TLV2460, TLV2461, TLV2462, TLV2463, TLV2464, TLV2465 FAMILY OF LOW POWER, RAIL-TO-RAIL INPUT/OUTPUT OPERATIONAL AMPLIFIERS WITH SHUTDOWN

SLOS220B – JULY 1998 – REVISED SEPTEMBER 1998

- Input Common-Mode Range Exceeds Both Supply Rails . . . V_{DD-} – 0.2V to V_{DD+} + 0.2V
- Gain Bandwidth Product . . . 4.4MHz
- Supply Current . . . 500μA/channel
- Input Offset Voltage . . . 100μV
- Input Noise Voltage . . . 11nV/√Hz
- Rail-to-Rail Output Swing
- Slew Rate . . . 1.8V/μs
- ±90mA Output Drive Capability
- Micropower Shutdown Mode (TLV2460/3/5) . . . I_{DD}=0.6μA/channel
- Available in 5- or 6-pin SOT23 and 8- or 10-Pin MSOP
- Characterized from T_A = –40°C to 125°C

description

The TLV246x is a family of low-power rail-to-rail input/output operational amplifiers specifically designed for portable applications. The input common-mode voltage range extends beyond the supply rails for maximum dynamic range in low-voltage systems. The amplifier output has rail-to-rail performance with high-output-drive capability, solving one of the limitations of older rail-to-rail input/output operational amplifiers. This rail-to-rail dynamic range and high output drive make the TLV246x ideal for buffering analog-to-digital converters.

The operational amplifier has 4.4 MHz of bandwidth and 1.8 V/μs of slew rate with only 500 μA of supply current providing good ac performance with low power consumption. Three members of the family offer a shutdown terminal, which places the amplifier in an ultra-low supply current mode (I_{DD} = 0.6 μA/ch). While in shutdown, the operational-amplifier output is placed in a high-impedance state. DC applications are also well served with an input noise voltage of 11 nV/√Hz and input offset voltage of 100 μV.

This family is available in the low-profile SOT23, MSOP, and TSSOP packages. The TLV2460 is the first rail-to-rail input/output operational amplifier with shutdown available in the 6-pin SOT23, making it perfect for high-density circuits. The family is specified over an expanded temperature range (T_A = –40°C to 125°C) for use in industrial control and automotive systems.

FAMILY PACKAGE TABLE

DEVICE	NO. OF Ch	PACKAGE TYPES					SHUTDOWN
		PDIP	SOIC	SOT-23	TSSOP	MSOP	
TLV2460	1	8	8	6†	—	—	X
TLV2461	1	8	8	5†	—	—	—
TLV2462	2	8	8	—	—	8	—
TLV2463	2	14	14	—	—	10†	X
TLV2464	4	14	14	—	14	—	—
TLV2465	4	16	16	—	16	—	X

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

TLV2460 and TLV2461 AVAILABLE OPTIONS

T_A	V_{IO}max AT 25°C	PACKAGED DEVICES			CHIP FORM‡ (Y)
		SMALL OUTLINE (D)	SOT-23† (DBV)	PLASTIC DIP (P)	
0°C to 70°C	2000 μV	TLV2460CD TLV2461CD	TLV2460CDBV TLV2461CDBV	TLV2460CP TLV2461CP	TLV2460Y TLV2461Y
-40°C to 125°C	2000 μV	TLV2460ID TLV2461ID	TLV2460IDBV TLV2461IDBV	TLV2460IP TLV2461IP	— —
	1500 μV	TLV2460AID TLV2461AID	— —	TLV2460AIP TLV2461AIP	— —

† This package is available taped and reeled. To order this packaging option, add an R suffix to the part number (e.g., TLV2460CDR).
‡ Chip forms are tested at T_A = 25°C only.

TLV2462 and TLV2463 AVAILABLE OPTIONS

T_A	V_{IO}max AT 25°C	PACKAGED DEVICES					CHIP FORM‡ (Y)
		SMALL OUTLINE† (D)	MSOP (DGK)	MSOP† (DGS)	PLASTIC DIP (N)	PLASTIC DIP (P)	
0°C to 70°C	2000 μV	TLV2462CD TLV2463CD	TLV2462CDGK —	— TLV2463CDGS	— TLV2463CN	TLV2462CP —	TLV2462Y TLV2463Y
–40°C to 125°C	2000 μV	TLV2462ID TLV2463ID	TLV2462IDGK —	— TLV2463IDGS	— TLV2463IN	TLV2462IP —	— —
	1500 μV	TLV2462AID TLV2463AID	— —	— —	— TLV2463AIN	TLV2462AIP —	— —

† This package is available taped and reeled. To order this packaging option, add an R suffix to the part number (e.g., TLV2462CDR).
‡ Chip forms are tested at T_A = 25°C only.

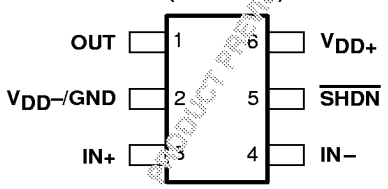
TLV2464 and TLV2465 AVAILABLE OPTIONS

T_A	V_{IO}max AT 25°C	PACKAGED DEVICES			CHIP FORM‡ (Y)
		SMALL OUTLINE (D)	PLASTIC DIP (N)	TSSOP (PW)	
0°C to 70°C	2000 μV	TLV2464CD TLV2465CD	TLV2464CN TLV2465CN	TLV2464CPW TLV2465CPW	TLV2464Y TLV2465Y
–40°C to 125°C	2000 μV	TLV2464ID TLV2465ID	TLV2464IN TLV2465IN	TLV2464IPW TLV2465IPW	— —
–40°C to 125°C	1500 μV	TLV2464AID TLV2465AID	TLV2464AIN TLV2465AIN	TLV2464AIPW TLV2465AIPW	— —

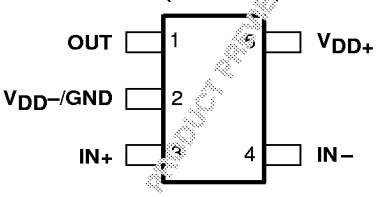
† This package is available taped and reeled. To order this packaging option, add an R suffix to the part number (e.g., TLV2464CDR).
‡ Chip forms are tested at T_A = 25°C only.

TLV246x PACKAGE PINOUTS

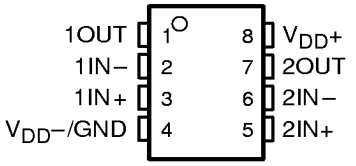
TLV2460
DBV PACKAGE
(TOP VIEW)



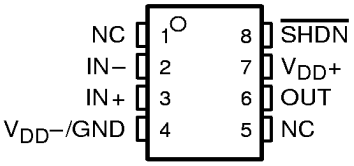
TLV2461
DBV PACKAGE
(TOP VIEW)



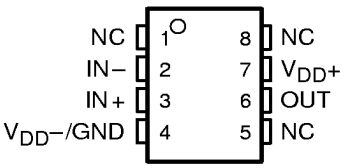
TLV2462
D, DGK, OR P PACKAGE
(TOP VIEW)



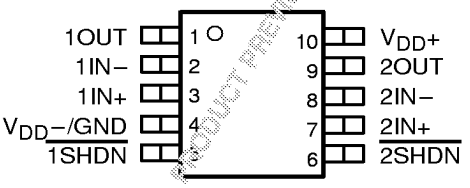
TLV2460
D OR P PACKAGE
(TOP VIEW)



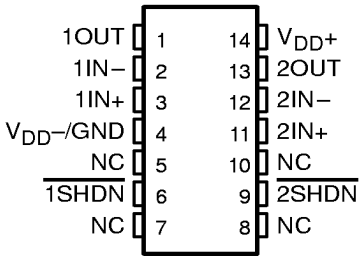
TLV2461
D OR P PACKAGE
(TOP VIEW)



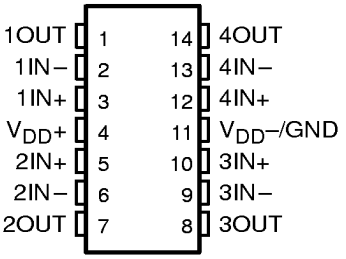
TLV2463
DGS PACKAGE
(TOP VIEW)



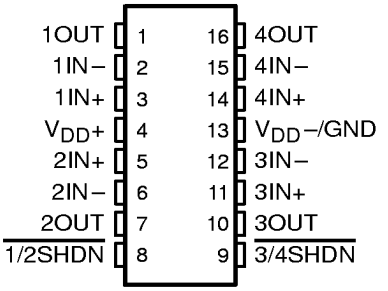
TLV2463
D OR N PACKAGE
(TOP VIEW)



TLV2464
D, N, OR PW PACKAGE
(TOP VIEW)



TLV2465
D, N, OR PW PACKAGE
(TOP VIEW)



NC – No internal connection

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

Supply voltage, V_{DD} (see Note 1) . . . . . 6 V
Differential input voltage, V_{ID} . . . . . V_{DD} – 0.2 V to V_{DD} + 0.2 V
Input current, I_I (any input) . . . . . ± 200 mA
Output current, I_O . . . . . ± 175 mA
Total input current, I_I (into V_{DD+}) . . . . . 175 mA
Total output current, I_O (out of V_{DD-}) . . . . . 175 mA
Continuous total power dissipation . . . . . See Dissipation Rating Table
Operating free-air temperature range, T_A: C suffix . . . . . 0°C to 70°C
I 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.

NOTE 1: All voltage values, except differential voltages, are with respect to V_{DD-}.

DISSIPATION RATING TABLE

PACKAGE	$T_A \le 25°C$ POWER RATING	DERATING FACTOR ABOVE $T_A = 25°C$	$T_A = 70°C$ POWER RATING	$T_A = 85°C$ POWER RATING	$T_A = 125°C$ POWER RATING
D	725 mW	5.8 mW/°C	464 mW	377 mW	145 mW
DBV	437 mW	3.5 mW/°C	280 mW	227 mW	87 mW
DGK	424 mW	3.4 mW/°C	271 mW	220 mW	85 mW
DGS	424 mW	3.4 mW/°C	271 mW	220 mW	85 mW
N	1150 mW	9.2 mW/°C	736 mW	598 mW	230 mW
P	1000 mW	8.0 mW/°C	640 mW	520 mW	200 mW
PW	700 mW	5.6 mW/°C	448 mW	364 mW	140 mW

recommended operating conditions

		MIN	MAX	UNIT
Supply voltage, V_{DD}	Single supply	2.7	6	V
	Split supply	±1.35	±3	
Common-mode input voltage range, V_{ICR}		V_{DD-}	V_{DD+}	V
Operating free-air temperature, T_A	C-suffix	0	70	°C
	I-suffix	–40	125	

electrical characteristics at specified free-air temperature, V_{DD} = 3 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS		T_A†	TLV246xC			UNIT
					MIN	TYP	MAX	
V_{IO}	Input offset voltage (TLV246xC)	V_{DD} = ±1.5 V, V_{IC} = 0,	V_O = 0, R_S = 50 Ω	25°C		100	2000	μV
				Full range		150	2200	
V_{IO}	Input offset voltage (TLV246xAC)			25°C		100	1500	μV
				Full range		150	1700	
α_{VIO}	Temperature coefficient of input offset voltage					2		μV/°C
I_{IO}	Input offset current			25°C		2.8	7	nA
				Full range		4.6	20	
I_{IB}	Input bias current			25°C		4.4	14	nA
				Full range			25	
V_{ICR}	Common-mode input voltage range	CMRR > 66 dB	R_S = 50 Ω	25°C	−0.2 to 3.2			V
		CMRR > 60 dB	R_S = 50 Ω	Full range	−0.2 to 3.2			
V_{OH}	High-level output voltage	I_{OH} = −2.5 mA		25°C		2.9		V
				Full range	2.8			
		I_{OH} = −10 mA		25°C		2.7		
				Full range	2.6			
V_{OL}	Low-level output voltage	V_{IC} = 1.5 V,	I_{OL} = 2.5 mA	25°C		0.1		V
				Full range			0.2	
		V_{IC} = 1.5 V,	I_{OL} = 10 mA	25°C		0.3		
				Full range			0.4	
I_{OS}	Short-circuit output current	Sourcing		25°C		50		mA
				Full range	20	40		
		Sinking		25°C		40		
				Full range	20	30		
I_O	Output current			25°C		±30		mA
A_{VD}	Large-signal differential voltage amplification	R_L = 10 kΩ		25°C	90	105		dB
				Full range	89	100		
$r_{i(d)}$	Differential input resistance			25°C		10^9		Ω
$c_{i(c)}$	Common-mode input capacitance	f = 10 kHz		25°C		7		pF
z_o	Closed-loop output impedance	f = 100 kHz,	A_V = 10	25°C		33		Ω
CMRR	Common-mode rejection ratio	V_{ICR} = −0.2 V to 3.2 V,	R_S = 50 Ω	25°C	66	80		dB
				Full range	64	73		
k_{SVR}	Supply voltage rejection ratio (ΔV_{DD} /ΔV_{IO})	V_{DD} = 2.7 V to 6 V, No load	V_{IC} = V_{DD}/2,	25°C	80	85		dB
				Full range	75	82		
		V_{DD} = 3 V to 5 V, No load	V_{IC} = V_{DD}/2,	25°C	85	95		
				Full range	80	90		
I_{DD}	Supply current (both channels) (TLV2462 and TLV2463)	V_O = 1.5 V, $\overline{SHDN}$ > 1.02 V	No load,	25°C		1	1.15	mA
				Full range			1.8	

† Full range is 0°C to 70°C.

electrical characteristics at specified free-air temperature, V_{DD} = 3 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS		T_A†	TLV2460C, TLV2463C TLV2465C			UNIT
					MIN	TYP	MAX	
$V_{(ON)}$	Turnon voltage level	A_V = 1	Channel 1	25°C		1.021		V
			Channel 2			1.02		
$V_{(OFF)}$	Turnoff voltage level	A_V = 1	Channel 1	25°C		0.822		V
			Channel 2			0.817		
$I_{DD(SHDN)}$	Supply current in shutdown (TLV2463)	$\overline{SHDN}$ < 0.8 V, Both channels in shutdown		25°C		0.6		μA
				Full range		0.9	5	

† Full range is 0°C to 70°C.

operating characteristics at specified free-air temperature, V_{DD} = 3 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS		T_A†	TLV246xC			UNIT
					MIN	TYP	MAX	
SR	Slew rate at unity gain	$V_{O(PP)}$ = 2 V, C_L = 160 pF, R_L = 10 kΩ		25°C	1	1.8		V/μs
				Full range	0.9	1		
V_n	Equivalent input noise voltage	f = 100 Hz		25°C		16		nV/√Hz
		f = 1 kHz		25°C		11		
I_n	Equivalent input noise current	f = 1 kHz		25°C		0.13		pA/√Hz
THD + N	Total harmonic distortion plus noise	$V_{O(PP)}$ = 2 V, R_L = 10 kΩ, f = 1 kHz	A_V = 1	25°C		0.006%		
			A_V = 10			0.02%		
			A_V = 100			0.08%		
$t_{(on)}$	Amplifier turnon time	A_V = 1, R_L = 10 kΩ	Both channels	25°C		7.6		μs
			Channel 1 only, Channel 2 on			7.65		
			Channel 2 only, Channel 1 on			7.25		
$t_{(off)}$	Amplifier turnoff time	A_V = 1, R_L = 10 kΩ	Both channels	25°C		333		ns
			Channel 1 only, Channel 2 on			328		
			Channel 2 only, Channel 1 on			329		
	Gain-bandwidth product	f = 10 kHz, C_L = 160 pF	R_L = 10 kΩ,	25°C		4		MHz
ϕ_m	Phase margin at unity gain	R_L = 10 kΩ,	C_L = 160 pF	25°C		44°		
	Gain margin			25°C		7		dB

† Full range is 0°C to 70°C.

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

PARAMETER		TEST CONDITIONS		T_A†	TLV246xC			UNIT
					MIN	TYP	MAX	
V_{IO}	Input offset voltage (TLV24x6C)	V_{DD} = ±2.5 V, V_{IC} = 0,	V_O = 0, R_S = 50 Ω	25°C		150	2000	μV
				Full range		170	2200	
V_{IO}	Input offset voltage (TLV246xAC)			25°C		150	1500	μV
				Full range		170	1700	
α_{VIO}	Temperature coefficient of input offset voltage					2		μV/°C
I_{IO}	Input offset current			25°C		0.3	7	nA
						0.7	15	
I_{IB}	Input bias current			25°C		1.3	14	nA
							30	
V_{ICR}	Common-mode input voltage range	CMRR > 71 dB,	R_S = 50 Ω	25°C	−0.2 to 5.2			V
		CMRR > 60 dB,	R_S = 50 Ω	Full range	−0.2 to 5.2			
V_{OH}	High-level output voltage	I_{OH} = −2.5 mA		25°C		4.9		V
				Full range	4.8			
		I_{OH} = −10 mA		25°C		4.8		
				Full range	4.7			
V_{OL}	Low-level output voltage	V_{IC} = 2.5 V,	I_{OL} = 2.5 mA	25°C		0.1		V
				Full range			0.2	
		V_{IC} = 2.5 V,	I_{OL} = 10 mA	25°C		0.2		
				Full range			0.3	
I_{OS}	Short-circuit output current	Sourcing		25°C		145		mA
				Full range		120		
		Sinking		25°C		100		
				Full range		78		
I_O	Output current			25°C		±90		mA
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	92	109		dB
				Full range	90	104		
$r_{i(d)}$	Differential input resistance			25°C		10^9		Ω
$c_{i(c)}$	Common-mode input capacitance	f = 10 kHz		25°C		7		pF
z_o	Closed-loop output impedance	f = 100 kHz,	A_V = 10	25°C		29		Ω
CMRR	Common-mode rejection ratio	V_{ICR} = −0.2 V to 5.2 V,	R_S = 50 Ω	25°C	71	85		dB
				Full range	69	73		
k_{SVR}	Supply voltage rejection ratio (ΔV_{DD} /ΔV_{IO})	V_{DD} = 2.7 V to 6 V, No load	V_{IC} = V_{DD}/2,	25°C	80	85		dB
				Full range	75	82		
		V_{DD} = 3 V to 5 V, No load	V_{IC} = V_{DD}/2,	25°C	85	95		
				Full range	80	90		
I_{DD}	Supply current (both channels) (TLV2462 and TLV2463)	V_O = 2.5 V, $\overline{SHDN}$ > 1.38 V	No load,	25°C		1.1	1.3	mA
				Full range			2	

† Full range is 0°C to 70°C.

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

PARAMETER		TEST CONDITIONS		T_A†	TLV2460C, TLV2463C TLV2465C			UNIT
					MIN	TYP	MAX	
$V_{(ON)}$	Turnon voltage level	A_V = 1	Channel 1	25°C		1.372		V
			Channel 2			1.368		
$V_{(OFF)}$	Turnoff voltage level	A_V = 1	Channel 1	25°C		1.315		V
			Channel 2			1.309		
$I_{DD(SHDN)}$	Supply current in shutdown (TLV2463)	$\overline{SHDN}$ < 1.3 V, Both channels in shutdown		25°C		2		μA
				Full range		3	6	

† Full range is 0°C to 70°C.

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

PARAMETER		TEST CONDITIONS		T_A†	TLV246xC			UNIT
					MIN	TYP	MAX	
SR	Slew rate at unity gain	$V_{O(PP)}$ = 2 V, R_L = 10 kΩ	C_L = 160 pF,	25°C	1	1.8		V/μs
				Full range	0.9	1		
V_n	Equivalent input noise voltage	f = 100 Hz		25°C		14		nV/√Hz
		f = 1 kHz		25°C		11		
I_n	Equivalent input noise current	f = 100 Hz		25°C		0.13		pA/√Hz
THD + N	Total harmonic distortion plus noise	$V_{O(PP)}$ = 4 V, R_L = 10 kΩ, f = 10 kHz	A_V = 1	25°C		0.004%		
			A_V = 10			0.01%		
			A_V = 100			0.04%		
$t_{(on)}$	Amplifier turnon time	A_V = 1, R_L = 10 kΩ	Both channels	25°C		7.6		μs
			Channel 1 only, Channel 2 on			7.65		
			Channel 2 only, Channel 1 on			7.25		
$t_{(off)}$	Amplifier turnoff time	A_V = 1, R_L = 10 kΩ	Both channels	25°C		333		ns
			Channel 1 only, Channel 2 on			328		
			Channel 2 only, Channel 1 on			329		
	Gain-bandwidth product	f = 10 kHz, C_L = 160 pF	R_L = 10 kΩ,	25°C		4.4		MHz
ϕ_m	Phase margin at unity gain	R_L = 10 kΩ,	C_L = 160 pF	25°C		45°		
	Gain margin			25°C		7		dB

† Full range is 0°C to 70°C.

electrical characteristics at specified free-air temperature, V_{DD} = 3 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS		T_A†	TLV246xI			UNIT
					MIN	TYP	MAX	
V_{IO}	Input offset voltage (TLV246xI)	V_{DD} = ±1.5 V, V_{IC} = 0,	V_O = 0, R_S = 50 Ω	25°C		100	2000	μV
				Full range		150	2200	
V_{IO}	Input offset voltage (TLV246xAI)			25°C		100	1500	μV
				Full range		150	1700	
α_{VIO}	Temperature coefficient of input offset voltage					2		μV/°C
I_{IO}	Input offset current			25°C		2.8	7	nA
				Full range		4.6	75	
I_{IB}	Input bias current			25°C		4.4	14	nA
				Full range			75	
V_{ICR}	Common-mode input voltage range	CMRR > 66 dB,	R_S = 50 Ω	25°C	−0.2 to 3.2			V
		CMRR > 60 dB,	R_S = 50 Ω	−40°C – 85°C	−0.2 to 3.2			
				Full range	0 to 3	−0.2 to 3.2		
V_{OH}	High-level output voltage	I_{OH} = −2.5 mA		25°C		2.9		V
				Full range	2.8			
		I_{OH} = −10 mA		25°C		2.7		
				Full range	2.5			
V_{OL}	Low-level output voltage	V_{IC} = 1.5 V,	I_{OL} = 2.5 mA	25°C		0.1		V
				Full range			0.2	
		V_{IC} = 1.5 V,	I_{OL} = 10 mA	25°C		0.3		
				Full range			0.5	
I_{OS}	Short-circuit output current	Sourcing		25°C		50		mA
				Full range		40		
		Sinking		25°C		40		
				Full range		30		
I_O	Output current			25°C		±30		mA
A_{VD}	Large-signal differential voltage amplification	R_L = 10 kΩ		25°C	90	105		dB
				Full range	89	100		
$r_{i(d)}$	Differential input resistance			25°C		10^9		Ω
$c_{i(c)}$	Common-mode input capacitance	f = 10 kHz		25°C		7		pF
z_o	Closed-loop output impedance	f = 100 kHz,	A_V = 10	25°C		33		Ω
CMRR	Common-mode rejection ratio	V_{ICR} = −0.2 V to 3.2 V,	R_S = 50 Ω	25°C	66	80		dB
				−40°C – 85°C	60	73		
		V_{ICR} = 0 V to 3 V,	R_S = 50 Ω	25°C	66	80		
				Full range	60	73		

† Full range is −40°C to 125°C.

electrical characteristics at specified free-air temperature, V_{DD} = 3 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS		T_A†	TLV2460I, TLV2463I TLV2465I			UNIT
					MIN	TYP	MAX	
k_{SVR}	Supply voltage rejection ratio (ΔV_{DD} /ΔV_{IO})	V_{DD} = 2.7 V to 6 V, No load	V_{IC} = V_{DD}/2,	25°C	80	85		dB
				Full range	75	82		
		V_{DD} = 3 V to 5 V, No load	V_{IC} = V_{DD}/2,	25°C	85	95		
				Full range	80	90		
I_{DD}	Supply current (both channels) (TLV2462, TLV2463)	V_O = 1.5 V, $\overline{SHDN}$ > 1.02 V	No load,	25°C		1	1.15	mA
				Full range			1.8	
$V_{(ON)}$	Turnon voltage level	A_V = 1	Channel 1	25°C		1.021		V
			Channel 2			1.02		
$V_{(OFF)}$	Turnoff voltage level	A_V = 1	Channel 1	25°C		0.822		V
			Channel 2			0.817		
$I_{DD(SHDN)}$	Supply current in shutdown (TLV2463)	$\overline{SHDN}$ < 0.8 V, Both channels in shutdown		25°C		0.6		µA
				Full range		0.9	5	

† Full range is –40°C to 125°C.

operating characteristics at specified free-air temperature, V_{DD} = 3 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS		T_A†	TLV246xI			UNIT
					MIN	TYP	MAX	
SR	Slew rate at unity gain	$V_{O(PP)}$ = 2 V, R_L = 10 kΩ	C_L = 160 pF,	25°C	1	1.8		V/µs
				Full range	0.8	1		
V_n	Equivalent input noise voltage	f = 100 Hz		25°C		16		nV/√Hz
		f = 1 kHz		25°C		11		
I_n	Equivalent input noise current	f = 1 kHz		25°C		0.13		pA/√Hz
THD + N	Total harmonic distortion plus noise	$V_{O(PP)}$ = 2 V, R_L = 10 kΩ, f = 1 kHz	A_V = 1	25°C		0.006%		
			A_V = 10			0.02%		
			A_V = 100			0.08%		
$t_{(on)}$	Amplifier turnon time	A_V = 1, R_L = 10 kΩ	Both channels	25°C		7.6		µs
			Channel 1 only, Channel 2 on			7.65		
			Channel 2 only, Channel 1 on			7.25		
$t_{(off)}$	Amplifier turnoff time	A_V = 1, R_L = 10 kΩ	Both channels	25°C		333		ns
			Channel 1 only, Channel 2 on			328		
			Channel 2 only, Channel 1 on			329		
	Gain-bandwidth product	f = 10 kHz, C_L = 160 pF	R_L = 10 kΩ,	25°C		4		MHz
ϕ_m	Phase margin at unity gain	R_L = 10 kΩ,	C_L = 160 pF	25°C		44°		
	Gain margin			25°C		7		dB

† Full range is –40°C to 125°C.

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

PARAMETER		TEST CONDITIONS		T_A†	TLV246xI			UNIT
					MIN	TYP	MAX	
V_{IO}	Input offset voltage (TLV246xAI)	V_{DD} = ±2.5 V, V_{IC} = 0,	V_O = 0, R_S = 50 Ω	25°C		150	2000	μV
				Full range		170	2200	
V_{IO}	Input offset voltage (TLV246xAI)			25°C		150	1500	μV
				Full range		170	1700	
α_{VIO}	Temperature coefficient of input offset voltage			25°C		2		μV/°C
I_{IO}	Input offset current			25°C		0.3	7	nA
				Full range		0.7	60	
I_{IB}	Input bias current			25°C		1.3	14	nA
				Full range			60	
V_{ICR}	Common-mode input voltage range	CMRR > 71 dB,	R_S = 50 Ω	25°C	−0.2 to 5.2			V
		CMRR > 60 dB,	R_S = 50 Ω	−40°C to 85°C	−0.2 to 5.2			
				Full range	0 to 5	−0.2 to 5.2		
V_{OH}	High-level output voltage	I_{OH} = −2.5 mA		25°C		4.9		V
				Full range	4.8			
		I_{OH} = −10 mA		25°C		4.8		
				Full range	4.7			
V_{OL}	Low-level output voltage	V_{IC} = 2.5 V,	I_{OL} = 2.5 mA	25°C		0.1		V
				Full range			0.2	
		V_{IC} = 2.5 V,	I_{OL} = 10 mA	25°C		0.2		
				Full range			0.3	
I_{OS}	Short-circuit output current	Sourcing		25°C		145		mA
				Full range		120		
		Sinking		25°C		100		
				Full range		78		
I_O	Output current			25°C		±90		mA
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	92	109		dB
				Full range	90	104		
$r_{i(d)}$	Differential input resistance			25°C		10^9		Ω
$c_{i(c)}$	Common-mode input capacitance	f = 10 kHz		25°C		7		pF
z_o	Closed-loop output impedance	f = 100 kHz,	A_V = 10	25°C		29		Ω
CMRR	Common-mode rejection ratio	V_{ICR} = −0.2 V to 5.2 V,	R_S = 50 Ω	25°C	71	85		dB
				−40°C to 85°C	60	73		
		V_{ICR} = 0 V to 5 V,	R_S = 50 Ω	Full range	60	73		

† Full range is −40°C to 125°C.

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

PARAMETER		TEST CONDITIONS		T_A†	TLV2460I, TLV2463I TLV2465I			UNIT
					MIN	TYP	MAX	
k_{SVR}	Supply voltage rejection ratio (ΔV_{DD} /ΔV_{IO})	V_{DD} = 2.7 V to 6 V, No load	V_{IC} = V_{DD}/2,	25°C	80	85		dB
				Full range	75	82		
		V_{DD} = 3 V to 5 V, No load	V_{IC} = V_{DD}/2,	25°C	85	95		dB
				Full range	80	90		
I_{DD}	Supply current (per channel)	V_O = 2.5 V, $\overline{SHDN}$ > 1.38 V	No load,	25°C		1.1	1.3	mA
				Full range			2	
$V_{(ON)}$	Turnon voltage level	A_V = 1	Channel 1	25°C		1.372		V
			Channel 2			1.368		
$V_{(OFF)}$	Turnoff voltage level	A_V = 1	Channel 1	25°C		1.315		V
			Channel 2			1.309		
$I_{DD(SHDN)}$	Supply current in shutdown (TLV2463)	$\overline{SHDN}$ < 1.3 V, Both channels in shutdown		25°C		2		µA
				Full range		3	6	

† Full range is –40°C to 125°C.

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

PARAMETER		TEST CONDITIONS		T_A†	TLV246xI			UNIT
					MIN	TYP	MAX	
SR	Slew rate at unity gain	$V_{O(PP)}$ = 2 V, R_L = 10 kΩ	C_L = 160 pF,	25°C	1	1.8		V/µs
				Full range	0.8	1		
V_n	Equivalent input noise voltage	f = 100 Hz		25°C		14		nV/√Hz
		f = 1 kHz		25°C		11		
I_n	Equivalent input noise current	f = 100 Hz		25°C		0.13		pA/√Hz
THD + N	Total harmonic distortion plus noise	$V_{O(PP)}$ = 4 V, R_L = 10 kΩ, f = 10 kHz	A_V = 1	25°C		0.004%		
			A_V = 10			0.01%		
			A_V = 100			0.04%		
$t_{(on)}$	Amplifier turnon time	A_V = 1, R_L = 10 kΩ	Both channels	25°C		7.6		µs
			Channel 1 only, Channel 2 on			7.65		
			Channel 2 only, Channel 1 on			7.25		
$t_{(off)}$	Amplifier turnoff time	A_V = 1, R_L = 10 kΩ	Both channels	25°C		333		ns
			Channel 1 only, Channel 2 on			328		
			Channel 2 only, Channel 1 on			329		
	Gain-bandwidth product	f = 10 kHz, C_L = 160 pF	R_L = 10 kΩ,	25°C		4.4		MHz
ϕ_m	Phase margin at unity gain	R_L = 10 kΩ,	C_L = 160 pF	25°C		45°		
	Gain margin			25°C		7		dB

† Full range is –40°C to 125°C.

TYPICAL CHARACTERISTICS

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TYPICAL CHARACTERISTICS

INPUT OFFSET VOLTAGE
vs
COMMON-MODE INPUT VOLTAGE

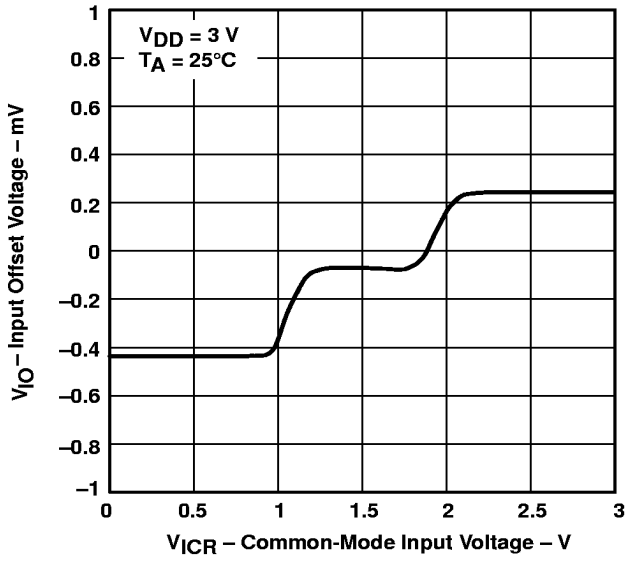


Figure 1

INPUT OFFSET VOLTAGE
vs
COMMON-MODE INPUT VOLTAGE

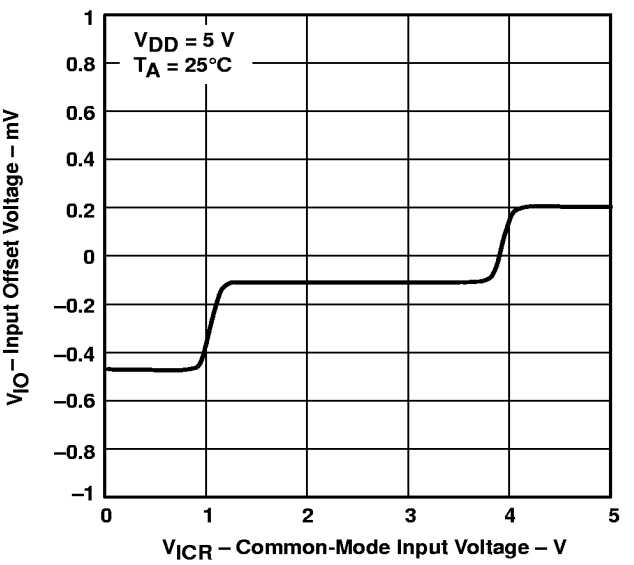


Figure 2

INPUT BIAS AND INPUT OFFSET CURRENT
vs
FREE-AIR TEMPERATURE

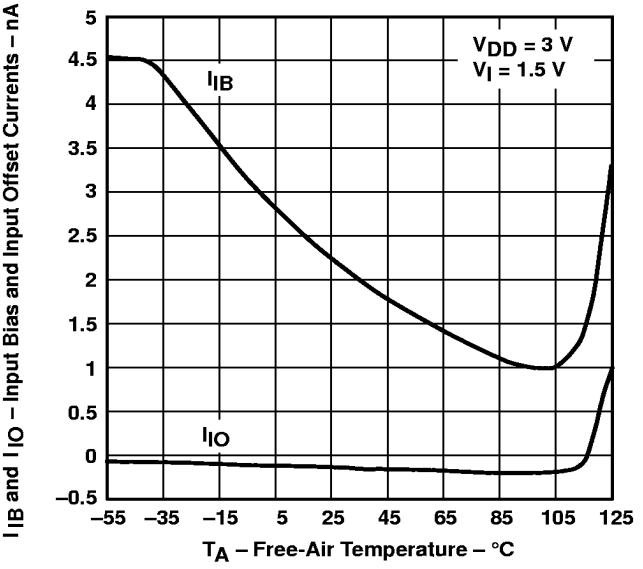


Figure 3

INPUT BIAS AND INPUT OFFSET CURRENT
vs
FREE-AIR TEMPERATURE

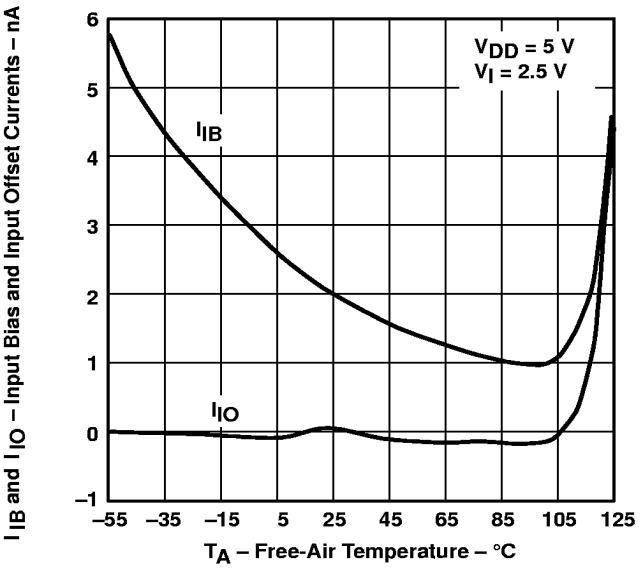


Figure 4

TYPICAL CHARACTERISTICS

HIGH-LEVEL OUTPUT VOLTAGE
vs
HIGH-LEVEL OUTPUT CURRENT

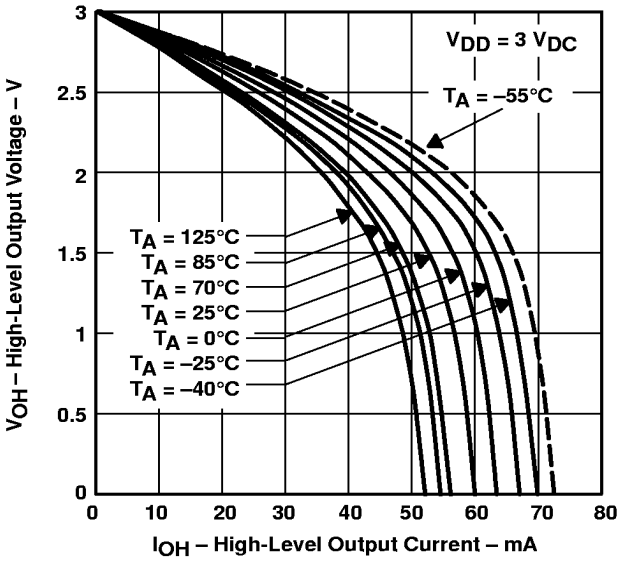


Figure 5

HIGH-LEVEL OUTPUT VOLTAGE
vs
HIGH-LEVEL OUTPUT CURRENT

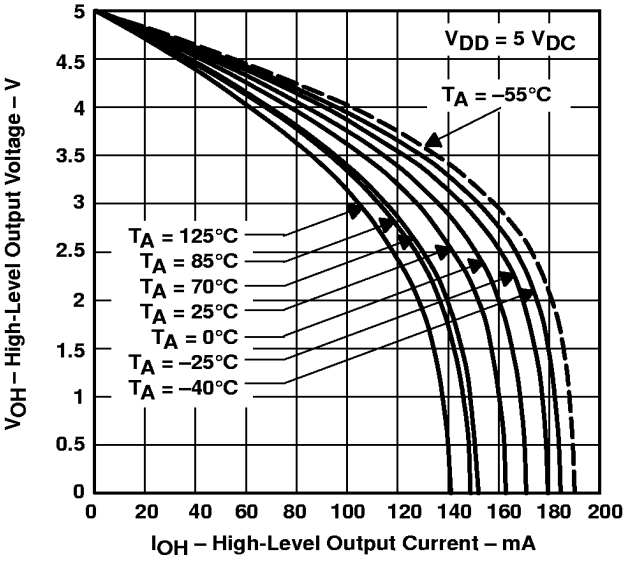


Figure 6

LOW-LEVEL OUTPUT VOLTAGE
vs
LOW-LEVEL OUTPUT CURRENT

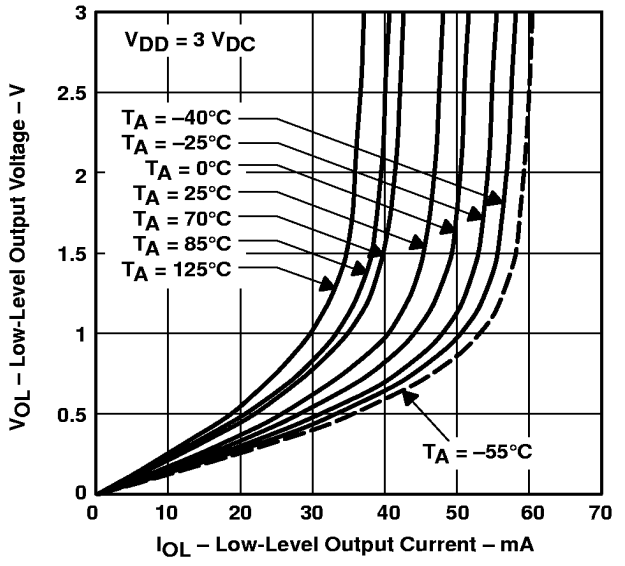


Figure 7

LOW-LEVEL OUTPUT VOLTAGE
vs
LOW-LEVEL OUTPUT CURRENT

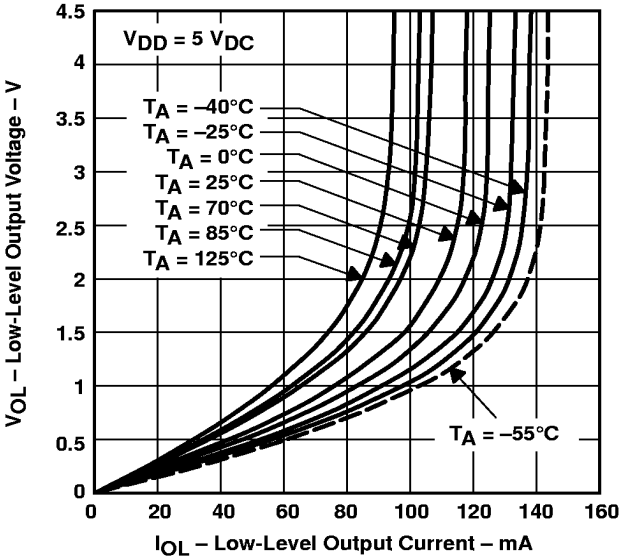


Figure 8

TYPICAL CHARACTERISTICS

PEAK-TO-PEAK OUTPUT VOLTAGE
vs
FREQUENCY

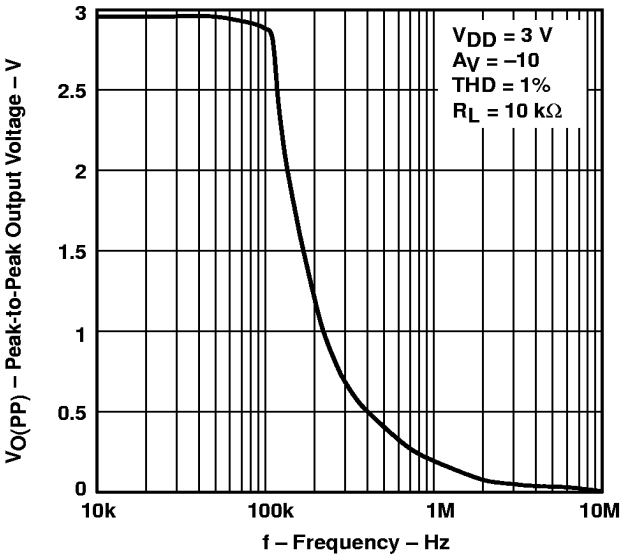


Figure 9

PEAK-TO-PEAK OUTPUT VOLTAGE
vs
FREQUENCY

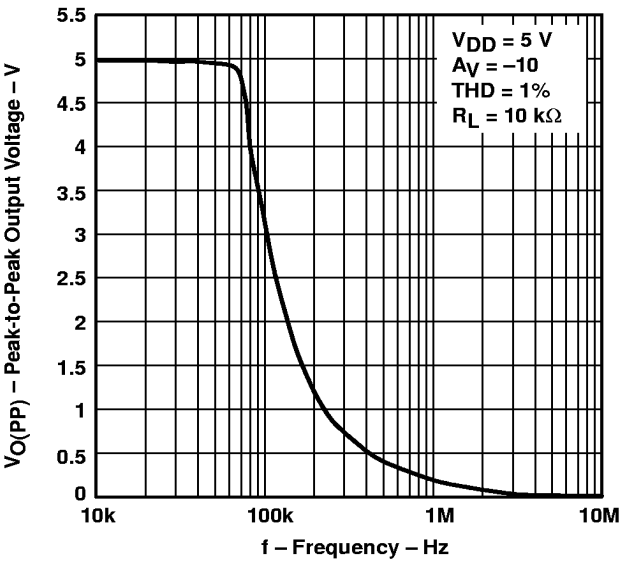


Figure 10

DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE
vs
FREQUENCY

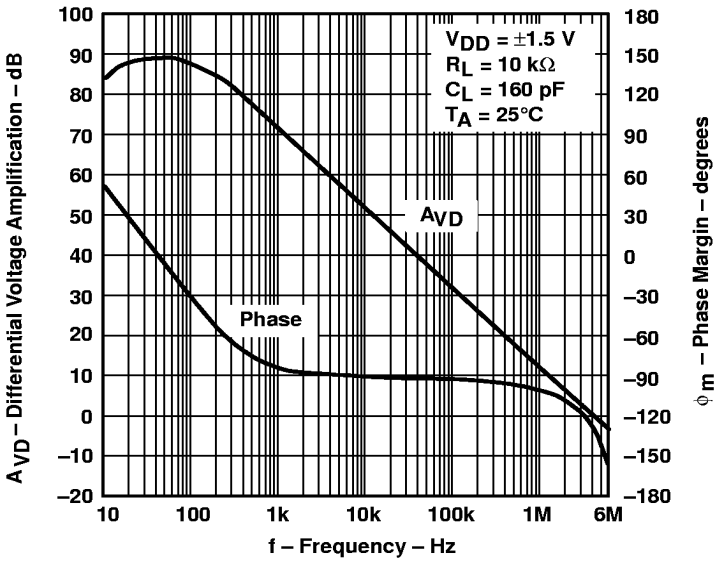


Figure 11

TYPICAL CHARACTERISTICS

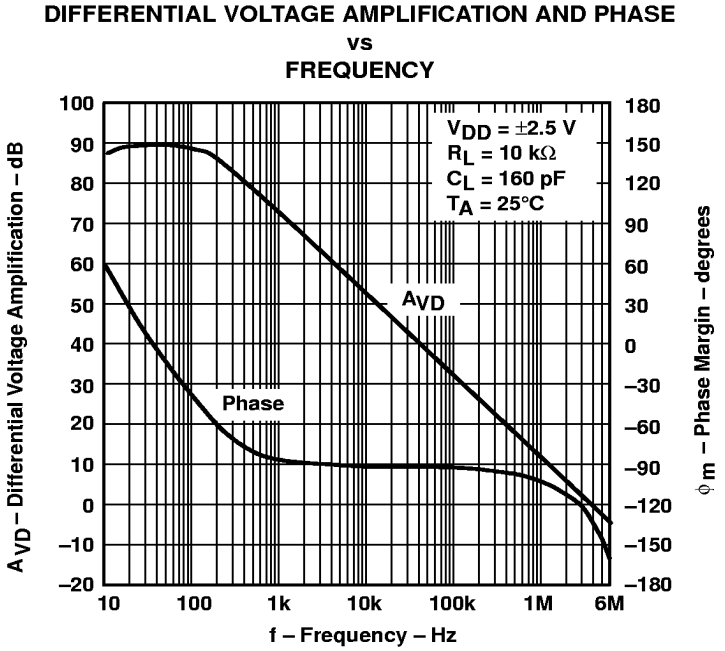


Figure 12

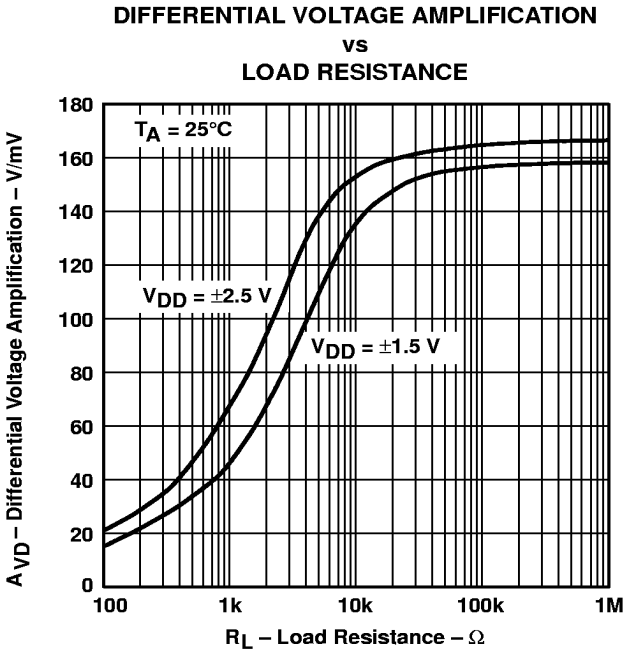


Figure 13

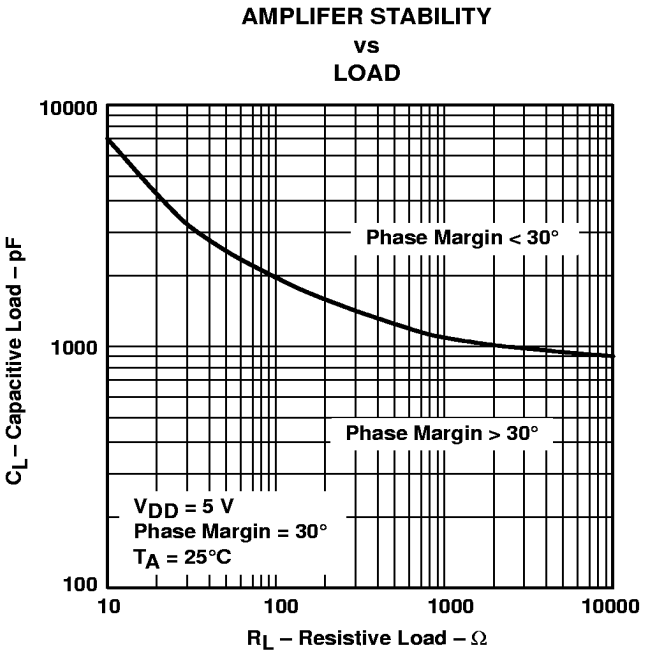


Figure 14

TYPICAL CHARACTERISTICS

OUTPUT IMPEDANCE vs FREQUENCY

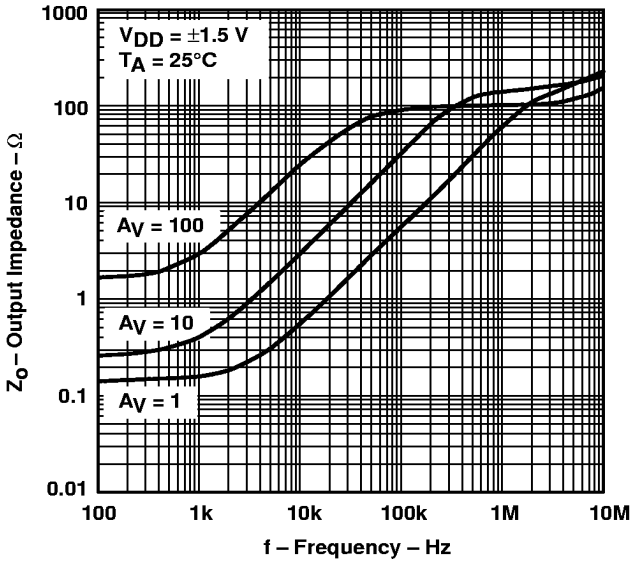


Figure 15

OUTPUT IMPEDANCE vs FREQUENCY

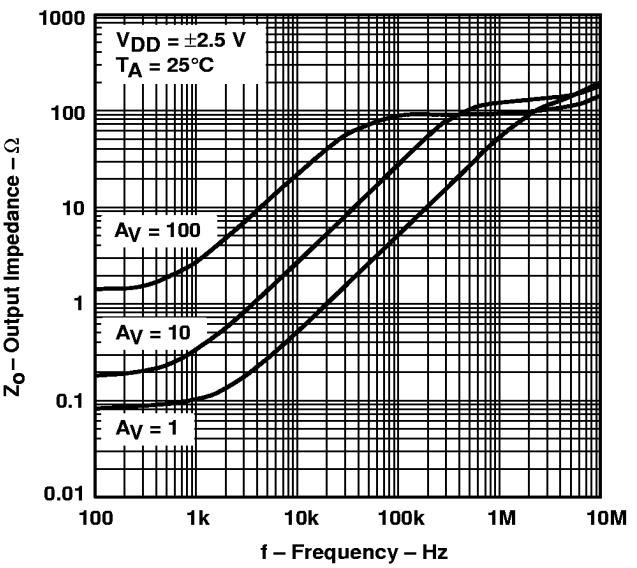


Figure 16

COMMON-MODE REJECTION RATIO vs FREQUENCY

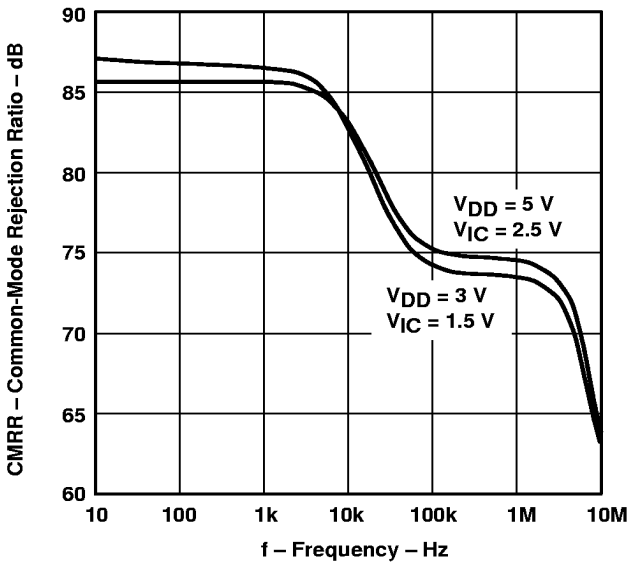


Figure 17

TYPICAL CHARACTERISTICS

SUPPLY-VOLTAGE REJECTION RATIO
vs
FREQUENCY

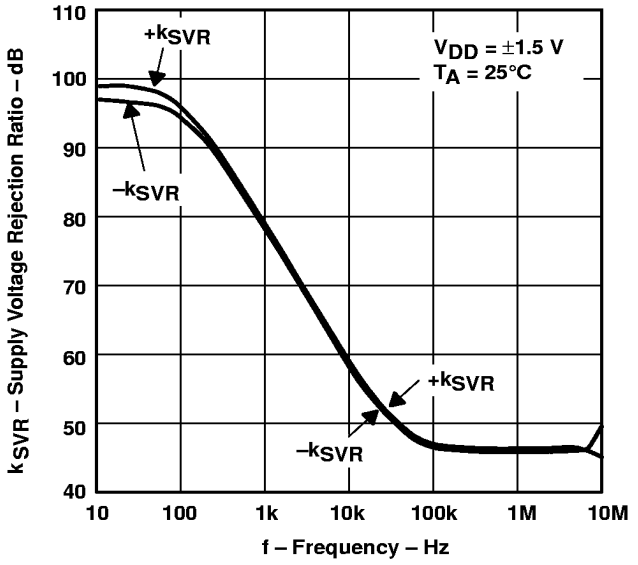


Figure 18

SUPPLY-VOLTAGE REJECTION RATIO
vs
FREQUENCY

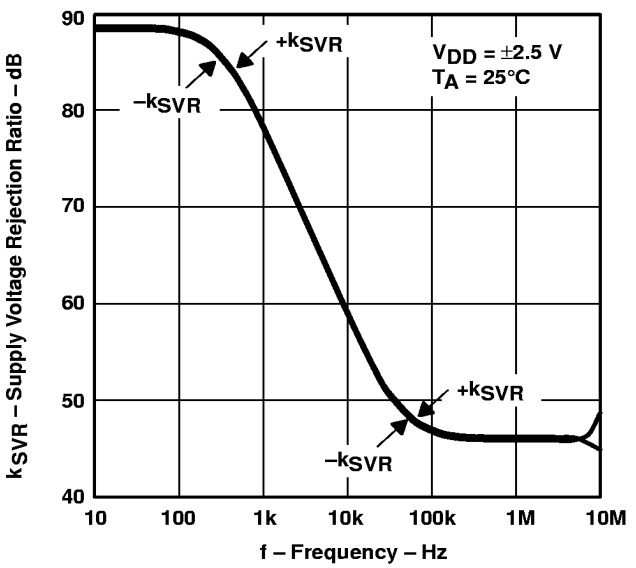


Figure 19

SUPPLY CURRENT
vs
SUPPLY VOLTAGE

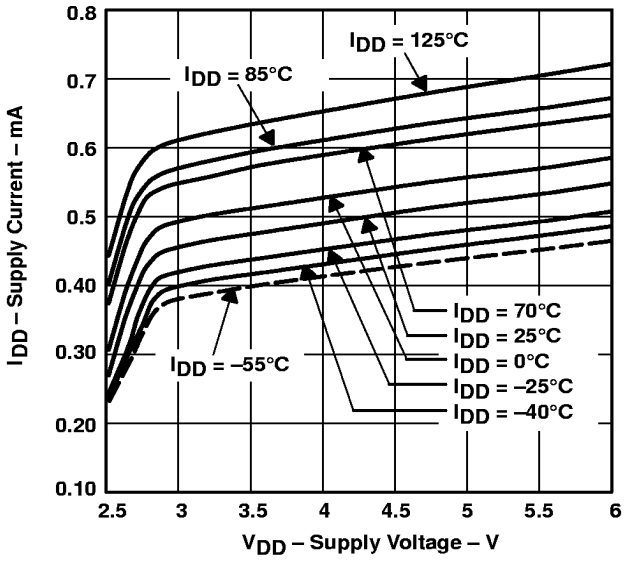


Figure 20

SUPPLY CURRENT
vs
FREE-AIR TEMPERATURE

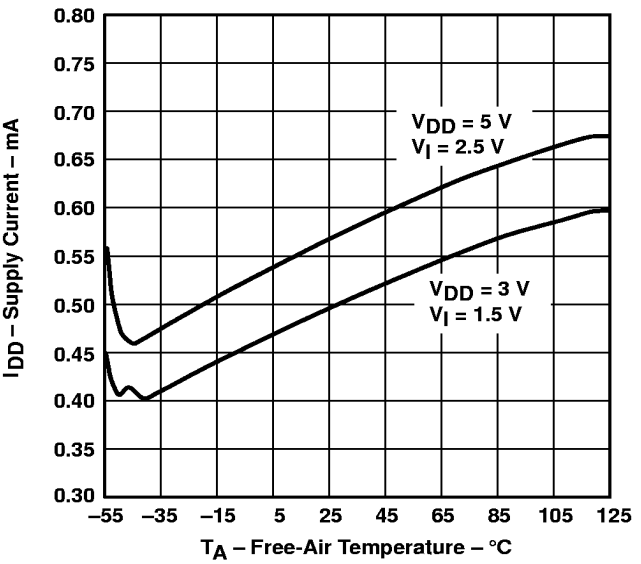


Figure 21

TYPICAL CHARACTERISTICS

AMPLIFIER WITH A SHUTDOWN PULSE
TURN-ON CHARACTERISTICS

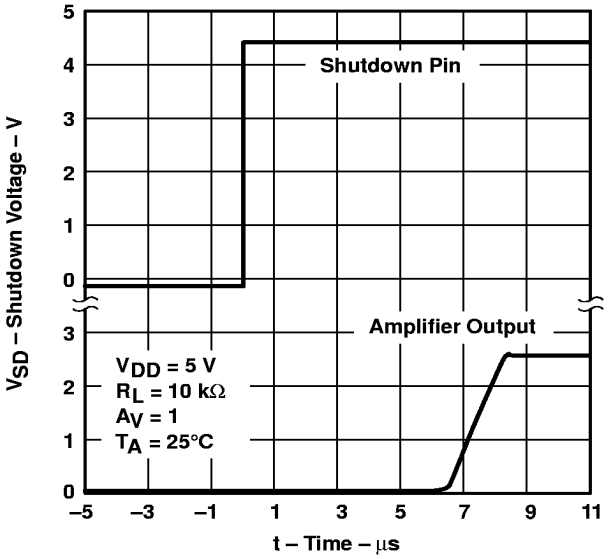


Figure 22

AMPLIFIER WITH A SHUTDOWN PULSE
TURN-OFF CHARACTERISTICS

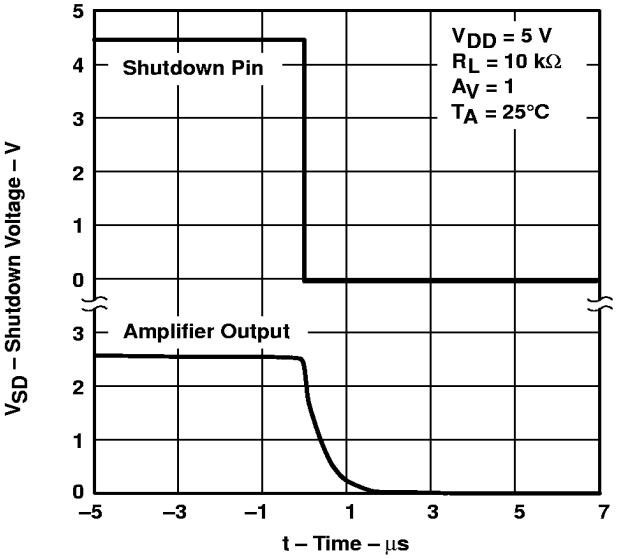


Figure 23

SUPPLY CURRENT WITH A SHUTDOWN PULSE
TURN-ON CHARACTERISTICS

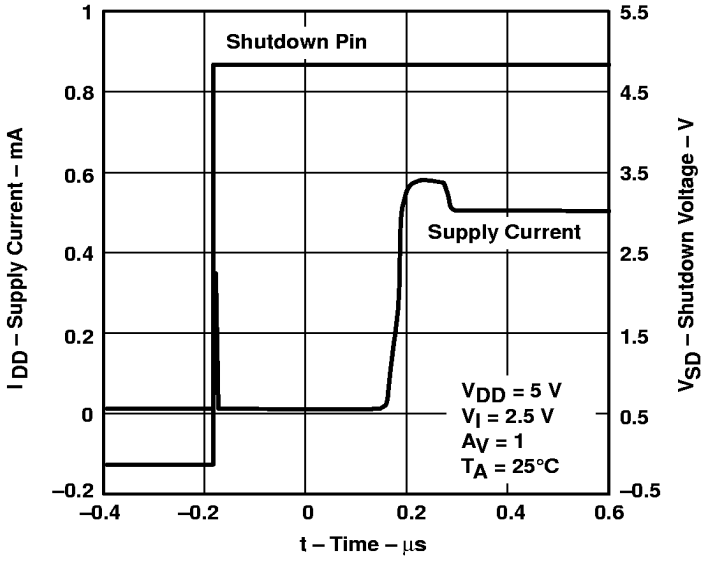


Figure 24

TYPICAL CHARACTERISTICS

TURN-OFF SUPPLY CURRENT WITH A SHUTDOWN PULSE

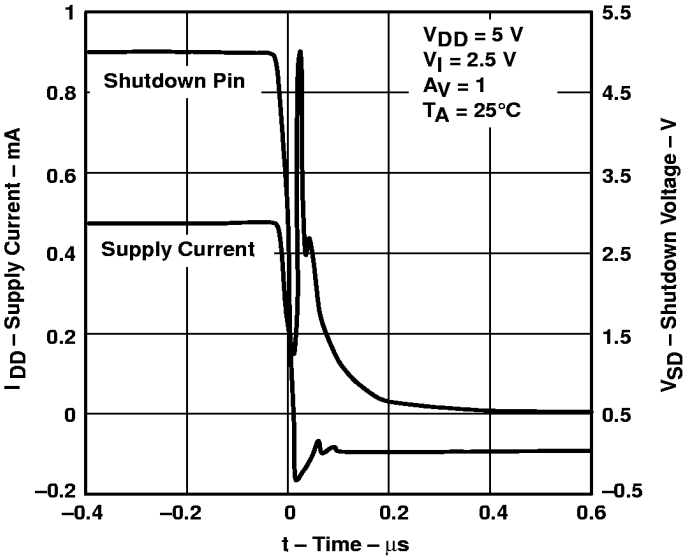


Figure 25

SHUTDOWN SUPPLY CURRENT vs FREE-AIR TEMPERATURE

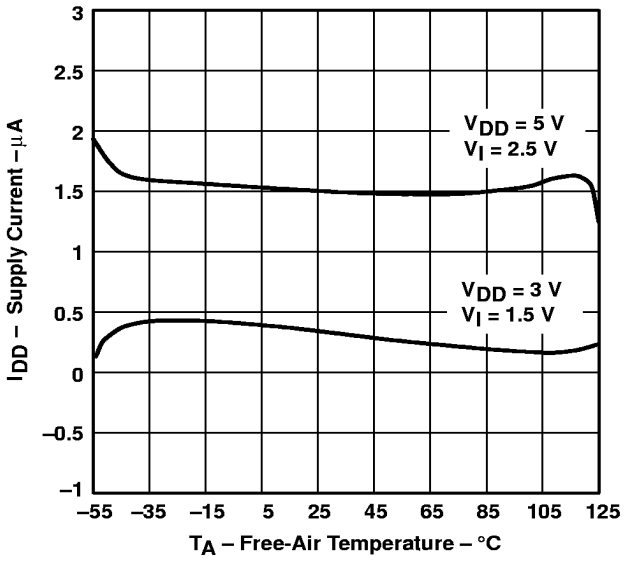


Figure 26

SLEW RATE vs SUPPLY VOLTAGE

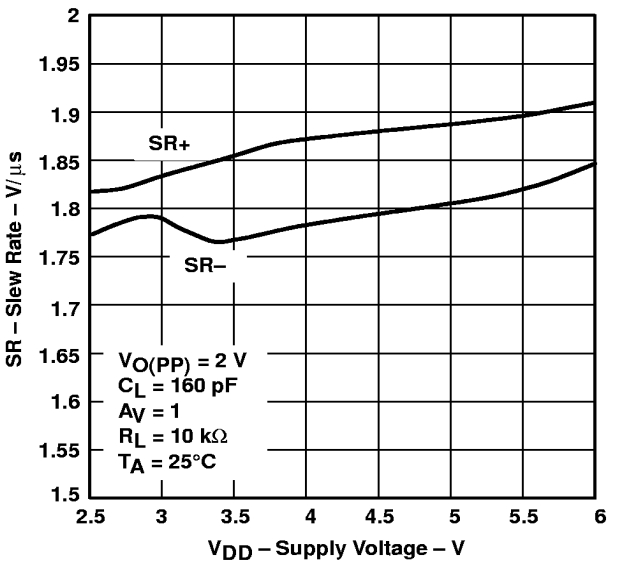


Figure 27

TYPICAL CHARACTERISTICS

EQUIVALENT INPUT NOISE VOLTAGE
vs
FREQUENCY

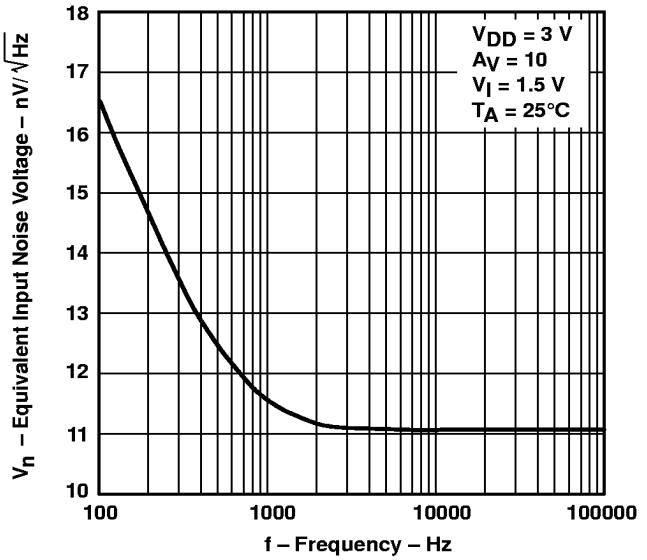


Figure 28

EQUIVALENT INPUT NOISE VOLTAGE
vs
FREQUENCY

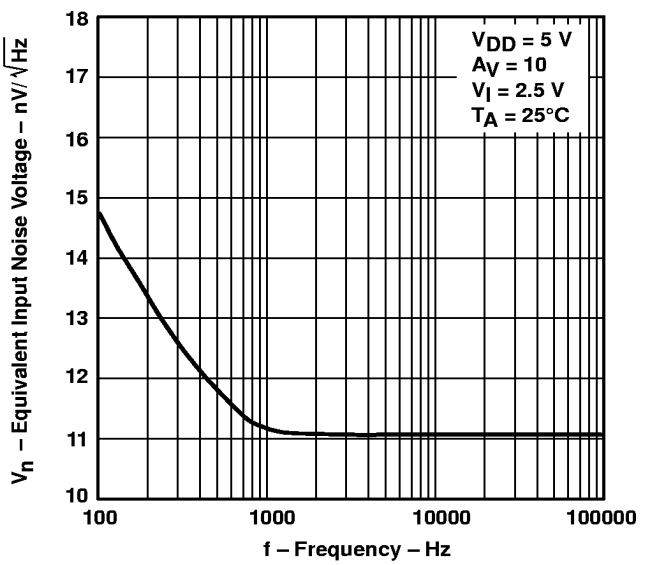


Figure 29

EQUIVALENT INPUT NOISE VOLTAGE
vs
COMMON-MODE INPUT VOLTAGE

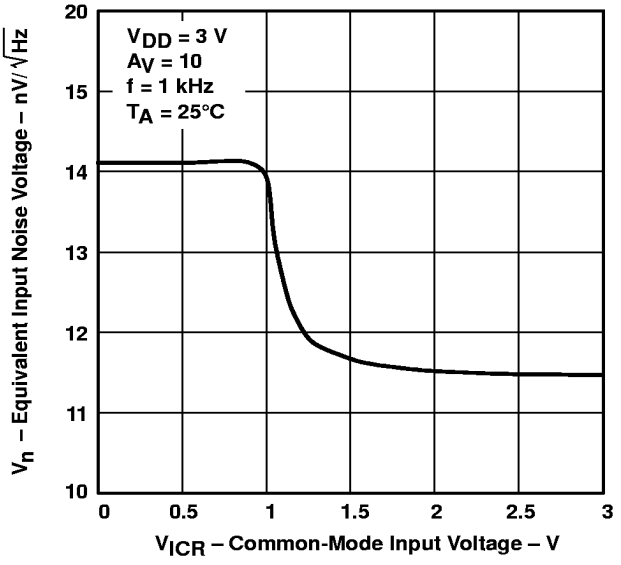


Figure 30

EQUIVALENT INPUT NOISE VOLTAGE
vs
COMMON-MODE INPUT VOLTAGE

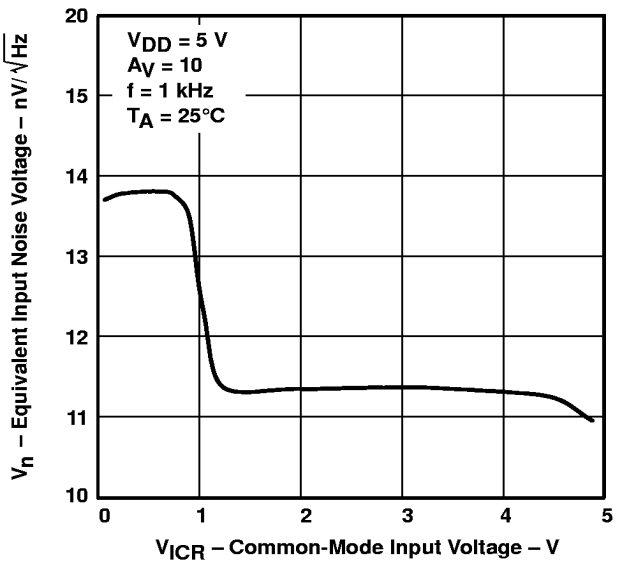


Figure 31

TYPICAL CHARACTERISTICS

TOTAL HARMONIC DISTORTION
vs
FREQUENCY

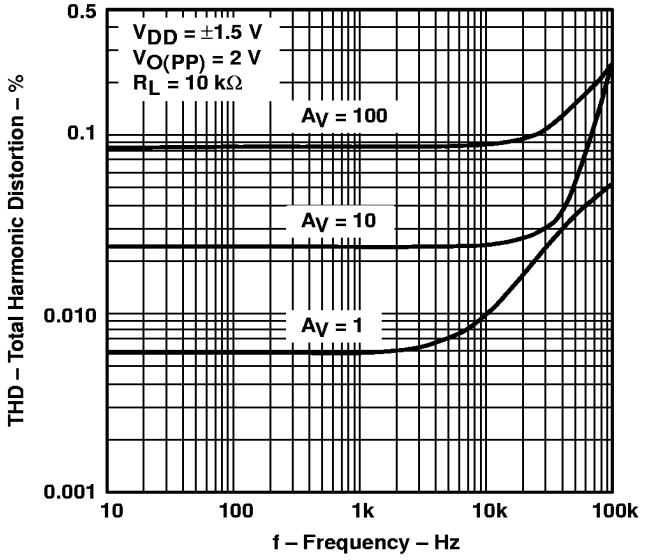


Figure 32

TOTAL HARMONIC DISTORTION
vs
FREQUENCY

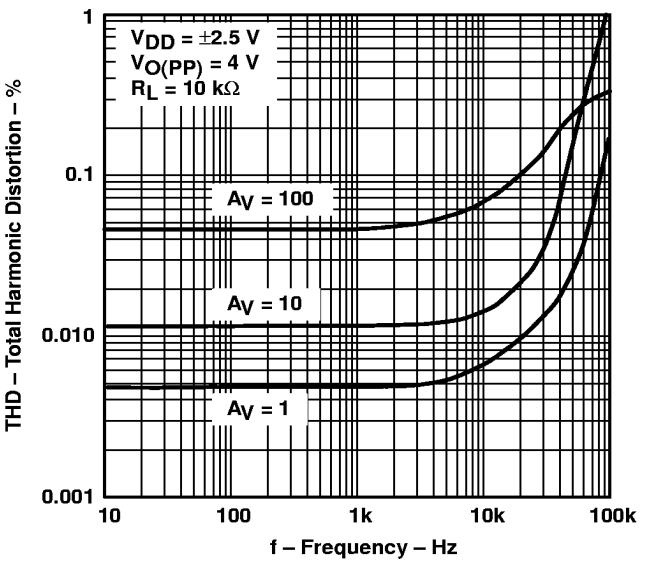


Figure 33

TOTAL HARMONIC DISTORTION PLUS NOISE
vs
PEAK-TO-PEAK SIGNAL AMPLITUDE

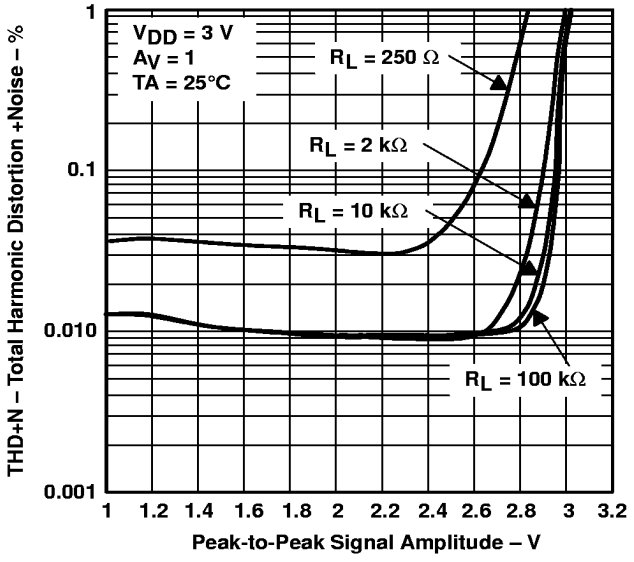


Figure 34

TOTAL HARMONIC DISTORTION PLUS NOISE
vs
PEAK-TO-PEAK SIGNAL AMPLITUDE

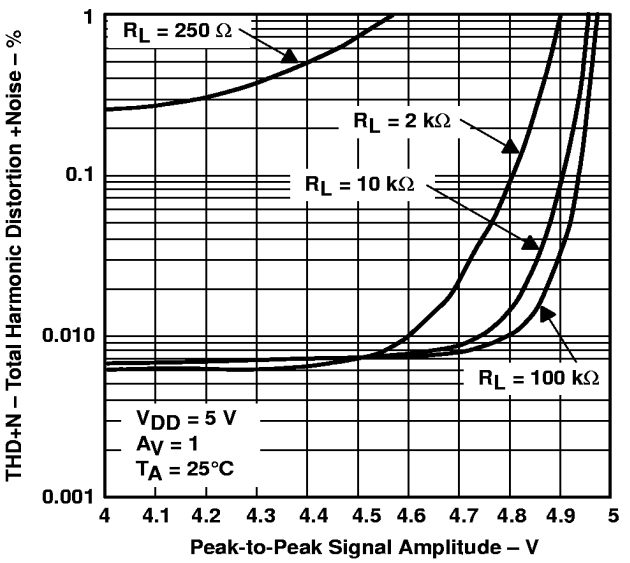


Figure 35

TYPICAL CHARACTERISTICS

PHASE MARGIN
vs
LOAD CAPACITANCE

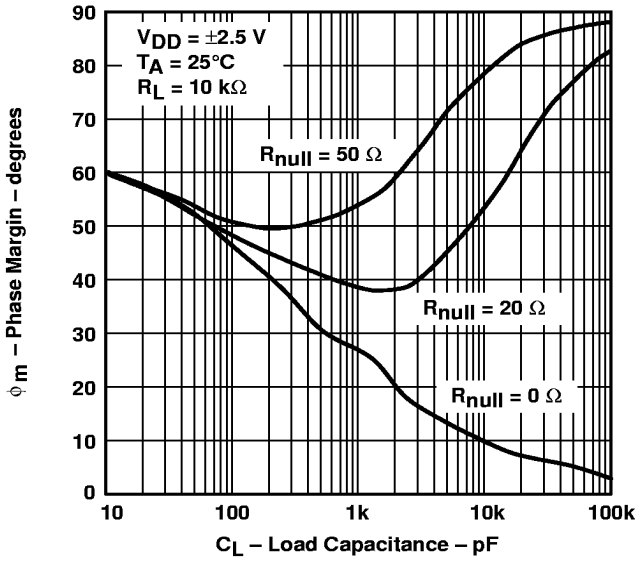


Figure 36

PHASE MARGIN
vs
FREE-AIR TEMPERATURE

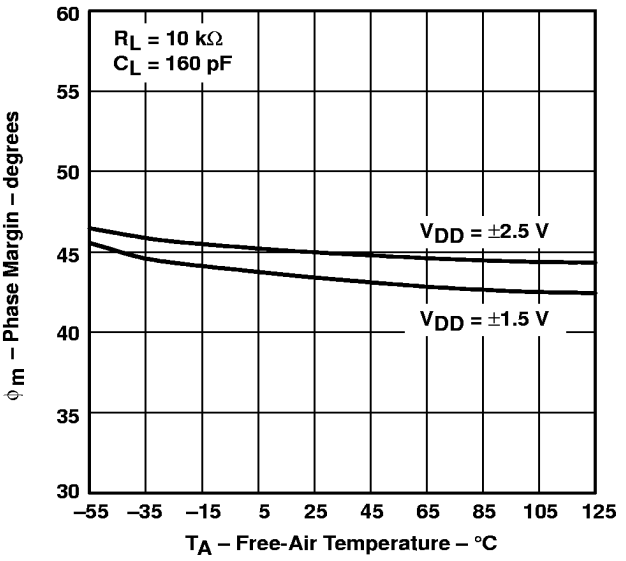


Figure 37

GAIN BANDWIDTH PRODUCT
vs
SUPPLY VOLTAGE

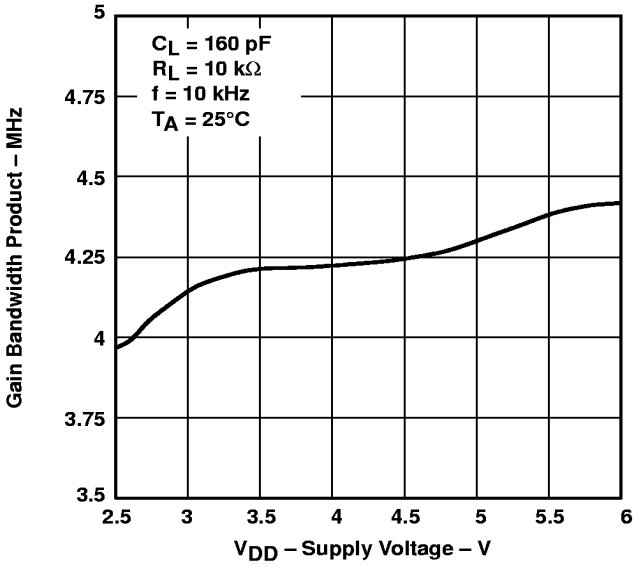


Figure 38

GAIN BANDWIDTH PRODUCT
vs
FREE-AIR TEMPERATURE

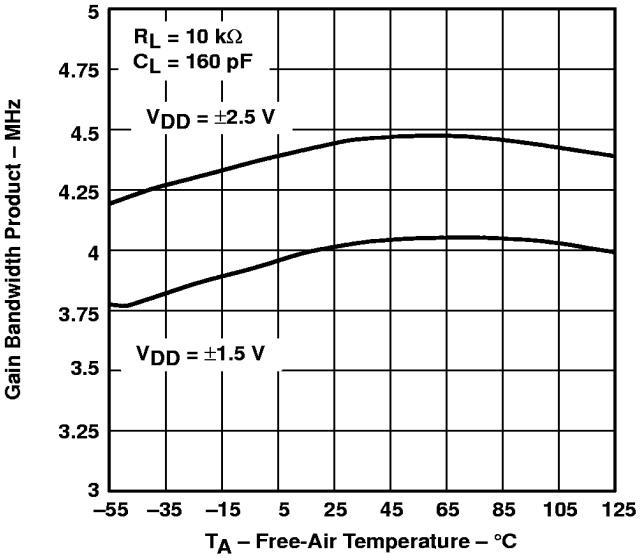


Figure 39

TYPICAL CHARACTERISTICS

LARGE SIGNAL FOLLOWER

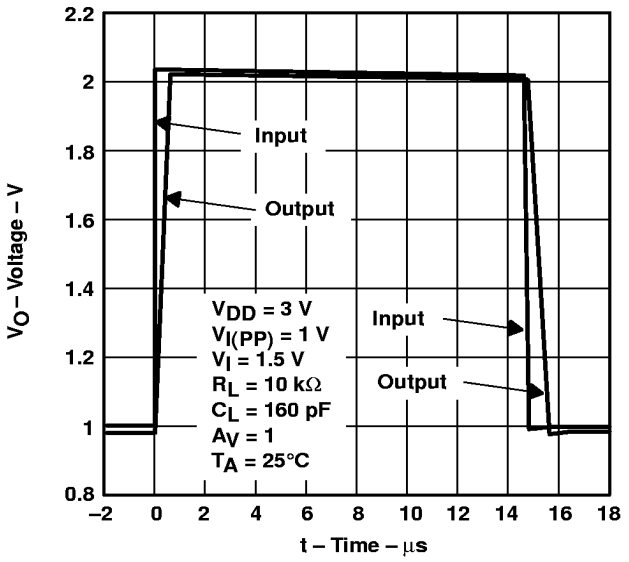


Figure 40

LARGE SIGNAL FOLLOWER

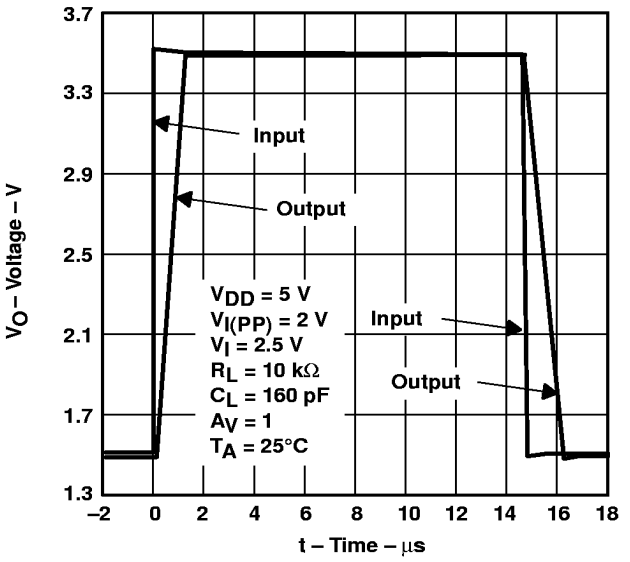


Figure 41

SMALL SIGNAL FOLLOWER

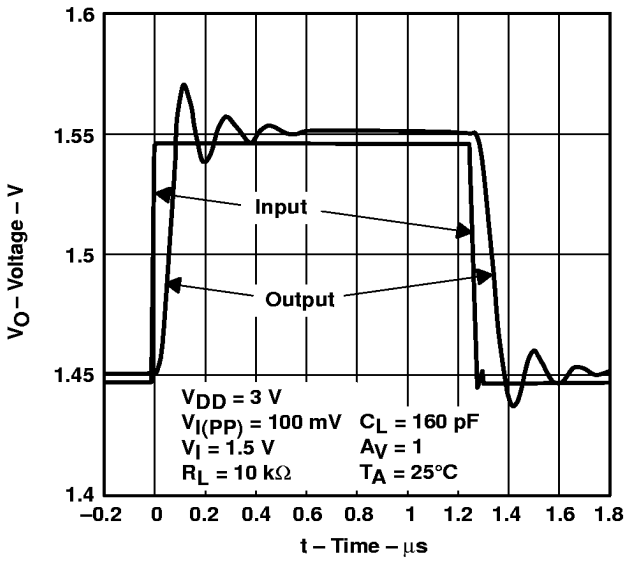


Figure 42

SMALL SIGNAL FOLLOWER

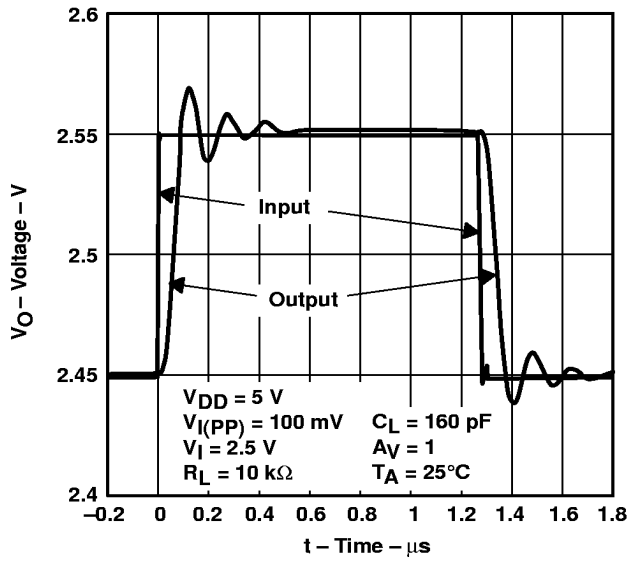


Figure 43

TYPICAL CHARACTERISTICS

INVERTING LARGE SIGNAL

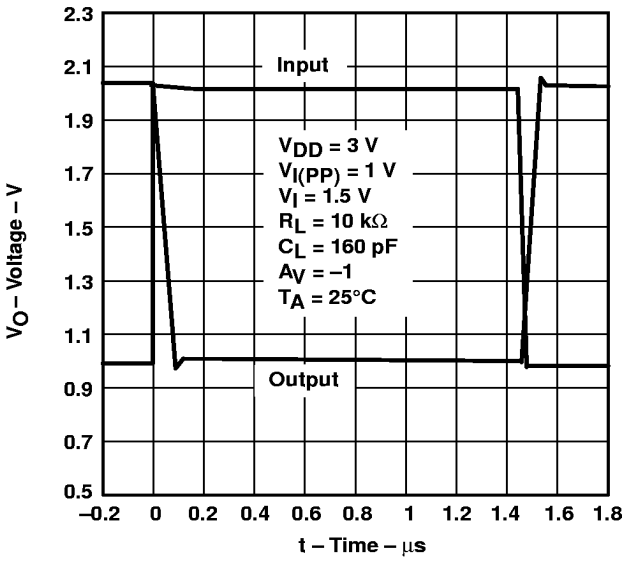


Figure 44

INVERTING LARGE SIGNAL

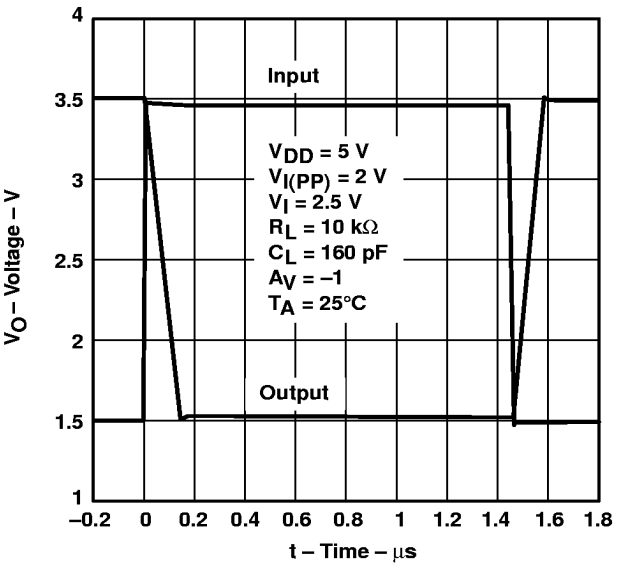


Figure 45

INVERTING SMALL SIGNAL

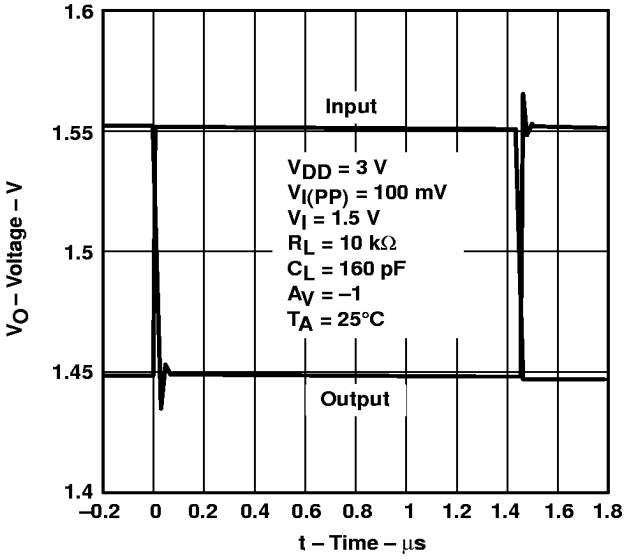


Figure 46

INVERTING SMALL SIGNAL

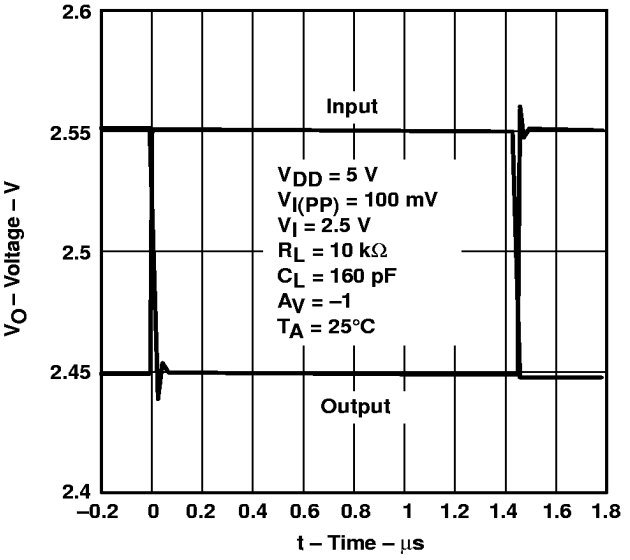


Figure 47

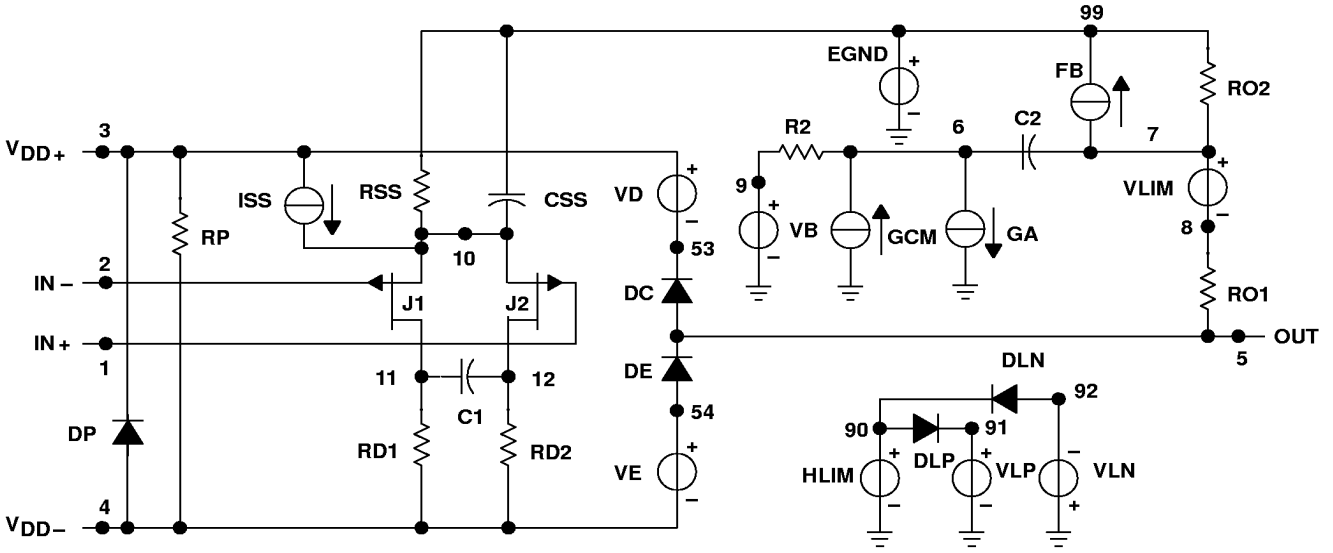
APPLICATION INFORMATION

macromodel information

Macromodel information provided was derived using Microsim *Parts*™ Release 8, the model generation software used with Microsim *PSpice*™. The Boyle macromodel (see Note 2) and subcircuit in Figure 48 are generated using the TLV246x typical electrical and operating characteristics at T_A = 25°C. Using this information, output simulations of the following key parameters can be generated to a tolerance of 20% (in most cases):

- Maximum positive output voltage swing
- Maximum negative output voltage swing
- Slew rate
- Quiescent power dissipation
- Input bias current
- Open-loop voltage amplification
- Unity-gain frequency
- Common-mode rejection ratio
- Phase margin
- DC output resistance
- AC output resistance
- Short-circuit output current limit

NOTE 2: G. R. Boyle, B. M. Cohn, D. O. Pederson, and J. E. Solomon, "Macromodeling of Intergrated Circuit Operational Amplifiers", *IEEE Journal of Solid-State Circuits,* SC-9, 353 (1974).




```
.SUBCKT TLV246X   1 2 3 4 5
C1          11      12      2.46034E–12
C2          6       7       10.0000E–12
CSS         10      99      443.21E–15
DC          5       53      DY
DE          54      5       DY
DLP         90      91      DX
DLN         92      90      DX
DP          4       3       DX
EGND        99      0       POLY (2) (3,0) (4,0) 0 .5 .5
FB          7       99      POLY (5) VB VC VE VLP
+ VLN 0 21.600E6 –1E3 1E3 22E6 –22E6
GA          6       0       11      12 345.26E–6
GCM         0       6       10      99 15.4226E–9
ISS         10      4       DC 18.850E–6
HLIM        90      0       VLIM 1K
J1          11      2       10 JX1
J2          12      1       10 JX2
R2          6       9       100.00E3
RD1         3       11      2.8964E3
RD2         3       12      2.8964E3
R01         8       5       5.6000
R02         7       99      6.2000
RP          3       4       8.9127
RSS         10      99      10.610E6
VB          9       0       DC 0
VC          3       53      DC .7836
VE          54      4       DC .7436
VLIM        7       8       DC 0
VLP         91      0       DC 117
VLN         0       92      DC 117
.MODEL DX D (IS=800.00E–18)
.MODEL DY D (IS=800.00E–18 Rs = 1m Cjo=10p)
.MODEL JX1 NJF (IS=1.0000E–12 BETA=6.3239E–3
+ VTO=–1)
.MODEL JX2 NJF (IS=1.0000E–12 BETA=6.3239E–3
+ VTO=–1)
.ENDS
```

Figure 48. Boyle Macromodel and Subcircuit

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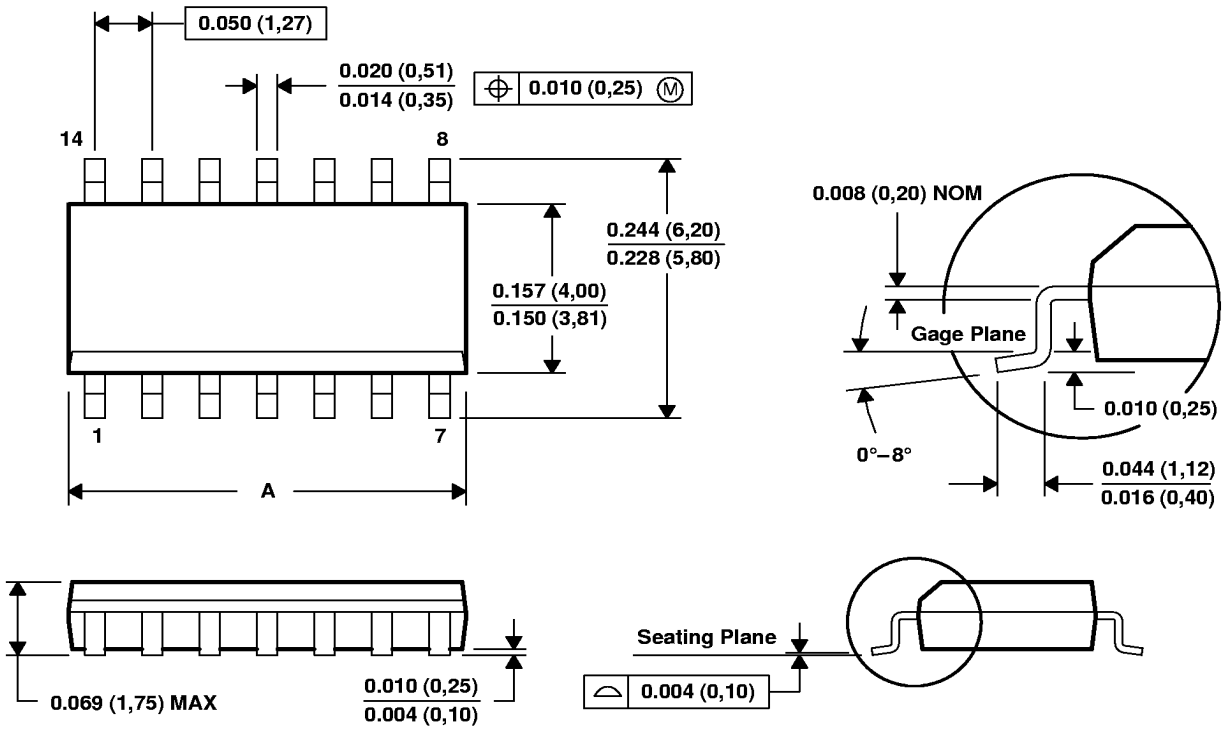
MECHANICAL DATA

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

14 PIN SHOWN



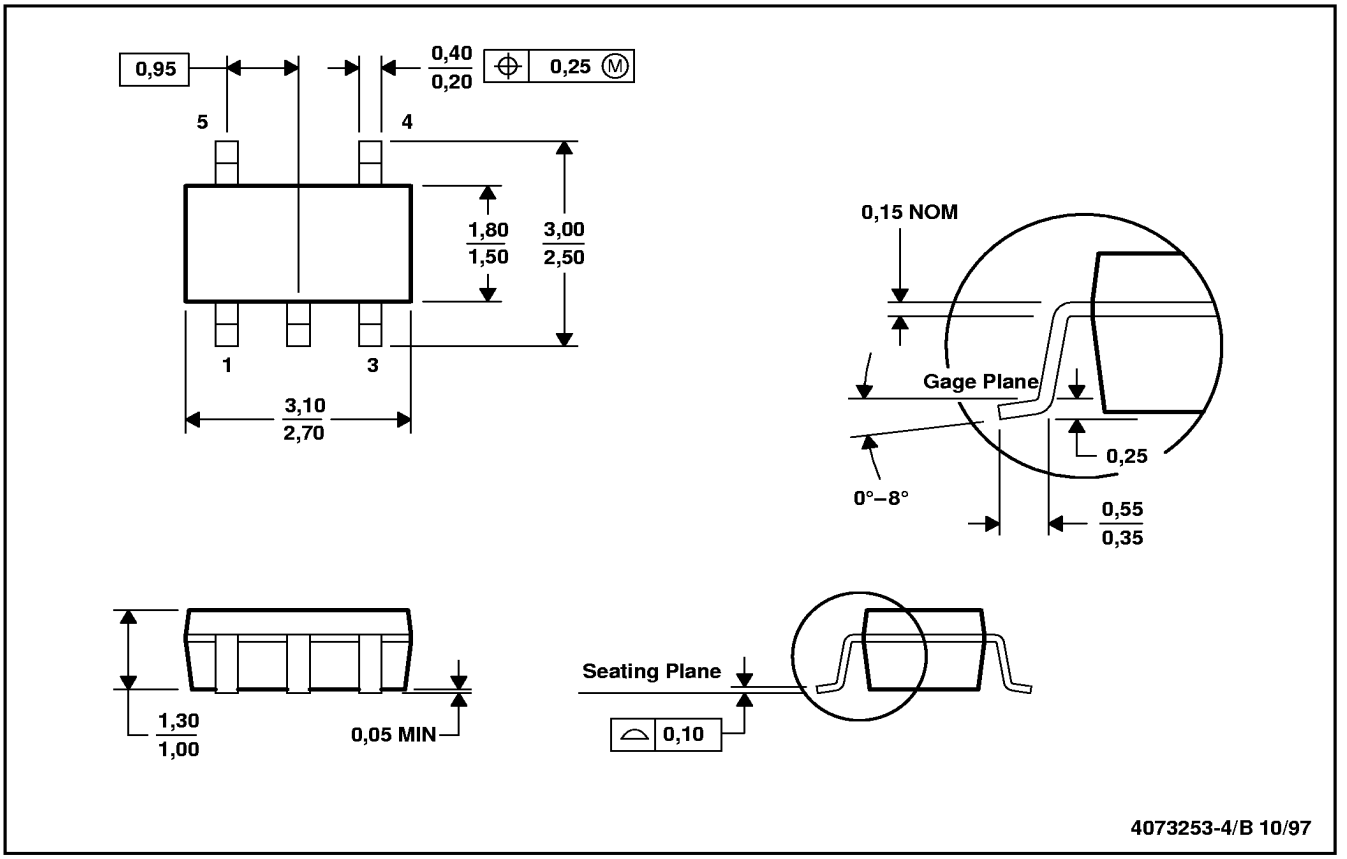
DIM \ PINS **	8	14	16
A MAX	0.197 (5,00)	0.344 (8,75)	0.394 (10,00)
A MIN	0.189 (4,80)	0.337 (8,55)	0.386 (9,80)

4040047/D 10/96

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

MECHANICAL DATA

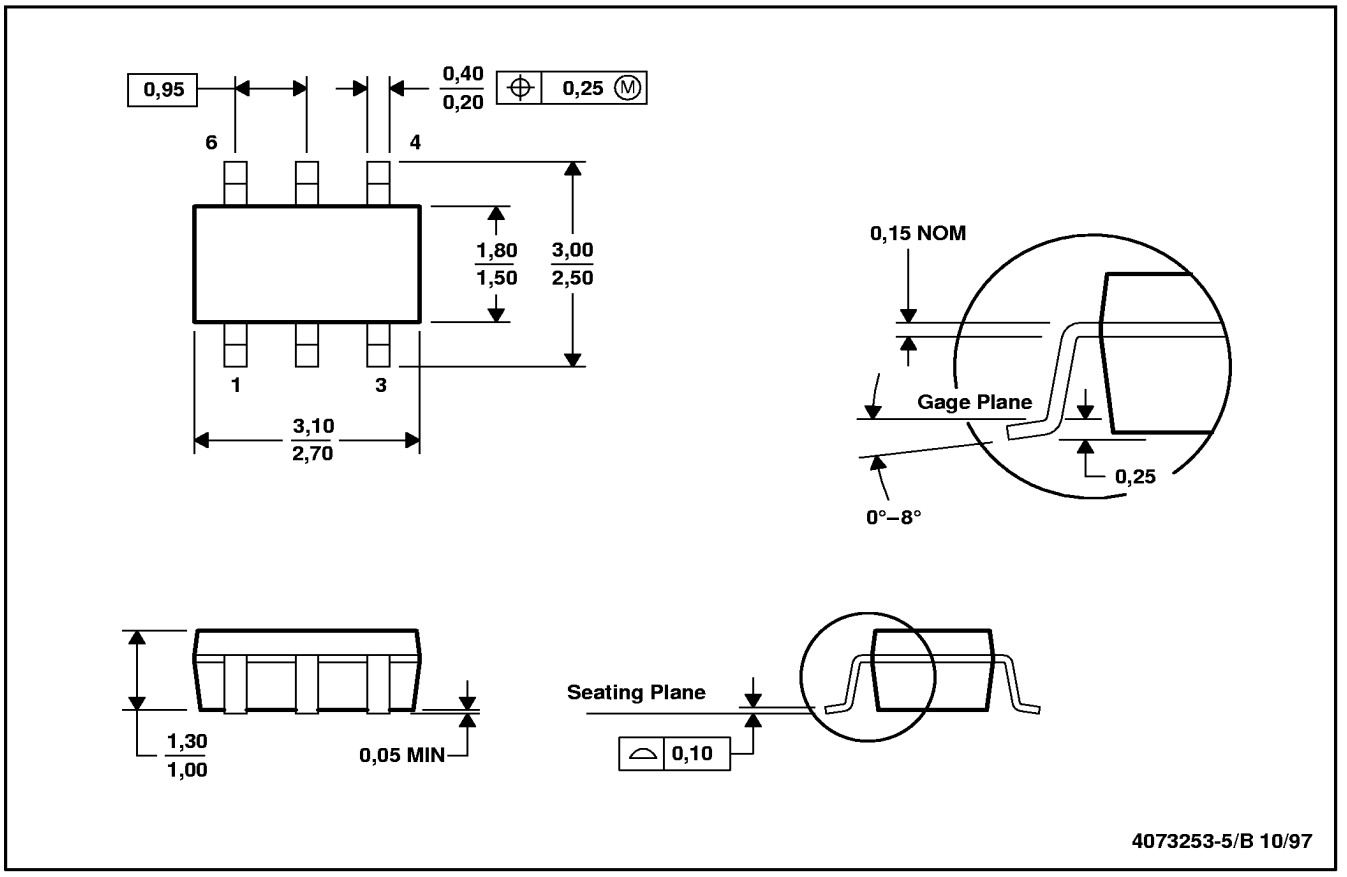
DBV (R-PDSO-G5) **PLASTIC SMALL-OUTLINE PACKAGE**



NOTES: A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions include mold flash or protrusion.

MECHANICAL DATA

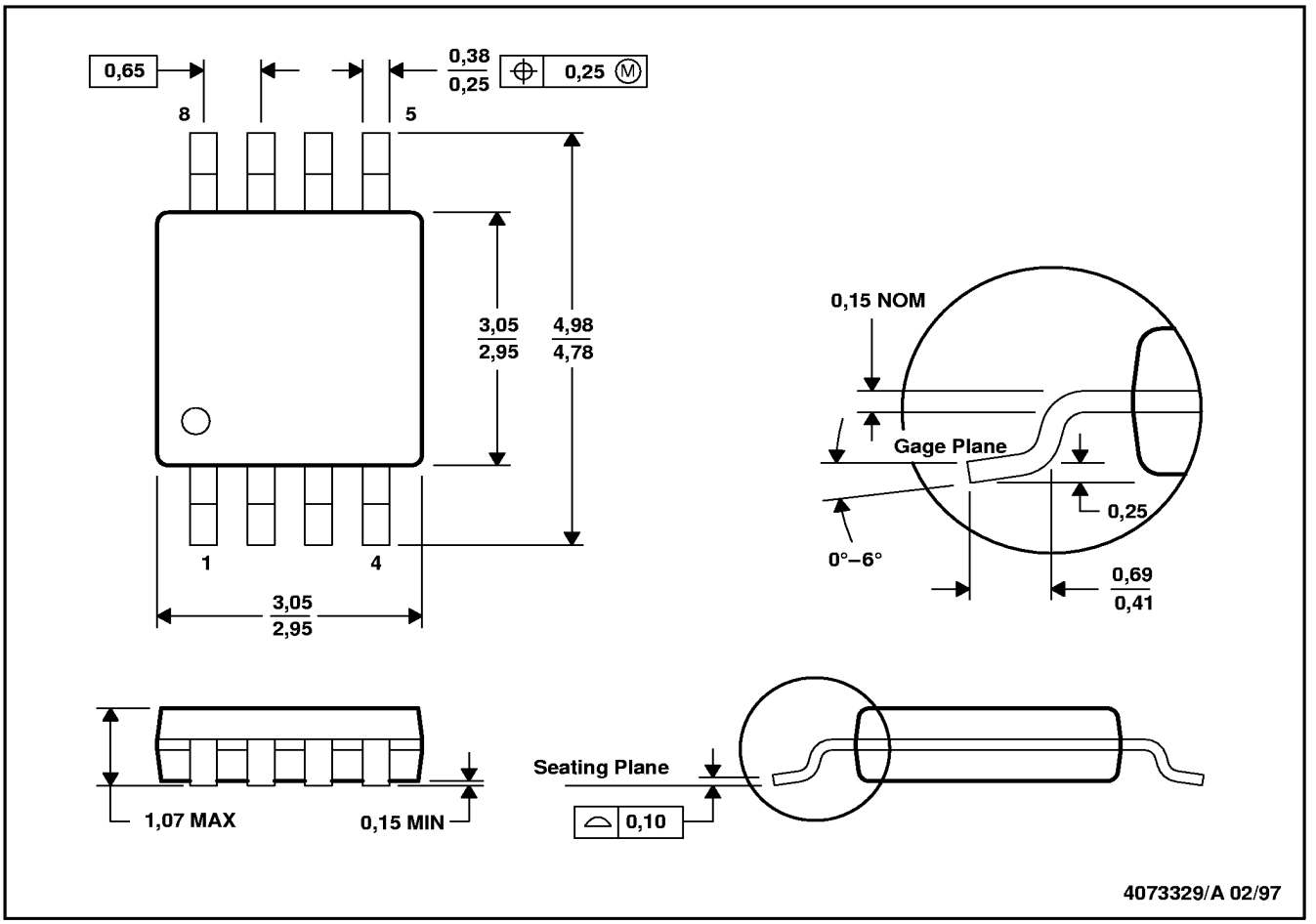
DBV (R-PDSO-G6) **PLASTIC SMALL-OUTLINE PACKAGE**



NOTES: A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions include mold flash or protrusion.

MECHANICAL DATA

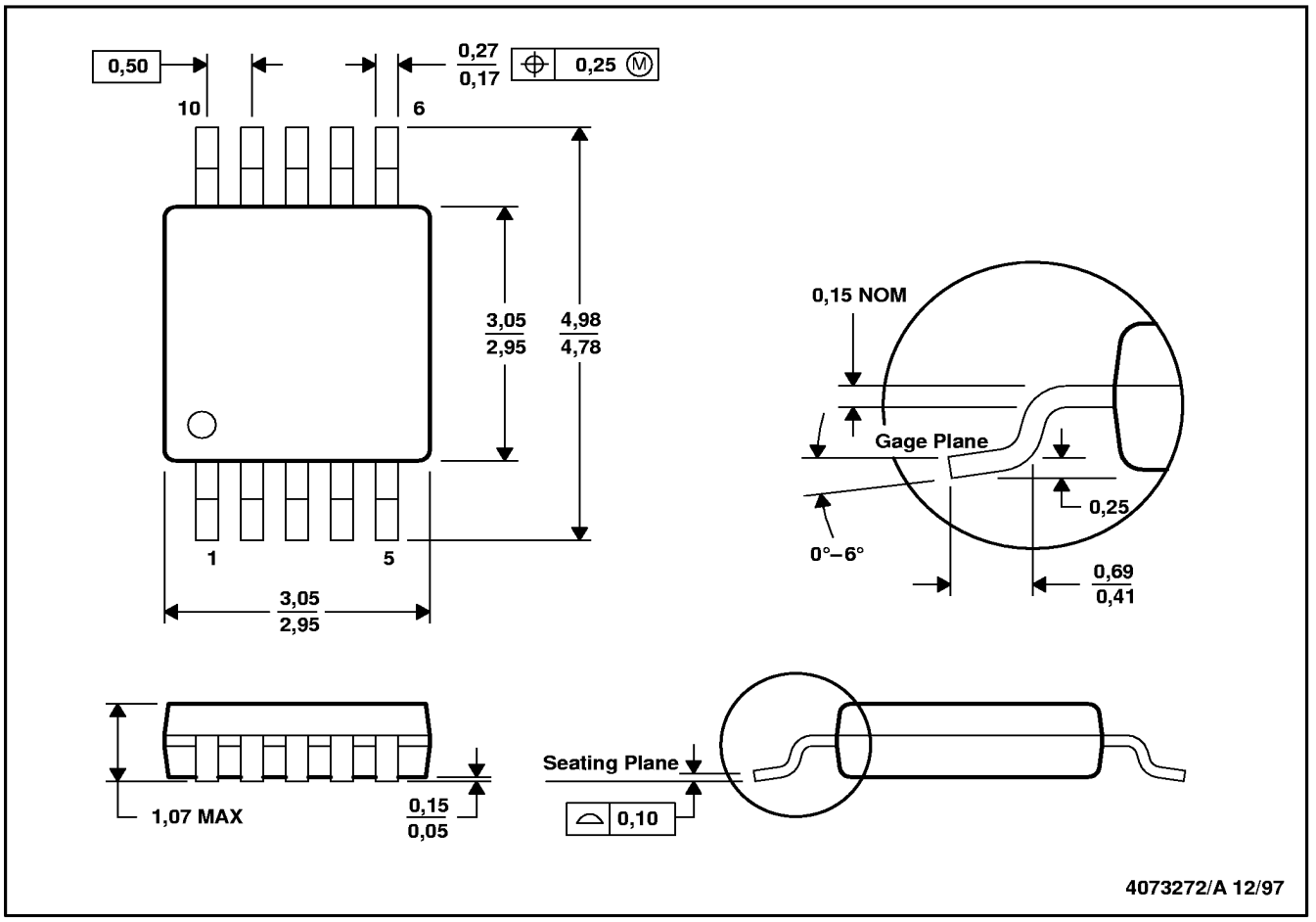
DGK (R-PDSO-G8) **PLASTIC SMALL-OUTLINE PACKAGE**



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

MECHANICAL DATA

DGS (S-PDSO-G10) **PLASTIC SMALL-OUTLINE PACKAGE**



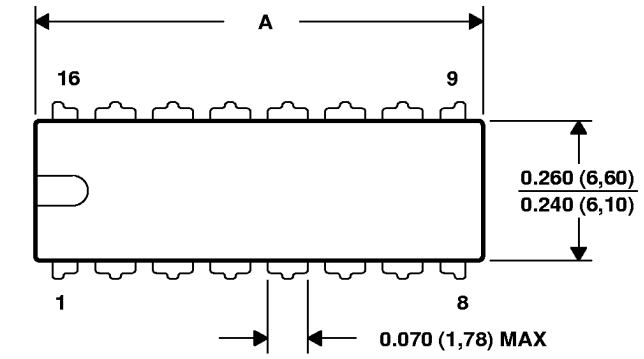
NOTES: A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion.

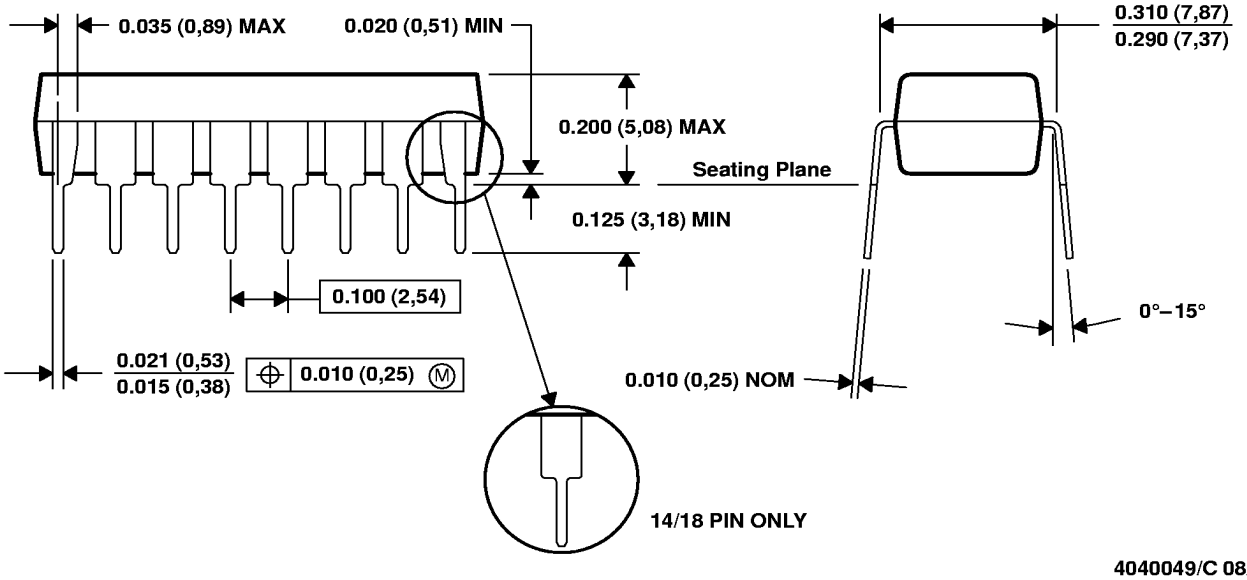
MECHANICAL DATA

N (R-PDIP-T)** **PLASTIC DUAL-IN-LINE PACKAGE**

16 PIN SHOWN

DIM \ PINS **	14	16	18	20
A MAX	0.775 (19,69)	0.775 (19,69)	0.920 (23.37)	0.975 (24,77)
A MIN	0.745 (18,92)	0.745 (18,92)	0.850 (21.59)	0.940 (23,88)



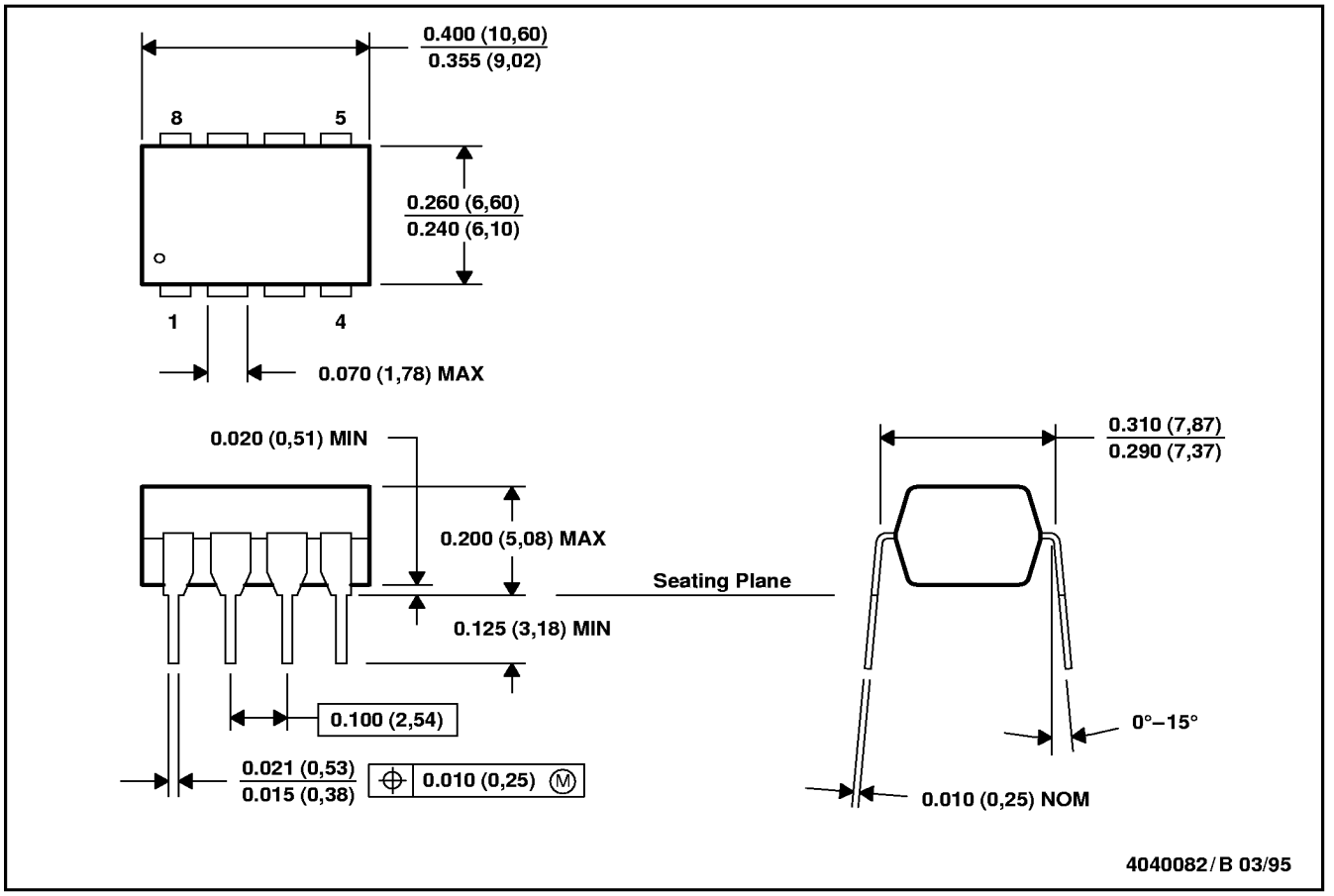


4040049/C 08/95

NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Falls within JEDEC MS-001 (20 pin package is shorter then MS-001.)

MECHANICAL DATA

P (R-PDIP-T8) **PLASTIC DUAL-IN-LINE PACKAGE**

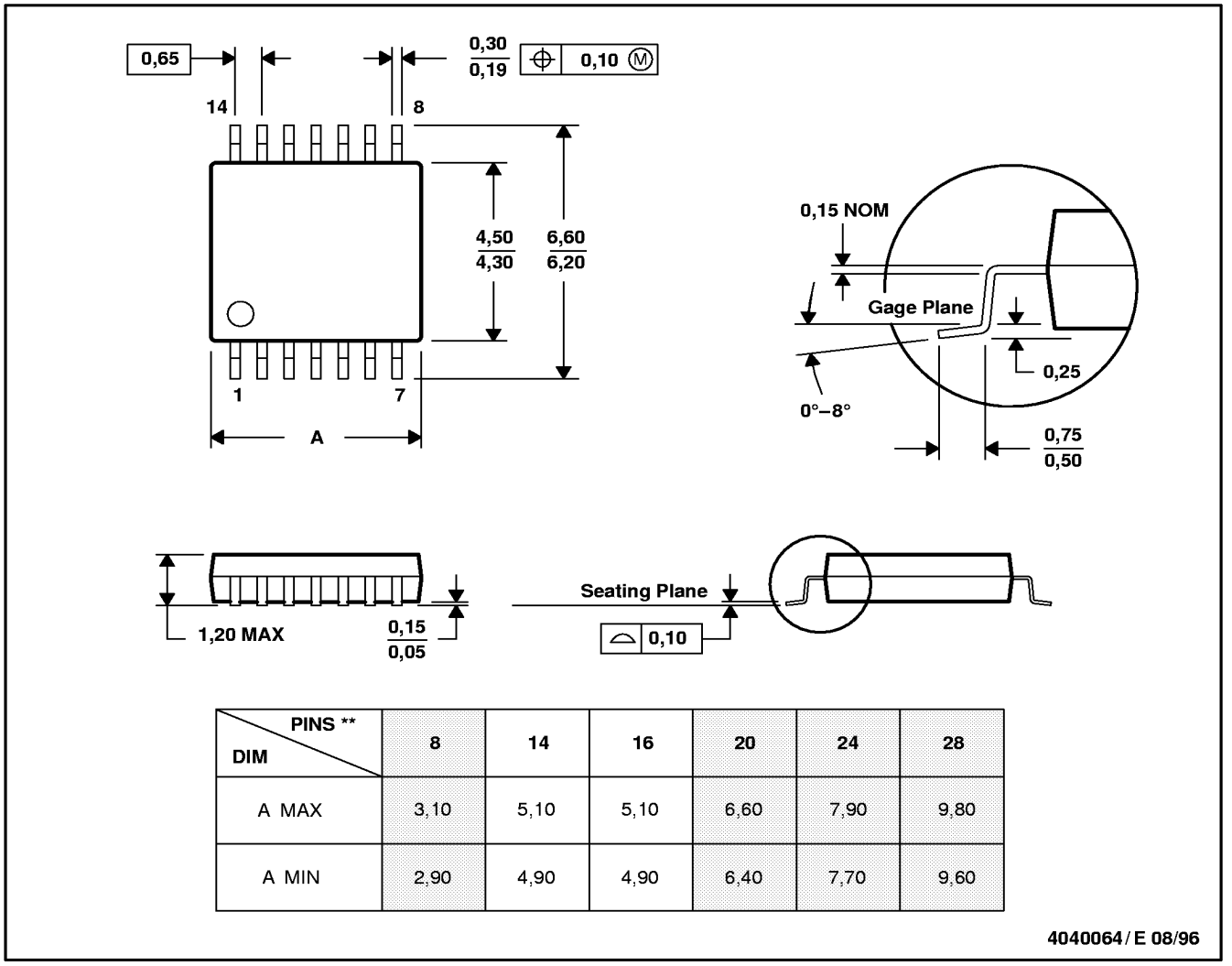


NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Falls within JEDEC MS-001

MECHANICAL DATA

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

14 PIN SHOWN



DIM \ PINS **	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 / E 08/96

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