

## REGULATING PULSE WIDTH MODULATOR

### DESCRIPTION

This monolithic integrated circuit contains all the control circuitry for a regulating power supply inverter or switching regulator. Included in a 16-pin dual-in-line package is the voltage reference, error amplifier, oscillator, pulse width modulator, pulse steering flip-flop, dual alternating output switches and current limiting and shut-down circuitry. This device can be used for switching regulators of either polarity, transformer coupled DC to DC converters, transformerless voltage doublers and polarity converters, as well as other power applications. The SG1524 is specified for operation over the full military ambient temperature range of  $-55^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ , the SG2524 for  $-25^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ , and the SG3524 is designed for commercial applications of  $0^{\circ}\text{C}$  to  $+70^{\circ}\text{C}$ .

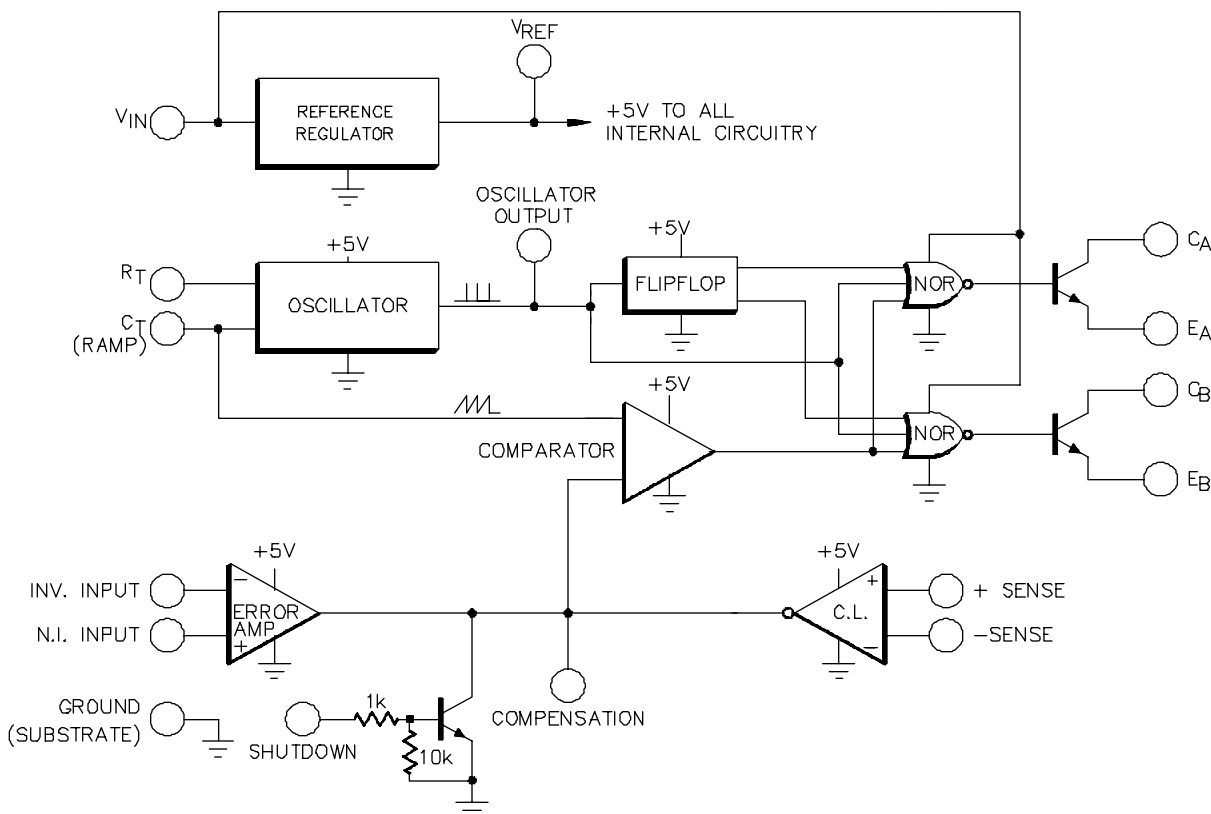
### FEATURES

- 8V to 40V operation
- 5V reference
- Reference line and load regulation of 0.4%
- Reference temperature coefficient  $< \pm 1\%$
- 100Hz to 300KHz oscillator range
- Excellent external sync capability
- Dual 50mA output transistors
- Current limit circuitry
- Complete PWM power control circuitry
- Single ended or push-pull outputs
- Total supply current less than 10mA

### HIGH RELIABILITY FEATURES - SG1524

- ◆ Available to MIL-STD-883B and DESC SMD
- ◆ MIL-M-38510/12601BEA - JAN1524J
- ◆ Radiation data available
- ◆ LMI level "S" processing available

### BLOCK DIAGRAM



## ABSOLUTE MAXIMUM RATINGS (Note 1)

Input Voltage (+V <sub>IN</sub> )	42V
Collector Voltage	40V
Logic Inputs	-0.3V to 5.5V
Current Limit Sense Inputs	-0.3V to 0.3V
Output Current (each transistor)	100mA
Reference Load Current	50mA

Note 1. Values beyond which damage may occur.

Oscillator Charging Current	5mA
Operating Junction Temperature	
Hermetic (J, L Packages)	150°C
Plastic (N, D Packages)	150°C
Storage Temperature Range	-65°C to 150°C
Pb-free / RoHS Peak Package Solder Reflow Temp (40 sec. max. exposure)... 260°C (+0, -5)	
Lead Temperature (Soldering, 10 seconds)	300°C

## THERMAL DATA

### J Package:

Thermal Resistance-Junction to Case, $\theta_{JC}$	30°C/W
Thermal Resistance-Junction to Ambient, $\theta_{JA}$	80°C/W

### N Package:

Thermal Resistance-Junction to Case, $\theta_{JC}$	40°C/W
Thermal Resistance-Junction to Ambient, $\theta_{JA}$	65°C/W

### D Package:

Thermal Resistance-Junction to Case, $\theta_{JC}$	50°C/W
Thermal Resistance-Junction to Ambient, $\theta_{JA}$	120°C/W

### L Package:

Thermal Resistance-Junction to Case, $\theta_{JC}$	35°C/W
Thermal Resistance-Junction to Ambient, $\theta_{JA}$	120°C/W

Note A. Junction Temperature Calculation:  $T_J = T_A + (P_D \times \theta_{JA})$ .

Note B. The above numbers for  $\theta_{JC}$  are maximums for the limiting thermal resistance of the package in a standard mounting configuration. The  $\theta_{JA}$  numbers are meant to be guidelines for the thermal performance of the device/pc-board system. All of the above assume no ambient airflow.

## RECOMMENDED OPERATING CONDITIONS (Note 2)

Input Voltage (+V <sub>IN</sub> )	8V to 40V
Collector Voltage	0V to 40V
Error Amp Common Mode Range	1.8V to 3.4V
Current Limit Sense Common Mode Range	-0.3V to 0.3V
Output Current (each transistor)	0 to 50mA
Reference Load Current	0 to 20mA
Oscillator Charging Current	30µA to 2mA

Oscillator Frequency Range	100Hz to 300KHz
Oscillator Timing Resistor (R <sub>T</sub> )	1.8KΩ to 100KΩ
Oscillator Timing Capacitor (C <sub>T</sub> )	1nF to 1.0µF
Operating Ambient Temperature Range	
SG1524	-55°C to 125°C
SG2524	-25°C to 85°C
SG3524	0°C to 70°C

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

## ELECTRICAL CHARACTERISTICS

(Unless otherwise specified, these specifications apply over the operating ambient temperatures for SG1524 with  $-55^\circ\text{C} \leq T_A \leq 125^\circ\text{C}$ , SG2524 with  $-25^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$ , SG3524 with  $0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$ , and +V<sub>IN</sub> = 20V. Low duty cycle pulse testing techniques are used which maintains junction and case temperatures equal to the ambient temperature.)

Parameter	Test Conditions	SG1524/2524			SG3524			Units
		Min.	Typ.	Max.	Min.	Typ.	Max.	
Reference Section (Note 3)								
Output Voltage	T <sub>J</sub> = 25°C	4.80	5.00	5.20	4.60	5.00	5.40	V
Line Regulation	V <sub>IN</sub> = 8V to 40V			20			30	mV
Load Regulation	I <sub>L</sub> = 0 to 20mA			50			50	mV
Temperature Stability (Note 7)	Over Operating Temperature Range			50			50	mV
Total Output Voltage Range (Note 7)	Over Line, Load and Temperature	4.80		5.20	4.60		5.40	V
Short Circuit Current	V <sub>RFF</sub> = 0V	25	50	150	25	50	150	mA

Note 3. I<sub>L</sub> = 0mA

# ELECTRICAL CHARACTERISTICS (continued)

Parameter	Test Conditions	SG1524/2524			SG3524			Units
		Min.	Typ.	Max.	Min.	Typ.	Max.	
Oscillator Section (Note 4)								
Initial Accuracy	T <sub>J</sub> = 25°C	36	40	44	36	40	44	KHz
	MIN ≤ T <sub>J</sub> ≤ MAX	34		46	34		46	KHz
Voltage Stability	V <sub>IN</sub> = 8V to 40V		0.1	1		0.1	1	%
Maximum Frequency	R <sub>T</sub> = 2KΩ, C <sub>T</sub> = 1nF	200	400		200	400		KHz
Sawtooth Peak Voltage	V <sub>IN</sub> = 40V	3		3.8	3		3.8	V
Sawtooth Valley Voltage	V <sub>IN</sub> = 8V	0.6	1	1.2	0.6	1	1.2	V
Clock Amplitude		3.2			3.2			V
Clock Pulse Width		0.3		1.5	0.3		1.5	μs
Error Amplifier Section (Note 5)								
Input Offset Voltage	R <sub>S</sub> ≤ 2KΩ		0.5	5		2	10	mV
Input Bias Current			1	10		1	10	μA
Input Offset Current				1			2	μA
DC Open Loop Gain	R <sub>L</sub> ≥10MΩ, T <sub>J</sub> = 25°C	72			60			dB
Output Low Level	V <sub>PIN 1</sub> - V <sub>PIN 2</sub> ≥ 150mV		0.2	0.5		0.2	0.5	V
Output High Level	V <sub>PIN 2</sub> - V <sub>PIN 1</sub> ≥150mV	3.8	4.2		3.8	4.2		V
Common Mode Rejection	V <sub>CM</sub> = 1.8V to 3.4V	70						dB
Supply Voltage Rejection	V <sub>IN</sub> = 8V to 40V	55						dB
Gain-Bandwidth Product (Note 7)	T <sub>J</sub> = 25°C	1	2		1	2		MHz
P.W.M. Comparator (Note 4)								
Minimum Duty Cycle	V <sub>COMP</sub> = 0.5V			0			0	%
Maximum Duty Cycle	V <sub>COMP</sub> = 3.6V	45	49		45	49		%
Current Limit Amplifier Section (Note 6)								
Sense Voltage	T <sub>J</sub> = 25°C	190	200	210	180	200	220	mV
Input Bias Current				200			200	μA
Shutdown Section								
Threshold Voltage	T <sub>J</sub> = 25°C	0.5	0.8	1.2	0.5	0.8	1.2	V
	MIN ≤ T <sub>J</sub> ≤ MAX	0.2		1.8	0.2		1.8	V
Output Section (each transistor)								
Collector Leakage Current	V <sub>CE</sub> = 40V			50			50	μA
Collector Saturation Voltage	I <sub>C</sub> = 50mA			2			2	V
Emitter Output Voltage	I <sub>E</sub> = 50mA	17			17			V
Collector Voltage Rise Time	R <sub>C</sub> = 2KΩ			0.4			0.4	μs
Collector Voltage Fall Time	R <sub>C</sub> = 2KΩ			0.2			0.2	μs
Power Consumption								
Standby Current	V <sub>IN</sub> = 40V		7	10		7	10	mA

Note 4.  $F_{OSC} = 40\text{KHz}$  ( $R_T = 2.9\text{K}\Omega, C_T = .01\mu\text{F}$ )

Note 5.  $V_{CM} = 2.5\text{V}$

Note 6.  $V_{CM} = 0\text{V}$

Note 7. These parameters, although guaranteed over the recommended operating conditions, are not 100% tested in production.



## APPLICATION NOTES (continued)

### CURRENT LIMITING

The current limiting circuitry of the SG1524 is shown in Figure 3. By matching the base-emitter voltages of Q1 and Q2, and assuming a negligible voltage drop across R1:

$$\text{C.L. Threshold} = V_{BE}(Q1) + I_1 \cdot R_2 - V_{BE}(Q2) = I_1 \cdot R_2 \\ \sim 200 \text{ mV}$$

Although this circuit provides a relatively small threshold with a negligible temperature coefficient, there are some limitations to its use because of its simplicity.

The most important of these is the limited common-mode voltage range:  $\pm 0.3$  volts around ground. This requires sensing in the ground or return line of the power supply. Also precautions should be taken to not turn on the parasitic substrate diode of the integrated circuit, even under transient conditions. A Schottky clamp diode at Pin 5 may be required in some configurations to achieve this.

A second factor to consider is that the response time is relatively slow. The current limit amplifier is internally compensated by  $R_1$ ,  $C_1$  and Q1, resulting in a roll-off pole at approximately 300 Hz. A third factor to consider is the bias current of the C.L. Sense pins. A constant current of approximately  $150\mu\text{A}$  flows out of Pin 4, and a variable current with a range of 0-150 $\mu\text{A}$  flows out of Pin 5. As a result, the equivalent source impedance seen by the current sense pins should be less than 50 ohms to keep the threshold error less than 5%.

Since the gain of this circuit is relatively low (42 dB), there is a transition region as the current limit amplifier takes over pulse width control from the error amplifier. For testing purposes, threshold is defined as the input voltage required to get 25% duty cycle (+2 volts at the error amplifier output) with the error amplifier signaling maximum duty cycle.

**APPLICATION NOTE:** If the current limit function is not used on the SG1524, the common-mode voltage range restriction requires both current sense pins to be grounded.

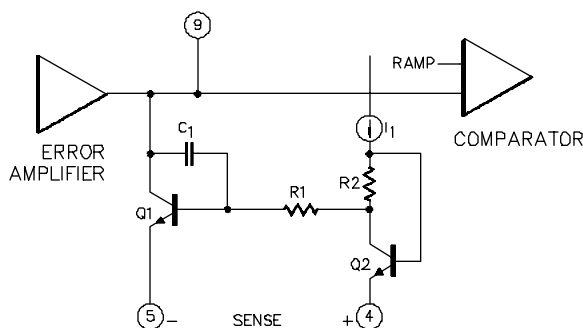
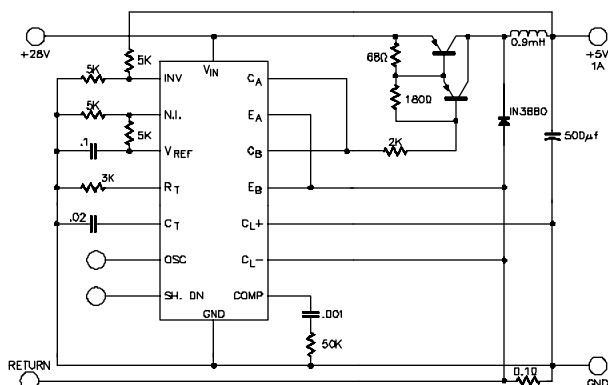
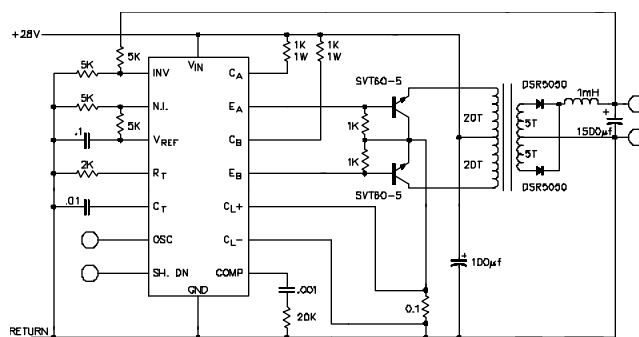


FIGURE 3 - CURRENT LIMITING CIRCUITRY OF THE SG1524



In this conventional single-ended regulator circuit, the two outputs of the SG1524 are connected in parallel for effective 0 - 90% duty-cycle modulation. The use of an output inductor requires an R-C phase compensation network for loop stability.



Push-pull outputs are used in this transformer-coupled DC-DC regulating converter. Note that the oscillator must be set at twice the desired output frequency as the SG1524's internal flip-flop divides the frequency by 2 as it switches the P.W.M. signal from one output to the other. Current limiting is done here in the primary so that the pulse width will be reduced should transformer saturation occur.

# CONNECTION DIAGRAMS & ORDERING INFORMATION (See Notes Below)

Package	Part No.	Ambient Temperature Range	Connection Diagram
16-PIN CERAMIC DIP J - PACKAGE	SG1524J/883B JAN1524J SG1524J/DESC SG1524J SG2524J SG3524J	-55°C to 125°C -55°C to 125°C -55°C to 125°C -55°C to 125°C -25°C to 85°C 0°C to 70°C	<p>N Package: RoHS / Pb-free Transition DC: 0503*. 100% Matte Tin Lead Finish</p>
16-PIN PLASTIC DIP N - PACKAGE	SG2524N SG3524N	-25°C to 85°C 0°C to 70°C	
16-PIN NARROW BODY PLASTIC S.O.I.C. D - PACKAGE	SG2524D SG3524D	-25°C to 85°C 0°C to 70°C	
20-PIN CERAMIC LEADLESS CHIP CARRIER L- PACKAGE	SG1524L/883B SG1524L	-55°C to 125°C -55°C to 125°C	

\*RoHS compliant

Note 1. Contact factory for JAN and DESC product availability.  
2. All packages are viewed from the top.