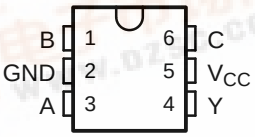
SINGLE-SUPPLY VOLTAGE-LEVEL TRANSLATOR WITH NINE CONFIGURABLE GATE LOGIC FUNCTIONS

SCES614A–OCTOBER 2004–REVISED SEPTEMBER 2005

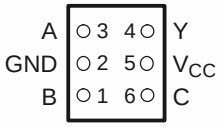
FEATURES

- Available in the Texas Instruments NanoStar™ and NanoFree™ Packages
- Single-Supply Voltage Translator
- 1.8 V to 3.3 V (at V_{CC} = 3.3 V)
- 2.5 V to 3.3 V (at V_{CC} = 3.3 V)
- 1.8 V to 2.5 V (at V_{CC} = 2.5 V)
- 3.3 V to 2.5 V (at V_{CC} = 2.5 V)
- Nine Configurable Gate Logic Functions
- Schmitt-Trigger Inputs Reject Input Noise and Provide Better Output Signal Integrity
- I_{off} Supports Partial-Power-Down Mode With Low Leakage Current (0.5 μA)
- 200-ns/V Input Rise/Fall Time Allows Slow Transition of Input Signal
- Very Low Static and Dynamic Power Consumption
- Pb-Free Packages Available: SOT-23 (DBV), SC-70 (DCK), and WCSP (NanoFree)
- Latch-Up Performance Exceeds 100 mA Per JESD 78, Class II
- ESD Performance Tested Per JESD 22
  - 2000-V Human-Body Model (A114-B, Class II)
  - 200-V Machine Model (A115-A)
  - 1000-V Charged-Device Model (C101)
- Related Devices: SN74AUP1T97, SN74AUP1T57, and SN74AUP1T58

DBV OR DCK PACKAGE
(TOP VIEW)



YEP OR YZP PACKAGE
(BOTTOM VIEW)



DESCRIPTION/ORDERING INFORMATION

AUP technology is the industry's lowest-power logic technology designed for use in battery-operated or battery backed-up equipment. The SN74AUP1T98 is designed for logic-level translation applications with input switching levels that accept 1.8-V LVCMOS signals, while operating from either a single 3.3-V or 2.5-V V_{CC} supply.

The wide V_{CC} range of 2.3 V to 3.6 V allows the possibility of battery voltage drop during system operation and ensures normal operation between this range.

Schmitt-trigger inputs (ΔV_T = 210 mV between positive and negative input transitions) offer improved noise immunity during switching transitions, which is especially useful on analog mixed-mode designs. Schmitt-trigger inputs reject input noise, ensure integrity of output signals, and allow for slow input signal transition.

The SN74AUP1T98 can be easily configured to perform a required gate function by connecting A, B, and C inputs to V_{CC} or ground (see Function Selection table). Up to nine commonly used logic gate functions can be performed.

I_{off} is a feature that allows for powered-down conditions (V_{CC} = 0 V) and is important in portable and mobile applications. When V_{CC} = 0 V, signals in the range from 0 V to 3.6 V can be applied to the inputs and outputs of the device. No damage occurs to the device under these conditions.

The SN74AUP1T98 is designed with optimized current-drive capability of 4 mA to reduce line reflections, overshoot, and undershoot caused by high-drive outputs.

Nanostar™ and Nanofree™ package technology is a major breakthrough in IC packaging concepts, using the die as the package.

ORDERING INFORMATION

T_A	PACKAGE(1)		ORDERABLE PART NUMBER	TOP-SIDE MARKING(2)
–40°C to 85°C	NanoStar™ – WCSP (DSBGA) 0.23-mm Large Bump – YEP	Tape and reel	SN74AUP1T98YEPR	_ _ _TK_
	NanoFree™ – WCSP (DSBGA) 0.23-mm Large Bump – YZP (Pb-free)	Tape and reel	SN74AUP1T98YZPR	
	SOT (SOT-23) – DBV	Tape and reel	SN74AUP1T98DBVR	HT6_
	SOT (SC-70) – DCK	Tape and reel	SN74AUP1T98DCKR	TK_

(1) Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.
(2) DBV/DCK: The actual top-side marking has one additional character that designates the assembly/test site.
YEP/YZP: The actual top-side marking has three preceding characters to denote year, month, and sequence code, and one following character to designate the assembly/test site. Pin 1 identifier indicates solder-bump composition (1 = SnPb, • = Pb-free).

FUNCTION SELECTION TABLE

LOGIC FUNCTION	FIGURE NO.
2-to-1 data selector	5
2-input AND gate	6
2-input OR gate with one inverted input	7
2-input NAND gate with one inverted input	7
2-input AND gate with one inverted input	8
2-input NOR gate with one inverted input	8
2-input OR gate	9
Inverter	10
Noninverted buffer	11

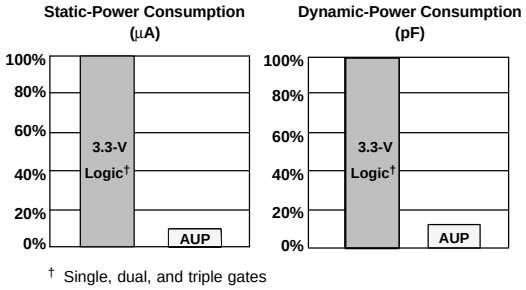


Figure 1. AUP – The Lowest-Power Family

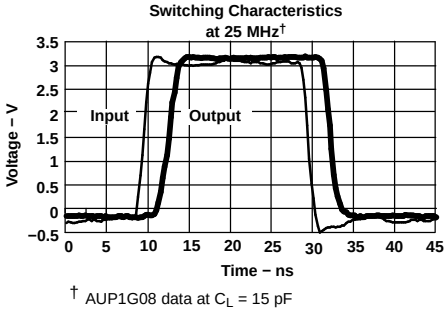


Figure 2. Excellent Signal Integrity

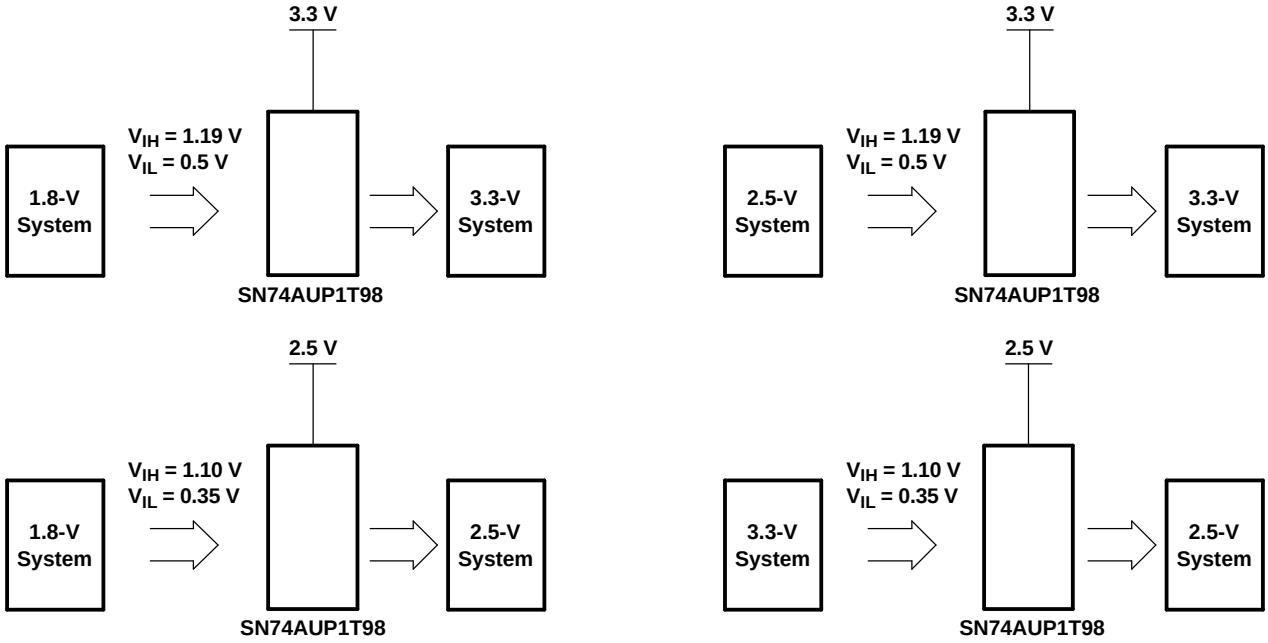


Figure 3. Possible Voltage-Translation Combinations

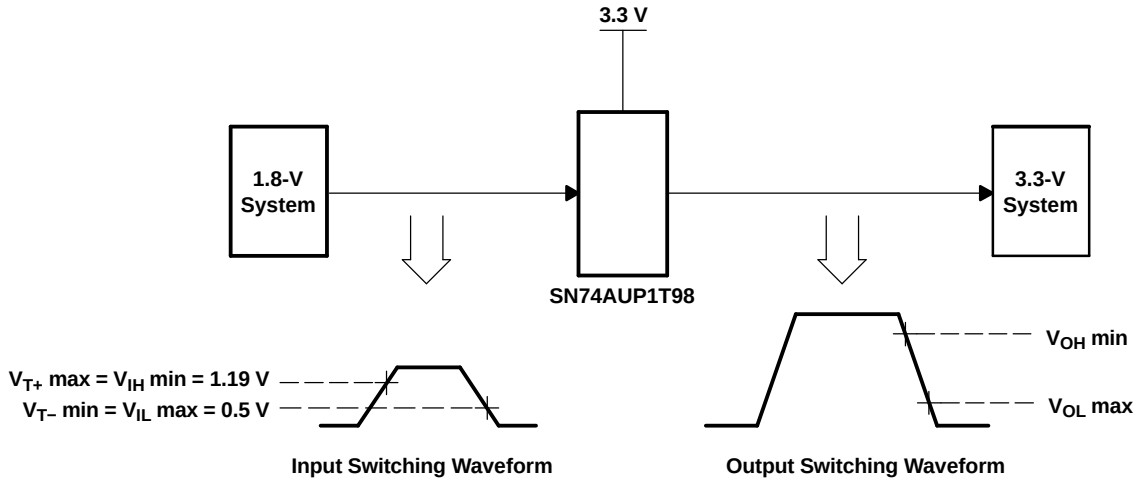
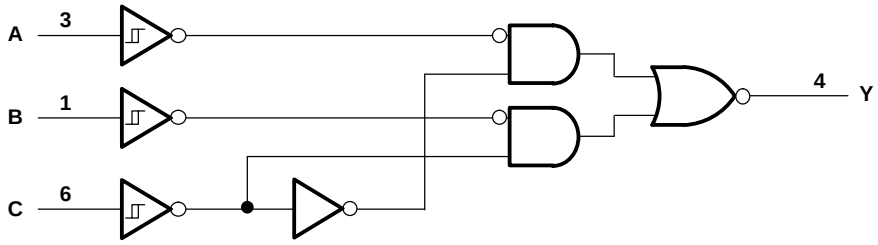


Figure 4. Switching Thresholds for 1.8-V to 3.3-V Translation

FUNCTION TABLE

INPUTS			OUTPUT
C	B	A	Y
L	L	L	H
L	L	H	H
L	H	L	L
L	H	H	L
H	L	L	H
H	L	H	L
H	H	L	H
H	H	H	L

LOGIC DIAGRAM (POSITIVE LOGIC)



LOGIC CONFIGURATIONS

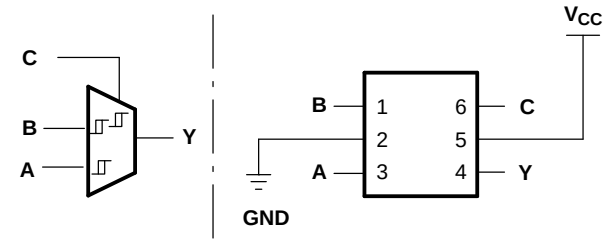


Figure 5. 157+04: 2-to-1 Data Selector With Inverted Output
When C is L, Y = $\overline{B}$
When C is H, Y = $\overline{A}$

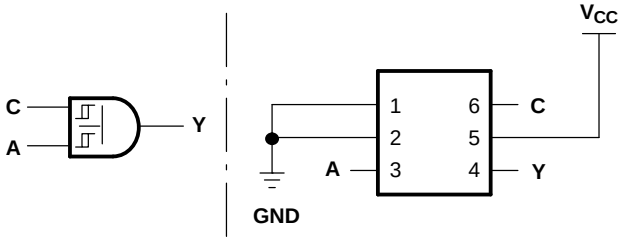


Figure 6. 00: 2-Input NAND Gate

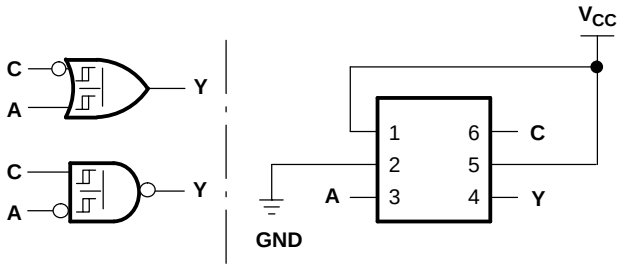


Figure 7. 14+02/14+08: 2-Input NOR Gate With One Inverted Input
2-Input AND Gate With One Inverted Input

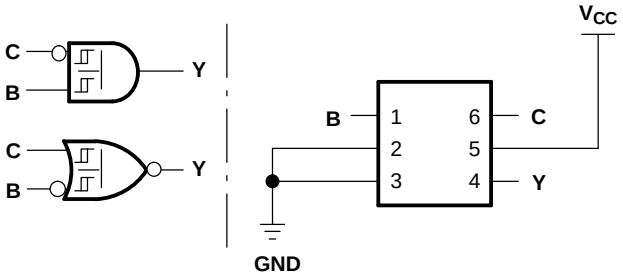


Figure 8. 14+00/14+32: 2-Input NAND Gate With One Inverted Input
2-Input OR Gate With One Inverted Input

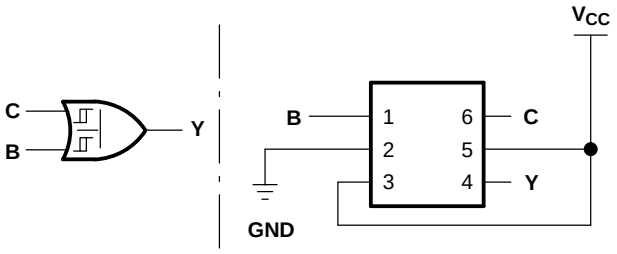


Figure 9. 32: 2-Input NOR Gate

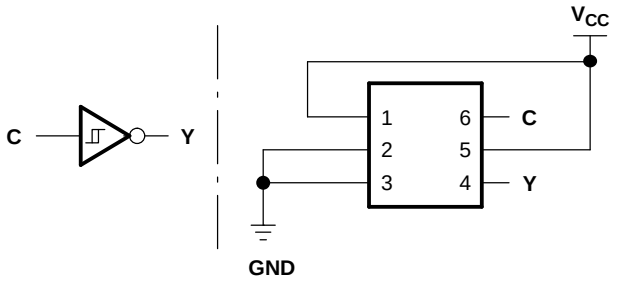


Figure 10. 17/34: Noninverted Buffer

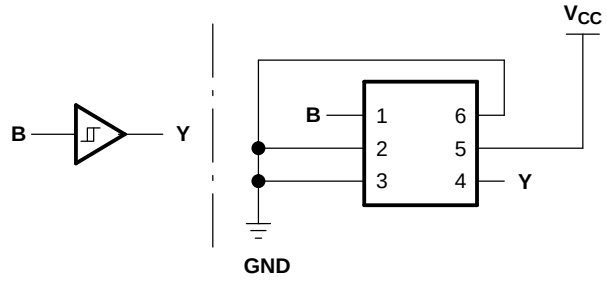


Figure 11. 04/14: Inverter

Absolute Maximum Ratings(1)

over operating free-air temperature range (unless otherwise noted)

			MIN	MAX	UNIT
V_{CC}	Supply voltage range		–0.5	4.6	V
V_I	Input voltage range(2)		–0.5	4.6	V
V_O	Voltage range applied to any output in the high-impedance or power-off state(2)		–0.5	4.6	V
V_O	Output voltage range in the high or low state(2)		–0.5	V_{CC} + 0.5	V
I_{IK}	Input clamp current	V_I < 0		–50	mA
I_{OK}	Output clamp current	V_O < 0		–50	mA
I_O	Continuous output current			±20	mA
	Continuous current through V_{CC} or GND			±50	mA
θ_{JA}	Package thermal impedance(3)	DBV package		165	°C/W
		DCK package		259	
		YEP/YZP package		123	
T_{stg}	Storage temperature range		–65	150	°C

(1) 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.
(2) The input negative-voltage and output voltage ratings may be exceeded if the input and output current ratings are observed.
(3) The package thermal impedance is calculated in accordance with JESD 51-7.

Recommended Operating Conditions(1)

			MIN	MAX	UNIT
V_{CC}	Supply voltage		2.3	3.6	V
V_I	Input voltage		0	3.6	V
V_O	Output voltage		0	V_{CC}	V
I_{OH}	High-level output current	V_{CC} = 2.3 V		–3.1	mA
		V_{CC} = 3 V		–4	
I_{OL}	Low-level output current	V_{CC} = 2.3 V		3.1	mA
		V_{CC} = 3 V		4	
$\Delta t/\Delta v$	Input transition rise or fall rate	V_{CC} = 2.3 V to 3.6 V		200	ns/V
T_A	Operating free-air temperature		–40	85	°C

(1) All unused 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

over recommended operating free-air temperature range (unless otherwise noted)

PARAMETER	TEST CONDITIONS	V_{CC}	T_A = 25°C			T_A = –40°C to 85°C		UNIT
			MIN	TYP	MAX	MIN	MAX	
V_{T+} Positive-going input threshold voltage		2.3 V to 2.7 V	0.6		1.1	0.6	1.1	V
		3 V to 3.6 V	0.75		1.16	0.75	1.19	
V_{T-} Negative-going input threshold voltage		2.3 V to 2.7 V	0.35		0.6	0.35	0.6	V
		3 V to 3.6 V	0.5		0.85	0.5	0.85	
ΔV_T Hysteresis ($V_{T+} - V_{T-}$)		2.3 V to 2.7 V	0.23		0.6	0.2	0.6	V
		3 V to 3.6 V	0.25		0.56	0.25	0.56	
V_{OH}	I_{OH} = –20 µA	2.3 V to 3.6 V	V_{CC} – 0.1			V_{CC} – 0.1		V
	I_{OH} = –2.3 mA	2.3 V	2.05			1.97		
	I_{OH} = –3.1 mA		1.9			1.85		
	I_{OH} = –2.7 mA	3 V	2.72			2.67		
	I_{OH} = –4 mA		2.6			2.55		
V_{OL}	I_{OL} = 20 µA	2.3 V to 3.6 V			0.1		0.1	V
	I_{OL} = 2.3 mA	2.3 V			0.31		0.33	
	I_{OL} = 3.1 mA				0.44		0.45	
	I_{OL} = 2.7 mA	3 V			0.31		0.33	
	I_{OL} = 4 mA				0.44		0.45	
I_I All inputs	V_I = 3.6 V or GND	0 V to 3.6 V			0.1		0.5	µA
I_{off}	V_I or V_O = 0 V to 3.6 V	0 V			0.1		0.5	µA
ΔI_{off}	V_I or V_O = 5.5 V	0 V to 0.2 V			0.2		0.5	µA
I_{CC}	V_I = 3.6 V or GND, I_O = 0	2.3 V to 3.6 V			0.5		0.9	µA
ΔI_{CC}	One input at 0.3 V or 1.1 V, Other inputs at 0 or V_{CC}, I_O = 0	2.3 V to 2.7 V					4	µA
	One input at 0.45 V or 1.2 V, Other inputs at 0 or V_{CC}, I_O = 0	3 V to 3.6 V					12	
C_i	V_I = V_{CC} or GND	3.3 V		1.5				pF
C_o	V_O = V_{CC} or GND	3.3 V		3				pF

Switching Characteristics

over recommended operating free-air temperature range, V_{CC} = 2.5 V ± 0.2 V, V_I = 1.8 V ± 0.15 V (unless otherwise noted) (see Figure 12)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	C_L	T_A = 25°C			T_A = –40°C to 85°C		UNIT
				MIN	TYP	MAX	MIN	MAX	
t_{pd}	A, B, or C	Y	5 pF	1.8	2.3	2.9	0.5	6.8	ns
			10 pF	2.3	2.8	3.4	1	7.9	
			15 pF	2.6	3.1	3.8	1	8.7	
			30 pF	3.8	4.4	5.1	1.5	10.8	

Switching Characteristics

over recommended operating free-air temperature range, V_{CC} = 2.5 V ± 0.2 V, V_I = 2.5 V ± 0.2 V (unless otherwise noted) (see Figure 12)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	C_L	T_A = 25°C			T_A = –40°C to 85°C		UNIT
				MIN	TYP	MAX	MIN	MAX	
t_{pd}	A, B, or C	Y	5 pF	1.8	2.3	3.1	0.5	6	ns
			10 pF	2.2	2.8	3.5	1	7.1	
			15 pF	2.6	3.2	5.2	1	7.9	
			30 pF	3.7	4.4	5.2	1.5	10	

Switching Characteristics

over recommended operating free-air temperature range, V_{CC} = 2.5 V ± 0.2 V, V_I = 3.3 V ± 0.3 V (unless otherwise noted) (see Figure 12)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	C_L	T_A = 25°C			T_A = –40°C to 85°C		UNIT
				MIN	TYP	MAX	MIN	MAX	
t_{pd}	A, B, or C	Y	5 pF	2	2.7	3.5	0.5	5.5	ns
			10 pF	2.4	3.1	3.9	1	6.5	
			15 pF	2.8	3.5	4.3	1	7.4	
			30 pF	4	4.7	5.5	1.5	9.5	

Switching Characteristics

over recommended operating free-air temperature range, V_{CC} = 3.3 V ± 0.3 V, V_I = 1.8 V ± 0.15 V (unless otherwise noted) (see Figure 12)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	C_L	T_A = 25°C			T_A = –40°C to 85°C		UNIT
				MIN	TYP	MAX	MIN	MAX	
t_{pd}	A, B, or C	Y	5 pF	1.6	2	2.5	0.5	8	ns
			10 pF	2	2.4	2.9	1	8.5	
			15 pF	2.3	2.8	3.3	1	9.1	
			30 pF	3.4	3.9	4.4	1.5	9.8	

Switching Characteristics

over recommended operating free-air temperature range, V_{CC} = 3.3 V ± 0.3 V, V_I = 2.5 V ± 0.2 V (unless otherwise noted) (see Figure 12)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	C_L	T_A = 25°C			T_A = –40°C to 85°C		UNIT
				MIN	TYP	MAX	MIN	MAX	
t_{pd}	A, B, or C	Y	5 pF	1.6	1.9	2.4	0.5	5.3	ns
			10 pF	2	2.3	2.7	1	6.1	
			15 pF	2.3	2.7	3.1	1	6.8	
			30 pF	3.4	3.8	4.2	1.5	8.5	

Switching Characteristics

over recommended operating free-air temperature range, V_{CC} = 3.3 V ± 0.3 V, V_I = 3.3 V ± 0.3 V (unless otherwise noted) (see Figure 12)

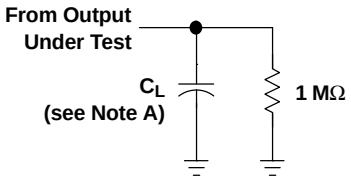
PARAMETER	FROM (INPUT)	TO (OUTPUT)	C_L	T_A = 25°C			T_A = –40°C to 85°C		UNIT
				MIN	TYP	MAX	MIN	MAX	
t_{pd}	A, B, or C	Y	5 pF	1.6	2.1	2.7	0.5	4.7	ns
			10 pF	2	2.4	3	1	5.7	
			15 pF	2.3	2.7	3.3	1	6.2	
			30 pF	3.4	3.8	4.4	1.5	7.8	

Operating Characteristics

T_A = 25°C

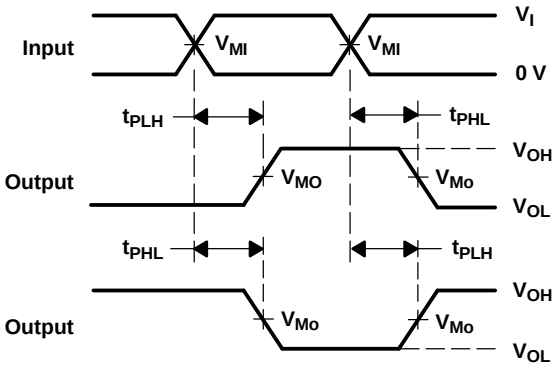
PARAMETER		TEST CONDITIONS	V_{CC} = 2.5 V	V_{CC} = 3.3 V	UNIT
			TYP	TYP	
C_{pd}	Power dissipation capacitance	f = 10 MHz	4	5	pF

PARAMETER MEASUREMENT INFORMATION



LOAD CIRCUIT

	V_{CC} = 2.5 V ± 0.2 V	V_{CC} = 3.3 V ± 0.3 V
C_L	5, 10, 15, 30 pF	5, 10, 15, 30 pF
V_{MI}	$V_I/2$	$V_I/2$
V_{MO}	$V_{CC}/2$	$V_{CC}/2$



VOLTAGE WAVEFORMS
PROPAGATION DELAY TIMES
INVERTING AND NONINVERTING OUTPUTS

NOTES: A. C_L includes probe and jig capacitance.
B. All input pulses are supplied by generators having the following characteristics: PRR ≤ 10 MHz, Z_O = 50 Ω, slew rate ≥ 1 V/ns.
C. The outputs are measured one at a time, with one transition per measurement.
D. t_{PLH} and t_{PHL} are the same as t_{pd}.

Figure 12. Load Circuit and Voltage Waveforms

PACKAGE OPTION ADDENDUM

12-Sep-2005

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)
SN74AUP1T98DBVR	ACTIVE	SOT-23	DBV	6	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN74AUP1T98DBVRE4	ACTIVE	SOT-23	DBV	6	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN74AUP1T98DBVT	ACTIVE	SOT-23	DBV	6	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN74AUP1T98DBVTE4	ACTIVE	SOT-23	DBV	6	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN74AUP1T98DCKR	ACTIVE	SC70	DCK	6	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN74AUP1T98DCKRE4	ACTIVE	SC70	DCK	6	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN74AUP1T98DCKT	ACTIVE	SC70	DCK	6	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN74AUP1T98DCKTE4	ACTIVE	SC70	DCK	6	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN74AUP1T98YEPR	PREVIEW	WCSP	YEP	6	3000	TBD	Call TI	Call TI
SN74AUP1T98YZPR	PREVIEW	WCSP	YZP	6	3000	TBD	Call TI	Call TI

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS) or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

PACKAGE OPTION ADDENDUM

12-Sep-2005

PACKAGING INFORMATION

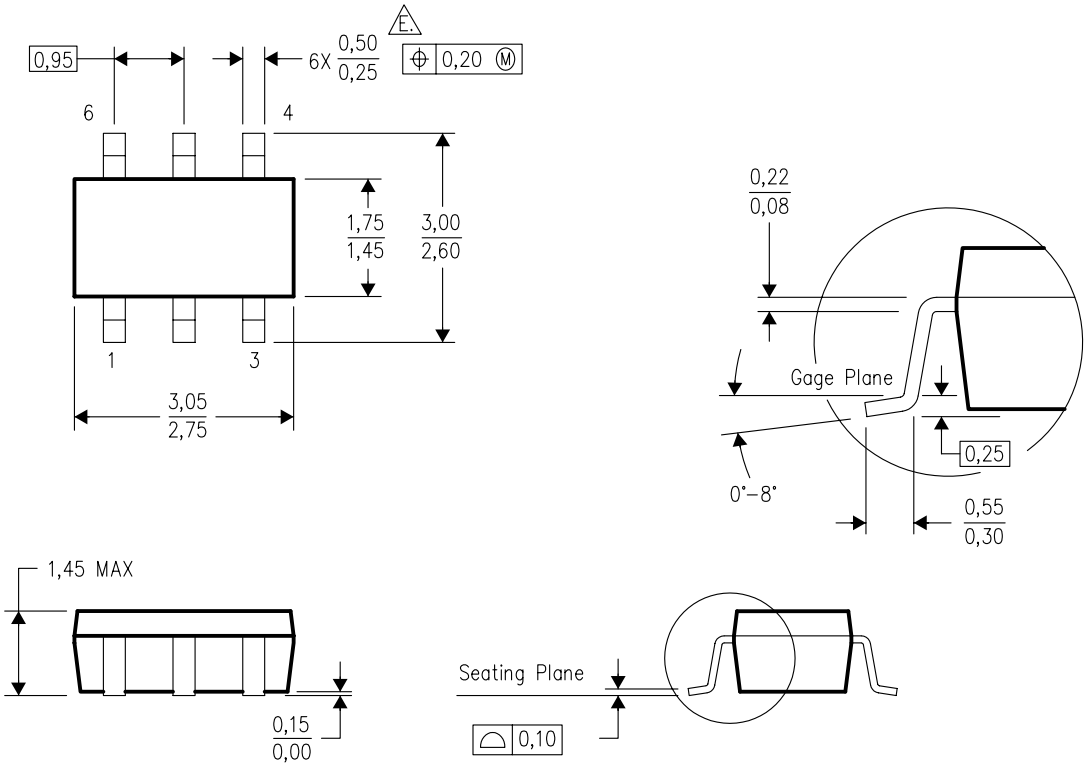
Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)
SN74AUP1T98DBVR	ACTIVE	SOT-23	DBV	6	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN74AUP1T98DBVRE4	ACTIVE	SOT-23	DBV	6	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN74AUP1T98DBVT	ACTIVE	SOT-23	DBV	6	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN74AUP1T98DBVTE4	ACTIVE	SOT-23	DBV	6	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN74AUP1T98DCKR	ACTIVE	SC70	DCK	6	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN74AUP1T98DCKRE4	ACTIVE	SC70	DCK	6	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN74AUP1T98DCKT	ACTIVE	SC70	DCK	6	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN74AUP1T98DCKTE4	ACTIVE	SC70	DCK	6	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN74AUP1T98YEPR	PREVIEW	WCSP	YEP	6	3000	TBD	Call TI	Call TI
SN74AUP1T98YZPR	PREVIEW	WCSP	YZP	6	3000	TBD	Call TI	Call TI

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS) or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

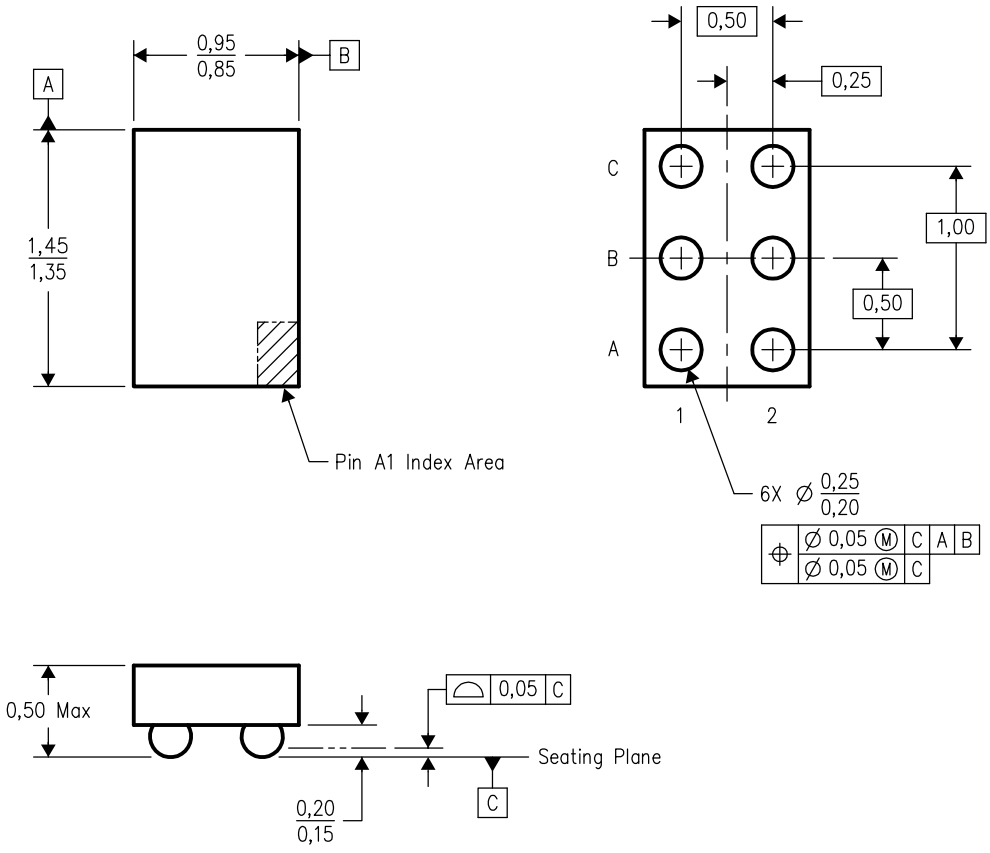
DBV (R–PDSO–G6) PLASTIC SMALL–OUTLINE PACKAGE



4073253–5/J 10/2005

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. Mold flash and protrusion shall not exceed 0.15 per side.
D. Leads 1,2,3 may be wider than leads 4,5,6 for package orientation.
E. Falls within JEDEC MO–178 Variation AB, except minimum lead width.

YZP (R–XBGA–N6) DIE–SIZE BALL GRID ARRAY

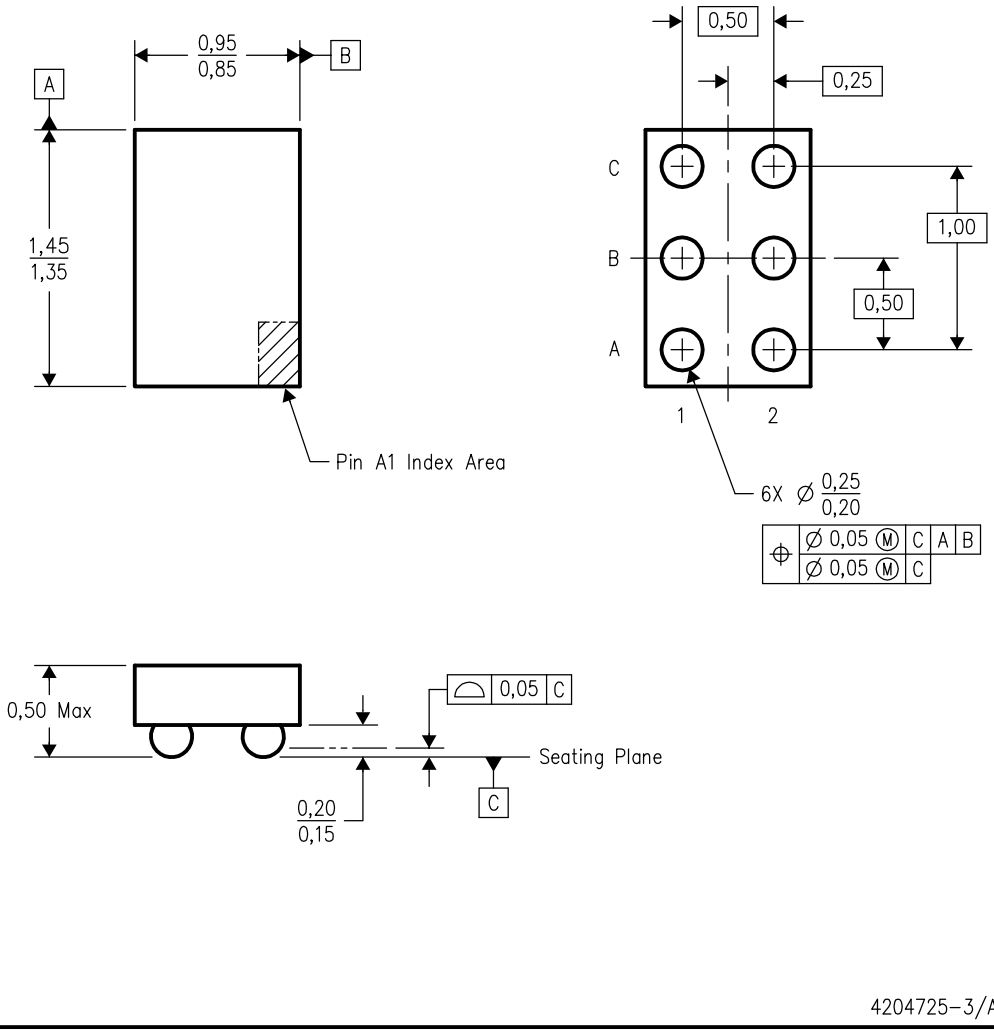


4204741–3/A 10/2002

NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. NanoFree™ package configuration.
D. This package is lead–free. Refer to the 6 YEP package (drawing 4204725) for tin–lead (SnPb).

NanoFree is a trademark of Texas Instruments.

YEP (R–XBGA–N6) DIE–SIZE BALL GRID ARRAY



NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. NanoStar™ package configuration.
D. This package is tin–lead (SnPb). Refer to the 6 YZP package (drawing 4204741) for lead–free.

NanoStar is a trademark of Texas Instruments.

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Mailing Address: Texas Instruments
Post Office Box 655303 Dallas, Texas 75265