

## LM1525A/LM3525A/LM1527A/LM3527A Pulse Width Modulator

### General Description

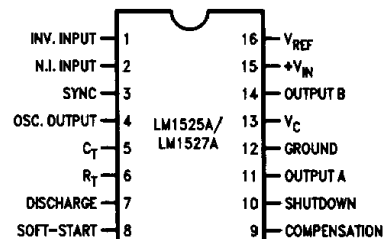
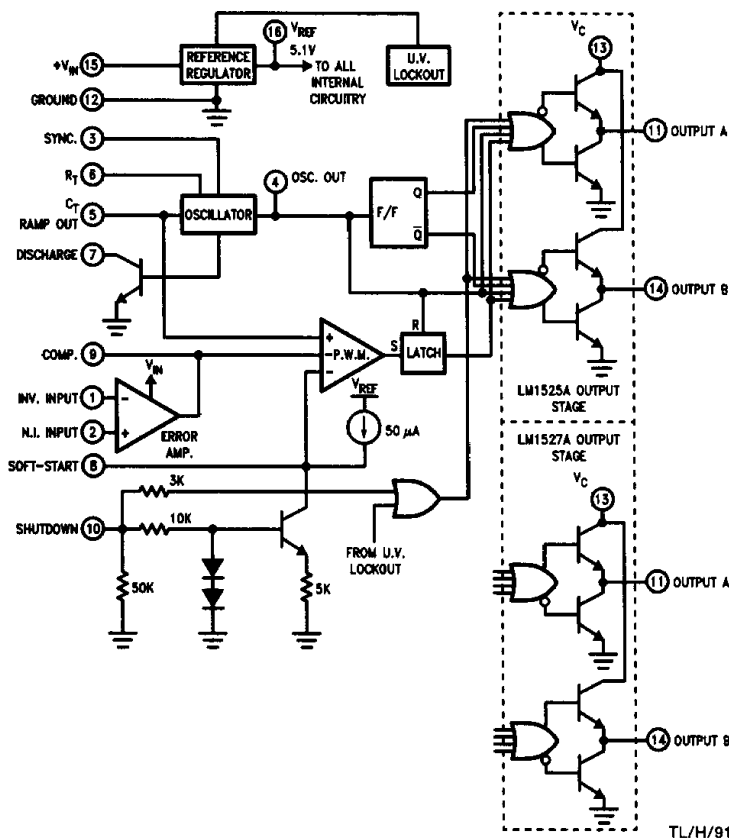
The LM1525A/1527A series of pulse-width-modulator integrated circuits are designed to offer improved performance and lowered external parts count when used to implement all types of switching power supplies. The on-chip  $+5.1\text{V}$  reference is trimmed to  $\pm 1\%$  initial accuracy, and the input common mode range of the error amplifier includes the reference voltage, eliminating external potentiometers and dividers. A Sync input to the oscillator permits multiple devices to be slaved together, or a single device to be synchronized to an external system clock. A single resistor between the  $C_T$  pin and the Discharge pin provides a wide range of deadtime adjustment. These devices also feature built-in soft-start circuitry with only a timing capacitor required externally. A Shutdown pin controls both the soft-start circuitry and the output stages, providing instantaneous turn-off with soft-start recycle for slow turn-on. These functions are also controlled by an undervoltage lockout which keeps the outputs off and the soft-start capacitor discharged for input voltages less than that required for normal operation. The undervoltage lockout circuitry features approximately 200 mV of hysteresis to prevent threshold oscillations. Another unique feature of these improved PWM in-

tegrated circuits is the latch following the comparator (thus preventing double-pulsing). Once a PWM pulse has been terminated for any reason, the outputs will remain OFF for the duration of that period. The latch is reset with each clock pulse. The output stages are totem-pole designs capable of sourcing or sinking more than 200 mA. The LM1525A output stage features NOR logic, resulting in LOW outputs for an OFF stage. The LM1527A uses OR logic which results in HIGH outputs when OFF.

### Features

- 8 to 35V operation
- 5.1V reference trimmed to  $\pm 1\%$
- 100 Hz to 500 kHz oscillator range
- Separate oscillator sync terminal
- Adjustable deadtime control
- Internal soft-start
- Input undervoltage lockout with hysteresis
- Latching P.W.M. to prevent multiple pulses
- Dual source/sink output drivers

### Block & Connection Diagrams



TL/H/9112-2

#### Top View

Order Number LM1525AJ,  
LM3525AJ, LM1527AJ, LM3527AJ,  
LM3525AN or LM3527AN  
See NS Package Number  
J16A or N16A

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**Absolute Maximum Ratings** (Note 7)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

Input Voltage (Pins 13, and 15)	−0.3V to +40V
Reference Output Current (Pin 16)	50 mA DC
Reference Output Short Circuit	5 Seconds
Output Current (Pins 11, 14)	±200 mA
Oscillator Current (Pins 5, 6, 7) (Note 8)	5 mA DC
Op Amp Inputs: $V_{CM}$	−0.3V to $V_{in}$
(Pins 1, 2) $V_{DIFF}$	±6V
Logic Inputs	−0.3V to +5.5V

Storage Temperature	−65°C to +150°C
Operating Temperature Range ( $T_{min} \leq T_j \leq T_{max}$ )	
LM1525A, LM1527A	−55°C to +150°C
LM3525A, LM3527A	0°C to +150°C
Lead Temperature (Soldering, 4 Seconds)	
J Package	+300°C
N Package	+260°C
Power Dissipation (Note 9)	1 Watt
ESD Tolerance	
Czap = 100 pF, Rzap = 1.5k	2000V

**Electrical Characteristics**

$V_{in} = 20 V_{dc}$ , **Boldface** limits apply from  $T_{MIN}$  to  $T_{MAX}$  (Note 1), all other limits  $T_j = 25^\circ\text{C}$  unless otherwise noted

Parameter	Conditions	LM1525A LM1527A			LM3525A LM3527A			Units
		Typical	Tested Limit (Note 2)	Design Limit (Note 3)	Typical	Tested Limit (Note 2)	Design Limit (Note 3)	
REFERENCE SECTION								
Reference Voltage Output	T <sub>j</sub> = 25°C	5.10	5.05 5.15		5.10	5.00 5.20		V <sub>min</sub> V <sub>max</sub>
Line Regulation	+ 8.0V ≤ V <sub>in</sub> ≤ + 35V	10	<b>20</b>		10	15	<b>20</b>	mV <sub>max</sub>
Load Regulation	0 mA ≤ I <sub>L</sub> ≤ 20 mA	20	<b>50</b>		20	20	<b>50</b>	mV <sub>max</sub>
Temperature Stability		20		<b>50</b>	20		<b>50</b>	mV <sub>max</sub>
Reference Voltage Output	+ 8.0V ≤ V <sub>in</sub> ≤ + 35V 0 mA ≤ I <sub>L</sub> ≤ 20 mA And Over Operating Temp.	5.08	<b>5.20</b> <b>5.00</b>		5.08		<b>5.25</b> <b>4.95</b>	V <sub>max</sub> V <sub>min</sub>
Short Circuit Current	T <sub>j</sub> = 25°C V <sub>ref</sub> = 0V	70	100		70	100		mA <sub>max</sub>
Output Noise Voltage	10 Hz ≤ f ≤ 10 kHz T <sub>j</sub> = 25°C	40		200	40		200	μV <sub>rms</sub> max
Long Term Stability	T <sub>j</sub> = 125°C	20		50	20		50	mV/KHour
OSCILLATOR SECTION (Note 4) Unless otherwise specified								
Initial Accuracy	T <sub>j</sub> = 25°C	±2	±6		±2	±6		%
Accuracy of Freq. vs. Temp.		±3	±8		±3		±10	%
Voltage Stability	8.0V ≤ V <sub>in</sub> ≤ 35V	±0.3	±1		±0.3	±2	±2	%
Temperature Stability	ΔF <sub>osc</sub> /F <sub>osc</sub>	±3		±6	±3		±6	%
Minimum Frequency	R <sub>T</sub> = 300 kΩ, C <sub>T</sub> = 0.1 μF, R <sub>D</sub> = 0 (Note 5)	70	<b>100</b>		70	90	<b>100</b>	Hz max
Maximum Frequency	R <sub>T</sub> = 2.0 kΩ, C <sub>T</sub> = 1 nF, R <sub>D</sub> = 0	450	<b>400</b>		450	430	<b>400</b>	kHz min
Current Mirror I <sub>pin 5</sub>	I <sub>RT</sub> = 2.0 mA	2.0	<b>1.7</b> <b>2.2</b>		2.0	1.8 2.1	<b>1.7</b> <b>2.2</b>	mA <sub>min</sub> mA <sub>max</sub>
Clock Amplitude	At pin 4	3.5		<b>3.0</b>	3.5		<b>3.0</b>	V <sub>min</sub>
Clock Width	T <sub>j</sub> = 25°C	0.5		1.0 0.3	0.5		1.0 0.3	μs max μs min
Sync Threshold	(Note 6)	1.8	<b>1.2</b> <b>2.8</b>		1.8	1.25 2.8	<b>1.2</b> <b>2.8</b>	V min V max
Sync Input Current	Sync Voltage = 3.5V	1.0	<b>2.5</b>		1.0	2.30	<b>2.5</b>	mA <sub>max</sub>

# Electrical Characteristics

$V_{in} = 20 V_{dc}$ . **Boldface** limits apply from  $T_{MIN}$  to  $T_{MAX}$  (Note 1), all other limits  $T_J = 25^\circ C$  unless otherwise noted (Continued)

Parameter	Conditions	LM1525A LM1527A			LM3525A LM3527A			Units
		Typical	Tested Limit (Note 2)	Design Limit (Note 3)	Typical	Tested Limit (Note 2)	Design Limit (Note 3)	
ERROR AMPLIFIER SECTION $V_{CM} = 5.1V$ , Unless otherwise noted								
Input Offset Voltage		0.5	5		2	7	10	mV <sub>max</sub>
Input Bias Current		1	10		1	2	10	$\mu A_{max}$
Input Offset Current		0.1	1		0.1	0.8	1	$\mu A_{max}$
DC Open Loop Gain	$R_L \geq 10\text{ M}\Omega$	80	66		80	66	60	dB min
Gain Bandwidth Product	$A_V = 0, T_J = 25^\circ C$ $C_L \leq 30\text{ pF}$	2		1	2		1	MHz <sub>min</sub>
Output Low Level		0.2	0.5		0.2	0.4	0.5	$V_{max}$
Output High Level		5.6	3.8		5.6	4.1	3.8	$V_{min}$
Common Mode Rejection	$V_{CM} = 1.5V$ to $5.2V$	80	66		80	70	66	dB min
Supply Voltage Rejection	$V_{IN} = 8V$ to $35V$	90	60		90	64	60	dB min
P.W.M. COMPARATOR								
Minimum Duty Cycle			0			0	0	% max
Maximum Duty Cycle		49	45		49	46	45	% min
Input Threshold	Zero Duty Cycle	0.9	0.6		0.9	0.70	0.6	$V_{min}$
Input Threshold	Max. Duty Cycle	3.3	3.6		3.3	3.6	3.6	$V_{max}$
Input Bias Current		0.05		1.0	0.05		1.0	$\mu A_{max}$
SOFT-START SECTION								
Soft Start Current	$V_{SHUTDOWN} = 0V$	50	80 25		50	74 36	80 25	$\mu A_{max}$ $\mu A_{min}$
Soft Start Voltage	$V_{SHUTDOWN} = 2.0V$	0.35	0.6		0.35	0.5	0.6	$V_{max}$
Shutdown Input Current	$V_{SHUTDOWN} = 2.5V$	0.4	1.0		0.4	0.85	1.0	mA <sub>max</sub>
OUTPUT DRIVERS (Each Output) $V_C = 20V$ , Unless otherwise noted								
Undervoltage Lockout Hysteresis		0.2			0.2			V
Output Low Level	$I_{SINK} = 20\text{ mA}$	0.2	0.4		0.2	0.35	0.4	$V_{max}$
	$I_{SINK} = 100\text{ mA}$	1.0	2.0		1.0	1.9	2.0	$V_{max}$
Output High Level	$I_{SOURCE} = 20\text{ mA}$	19	18		19	18.2	18	$V_{min}$
	$I_{SOURCE} = 100\text{ mA}$	18	17		18	17.4	17	$V_{min}$
Undervoltage Lockout	$V_{COMP}$ and $V_{SS} = \text{High}$	7	8 6		7	7.7 6.3	8 6	$V_{max}$ $V_{min}$
Collector Leakage	LM1525A and LM3525A Only $V_C = 35V$		200			120	200	$\mu A_{max}$
Rise Time	$C_L = 1\text{ nf}, T_J = 25^\circ C$	100		600	100		600	ns max
Fall Time	$C_L = 1\text{ nf}, T_J = 25^\circ C$	50		300	50		300	ns max

## Electrical Characteristics

$V_{in} = 20 V_{dc}$ , **Boldface** limits apply from  $T_{MIN}$  to  $T_{MAX}$  (Note 1), all other limits  $T_j = 25^\circ C$  unless otherwise noted (Continued)

Parameter	Conditions	LM1525A LM1527A			LM3525A LM3527A			Units
		Typical	Tested Limit (Note 2)	Design Limit (Note 3)	Typical	Tested Limit (Note 2)	Design Limit (Note 3)	
Shutdown Delay	$V_{SD} = 3V$ , $C_L = 0$ , $T_j = 25^\circ C$	200		500	200		500	ns max
<b>TOTAL STANDBY CURRENT</b>								
Supply Current	$V_{IN} = 35V$	13	<b>18</b>		13	14.5	<b>20</b>	mA

**Note 1:** Unless otherwise noted these specifications apply:  $-55^\circ C < T_j < +125^\circ C$  for LM1525A and LM1527A,  $0^\circ C < T_j < +125^\circ C$  for LM3525A and LM3527A.

**Note 2:** Tested limits are guaranteed and 100% tested in production.

**Note 3:** Design limits are guaranteed (but not 100% production tested) over the indicated temperature and supply ranges.

**Note 4:** Tested at  $F_{osc} = 40 \text{ kHz}$  ( $R_t = 3.6k$ ,  $C_t = 0.01 \mu F$ ,  $R_d = 0$ ).

**Note 5:** These specifications are also guaranteed with  $R_t = 150k$ ,  $C_t = 0.2 \mu F$ ,  $R_d = 0$ .

**Note 6:** Tested with a pulse of width 500 ns and amplitudes of 1.2 and 2.8V at 50 kHz.

**Note 7:** Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. DC and AC electrical specifications do not apply when operating the device beyond its rated operating conditions. See Note 1 and conditions.

**Note 8:** Do not ground pin 6.

**Note 9:** For operation at elevated temperatures, devices in the J package must be derated based on thermal resistance of  $90^\circ C/W$  (junction to ambient), or  $85^\circ C/W$  in the N package.

### SHUTDOWN OPTIONS (See Block Diagram)

1. 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.
2. An alternative approach is the use of the shutdown circuitry of pin 10. Activating this circuit by applying a positive-going pulse at pin 10 will result in the output of the comparator going high, and thus turning off the outputs. The pulse will start the fast discharge of the 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.

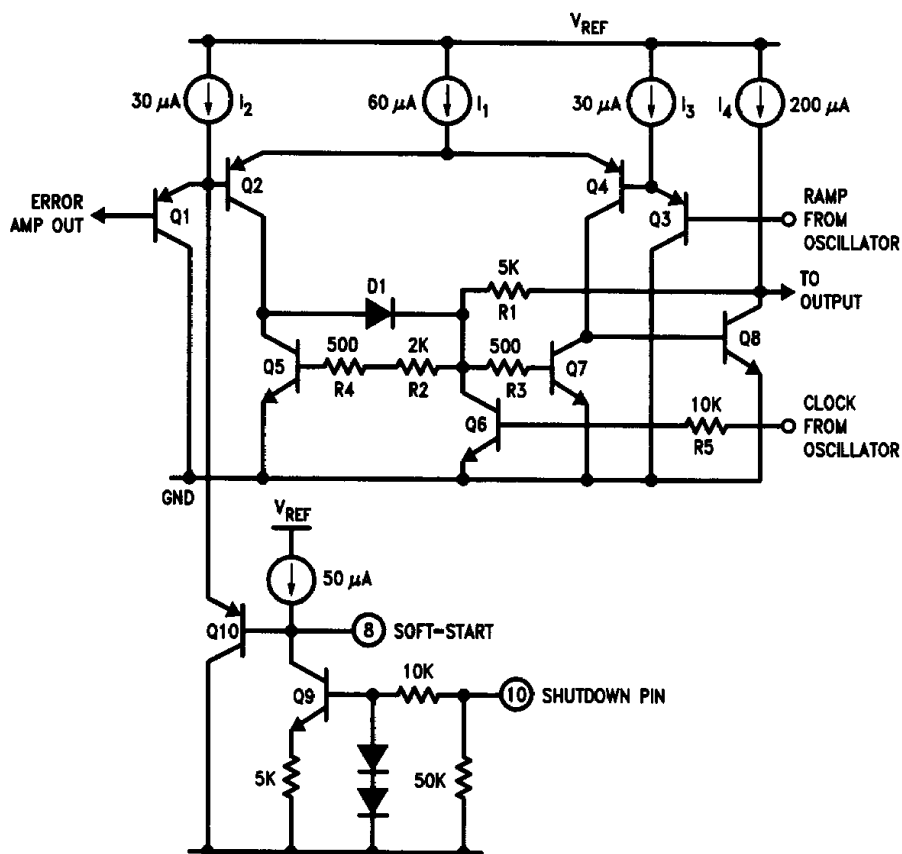
Holding pin 10 high for a long time will ultimately discharge the soft-start capacitor, thus recycling slow turn on upon release. This method of shutdown is the fastest shutdown possible.

### SYNCHRONIZATION PROCEDURE

The device may be synchronized to an external clock; however the following points have to be observed: a) The frequency of the free-running oscillator of the device must be set at least 10% less than the frequency of the external clock. b) The external clock pulse must be at least 300 ns wide but must not exceed the free-running pulse width (pin 4) by more than 200 ns. c) The amplitude of the external pulse must be between 2 and 5V.

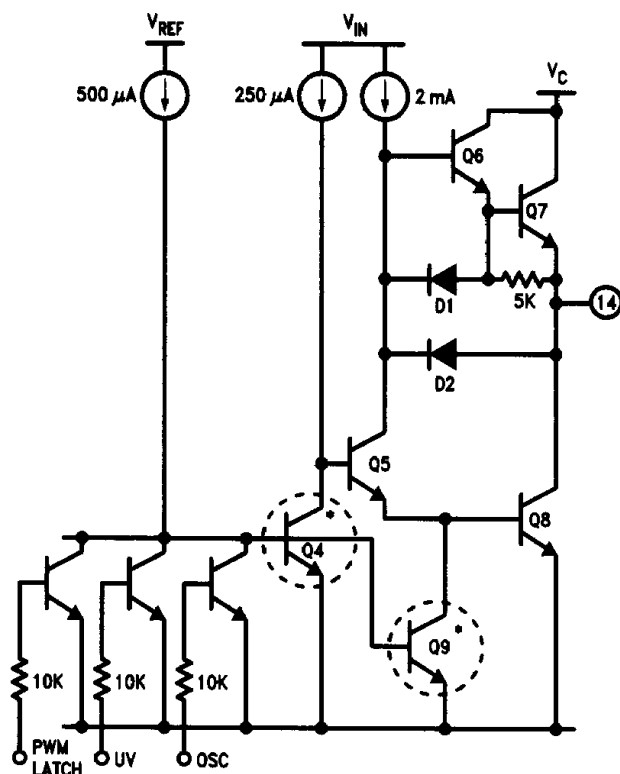
Multiple devices may be synchronized together by connecting all pin 4's together and all pin 5's together; pins 6 and 7 of slave oscillator must be left open.

# LM1525A Comparator



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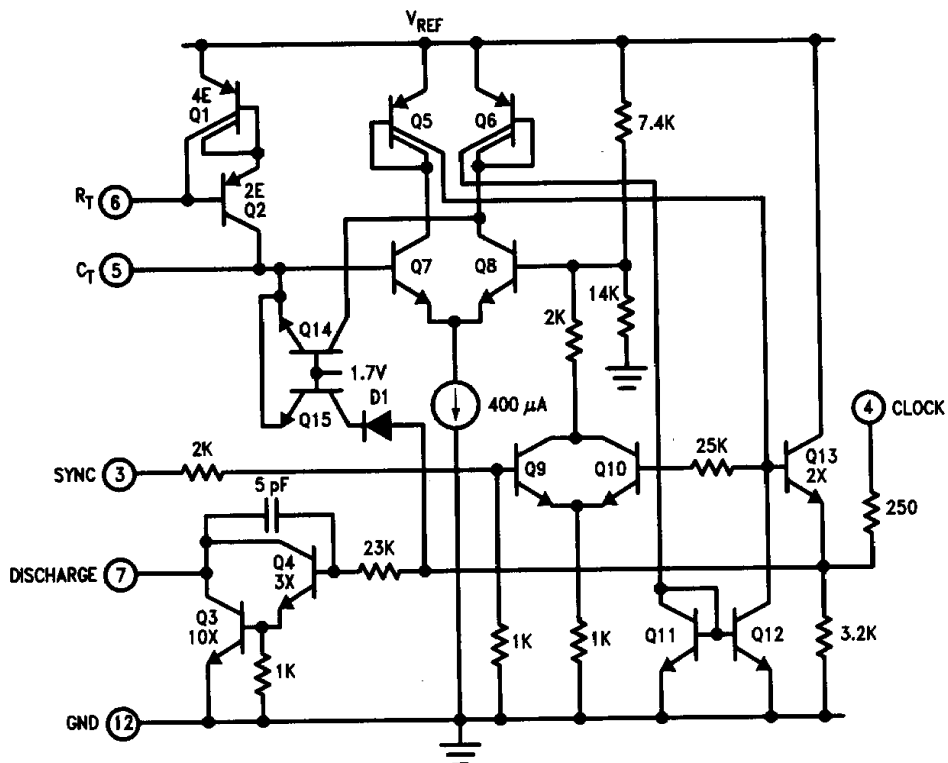
## LM1525A Output Section



\*Q<sub>4</sub> omitted in LM1527A.  
Q<sub>9</sub> replaced by a 2K resistor in LM1527A.

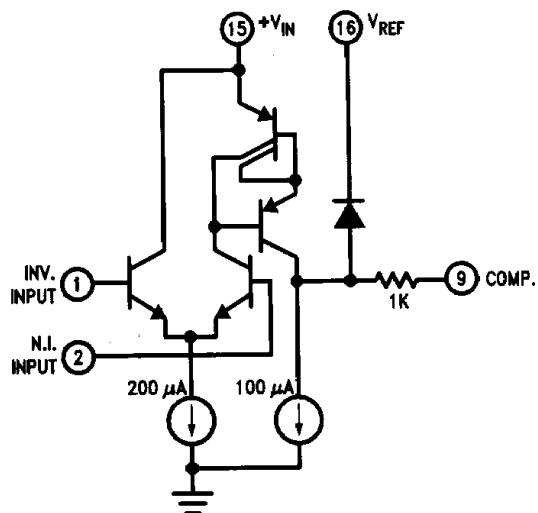
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### LM1525A Oscillator

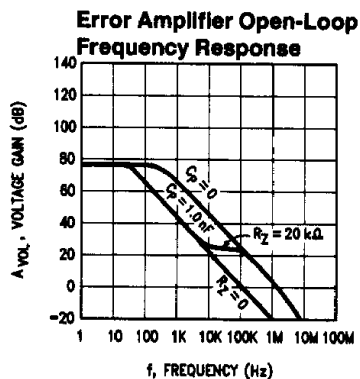
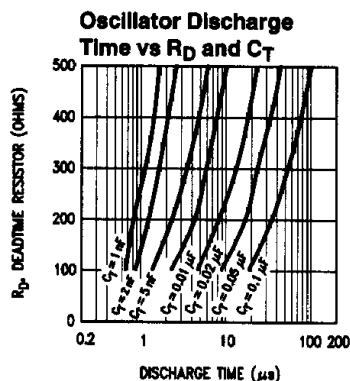
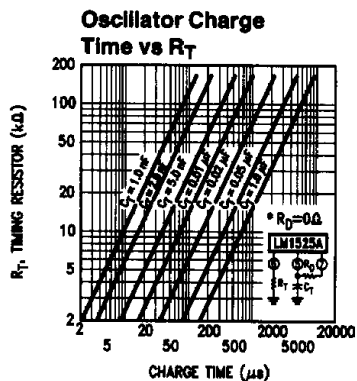
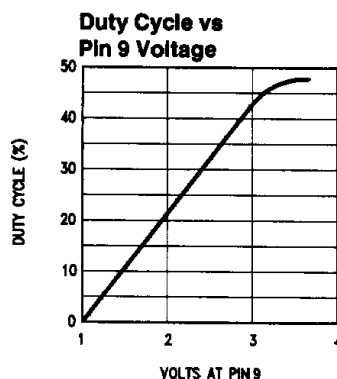
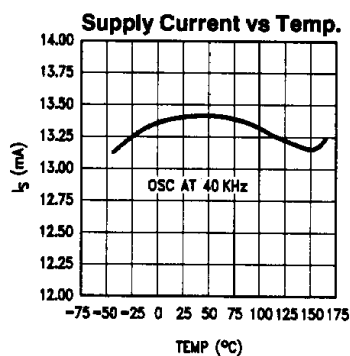
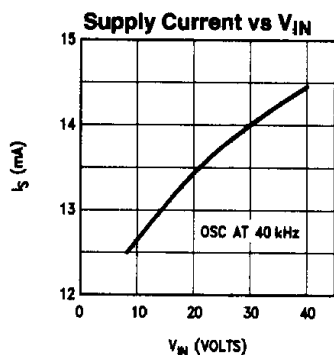
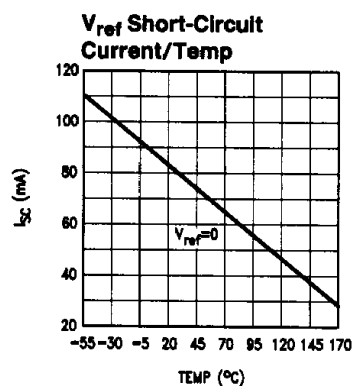
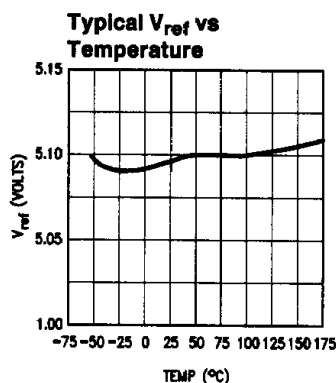
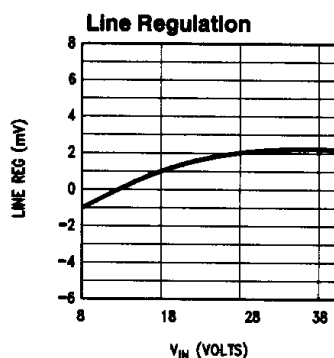
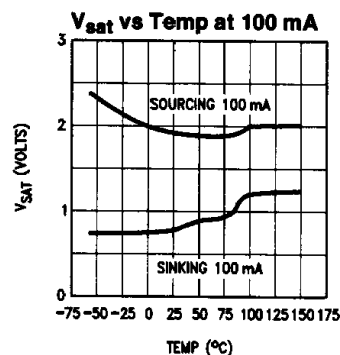
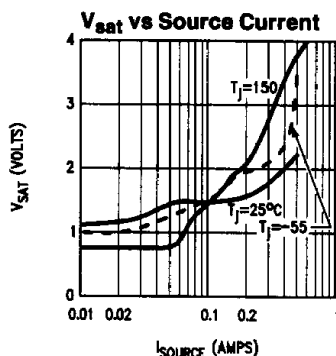
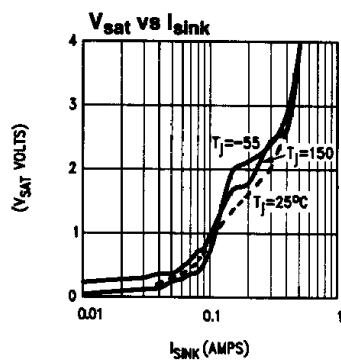


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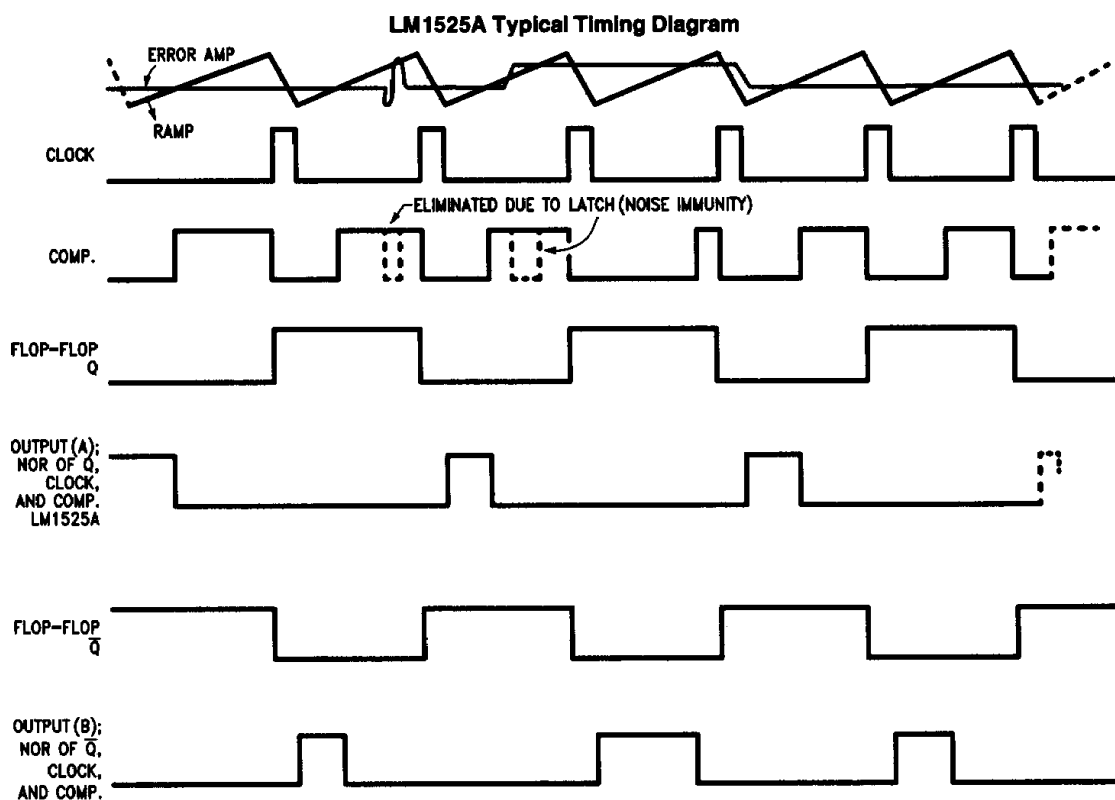
## LM1525A Error Amplifier



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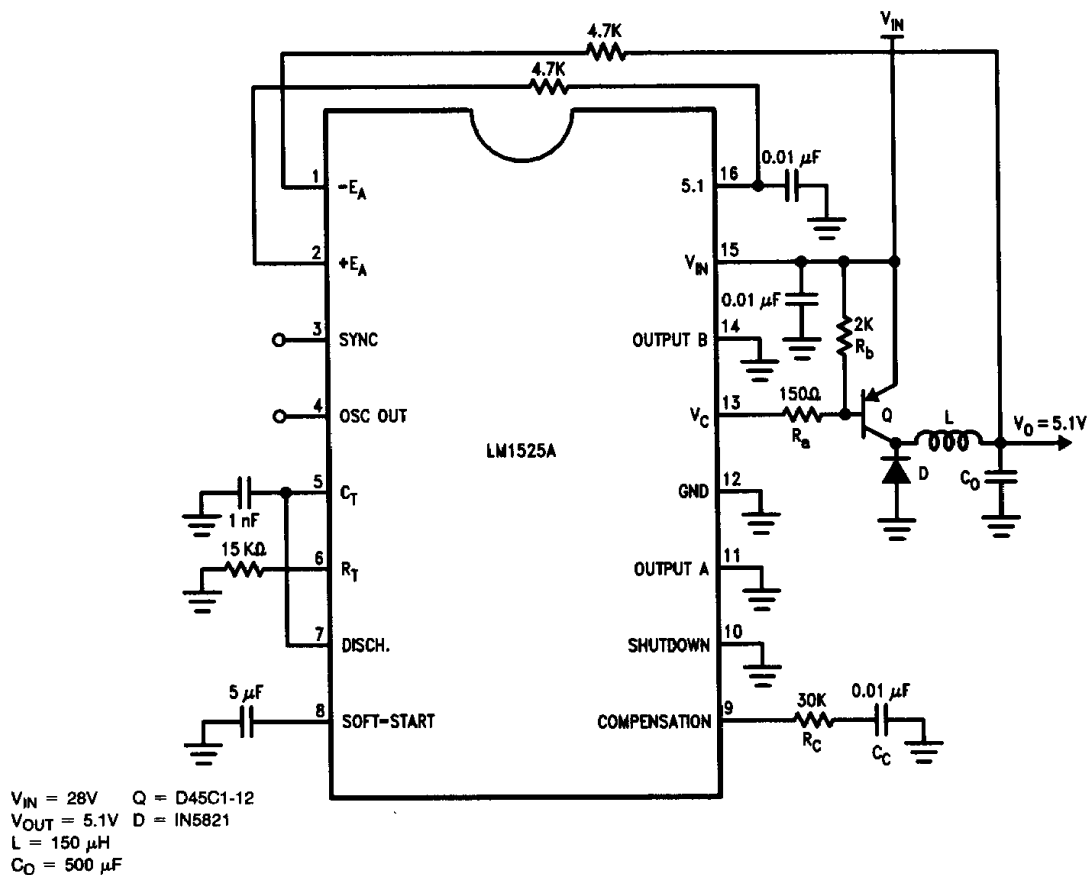
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## Typical Applications

### 5 Watt Single Ended Step Down Converter

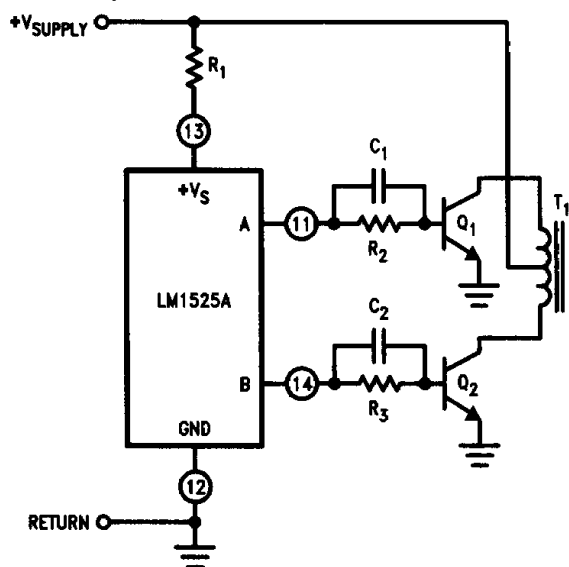


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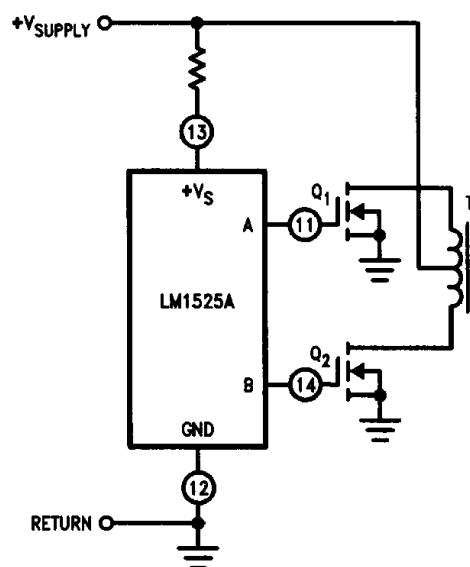
# Typical Applications (Continued)

## Bipolar Drive for Push-Pull Converters



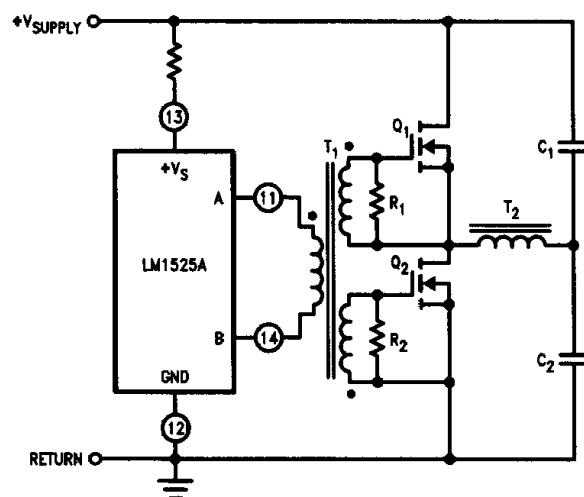
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## 3 MOSFET Drive for Push-Pull Converters



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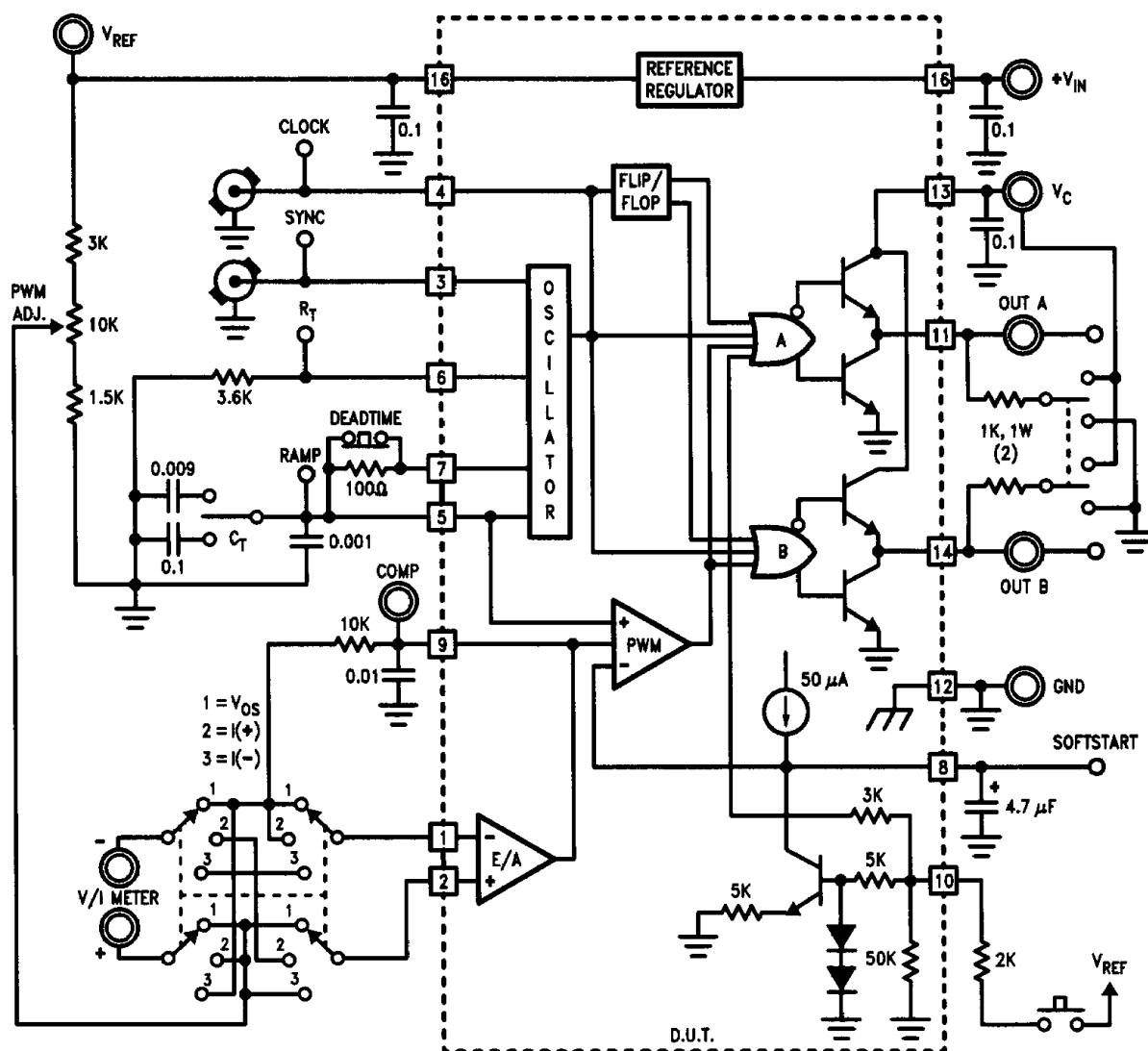
## Direct Drive for Transformer



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### Typical Applications (Continued)

## LM1525A/1527A Lab Test Fixture



TL/H/9112-12

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