Regulating Pulse Width Modulator

OBSOLETE:
FOR INFORMATION PURPOSES ONLY
Contact Linear Technology for Potential Replacement

FEATURES

- 8V to 35V Operation
- *Guaranteed* ±1% 5V Reference
- *Guaranteed* 10mV/1000 Hrs. Long Term Stability
- *Guaranteed* ±3% Oscillator Temperature Stability
- Undervoltage Lockout
- 100mA Source/Sink Outputs

APPLICATIONS

- Switching Power Supplies
- Motor Speed Control
- Power Converters

DESCRIPTION

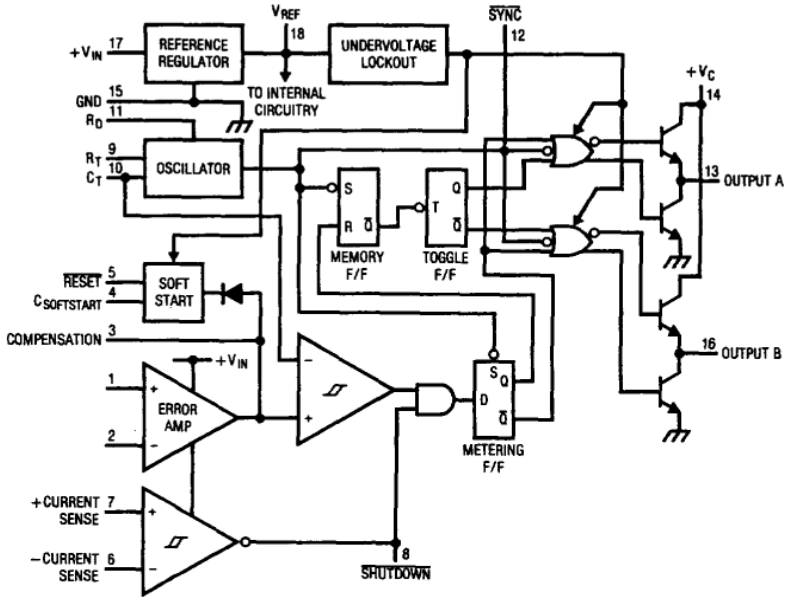
The LT1526 is an improved general purpose switching regulator control ciruit. Included on the chip are a 1% voltage reference, oscillator, error amplifier, pulse width modulator and low impedance output drivers. Also included are protective features such as a current limit comparator, undervoltage lockout, soft-start circuitry, and adjustable deadtime. This versatile device can be used to implement single-ended or push-pull switching regulators of either polarity, both transformerless and transformer-coupled.

Although pin-for-pin and functionally compatible with industry standard 1526 and 3526 devices, Linear Technology has incorporated several improvements in the design of the LT1526. A subsurface zener has been used to provide excellent reference voltage stability and the reference offers improved line regulation and load regulation. The current limit comparator sense voltage initial accuracy and temperature stability have been greatly improved.

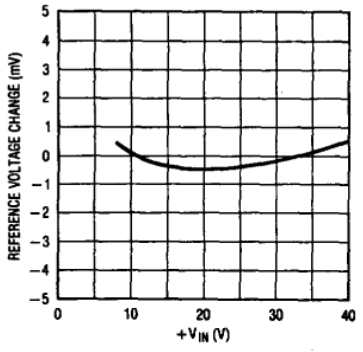
The combination of improved features and advanced linear processing for high reliability make Linear Technology's switching regulators a superior choice.

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BLOCK DIAGRAM



Reference Line Regulation

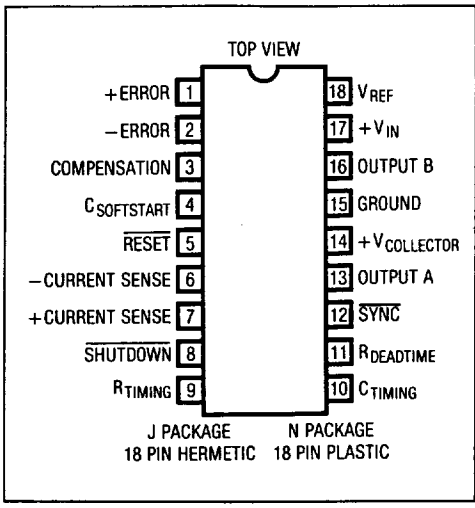


ABSOLUTE MAXIMUM RATINGS

(Note 1)

Input Voltage ($+V_{IN}$) ..... +40V
Collector Supply Voltage ($+V_C$) ..... +40V
Logic Inputs ..... −0.3V to +5.5V
Analog Inputs ..... −0.3V to $+V_{IN}$
Source/Sink Load Current (each output) 200mA
Reference Load Current 50mA
Logic Sink Current 15mA
Operating Junction Temperature Range
LT1526 ..... −55°C to +150°C
LT3526 ..... 0°C to +125°C
Storage Temperature Range ..... −65°C to +150°C
Lead Temperature (Soldering, 10sec) ..... +300°C

PACKAGE/ORDER INFORMATION



ORDER PART NUMBER
LT1526J LT3526J LT3526N

RECOMMENDED OPERATING CONDITIONS (Note 2)

Input Voltage ..... +8V to +35V
Collector Supply Voltage ..... +4.5V to +35V
Sink/Source Load Current (each output) ... 0mA to 100mA
Reference Load Current ..... −5mA to 20mA
Oscillator Frequency Range ..... 1Hz to 400kHz
Oscillator Timing Resistor ..... 2kΩ to 150kΩ
Oscillator Timing Capacitor ..... 1nF to 20μF
Available Deadtime Range at 40kHz ..... 3% to 50%

ELECTRICAL CHARACTERISTICS

($+V_{IN}$ = 15V, and over operating junction temperature, unless otherwise specified.)

PARAMETER	CONDITIONS		LT1526 MIN	LT1526 TYP	LT1526 MAX	LT3526 MIN	LT3526 TYP	LT3526 MAX	UNITS
REFERENCE SECTION (Note 3)									
Output Voltage	T_j = +25°C		4.95	5.00	5.05	4.90	5.00	5.10	V
Line Regulation	$+V_{IN}$ = 8V to 35V	●		2	10		2	15	mV
Load Regulation	I_L = −5mA to +20mA	●		5	10		5	20	mV
Temperature Stability		●		15	50		15	50	mV
Total Output Voltage Range	Over Recommended Operating Conditions	●	4.90	5.00	5.10	4.85	5.00	5.15	V
Short Circuit Current	V_{REF} = 0V	●	25	50	100	25	50	100	mA
Long Term Stability	T_j = 125°C			2	10		2	10	mV/√khr
UNDERVOLTAGE LOCKOUT									
RESET Output Voltage	V_{REF} = 3.8V	●		0.2	0.4		0.2	0.4	V
RESET Output Voltage	V_{REF} = 4.8V	●	2.4	4.8		2.4	4.8		V
OSCILLATOR SECTION (Note 4)									
Initial Accuracy	T_j = +25°C			±3	±8		±3	±8	%
Voltage Stability	$+V_{IN}$ = 8V to 35V	●		0.5	1		0.5	1	%
Temperature Stability		●		1	3		1	3	%

ELECTRICAL CHARACTERISTICS

(+ V_{IN} = 15V, and over operating junction temperature, unless otherwise specified.)

PARAMETER	CONDITIONS		LT1526 MIN	LT1526 TYP	LT1526 MAX	LT3526 MIN	LT3526 TYP	LT3526 MAX	UNITS
OSCILLATOR SECTION (Note 4)									
Minimum Frequency	R_T = 150kΩ, C_T = 20μF	●			1			1	Hz
Maximum Frequency	R_T = 2kΩ, C_T = 1.0nF	●		400			400		kHz
Sawtooth Peak Voltage	+ V_{IN} = 35V	●		3.0	3.5		3.0	3.5	V
Sawtooth Valley Voltage	+ V_{IN} = 8V	●	0.5	1.0		0.5	1.0		V
ERROR AMPLIFIER SECTION (Note 5)									
Input Offset Voltage	R_S ≤ 2kΩ	●		2	5		2	10	mV
Input Bias Current		●		−350	−1000		−350	−2000	nA
Input Offset Current		●		35	100		35	200	nA
DC Open Loop Gain	R_L ≥ 10MΩ	●	64	72		60	72		dB
High Output Voltage	$V_{pin1} - V_{pin2}$ ≥ 150mV, I_{source} = 100μA	●	3.6	4.2		3.6	4.2		V
Low Output Voltage	$V_{pin2} - V_{pin1}$ ≥ 150mV, I_{sink} = 100μA	●		0.2	0.4		0.2	0.4	V
Common-Mode Rejection	R_S ≤ 2kΩ	●	70	94		70	94		dB
Supply Voltage Rejection	+ V_{IN} = 12V to 18V	●	66	80		66	80		dB
PWM COMPARATOR (Note 4)									
Minimum Duty Cycle	$V_{compensation}$ = +0.4V	●			0			0	%
Maximum Duty Cycle	$V_{compensation}$ = +3.6V	●	45	49		45	49		%
DIGITAL PORTS ($\overline{SYNC}$, $\overline{SHUTDOWN}$, and $\overline{RESET}$)									
HIGH Output Voltage	I_{source} = 40μA	●	2.4	4.0		2.4	4.0		V
LOW Output Voltage	I_{sink} = 3.6mA	●		0.2	0.4		0.2	0.4	V
HIGH Input Current	V_{IH} = +2.4V	●		−125	−200		−125	−200	μA
LOW Input Current	V_{IL} = +0.4V	●		−225	−360		−225	−360	μA
CURRENT LIMIT COMPARATOR (Note 6)									
Sense Voltage	R_S ≤ 50Ω	●	90	100	110	80	100	120	mV
Input Bias Current		●		−3	−10		−3	−10	μA
SOFT-START SECTION									
Error Clamp Voltage	$\overline{RESET}$ = +0.4V	●		0.1	0.4		0.1	0.4	V
C_S Charging Current	$\overline{RESET}$ = +2.4V	●	50	100	150	50	100	150	μA
OUTPUT DRIVERS (Each Output) (Note 7)									
HIGH Output Voltage	I_{source} = 20mA	●	12.5	13.5		12.5	13.5		V
	I_{source} = 100mA	●	12	13		12	13		V
LOW Output Voltage	I_{sink} = 20mA	●		0.2	0.3		0.2	0.3	V
	I_{sink} = 100mA	●		1.2	2.0		1.2	2.0	V
Collector Leakage	V_C = 40V	●		50	150		50	150	μA
Rise Time	C_L = 1000pF	●		0.3	0.6		0.3	0.6	μs
Fall Time	C_L = 1000pF	●		0.1	0.2		0.1	0.2	μs
POWER CONSUMPTION (Note 8)									
Standby Current	$\overline{SHUTDOWN}$ = +0.4V	●		18	30		18	30	mA

The ● denotes specifications that apply over the full operating temperature range.

The shaded electrical specifications indicate those parameters which have been improved or guaranteed test limits provided for the first time.

Note 1: Values beyond which damage may occur.

Note 2: Range over which the device is functional and parameter limits are guaranteed.

Note 3: I_L = 0mA.

Note 4: f_{OSC} = 40kHz (R_T = 4.12kΩ ± 1%, C_T = 0.01μF ± 1%, R_D = 0Ω).

Note 5: V_{CM} = 0V to +5.2V.

Note 6: V_{CM} = 0 to V_{IN} − 3V. The current limit sense voltage for the LT1526 is 80mV ≤ V_{SENSE} ≤ 120mV for temperatures less than 0°C or greater than 125°C.

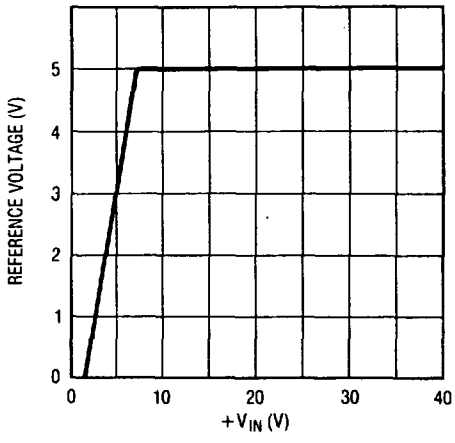
Note 7: V_C = +15V.

Note 8: + V_{IN} = +35V, R_T = 4.12kΩ.

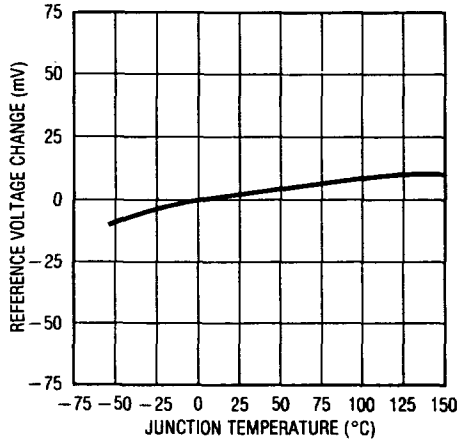
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TYPICAL PERFORMANCE CHARACTERISTICS

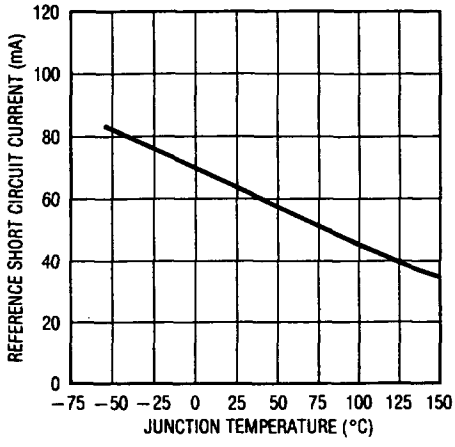
Reference Voltage vs Supply Voltage



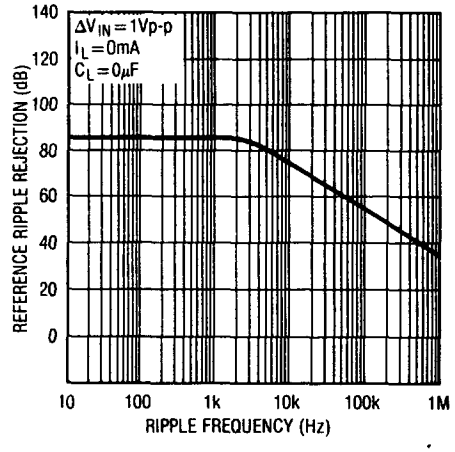
Reference Temperature Stability



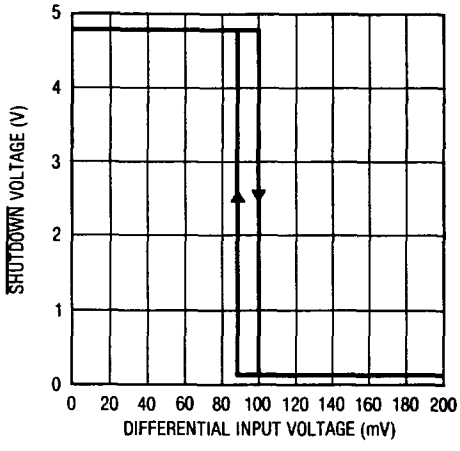
Reference Short Circuit Current



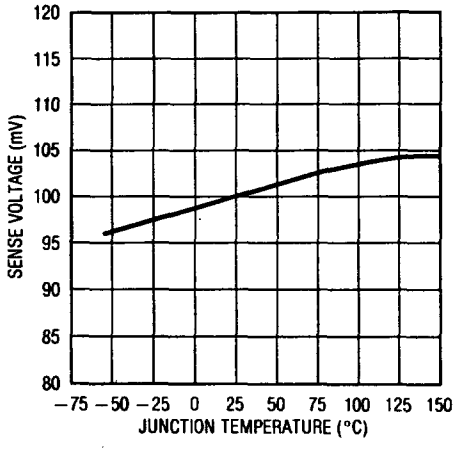
Reference Ripple Rejection



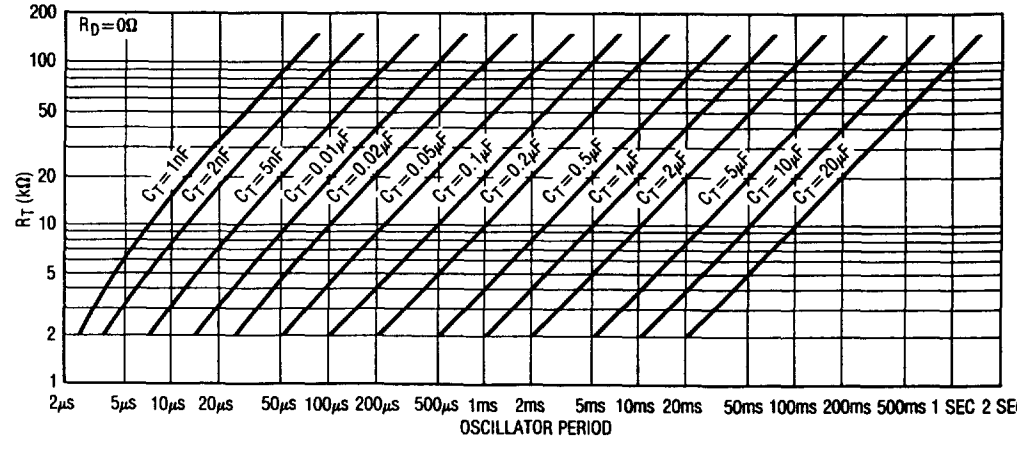
Current Limit Comparator Transfer Function



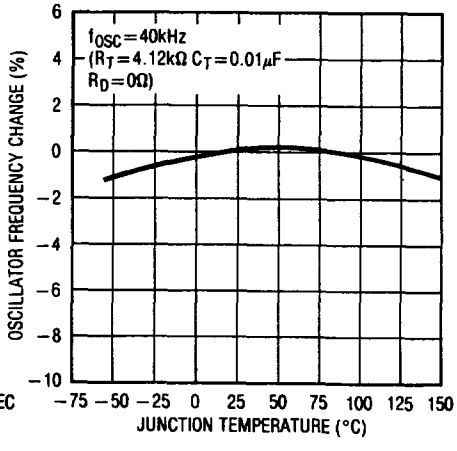
Current Limit Comparator Sense Voltage



Oscillator Period vs R_T and C_T

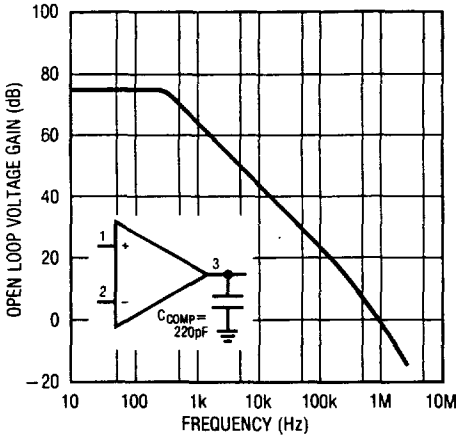


Oscillator Frequency Temperature Stability

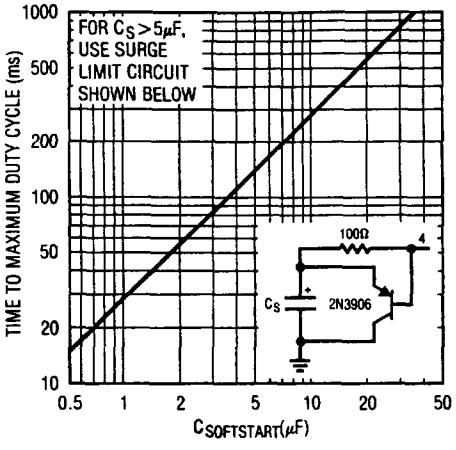


TYPICAL PERFORMANCE CHARACTERISTICS

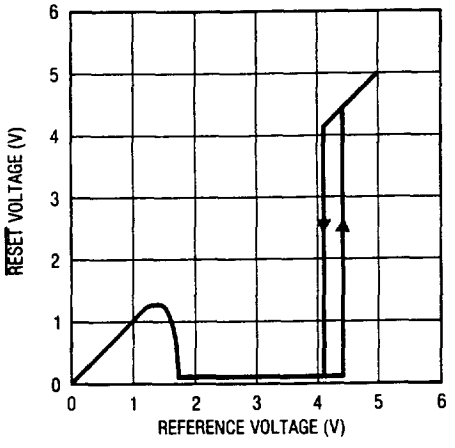
Error Amplifier Open Loop Gain vs Frequency



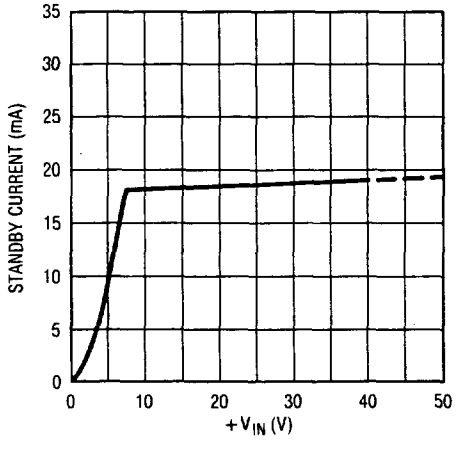
Soft-start Time Constant vs C_S



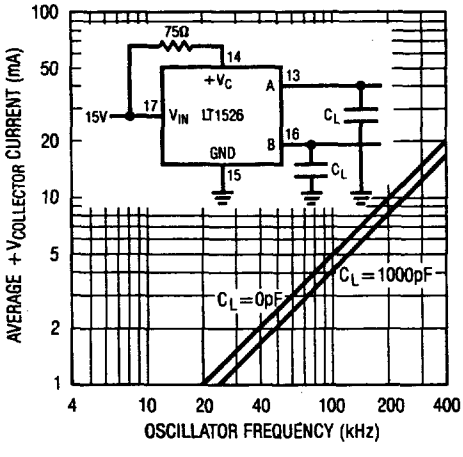
Undervoltage Lockout Characteristic



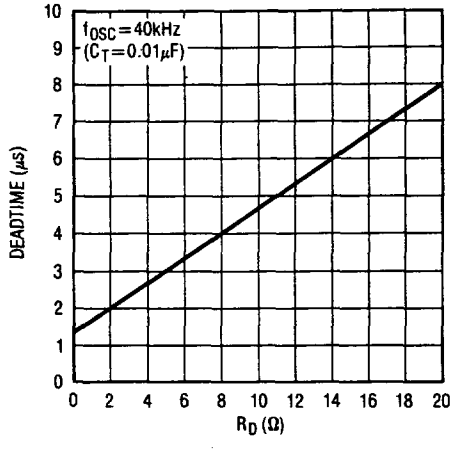
Standby Current vs Supply Voltage



+ $V_{COLLECTOR}$ Current (Note 9)

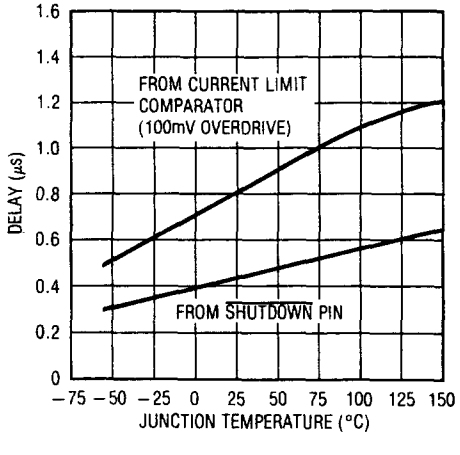


Output Driver Deadtime vs R_D

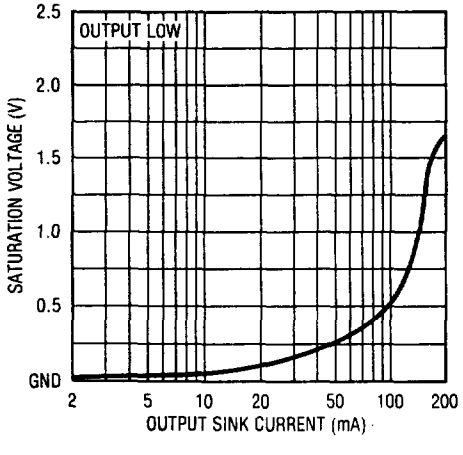


NOTE 9: TRANSIENT CURRENTS OCCUR WITHIN THE OUTPUT STAGES DURING SWITCHING, INDEPENDENT OF LOADING. THE GRAPH SHOWS THE AVERAGE (DC) VALUE OF THE TRANSIENT CURRENTS.

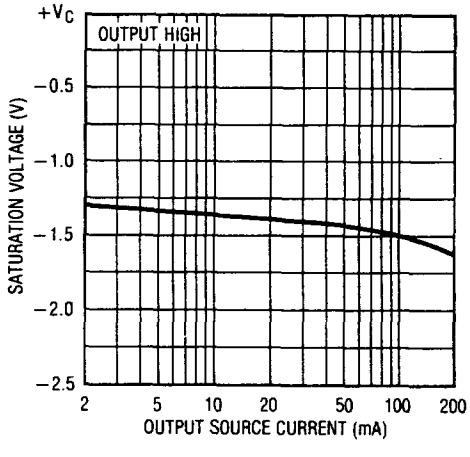
Output Driver Shutdown Delay



Output Driver Saturation Voltage vs I_{SINK}



Output Driver Saturation Voltage vs I_{SOURCE}



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APPLICATIONS INFORMATION

FUNCTIONAL DESCRIPTION AND PIN FUNCTION

Voltage Reference

The reference regulator (pin 18) supplies a regulated 5.0V to all internal circuitry, as well as up to 20mA for external circuitry. It is fully active at supply voltages (pin 17) of 8V and greater.

The LT1526 can operate from a 5V supply by connecting $+V_{IN}$ to V_{REF} (pin 18 to pin 17) and maintaining the supply between 4.8V and 5.2V.

Undervoltage Lockout

The undervoltage lockout circuitry protects both the switching regulator and the power devices it controls from inadequate supply voltage, which can result in unstable control circuitry. If $+V_{IN}$ is too low, the circuit turns off the output drivers, holds $\overline{RESET}$ (pin 5) low and the soft-start capacitor in a discharged state.

Soft-Start

The soft-start circuitry protects the power devices from high surge currents during power supply turn-on by limiting the available PWM duty cycle.

When $+V_{IN}$ reaches a sufficient voltage to allow $\overline{RESET}$ to go high, a 100μA current source charges the external C_S capacitor (pin 4) linearly to 5V. The ERROR AMPLIFIER output is clamped to 600mV above the C_S voltage, and the available duty cycle of the PWM increases linearly. Maximum duty cycle is available when the C_S voltage reaches about 3V.

Digital Control Ports

The three digital control ports are bidirectional. Each port can drive TTL and 5V CMOS logic directly. They can also be driven by open-collector TTL, open-drain CMOS, and open-collector voltage comparators.

Driving $\overline{SYNC}$ (pin 12) low causes a discharge cycle in the oscillator. Driving $\overline{SHUTDOWN}$ (pin 8) low causes the outputs to turn off. Driving $\overline{RESET}$ (pin 5) low causes the outputs to turn off and discharges the C_S capacitor.

Oscillator

The internal oscillator circuitry sets the frequency of operation for the switching regulator. Frequency is set by R_T (pin 9), C_T (pin 10), and R_D (pin 11). With $R_D = 0\Omega$, the values for R_T and C_T may be chosen from the oscillator period graph. If the desired deadtime is increased, the value of R_T may need to be decreased to maintain the desired frequency.

The frequency at either output is half that of the oscillator, and the frequency at $+V_C$ (pin 14) is equal to the oscillator.

Synchronous Operation

Two or more switching regulators may be synchronized by setting the master to the desired frequency and sharing the oscillator signals with the slave units. Slave C_T pins are tied to the master C_T pin, and slave $\overline{SYNC}$ pins are tied to the master $\overline{SYNC}$ pin. Slave R_T and R_D pins are left open.

External logic synchronization can be used by setting the oscillator period to be 10% longer than the external clock period, and connecting the external clock to the $\overline{SYNC}$ pin. A periodic low of about 0.5μs wide will lock the oscillator to the external frequency.

Error Amplifier

The differential input (pins 1 and 2), single-ended output (pin 3) transconductance amplifier provides about 70dB of gain. The output has an impedance of 2MΩ, and since all voltage gain occurs at the output, the gain characteristics can be controlled with shunt reactance to ground.

Output Drivers

The totem-pole output drivers can source and sink 100mA continuously and 200mA peak. The outputs are driven 180° out of phase by the flip-flop. Loads can be driven either from the outputs or the $+V_C$ pin. Since large transient currents occur within the output stages during switching, a resistor is recommended in series with $+V_C$ (pin 14) to limit the peak current. The resistor value should be $+V_C/200mA$.

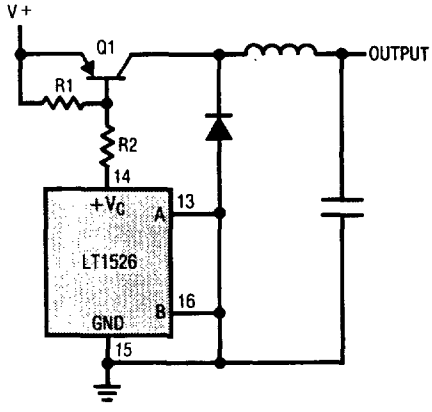
APPLICATIONS INFORMATION

Current Limit

The current limit comparator turns off the outputs when the input voltage (pin 7 to pin 6) exceeds 100mV. Hysteresis is built into the trip point, of about 10mV, to prevent oscillations.

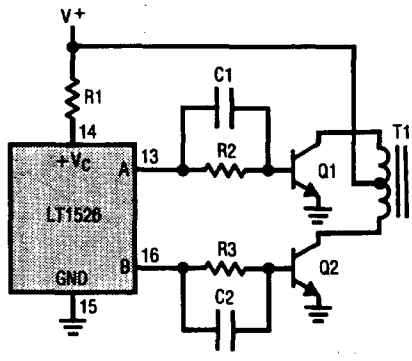
TYPICAL APPLICATIONS

Single Ended Supply



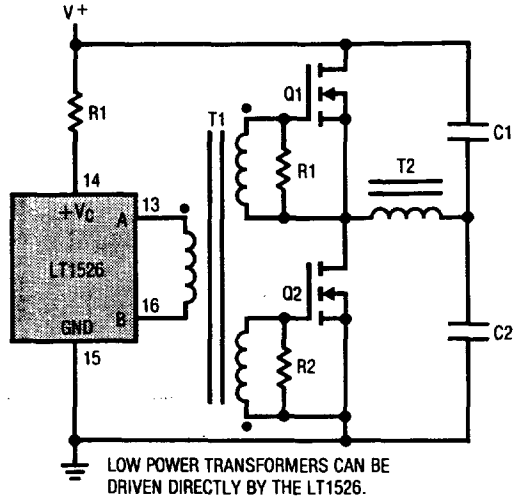
FOR SINGLE ENDED SUPPLIES, THE DRIVER OUTPUTS ARE GROUNDED. THE $+V_C$ TERMINAL IS SWITCHED TO GROUND BY THE TOTEM POLE SOURCE TRANSISTORS ON EVERY OSCILLATOR CYCLE.

Bipolar Push-Pull Supply



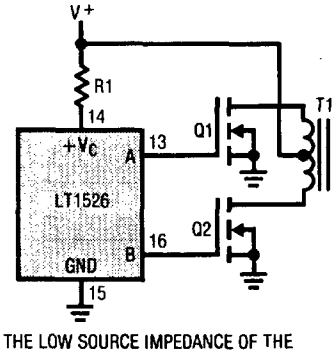
IN CONVENTIONAL BIPOLAR PUSH-PULL DESIGNS, FORWARD BASE DRIVE IS CONTROLLED BY R1-R3. RAPID TURN-OFF TIMES FOR THE POWER DEVICES ARE ACHIEVED WITH SPEED-UP CAPACITORS C1 AND C2.

Driving Transformers Directly



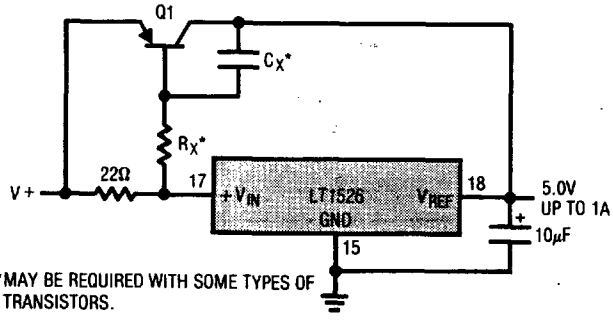
LOW POWER TRANSFORMERS CAN BE DRIVEN DIRECTLY BY THE LT1526. AUTOMATIC RESET OCCURS DURING DEAD-TIME, WHEN BOTH ENDS OF THE PRIMARY WINDING ARE SWITCHED TO GROUND.

Power FETs Push-Pull Supply



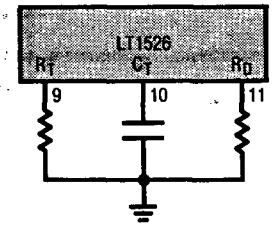
THE LOW SOURCE IMPEDANCE OF THE OUTPUT DRIVERS PROVIDES RAPID CHARGING OF POWER FET INPUT CAPACITANCE, WHILE MINIMIZING EXTERNAL COMPONENTS.

Extending Reference Output Current

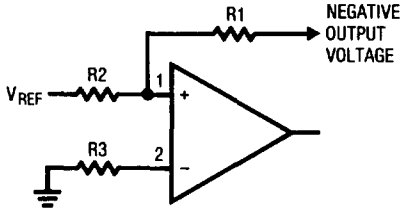


*MAY BE REQUIRED WITH SOME TYPES OF TRANSISTORS.

Oscillator Connections

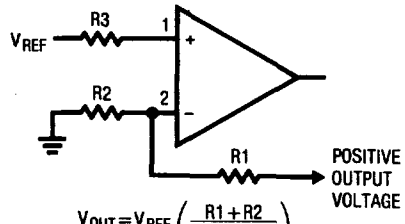


Error Amplifier Connections



$$V_{OUT} = V_{REF}\left(\frac{R1}{R2}\right)$$

$$R3 = \left(\frac{R1R2}{R1+R2}\right)$$

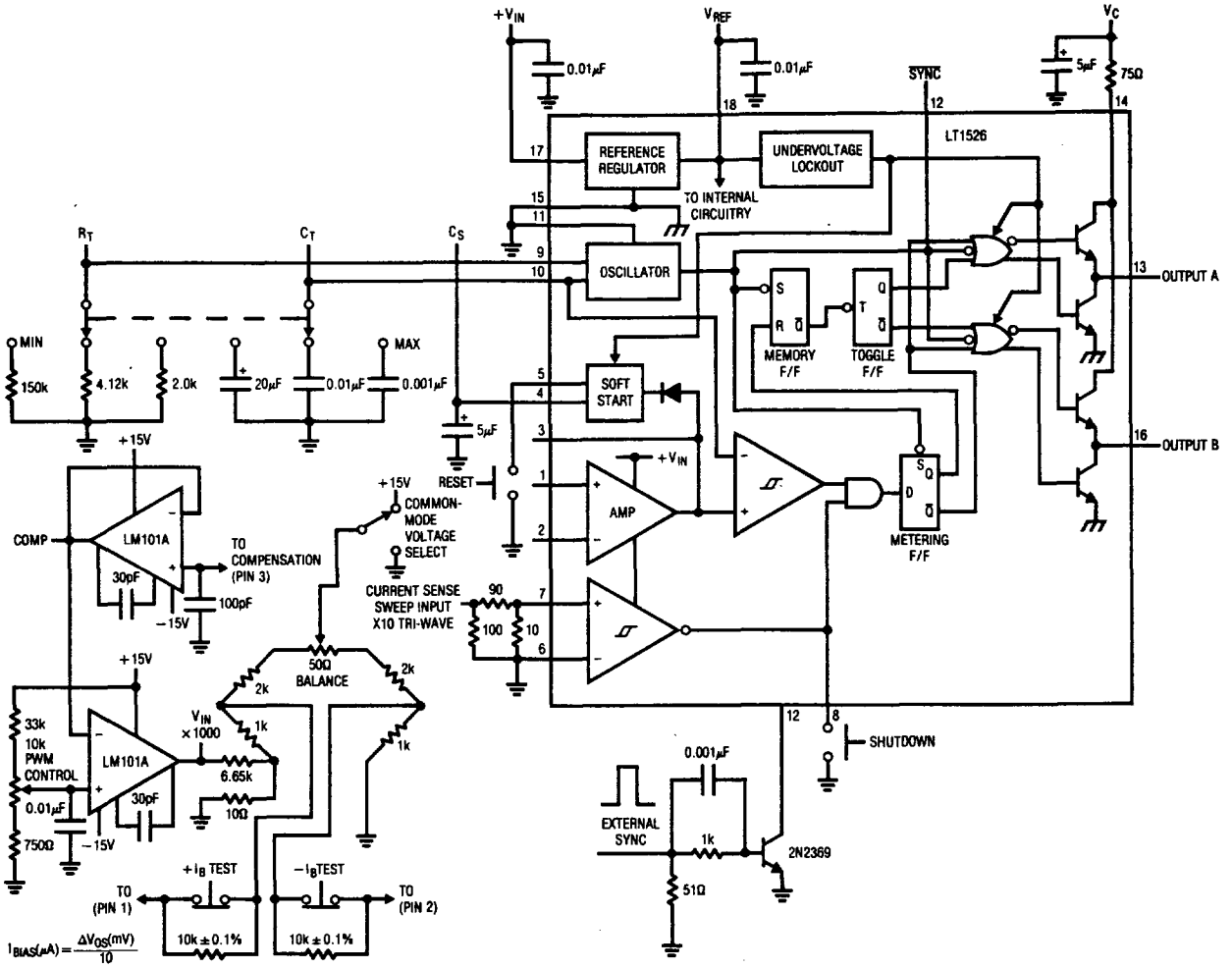


$$V_{OUT} = V_{REF}\left(\frac{R1+R2}{R2}\right)$$

$$R3 = \left(\frac{R1R2}{R1+R2}\right)$$

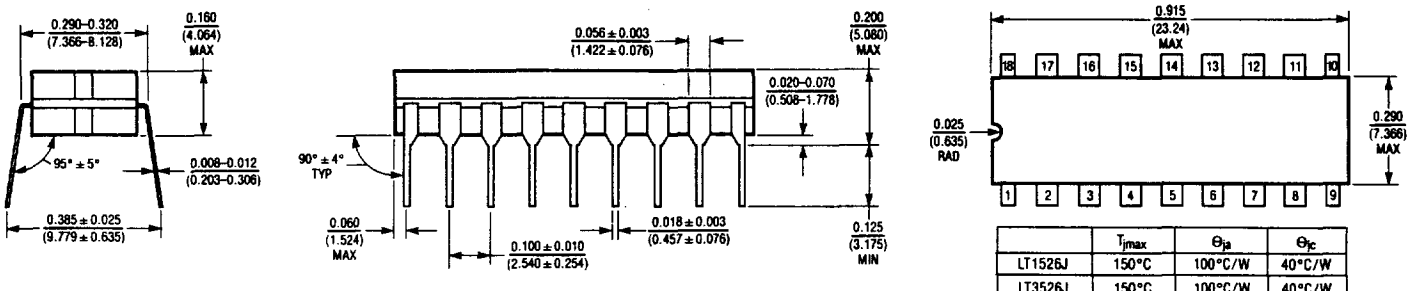
TYPICAL APPLICATIONS

LT1526 Lab Test Fixture



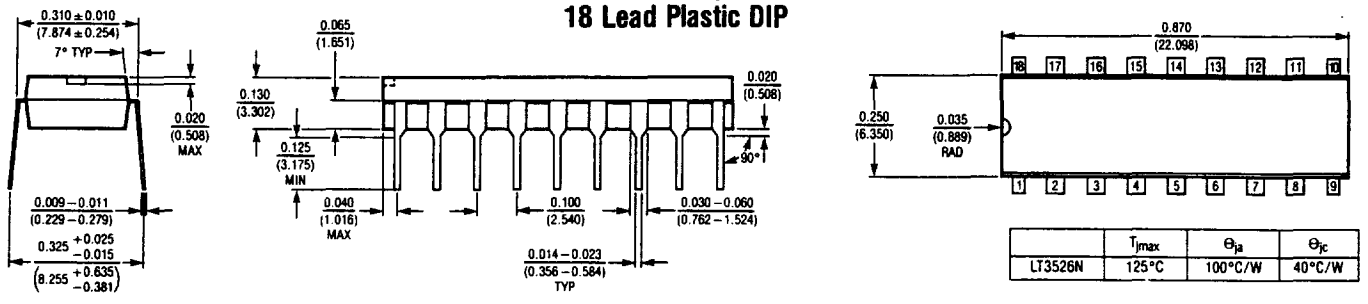
PACKAGE DESCRIPTION

J Package
18 Lead Ceramic DIP



	T_{jmax}	Θ_{ja}	Θ_{jc}
LT1526J	150°C	100°C/W	40°C/W
LT3526J	150°C	100°C/W	40°C/W

N Package
18 Lead Plastic DIP



	T_{jmax}	Θ_{ja}	Θ_{jc}
LT3526N	125°C	100°C/W	40°C/W

LINEAR TECHNOLOGY