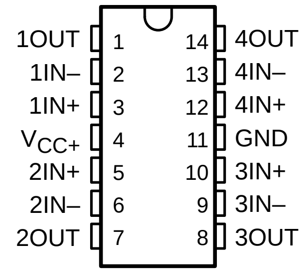
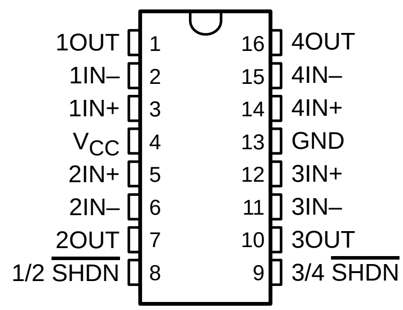
- **2.7-V and 5-V Performance**
- **Low-Power Shutdown Mode (LMV324S)**
- **No Crossover Distortion**
- **Low Supply Current:**
  LMV321 . . . 130 μA Typ
  LMV358 . . . 210 μA Typ
  LMV324 . . . 410 μA Typ
  LMV324S . . . 410 μA Typ
- **Rail-to-Rail Output Swing**
- **ESD Protection Exceeds JESD 22**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

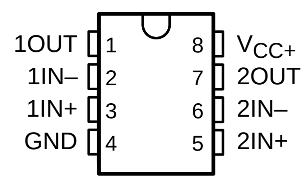
LMV324 . . . D OR PW PACKAGE
(TOP VIEW)



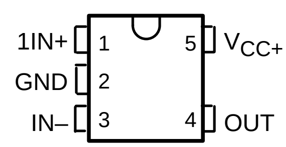
LMV324S . . . D OR PW PACKAGE
(TOP VIEW)



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



LMV321 . . . DBV OR DCK PACKAGE
(TOP VIEW)



description/ordering information

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 is a variation of the standard LMV324 that includes a power-saving shutdown feature that reduces supply current to a maximum of 5 μA per channel when the amplifiers are not needed.

The LMV321, LMV358, LMV324, and LMV324S are the most cost-effective solutions 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/μs slew rate.

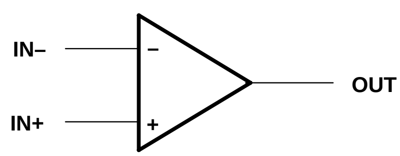
The LMV321 is available in the ultra-small DCK (SC-70) package, which is approximately one-half the size of the DBV (SOT-23) package. This package saves space on printed circuit boards and enables the design of small portable electronic devices. It also allows the designer to place the device closer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

ORDERING INFORMATION

T_A		PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING‡
–40°C to 85°C	Single	SC-70 (DCK)	Reel of 3000	LMV321IDCKR	R3_
			Reel of 250	LMV321IDCKT	
		SOT23 (DBV)	Reel of 3000	LMV321IDBVR	RC1_
	Dual	MSOP/VSSOP (DGK)	Reel of 2500	LMV358IDGKR	R5S
		SOIC (D)	Tube of 75	LMV358ID	MV358I
			Reel of 2500	LMV358IDR	
		TSSOP (PW)	Reel of 2000	LMV358IPWR	MV358I
	Quad	SOIC (D)	Tube of 50	LMV324ID	LMV324I
			Reel of 2500	LMV324IDR	
			Tube of 40	LMV324SID	LMV324SI
			Reel of 2500	LMV324SIDR	
		TSSOP (PW)	Reel of 2000	LMV324IPWR	MV324I
				LMV324SIPWR	MV324SI

† Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.
‡ DBV/DCK: The actual top-side marking has one additional character that designates the assembly/test site.

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°C,
V_{CC} ≤ 5.5 V (see Note 3) .... Unlimited
Operating virtual junction temperature .... 150°C
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 package .... 206°C/W
DCK package .... 252°C/W
DGK 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
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:
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 turn-on voltage level (LMV324S)‡	V_{CC} = 2.7 V	1.7		V
		V_{CC} = 5 V	3.5		
V_{IL}	Amplifier turn-off voltage level (LMV324S)	V_{CC} = 2.7 V		0.7	V
		V_{CC} = 5 V		1.5	
T_A	Operating free-air temperature		–40	85	°C

‡ 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	mV
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		$nV/\sqrt{Hz}$
I_n	Equivalent input noise current	f = 1 kHz			0.17		$pA/\sqrt{Hz}$

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 turn-on time	A_V = 1, R_L = Open (measured at 50% point)		2		μs
$t_{(off)}$	Amplifier turn-off 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
				–40°C to 85°C			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
				–40°C to 85°C			500	
I_{IO}	Input offset current			25°C		5	50	nA
				–40°C to 85°C			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
				–40°C to 85°C	V_{CC}–400			
			Low level	25°C		120	300	
				–40°C to 85°C			400	
		R_L = 10 kΩ to 2.5 V	High level	25°C	V_{CC}–100	V_{CC}–10		
				–40°C to 85°C	V_{CC}–200			
			Low level	25°C		65	180	
				–40°C to 85°C			280	
A_{VD}	Large-signal differential voltage gain	R_L = 2 kΩ		25°C	15	100		V/mV
				–40°C to 85°C	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
				–40°C to 85°C			350	
		LMV358I (both amplifiers)		25°C		210	440	
				–40°C to 85°C			615	
		LMV324I/LMV324SI (all four amplifiers)		25°C		410	830	
				–40°C to 85°C			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

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 turn-on time	A_V = 1, R_L = Open (measured at 50% point)			2		μs
$t_{(off)}$	Amplifier turn-off time	A_V = 1, R_L = Open (measured at 50% point)			40		ns

TYPICAL CHARACTERISTICS

GAIN AND PHASE MARGIN
vs
FREQUENCY

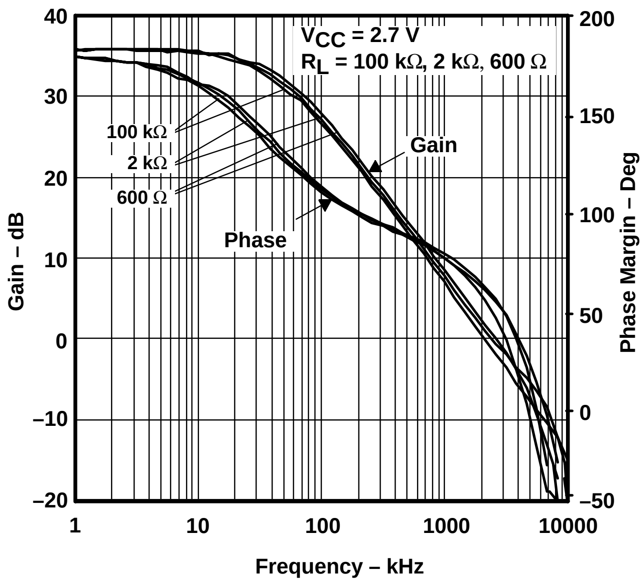


Figure 1

GAIN AND PHASE MARGIN
vs
FREQUENCY

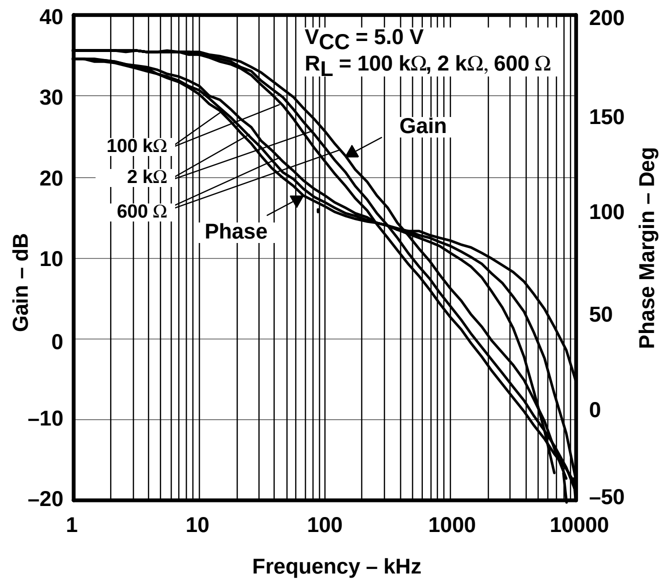


Figure 2

GAIN AND PHASE MARGIN
vs
FREQUENCY

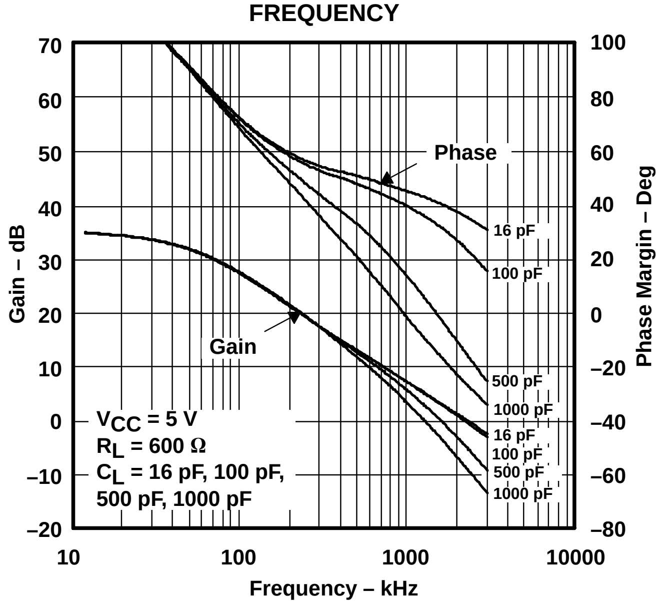


Figure 3

GAIN AND PHASE MARGIN
vs
FREQUENCY

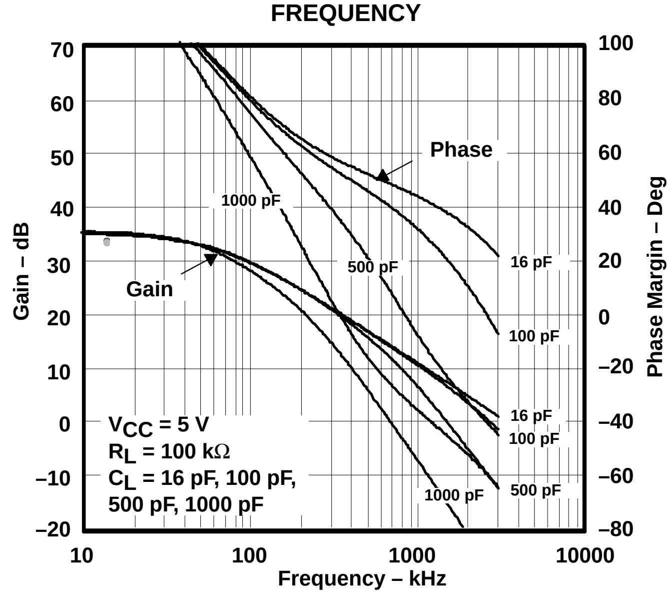


Figure 4

TYPICAL CHARACTERISTICS

GAIN AND PHASE MARGIN
vs
FREQUENCY

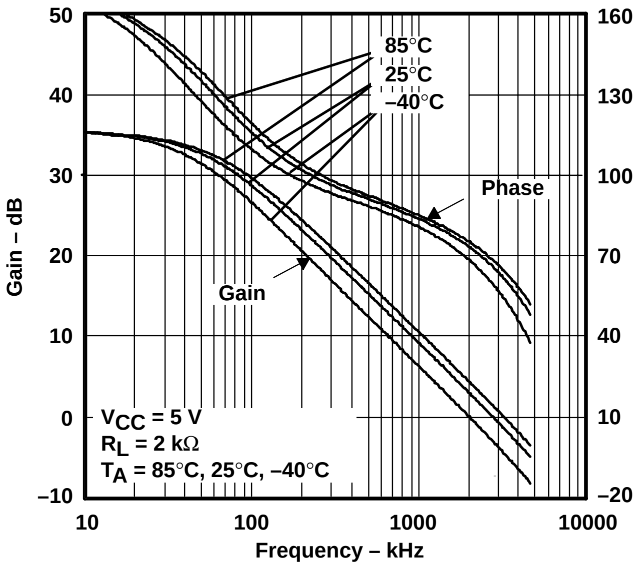


Figure 5

STABILITY
vs
CAPACITIVE LOAD

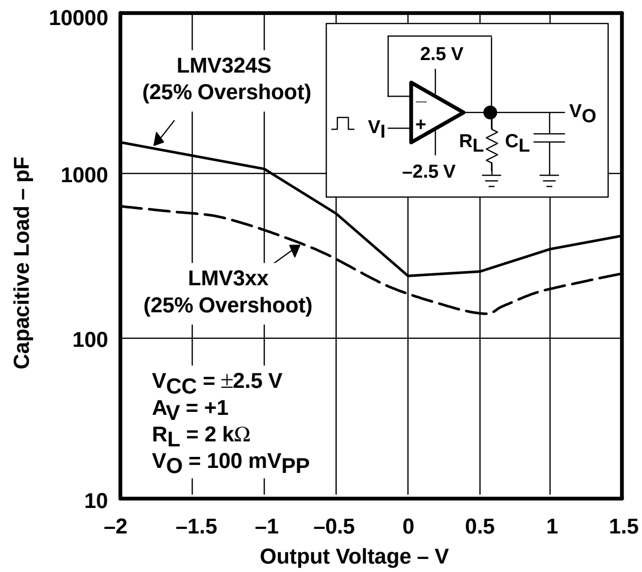


Figure 6

STABILITY
vs
CAPACITIVE LOAD

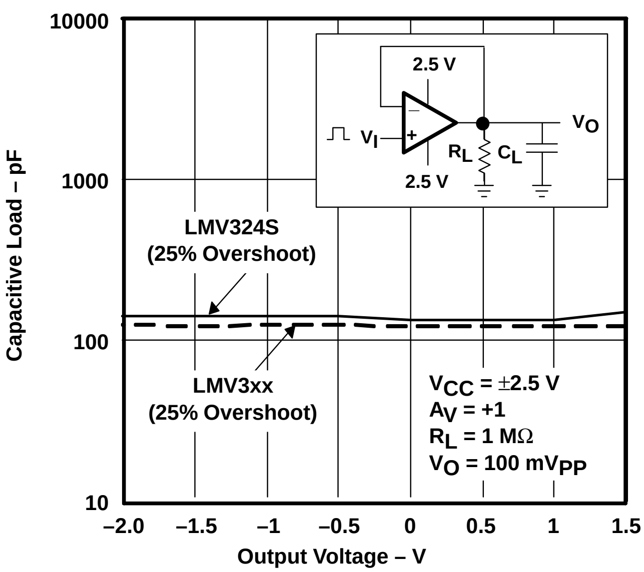


Figure 7

STABILITY
vs
CAPACITIVE LOAD

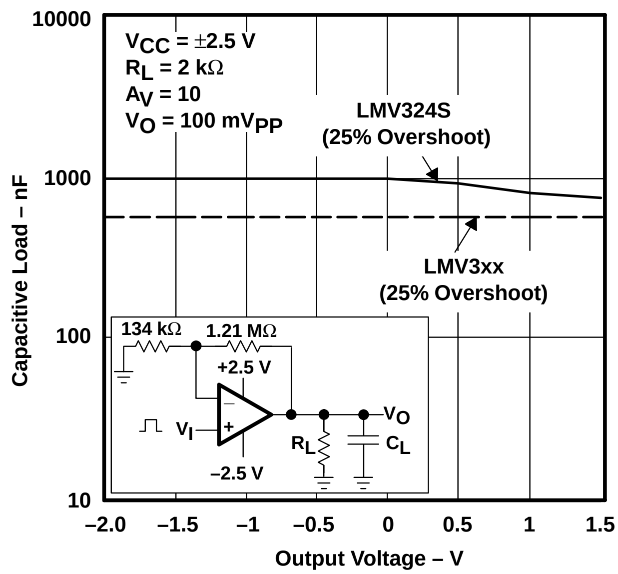


Figure 8

TYPICAL CHARACTERISTICS

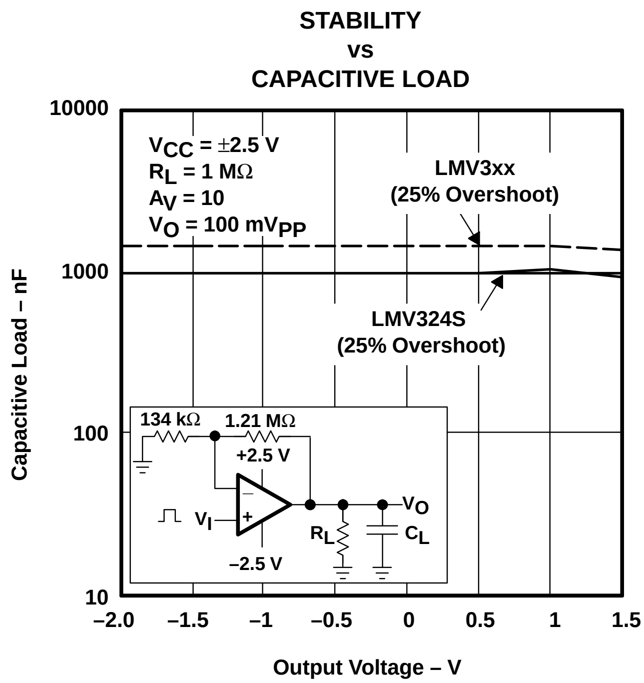


Figure 9

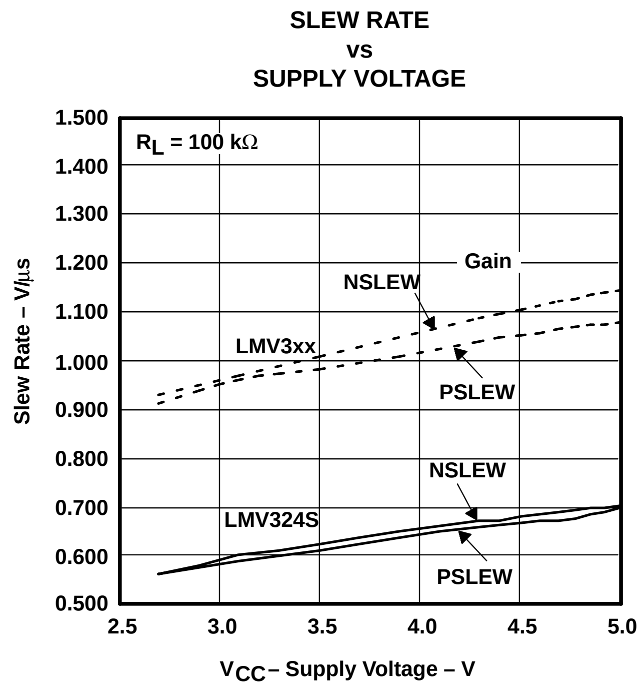


Figure 10

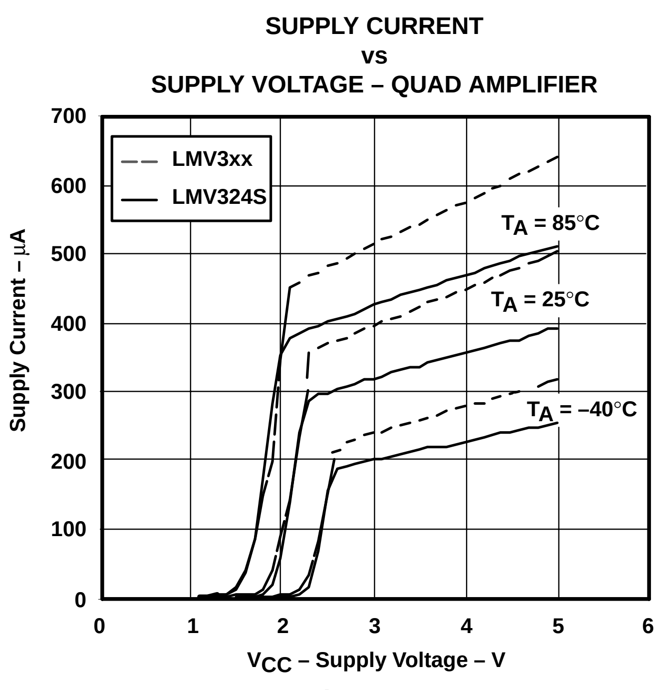


Figure 11

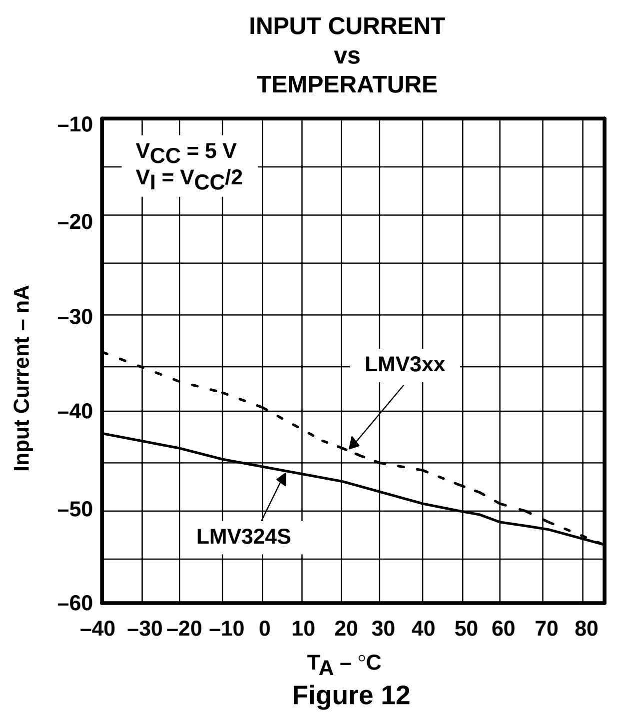


Figure 12

TYPICAL CHARACTERISTICS

SOURCE CURRENT vs OUTPUT VOLTAGE

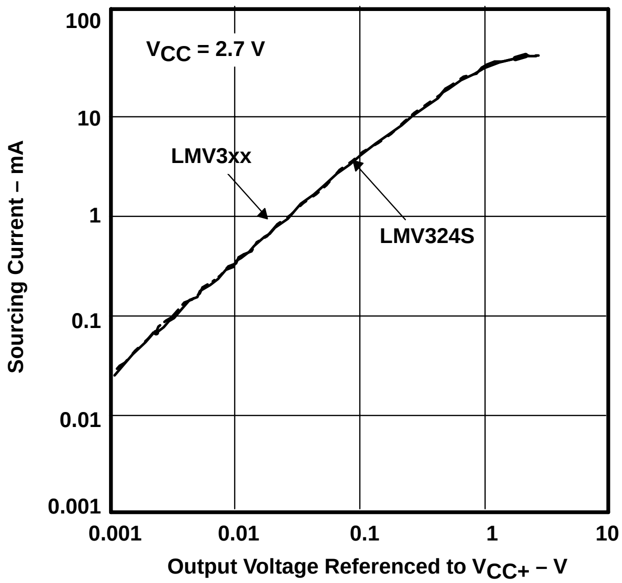


Figure 13

SOURCE CURRENT vs OUTPUT VOLTAGE

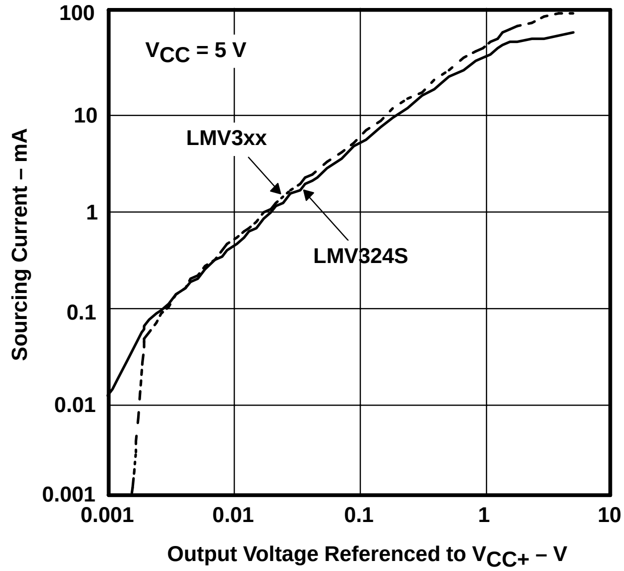


Figure 14

SINKING CURRENT vs OUTPUT VOLTAGE

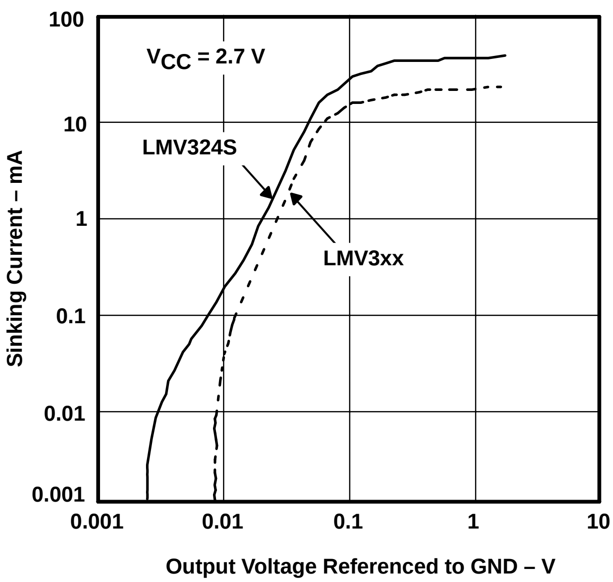


Figure 15

SINKING CURRENT vs OUTPUT VOLTAGE

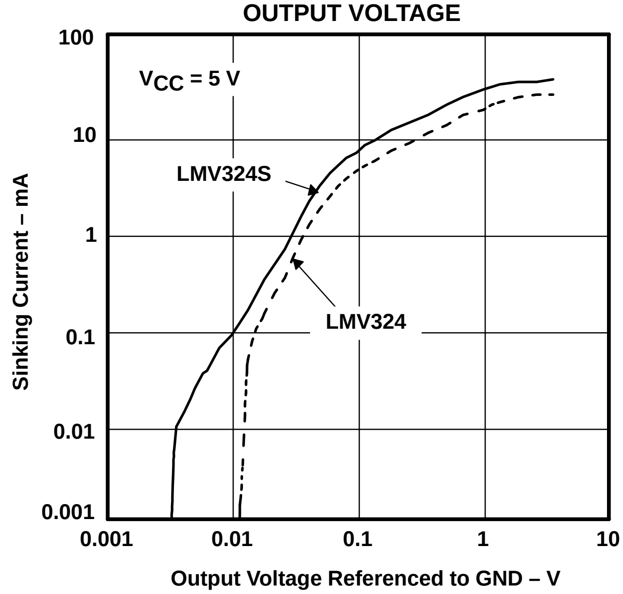


Figure 16

TYPICAL CHARACTERISTICS

SHORT-CIRCUIT CURRENT vs TEMPERATURE

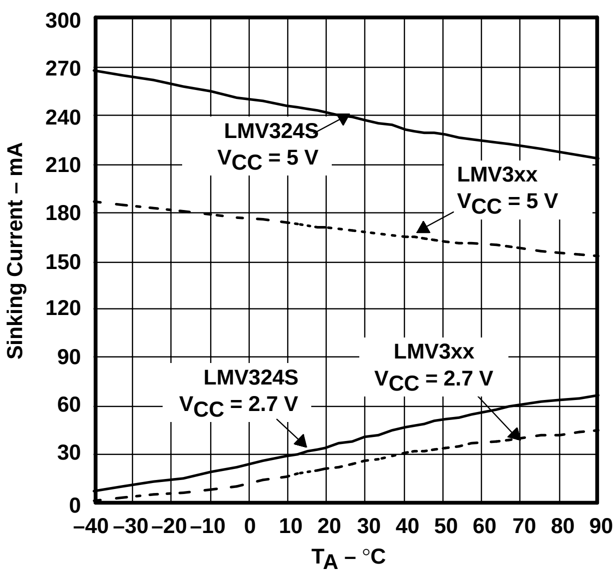


Figure 17

SHORT-CIRCUIT CURRENT vs TEMPERATURE

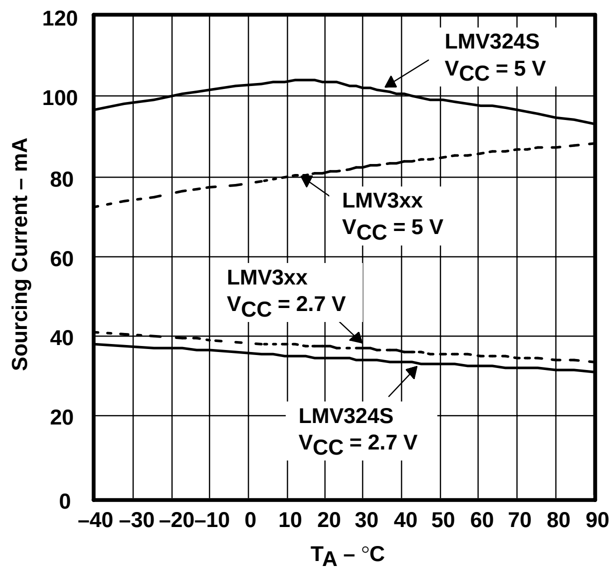


Figure 18

$-k_{SVR}$ vs FREQUENCY

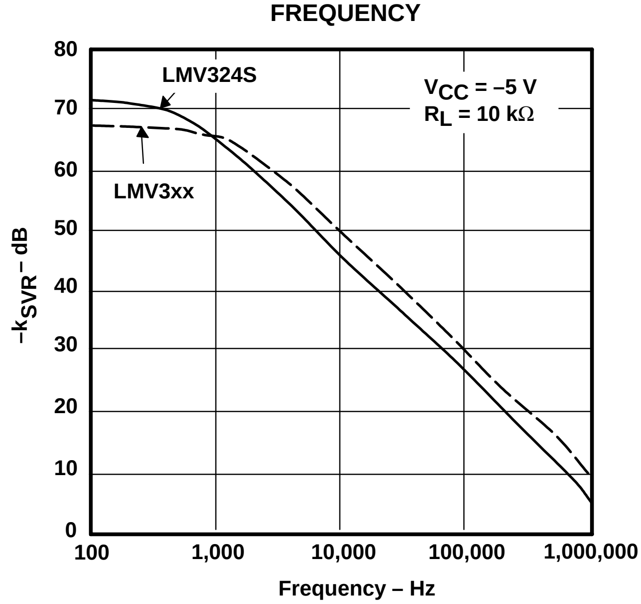


Figure 19

$+k_{SVR}$ vs FREQUENCY

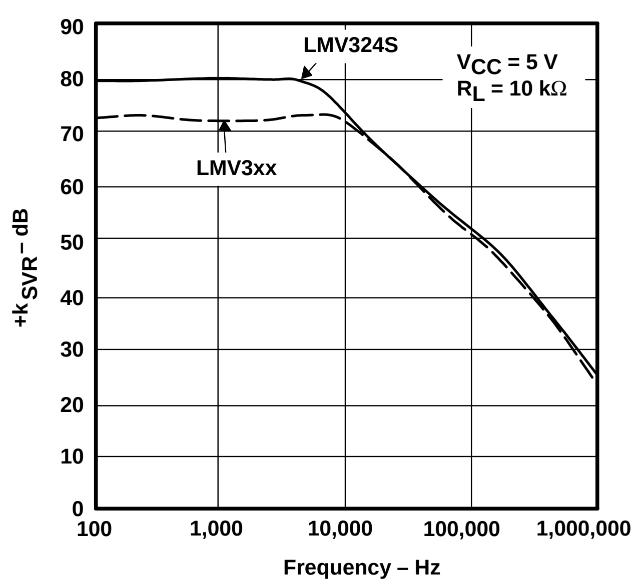


Figure 20

TYPICAL CHARACTERISTICS

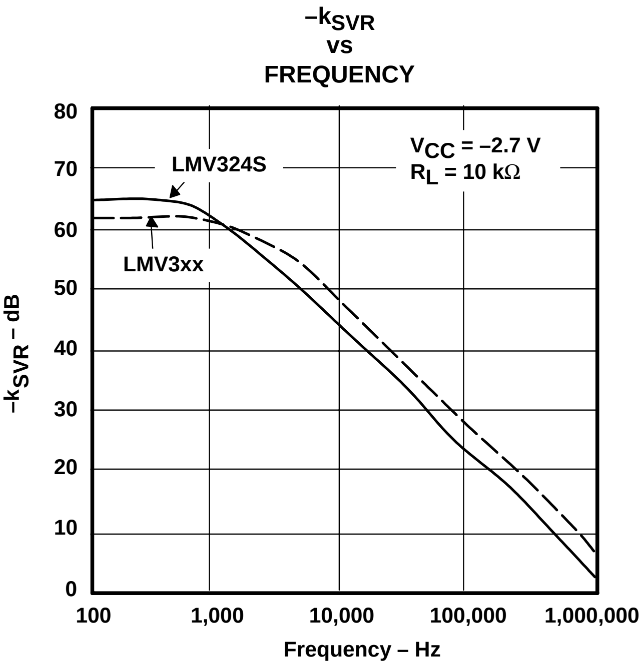


Figure 21

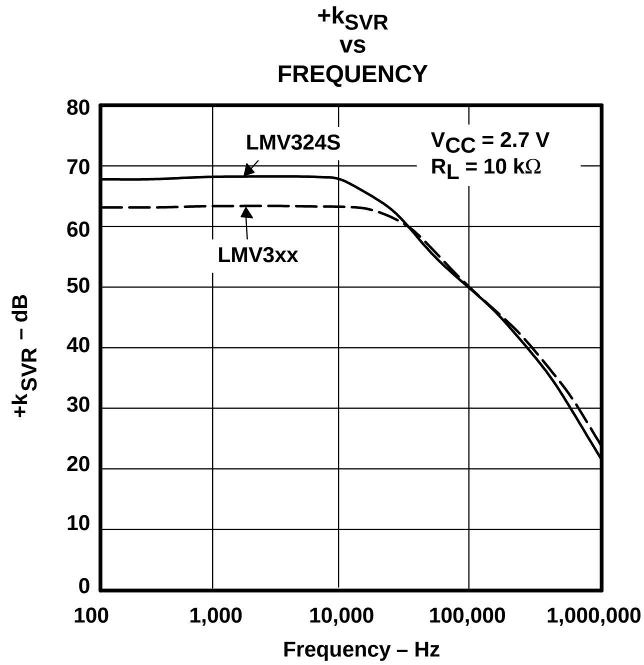


Figure 22

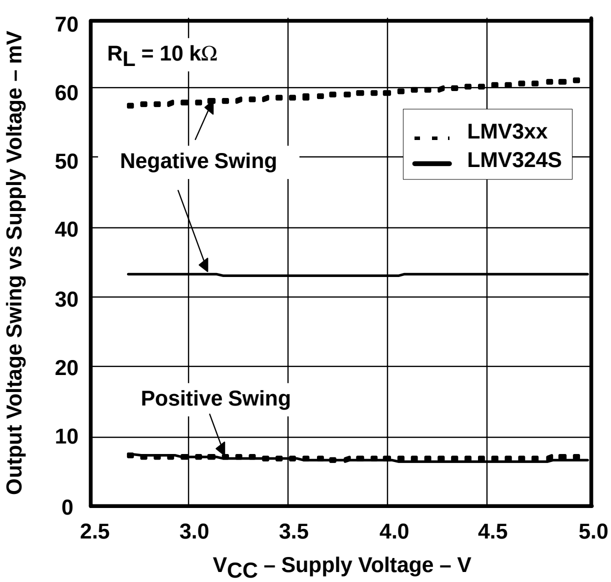


Figure 23

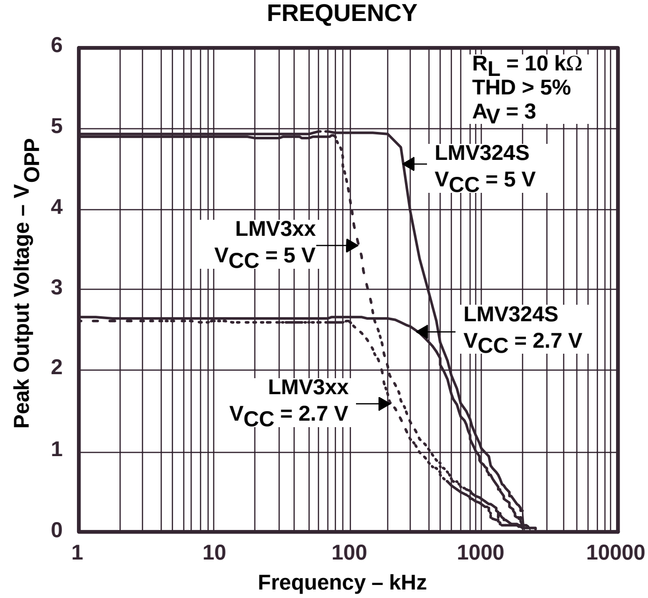


Figure 24

TYPICAL CHARACTERISTICS

OPEN-LOOP OUTPUT IMPEDANCE vs FREQUENCY

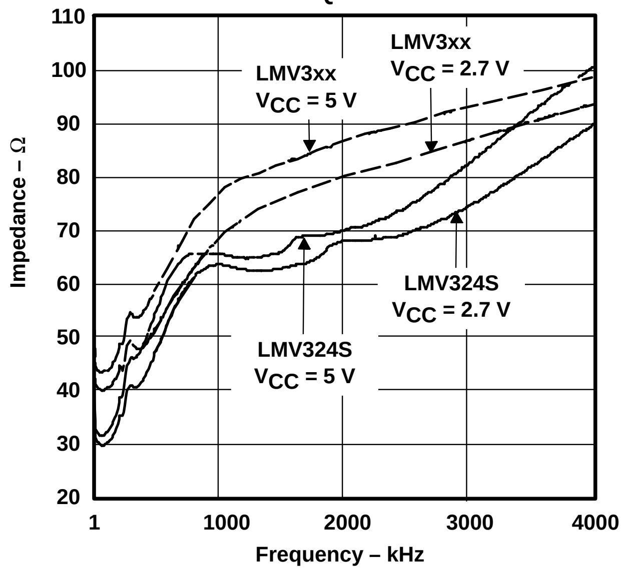


Figure 25

CROSSTALK REJECTION vs FREQUENCY

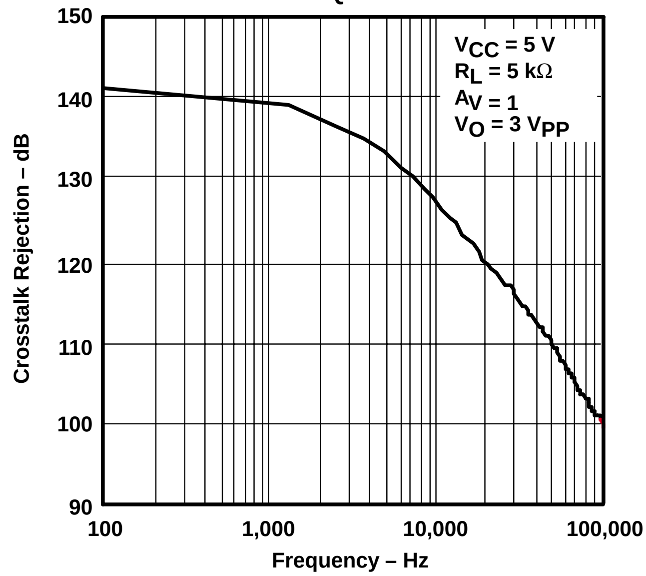


Figure 26

TYPICAL CHARACTERISTICS

NONINVERTING LARGE-SIGNAL PULSE RESPONSE

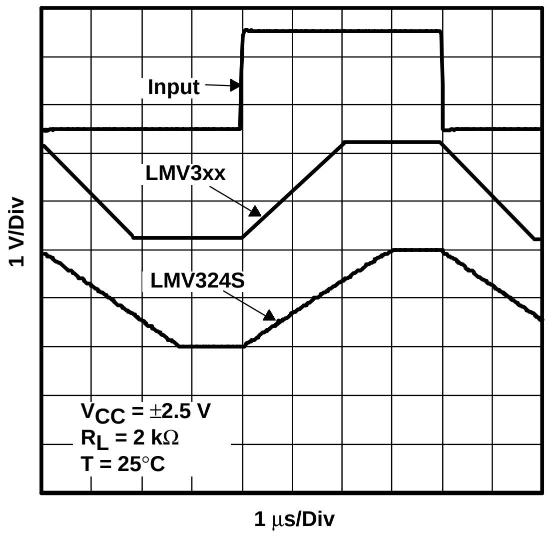


Figure 27

NONINVERTING LARGE-SIGNAL PULSE RESPONSE

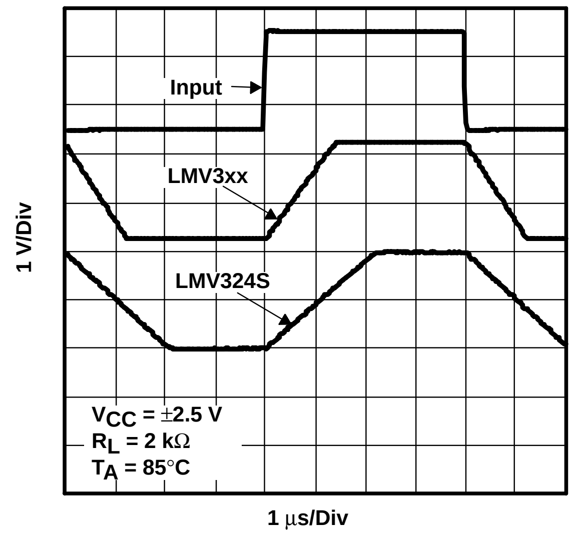


Figure 28

NONINVERTING LARGE-SIGNAL PULSE RESPONSE

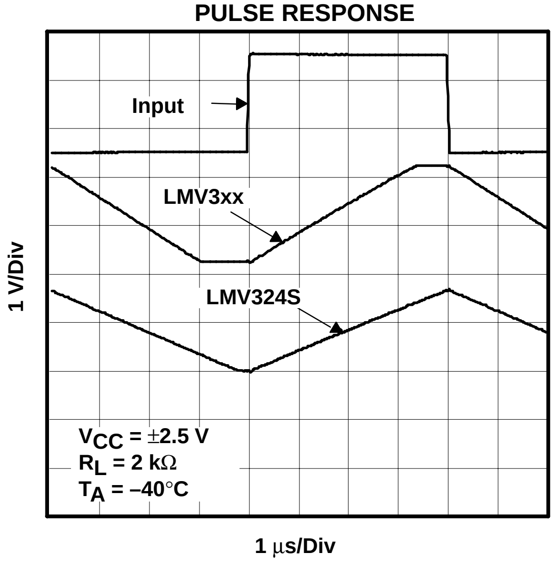


Figure 29

TYPICAL CHARACTERISTICS

NONINVERTING SMALL-SIGNAL PULSE RESPONSE

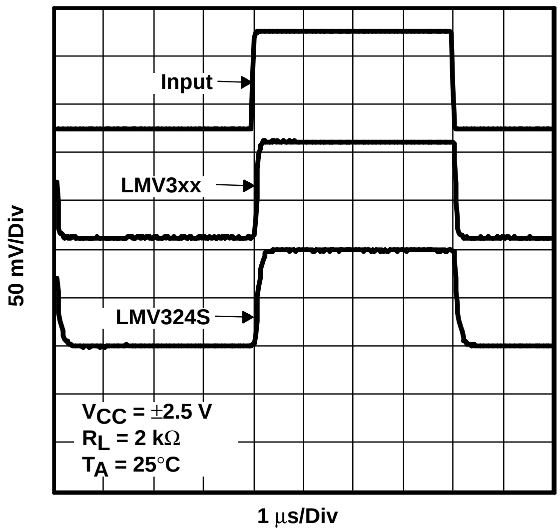


Figure 30

NONINVERTING SMALL-SIGNAL PULSE RESPONSE

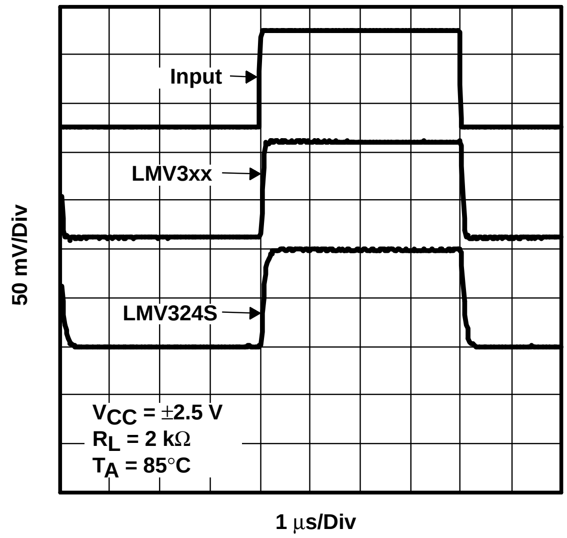


Figure 31

NONINVERTING SMALL-SIGNAL PULSE RESPONSE

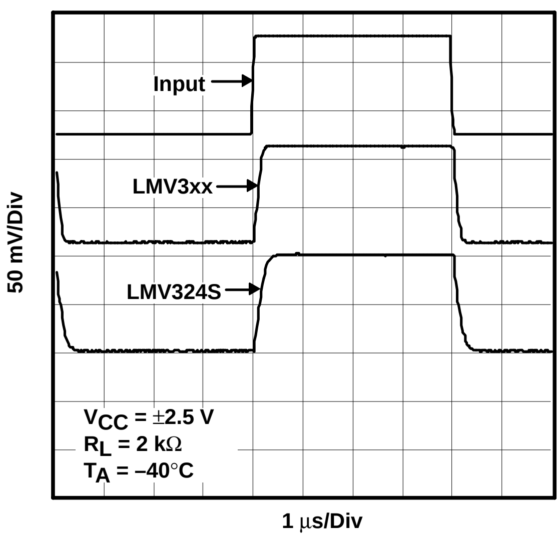


Figure 32

TYPICAL CHARACTERISTICS

INVERTING LARGE-SIGNAL PULSE RESPONSE

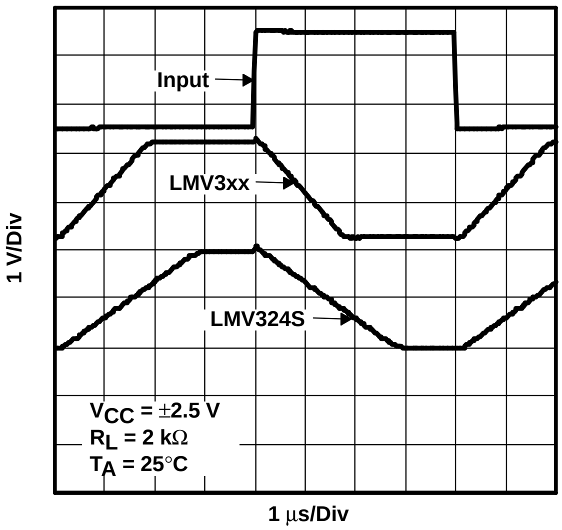


Figure 33

INVERTING LARGE-SIGNAL PULSE RESPONSE

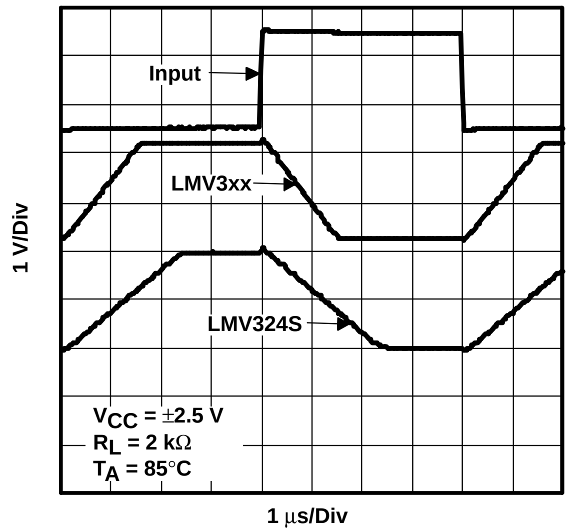


Figure 34

INVERTING LARGE-SIGNAL PULSE RESPONSE

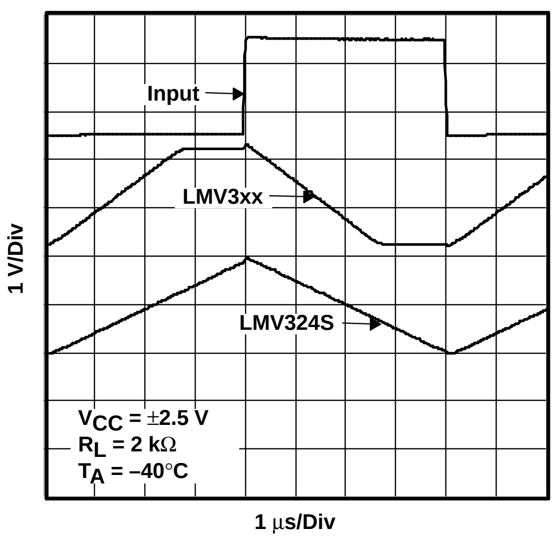


Figure 35

TYPICAL CHARACTERISTICS

INVERTING SMALL-SIGNAL PULSE RESPONSE

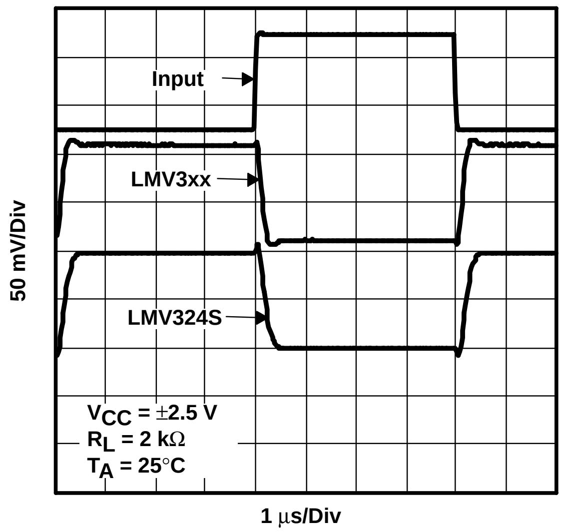


Figure 36

INVERTING SMALL-SIGNAL PULSE RESPONSE

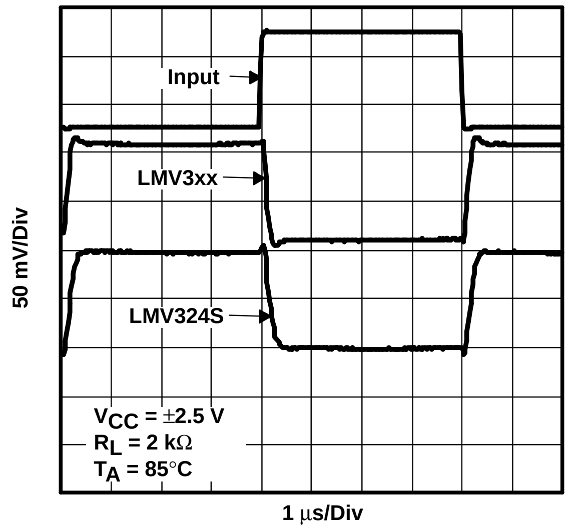


Figure 37

INVERTING SMALL-SIGNAL PULSE RESPONSE

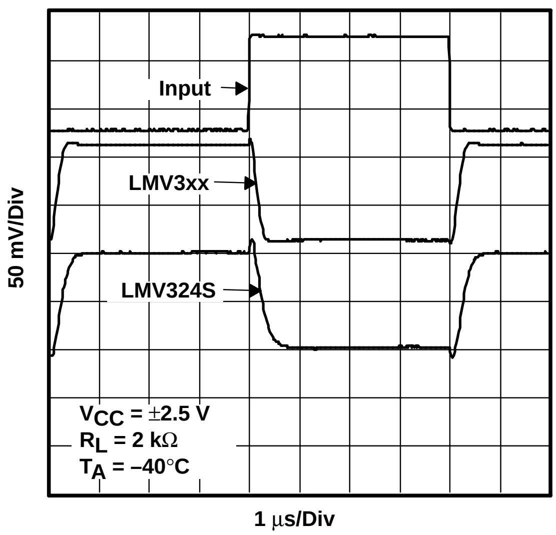


Figure 38

TYPICAL CHARACTERISTICS

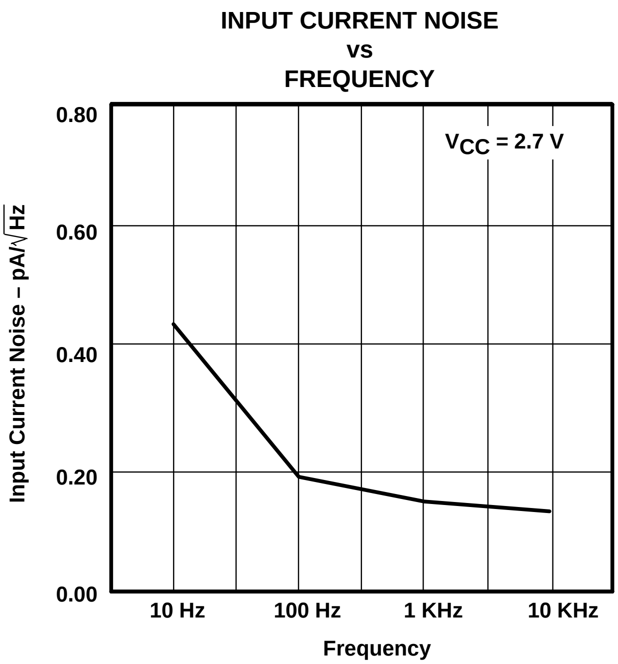


Figure 39

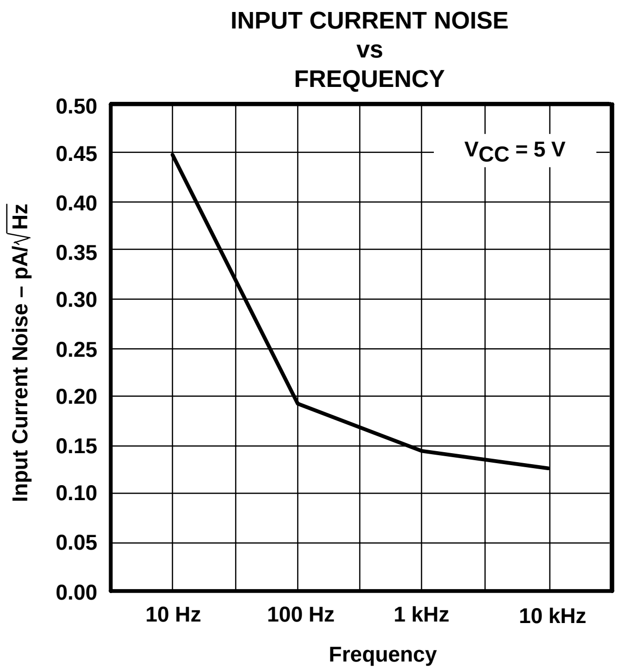


Figure 40

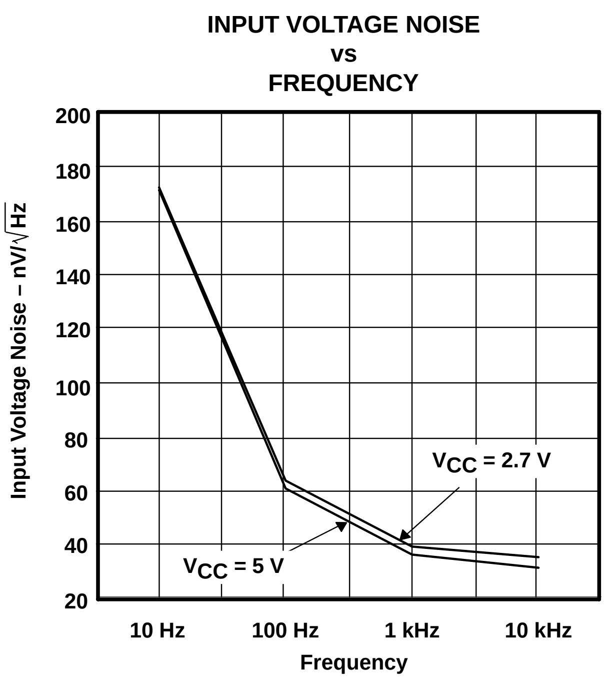


Figure 41

TYPICAL CHARACTERISTICS

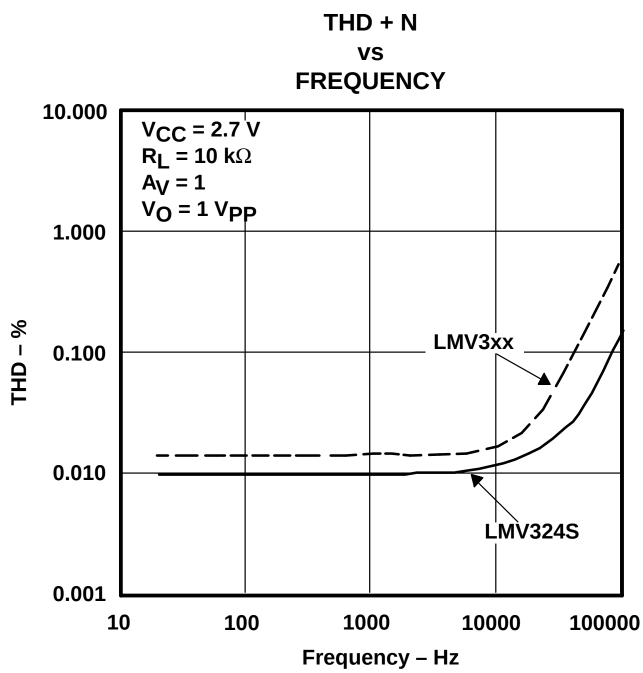


Figure 42

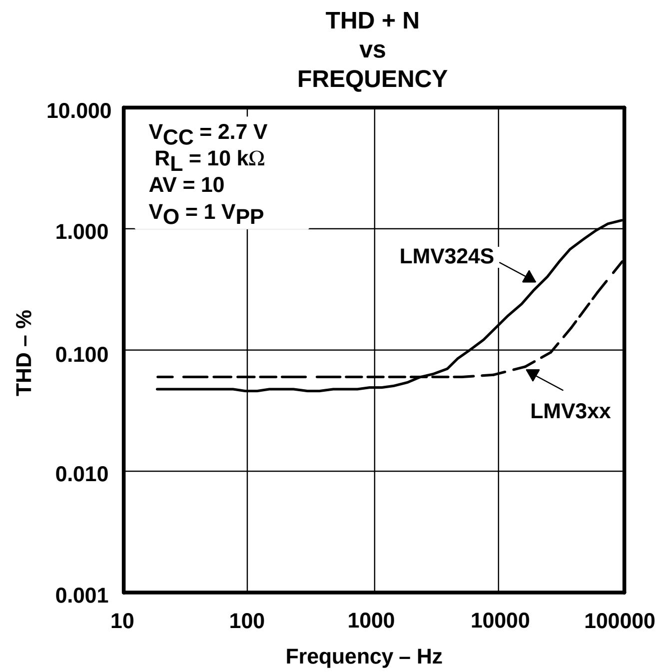


Figure 43

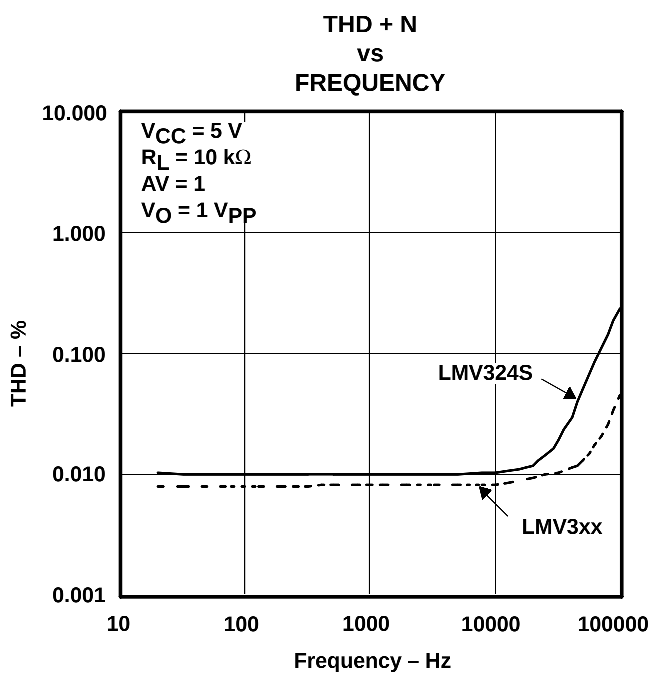


Figure 44

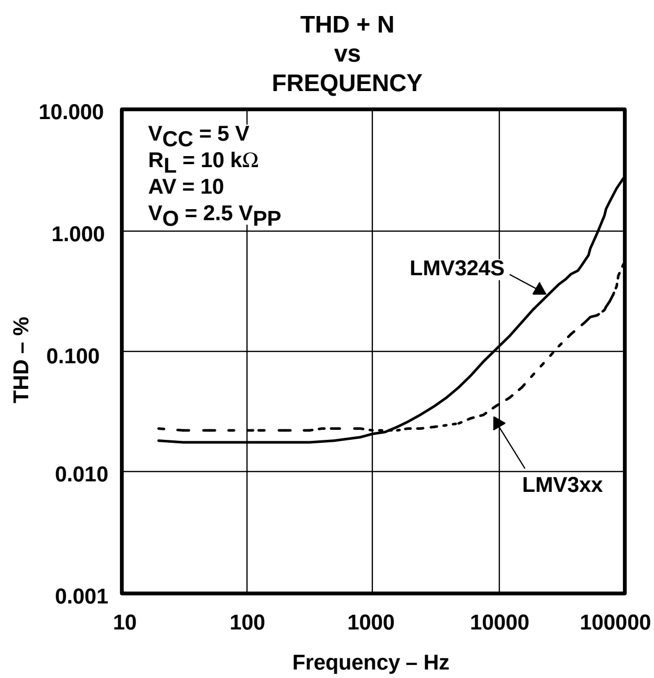
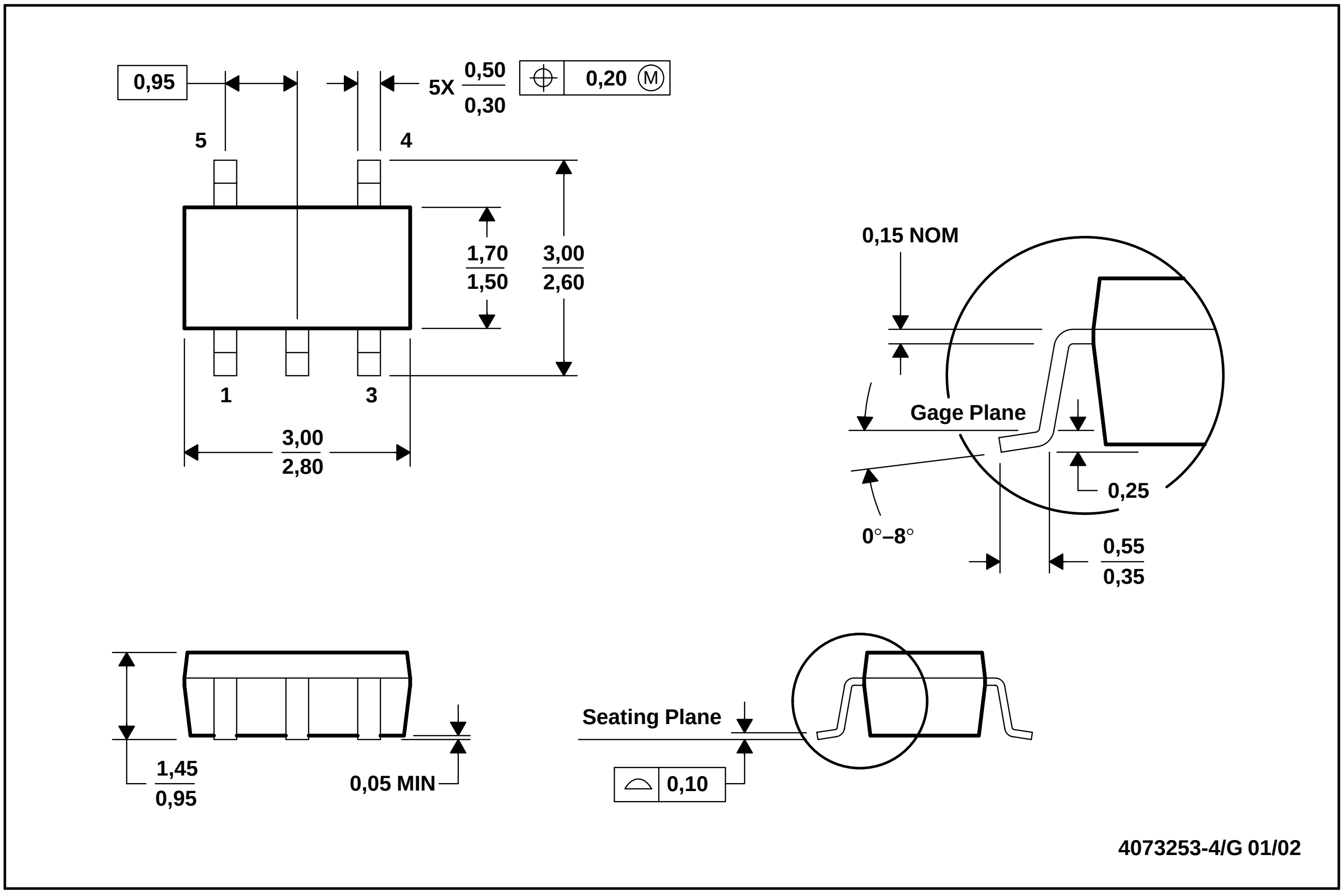


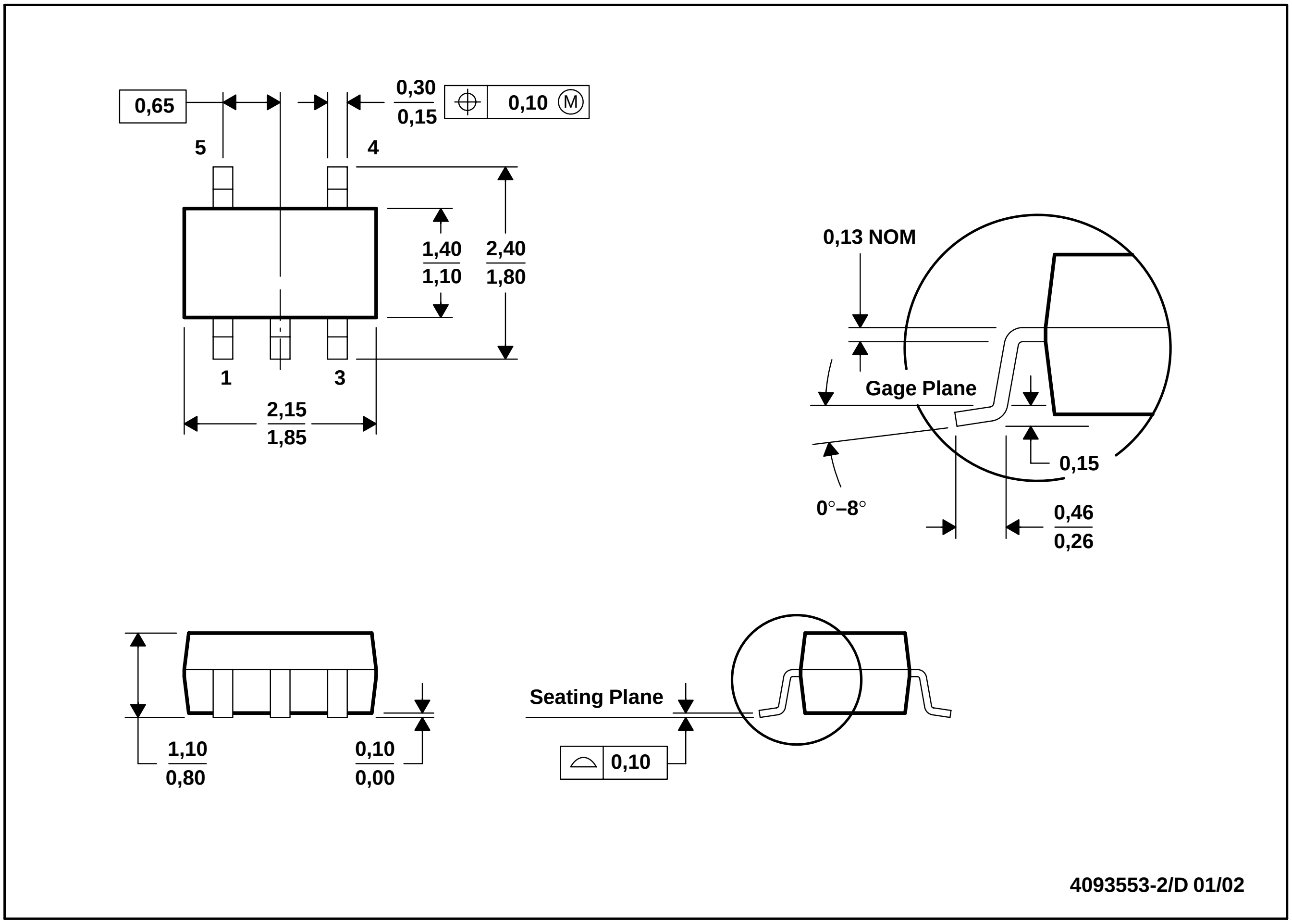
Figure 45

DBV (R-PDSO-G5) **PLASTIC SMALL-OUTLINE**



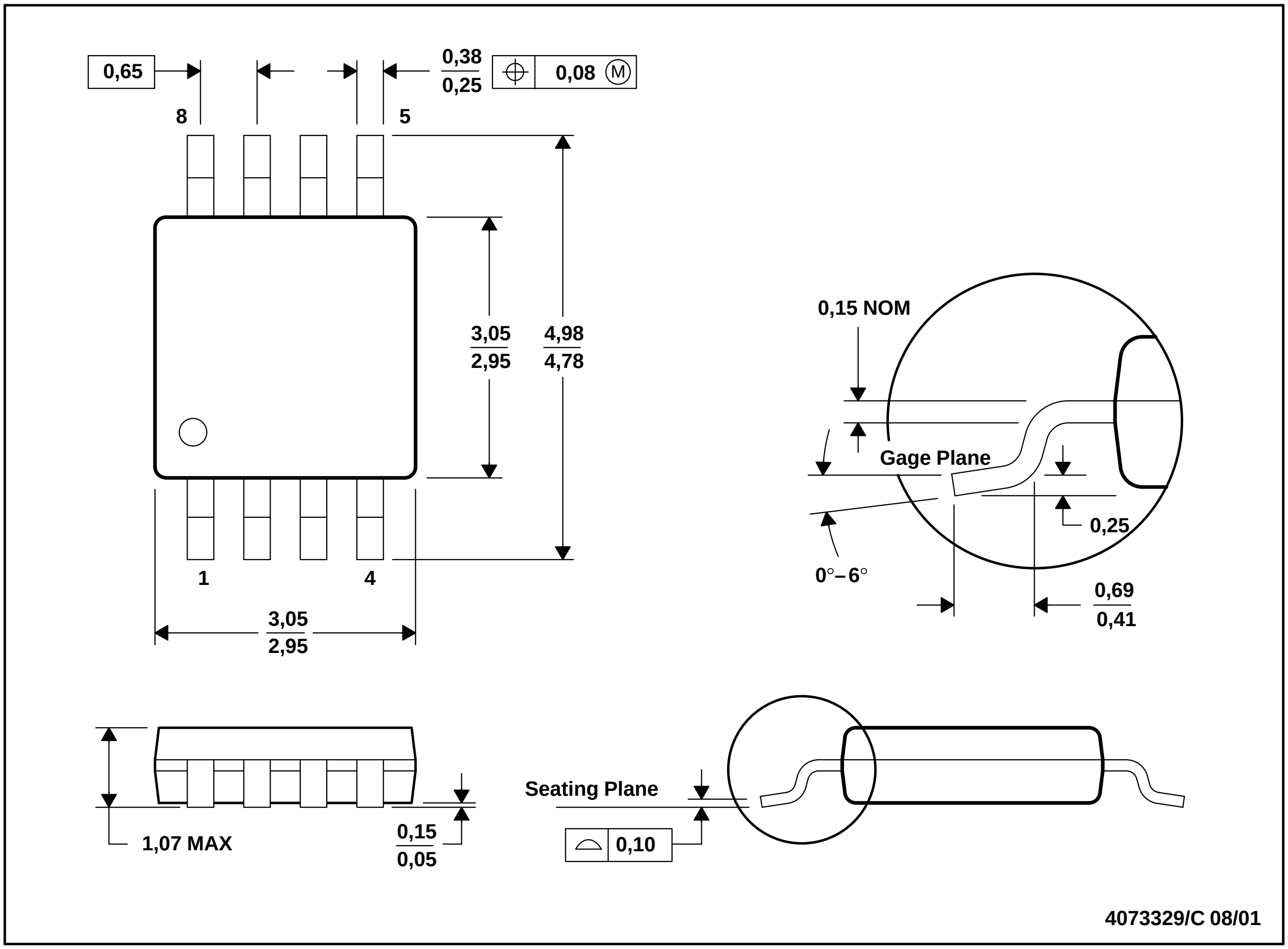
NOTES: A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion.
D. Falls within JEDEC MO-178

DCK (R-PDSO-G5) **PLASTIC SMALL-OUTLINE PACKAGE**



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.
D. Falls within JEDEC MO-203

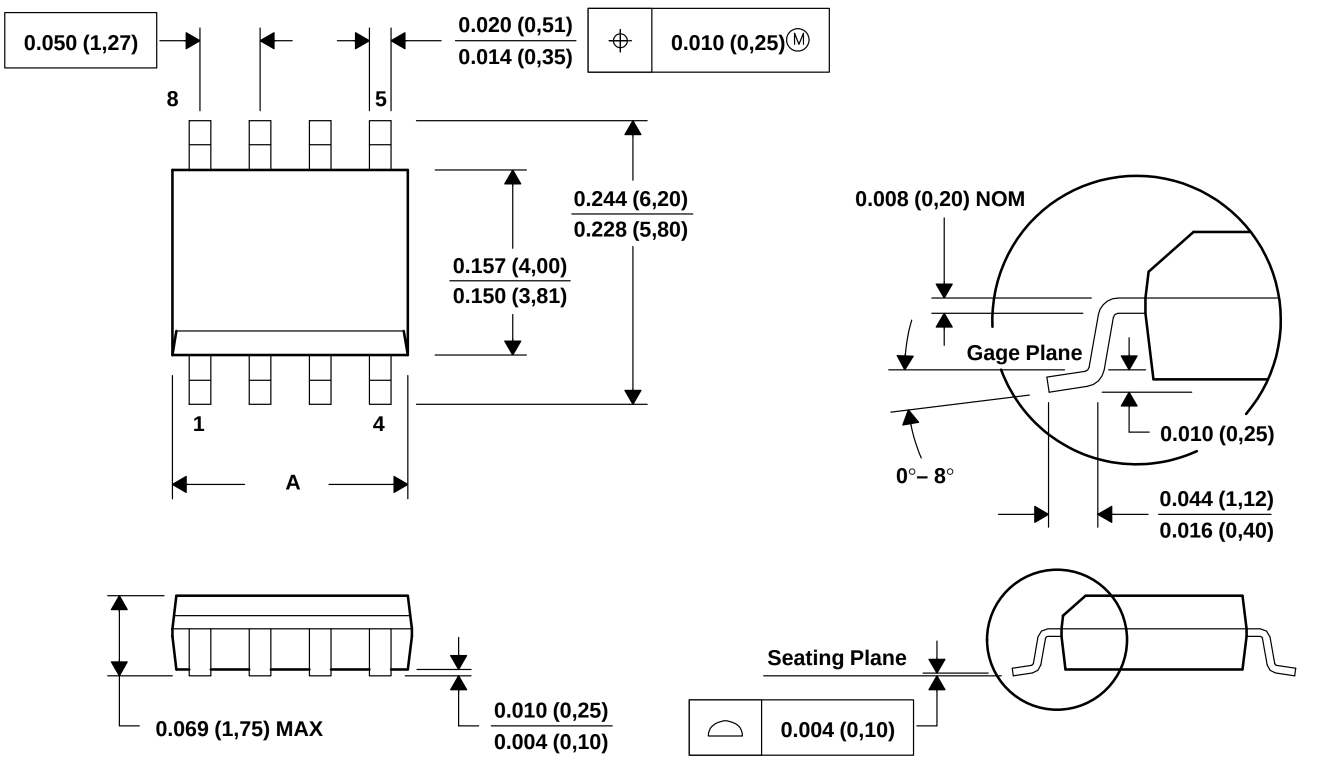
DGK (R-PDSO-G8) **PLASTIC SMALL-OUTLINE PACKAGE**



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.
D. Falls within JEDEC MO-187

D (R-PDSO-G)** **PLASTIC SMALL-OUTLINE PACKAGE**

8 PINS SHOWN



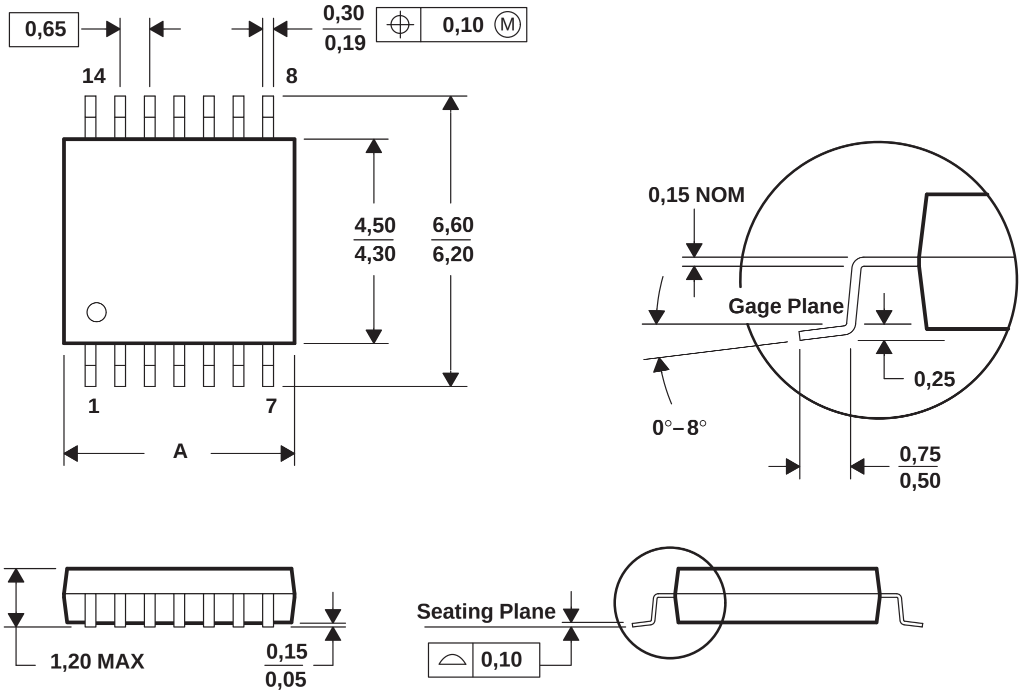
DIM \ PINS **	8	14	16
A MAX	0.197 (5,00)	0.344 (8,75)	0.394 (10,00)
A MIN	0.189 (4,80)	0.337 (8,55)	0.386 (9,80)

4040047/E 09/01

NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion, not to exceed 0.006 (0,15).
D. Falls within JEDEC MS-012

PW (R-PDSO-G)** **PLASTIC SMALL-OUTLINE PACKAGE**

14 PINS SHOWN



PINS ** / DIM	8	14	16	20	24	28
A MAX	3,10	5,10	5,10	6,60	7,90	9,80
A MIN	2,90	4,90	4,90	6,40	7,70	9,60

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

IMPORTANT NOTICE

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