

# SG1524C/2524C/3524C

## Switched-Mode Power Supply Control Circuits

*Preliminary Specification*

### Linear Products

#### 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 control applications.

#### FEATURES

- Fully interchangeable with standard SG1524 family
- Precision reference internally trimmed to within 1% and guaranteed
- High-speed current limit function
- Low supply protection with hysteresis
- 200mA of output current
- 60V output capability
- Wide common-mode input range for both error amp and current limit comparator
- Very good CMRR & PSRR for both error amp and current limit comparator
- Superior logic design using ECL circuits for glitch-free high-speed operation and fault protection

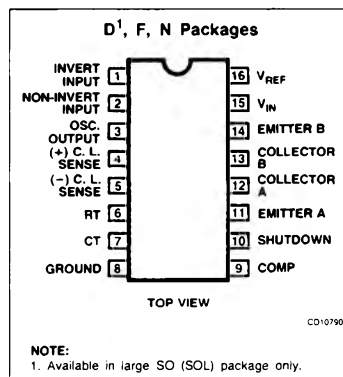
#### APPLICATIONS

- Switched-mode power supplies
- Motor control circuitry

#### ORDERING INFORMATION

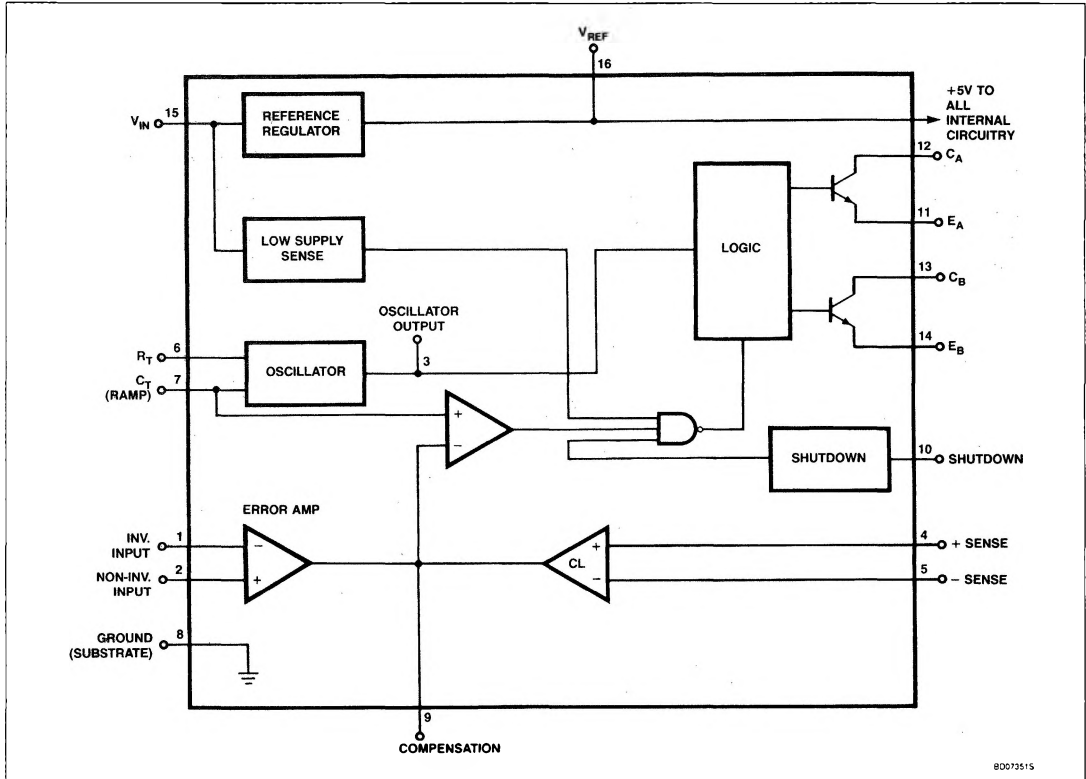
DESCRIPTION	TEMPERATURE RANGE	ORDER CODE
16-Pin Plastic DIP	0 to +70°C	SG3524CN
16-Pin Ceramic DIP	0 to +70°C	SG3524CF
16-Pin Plastic SOL	0 to +70°C	SG3524CD
16-Pin Plastic DIP	-40°C to +85°C	SG2524CN
16-Pin Ceramic DIP	-40°C to +85°C	SG2524CF
16-Pin Plastic SOL	-40°C to +85°C	SG2524CD
16-Pin Plastic DIP	-55°C to +125°C	SG1524CN
16-Pin Ceramic DIP	-55°C to +125°C	SG1524CF

#### PIN CONFIGURATION



# Switched-Mode Power Supply Control Circuits SG1524C/2524C/3524C

## BLOCK DIAGRAM



80073515

# Switched-Mode Power Supply Control Circuits SG1524C/2524C/3524C

## ABSOLUTE MAXIMUM RATINGS

SYMBOL	PARAMETER	RATING	UNIT
$V_{IN}$	Supply voltage	40	V
$V_C$	Collector supply voltage	60	V
$I_O$	Output current (each output)	250	mA
$I_{REF}$	Reference output current <sup>1</sup>	50	mA
$V_{REF}$	Externally forced reference voltage	5.5	V
	Error amp inputs	$V_{IN} - 3$	V
	Error amp max. diff. voltage <sup>2</sup>	0.5	V
	Oscillator charging current	5	mA
	Current limit sense inputs	$V_{IN}$	V
	Current limit max. diff. voltage	40	V
	Shutdown inputs	5.5	V
$P_D$	Maximum power dissipation $T_A = 25^\circ\text{C}$ (still-air) <sup>3, 4</sup>		
	F package	1190	mW
	N package	1450	mW
	D package	1090	mW
$T_J$	Operating junction temperature	150	$^\circ\text{C}$
$T_{STG}$	Storage temperature range	-65 to +150	$^\circ\text{C}$
$T_{SOLD}$	Lead soldering temperature (10sec max)	300	$^\circ\text{C}$

### NOTES:

- Short-circuit protected.
- Inputs are clamped by two diodes. Resistors should be used to limit input current to less than 1mA maximum.
- $P_D = I_{SB}V_{IN} + 2$  duty cycle ( $I_{OUT} V_{CE ON}$ ) +  $I_{REF} (V_{IN} - 5V) + 2I_{CT} (V_{IN} - 3.6)$
- Derate above  $25^\circ\text{C}$ , at the following rates:
  - F package at  $9.5\text{mW}/^\circ\text{C}$
  - N package at  $11.6\text{mW}/^\circ\text{C}$
  - D package at  $8.7\text{mW}/^\circ\text{C}$

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**RECOMMENDED OPERATING CONDITIONS**

<b>SYMBOL</b>	<b>PARAMETER</b>	<b>RATING</b>	<b>UNIT</b>
$V_{IN}$	Supply voltage	7 to 40	V
$V_C$	Collector supply voltage (with emitters grounded)	0 to 60	V
$I_O$	Output current (each output) ( $V_{CE} < 2.5V$ )	0 to 200	mA
$I_{REF}$	Reference load current	0 to 20	mA
$V_{CM}$	Error amp common-mode input	1.5 to ( $V_{IN} - 4$ )	V
$V_{CM}$	Current limit amp common-mode input	0 to ( $V_{IN} - 4$ )	V
	Oscillator charging current	0.02 to 2	mA
$R_T$	Oscillator timing resistor	2 to 150	k $\Omega$
$T_A$	Operating ambient temperature range SG1524C SG2524C SG3524C	-55 to 125 -40 to 85 0 to 70	$^{\circ}C$ $^{\circ}C$ $^{\circ}C$
$T_J$	Operating junction temperature range SG1524C SG2524C SG3524C	-55 to 150 -40 to 125 0 to 125	$^{\circ}C$ $^{\circ}C$ $^{\circ}C$
$C_T$	Oscillator timing capacitor	0.47 to 100	nF
$f_{OSC}$	Oscillator frequency	0.1 to 400	kHz

# Switched-Mode Power Supply Control Circuits SG1524C/2524C/3524C

**DC AND AC ELECTRICAL CHARACTERISTICS** Minimum and maximum limits apply over recommended operating junction temperature range, typical data applies at  $T_J = 25^\circ\text{C}$ , and  $V_{IN} = V_C = 20\text{V}$ ,  $R_T = 2.7\text{k}\Omega$ ,  $C_T = 0.01\mu\text{F}$ , unless otherwise specified.

SYMBOL	PARAMETER	TEST CONDITIONS	SG1524C/2524C			SG3524C			UNIT
			Min	Typ	Max	Min	Typ	Max	
<b>Turn-on characteristics</b>									
$V_{IN}$	Input minimum voltage	After turn-on	7		40	7		40	V
	Turn-on input voltage		4.9	6	6.5	4.9	6	6.5	V
	Input voltage hysteresis		100	240	360	100	240	360	mV
$V_{REF}$	Turn-on reference voltage		4.3	4.60	4.8	4.3	4.60	4.8	V
	Reference voltage hysteresis		100	240	360	100	240	360	mV
<b>Reference section<sup>1</sup></b>									
$V_{OUT}$	Output voltage	Over temperature	4.9		5.1	4.9		5.1	V
$V_{OUT}$	Output voltage	$T_J = 25^\circ\text{C}$	4.95	5.00	5.05	4.915	5.00	5.105	V
	Temperature stability			15	50		15	50	mV
	Line regulation	$V_{IN} = 7$ to $40\text{V}$		1.0	15		1.0	15	mV
	Load regulation	$I_L = 0$ to $20\text{mA}$		10	20		10	20	mV
	Total output variation	$7\text{V} < V_{IN} < 40\text{V}$ , $0\text{mA} < I_L < 20\text{mA}$	4.90	5.0	5.10	4.90	5.0	5.10	V
$I_{OUT}$	Maximum output current	$V_{REF} = 0\text{V}$	-120	-60	-25	-120	-60	-25	mA
	Output noise voltage	$10\text{Hz} < f < 10\text{kHz}$ , $T_A = 25^\circ\text{C}$		170			170		$\mu\text{VRMS}$
	Long-term stability	$T_A = 25^\circ\text{C}$ , 1khrs		20			20		mV
RR	Ripple rejection	$T_A = 25^\circ\text{C}$ , $f = 2400\text{Hz}$		60			60		dB
<b>Oscillator section</b>									
	Initial frequency		38	41	44	38	41	44	kHz
	Frequency temp. stability				2			2	%
	Voltage stability	$V_{IN} = 7$ to $40\text{V}$		0.5	1.0		0.5	1.0	%
	Sawtooth peak voltage	$V_{IN} = 40\text{V}$	3.2	3.5	3.8	3.2	3.5	3.8	V
	Sawtooth valley voltage	$V_{IN} = 7\text{V}$	0.5	.75	1.0	0.5	.75	1.0	V
	Clock amplitude		2.85	3.4		2.85	3.4		V
	Clock pulse width	Measured level = 2.0V	.25	0.5	.75	.25	0.5	.75	$\mu\text{s}$
$f_{MIN}$	Minimum frequency	$R_T = 150\text{k}\Omega$ , $C_T = 0.1\mu\text{F}$		100			100		Hz
$f_{MAX}$	Maximum frequency	$R_T = 2\text{k}\Omega$ , $C_T = 470\text{pF}$ , $T_J = 25^\circ\text{C}$		550			550		kHz
$f_{MAX}$	Maximum frequency	$R_T = 2\text{k}\Omega$ , $C_T = 470\text{pF}$	400			400			kHz
$f_{MAX}$	Maximum frequency	$R_T = 2\text{k}\Omega$ , $C_T = 1\text{nF}$	290			290			kHz
	Current mirror	$I_{RT} = -2\text{mA}^4$	-2.0	-1.86	-1.7	-2.0	-1.86	-1.7	mA
	Saturation voltage	$I_{CT} = 5\text{mA}$ , $V_{p3} = 5\text{V}$	.55	0.72	1.0	.55	0.72	1.0	V

## Switched-Mode Power Supply Control Circuits SG1524C/2524C/3524C

**DC AND AC ELECTRICAL CHARACTERISTICS** (Continued) Minimum and maximum limits apply over recommended operating junction temperature range, typical data applies at  $T_J = 25^\circ\text{C}$ , and  $V_{IN} = V_C = 20\text{V}$ ,  $R_T = 2.7\text{k}\Omega$ ,  $C_T = 0.01\mu\text{F}$ , unless otherwise specified.

SYMBOL	PARAMETER	TEST CONDITIONS	SG1524C/2524C			SG3524C			UNIT
			Min	Typ	Max	Min	Typ	Max	
<b>Error amplifier section<sup>2</sup></b>									
$V_{OS}$	Input offset voltage	$R_S = 2\text{k}\Omega$		1.0	5.0		1.0	10	mV
$I_{BIAS}$	Input bias current	$R_S = 1\text{k}\Omega$		1.0	5.0		1.0	10	$\mu\text{A}$
$I_{OS}$	Input offset current	$R_S = 1\text{k}\Omega$		0.04	1.0		0.04	1.0	$\mu\text{A}$
CMRR	Common-mode rejection ratio	$V_{CM} = 1.5$ to $12.5\text{V}$	75	85		75	85		dB
PSRR	Supply voltage rejection ratio	$V_{IN} = 7$ to $40\text{V}$	80	93		80	93		dB
	DC open-loop gain	$C_L = 0.01\mu\text{F}$ , $V_g = 1$ to $4\text{V}$	60	79		60	79		dB
	Gain bandwidth product	$T_A = 25^\circ\text{C}$ , $A_V = 0\text{B}$	2	5		2	5		MHz
	Output low level	$I_{SINK} = 100\mu\text{A}$ , $V_{CC1} - V_{CC2} > 0.15\text{V}$		0.3	0.5		0.3	0.5	V
	Output high level	$I_{SOURCE} = 100\mu\text{A}$ , $V_2 - V_1 > 0.15\text{V}$	5.0	5.6	6.0	5.0	5.6	6.0	V
	Output sink current	$V_1 - V_2 > 0.15\text{V}$ , $V_g = 2.5\text{V}$	100	136	170	100	136	170	$\mu\text{A}$
	Output source current	$V_2 - V_1 > 0.15\text{V}$ , $V_g = 2.5\text{V}$	-170	-140	-100	-170	-140	-100	$\mu\text{A}$
<b>PWM comparator section</b>									
	Minimum duty cycle	$V_2 = 0.5\text{V}$ , $V_g = V_1$			0			0	%
	Maximum duty cycle	$V_2 = 3.9\text{V}$ , $V_g = V_1$	45	48.7	50	45	48.7	50	%
	Duty cycle for max. freq.	$V_2 - V_1 > 0.15\text{V}$ , $R_T = 2\text{k}\Omega$ , $C_T = 470\text{pF}$	32		42	32		42	%
$I_{BIAS}$	Input bias current	$I_{RT} = 0\text{mA}$ , $V_2 = 2.5\text{V}$ , $V_g = V_1$	-5.0		0	-5.0		0	$\mu\text{A}$
	Propagation delay to output			0.5			0.5		$\mu\text{s}$
<b>Current-limiting section<sup>2</sup></b>									
	Sense voltage		180		220	170		230	mV
$I_{BIAS}$	Input bias current	$R_S = 10\text{k}\Omega$ , $V_2 - V_1 > 0.15\text{V}$	-5		0	-5		0	$\mu\text{A}$
CMRR	Common-mode rejection ratio	$V_{CM} = 0$ to $12.5\text{V}$	50	90		50	90		dB
PSRR	Power supply rejection ratio	$V_{IN} = 7$ to $40\text{V}$	50	90		50	90		dB
$V_{OL}$	Output low voltage	$V_2 - V_1 > 0.15\text{V}$ , $V_4 - V_5 > 0.3\text{V}$	0	0.28	0.2	0	0.28	0.2	V
$t_{PD}$	Propagation delay to output			0.7			0.7		$\mu\text{s}$

# Switched-Mode Power Supply Control Circuits SG1524C/2524C/3524C

**DC AND AC ELECTRICAL CHARACTERISTICS (Continued)** Minimum and maximum limits apply over recommended operating junction temperature range, typical data applies at  $T_J = 25^\circ\text{C}$ , and  $V_{IN} = V_C = 20\text{V}$ ,  $R_T = 2.7\text{k}\Omega$ ,  $C_T = 0.01\mu\text{F}$ , unless otherwise specified.

SYMBOL	PARAMETER	TEST CONDITIONS	SG1524C/2524C			SG3524C			UNIT
			Min	Typ	Max	Min	Typ	Max	
<b>Shutdown input</b>									
$I_{BIAS}$	Input bias current	$T_J = 25^\circ\text{C}$ , $V_{I0} = 1\text{V}$	10		200	10		200	$\mu\text{A}$
	Shutdown threshold voltage	$T_J = 25^\circ\text{C}$	0.6	0.8	1.0	0.6	0.8	1.0	V
	Shutdown threshold voltage		0.4		1.3	0.4		1.3	V
$t_{PD}$	Propagation delay to outputs			0.5			0.5		$\mu\text{s}$
<b>Output section (each output)</b>									
$V_{CE}$	Collector emitter voltage	$I_C = 100\mu\text{A}$	60	75		50	75		V
	Collector leakage current	$V_{CE} = 60\text{V}$ , $V_{I0} = 1.5\text{V}$		0.1	20		0.1	20	$\mu\text{A}$
	Collector saturation voltage	$I_C = 20\text{mA}$		0.2	0.4		0.2	0.4	V
	Collector saturation voltage	$I_C = 200\text{mA}$		1.2	2.0		1.2	2.0	V
	Emitter output voltage	$I_E = 20\text{mA}$	17.5	18		17.5	18		V
	Emitter output voltage	$I_E = 200\text{mA}$	16.5	17.5		16.5	17.5		V
$t_R$	Collector rise time	$T_A = 25^\circ\text{C}$ , $I_C = I_E = 10\text{mA}$ , $C_L = 15\text{pF}$		0.5	0.6		0.5	0.6	$\mu\text{s}$
	Emitter rise time			0.1	0.2		0.1	0.2	$\mu\text{s}$
$t_F$	Collector fall time	$T_A = 25^\circ\text{C}$ , $I_C = I_E = 10\text{mA}$ , $C_L = 15\text{pF}$		0.1	0.2		0.1	0.2	$\mu\text{s}$
	Emitter fall time			0.1	0.2		0.1	0.2	$\mu\text{s}$
<b>Total supply current<sup>3</sup></b>									
$I_{SB}$	Standby supply current	$V_{IN} = 40\text{V}$ , $I_{RT} = 0\text{mA}$ , $V_{I0} = 1.5\text{V}$		9.0	11.0		9.0	11.0	$\text{mA}$
$I_{CC}$	Operating supply current	$V_{IN} = 40\text{V}$ , $I_C = I_E = 10\text{mA}$		11	15		11	15	$\text{mA}$

**NOTES:**

1. Unless otherwise specified,  $I_L = 0\text{mA}$ .
2. Unless otherwise specified,  $V_{CM} = 2.5\text{V}$ .
3. Unless otherwise specified,  $I_{REF} = 0\text{mA}$ .
4.  $I_{RT}$  is the current into Pin 6.