

# Regulating Pulse Width Modulators

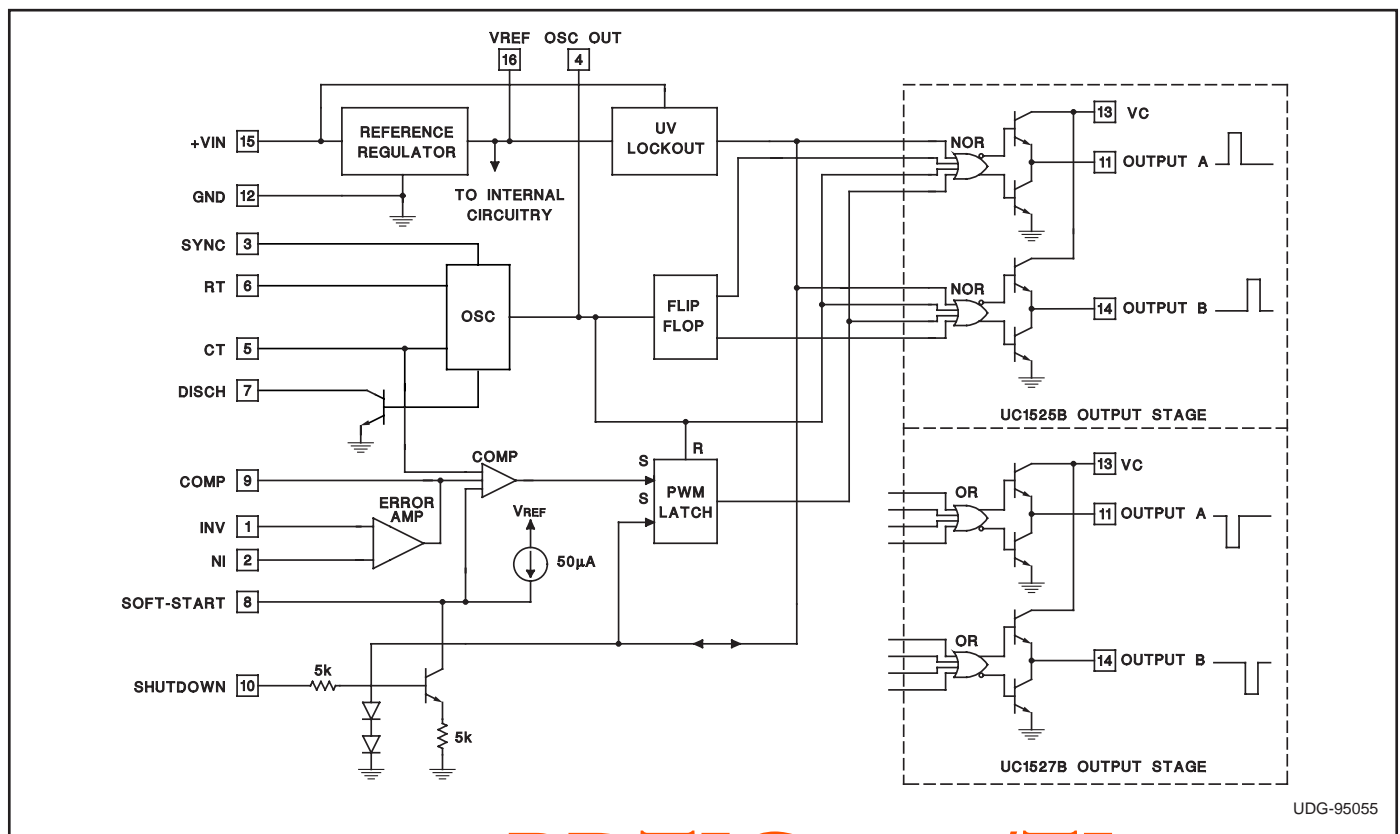
## FEATURES

- 8 to 35V Operation
- 5.1V Buried Zener Reference Trimmed to  $\pm 0.75\%$
- 100Hz to 500kHz Oscillator Range
- Separate Oscillator Sync Terminal
- Adjustable Deadtime Control
- Internal Soft-Start
- Pulse-by-Pulse Shutdown
- Input Undervoltage Lockout with Hysteresis
- Latching PWM to Prevent Multiple Pulses
- Dual Source/Sink Output Drivers
- Low Cross Conduction Output Stage
- Tighter Reference Specifications

## DESCRIPTION

The UC1525B/1527B series of pulse width modulator integrated circuits are designed to offer improved performance and lowered external parts count when used in designing all types of switching power supplies. The on-chip +5.1V buried zener reference is trimmed to  $\pm 0.75\%$  and the input common-mode range of the error amplifier includes the reference voltage, eliminating external resistors. A sync input to the oscillator allows multiple units to be slaved or a single unit to be synchronized to an external system clock. A single resistor between the CT and the discharge terminals provide a wide range of dead time adjustment. These devices also feature built-in soft-start circuitry with only an external timing capacitor required. A shutdown terminal controls both the soft-start circuitry and the output stages, providing instantaneous turn off through the PWM latch with pulsed shutdown, as well as soft-start recycle with longer shutdown commands. These functions are also controlled by an undervoltage lockout which keeps the outputs off and the soft-start capacitor discharged for sub-normal input voltages. This lockout circuitry includes approximately 500mV of hysteresis for jitter-free operation. Another feature of these PWM circuits is a latch following the comparator. Once a PWM pulse has been terminated for any reason, the outputs will remain off for the duration of the period. The latch is reset with each clock pulse. The output stages are totem-pole designs capable of sourcing or sinking in excess of 200mA. The UC1525B output stage features NOR logic, giving a LOW output for an OFF state. The UC1527B utilizes OR logic which results in a HIGH output level when OFF.

## BLOCK DIAGRAM



## ABSOLUTE MAXIMUM RATINGS

Supply Voltage, (+VIN)	+40V
Collector Supply Voltage (VC)	+40V
Logic Inputs	−0.3V to +5.5V
Analog Inputs	−0.3V to VIN
Output Current, Source or Sink	500mA
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 Junction Temperature	−55°C to +150°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 10 sec.)	+300°C

All currents are positive into, negative out of the specified terminal. Consult Packaging Section of Databook for thermal limitations and considerations of packages.

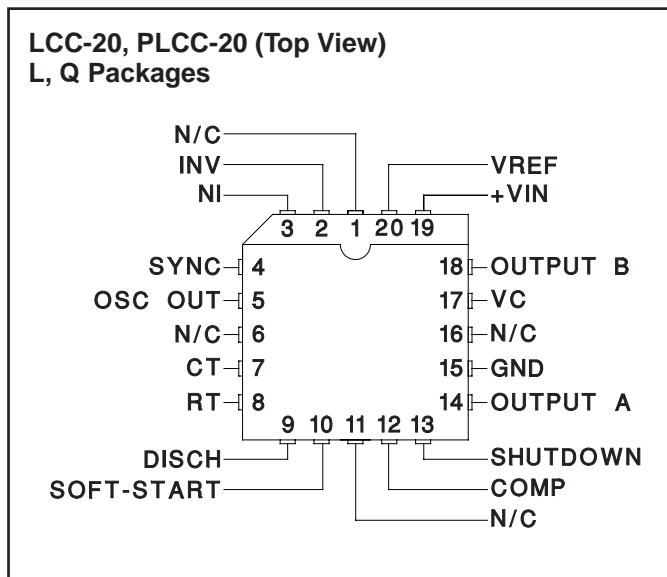
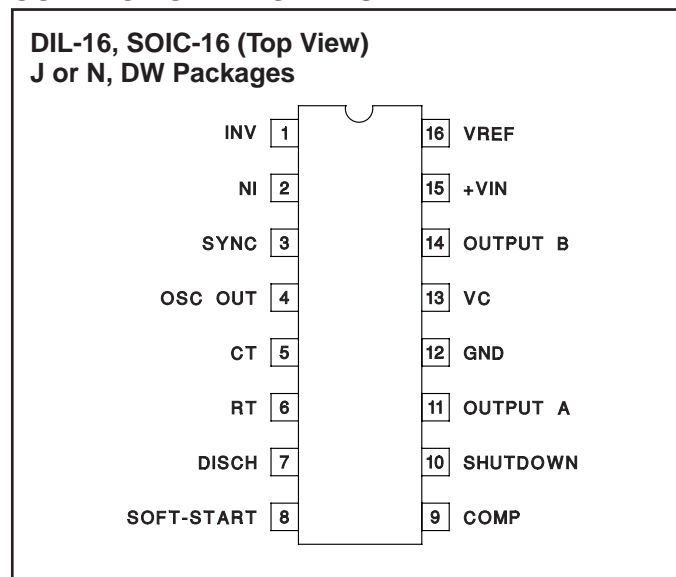
## RECOMMENDED OPERATING CONDITIONS

(Note 1)

Input Voltage (+VIN)	+8V to +35V
Collector Supply Voltage (VC)	+4.5V to +35V
Sink/Source Load Current (steady state)	0 to 100mA
Sink/Source Load Current (peak)	0 to 400mA
Reference Load Current	0 to 20mA
Oscillator Frequency Range	100Hz to 400kHz
Oscillator Timing Resistor	2k $\Omega$ to 150k $\Omega$
Oscillator Timing Capacitor	0.001 $\mu\text{F}$ to 0.1 $\mu\text{F}$
Dead Time Resistor Range	0 $\Omega$ to 500 $\Omega$

Note 1: Range over which the device is functional and parameter limits are guaranteed.

## CONNECTION DIAGRAMS



**ELECTRICAL CHARACTERISTICS:** Unless otherwise stated, these specifications apply for  $T_A = -55^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$  for the UC1525B and UC1527B;  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$  for the UC2525B and UC2527B;  $0^{\circ}\text{C}$  to  $+70^{\circ}\text{C}$  for the UC3525B and UC3527B;  $+VIN = 20\text{V}$ ,  $T_A = T_J$ .

PARAMETER	TEST CONDITIONS	UC1525B/UC2525B UC1527B/UC2527B			UC3525B UC3527B			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Reference Section								
Output Voltage	T <sub>J</sub> = 25°C	5.062	5.10	5.138	5.036	5.10	5.164	V
Line Regulation	V <sub>IN</sub> = 8V to 35V		5	10		5	10	mV
Load Regulation	I <sub>L</sub> = 0mA to 20mA		7	15		7	15	mV
Temperature Stability (Note 2)	Over Operating Range		10	50		10	50	mV
Total Output Variation	Line, Load, and Temperature	5.036		5.164	5.024		5.176	V
Short Circuit Current	V <sub>REF</sub> = 0, T <sub>J</sub> =25°C		80	100		80	100	mA
Output Noise Voltage (Note 2)	10Hz ≤ f ≤10kHz, T <sub>J</sub> = 25°C		40	200		40	200	μVrms
Long Term Stability (Note 2)	T <sub>J</sub> = 125°C, 1000 Hrs.		3	10		3	10	mV

**ELECTRICAL CHARACTERISTICS:** Unless otherwise stated, these specifications apply for  $T_A = -55^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$  for the UC1525B and UC1527B;  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$  for the UC2525B and UC2527B;  $0^{\circ}\text{C}$  to  $+70^{\circ}\text{C}$  for the UC3525B and UC3527B;  $+V_{IN} = 20\text{V}$ ,  $T_A = T_J$ .

PARAMETER	TEST CONDITIONS	UC1525B/UC2525B UC1527B/UC2527B			UC3525B UC3527B			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Oscillator Section (Note 3)								
Initial Accuracy (Notes 2 & 3)	T <sub>J</sub> = 25°C		±2	±6		±2	±6	%
Voltage Stability (Notes 2 & 3)	V <sub>IN</sub> = 8V to 35V		±0.3	±1		±1	±2	%
Temperature Stability (Note 2)	Over Operating Range		±3	±6		±3	±6	%
Minimum Frequency	RT = 200kΩ, CT = 0.1μF			120			120	Hz
Maximum Frequency	RT = 2kΩ, CT = 470pF	400			400			kHz
Current Mirror	I <sub>RT</sub> = 2mA	1.7	2.0	2.2	1.7	2.0	2.2	mA
Clock Amplitude (Notes 2 & 3)		3.0	3.5		3.0	3.5		V
Clock Width (Notes 2 & 3)	T <sub>J</sub> = 25°C	0.3	0.5	1.0	0.3	0.5	1.0	μs
Sync Threshold		1.2	2.0	2.8	1.2	2.0	2.8	V
Sync Input Current	Sync Voltage = 3.5V		1.0	2.5		1.0	2.5	mA
Error Amplifier Section (V <sub>CM</sub> = 5.1V)								
Input Offset Voltage			0.5	5		2	10	mV
Input Bias Current			1	10		1	10	μA
Input Offset Current				1			1	μA
DC Open Loop Gain	R <sub>L</sub> ≥ 10 MegΩ	60	75		60	75		dB
Gain-Bandwidth Product (Note 2)	A <sub>V</sub> = 0dB, T <sub>J</sub> = 25°C	1	2		1	2		MHz
Output Low Level			0.2	0.5		0.2	0.5	V
Output High Level		3.8	5.6		3.8	5.6		V
Common Mode Rejection	V <sub>CM</sub> = 1.5V to 5.2V	60	75		60	75		dB
Supply Voltage Rejection	V <sub>IN</sub> = 8V to 35V	50	60		50	60		dB
PWM Comparator								
Minimum Duty Cycle				0			0	%
Maximum Duty Cycle (Note 3)		45	49		45	49		%
Input Threshold (Note 3)	Zero Duty Cycle	0.7	0.9		0.7	0.9		V
Input Threshold (Note 3)	Maximum Duty Cycle		3.3	3.6		3.3	3.6	V
Input Bias Current (Note 2)			0.05	1.0		0.05	1.0	μA
Shutdown Section								
Soft Start Current	V <sub>SHUTDOWN</sub> = 0V, V <sub>SOFTSTART</sub> = 0V	25	50	80	25	50	80	μA
Soft Start Low Level	V <sub>SHUTDOWN</sub> = 2.5V		0.4	0.7		0.4	0.7	V
Shutdown Threshold	To outputs, V <sub>SOFTSTART</sub> = 5.1V, T <sub>J</sub> =25°C	0.6	0.8	1.0	0.6	0.8	1.0	V
Shutdown Input Current	V <sub>SHUTDOWN</sub> = 2.5V		0.4	1.0		0.4	1.0	mA
Shutdown Delay (Note 2)	V <sub>SHUTDOWN</sub> = 2.5V, T <sub>J</sub> = 25°C		0.2	0.5		0.2	0.5	μs
Output Drivers (Each Output) (V <sub>c</sub> = 20V)								
Output Low Level	I <sub>SINK</sub> = 20mA		0.2	0.4		0.2	0.4	V
	I <sub>SINK</sub> = 100mA		1.0	2.0		1.0	2.0	V
Output Hgh Level	I <sub>SOURCE</sub> = 20mA	18	19		18	19		V
	I <sub>SOURCE</sub> = 100mA	17	18		17	18		V
Undervoltage Lockout	V <sub>COMP</sub> and V <sub>SOFTSTART</sub> = High	6	7	8	6	7	8	V
Collector Leakage	V <sub>C</sub> = 35V			200			200	uA

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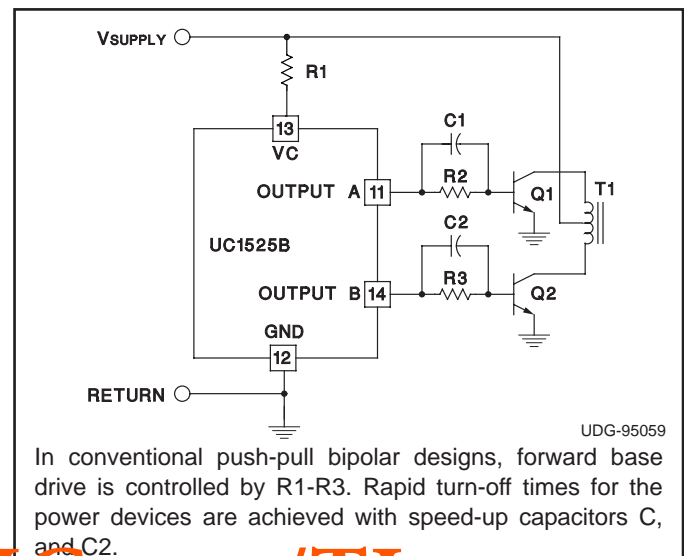
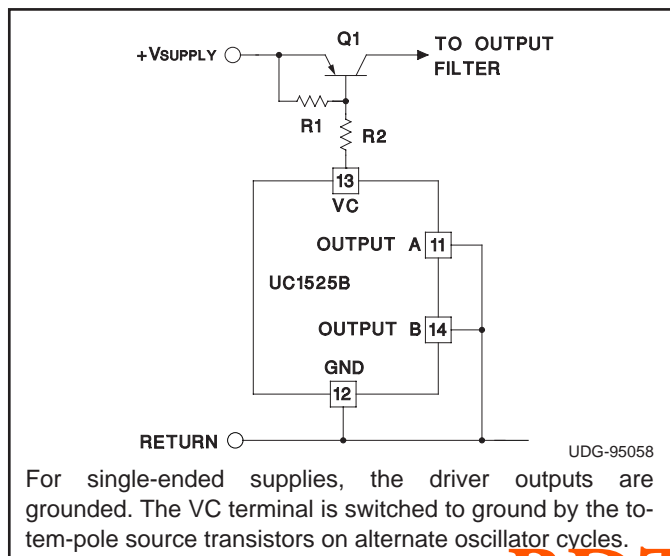
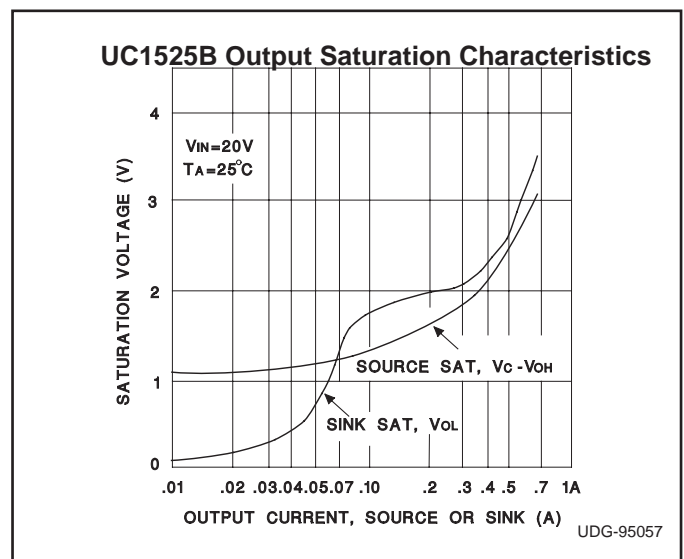
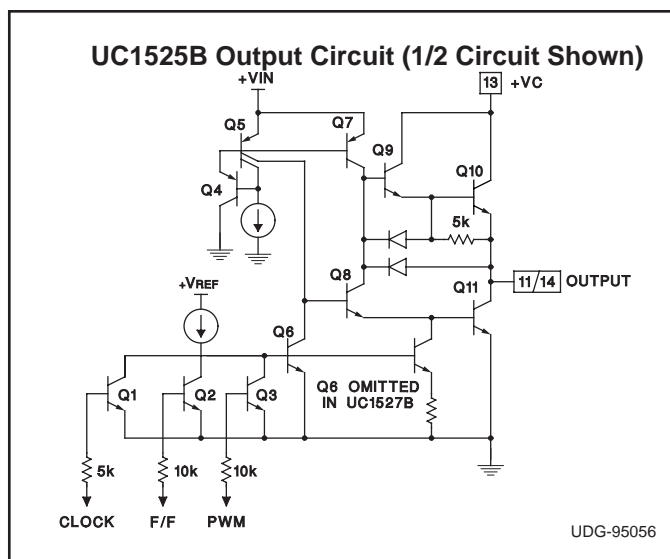
PARAMETER	TEST CONDITIONS	UC1525B/UC2525B UC1527B/UC2527B			UC3525B UC3527B			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Output Drivers (Each Output) (VC = 20V) (cont.)								
Rise Time (Note 2)	CL = 1nF, TJ = 25°C		100	600		100	600	ns
Fall Time (Note 2)	CL = 1nF, TJ = 25°C		50	300		50	300	ns
Cross conduction charge	Per cycle, TJ = 25°C		30			30		nc
Total Standby Current								
Supply Current	VIN = 35V		14	20		14	20	mA

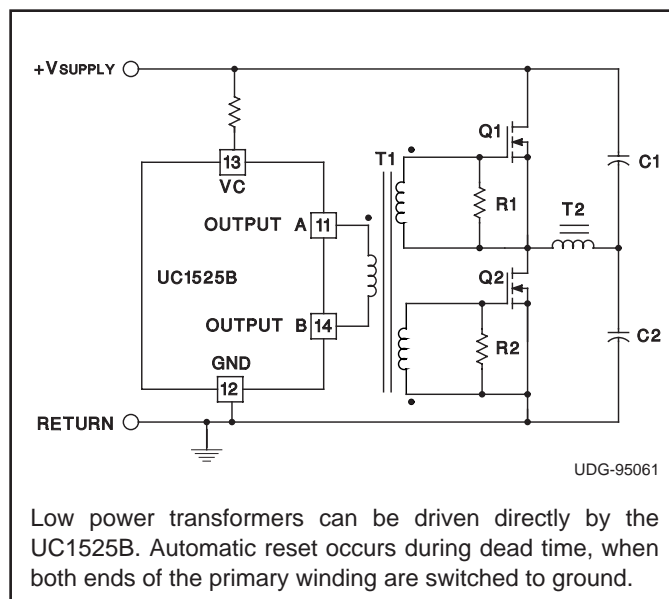
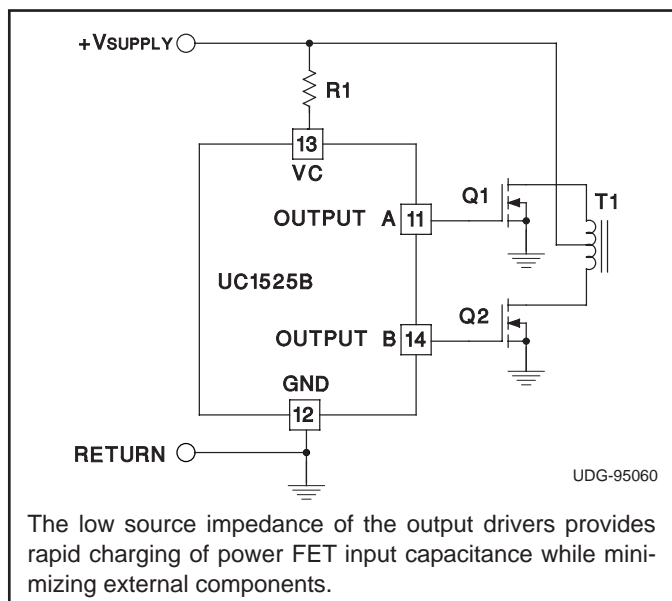
Note 2: Ensured by design. Not 100% tested in production.

Note 3: Tested at  $f_{osc} = 40\text{kHz}$  ( $R_T = 3.6\text{K}\Omega$ ,  $C_T = 0.01\mu\text{F}$ ,  $R_D = 0\Omega$ ). Approximate oscillator frequency is defined by:

$$f = \frac{1}{C_T \cdot (0.7 \cdot R_T + 3R_D)}$$

## PRINCIPLES OF OPERATION AND TYPICAL CHARACTERISTICS





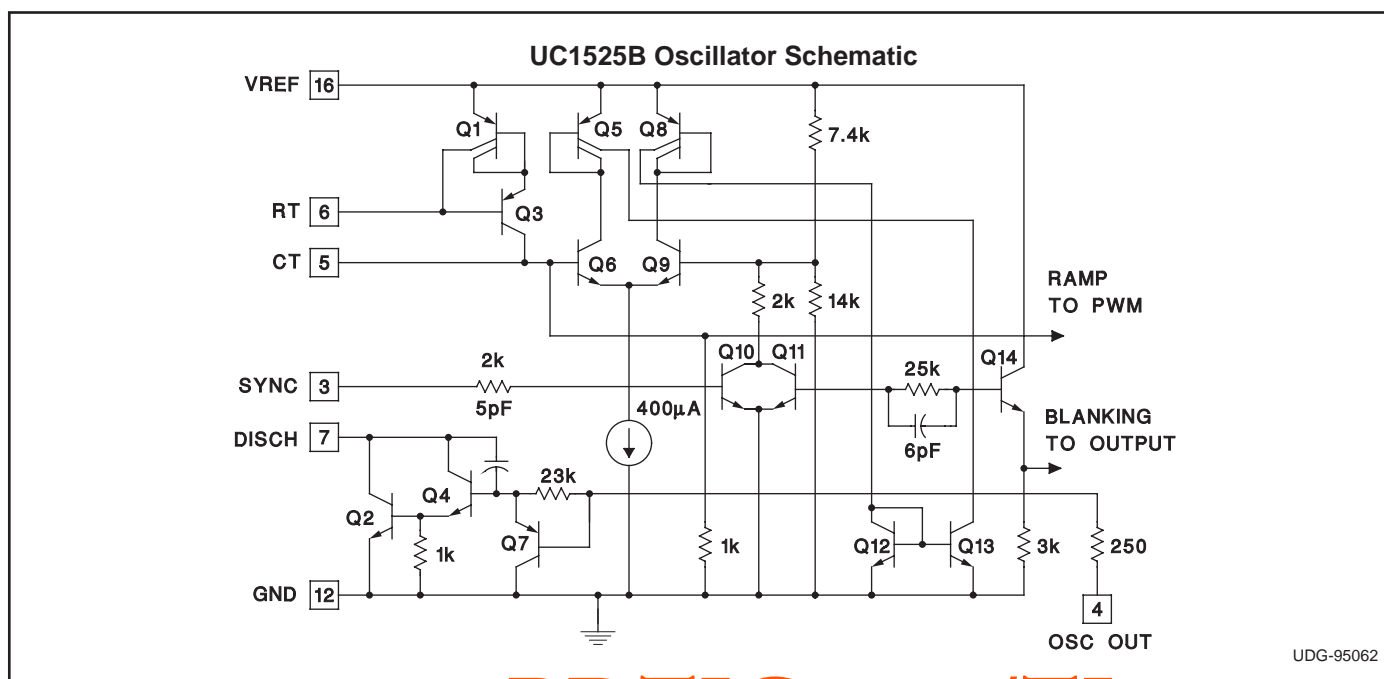
## PRINCIPLES OF OPERATION AND TYPICAL CHARACTERISTICS

### Shutdown Options (See Block Diagram)

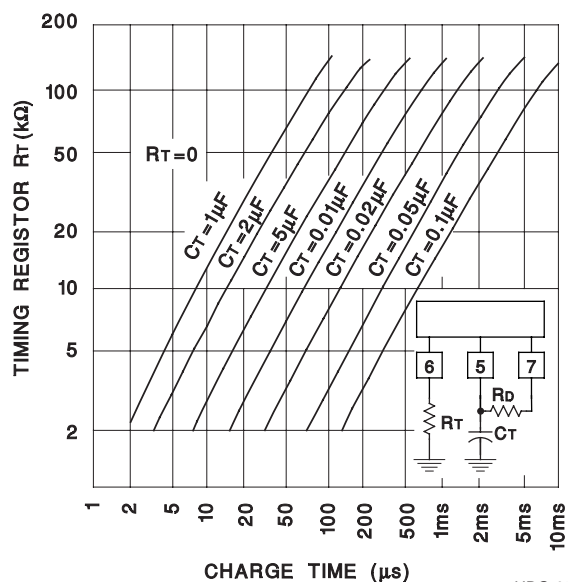
Since both the compensation and soft-start terminals (Pins 9 and 8) have current source pull-ups, either can readily accept a pull-down signal which only has to sink a maximum of 100 $\mu$ A to turn off the outputs. This is subject to the added requirement of discharging whatever external capacitance may be attached to these pins.

An alternate approach is the use of the shutdown circuitry of Pin 10 which has been improved to enhance the available shutdown options. Activating this circuit by ap-

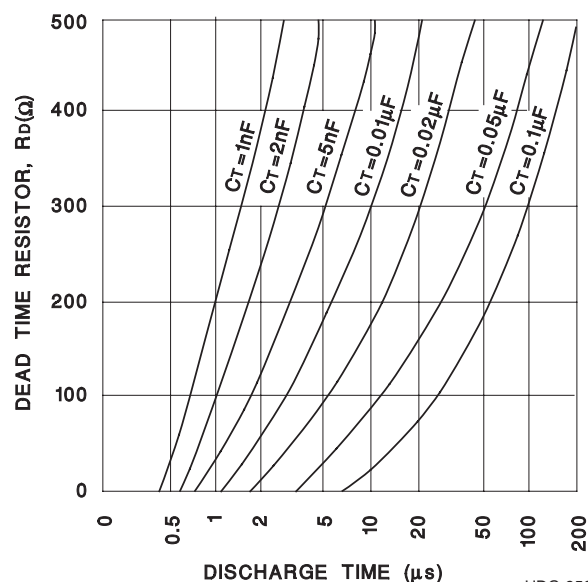
plying a positive signal on Pin 10 performs two functions: the PWM latch is immediately set providing the fastest turn-off signal to the external soft-start capacitor. If the shutdown command is short, the PWM signal is terminated without significant discharge of the soft-start capacitor, thus, allowing, for example, a convenient implementation of pulse-by-pulse current limiting. Holding Pin 10 high for a longer duration, however, will ultimately discharge this external capacitor, recycling slow turn-on upon release.



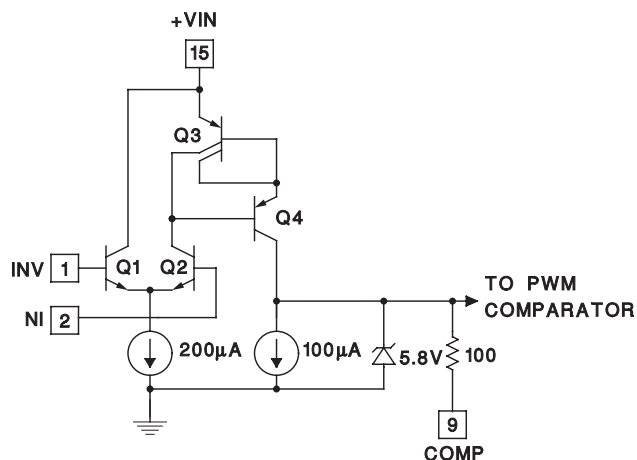
Oscillator Charge Time vs.  $R_T$  and  $C_T$



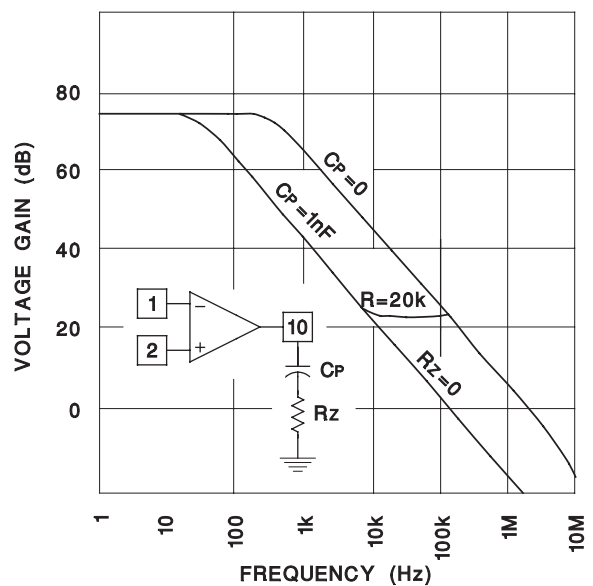
Oscillator Discharge Time vs.  $R_D$  and  $C_T$



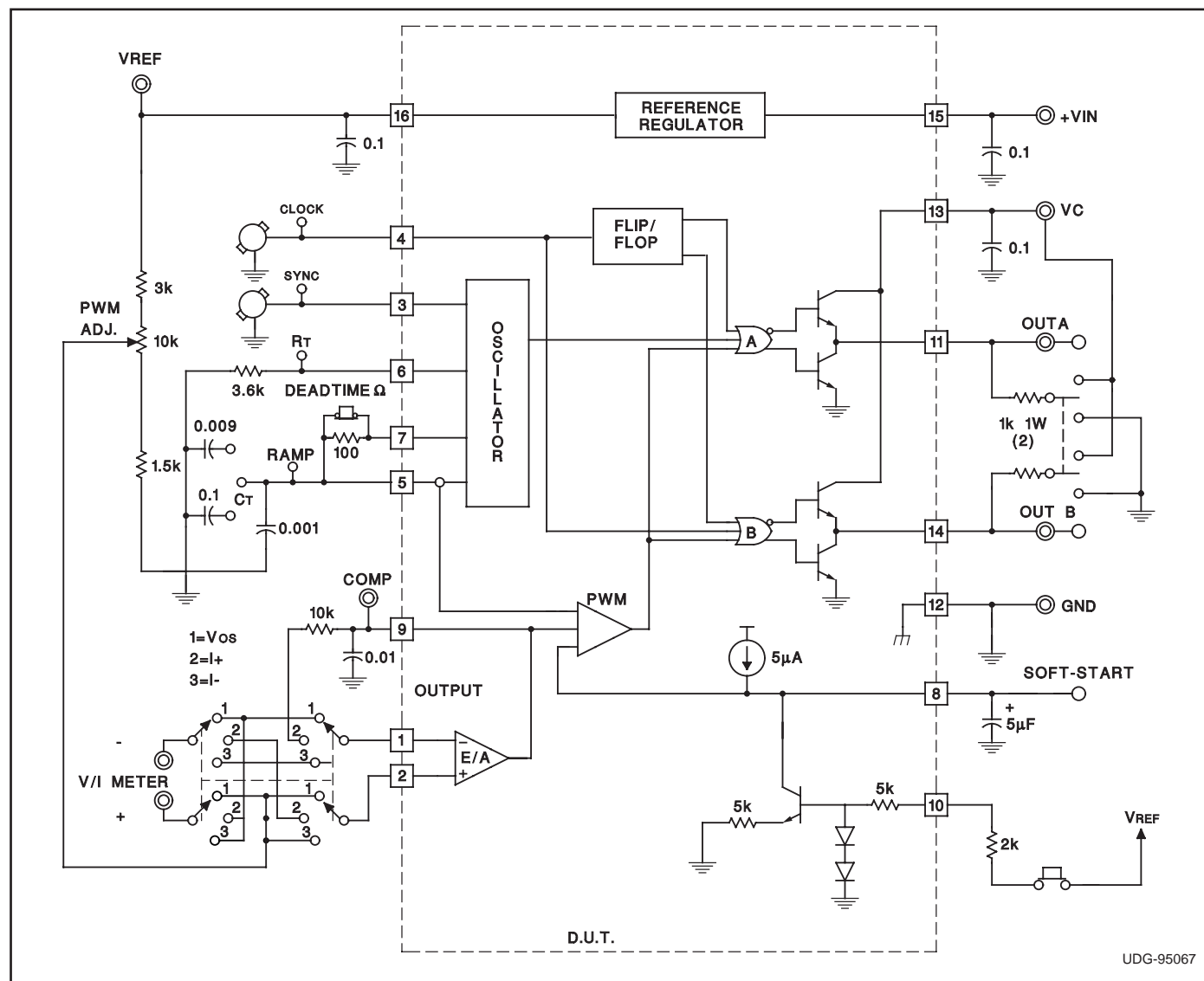
UC1525B Error Amplifier



Error Amplifier Open-Loop Frequency Response



# LAB TEST FIXTURE



**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>
5962-8951105EA	ACTIVE	CDIP	J	16	1	TBD	A42	N / A for Pkg Type
UC1525BJ	ACTIVE	CDIP	J	16	1	TBD	A42	N / A for Pkg Type
UC1525BJ883B	ACTIVE	CDIP	J	16	1	TBD	A42	N / A for Pkg Type
UC2525BDWTR	ACTIVE	SOIC	DW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
UC2525BDWTRG4	ACTIVE	SOIC	DW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
UC3525BDW	ACTIVE	SOIC	DW	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
UC3525BDWG4	ACTIVE	SOIC	DW	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
UC3525BDWTR	ACTIVE	SOIC	DW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
UC3525BDWTRG4	ACTIVE	SOIC	DW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
UC3525BN	ACTIVE	PDIP	N	16	25	Green (RoHS & no Sb/Br)	CU NIPDAU	N / A for Pkg Type
UC3525BNG4	ACTIVE	PDIP	N	16	25	Green (RoHS & no Sb/Br)	CU NIPDAU	N / A for Pkg Type
UC3527BN	ACTIVE	PDIP	N	16	25	Green (RoHS & no Sb/Br)	CU NIPDAU	N / A for Pkg Type
UC3527BNG4	ACTIVE	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.

**OBsolete:** 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)

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

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**OTHER QUALIFIED VERSIONS OF UC1525B, UC3525B :**

- Space: [UC1525B-SP](#)

NOTE: Qualified Version Definitions:

- Space - Radiation tolerant, ceramic packaging and qualified for use in Space-based application

**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
UC2525BDWTR	SOIC	DW	16	2000	330.0	16.4	10.85	10.8	2.7	12.0	16.0	Q1
UC3525BDWTR	SOIC	DW	16	2000	330.0	16.4	10.85	10.8	2.7	12.0	16.0	Q1

**TAPE AND REEL BOX DIMENSIONS**



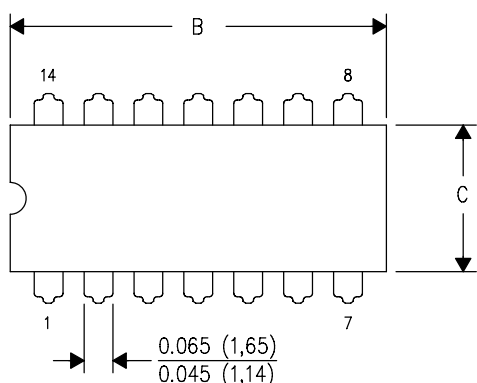
\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
UC2525BDWTR	SOIC	DW	16	2000	346.0	346.0	33.0
UC3525BDWTR	SOIC	DW	16	2000	346.0	346.0	33.0

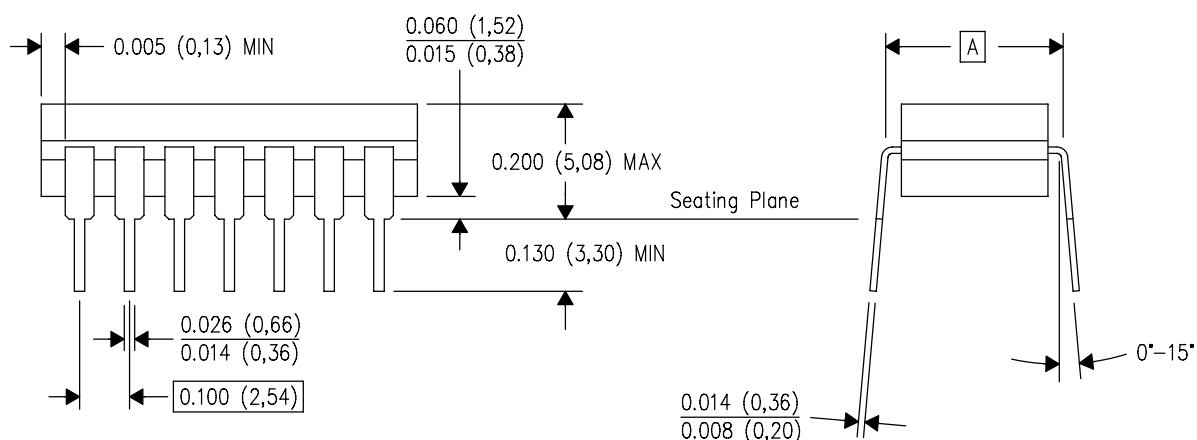
J (R-GDIP-T\*\*)

14 LEADS SHOWN

# CERAMIC DUAL IN-LINE PACKAGE

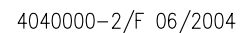


PINS ** DIM	14	16	18	20
A	0.300 (7,62) BSC	0.300 (7,62) BSC	0.300 (7,62) BSC	0.300 (7,62) BSC
B MAX	0.785 (19,94)	.840 (21,34)	0.960 (24,38)	1.060 (26,92)
B MIN	—	—	—	—
C MAX	0.300 (7,62)	0.300 (7,62)	0.310 (7,87)	0.300 (7,62)
C MIN	0.245 (6,22)	0.245 (6,22)	0.220 (5,59)	0.245 (6,22)



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.

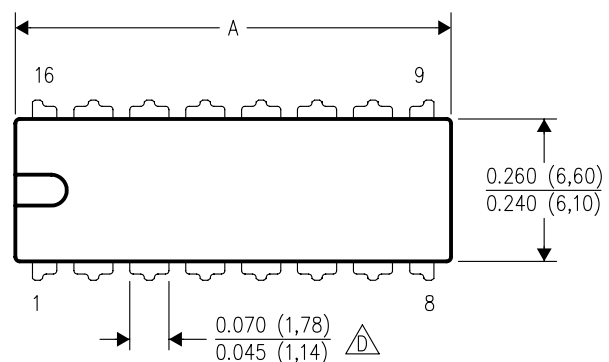


NOTES: A. All linear dimensions are in inches (millimeters).  
B. This drawing is subject to change without notice.  
C. Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).  
D. Falls within JEDEC MS-013 variation AA.

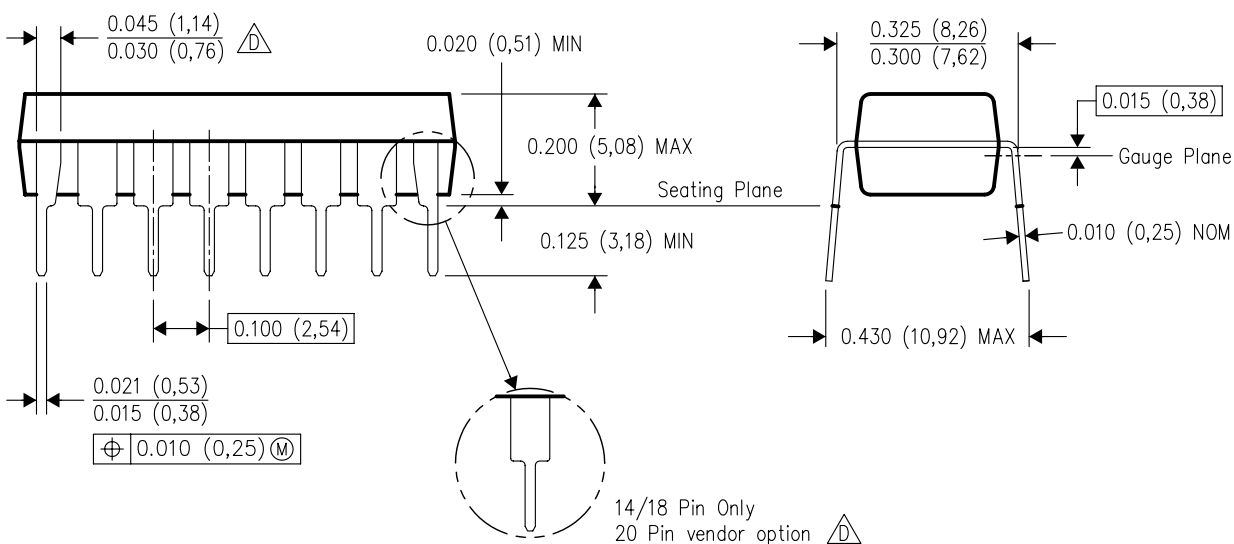
N (R-PDIP-T\*\*)

16 PINS SHOWN

# PLASTIC DUAL-IN-LINE PACKAGE





PINS ** DIM	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	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.
-  Falls within JEDEC MS-001, except 18 and 20 pin minimum body length (Dim A).  
 The 20 pin end lead shoulder width is a vendor option, either half or full width.

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