

## Advanced Regulating Pulse Width Modulators

### FEATURES

- Fully Interchangeable with Standard UC1524 Family
- Precision Reference Internally Trimmed to  $\pm 1\%$
- High-Performance Current Limit Function
- Under-Voltage Lockout with Hysteretic Turn-on
- Start-Up Supply Current Less Than 4mA
- Output Current to 200mA
- 60V Output Capability
- Wide Common-Mode Input Range for both Error and Current Limit Amplifiers
- PWM Latch Insures Single Pulse per Period
- Double Pulse Suppression Logic
- 200ns Shutdown through PWM Latch
- Ensured Frequency Accuracy
- Thermal Shutdown Protection

### DESCRIPTION

The UC1524A family of regulating PWM ICs has been designed to retain the same highly versatile architecture of the industry standard UC1524 (SG1524) while offering substantial improvements to many of its limitations. The UC1524A is pin compatible with "non-A" models and in most existing applications can be directly interchanged with no effect on power supply performance. Using the UC1524A, however, frees the designer from many concerns which typically had required additional circuitry to solve.

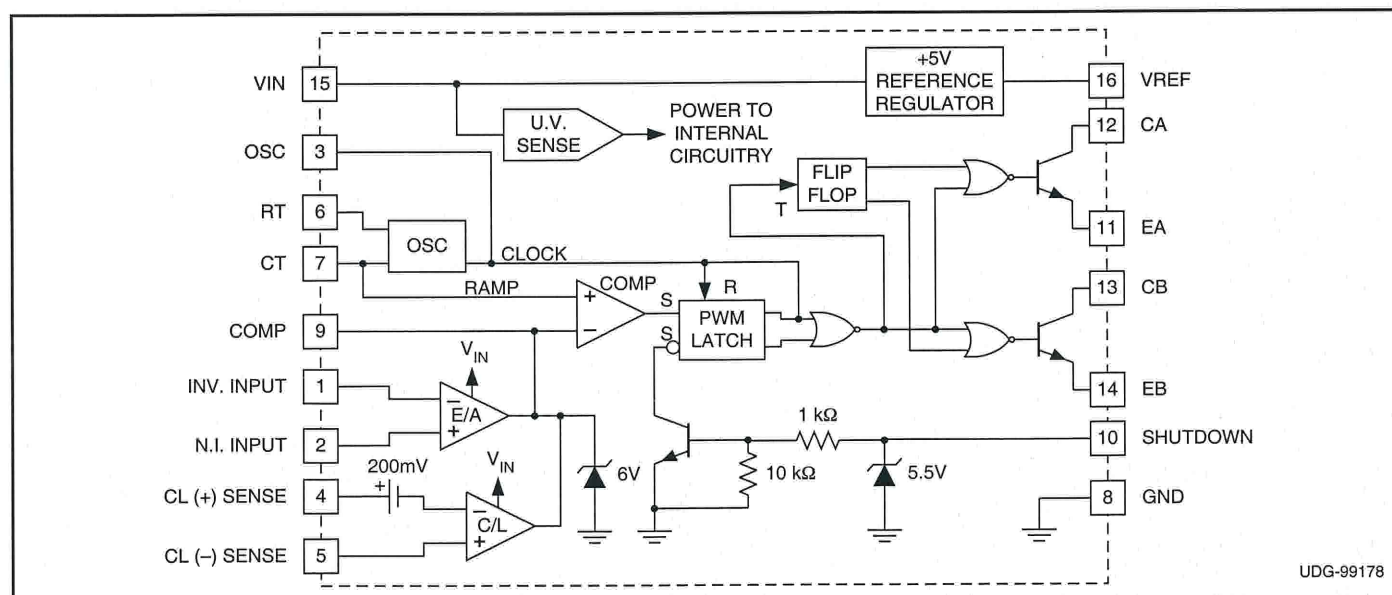
The UC1524A includes a precise 5V reference trimmed to  $\pm 1\%$  accuracy, eliminating the need for potentiometer adjustments; an error amplifier with an input range which includes 5V, eliminating the need for a reference divider; a current sense amplifier useful in either the ground or power supply output lines; and a pair of 60V, 200mA uncommitted transistor switches which greatly enhance output versatility.

An additional feature of the UC1524A is an under-voltage lockout circuit which disables all the internal circuitry, except the reference, until the input voltage has risen to 8V. This holds standby current low until turn-on, greatly simplifying the design of low power, off-line supplies. The turn-on circuit has approximately 600mV of hysteresis for jitter-free activation.

Other product enhancements included in the UC1524A's design include a PWM latch which insures freedom from multiple pulsing within a period, even in noisy environments, logic to eliminate double pulsing on a single output, a 200ns external shutdown capability, and automatic thermal protection from excessive chip temperature. The oscillator circuit of the UC1524A is usable beyond 500kHz and is now easier to synchronize with an external clock pulse.

The UC1524A is packaged in a hermetic 16-pin DIP and is rated for operation from  $-55^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ . The UC2524A and 3524A are available in either ceramic or plastic packages and are rated for operation from  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$  and  $0^{\circ}\text{C}$  to  $70^{\circ}\text{C}$ , respectively. Surface mount devices are also available.

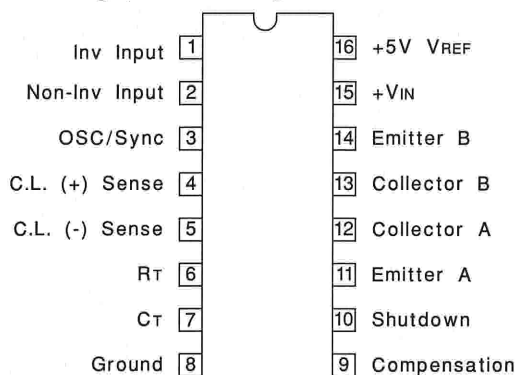
### BLOCK DIAGRAM



## ABSOLUTE MAXIMUM RATINGS

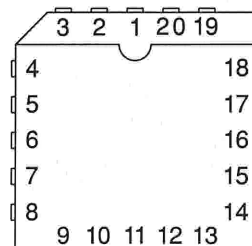
Supply Voltage ( $V_{IN}$ ) ..... 40V  
 Collector Supply Voltage ( $V_C$ ) ..... 60V  
 Output Current (each Output) ..... 200mA  
 Maximum Forced Voltage (Pin 9, 10) ..... -3 to +5V  
 Maximum Forced Current (Pin 9, 10) .....  $\pm 10$ mA  
 Reference Output Current ..... 50mA  
 Oscillator Charging Current ..... 5mA  
 Power Dissipation at  $T_A = +25^\circ\text{C}$  ..... 1000mW  
 Power Dissipation at  $T_C = +25^\circ\text{C}$  ..... 2000mW  
 Operating Temperature Range .....  $-55^\circ\text{C}$  to  $+125^\circ\text{C}$   
 Storage Temperature Range .....  $-65^\circ\text{C}$  to  $+150^\circ\text{C}$   
 Lead Temperature, (Soldering, 10 seconds) .....  $+300^\circ\text{C}$   
*Note: Consult packaging section of Databook for thermal limitations and considerations of package.*

### DIL-16, SOIC-16 (TOP VIEW) J or N Package, DW Package



## CONNECTION DIAGRAMS

### PLCC-20, LCC-20 (TOP VIEW) Q or L Package



PACKAGE PIN FUNCTION	
FUNCTION	PIN
N/C	1
Inv. Input	2
Non-Inv. Input	3
OSC/SYNC	4
C.L. (+) sense	5
N/C	6
C.L. (-) sense	7
$R_T$	8
$C_T$	9
Ground	10
N/C	11
Compensation	12
Shutdown	13
Emitter A	14
Collector A	15
N/C	16
Collector B	17
Emitter B	18
$+V_{IN}$	19
$+5V V_{REF}$	20

**ELECTRICAL CHARACTERISTICS:** Unless otherwise stated, these specifications apply for  $T_A = -55^\circ\text{C}$  to  $+125^\circ\text{C}$  for the UC1524A,  $-40^\circ$  to  $+85^\circ\text{C}$  for the UC2524A, and  $0^\circ\text{C}$  to  $+70^\circ\text{C}$  for the UC3524A;  $V_{IN} = V_C = 20V$ ,  $T_A = T_J$ .

PARAMETER	TEST CONDITIONS	UC1524A / UC2524A			UC3524A			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Turn-on Characteristics								
Input Voltage	Operating Range after Turn-on	8		40	8		40	V
Turn-on Threshold		6.5	7.5	8.5	6.5	7.5	8.5	V
Turn-on Current	V <sub>IN</sub> = 6V		2.5	4		2.5	4	mA
Operating Current	V <sub>IN</sub> = 8 to 40V		5	10		5	10	mA
Turn-on Hysteresis*			0.5			0.5		V
Reference Section								
Output Voltage	T <sub>J</sub> = 25°C	4.95	5.00	5.05	4.90	5.00	5.10	V
	Over Operating Range	4.9		5.1	4.85		5.15	V
Line Regulation	V <sub>IN</sub> = 10 to 40V		10	20		10	30	mV
Load Regulation	I <sub>L</sub> = 0 to 20 mA		20	25		20	35	mV
Temperature Stability*	Over Operating Range*		20	25		20	35	mV
Short Circuit Current	V <sub>REF</sub> = 0, 25°C ≤ T <sub>J</sub> ≤ 125°C		80	100		80	100	mA
Output Noise Voltage*	10Hz ≤ f ≤ 10kHz, T <sub>J</sub> =25°C		40			40		μV <sub>rms</sub>
Long Term Stability*	T <sub>J</sub> =125°C, 1000 Hrs.		20	50		20	50	mV

\* These parameters are ensured by design but not 100% tested in production.



**ELECTRICAL CHARACTERISTICS:** Unless otherwise stated, these specifications apply for  $T_A = -55^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$  for the UC1524A,  $-40^{\circ}$  to  $+85^{\circ}\text{C}$  for the UC2524A, and  $0^{\circ}\text{C}$  to  $+70^{\circ}\text{C}$  for the UC3524A;  $V_{IN} = V_C = 20\text{V}$ ,  $T_A = T_J$ .

PARAMETER	TEST CONDITIONS	UC1524A / UC2524A			UC3524A			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Oscillator Section (Unless otherwise specified, RT = 2700Ω, CT = 0.01 mfd)								
Initial Accuracy	TJ = 25°C	41	43	45	39	43	47	kHz
	Over Operating Range	40.2		45.9	38.2		47.9	kHz
Temperature Stability*	Over Operating Temperature Range		1	2		1	2	%
Minimum Frequency	RT = 150kΩ, CT = 0.1mfd			140			120	Hz
Maximum Frequency	RT = 2.0kΩ, CT = 470pF	500			500			kHz
Output Amplitude*		3	3.5		3	3.5		V
Output Pulse Width*		0.29	0.5	1.0	0.3	0.5	1.0	μs
Ramp Peak		3.3	3.5	3.7	3.3	3.5	3.7	V
Ramp Valley	TJ = 25°C	0.7	0.8	0.9	0.7	0.8	0.9	V
Ramp Valley T.C.			-1.0			-1.0		mV/°C
Error Amplifier Section (Unless otherwise specified, VCM = 2.5V)								
Input Offset Voltage			0.5	5		2	10	mV
Input Bias Current			1	5		1	10	μA
Input Offset Current			.05	1		0.5	1	μA
Common Mode Rejection Ratio	VCM = 1.5 to 5.5V	70	80		70	80		dB
Power Supply Rejection Ratio	VIN = 10 to 40V	70	80		70	80		dB
Output Swing (Note 1)		5.0		0.5	5.0		0.5	V
Open Loop Voltage Gain	ΔVO= 1 to 4V, RL ≥ 10MΩ	72	80		64	80		dB
Gain-Bandwidth*	TJ = 25°C, Av = 0dB	1	3		1	3		MHz
DC Transconductance*§	TJ = 25°C, 30kΩ ≤ RL ≤ 1MΩ	1.7	2.3		1.7	2.3		mS
P.W.M. Comparator (RT = 2kΩ, CT = 0.01mfd)								
Minimum Duty Cycle	VCOMP = 0.5V			0			0	%
Maximum Duty Cycle	VCOMP = 3.8V	45			45			%
Current Limit Amplifier (Unless otherwise specified, Pin 5 = 0V)								
Input Offset Voltage	TJ = 25°C, E/A Set for Maximum Output	190	200	210	180	200	220	mV
	Over Operating Temperature Range	180		220	170		230	mV
Input Bias Current			-1	-10		-1	-10	μA
Common Mode Rejection Ratio	V(pin 5) = -0.3V to + 5.5V	50	60		50	60		dB
Power Supply Rejection Ratio	VIN = 10 to 40V	50	60		50	60		dB
Output Swing (Note 1)	Minimum Total Range	5.0		0.5	5.0		0.5	V
Open-Loop Voltage Gain	ΔVO = 1 to 4V, RL ≥ 10MΩ	70	80		70	80		dB
Delay Time*	Pin 4 to Pin 9, ΔVIN = 300mV		300			300		ns
Output Section (Each Output)								
Collector Emitter Voltage	Ic = 100μA	60	80		60	80		V
Collector Leakage Current	VCE = 50V		.1	20		.1	20	μA

\* These parameters are ensured by design but not 100% tested in production.

§ DC transconductance ( $g_m$ ) relates to DC open-loop voltage gain according to the following equation:  $A_v = g_m R_L$  where  $R_L$  is the resistance from pin 9 to the common mode voltage.

The minimum  $g_m$  specification is used to calculate minimum  $A_v$  when the error amplifier output is loaded.

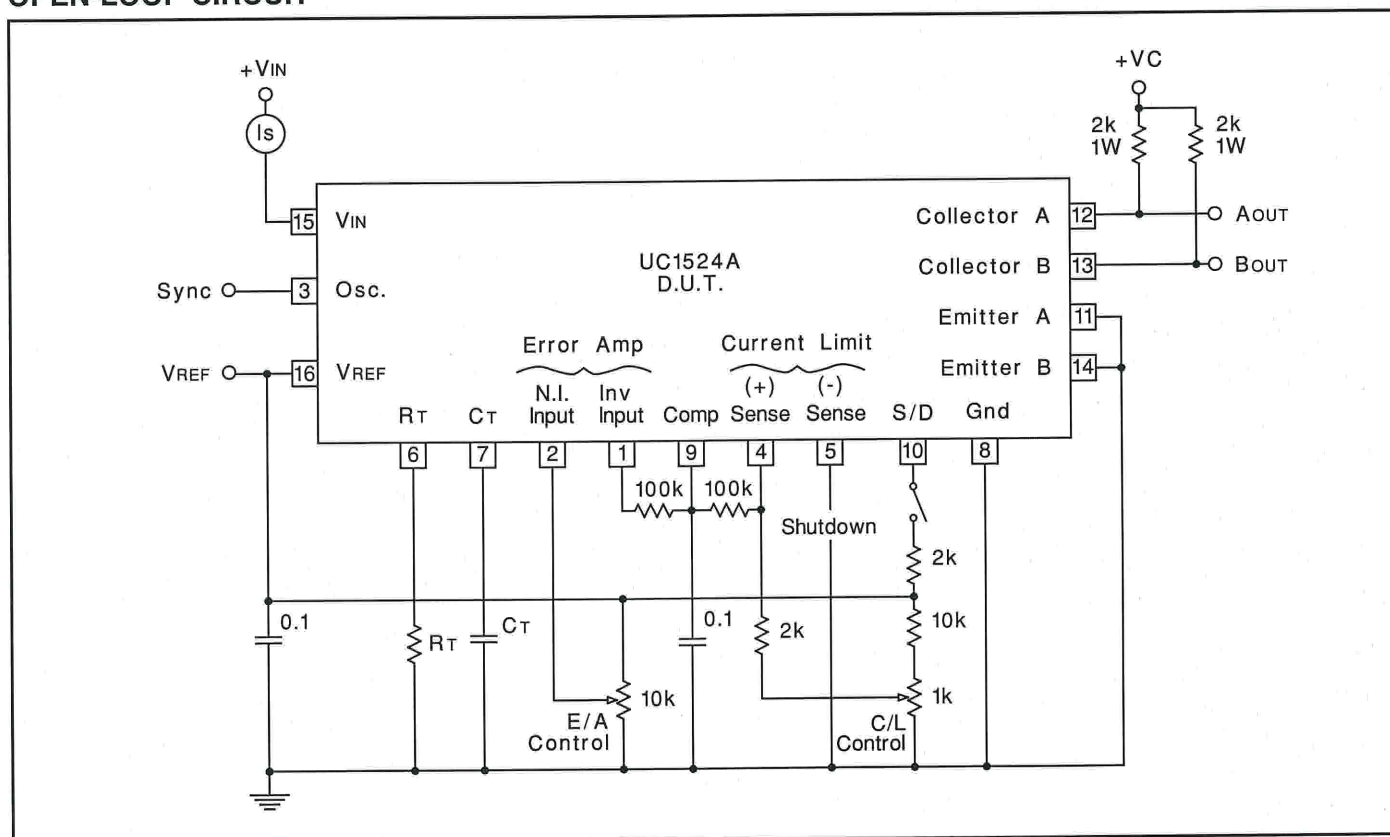
Note 1: Min Limit applies to output high level, max limit applies to output low level.

**ELECTRICAL CHARACTERISTICS:** Unless otherwise stated, these specifications apply for  $T_A = -55^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$  for the UC1524A,  $-40^{\circ}$  to  $+85^{\circ}\text{C}$  for the UC2524A, and  $0^{\circ}\text{C}$  to  $+70^{\circ}\text{C}$  for the UC3524A;  $V_{IN} = V_C = 20\text{V}$ .  $T_A = T_J$ .

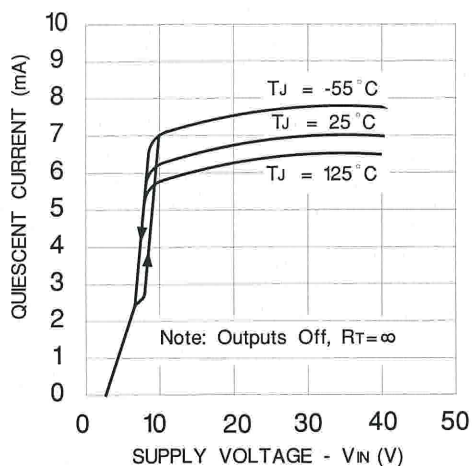
PARAMETER	TEST CONDITIONS	UC1524A / UC2524A			UC3524A			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Output Section ( cont.) (Each Output)								
Saturation Voltage	Ic = 20mA Ic = 200mA		.2 1	.4 2.2		.2 1	.4 2.2	V V
Emitter Output Voltage	IE = 50mA	17	18		17	18		V
Rise Time*	TJ = 25°C, R = 2kΩ		120	400		120	400	ns
Fall Time*	TJ = 25°C, R = 2kΩ		25	200		25	200	ns
Comparator Delay*	TJ = 25°C, Pin 9 to output		300			300		ns
Shutdown Delay*	TJ = 25°C, Pin 10 to output		200			200		ns
Shutdown Threshold	TJ = 25°C, Rc = 2kΩ	0.6	.7	1.0	0.6	.7	1.0	V
S/D Threshold Over Temp.	Over Operating Temperature Range	0.4		1.2	0.4		1.0	V
Thermal Shutdown*			165			165		°C

\* These parameters are ensured by design but not 100% tested in production.

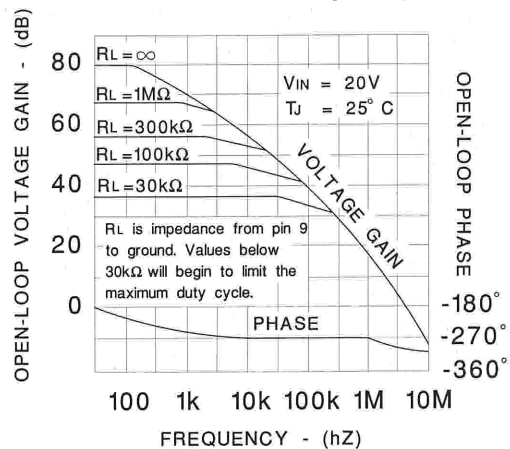
## OPEN-LOOP CIRCUIT



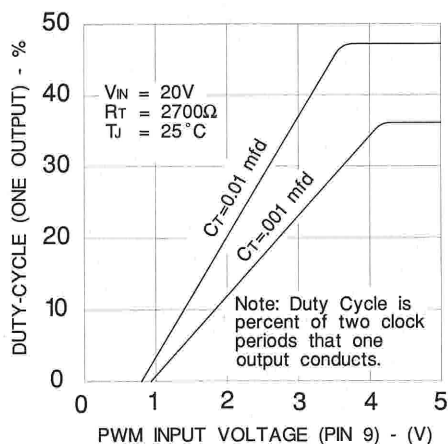
Supply Current vs Voltage



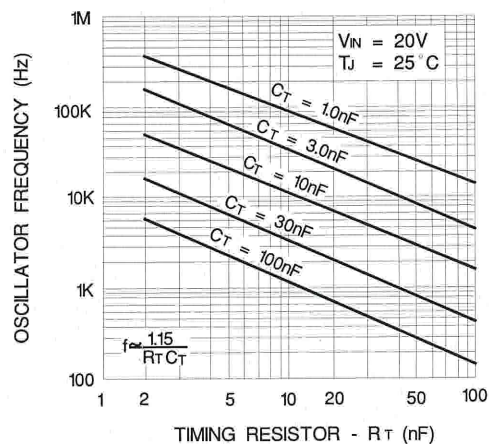
Error Amplifier Voltage Gain and Phase vs Frequency



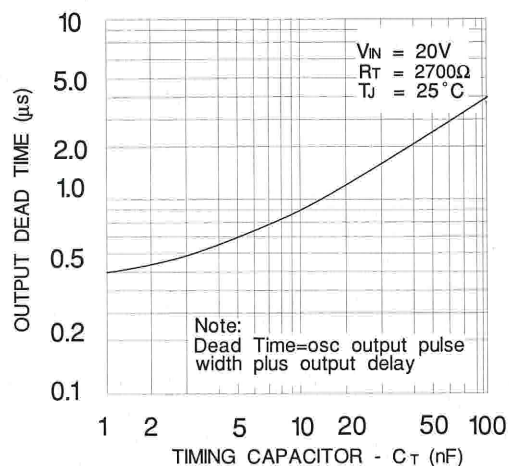
Pulse Width Modulator Transfer Function



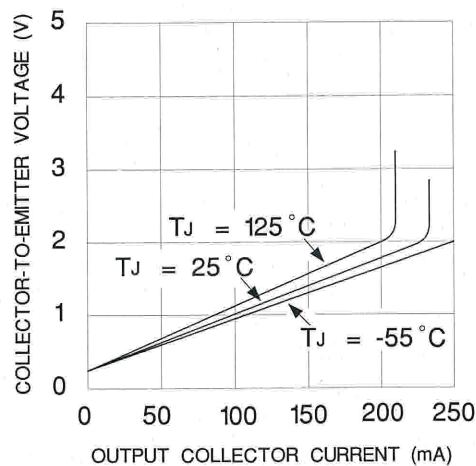
Oscillator Frequency vs Timing Components



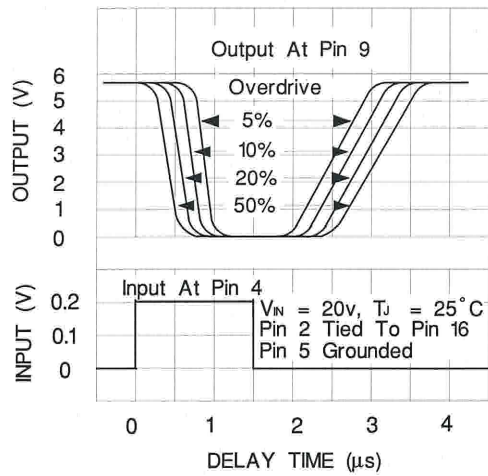
Output Dead Time vs Timing Capacitor Value



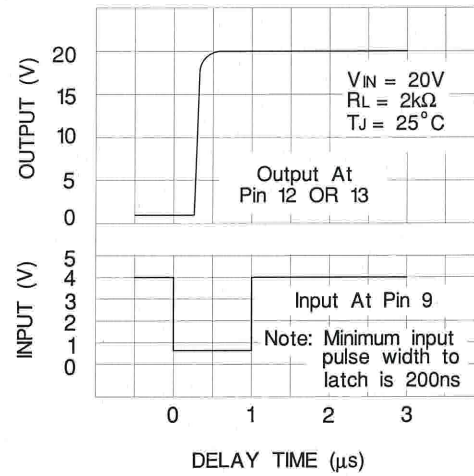
Output Saturation Voltage



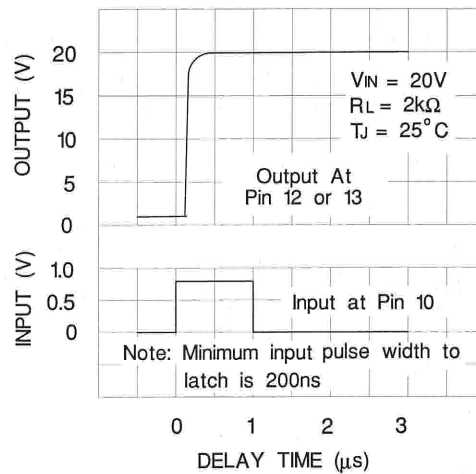
### Current Limit Amplifier Delay



### Shutdown Delay From PWM Comparator - Pin 9



### Turn-Off Delay From Shutdown - Pin 10





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**PACKAGING INFORMATION**

Orderable Device	Status <sup>(1)</sup>	Package Type	Package Drawing	Pins	Package Qty	Eco Plan <sup>(2)</sup>	Lead/Ball Finish	MSL Peak Temp <sup>(3)</sup>
5962-8764502EA	ACTIVE	CDIP	J	16	1	TBD	A42	N / A for Pkg Type
UC1524AJ	ACTIVE	CDIP	J	16	1	TBD	A42	N / A for Pkg Type
UC1524AJ883B	ACTIVE	CDIP	J	16	1	TBD	A42	N / A for Pkg Type
UC1524AL	ACTIVE	LCCC	FK	20	1	TBD	POST-PLATE	N / A for Pkg Type
UC1524AL883B	ACTIVE	LCCC	FK	20	1	TBD	POST-PLATE	N / A for Pkg Type
UC2524ADW	ACTIVE	SOIC	DW	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
UC2524ADWG4	ACTIVE	SOIC	DW	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
UC2524ADWTR	ACTIVE	SOIC	DW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
UC2524ADWTRG4	ACTIVE	SOIC	DW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
UC2524AJ	ACTIVE	CDIP	J	16	1	TBD	A42	N / A for Pkg Type
UC2524AN	ACTIVE	PDIP	N	16	25	Green (RoHS & no Sb/Br)	CU NIPDAU	N / A for Pkg Type
UC2524ANG4	ACTIVE	PDIP	N	16	25	Green (RoHS & no Sb/Br)	CU NIPDAU	N / A for Pkg Type
UC3524ADW	ACTIVE	SOIC	DW	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
UC3524ADWG4	ACTIVE	SOIC	DW	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
UC3524ADWTR	ACTIVE	SOIC	DW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
UC3524ADWTRG4	ACTIVE	SOIC	DW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
UC3524AJ	ACTIVE	CDIP	J	16	1	TBD	A42	N / A for Pkg Type
UC3524AN	NRND	PDIP	N	16	25	Green (RoHS & no Sb/Br)	CU NIPDAU	N / A for Pkg Type
UC3524ANG4	NRND	PDIP	N	16	25	Green (RoHS & no Sb/Br)	CU NIPDAU	N / A for Pkg Type

<sup>(1)</sup> 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.

**OBSELETE:** TI has discontinued the production of the device.

<sup>(2)</sup> Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), 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.

**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

**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.

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**TAPE AND REEL INFORMATION**


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
UC2524ADWTR	SOIC	DW	16	2000	330.0	16.4	10.85	10.8	2.7	12.0	16.0	Q1
UC3524ADWTR	SOIC	DW	16	2000	330.0	16.4	10.85	10.8	2.7	12.0	16.0	Q1

## TAPE AND REEL BOX DIMENSIONS



\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
UC2524ADWTR	SOIC	DW	16	2000	346.0	346.0	33.0
UC3524ADWTR	SOIC	DW	16	2000	346.0	346.0	33.0

J (R-GDIP-T\*\*)

14 LEADS SHOWN

# CERAMIC DUAL IN-LINE PACKAGE



PINS ** DIM	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.



## FK (S-CQCC-N\*\*)

## LEADLESS CERAMIC CHIP CARRIER

28 TERMINAL SHOWN



- NOTES:
- All linear dimensions are in inches (millimeters).
  - This drawing is subject to change without notice.
  - This package can be hermetically sealed with a metal lid.
  - The terminals are gold plated.
  - Falls within JEDEC MS-004

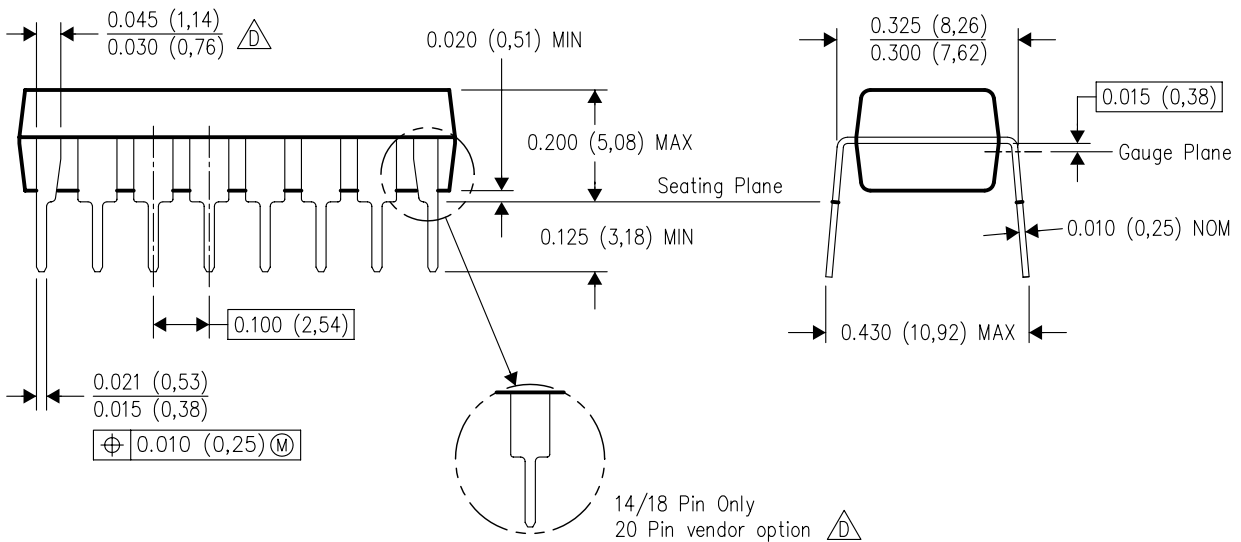
## N (R-PDIP-T\*\*)

16 PINS SHOWN

## PLASTIC DUAL-IN-LINE PACKAGE



PINS **	14	16	18	20
DIM				
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	AA	BB	AC	AD

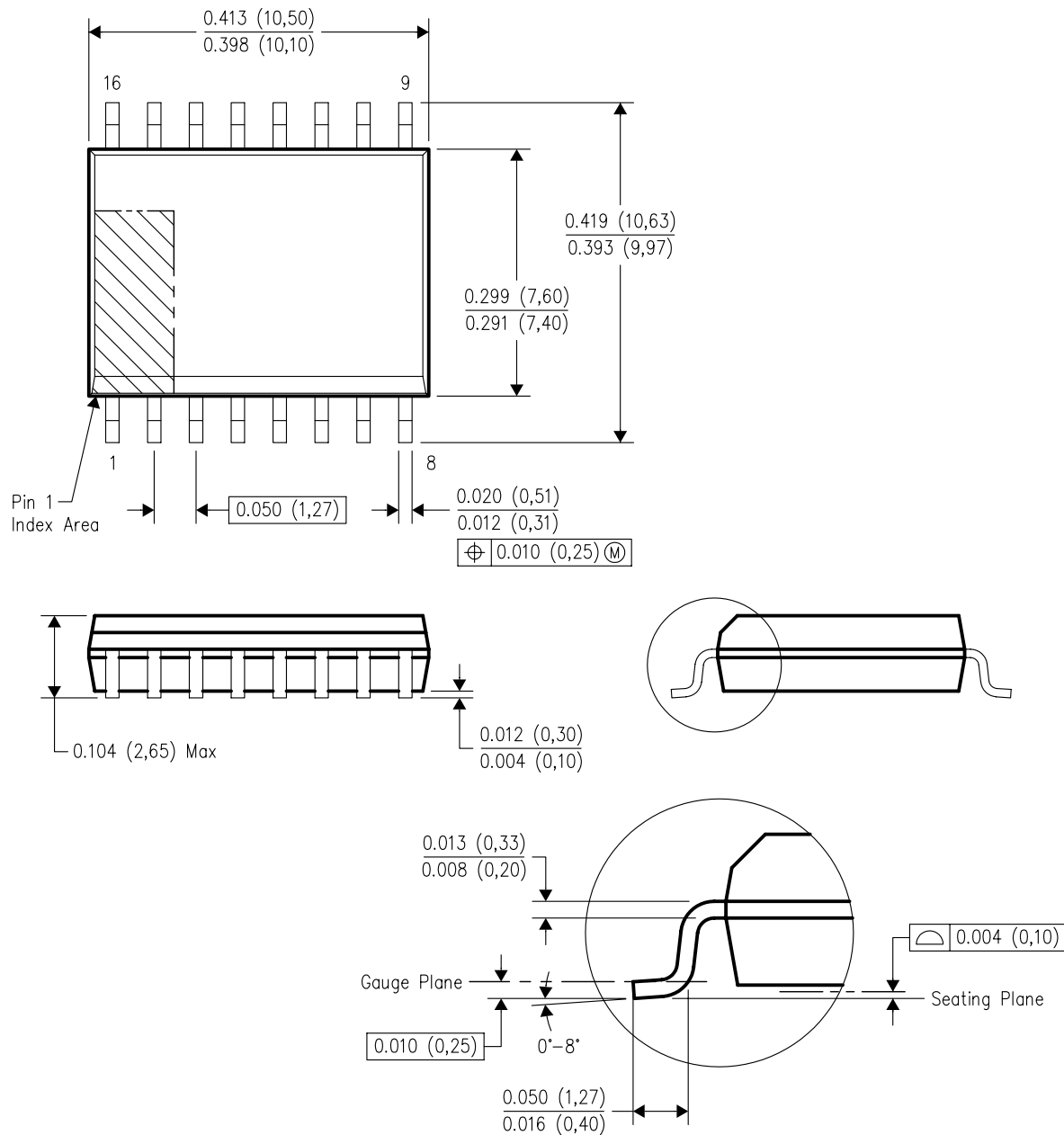


4040049/E 12/2002

- 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.

## DW (R-PDSO-G16)

## PLASTIC SMALL-OUTLINE PACKAGE



4040000-2/F 06/2004

- NOTES:
- All linear dimensions are in inches (millimeters).
  - This drawing is subject to change without notice.
  - Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
  - Falls within JEDEC MS-013 variation AA.

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DLP® Products	<a href="http://www.dlp.com">www.dlp.com</a>	Communications and Telecom	<a href="http://www.ti.com/communications">www.ti.com/communications</a>
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Logic	<a href="http://logic.ti.com">logic.ti.com</a>	Industrial	<a href="http://www.ti.com/industrial">www.ti.com/industrial</a>
Power Mgmt	<a href="http://power.ti.com">power.ti.com</a>	Medical	<a href="http://www.ti.com/medical">www.ti.com/medical</a>
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