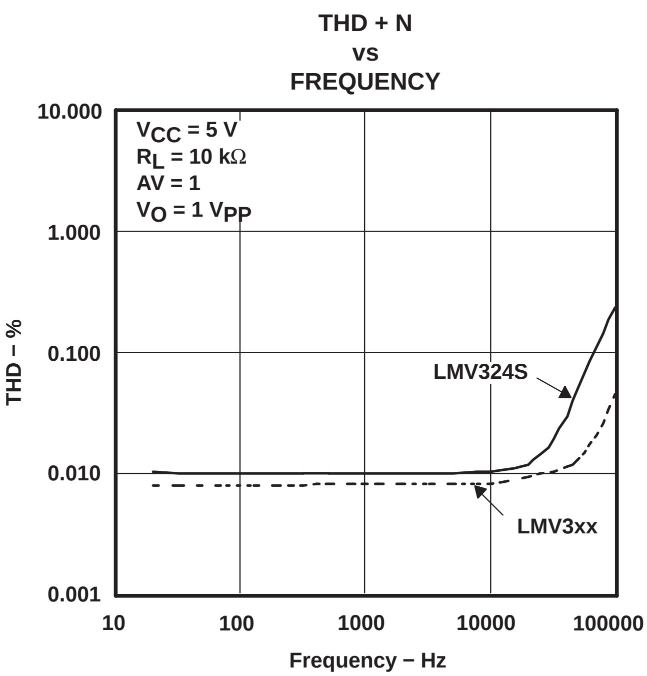


Figure 44

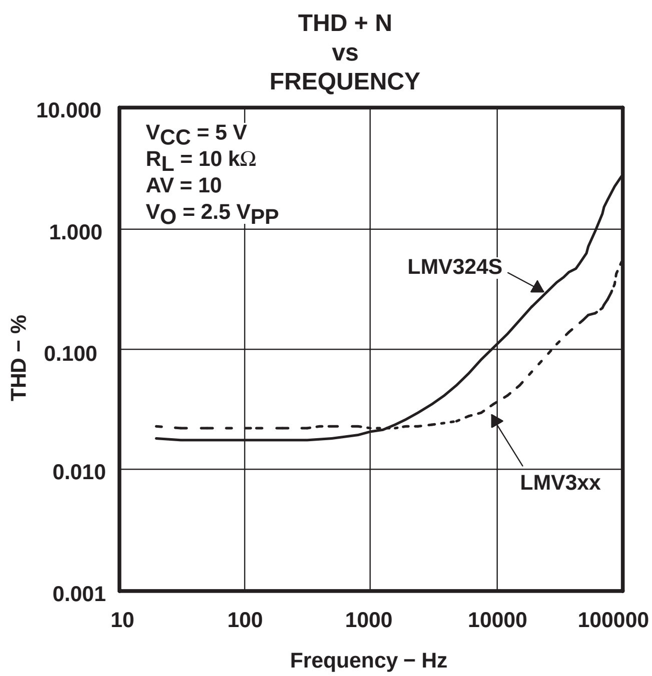


Figure 45