

# Regulating Pulse Width Modulators

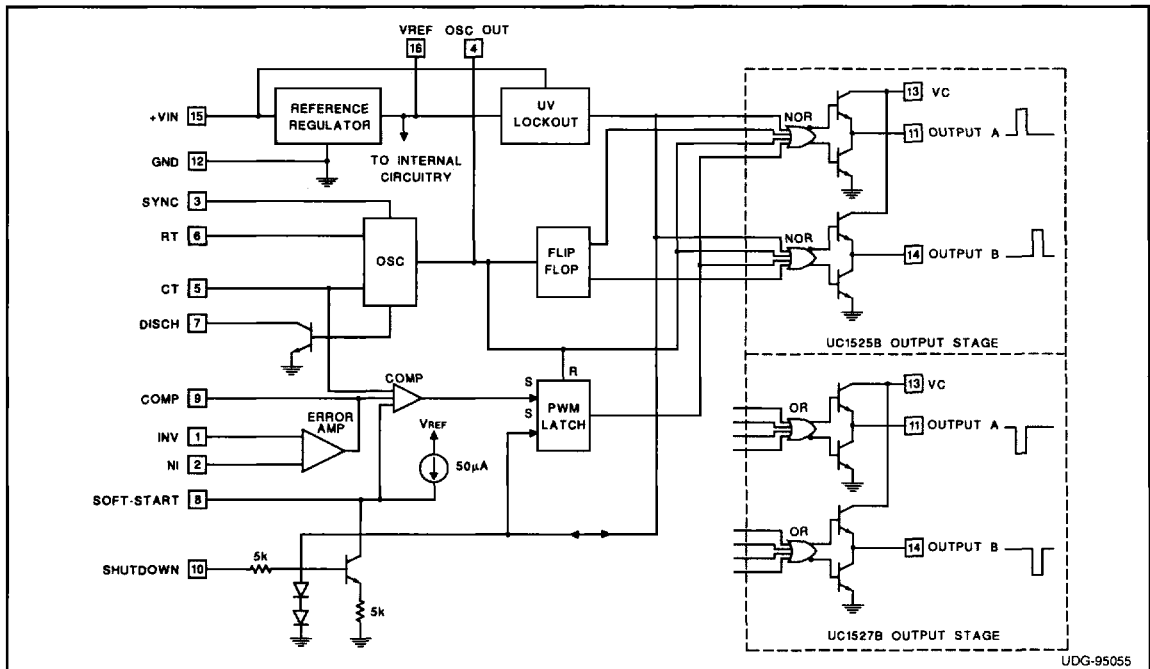
## FEATURES

- 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



GENERAL POWER SUPPLY

**UC1525B UC1527B**  
**UC2525B UC2527B**  
**UC3525B UC3527B**

**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 TA = +25°C	.1000mW
Power Dissipation at Tc = +25°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.*

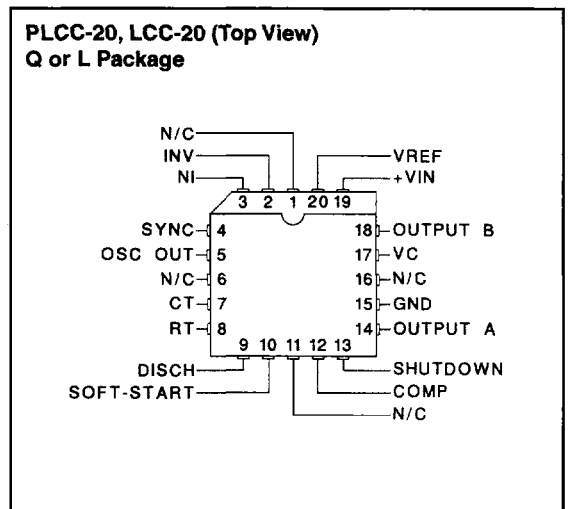
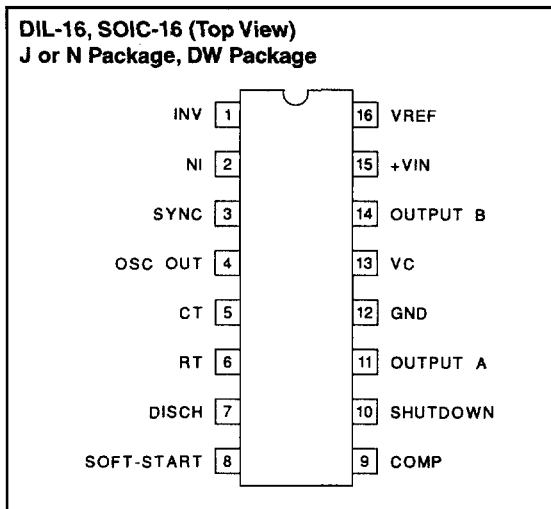
**RECOMMENDED OPERATING CONDITIONS**

(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	.2kΩ to 150kΩ
Oscillator Timing Capacitor	.0.001μF to 0.1μF
Dead Time Resistor Range	.0Ω to 500Ω

*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 TA = -55°C to +125°C for the UC1525B and UC1527B; -40°C to +85°C for the UC2525B and UC2527B; 0°C to +70°C for the UC3525B and UC3527B; +VIN = 20V, TA = TJ.

PARAMETER	TEST CONDITIONS	UC1525B/UC2525B UC1527B/UC2527B			UC3525B UC3527B			UNIT
		MIN	TYP	MAX	MIN	TYP	MAX	
<b>Reference Section</b>								
Output Voltage	TJ = 25°C	5.062	5.10	5.138	5.036	5.10	5.164	V
Line Regulation	VIN = 8V to 35V		5	10		5	10	mV
Load Regulation	IL = 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	VREF = 0, TJ = 25°C		80	100		80	100	mA
Output Noise Voltage (Note 2)	10Hz ≤ f ≤ 10kHz, TJ = 25°C		40	200		40	200	μVrms
Long Term Stability (Note 2)	TJ = 125°C, 1000 Hrs.		3	10		3	10	mV

**ELECTRICAL CHARACTERISTICS (cont.)** 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 UC2527B			UNIT
		MIN	TYP	MAX	MIN	TYP	MAX	
<b>Oscillator Section (Note 3)</b>								
Initial Accuracy (Notes 2 & 3)	$T_J = 25^{\circ}\text{C}$		$\pm 2$	$\pm 6$		$\pm 2$	$\pm 6$	%
Voltage Stability (Notes 2 & 3)	$V_{IN} = 8\text{V}$ to $35\text{V}$		$\pm 0.3$	$\pm 1$		$\pm 1$	$\pm 2$	%
Temperature Stability (Note 2)	Over Operating Range		$\pm 3$	$\pm 6$		$\pm 3$	$\pm 6$	%
Minimum Frequency	$R_T = 200\text{k}\Omega$ , $C_T = 0.1\mu\text{F}$			120			120	Hz
Maximum Frequency	$R_T = 2\text{k}\Omega$ , $C_T = 470\text{pF}$	400			400			kHz
Current Mirror	$I_{RT} = 2\text{mA}$	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)	$T_J = 25^{\circ}\text{C}$	0.3	0.5	1.0	0.3	0.5	1.0	$\mu\text{s}$
Sync Threshold		1.2	2.0	2.8	1.2	2.0	2.8	V
Sync Input Current	Sync Voltage = $3.5\text{V}$		1.0	2.5		1.0	2.5	mA
<b>Error Amplifier Section (VCM = 5.1V)</b>								
Input Offset Voltage			0.5	5		2	10	mV
Input Bias Current			1	10		1	10	$\mu\text{A}$
Input Offset Current				1			1	$\mu\text{A}$
DC Open Loop Gain	$R_L \geq 10\text{ Meg}\Omega$	60	75		60	75		dB
Gain-Bandwidth Product (Note 2)	$A_v = 0\text{dB}$ , $T_J = 25^{\circ}\text{C}$	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	$V_{CM} = 1.5\text{V}$ to $5.2\text{V}$	60	75		60	75		dB
Supply Voltage Rejection	$V_{IN} = 8\text{V}$ to $35\text{V}$	50	60		50	60		dB
<b>PWM Comparator</b>								
Minimum Duty Cycle				0			0	%
Maximum Duty Cycle		45	49		45	49		%
Input Threshold (Note 3)	Zero Duty Cycle	0.7	0.9		0.7	0.9		V
Input Threshold (Note3)	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	$\mu\text{A}$
<b>Shutdown Section</b>								
Soft Start Current	$V_{SHUTDOWN} = 0\text{V}$ , $V_{SOFTSTART} = 0\text{V}$	25	50	80	25	50	80	$\mu\text{A}$
Soft Start Low Level	$V_{SHUTDOWN} = 2.5\text{V}$		0.4	0.7		0.4	0.7	V
Shutdown Threshold	To outputs, $V_{SOFTSTART} = 5.1\text{V}$ , $T_J = 25^{\circ}\text{C}$	0.6	0.8	1.0	0.6	0.8	1.0	V
Shutdown Input Current	$V_{SHUTDOWN} = 2.5\text{V}$		0.4	1.0		0.4	1.0	mA
Shutdown Delay (Note 2)	$V_{SHUTDOWN} = 2.5\text{V}$ , $T_J = 25^{\circ}\text{C}$		0.2	0.5		0.2	0.5	$\mu\text{s}$
<b>Output Drivers (Each Output) (VC = 20V)</b>								
Output Low Level	$I_{SINK} = 20\text{mA}$		0.2	0.4		0.2	0.4	V
	$I_{SINK} = 100\text{mA}$		1.0	2.0		1.0	2.0	V
Output High Level	$I_{SOURCE} = 20\text{mA}$	18	19		18	19		V
	$I_{SOURCE} = 100\text{mA}$	17	18		17	18		V
Undervoltage Lockout	$V_{COMP}$ and $V_{SOFTSTART} = \text{High}$	6	7	8	6	7	8	V
Collector Leakage	$V_C = 35\text{V}$			200			200	$\mu\text{A}$



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**ELECTRICAL CHARACTERISTICS (cont.)** 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;  $+V_{IN} = 20\text{V}$ ,  $T_A = T_J$ .

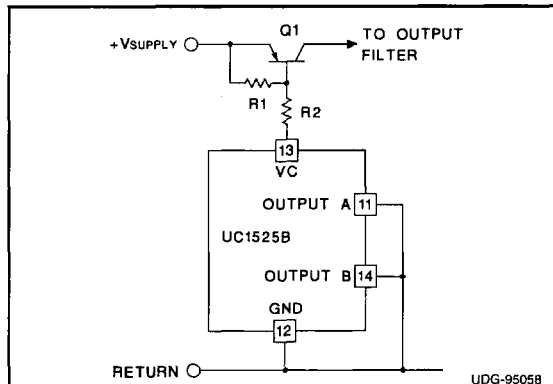
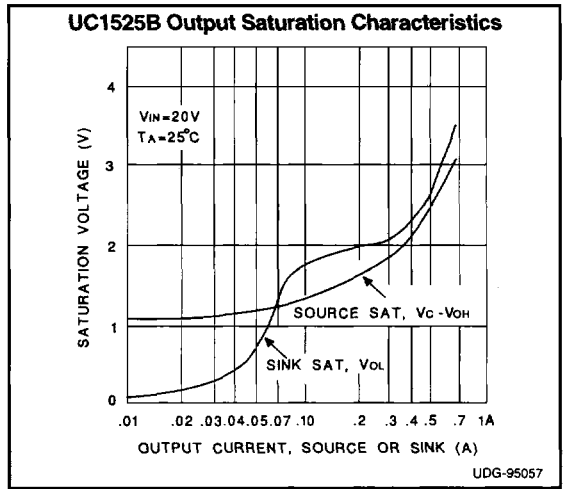
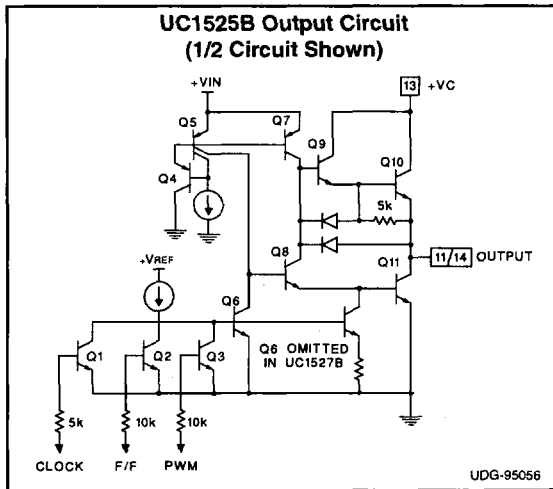
PARAMETER	TEST CONDITIONS	UC1525B/UC2525B UC1527B/UC2527B			UC3525B UC2527B			UNIT
		MIN	TYP	MAX	MIN	TYP	MAX	
<b>Output Drivers (Each Output) (<math>V_C = 20\text{V}</math>) (cont.)</b>								
Rise Time (Note 2)	$C_L = 1\text{nF}$ , $T_J = 25^\circ\text{C}$		100	600		100	600	ns
Fall Time (Note 2)	$C_L = 1\text{nF}$ , $T_J = 25^\circ\text{C}$		50	300		50	300	ns
Cross conduction charge	Per cycle, $T_J = 25^\circ\text{C}$		30			30		nc
<b>Total Standby Current</b>								
Supply Current	$V_{IN} = 35\text{V}$		14	20		14	20	mA

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

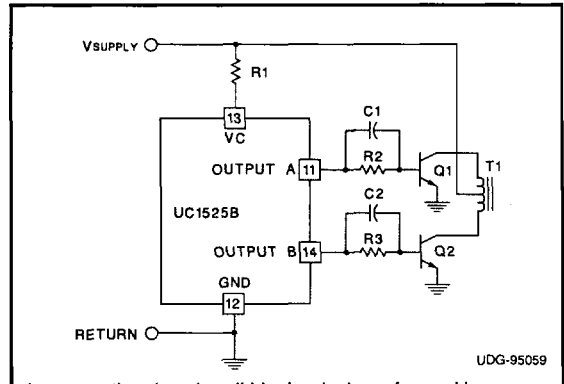
Note 3: Tested at  $f_{osc} = 40\text{kHz}$  ( $R_T = 3.6\Omega$ ,  $C_T = 0.01\mu\text{F}$ ,  $R_D = 0\Omega$ ). Approximate oscillator frequency is defined by:

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

### PRINCIPLES OF OPERATION AND TYPICAL CHARACTERISTICS

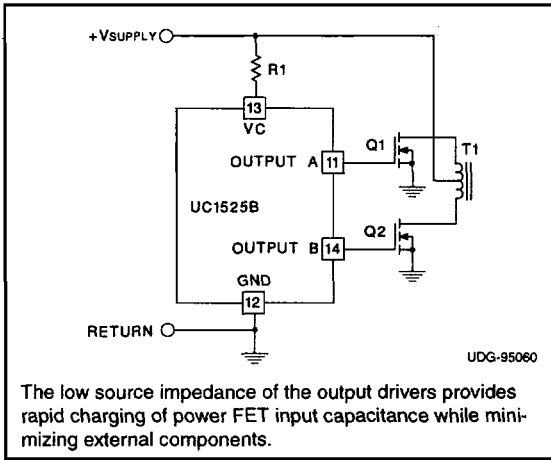


For single-ended supplies, the driver outputs are grounded. The VC terminal is switched to ground by the totem-pole source transistors on alternate oscillator cycles.

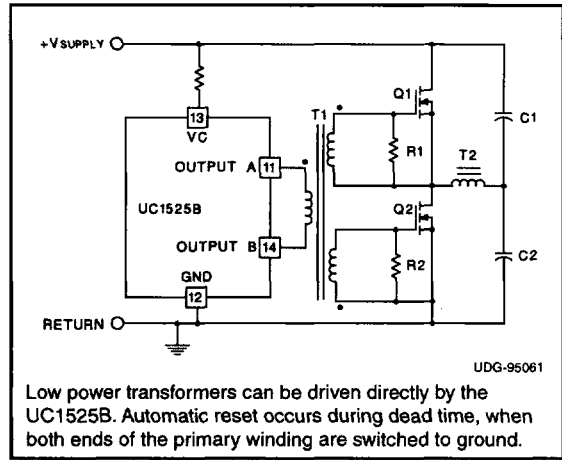


In conventional push-pull bipolar designs, forward base drive is controlled by R1-R3. Rapid turn-off times for the power devices are achieved with speed-up capacitors C1 and C2.

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 UC2525B UC2527B  
 UC3525B UC3527B



The low source impedance of the output drivers provides rapid charging of power FET input capacitance while minimizing external components.



Low power transformers can be driven directly by the UC1525B. Automatic reset occurs during dead time, when both ends of the primary winding are switched to ground.

## PRINCIPLES OF OPERATION AND TYPICAL CHARACTERISTICS

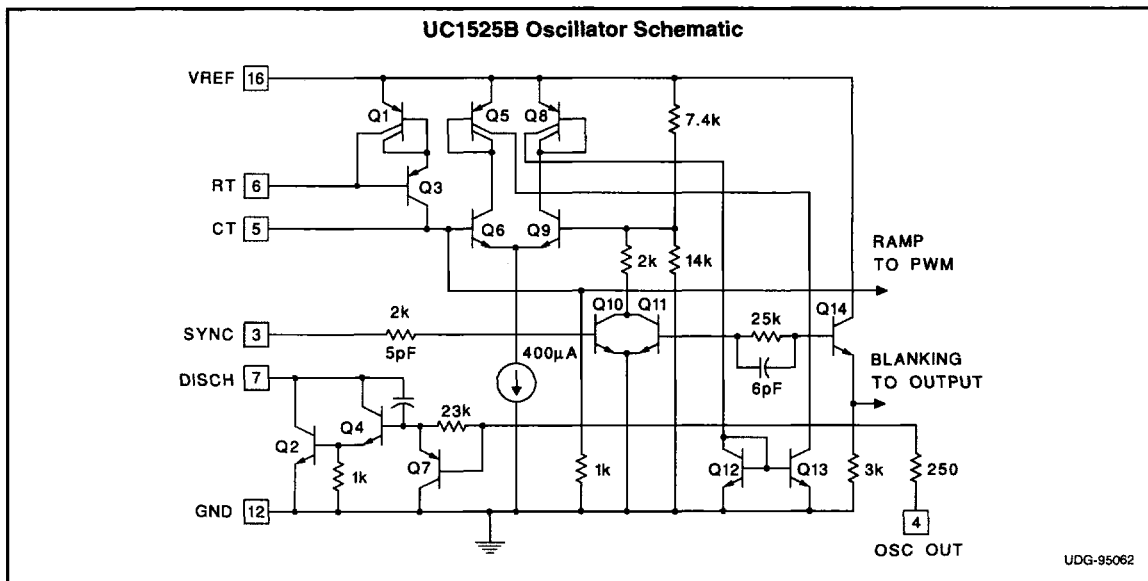
### Shutdown Options (See Block Diagram)

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.

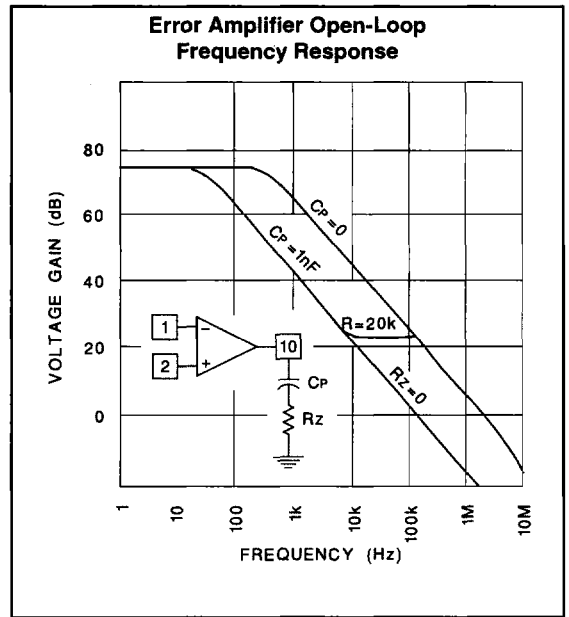
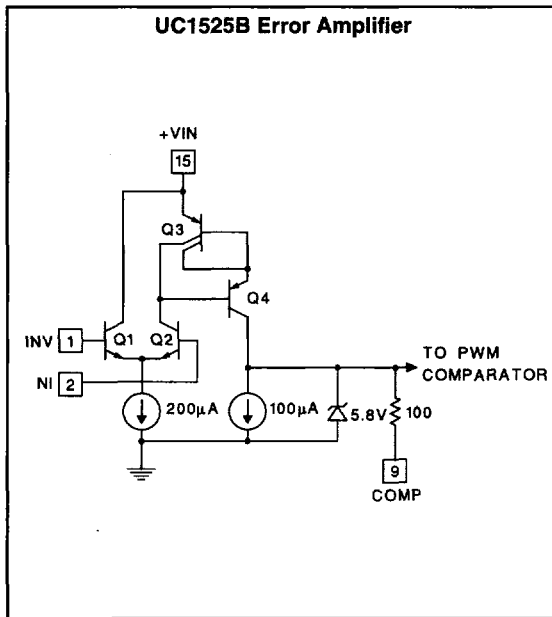
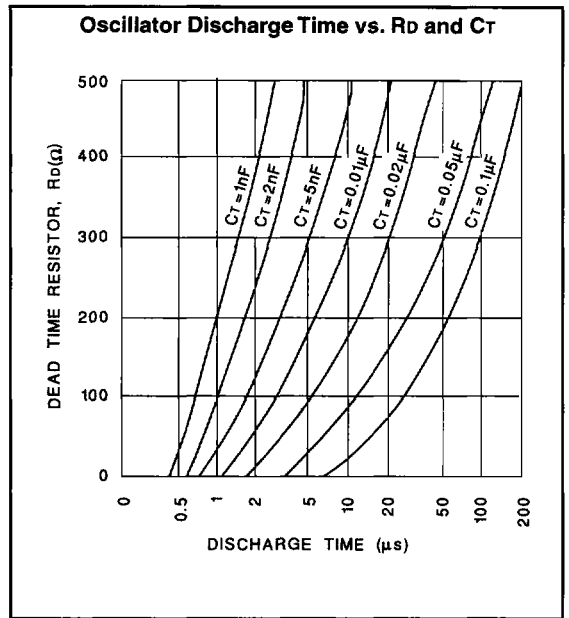
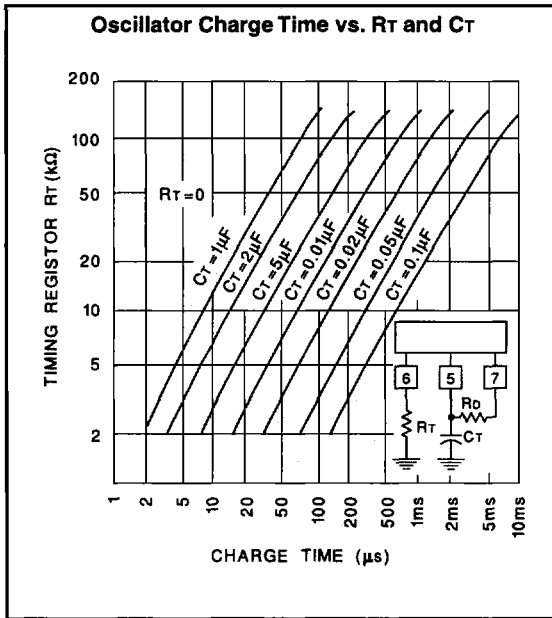
An alternate approach is the use of the shutdown circuitry of Pin 10 which has been improved to enhance the available shutdown options. Activating this circuit by

applying 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.

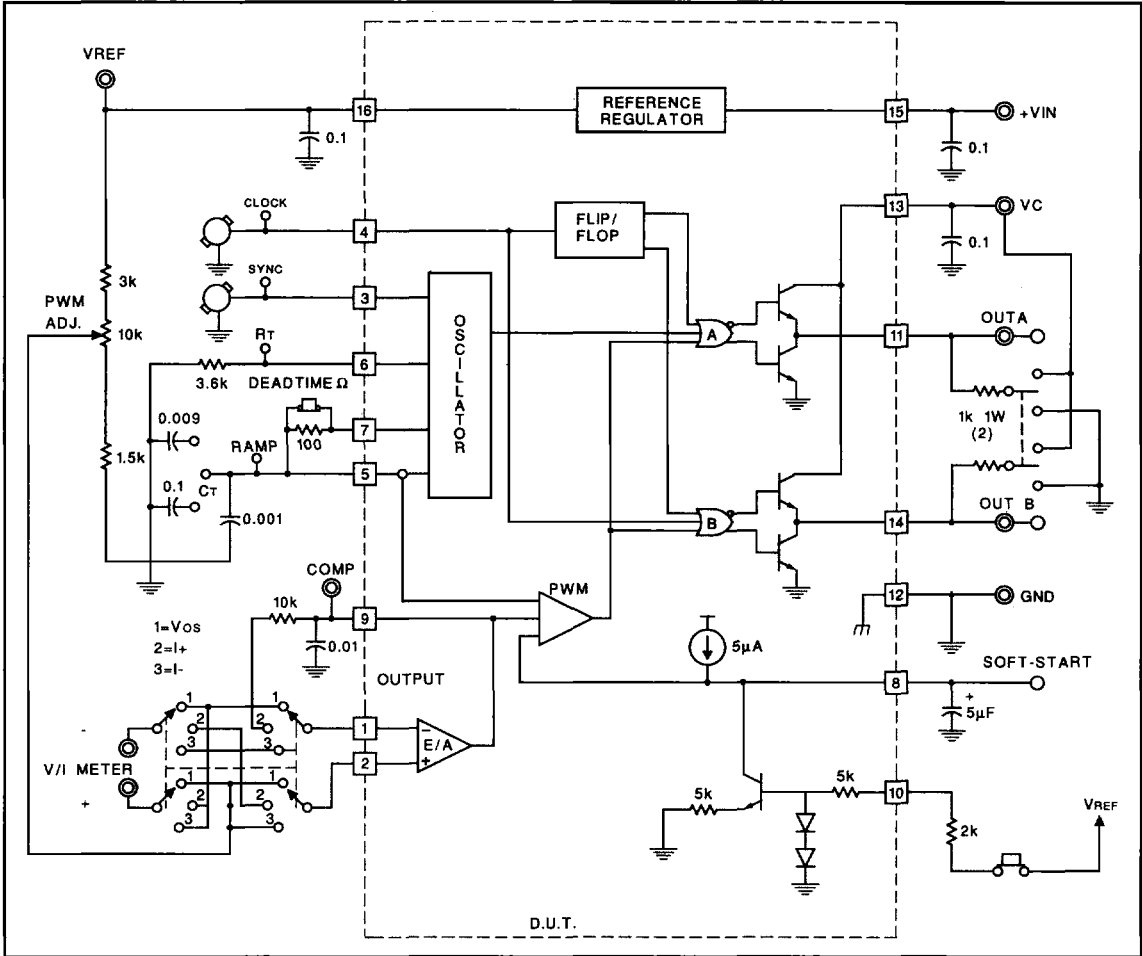
Pin 10 should not be left floating as noise pickup could conceivably interrupt normal operation.



GENERAL POWER SUPPLY



LAB TEST FIXTURE



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