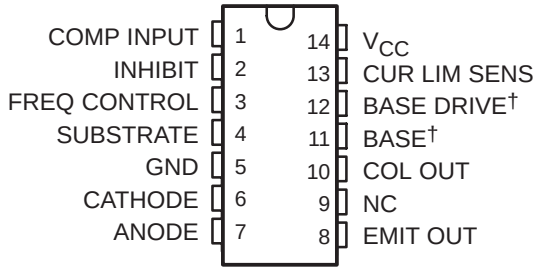
500-mA PEAK STEP-UP, STEP-DOWN, INVERTING SWITCHING VOLTAGE REGULATOR

SLVS009F − JUNE 1976 − REVISED FEBRUARY 2005

- **High Efficiency . . . 60% or Greater**
- **Peak Switch Current . . . 500 mA**
- **Input Current Limit Protection**
- **TTL-Compatible Inhibit**
- **Adjustable Output Voltage**
- **Input Regulation . . . 0.2% Typ**
- **Output Regulation . . . 0.4% Typ**
- **Soft Start-Up Capability**
- **Can be Used in Buck, Boost, and Inverting Configurations**

D, N, OR PW PACKAGE
(TOP VIEW)



NC − No internal connection
† BASE (11) and BASE DRIVE (12) are used for device testing only. They normally are not used in circuit applications of the device.

description/ordering information

The TL497A incorporates all the active functions required in the construction of switching voltage regulators. It also can be used as the control element to drive external components for high-power-output applications. The TL497A was designed for ease of use in step-up, step-down, or voltage-inversion applications requiring high efficiency.

The TL497A is a fixed-on-time variable-frequency switching-voltage-regulator control circuit. The switch-on time is programmed by a single external capacitor connected between FREQ CONTROL and GND. This capacitor, C_T, is charged by an internal constant-current generator to a predetermined threshold. The charging current and the threshold vary proportionally with V_{CC}. Thus, the switch-on time remains constant over the specified range of input voltage (4.5 V to 12 V). Typical on times for various values of C_T are as follows:

TIMING CAPACITOR, C_T (pF)	200	250	350	400	500	750	1000	1500	2000
ON TIME (µs)	19	22	26	32	44	56	80	120	180

The output voltage is controlled by an external resistor ladder network (R1 and R2 in Figures 1, 2, and 3) that provides a feedback voltage to the comparator input. This feedback voltage is compared to the reference voltage of 1.2 V (relative to SUBSTRATE) by the high-gain comparator. When the output voltage decays below the value required to maintain 1.2 V at the comparator input, the comparator enables the oscillator circuit, which charges and discharges C_T as described above. The internal pass transistor is driven on during the charging of C_T. The internal transistor can be used directly for switching currents up to 500 mA. Its collector and emitter are uncommitted, and it is current driven to allow operation from the positive supply voltage or ground. An internal Schottky diode matched to the current characteristics of the internal transistor also is available for blocking or commutating purposes. The TL497A also has on-chip current-limit circuitry that senses the peak currents in the switching regulator and protects the inductor against saturation and the pass transistor against overstress. The current limit is adjustable and is programmed by a single sense resistor, R_{CL}, connected between V_{CC} and CUR LIM SENS. The current-limit circuitry is activated when 0.7 V is developed across R_{CL}. External gating is provided by the INHIBIT input. When the INHIBIT input is high, the output is turned off.

Simplicity of design is a primary feature of the TL497A. With only six external components (three resistors, two capacitors, and one inductor), the TL497A operates in numerous voltage-conversion applications (step-up, step-down, invert) with as much as 85% of the source power delivered to the load. The TL497A replaces the TL497 in all applications.

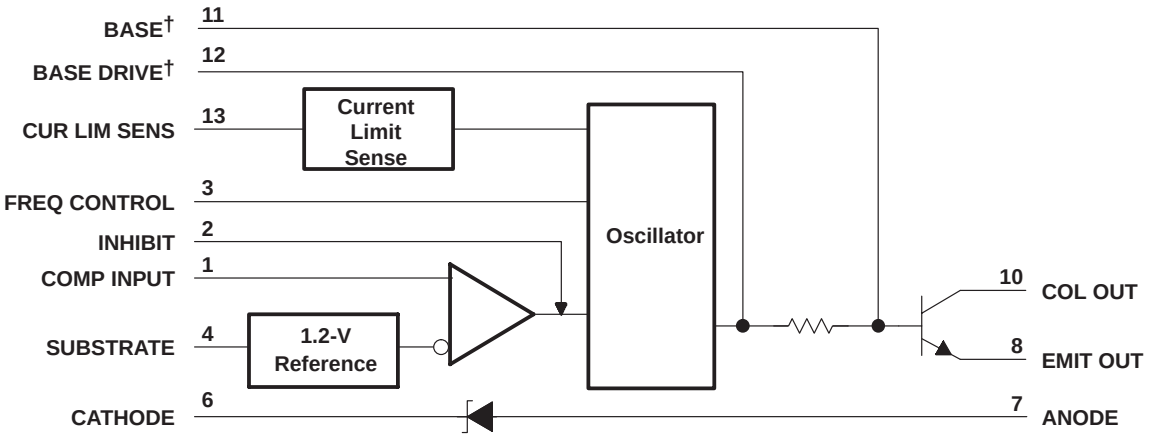
The TL497AC is characterized for operation from 0°C to 70°C. The TL497AI is characterized for operation from −40°C to 85°C.

AVAILABLE OPTIONS

T_A	PACKAGED DEVICES			CHIP FORM (Y)
	SMALL-OUTLINE (D)	PLASTIC DIP (N)	SHRINK SMALL-OUTLINE (PW)	
0°C to 70°C	TL497ACD	TL497ACN	TL497ACPW	TL497AY
−40°C to 85°C	TL497AID	TL497AIN	—	—

The D and PW packages are only taped and reeled. Add the suffix R to the device type (e.g., TL497ACPWR). Chip forms are tested at 25°C.

functional block diagram



† BASE and BASE DRIVE are used for device testing only. They normally are not used in circuit applications of the device.

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

Supply voltage, V_{CC} (see Note 1) . . . . . 15 V
Output voltage, V_O . . . . . 35 V
Input voltage, V_I(COMP INPUT) . . . . . 5 V
Input voltage, V_I(INHIBIT) . . . . . 5 V
Diode reverse voltage . . . . . 35 V
Power switch current . . . . . 750 mA
Diode forward current . . . . . 750 mA
Package thermal impedance, θ_{JA} (see Notes 2 and 3): D package . . . . . 86°C/W
N package . . . . . 101°C/W
PW package . . . . . 113°C/W
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds . . . . . 260°C
Storage temperature range, T_{stg} . . . . . −65°C to 150°C

†Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

NOTES: 1. All voltage values, except diode voltages, are with respect to network ground terminal.
2. Maximum power dissipation is a function of $T_J(max)$, θ_{JA}, and T_A. The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_J(max) - T_A)/\theta_{JA}$. Operating at the absolute maximum T_J of 150°C can impact reliability.
3. The package thermal impedance is calculated in accordance with JESD 51, except for through-hole packages, which use a trace length of zero.

recommended operating conditions

			MIN	MAX	UNIT
Supply voltage, V_{CC}			4.5	12	V
High-level input voltage, V_{IH}	INHIBIT pin		2.5		V
Low-level input voltage, V_{IL}	INHIBIT pin			0.8	V
Output voltage	Step-up configuration (see Figure 1)		$V_I + 2$	30	V
	Step-down configuration (see Figure 2)		V_{ref}	$V_I - 1$	
	Inverting regulator (see Figure 3)		$-V_{ref}$	−25	
Power switch current				500	mA
Diode forward current				500	mA
Operating free-air temperature range, T_A		TL497AC	0	70	°C
		TL497AI	−40	85	

electrical characteristics over recommended operating conditions, V_{CC} = 6 V (unless otherwise noted)

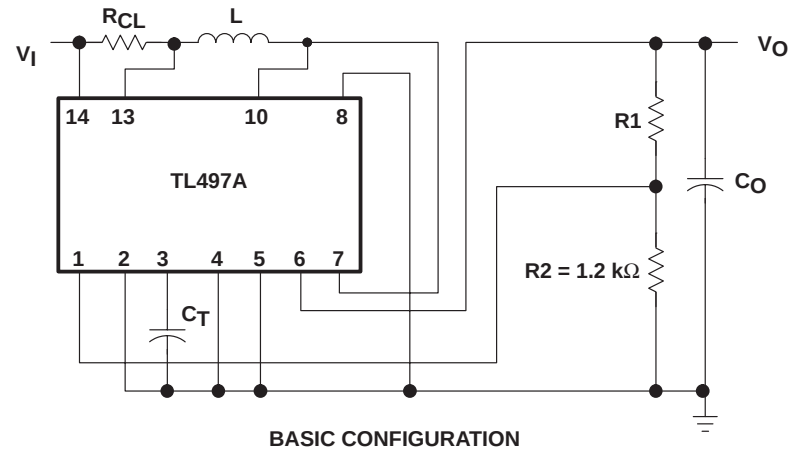
PARAMETER	TEST CONDITIONS		T_A†	TL497AC			TL497AI			UNIT
				MIN	TYP‡	MAX	MIN	TYP‡	MAX	
High-level input current, INHIBIT	$V_{I(I)}$ = 5 V		Full range		0.8	1.5		0.8	1.5	mA
Low-level input current, INHIBIT	$V_{I(I)}$ = 0 V		Full range		5	10		5	20	μA
Comparator reference voltage	V_I = 4.5 V to 6 V		Full range	1.08	1.2	1.32	1.14	1.2	1.26	V
Comparator input bias current	V_I = 6 V		Full range		40	100		40	100	μA
Switch on-state voltage	V_I = 4.5 V	I_O = 100 mA	25°C		0.13	0.2		0.13	0.2	V
		I_O = 500 mA	Full range			0.85			1	
Switch off-state current	V_I = 4.5 V, V_O = 30 V		25°C		10	50		10	50	μA
			Full range			200			500	
Sense voltage, CUR LIM SENS	V_I = 6 V		25°C	0.45		1	0.45		1	V
Diode forward voltage	I_O = 10 mA		Full range		0.75	0.85		0.75	0.95	V
	I_O = 100 mA		Full range		0.9	1		0.9	1.1	
	I_O = 500 mA		Full range		1.33	1.55		1.33	1.75	
Diode reverse voltage	I_O = 500 μA		Full range				30			V
	I_O = 200 μA		Full range	30						
On-state supply current			25°C		11	14		11	14	mA
			Full range			15			16	
Off-state supply current			25°C		6	9		6	9	mA
			Full range			10			11	

† Full range is 0°C to 70°C for the TL497AC and −40°C to 85°C for the TL497AI.
‡ All typical values are at T_A = 25°C.

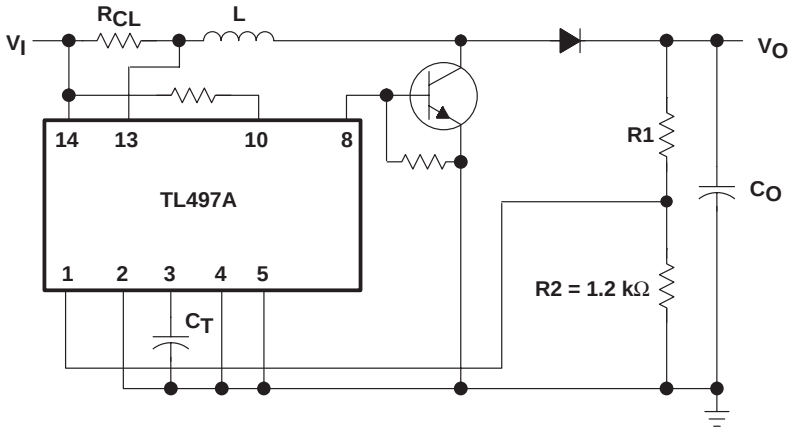
electrical characteristics over recommended operating conditions, V_{CC} = 6 V, T_A = 25°C (unless otherwise noted)

PARAMETER	TEST CONDITIONS	TL497AY			UNIT
		MIN	TYP	MAX	
High-level input current, INHIBIT	$V_{I(I)}$ = 5 V		0.8		mA
Low-level input current, INHIBIT	$V_{I(I)}$ = 0 V		5		μA
Comparator reference voltage	V_I = 4.5 V to 6 V		1.2		V
Comparator input bias current	V_I = 6 V		40		μA
Switch on-state voltage	V_I = 4.5 V, I_O = 100 mA		0.13		V
Switch off-state current	V_I = 4.5 V, V_O = 30 V		10		μA
Diode forward voltage	I_O = 10 mA		0.75		V
	I_O = 100 mA		0.9		
	I_O = 500 mA		1.33		
On-state supply current			11		mA
Off-state supply current			6		mA

APPLICATION INFORMATION



BASIC CONFIGURATION
(Peak Switching Current = $I_{(PK)}$ < 500 mA)



EXTENDED POWER CONFIGURATION
(using external transistor)

DESIGN EQUATIONS

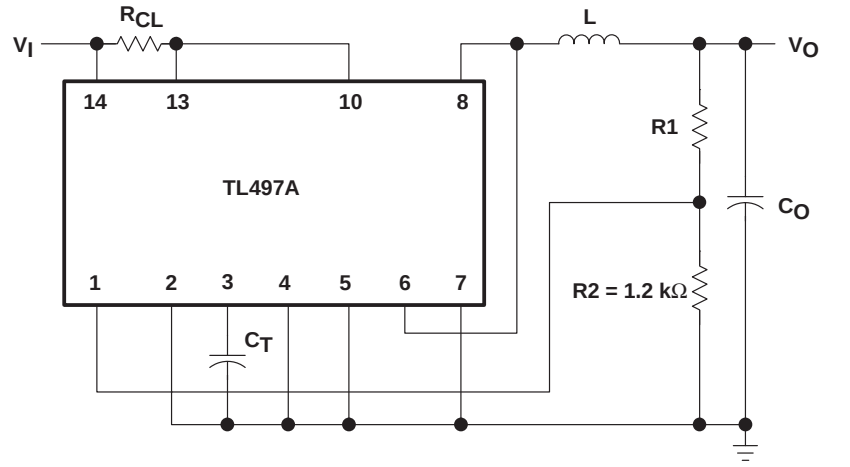
- $I_{(PK)} = 2\, I_O \max\left[\frac{V_O}{V_I}\right]$
- $L\ (\mu H) = \frac{V_I}{I_{(PK)}} t_{on}\ (\mu s)$

Choose L (50 to 500 μH), calculate t_{on} (25 to 150 μs)

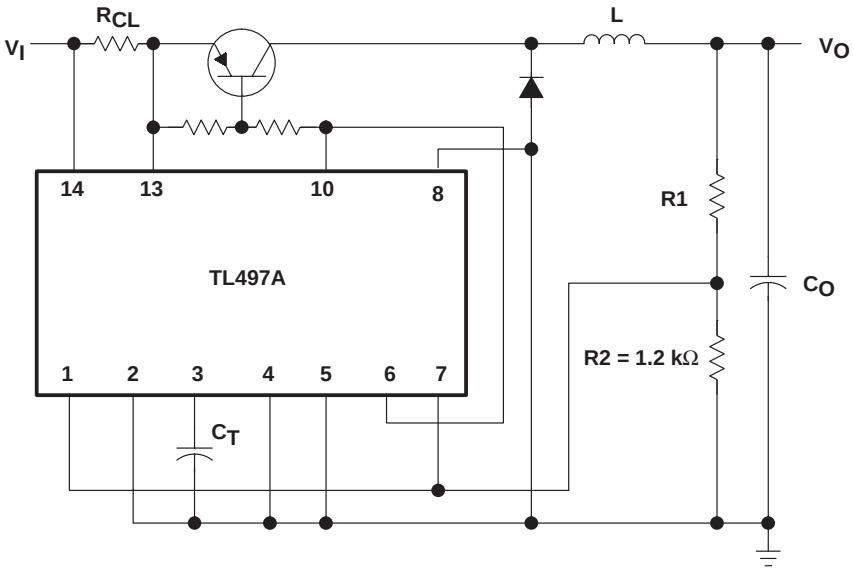
- $C_T (pF) \approx 12\, t_{on}\ (\mu s)$
- $R1 = (V_O - 1.2\ V)\ k\Omega$
- $R_{CL} = \frac{0.5\ V}{I_{(PK)}}$
- $C_O\ (\mu F) \approx t_{on}(\mu s) \frac{\left[\frac{V_I}{V_O} I_{(PK)} + I_O\right]}{V_{ripple\ (PK)}}$

Figure 1. Positive Regulator, Step-Up Configurations

APPLICATION INFORMATION



BASIC CONFIGURATION
(Peak Switching Current = $I_{(PK)}$ < 500 mA)



EXTENDED POWER CONFIGURATION
(using external transistor)

DESIGN EQUATIONS

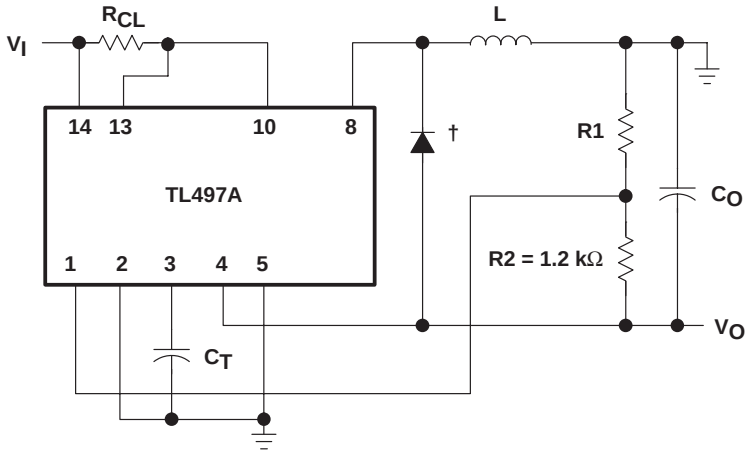
- $I_{(PK)} = 2\, I_O$ max
- $L\ (\mu H) = \dfrac{V_I - V_O}{I_{(PK)}} t_{on}(\mu s)$

Choose L (50 to 500 μH), calculate t_{on} (10 to 150 μs)

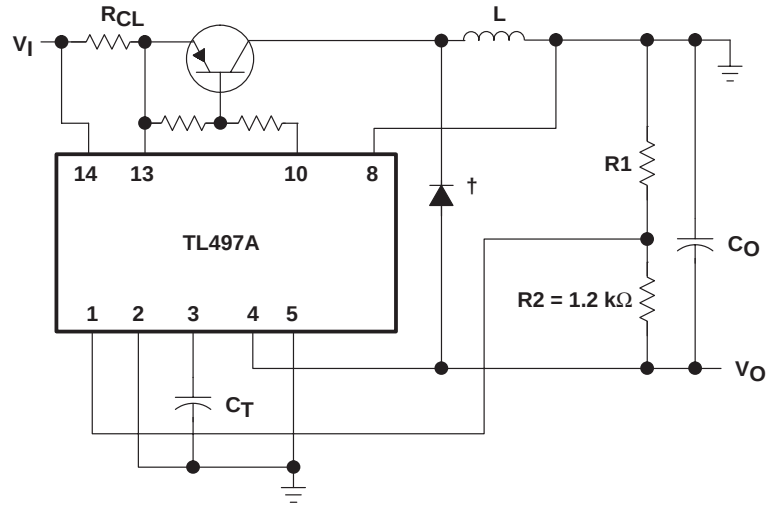
- $C_T(pF) \approx 12\, t_{on}(\mu s)$
- $R1 = (V_O - 1.2\ V)\ k\Omega$
- $R_{CL} = \dfrac{0.5\ V}{I_{(PK)}}$
- $C_O\ (\mu F) \approx t_{on}(\mu s) \dfrac{\left[\dfrac{V_I - V_O}{V_O} I_{(PK)} + I_O\right]}{V_{ripple}\ (PK)}$

Figure 2. Positive Regulator, Step-Down Configurations

APPLICATION INFORMATION



BASIC CONFIGURATION
(Peak Switching Current = $I_{(PK)}$ < 500 mA)



EXTENDED POWER CONFIGURATION
(using external transistor)

DESIGN EQUATIONS

- $I_{(PK)} = 2\, I_O \max\left[1 + \frac{|V_O|}{V_I}\right]$
- $L\ (\mu H) = \frac{V_I}{I_{(PK)}} t_{on}(\mu s)$

Choose L (50 to 500 μH), calculate t_{on} (10 to 150 μs)

- $C_T(pF) \approx 12\, t_{on}(\mu s)$
- $R1 = \left(|V_O| - 1.2\ V\right) k\Omega$

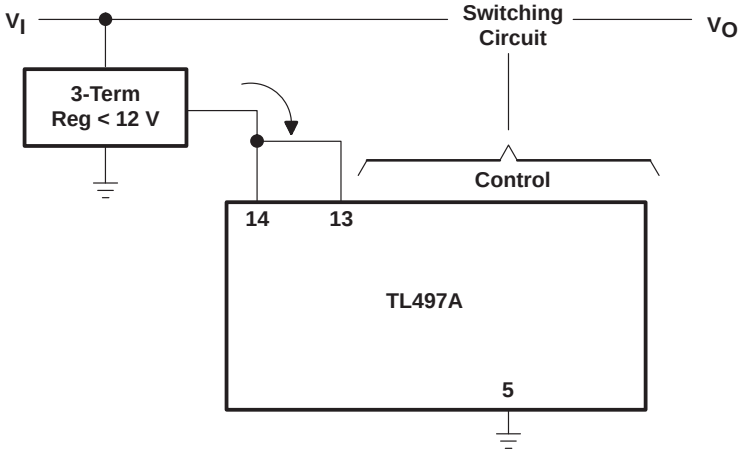
$$R_{CL} = \frac{0.5\ V}{I_{(PK)}}$$

- $C_O\ (\mu F) \approx t_{on}(\mu s) \dfrac{\left[\frac{V_I}{|V_O|} I_{(PK)} + I_O\right]}{V_{ripple}\ (PK)}$

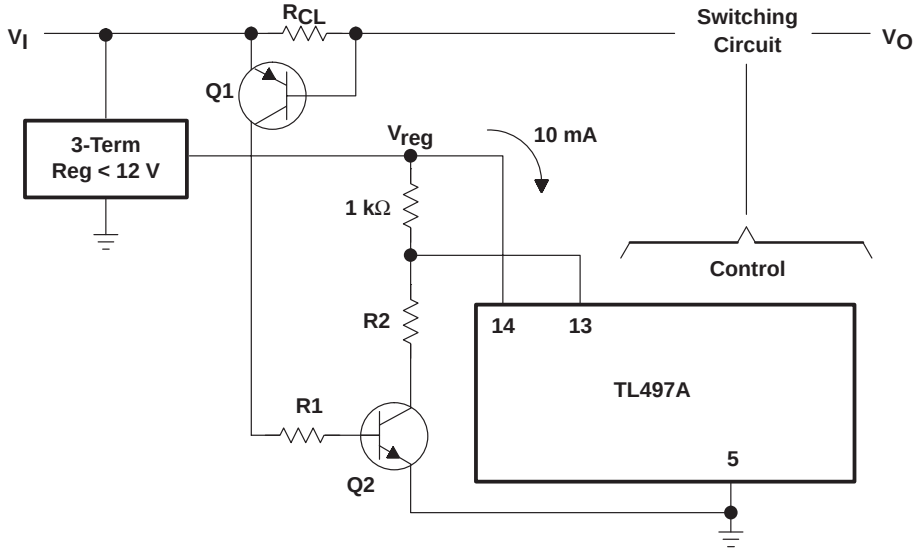
† Use external catch diode, e.g., 1N4001, when building an inverting supply with the TL497A.

Figure 3. Inverting Applications

APPLICATION INFORMATION



EXTENDED INPUT CONFIGURATION WITHOUT CURRENT LIMIT



DESIGN EQUATIONS

- $R_{CL} = \frac{V_{BE(Q1)}}{I_{limit\ (PK)}}$
- $R1 + \frac{V_I}{I_{B(Q2)}}$
- $R2 = \left(V_{reg} - 1\right) 10\ k\Omega$

CURRENT LIMIT FOR EXTENDED INPUT CONFIGURATION

Figure 4. Extended Input Voltage Range (V_I > 12 V)

PACKAGING INFORMATION

Orderable Device	Status [1]	Package Type	Package Drawing	Pins	Package Qty	Eco Plan [2]	Lead/Ball Finish	MSL Peak Temp [3]
TL497ACD	ACTIVE	SOIC	D	14	50	Pb-Free (RoHS)	CU NIPDAU	Level-2-250C-1 YEAR
TL497ACDR	ACTIVE	SOIC	D	14	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-250C-1 YEAR
TL497ACN	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	Level-NC-NC-NC
TL497ACNSLE	OBSOLETE	SO	NS	14		None	Call TI	Call TI
TL497ACNSR	ACTIVE	SO	NS	14	2000	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1 YEAR/ Level-1-235C-UNLIM
TL497ACPWR	ACTIVE	TSSOP	PW	14	2000	Pb-Free (RoHS)	CU NIPDAU	Level-1-250C-UNLIM
TL497AID	ACTIVE	SOIC	D	14	50	Pb-Free (RoHS)	CU NIPDAU	Level-2-250C-1 YEAR
TL497AIDR	ACTIVE	SOIC	D	14	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-250C-1 YEAR
TL497AIJ	OBSOLETE	CDIP	J	14		None	Call TI	Call TI
TL497AIN	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	Level-NC-NC-NC

[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.

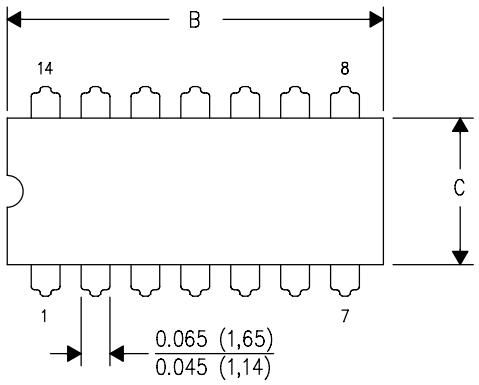
[2] Eco Plan - May not be currently available - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
None: Not yet available Lead (Pb-Free).
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are 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" and in addition, uses package materials that do not contain halogens, including bromine (Br) or antimony (Sb) above 0.1% of total product weight.

[3] MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDECindustry standard classifications, and peak solder temperature.

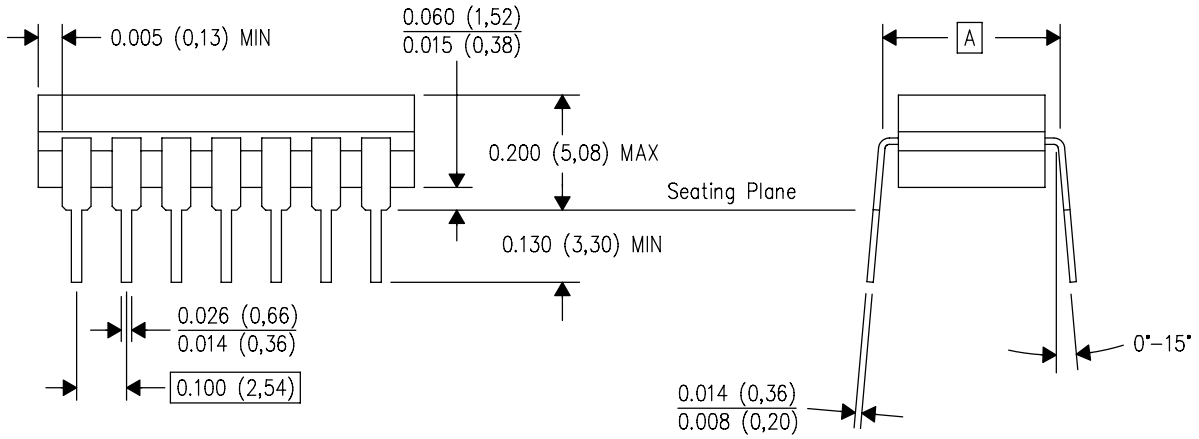
J (R–GDIP–T**)

14 LEADS SHOWN

CERAMIC DUAL IN–LINE PACKAGE



DIM \ PINS **	14	16	18	20
A	0.300 (7,62) BSC	0.300 (7,62) BSC	0.300 (7,62) BSC	0.300 (7,62) BSC
B MAX	0.785 (19,94)	.840 (21,34)	0.960 (24,38)	1.060 (26,92)
B MIN	—	—	—	—
C MAX	0.300 (7,62)	0.300 (7,62)	0.310 (7,87)	0.300 (7,62)
C MIN	0.245 (6,22)	0.245 (6,22)	0.220 (5,59)	0.245 (6,22)



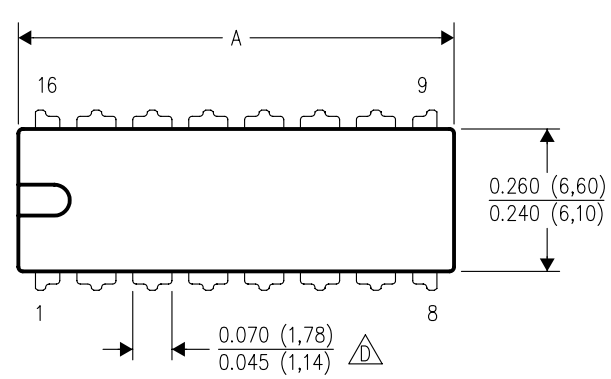
4040083/F 03/03

NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. This package is hermetically sealed with a ceramic lid using glass frit.
D. Index point is provided on cap for terminal identification only on press ceramic glass frit seal only.
E. Falls within MIL STD 1835 GDIP1–T14, GDIP1–T16, GDIP1–T18 and GDIP1–T20.

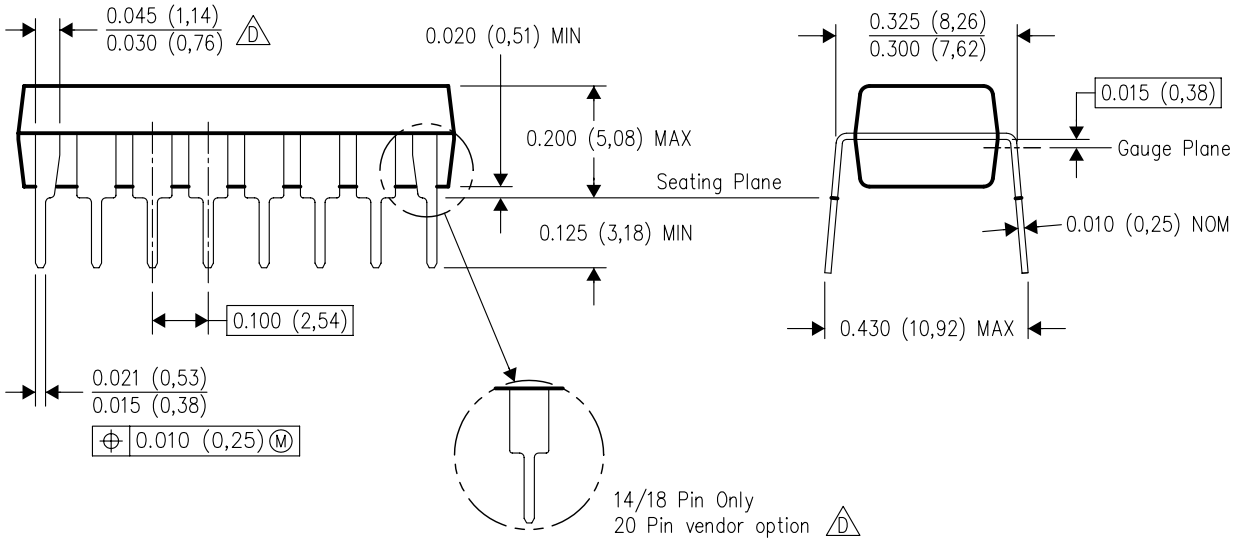
N (R–PDIP–T**)

PLASTIC DUAL–IN–LINE PACKAGE

16 PINS SHOWN



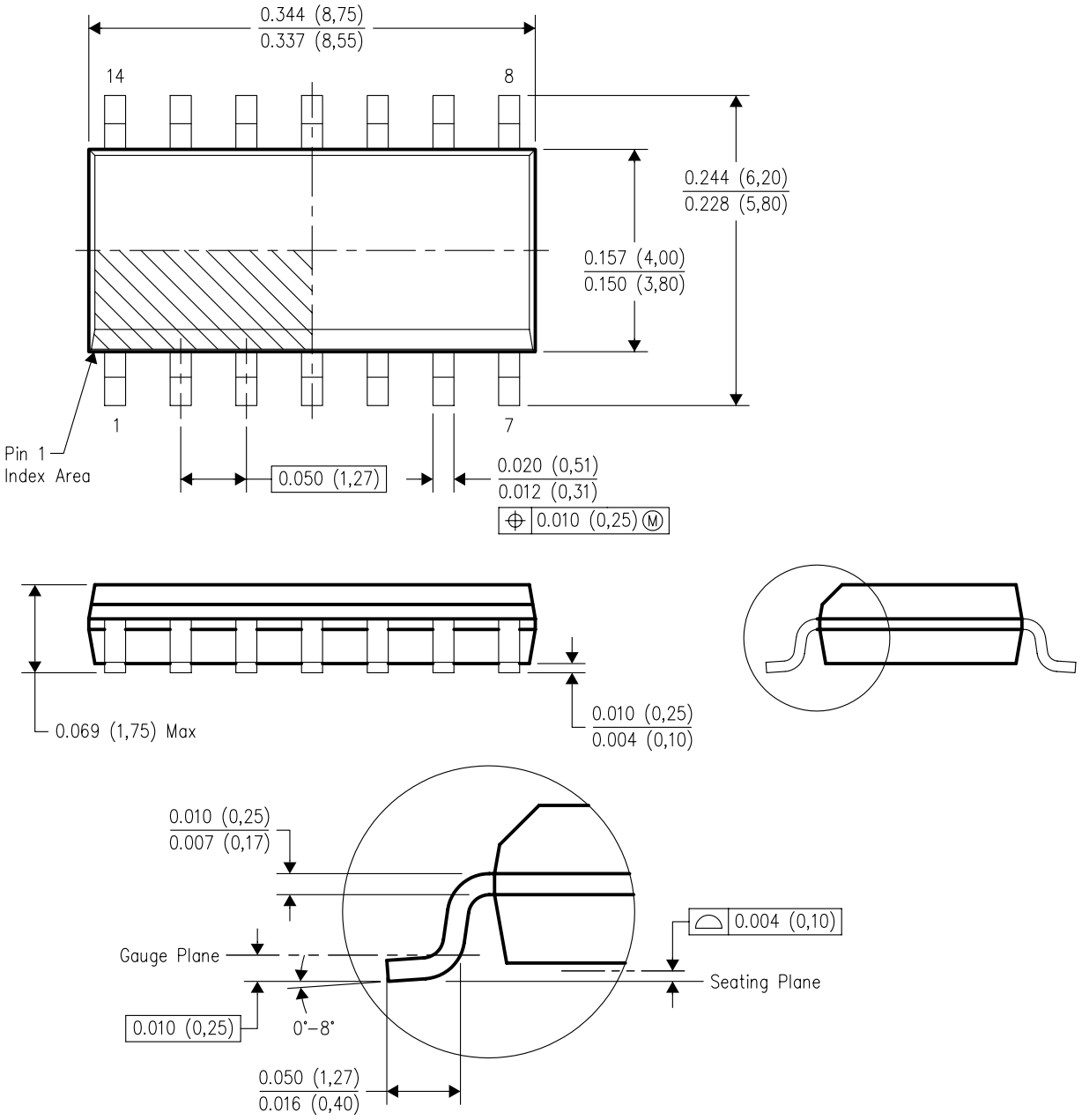
DIM \ PINS **	14	16	18	20
A MAX	0.775 (19,69)	0.775 (19,69)	0.920 (23,37)	1.060 (26,92)
A MIN	0.745 (18,92)	0.745 (18,92)	0.850 (21,59)	0.940 (23,88)
MS–001 VARIATION (C)	AA	BB	AC	AD



4040049/E 12/2002

NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Falls within JEDEC MS–001, except 18 and 20 pin minimum body length (Dim A).
D. The 20 pin end lead shoulder width is a vendor option, either half or full width.

D (R–PDSO–G14) PLASTIC SMALL–OUTLINE PACKAGE

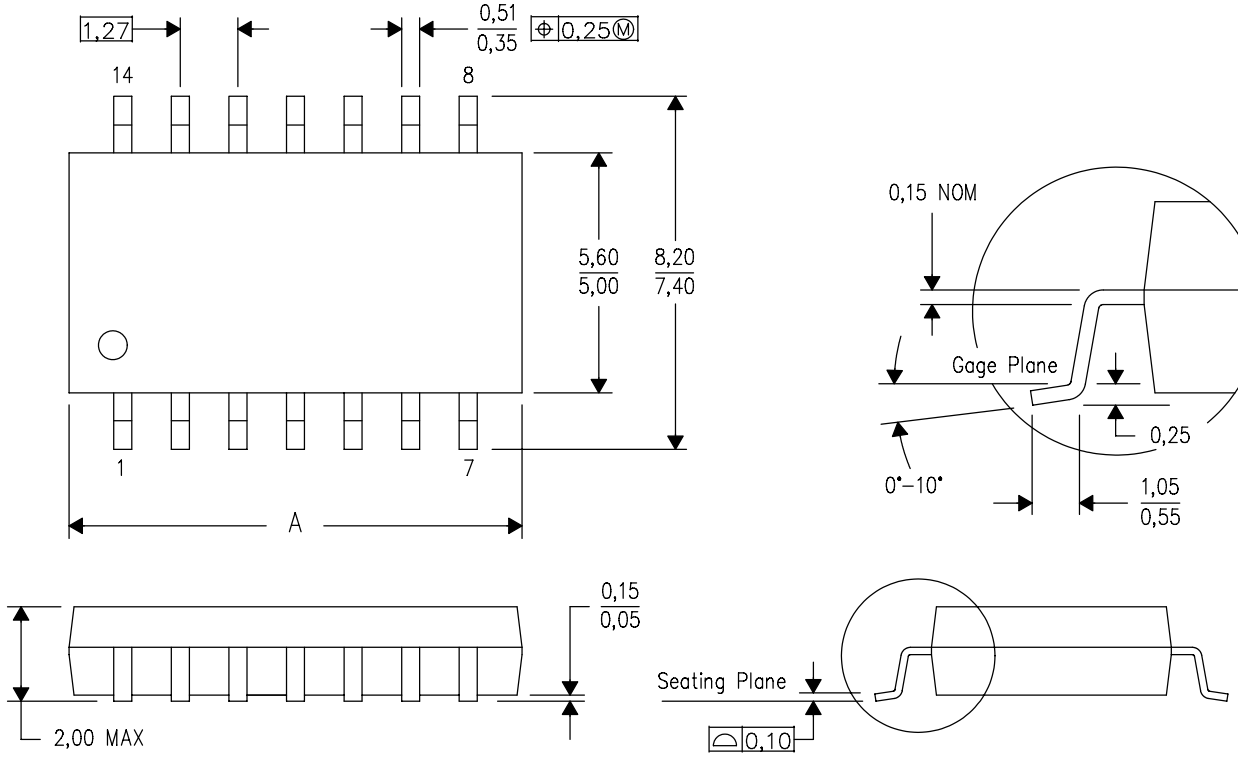


NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
D. Falls within JEDEC MS–012 variation AB.

MECHANICAL DATA

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

14-PINS SHOWN



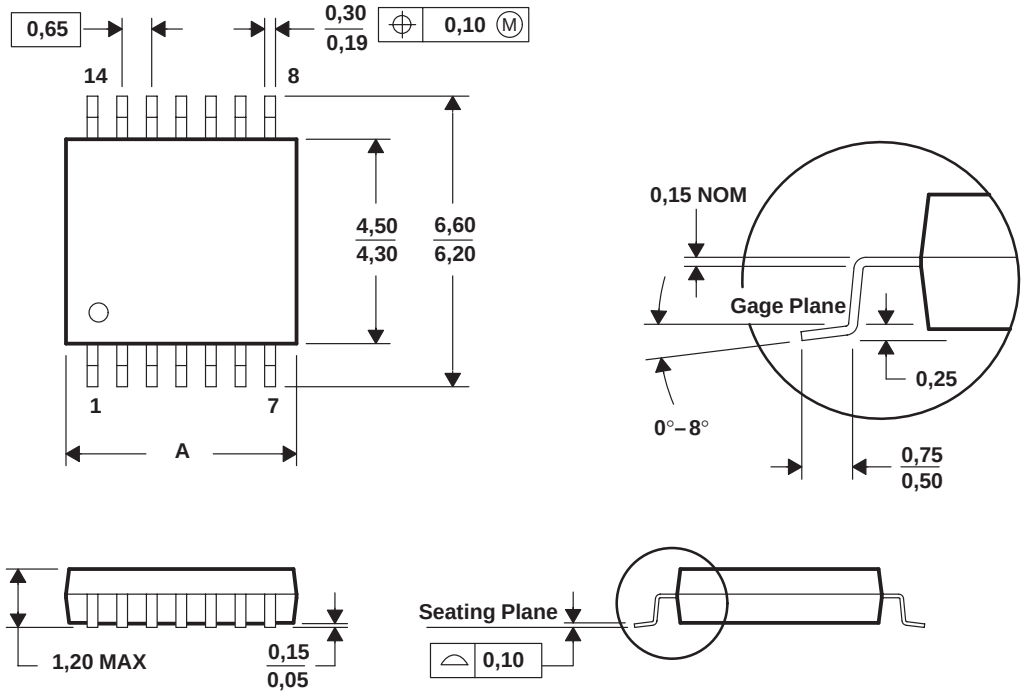
DIM \ PINS **	14	16	20	24
A MAX	10,50	10,50	12,90	15,30
A MIN	9,90	9,90	12,30	14,70

4040062/C 03/03

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.

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

14 PINS 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/F 01/97

NOTES: A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion not to exceed 0,15.
D. Falls within JEDEC MO-153

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products		**Applications**	
Amplifiers	amplifier.ti.com	Audio	www.ti.com/audio
Data Converters	dataconverter.ti.com	Automotive	www.ti.com/automotive
DSP	dsp.ti.com	Broadband	www.ti.com/broadband
Interface	interface.ti.com	Digital Control	www.ti.com/digitalcontrol
Logic	logic.ti.com	Military	www.ti.com/military
Power Mgmt	power.ti.com	Optical Networking	www.ti.com/opticalnetwork
Microcontrollers	microcontroller.ti.com	Security	www.ti.com/security
		Telephony	www.ti.com/telephony
		Video & Imaging	www.ti.com/video
		Wireless	www.ti.com/wireless

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