INTEGRATED CIRCUITS
UNITRODE

UC1525A/27A
UC2525A/27A
UC3525A/27A

Regulating Pulse Width Modulators

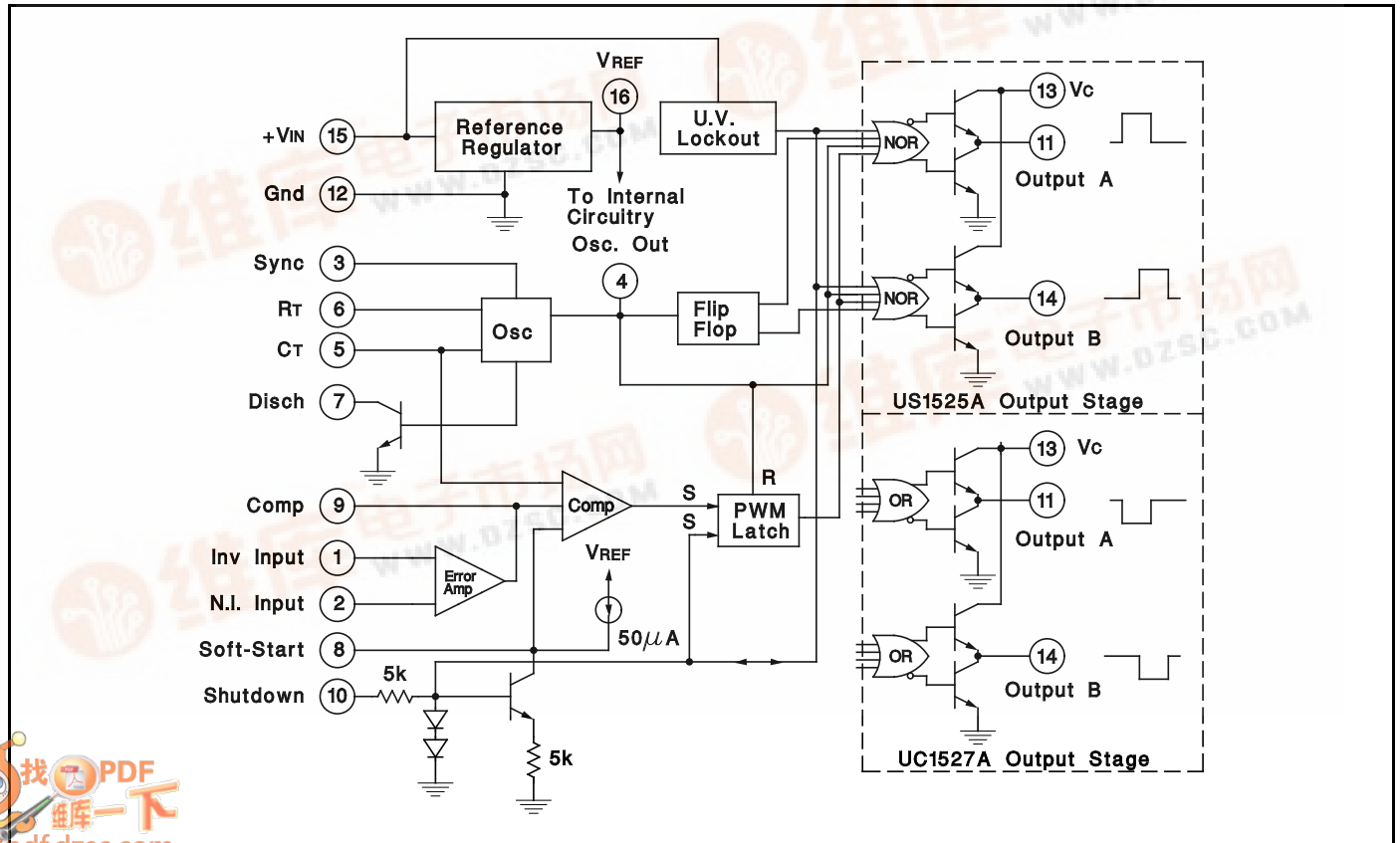
FEATURES

- 8 to 35V Operation
- 5.1V Reference Trimmed to ±1%
- 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

DESCRIPTION

The UC1525A/1527A 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 reference is trimmed to ±1% 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 C_T and the discharge terminals provides 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 UC1525A output stage features NOR logic, giving a LOW output for an OFF state. The UC1527A utilizes OR logic which results in a HIGH output level when OFF.

BLOCK DIAGRAM



ABSOLUTE MAXIMUM RATINGS (Note 1)

Supply Voltage, (+V_{IN}) . . . . . +40V
Collector Supply Voltage (V_C) . . . . . +40V
Logic Inputs . . . . . -0.3V to +5.5V
Analog Inputs . . . . . -0.3V to +V_{IN}
Output Current, Source or Sink 500mA
Reference Output Current 50mA
Oscillator Charging Current 5mA
Power Dissipation at T_A = +25°C (Note 2) 1000mW
Power Dissipation at T_C = +25°C (Note 2) 2000mW
Operating Junction Temperature . . . . . -55°C to +150°C
Storage Temperature Range . . . . . -65°C to +150°C
Lead Temperature (Soldering, 10 seconds) . . . . . +300°C

Note 1: Values beyond which damage may occur.
Note 2: Consult packaging Section of Databook for thermal limitations and considerations of package.

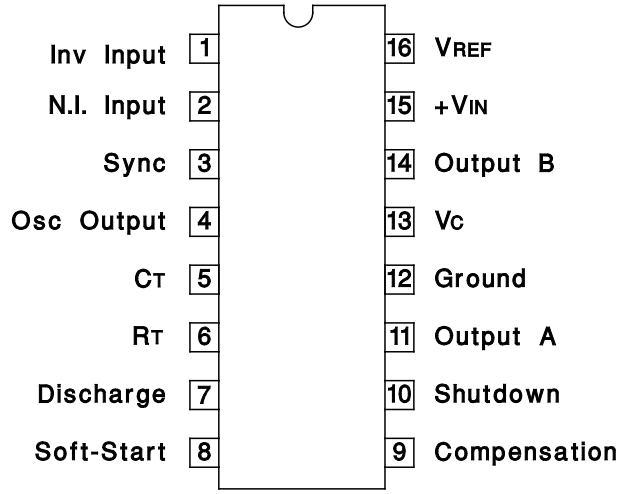
RECOMMENDED OPERATING CONDITIONS (Note 3)

Input Voltage (+V_{IN}) . . . . . +8V to +35V
Collector Supply Voltage (V_C) . . . . . +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 . . . . . .001µF to 0.1µF
Dead Time Resistor Range . . . . . 0 to 500Ω
Operating Ambient Temperature Range
UC1525A, UC1527A . . . . . -55°C to +125°C
UC2525A, UC2527A . . . . . -25°C to +85°C
UC3525A, UC3527A . . . . . 0°C to +70°C

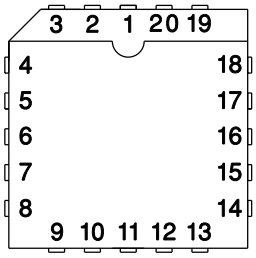
Note 3: Range over which the device is functional and parameter limits are guaranteed.

CONNECTION DIAGRAMS

DIL-16 (TOP VIEW)
J or N Package



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



PACKAGE PIN FUNCTION	
FUNCTION	**PIN**
N/C	1
Inv. Input	2
N.I. Input	3
SYNC	4
OSC. output	5
N/C	6
C_T	7
R_T	8
Discharge	9
Softstart	10
N/C	11
Compensation	12
Shutdown	13
Output A	14
Ground	15
N/C	16
V_C	17
Output B	18
+V_{IN}	19
V_{REF}	20

ELECTRICAL CHARACTERISTICS: $+V_{IN}$ = 20V, and over operating temperature, unless otherwise specified, $T_A = T_J$

PARAMETER	TEST CONDITIONS	UC1525A/UC2525A UC1527A/UC2527A			UC3525A UC3527A			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Reference Section								
Output Voltage	T_J = 25°C	5.05	5.10	5.15	5.00	5.10	5.20	V
Line Regulation	V_{IN} = 8 to 35V		10	20		10	20	mV
Load Regulation	I_L = 0 to 20mA		20	50		20	50	mV
Temperature Stability (Note 5)	Over Operating Range		20	50		20	50	
Total Output Variation (Note 5)	Line, Load, and Temperature	5.00		5.20	4.95		5.25	V
Shorter Circuit Current	V_{REF} = 0, T_J = 25°C		80	100		80	100	mA
Output Noise Voltage (Note 5)	10Hz ≤ 10kHz, T_J = 25°C		40	200		40	200	μVrms
Long Term Stability (Note 5)	T_J = 125°C		20	50		20	50	mV
Oscillator Section (Note 6)								
Initial Accuracy (Notes 5 & 6)	T_J = 25°C		± 2	± 6		± 2	± 6	%
Voltage Stability (Notes 5 & 6)	V_{IN} = 8 to 35V		± 0.3	± 1		± 1	± 2	%
Temperature Stability (Note 5)	Over Operating Range		± 3	± 6		± 3	± 6	%
Minimum Frequency	R_T = 200kΩ, C_T = 0.1μF			120			120	Hz
Maximum Frequency	R_T = 2kΩ, C_T = 470pF	400			400			kHz
Current Mirror	I_{RT} = 2mA	1.7	2.0	2.2	1.7	2.0	2.2	mA
Clock Amplitude (Notes 5 & 6)		3.0	3.5		3.0	3.5		V
Clock Width (Notes 5 & 6)	T_J = 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_{CM} = 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_L ≥ 10MΩ	60	75		60	75		dB
Gain-Bandwidth Product (Note 5)	A_V = 0dB, T_J = 25°C	1	2		1	2		MHz
DC Transconductance (Notes 5 & 7)	T_J = 25°C, 30kΩ ≤ R_L ≤ 1MΩ	1.1	1.5		1.1	1.5		mS
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 to 5.2V	60	75		60	75		dB
Supply Voltage Rejection	V_{IN} = 8 to 35V	50	60		50	60		dB

Note 5: These parameters, although guaranteed over the recommended operating conditions, are not 100% tested in production.

Note 6: Tested at f_{OSC} = 40kHz (R_T = 3.6kΩ, C_T = 0.01μF, R_D = 0Ω). Approximate oscillator frequency is defined by:

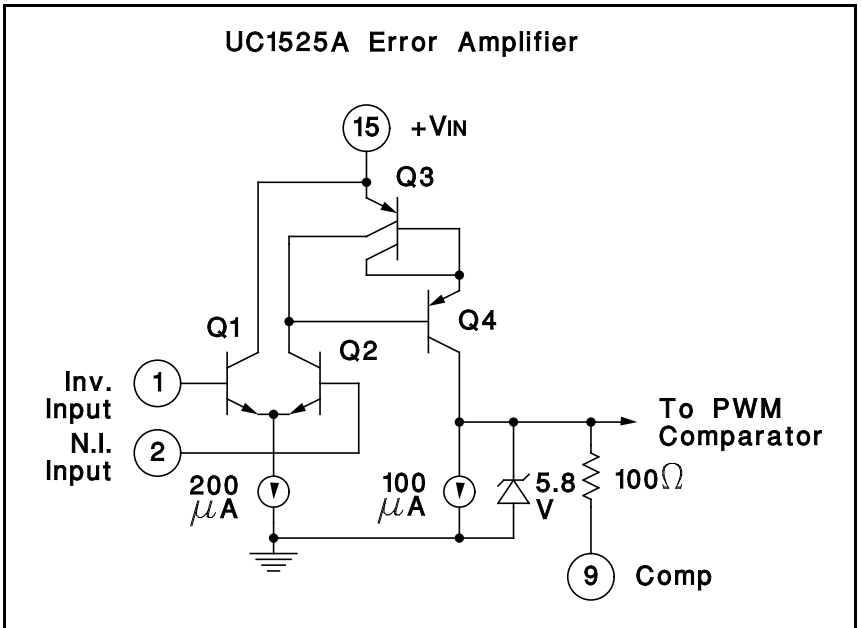
$$f = \frac{1}{C_T\,(0.7R_T + 3R_D)}$$

Note 7: DC transconductance (g_M) relates to DC open-loop voltage gain (A_V) according to the following equation: $A_V = g_M R_L$ where R_L is the resistance from pin 9 to ground..
The minimum g_M specification is used to calculate minimum A_V when the error amplifier output is loaded.

ELECTRICAL CHARACTERISTICS: +V_{IN} = 20V, and over operating temperature, unless otherwise specified, $T_A = T_J$

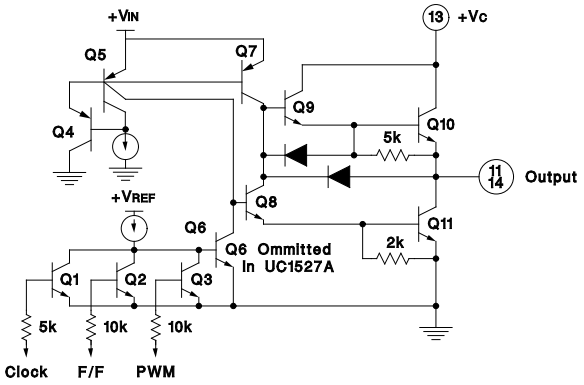
PARAMETER	TEST CONDITIONS	UC1525A/UC2525A UC1527A/UC2527A			UC3525A UC3527A			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
PWM Comparator								
Minimum Duty-Cycle				0			0	%
Maximum Duty-Cycle		45	49		45	49		%
Input Threshold (Note 6)	Zero Duty-Cycle	0.7	0.9		0.7	0.9		V
	Maximum Duty-Cycle		3.3	3.6		3.3	3.6	V
Input Bias Current (Note 5)			.05	1.0		.05	1.0	µA
Shutdown Section								
Soft Start Current	V_{SD} = 0V, V_{SS} = 0V	25	50	80	25	50	80	µA
Soft Start Low Level	V_{SD} = 2.5V		0.4	0.7		0.4	0.7	V
Shutdown Threshold	To outputs, V_{SS} = 5.1V, T_J = 25°C	0.6	0.8	1.0	0.6	0.8	1.0	V
Shutdown Input Current	V_{SD} = 2.5V		0.4	1.0		0.4	1.0	mA
Shutdown Delay (Note 5)	V_{SD} = 2.5V, T_J = 25°C		0.2	0.5		0.2	0.5	µs
Output Drivers (Each Output) (V_C = 20V)								
Output Low Level	I_{SINK} = 20mA		0.2	0.4		0.2	0.4	V
	I_{SINK} = 100mA		1.0	2.0		1.0	2.0	V
Output High Level	I_{SOURCE} = 20mA	18	19		18	19		V
	I_{SOURCE} = 100mA	17	18		17	18		V
Under-Voltage Lockout	V_{COMP} and V_{SS} = High	6	7	8	6	7	8	V
V_C OFF Current (Note 7)	V_C = 35V			200			200	µA
Rise Time (Note 5)	C_L = 1nF, T_J = 25°C		100	600		100	600	ns
Fall Time (Note 5)	C_L = 1nF, T_J = 25°C		50	300		50	300	ns
Total Standby Current								
Supply Current	V_{IN} = 35V		14	20		14	20	mA

Note 5: These parameters, although guaranteed over the recommended operating conditions, are not 100% tested in production.
Note 6: Tested at f_{OSC} = 40kHz (R_T = 3.6kΩ, C_T = 0.01µF, R_D = 0Ω).
Note 7: Collector off-state quiescent current measured at pin 13 with outputs low for UC1525A and high for UC1527A.

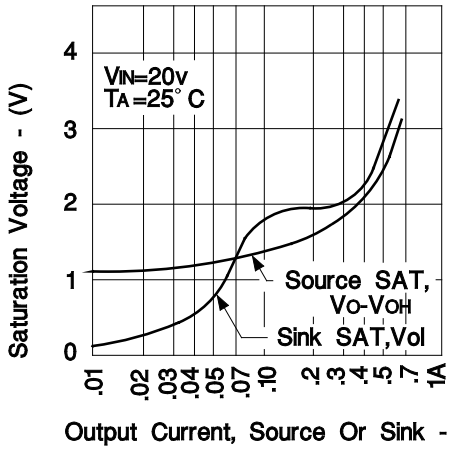


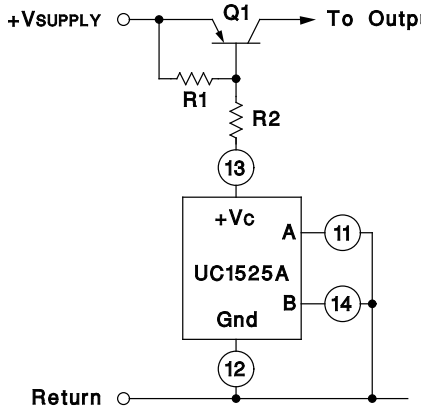
PRINCIPLES OF OPERATION AND TYPICAL CHARACTERISTICS

UC1525A Output Circuit
(1/2 Circuit Shown)

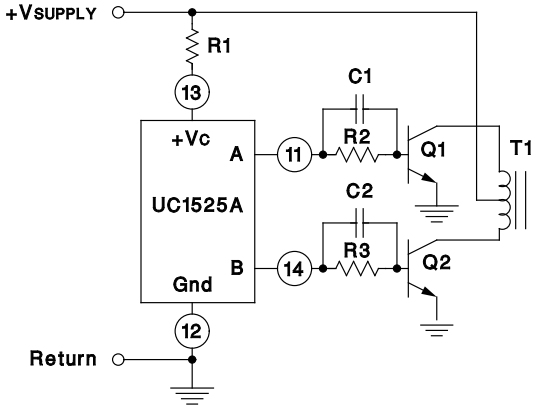


UC1525A Output Saturation Characteristics

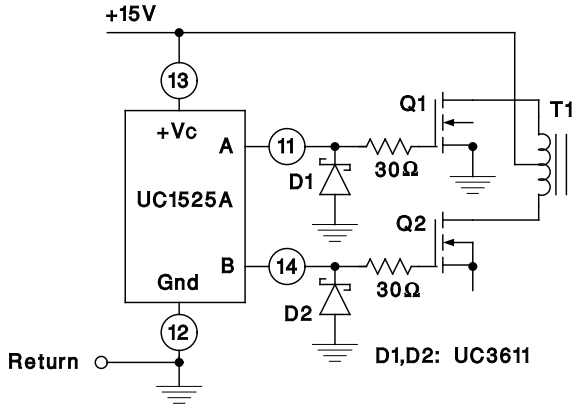




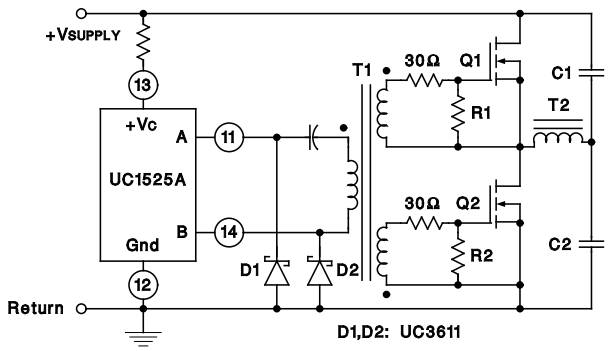
For single-ended supplies, the driver outputs are grounded. The Vc terminal is switched to ground by the totem-pole source transistors on alternate oscillator cycles.



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.

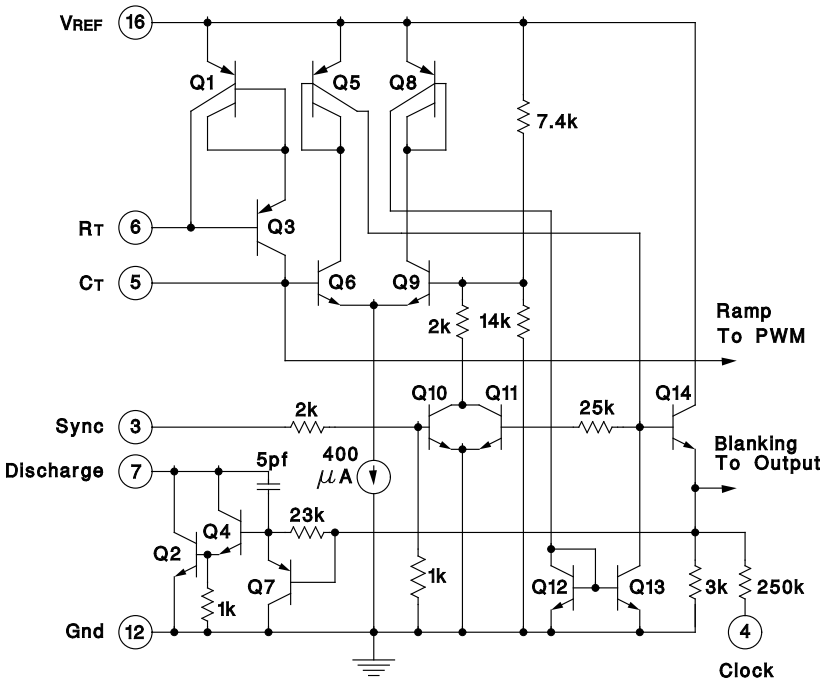


The low source impedance of the output drivers provides rapid charging of power FET Input capacitance while minimizing external components.



Low power transformers can be driven by the UC1525A. Automatic reset occurs during dead time, when both ends of the primary winding are switched to ground.

UC1525A Oscillator Schematic



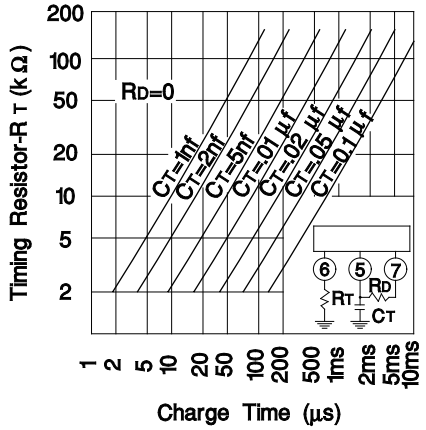
PRINCIPLES OF OPERATION AND TYPICAL CHARACTERISTIC SHUTDOWN OPTIONS
(See Block Diagram)

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 100μA to turn off the outputs. This is subject to the added requirement of discharging whatever external capacitance may be attached to these pins.

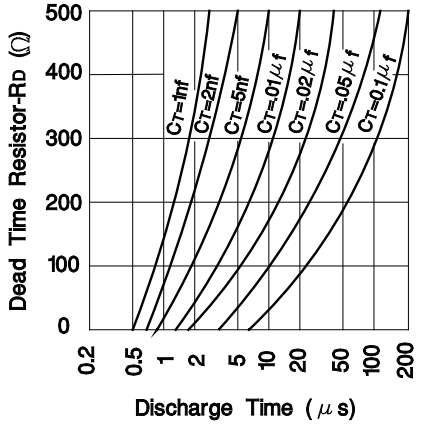
An alternate approach is the use of the shutdown circuitry of Pin 10 which has been improved to enhance the available shutdown options. Activating this circuit by applying a positive signal on Pin 10 performs two functions; the PWM latch is immediately set providing the fastest turn-off signal to the outputs; and a 150μA-current sink begins to discharge 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.

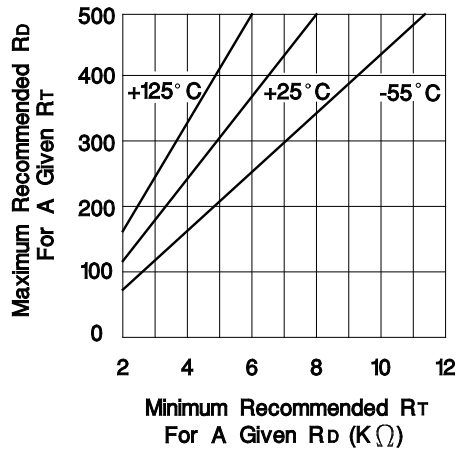
Oscillator Charge Time vs RT and CT



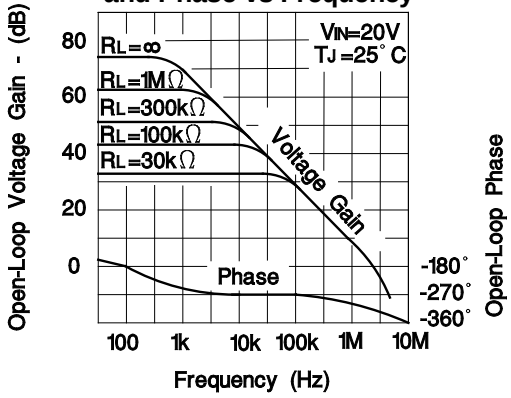
Oscillator Discharge Time vs RD and CT



Maximum Value R_D vs Minimum Value R_T

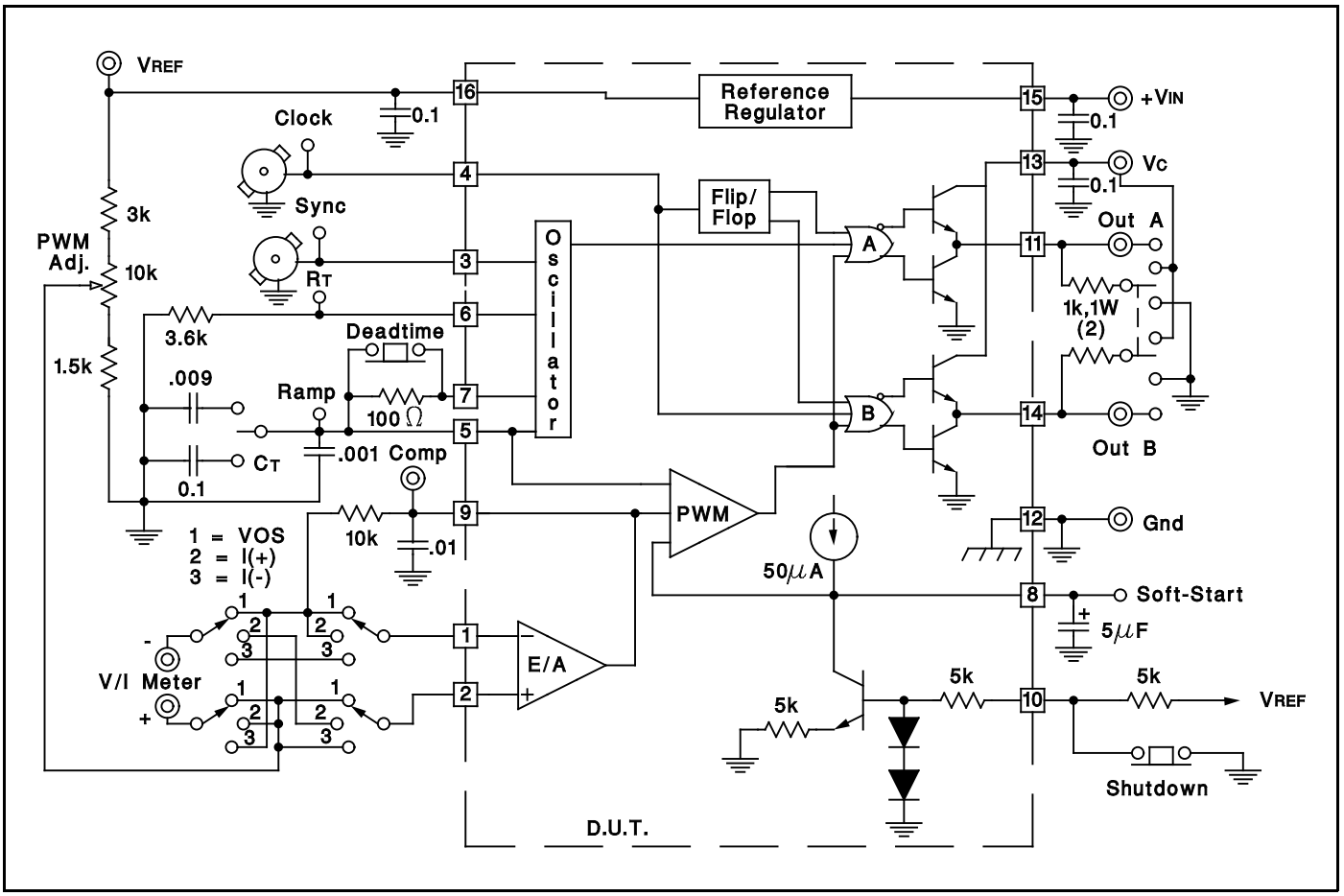


Error Amplifier Voltage Gain and Phase vs Frequency



R_L is impedance from pin 9 to ground. Values below 30kΩ will begin to limit the maximum duty cycle.

LAB TEST FIXTURE



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