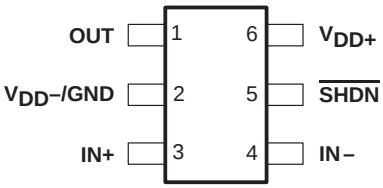
- **Supply Current . . . 23μA/Channel**
- **Gain-Bandwidth Product…290 kHz**
- **Rail-To-Rail Input/Output (RRIO)**
- **±10-mA Output Drive Capability**
- **6-Pin SOT23 Package (TLV2450)**
- **Input Offset Voltage . . . 1 mV (max)**
- **V_{DD} Range . . . +2.7 V to +6 V**
- **Unity Gain Stable Driving Large Capacitive Loads**
- **Ultra-Low Power Shutdown Mode**
  I_{DD} = 16nA/ch
- **Power Supply Rejection Ratio . . . 106dB**
- **8/10-Pin MSOP Package (TLV2452/3)**

TLV2450
DBV† PACKAGE
(TOP VIEW)



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

description

The TLV245x is a family of rail-to-rail input/output operational amplifiers that set a new performance point for supply current and ac performance. These devices consume a mere 23 μA/channel while offering 290 kHz of gain bandwidth product; much higher than competitive devices with similar supply current levels. Along with increased ac performance, the amplifier provides high output drive capability; solving a major shortcoming of older micropower rail-to-rail input/output operational amplifiers. The TLV245x can swing to within 250 mV of each supply rail while driving a 5-mA load. Both the inputs and outputs swing rail-to-rail for increased dynamic range in low-voltage applications. This performance makes the TLV245x family ideal for portable medical equipment, patient monitoring systems, and data acquisition circuits.

Three members of the family (TLV2450/3/5) offer a shutdown terminal for conserving battery life in portable applications. During shutdown, the outputs are placed in a high-impedance state and the amplifier consumes only 16 nA/channel. The family is fully specified at 3 V and 5 V across an expanded industrial temperature range (–40°C to 125°C). The singles and duals are available in the SOT23 and MSOP packages, while the quads are available in TSSOP. The TLV2450 offers an amplifier with shutdown functionality all in a 6-pin SOT23 package, making it perfect for high density circuits.

FAMILY PACKAGE TABLE

DEVICE	NUMBER OF CHANNELS	PACKAGE TYPES					SHUTDOWN
		PDIP	SOIC	SOT-23	TSSOP	MSOP	
TLV2450	1	8	8	6‡	—	—	X
TLV2451	1	8	8	5‡	—	—	—
TLV2452‡	2	8	8	—	—	8	—
TLV2453‡	2	14	14	—	—	10	X
TLV2454‡	4	14	14	—	14	—	—
TLV2455‡	4	16	16	—	16	—	X

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

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.

TLV2450 and TLV2451 AVAILABLE OPTIONS

T_A	PACKAGED DEVICES			CHIP FORM‡ (Y)
	SMALL OUTLINE (D)†	SOT-23 (DBV)†	PLASTIC DIP (P)	
0°C to 70°C	TLV2450CD TLV2451CD	TLV2450CDBV TLV2451CDBV	TLV2450CP TLV2451CP	TLV2450Y TLV2451Y
–40°C to 125°C	TLV2450ID TLV2451ID	TLV2450IDBV TLV2451IDBV	TLV2450IP TLV2451IP	— —
	TLV2450AID TLV2451AID	— —	TLV2450AIP TLV2451AIP	— —

† This package is available taped and reeled. To order this packaging option, add an R suffix to the part number (e.g., TLV2450CDR).
‡ Chip forms are tested at T_A = 25°C only.

TLV2452 and TLV2453 AVAILABLE OPTIONS

T_A	PACKAGED DEVICES					CHIP FORM‡ (Y)
	SMALL OUTLINE (D)†	MSOP (DGK)†	MSOP (DGS)†	PLASTIC DIP (N)	PLASTIC DIP (P)	
0°C to 70°C	TLV2452CD TLV2453CD	TLV2452CDGK —	— TLV2453CDGS	— TLV2453CN	TLV2452CP —	TLV2452Y TLV2453Y
–40°C to 125°C	TLV2452ID TLV2453ID	TLV2452IDGK —	— TLV2453IDGS	— TLV2453IN	TLV2452IP —	— —
	TLV2452AID TLV2453AID	— —	— —	— TLV2453AIN	TLV2452AIP —	— —

† This package is available taped and reeled. To order this packaging option, add an R suffix to the part number (e.g., TLV2452CDR).
‡ Chip forms are tested at T_A = 25°C only.

TLV2454 and TLV2455 AVAILABLE OPTIONS

T_A	PACKAGED DEVICES			CHIP FORM‡ (Y)
	SMALL OUTLINE (D)†	PLASTIC DIP (N)	TSSOP (PW)†	
0°C to 70°C	TLV2454CD TLV2455CD	TLV2454CN TLV2455CN	TLV2454CPW TLV2455CPW	TLV2454Y TLV2455Y
–40°C to 125°C	TLV2454ID TLV2455ID	TLV2454IN TLV2455IN	TLV2454IPW TLV2455IPW	— —
	TLV2454AID TLV2455AID	TLV2454AIN TLV2455AIN	TLV2454AIPW TLV2455AIPW	— —

† This package is available taped and reeled. To order this packaging option, add an R suffix to the part number (e.g., TLV2454CDR).
‡ Chip forms are tested at T_A = 25°C only.

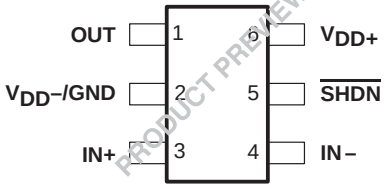
PACKAGE SYMBOLS

PACKAGE TYPE	PINS	PART NUMBER	SYMBOL†
SOT23	6 Pin	TLV2450CDBV	VAQC
		TLV2450IDBV	VAQI
	5 Pin	TLV2451CDBV	VARC
		TLV2451IDBV	VARI
MSOP	8 Pin	TLV2452CDGK	xxTIABI
		TLV2452IDGK	xxTIABJ
	10 Pin	TLV2453CDGK	xxTIABK
		TLV2453IDGK	xxTIABL

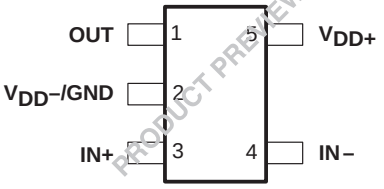
† xx represents the device date code.

TLV245x PACKAGE PINOUTS

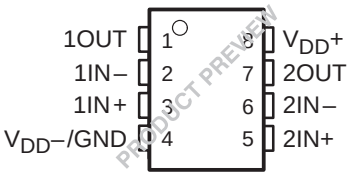
TLV2450
DBV PACKAGE
(TOP VIEW)



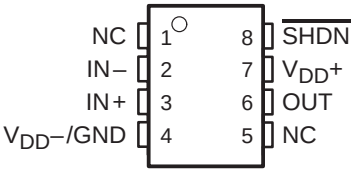
TLV2451
DBV PACKAGE
(TOP VIEW)



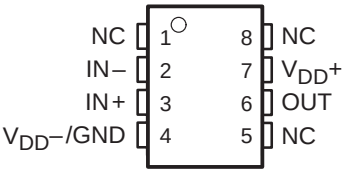
TLV2452
D, DGK, OR P PACKAGE
(TOP VIEW)



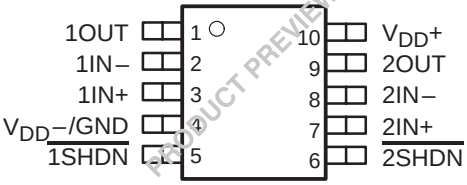
TLV2450
D OR P PACKAGE
(TOP VIEW)



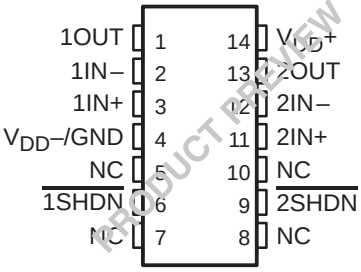
TLV2451
D OR P PACKAGE
(TOP VIEW)



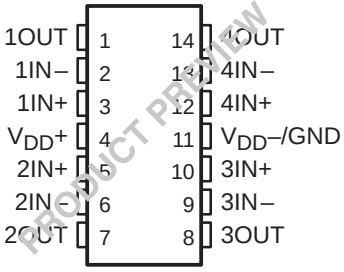
TLV2453
DGS PACKAGE
(TOP VIEW)



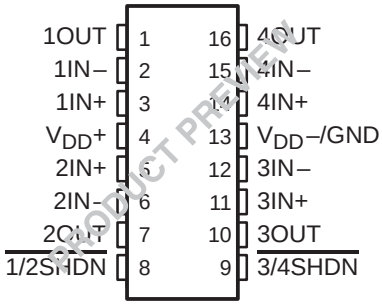
TLV2453
D OR N PACKAGE
(TOP VIEW)



TLV2454
D, N, OR PW PACKAGE
(TOP VIEW)



TLV2455
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) . . . . . 6.5 V
Differential input voltage, V_{ID} . . . . . $\pm V_{DD}$
Input current, I_I (any input) . . . . . ±200 mA
Output current, I_O . . . . . ±20 mA
Total input current, I_I (into V_{DD+}) . . . . . 20 mA
Total output current, I_O (out of V_{DD-}) . . . . . 20 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: 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} = 5 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS		T_A†	TLV245xC			UNIT
					MIN	TYP	MAX	
V_{IO}	Input offset voltage	V_{DD} = ±2.5 V, V_{IC} = 0,	V_O = 0, R_S = 50 Ω	25°C		33	1500	μV
				Full range		61	2000	
α_{VIO}	Temperature coefficient of input offset voltage			25°C to 125°C		3		μV/°C
I_{IO}	Input offset current			25°C		0.3	1	nA
				Full range		0.5	1.5	
I_{IB}	Input bias current			25°C		0.6	5	nA
				Full range		1	7	
V_{ICR}	Common-mode input voltage range	CMRR > 70 dB,	R_S = 50 Ω	25°C	0 to 5			V
		CMRR > 68 dB,	R_S = 50 Ω	Full range	0 to 5			
V_{OH}	High-level output voltage	I_{OH} = –500 μA,		25°C	4.87	4.97		V
				Full range	4.85	4.96		
V_{OL}	Low-level output voltage	V_{IC} = 1.5 V,	I_{OL} = 500 μA	25°C		0.04	0.15	V
				Full range		0.6	0.16	
I_{OS}	Short-circuit output current	Sourcing		25°C	22	32		mA
				Full range	20	26		
		Sinking		25°C	12	18		
				Full range	10	14		
I_O	Output current			25°C		±10		mA
A_{VD}	Large-signal differential voltage amplification	$V_{O(PP)}$ = 3 V,	R_L = 10 kΩ	25°C	96	103		dB
				Full range	91			
$R_{I(d)}$	Differential input resistance			25°C		10^9		Ω
$C_{I(c)}$	Common-mode input capacitance	f = 10 kHz		25°C		8.5		pF
z_o	Closed-loop output impedance	f = 100 kHz,	A_V = 10	25°C		300		Ω
CMRR	Common-mode rejection ratio	V_{IC} = 0 to 5 V,	R_S = 50 Ω	25°C	70	86		dB
				Full range	68	85		
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	89		dB
				Full range	79	89		
		V_{DD} = 3 V to 5 V, No load	V_{IC} = V_{DD}/2,	25°C	90	106		dB
				Full range	89	106		
I_{DD}	Supply current (TLV2450, TLV2451)	V_O = 2.5 V,	No load	25°C		23	34	μA
				Full range		27	35	
$V_{(ON)}$	Turn-on voltage level (TLV2450)	A_V = 1		25°C		1.73		V
$V_{(OFF)}$	Turn-off voltage level (TLV2450)	A_V = 1		25°C		1.45		V
$I_{DD(SHDN)}$	Supply current in shutdown (TLV2450)	SHDN = < 1.45 V		25°C		16	65	nA
				Full range		16	65	

† 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†	TLV245xC			UNIT
					MIN	TYP	MAX	
SR	Slew rate at unity gain	$V_{O(PP)}$ = 3 V, C_L = 150 pF, R_L = 10 kΩ		25°C	0.05	0.12		V/μs
				Full range	0.02	0.9		
V_n	Equivalent input noise voltage	f = 100 Hz		25°C		59		nV/√Hz
		f = 1 kHz		25°C		49		
I_n	Equivalent input noise current	f = 100 Hz		25°C		3.5		pA/√Hz
THD + N	Total harmonic distortion plus noise	$V_{O(PP)}$ = 3 V, R_L = 10 kΩ, f = 1 kHz	A_V = 1	25°C		0.02%		
			A_V = 10			0.18%		
			A_V = 100			0.9%		
$t_{(on)}$	Amplifier turn-on time	A_V = 5, R_L = OPEN, Measured at 50% point		25°C		59		μs
$t_{(off)}$	Amplifier turn-off time			25°C		836		ns
	Gain-bandwidth product	f = 10 kHz, R_L = 10 kΩ, C_L = 160 pF		25°C		290		kHz
ϕ_m	Phase margin at unity gain	R_L = 10 kΩ, C_L = 1000 pF		25°C		56°		
	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†	TLV245xI			UNIT
						MIN	TYP	MAX	
V_{IO}	Input offset voltage	TLV245x	V_{DD} = ±2.5 V, V_{IC} = 0,	V_O = 0, R_S = 50 Ω	25°C		33	1500	μV
					Full range		61	2000	
		TLV245xA			25°C		33	1000	
					Full range		61	1300	
α_{VIO}	Temperature coefficient of input offset voltage				25°C to 125°C		3		μV/°C
I_{IO}	Input offset current				25°C		0.3	1	nA
					Full range		0.5	1.5	
I_{IB}	Input bias current				25°C		0.6	5	pA
					Full range		1	7	
V_{ICR}	Common-mode input voltage range		CMRR > 70 dB	R_S = 50 Ω	25°C	0 to 5			V
			CMRR > 68 dB	R_S = 50 Ω	–40°C to 85°C	0 to 5			
			CMRR > 52 dB	R_S = 50 Ω	Full range	0 to 5			
V_{OH}	High-level output voltage		I_{OH} = –500 μA		25°C	4.87	4.97		V
					Full range	4.85	4.96		
V_{OL}	Low-level output voltage		V_{IC} = 1.5 V,	I_{OL} = 500 μA	25°C		0.04	0.15	V
					Full range		0.06	0.16	
I_{OS}	Short-circuit output current		Sourcing		25°C	22	32		mA
					Full range	20	26		
			Sinking		25°C	12	18		
					Full range	10	14		
I_O	Output current				25°C		±10		mA
A_{VD}	Large-signal differential voltage amplification		$V_{O(PP)}$ = 3 V,	R_L = 10 kΩ	25°C	96	103		dB
					Full range	91			
$r_{i(d)}$	Differential input resistance				25°C		10^9		Ω
C_{IC}	Common-mode input capacitance		f = 10 kHz		25°C		8.5		pF
z_o	Closed-loop output impedance		f = 10 kHz,	A_V = 10	25°C		300		Ω
CMRR	Common-mode rejection ratio		V_{IC} = 0 to 5 V,	R_S = 50 Ω	25°C	70	86		dB
					–40°C to 85°C	68	85		
			V_{IC} = 0 to 5 V,	R_S = 50 Ω	Full range	52	61		
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	89		dB
					Full range	79	89		
			V_{DD} = 3 V to 5 V, No load	V_{IC} = V_{DD}/2,	25°C	90	106		
					Full range	89	106		

† Full range is –40°C to 125°C.

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

PARAMETER		TEST CONDITIONS		T_A†	TLV245xI			UNIT
					MIN	TYP	MAX	
I_{DD}	Supply current (TLV2450, TLV2451)	V_O = 2.5 V,	No load	25°C		23	34	μA
				Full range		32	42	
$V_{(ON)}$	Turn-on voltage level (TLV2450)	A_V = 1		25°C		1.73		V
$V_{(OFF)}$	Turn-off voltage level (TLV2450)	A_V = 1		25°C		1.45		V
$I_{DD(SHDN)}$	Supply current in shutdown mode (TLV2450)	SHDN = < 1.45 V		25°C		16	65	nA
				Full range		30	80	

† 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†	TLV245xI			UNIT
					MIN	TYP	MAX	
SR	Slew rate at unity gain	$V_{O(PP)}$ = 3 V, R_L = 10 kΩ	C_L = 150 pF,	25°C	0.05	0.12		V/μs
				Full range	0.02	0.7		
V_n	Equivalent input noise voltage	f = 100 Hz		25°C		59		nV/√Hz
		f = 1 kHz		25°C		49		
I_n	Equivalent input noise current	f = 1 kHz		25°C		3.5		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		0.02%		
			A_V = 10			0.18%		
			A_V = 100			0.9%		
$t_{(on)}$	Amplifier turn-on time (TLV2450)	A_V = 5, Measured at 50% point	R_L = OPEN,	25°C		59		μs
$t_{(off)}$	Amplifier turn-off time (TLV2450)			25°C		836		ns
	Gain-bandwidth product	f = 10 kHz, C_L = 160 pF	R_L = 10 kΩ,	25°C		290		kHz
ϕ_m	Phase margin at unity gain	R_L = 10 kΩ,	C_L = 1000 pF	25°C		56°		
	Gain margin			25°C		7		dB

† Full range is –40°C to 125°C.

TYPICAL CHARACTERISTICS

Table of Graphs

			FIGURE
V_{IO}	Input offset voltage	vs Common-mode input voltage	1
I_{IO}	Input offset current	vs Common-mode input voltage vs Free-air temperature	2 4
I_{IB}	Input bias current	vs Common-mode input voltage vs Free-air temperature	3 4
V_{OH}	High-level output voltage	vs High-level output current	5
V_{OL}	Low-level output voltage	vs Low-level output current	6
A_{VD}	Differential voltage amplification	vs Frequency	7
	Phase	vs Frequency	7
Z_o	Output impedance	vs Frequency	8
CMRR	Common-mode rejection ratio	vs Frequency	9
PSRR	Power supply rejection ratio	vs Frequency	10
I_{DD}	Supply current	vs Supply voltage vs Free-air temperature	11 12
V_n	Equivalent input noise voltage	vs Frequency	13
THD + N	Total harmonic distortion plus noise	vs Frequency	14
$V_{O(PP)}$	Maximum peak-to-peak output voltage	vs Frequency	15
	Gain-bandwidth product	vs Supply voltage	16
ϕ_m	Phase margin	vs Load capacitance	17
SR	Slew rate	vs Load capacitance vs Free-air temperature	18 19
	Large-signal inverting pulse response	vs Time	20
	Small-signal inverting pulse response	vs Time	21
	Large-signal follower pulse response	vs Time	22
	Small-signal follower pulse response	vs Time	23
	Shutdown on supply current	vs Time	24
	Shutdown off supply current	vs Time	25
	Shutdown on pulse response	vs Time	26
	Shutdown off pulse response	vs Time	27
	Shutdown mode supply current	vs Free-air temperature	28

TYPICAL CHARACTERISTICS

INPUT OFFSET VOLTAGE vs COMMON-MODE INPUT VOLTAGE

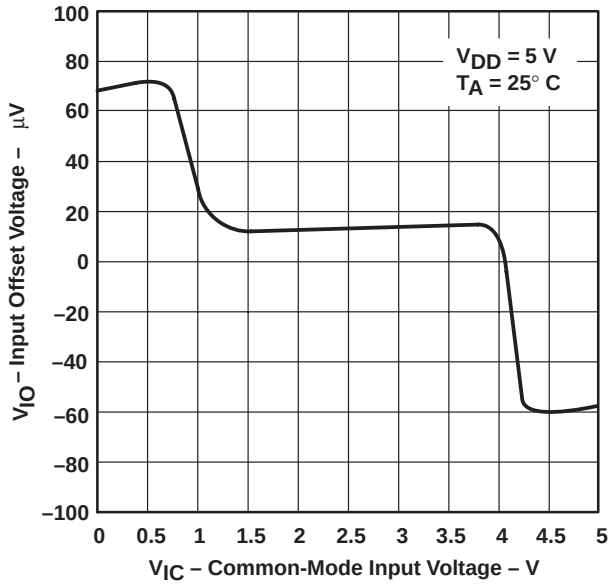


Figure 1

INPUT OFFSET CURRENT vs COMMON-MODE INPUT VOLTAGE

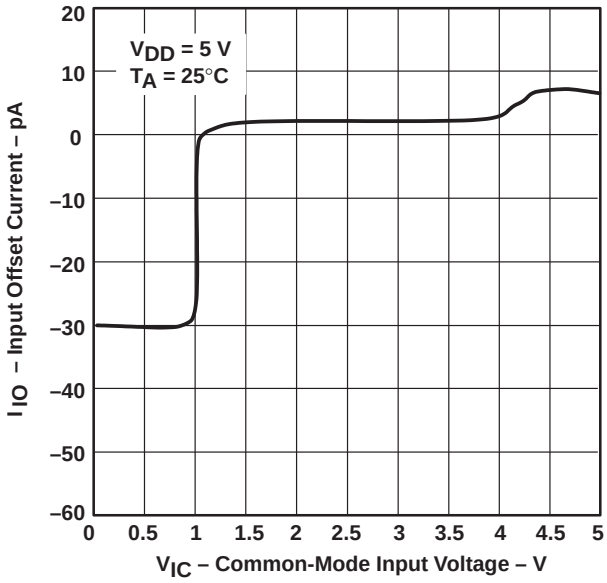


Figure 2

INPUT BIAS CURRENT vs COMMON-MODE INPUT VOLTAGE

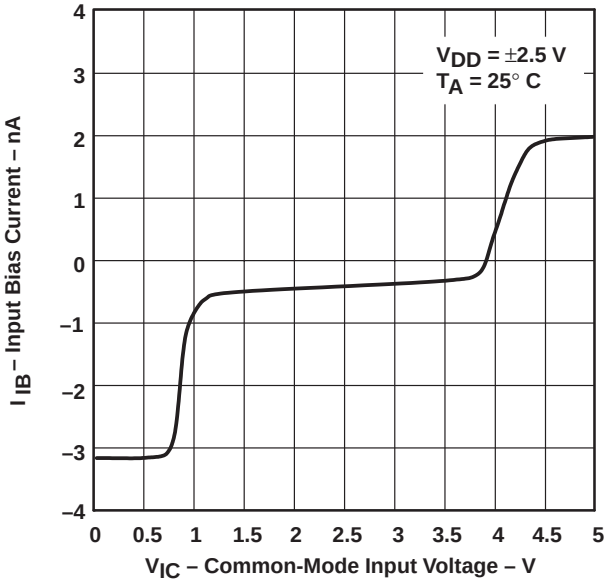


Figure 3

INPUT OFFSET CURRENT AND INPUT BIAS CURRENT vs FREE–AIR TEMPERATURE

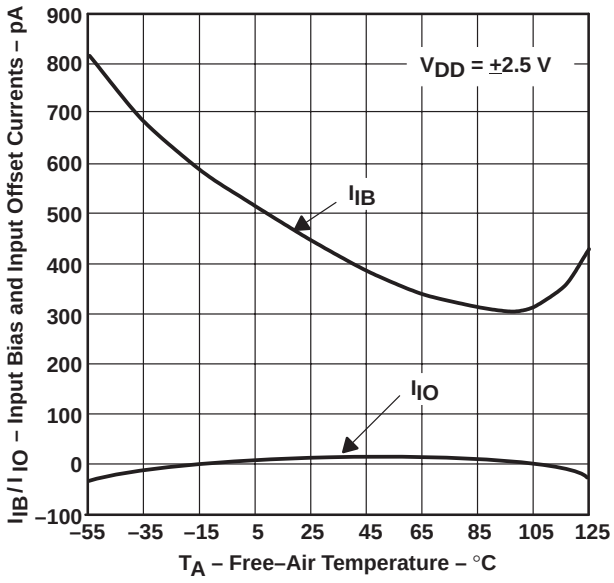


Figure 4

TYPICAL CHARACTERISTICS

HIGH-LEVEL OUTPUT VOLTAGE vs HIGH-LEVEL OUTPUT CURRENT

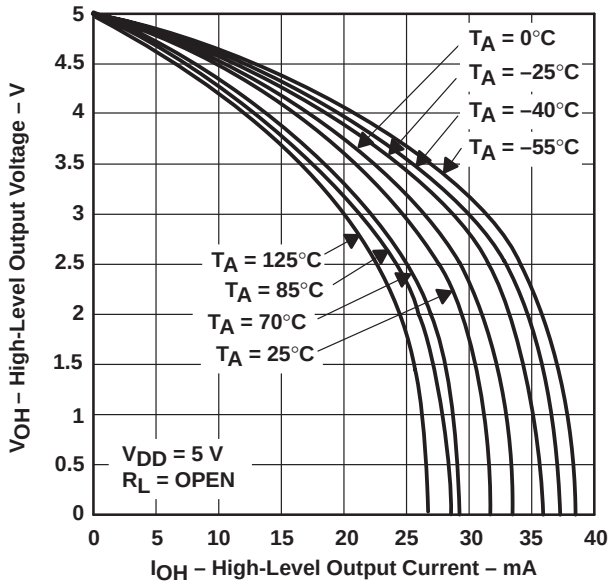


Figure 5

LOW-LEVEL OUTPUT VOLTAGE vs LOW-LEVEL OUTPUT CURRENT

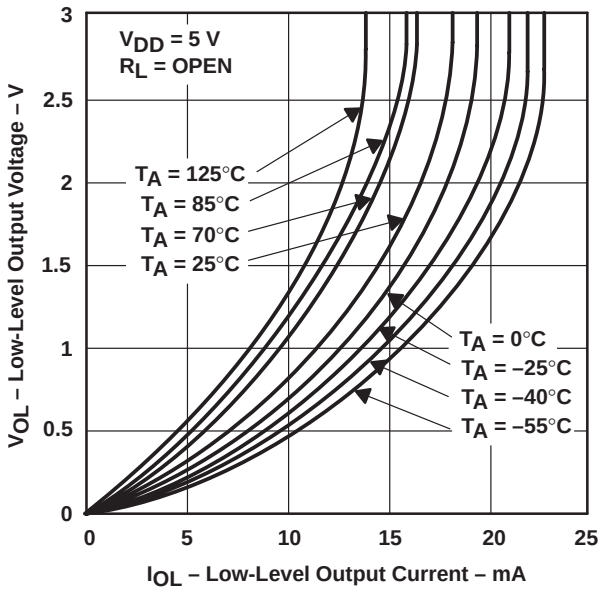


Figure 6

DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE vs FREQUENCY

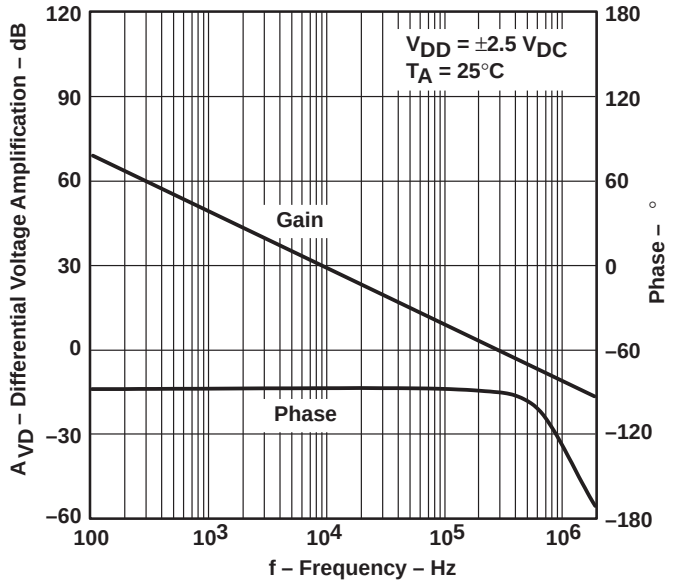


Figure 7

TYPICAL CHARACTERISTICS

OUTPUT IMPEDANCE vs FREQUENCY

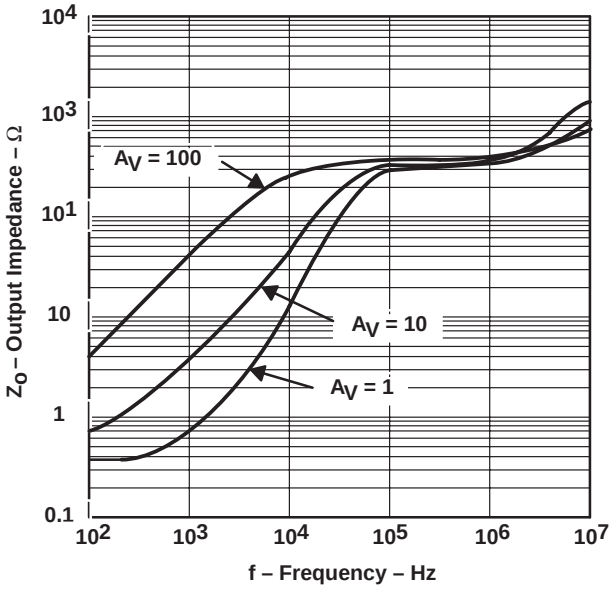


Figure 8

COMMON-MODE REJECTION RATIO vs FREQUENCY

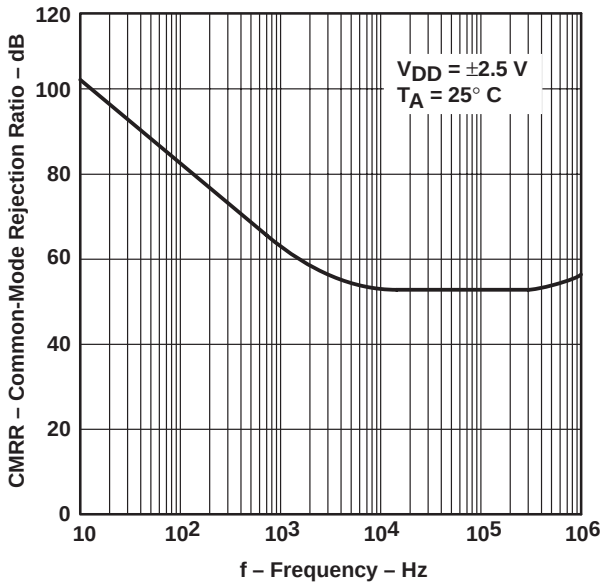


Figure 9

POWER SUPPLY REJECTION RATIO vs FREQUENCY

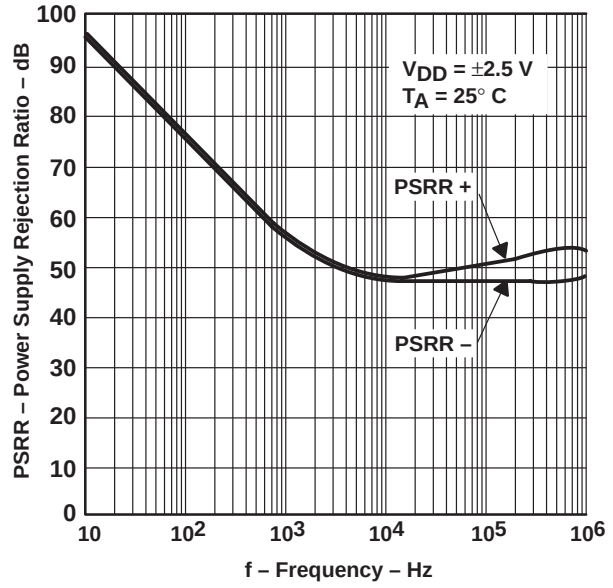


Figure 10

SUPPLY CURRENT vs SUPPLY VOLTAGE

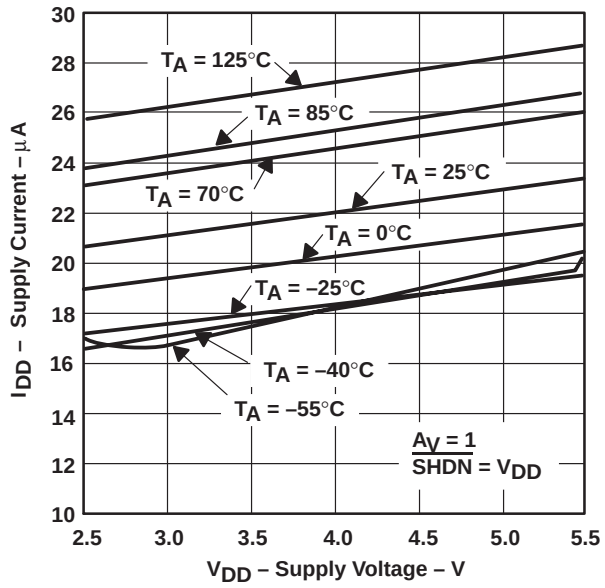


Figure 11

TYPICAL CHARACTERISTICS

SUPPLY CURRENT vs FREE-AIR TEMPERATURE

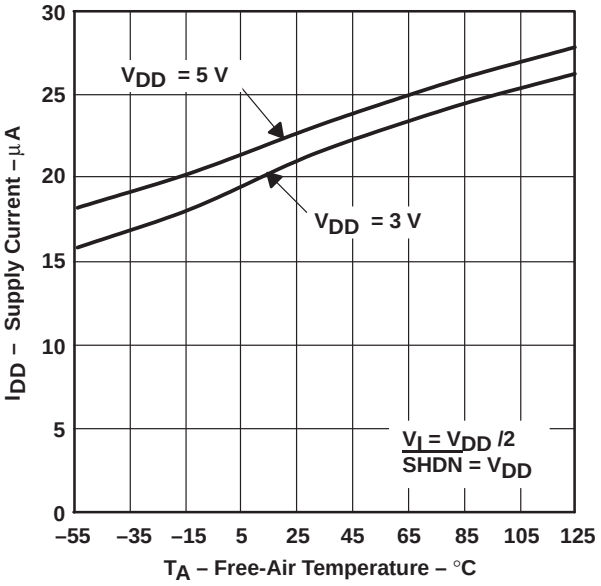


Figure 12

EQUIVALENT INPUT NOISE VOLTAGE vs FREQUENCY

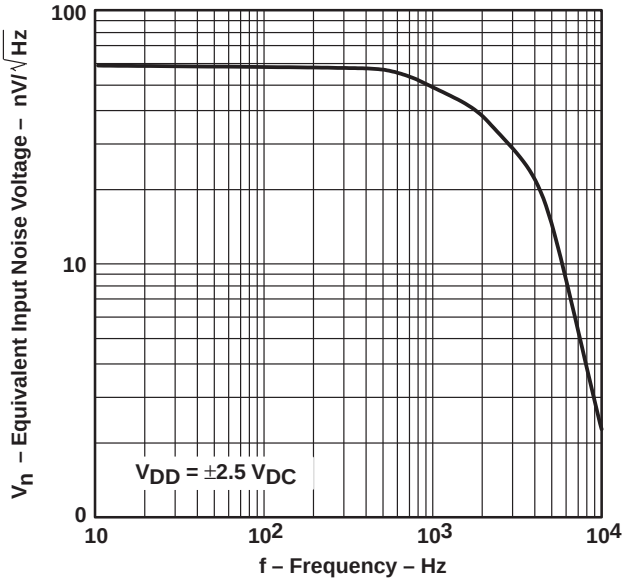


Figure 13

TOTAL HARMONIC DISTORTION PLUS NOISE vs FREQUENCY

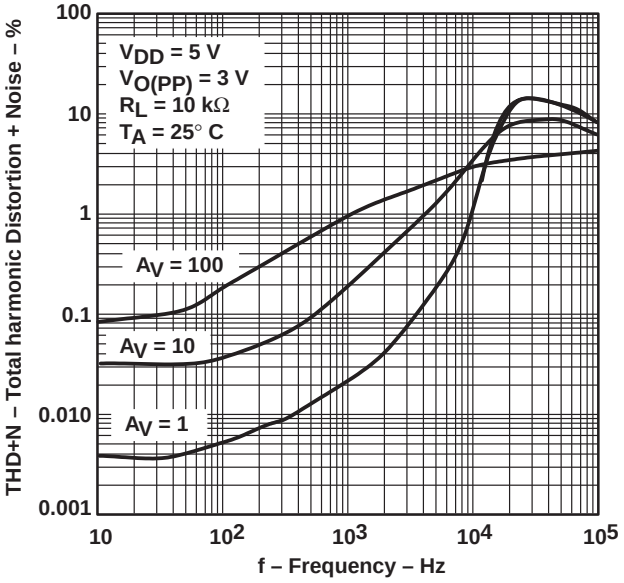


Figure 14

MAXIMUM PEAK-TO-PEAK OUTPUT VOLTAGE vs FREQUENCY

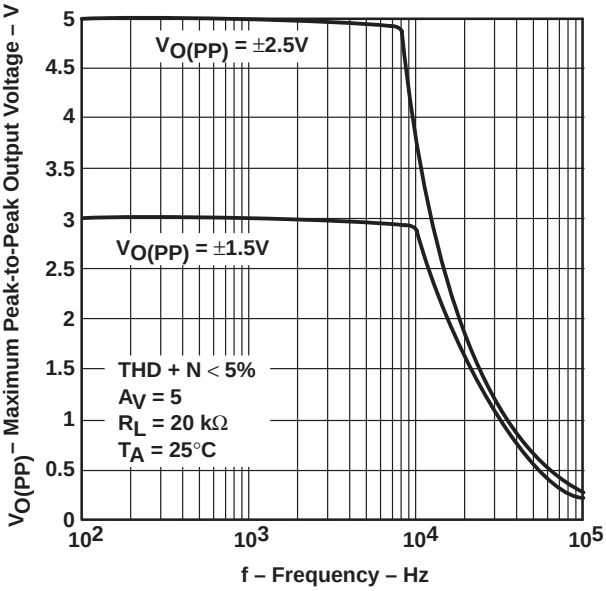


Figure 15

TYPICAL CHARACTERISTICS

PHASE MARGIN vs LOAD CAPACITANCE

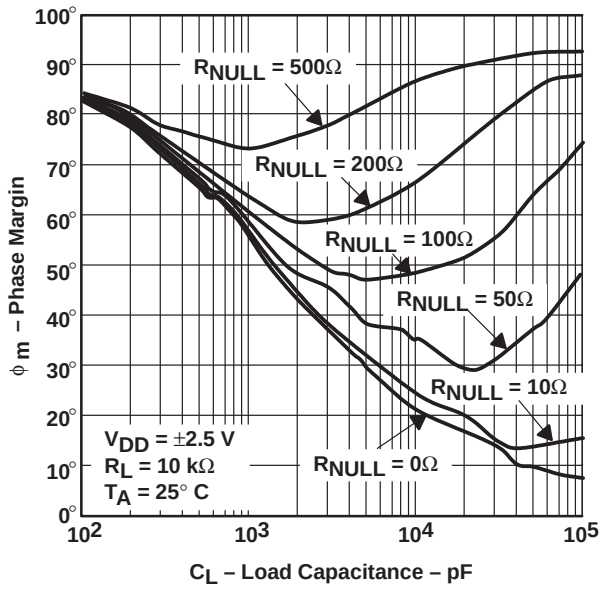


Figure 16

GAIN BANDWIDTH PRODUCT vs SUPPLY VOLTAGE

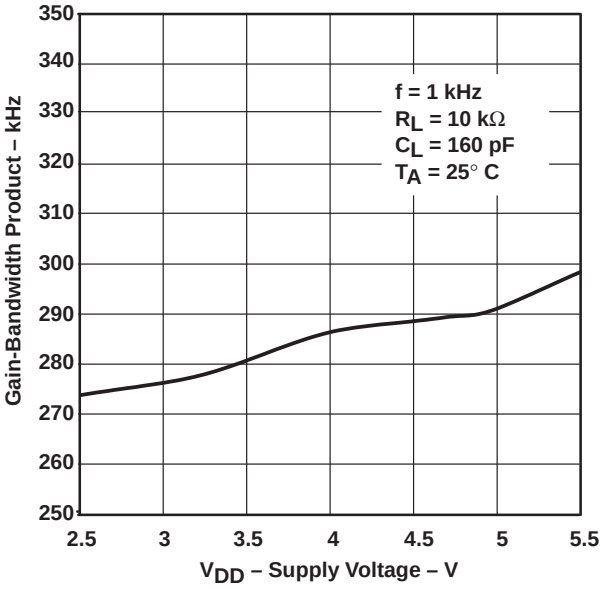


Figure 17

SLEW RATE vs SUPPLY VOLTAGE

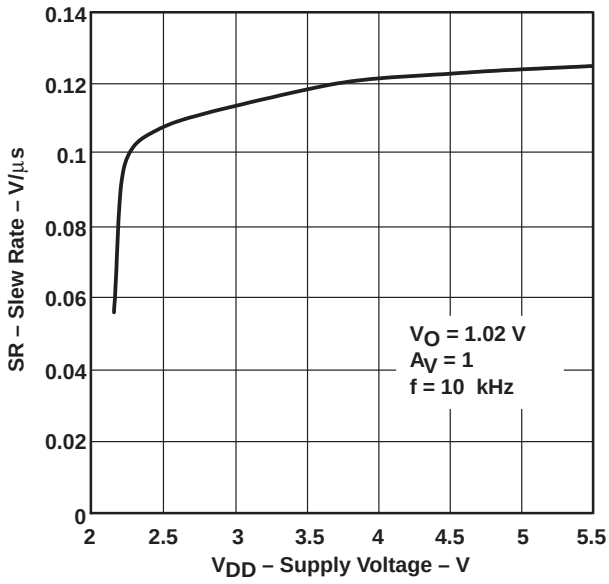


Figure 18

SLEW RATE vs FREE-AIR TEMPERATURE

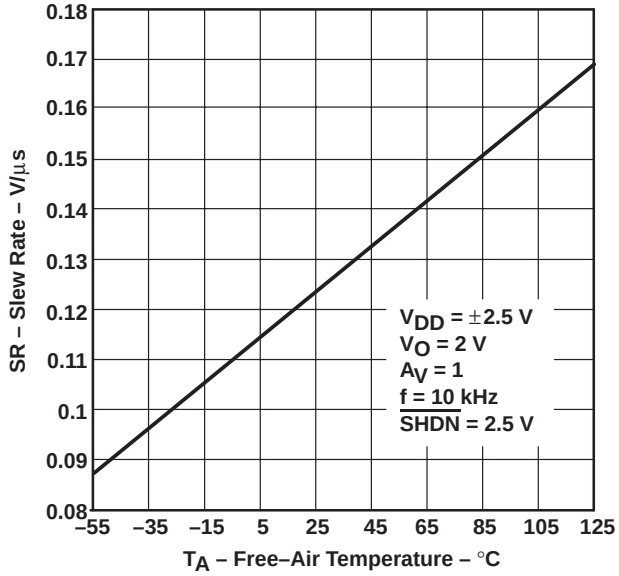


Figure 19

TYPICAL CHARACTERISTICS

LARGE-SIGNAL INVERTING PULSE RESPONSE
vs
TIME

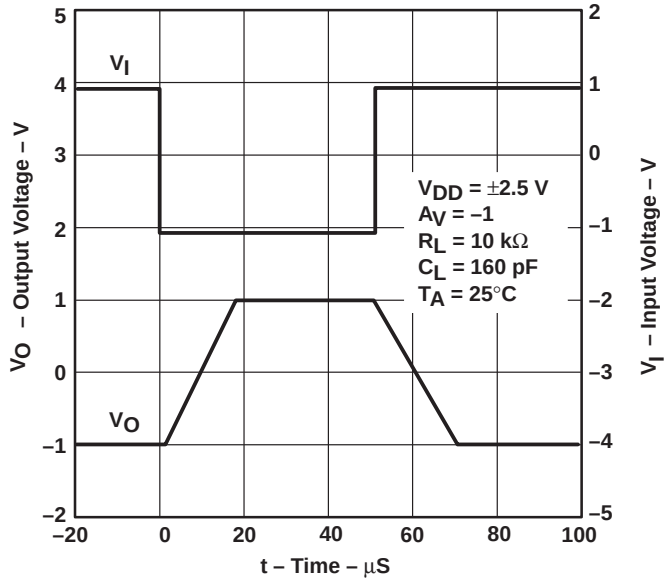


Figure 20

SMALL-SIGNAL INVERTING PULSE RESPONSE
vs
TIME

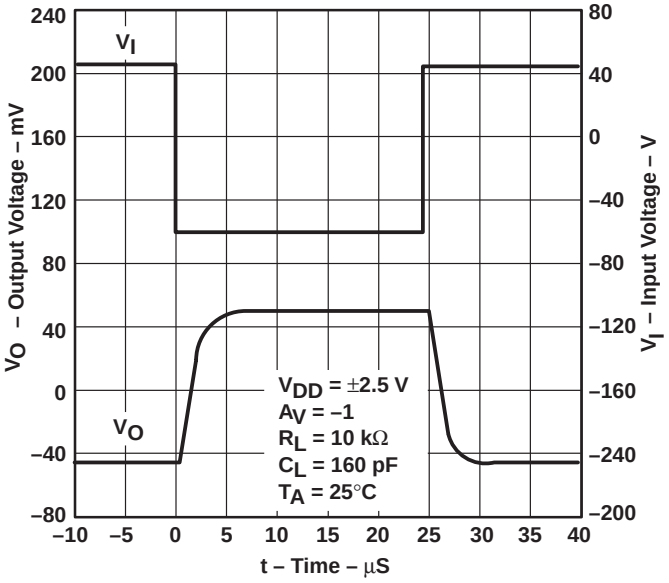


Figure 21

TYPICAL CHARACTERISTICS

LARGE-SIGNAL FOLLOWER PULSE RESPONSE vs TIME

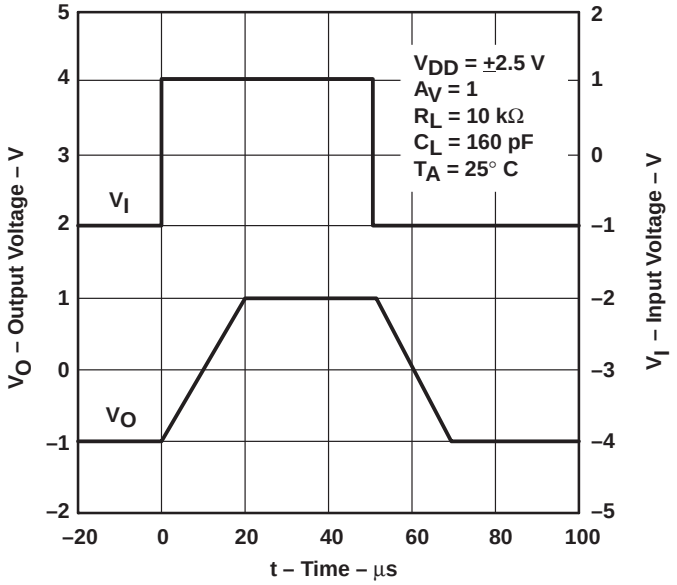


Figure 22

SMALL-SIGNAL FOLLOWER PULSE RESPONSE vs TIME

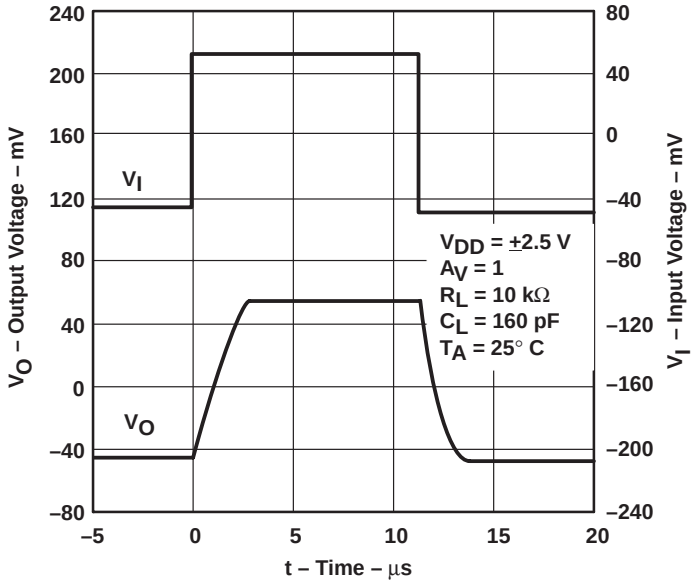


Figure 23

TYPICAL CHARACTERISTICS

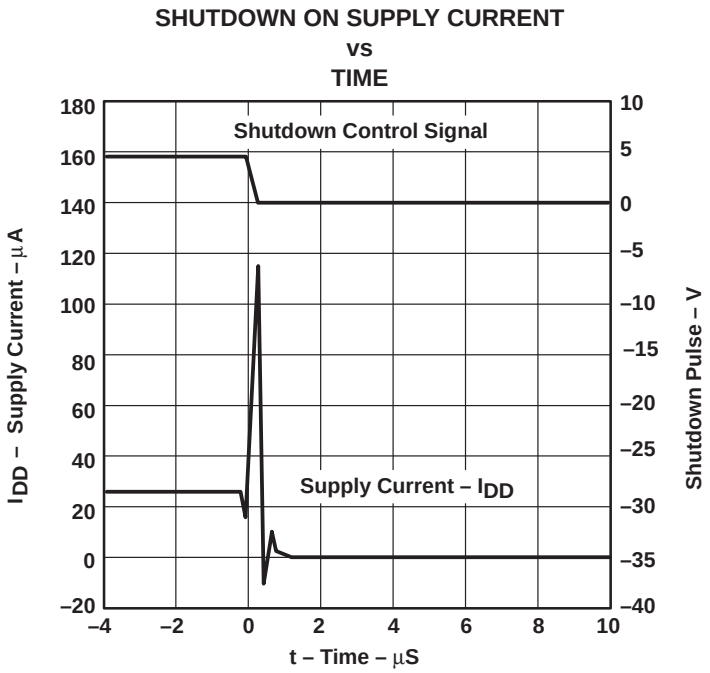


Figure 24

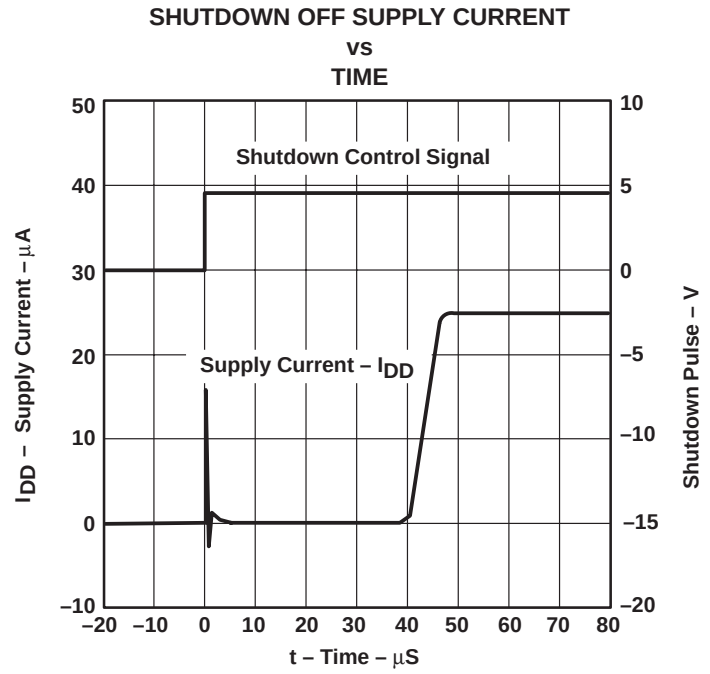


Figure 25

TYPICAL CHARACTERISTICS

SHUTDOWN ON PULSE RESPONSE

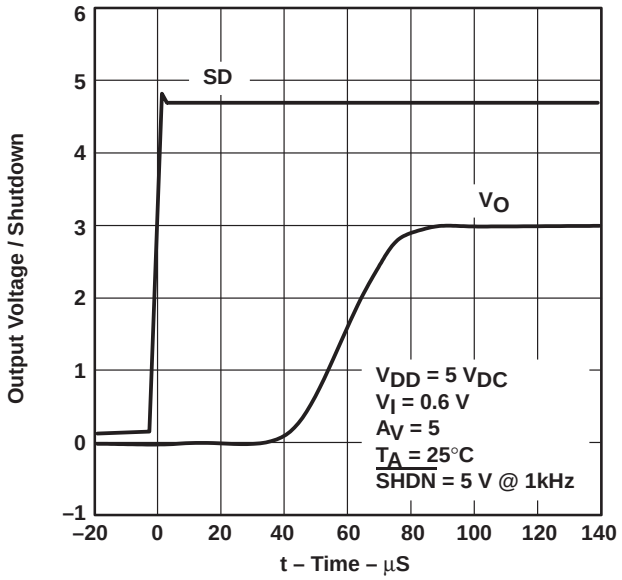


Figure 26

SHUTDOWN OFF PULSE RESPONSE

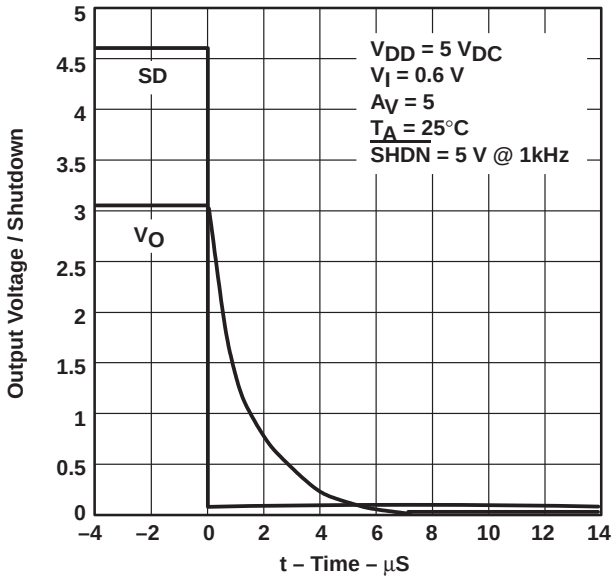


Figure 27

SHUTDOWN MODE SUPPLY CURRENT
vs
FREE–AIR TEMPERATURE

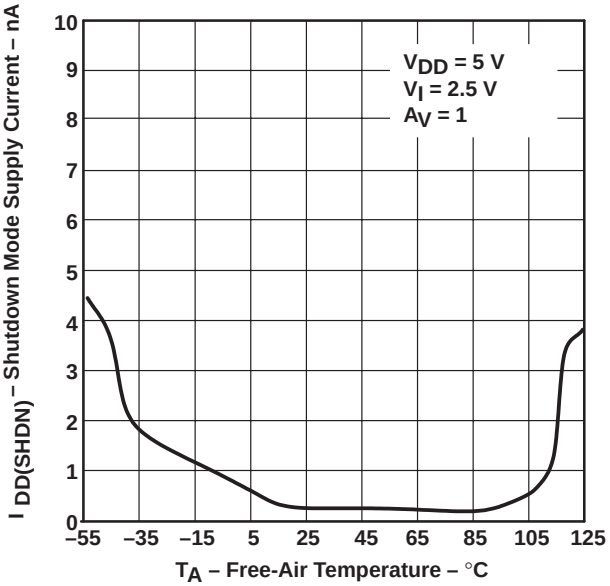


Figure 28

APPLICATION INFORMATION

shutdown function

Three members of the TLV245x family (TLV2450/3/5) have a shutdown terminal for conserving battery life in portable applications. When the shutdown terminal is tied low, the amplifier supply current is reduced to 16 nA/channel, the amplifier is disabled, and the outputs are placed in a high-impedance mode. To enable the amplifier, the shutdown terminal must be pulled high. The shutdown terminal threshold is always referenced to $V_{DD}/2$. Therefore, when operating the device with split supply voltages (e.g. ±2.5V), the shutdown terminal needs to be pulled to $V_{DD}–$ (not GND) to disable the operational amplifier.

Figures 26 and 27 show the amplifier's output with a shutdown pulse. The amplifier is configured as a noninverting configuration with a gain of 5. The signal frequency on the shutdown terminal is 1 kHz. The amplifier turn-on and turn-off times are measured from the 50% point of the shutdown pulse to the 50% point of the output waveform. These delay times are 59 μs and 836 ns, respectively.

macromodel information

Macromodel information provided was derived using Microsim *Parts*™, the model generation software used with Microsim *PSpice*™. The Boyle macromodel (see Note 1) and subcircuit in Figure 29 are generated using the TLV245x 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 1: G. R. Boyle, B. M. Cohn, D. O. Pederson, and J. E. Solomon, "Macromodeling of Integrated Circuit Operational Amplifiers," *IEEE Journal of Solid-State Circuits,* SC-9, 353 (1974).

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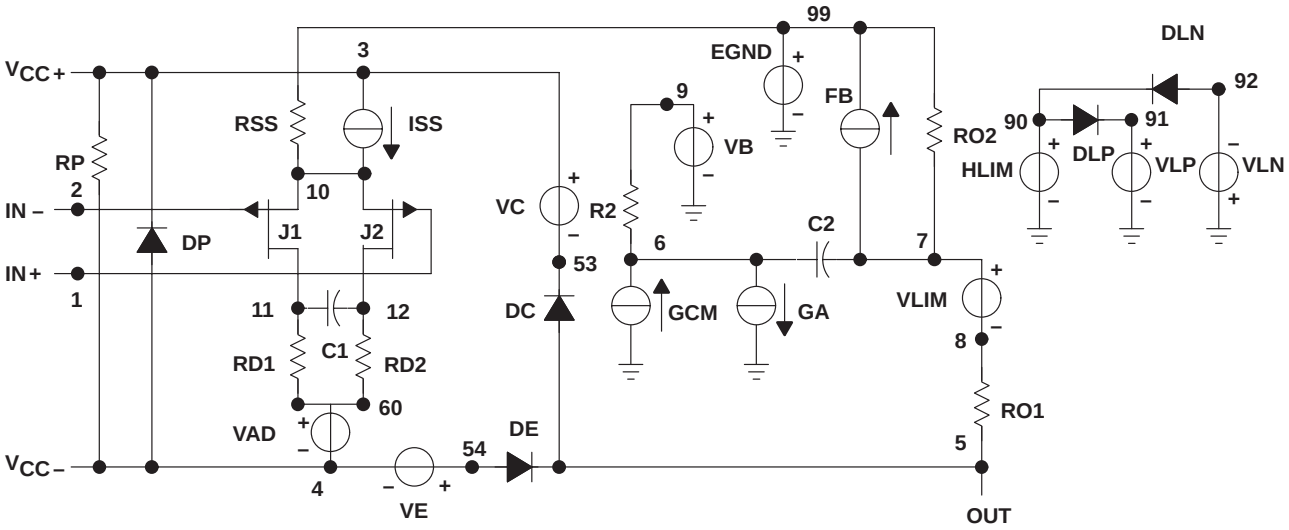
APPLICATION INFORMATION




```
* AMP_TLV2450–X operational amplifier "macromodel" subcircuit
* created using Parts release 8.0 on 10/12/98 at 11:06
* Parts is a MicroSim product.
*
* connections:   non–inverting input
*                | inverting input
*                | | positive power supply
*                | | | negative power supply
*                | | | | output
*                | | | | |
.subckt AMP_TLV2450–X 1 2 3 4 5
*
c1      11      12      354.48E–15
c2      6       7       7.5000E–12
cee     10      99      42.237E–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
+ 207.31E6 –1E3 1E3 210E6 –210E6
ga      6       0       11      12 15.254E–6
gcm     0       6       10      99 48.237E–12
iee     10      4       dc      938.61E–9
hlim    90      0       vlim 1K
q1      11      2       13 qx1
q2      12      1       14 qx2
r2      6       9       100.00E3
rc1     3       11      65.557E3
rc2     3       12      65.557E3
re1     13      10      10.367E3
re2     14      10      10.367E3
ree     10      99      213.08E6
ro1     8       5       10
ro2     7       99      10
rp      3       4       147.06
vb      9       0       dc 0
vc      3       53      dc .82
ve      54      4       dc .82
vlim    7       8       dc 0
vlp     91      0       dc 38
vln     0       92      dc 38
.model  dx      D(Is=800.00E–18)
.model  dy      D(Is=800.00E–18 Rs=1m Cjo=10p)
.model  qx1     NPN(Is=800.00E–18 Bf=843.08)
.model  qx2     NPN(Is=800.0000E–18 Bf=843.08)
.ends
```

```
* Schematics Subcircuit *
.subckt TLV2450_ver1 Vout Vdd GND V+ V– SD
*
S_S2      $N_0001 GND SD GND S2
RS_S2     SD GND 1G
.MODEL S2 VSWITCH Roff=1e6 Ron=1.0 Voff=0.0
+  Von=1.0
S_S1      $N_0002 VDD SD GND S1
RS_S1     SD GND 1G
.MODEL S1 VSWITCH Roff=1e6 Ron=1.0 Voff=0.0
+  Von=1.0
S_S3      Vout $N_0003 SD GND S3
RS_S3     SD GND 1G
.MODEL S3 VSWITCH Roff=1e6 Ron=1.0 Voff=0.0
+  Von=1.0
X_SUB_U1        V+ V– $N_0002 $N_003
+ AMP_TLV2450–X
.ENDS     tlv2450_ver1
```

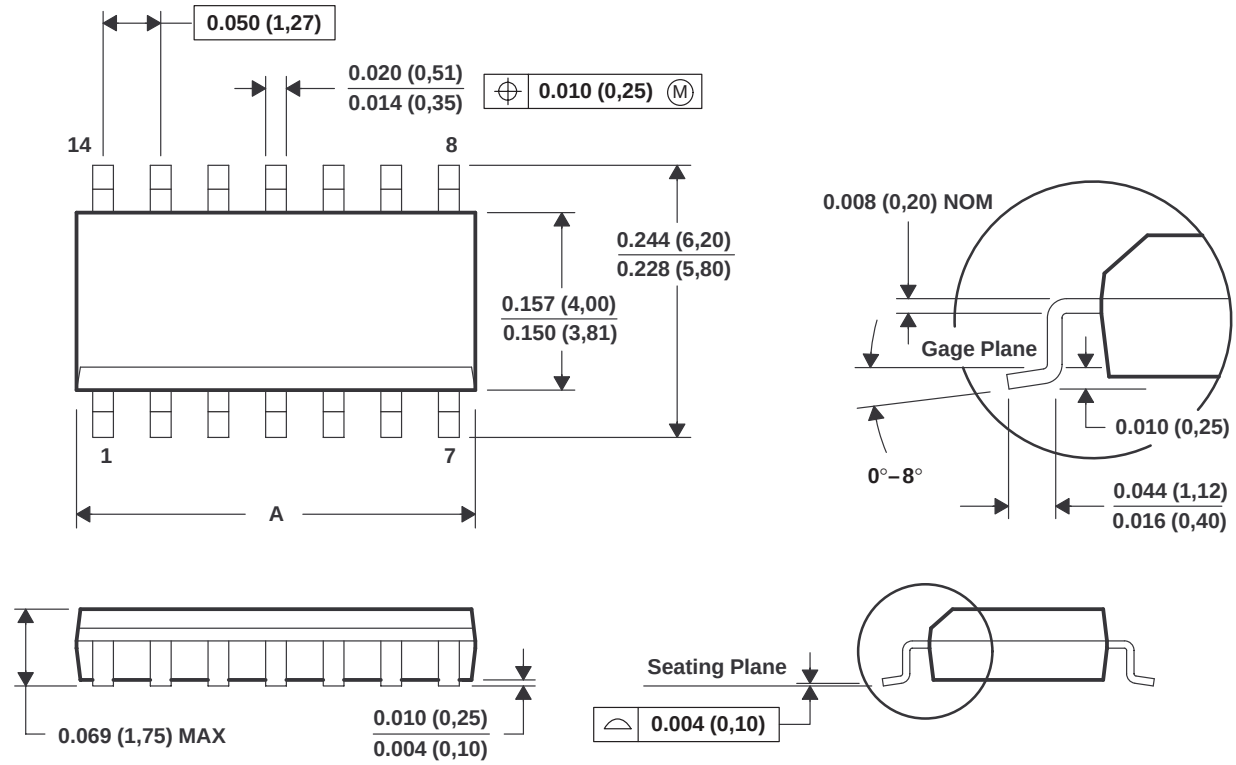
```
* Schematics Subcircuit *
.subckt TLV2451_ver1 V+ V– Vout Vdd GND
*
X_SUB_U1        V+ V– GND Vout AMP_TLV2450–X
.ENDS     tlv2451_ver1
```

Figure 29. Boyle Macromodel and Subcircuit

MECHANICAL DATA

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

14 PIN SHOWN



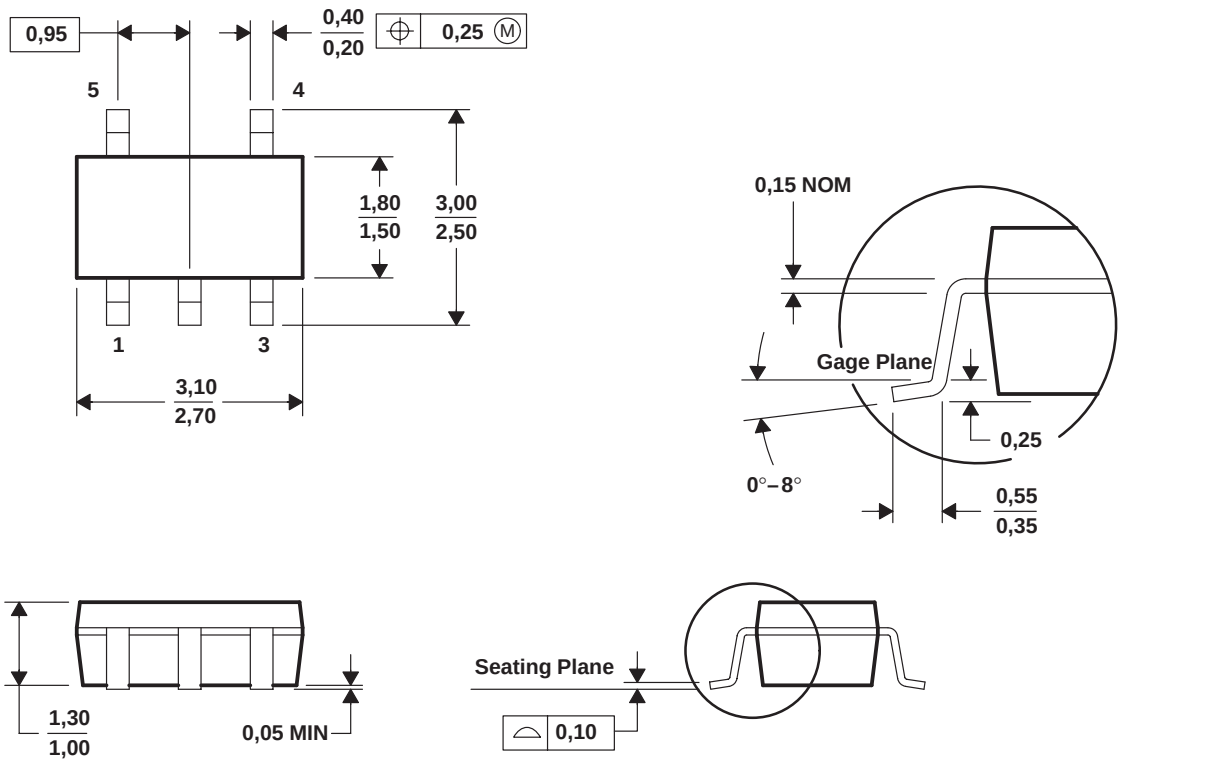
DIM \ PINS **	8	14	16
A MAX	0.197 (5,00)	0.344 (8,75)	0.394 (10,00)
A MIN	0.189 (4,80)	0.337 (8,55)	0.386 (9,80)

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 INFORMATION

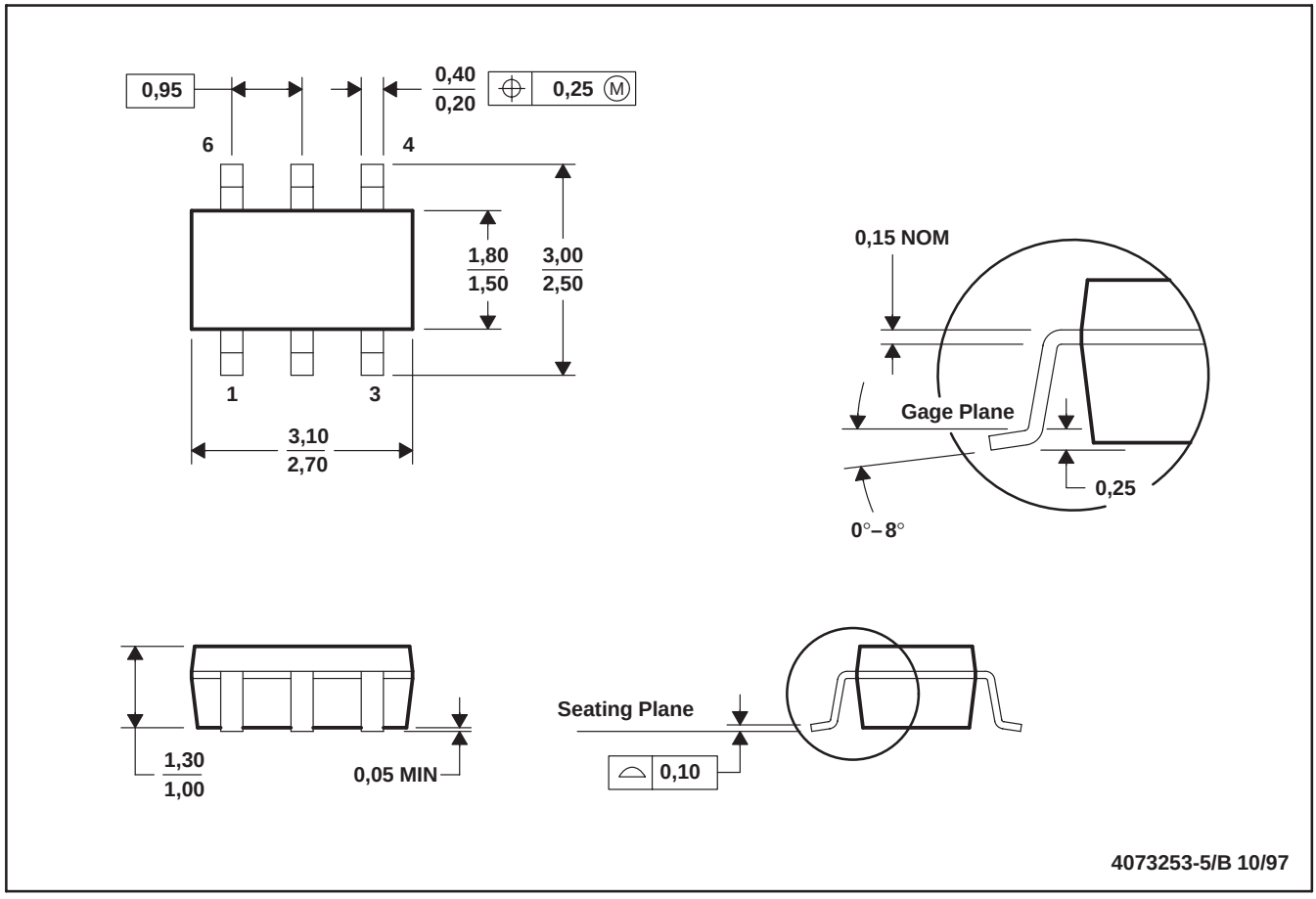
DBV (R-PDSO-G5) **PLASTIC SMALL-OUTLINE PACKAGE**



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 INFORMATION

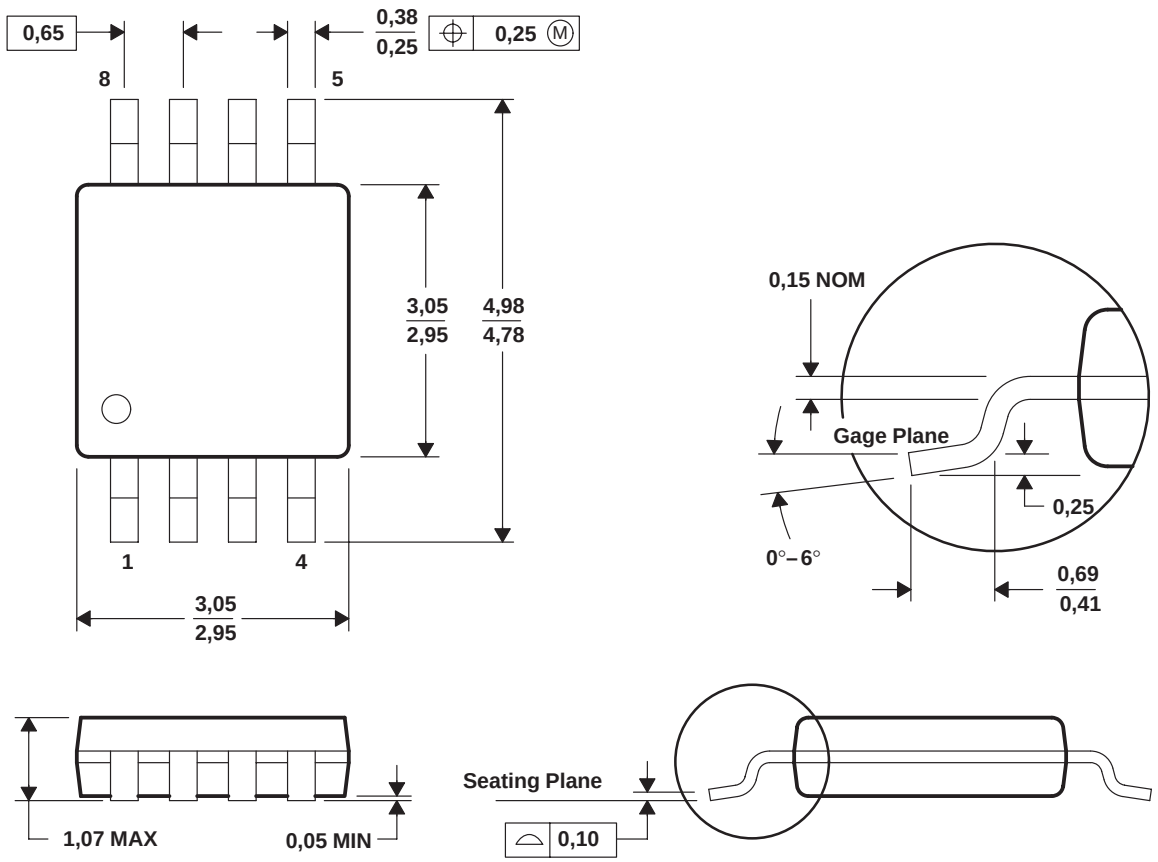
DBV (R-PDSO-G6) **PLASTIC SMALL-OUTLINE PACKAGE**



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 INFORMATION

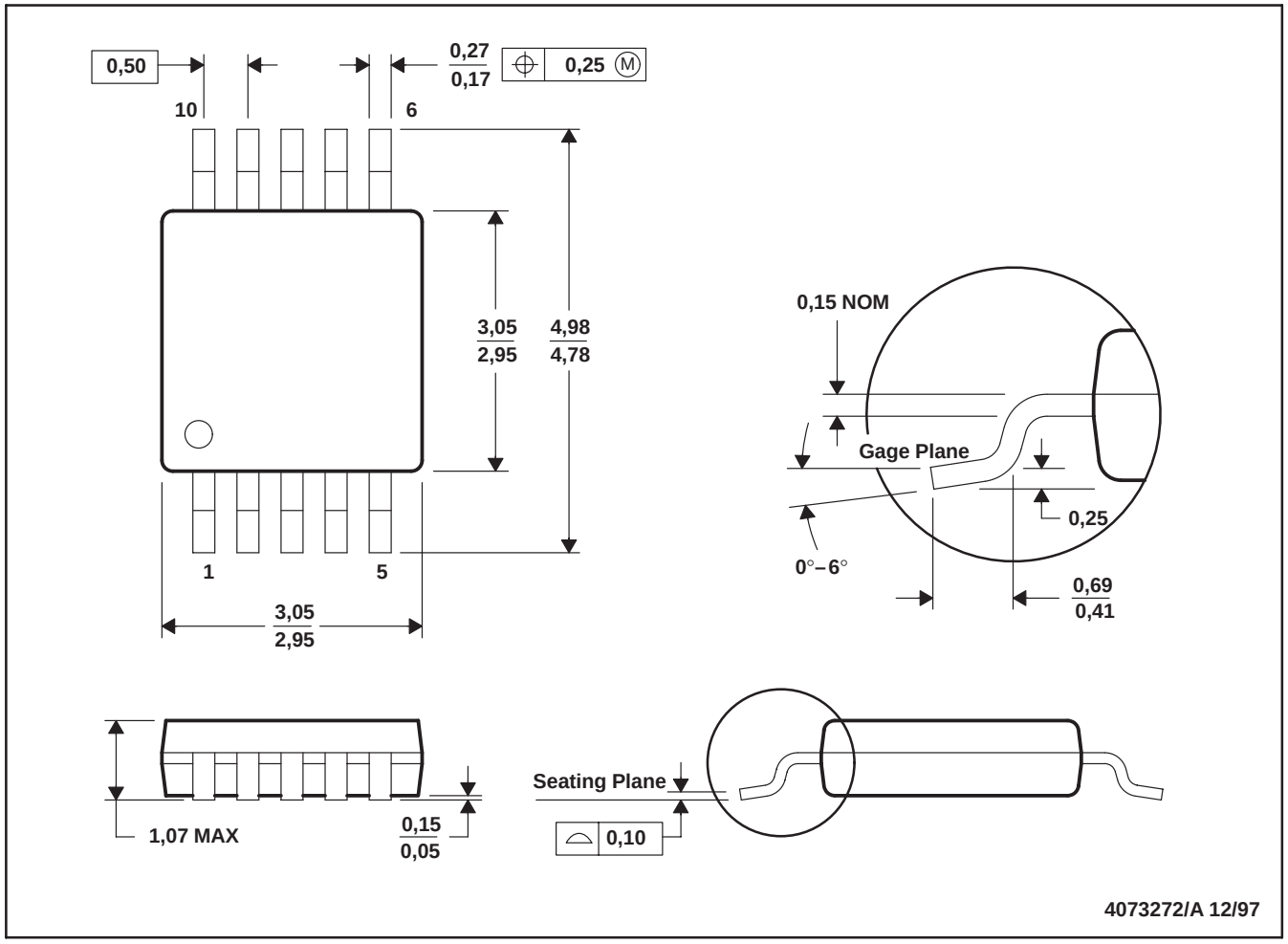
DGK (R-PDSO-G8) **PLASTIC SMALL-OUTLINE PACKAGE**



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.

MECHANICAL INFORMATION

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



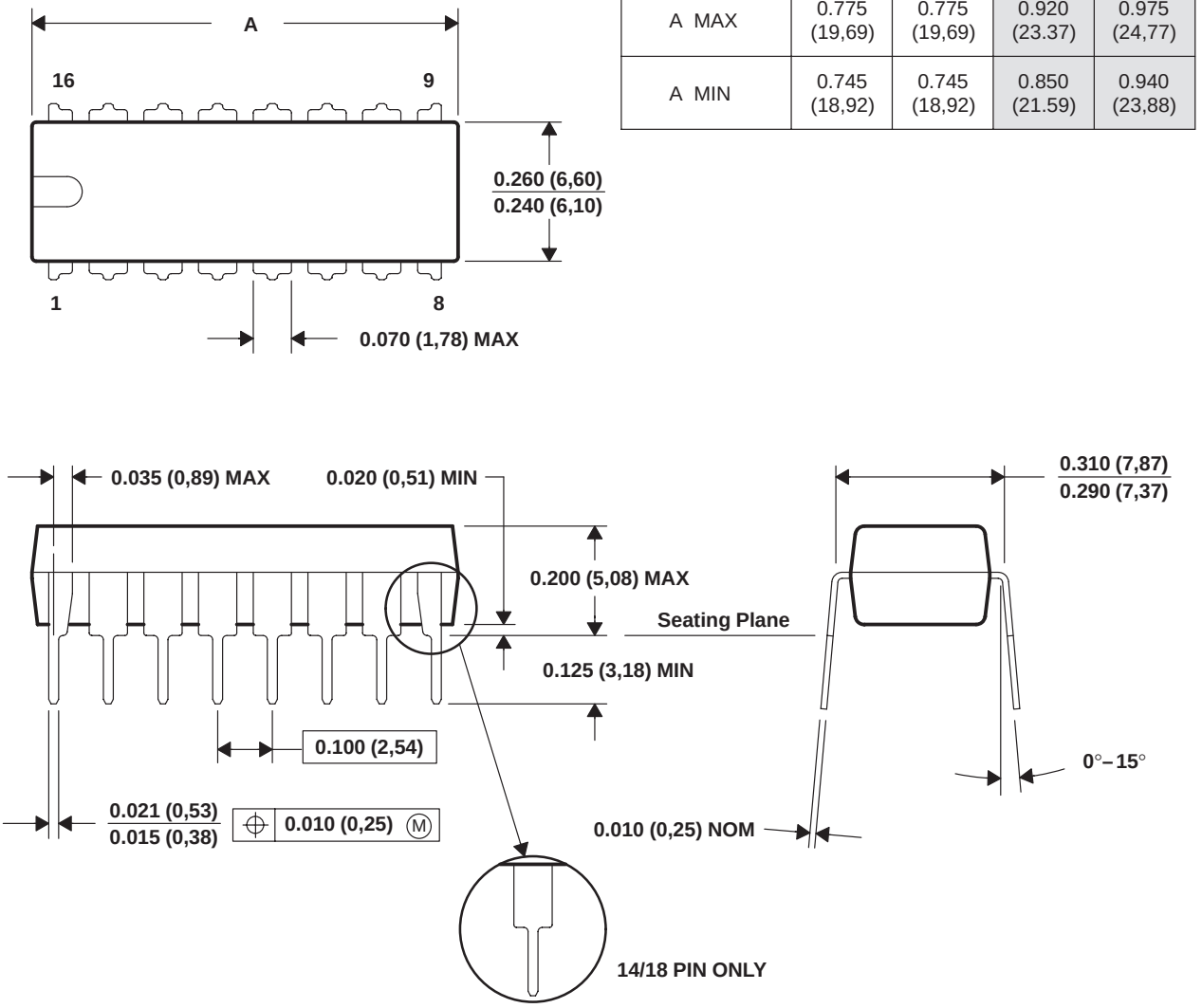
NOTES: A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion.

MECHANICAL INFORMATION

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

16 PIN SHOWN

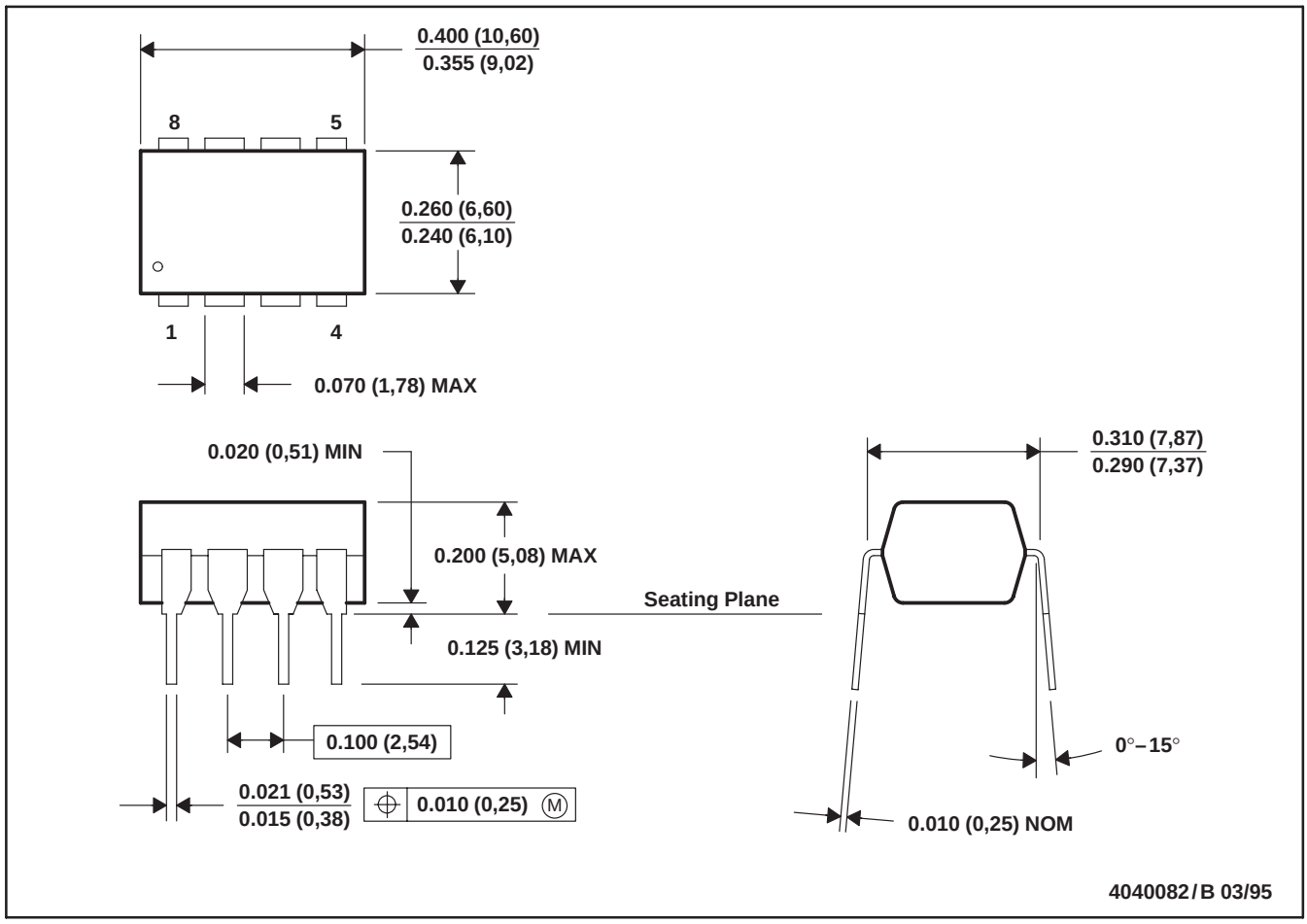
DIM \ PINS **	14	16	18	20
A MAX	0.775 (19,69)	0.775 (19,69)	0.920 (23.37)	0.975 (24,77)
A MIN	0.745 (18,92)	0.745 (18,92)	0.850 (21.59)	0.940 (23,88)



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 INFORMATION

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

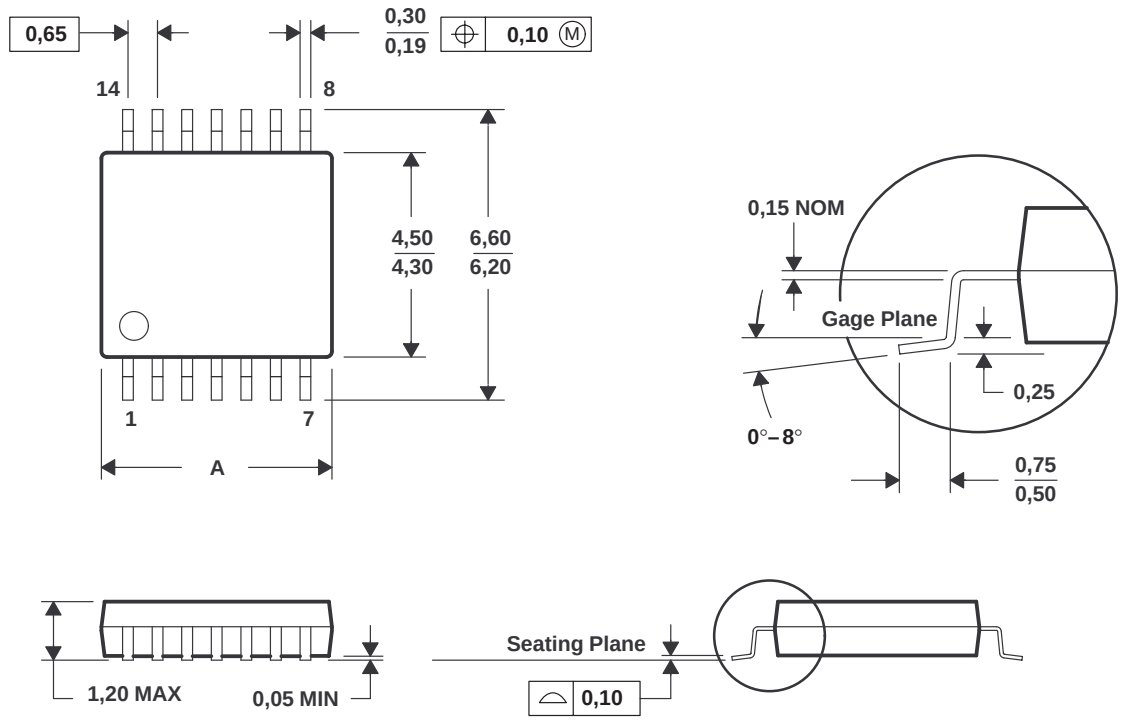


NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Falls within JEDEC MS-001

MECHANICAL INFORMATION

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

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