CHERRY SEMICONDUCTOR

CS-1524
CS-2524
CS-3524

CS-1524/2524/3524

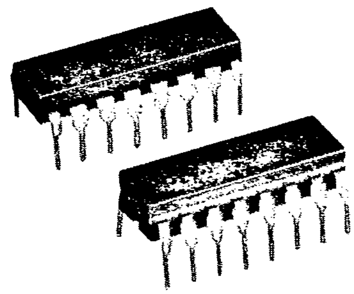
PULSE WIDTH MODULATOR CONTROL CIRCUIT
DUAL OUTPUT FOR SINGLE-ENDED OR PUSH-PULL APPLICATIONS

DESCRIPTION

The CS-1524, CS-2524 and CS-3524 incorporate all the functions required for the control of regulating power supplies, inverters or switching regulators. They can also be used as the control element for high-power-output applications. The CS-1524 family was designed for switching regulators of either polarity, transformer-coupled dc-to-dc converters, transformerless voltage doublers and polarity converter applications employing fixed-frequency, pulse-width modulation techniques. The dual alternating outputs allow either single-ended or push-pull applications. Each device includes an on-chip reference, error amplifier, programmable oscillator, pulse-steering flip-flop, two uncommitted output transistors, a high-gain comparator, and current-limiting and shut-down circuitry. The CS-1524 is characterized for operation over the full military temperature range of -55° C to +125° C. The CS-2524 and CS-3524 are designed for operation from -25° C to +85° C and 0° C to +70° C respectively.

RECOMMENDED OPERATING CONDITIONS

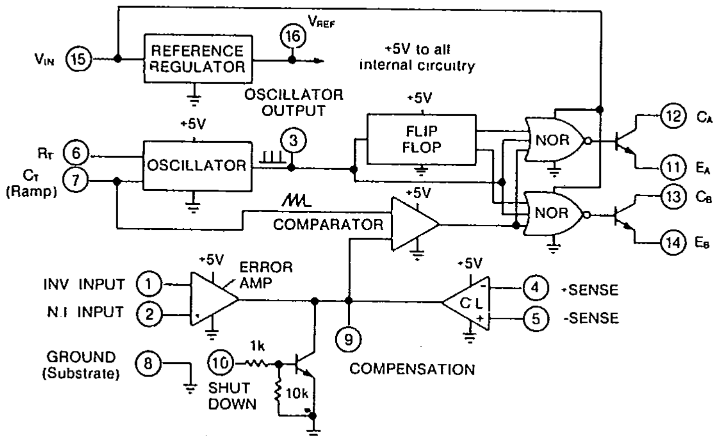
Supply Voltage, V_{CC}	8V to 40V
Reference Output Current	0 to 20mA
Current through C_T Terminal	-0.03mA to -2mA
Timing Resistor, R_T	1.8KΩ to 100KΩ
Timing Capacitor, C_T	0.001μF to 0.1μF



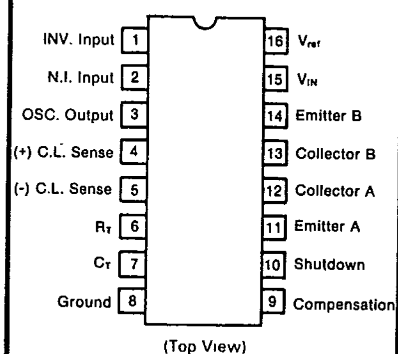
FEATURES:

- Complete PWM Control Circuit
- Single Ended or Push-Pull Outputs
- Low Standby Current (8mA Typical)
- 5V ± 4% Reference
- 1% Temperature Stability, V_{ref}
- Operation to 300 KHz
- Current Limiting

BLOCK DIAGRAM



PIN CONNECTIONS



ABSOLUTE MAXIMUM RATINGS

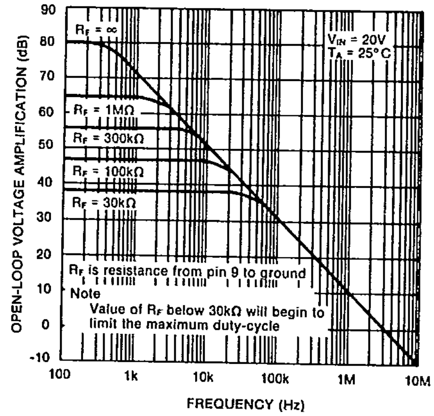
Supply Voltage, V_{CC} 40V
Collector Output Current 100mA
Reference Output Current 50mA
Current Through C_T Terminal .... -5mA
Power Dissipation at T_A = +25°C 1000mW
Derate Above 25°C .... 8mW/°C
Storage Temperature Range .... -65 to +150°C
Operating Junction Temperature .... -55 to +150°C

ELECTRICAL CHARACTERISTICS (Unless otherwise stated, these specifications apply for T_A = -55°C to +125°C for the CS1524, -25°C to +85°C for the CS2524 and 0°C to +70°C for the CS3524, V_{IN} = 20V, and f = 20kHz)

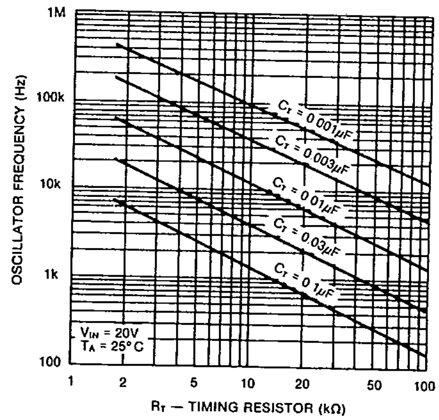
PARAMETER	TEST CONDITIONS	CS1524/CS2524			CS3524			UNITS
		MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	
Reference Section								
Output Voltage		4.8	5.0	5.2	4.6	5.0	5.4	V
Line Regulation	V_{IN} = 8 to 40V		10	20		10	30	mV
Load Regulation	I_L = 0 to 20mA		20	50		20	50	mV
Ripple Rejection	f = 120Hz, T_A = 25°C		66			66		dB
Short Circuit Current Limit	V_{REF} = 0, T_A = 25°C		100			100		mA
Temperature Stability	Over Operating Temperature Range		0.3	1		0.3	1	%
Long Term Stability	T_A = 25° C, t = 1000 Hrs.		20			20		mV
Oscillator Section								
Maximum Frequency	C_T = .001μF, R_T = 2kΩ		300			300		kHz
Intial Accuracy	R_T and C_T Constant		5			5		%
Voltage Stability	V_{IN} = 8 to 40V, T_A = 25°C			1			1	%
Temperature Stability	Over Operating Temperature Range			2			2	%
Output Amplitude	Pin 3, T_A = 25°C		3.5			3.5		V
Output Pulse Width	C_T = .01μF, T_A = 25°C		0.5			0.5		μs
Error Amplifier Section								
Input Offset Voltage	V_{CM} = 2.5V		0.5	5		2	10	mV
Input Bias Current	V_{CM} = 2.5V		2	10		2	10	μA
Open Loop Voltage Gain		72	80		60	80		dB
Common Mode Voltage	T_A = 25°C	1.8		3.4	1.8		3.4	V
Common Mode Rejection Ratio	T_A = 25°C		70			70		dB
Small Signal Bandwidth	A_V = 0dB, T_A = 25°C		3			3		MHz
Output Voltage	T_A = 25°C	0.5		3.8	0.5		3.8	V
Comparator Section								
Duty-Cycle	% Each Output On	0		45	0		45	%
Input Threshold	Zero Duty-Cycle		1			1		V
Input Threshold	Maximum Duty-Cycle		3.5			3.5		V
Input Bias Current			1			1		μA
Current Limiting Section								
Sense Voltage	Pin 9 = 2V with Error Amplifier Set for Maximum Out, T_A = 25°C	190	200	210	180	200	220	mV
Sense Voltage T.C.			0.2			0.2		mV/°C
Common Mode Voltage		-1		+1	-1		+1	V
Output Section (Each Output)								
Collector-Emitter Voltage		40			40			V
Collector Leakage Current	V_{CE} = 40V		0.1	50		0.1	50	μA
Saturation Voltage	I_C = 50mA		1	2		1	2	V
Emitter Output Voltage	V_{IN} = 20V	17	18		17	18		V
Rise Time	R_C = 2K ohm, T_A = 25°C		0.2			0.2		μs
Fall Time	R_C = 2K ohm, T_A = 25°C		0.1			0.1		μs
Total Standby Current (Excluding oscillator charging current, error and current limit dividers, and with outputs open)	V_{IN} = 40V		8	10		8	10	mA

TYPICAL CHARACTERISTICS

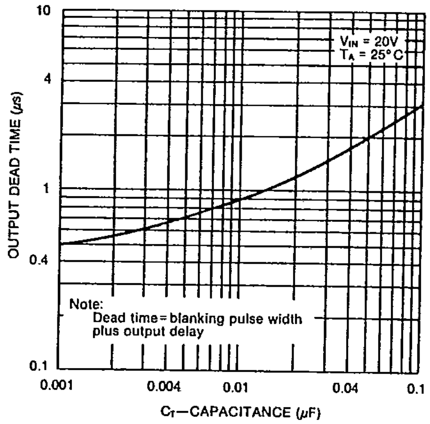
Open-Loop Voltage Amplification of Error Amplifier vs Frequency



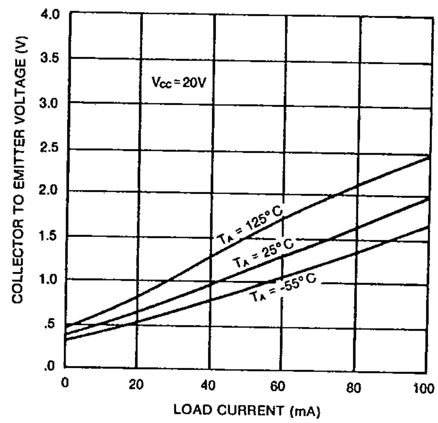
Oscillator Frequency vs Timing Components



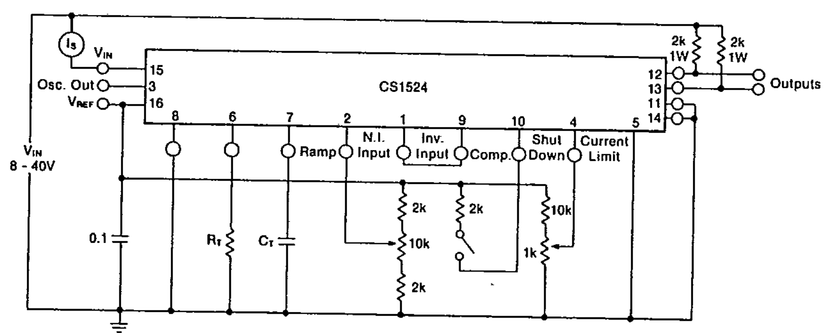
Output Dead Time vs Timing Capacitance Value



Output Saturation Voltage vs Load Current



OPEN LOOP TEST CIRCUIT



PRINCIPLES OF OPERATION

The CS1524 is a fixed-frequency pulse-width-modulation voltage regulator control circuit. The regulator operates at a frequency that is programmed by one timing resistor (R_T) and one timing capacitor (C_T). R_T establishes a constant charging current for C_T. This results in a linear voltage ramp at C_T, which is fed to the comparator providing linear control of the output pulse width by the error amplifier. The CS1524 contains an on-board 5V regulator that serves as a reference as well as powering the CS1524's internal control circuitry and is also useful in supplying external support functions. This reference voltage is lowered externally by a resistor divider to provide a reference within the common-mode range of the error amplifier or an external reference may be used. The power supply output is sensed by a second resistor divider network to generate a feedback signal to the error amplifier. The amplifier output voltage is then compared to the linear voltage ramp at C_T.

The resulting modulated pulse out of the high-gain comparator is then steered to the appropriate output pass transistor (Q_1 or Q_2) by the pulse-steering flip-flop, which is synchronously toggled by the oscillator output. The oscillator output pulse also serves as a blanking pulse to assure both outputs are never on simultaneously during the transition times. The width of the blanking pulse is controlled by the value of C_T. The outputs may be applied in a push-pull configuration in which their frequency is half that of the base oscillator, or paralleled for single-ended applications in which the frequency is equal to the oscillator. The output of the error amplifier shares a common input to the comparator with the current limiting and shutdown circuitry and can be overridden by signals from either of these inputs. This common point is also available externally and may be employed to control the gain of, or to compensate, the error amplifier, or to provide additional control to the regulator.

TYPICAL APPLICATIONS DATA

Oscillator

The oscillator controls the frequency of the CS1524 and is programmed by R_T and C_T according to the approximate formula:

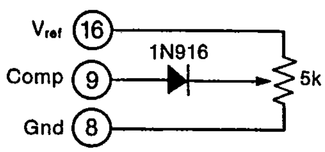
$$f \approx \frac{1.18}{R_T C_T}$$

where R_T is in kilhoms
C_T is in microfarads
f is in kilohertz

Practical values of C_T fall between 0.001 and 0.1 microfarad. Practical values of R_T fall between 1.8 and 100 kilohms. This results in a frequency range typically from 120 hertz to 500 kilohertz.

Blanking

The output pulse of the oscillator is used as a blanking pulse at the output. This pulse width is controlled by the value of C_T. If small values of C_T are required for frequency control, the oscillator output pulse width may still be increased by applying a shunt capacitance of up to 100pF from pin 3 to ground. If still greater dead-time is required, it should be accomplished by limiting the maximum duty cycle by clamping the output of the error amplifier. This can easily be done with the circuit below:



Synchronous Operation

When an external clock is desired, a clock pulse of approximately 3V can be applied directly to the oscillator output terminal. The impedance to ground at this point is approximately 2 kilohms. In this configuration R_T C_T must be selected for a clock period slightly greater than that of the external clock.

If two or more CS1524 regulators are to be operated synchronously, all oscillator output terminals should be tied together, all C_T terminals connected to a single timing capacitor, and the timing resistor connected to a single R_T terminal. The other R_T terminals can be left open or shorted V_{REF}. Minimum lead lengths should be used between the C_T terminals.

Current Limiting

The current limiting circuitry of the CS1524 is shown below. By matching the base-emitter voltages of Q1 and Q2 and assuming negligible voltage drop across R_1.

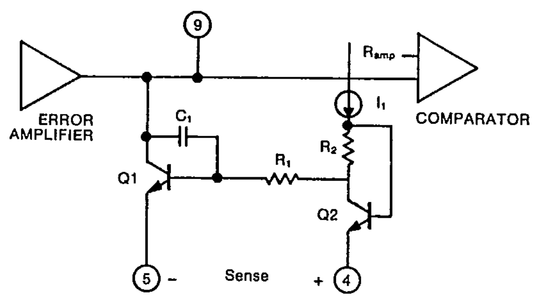
$$\text{Threshold} = V_{BE}\,(Q1) + I_1 R_2 - V_{BE}\,(Q2) = I_1 R_2$$

$$\approx 200\,\text{mV}$$

Although this circuit provides a relatively small threshold with a negligible temperature coefficient, there are some limitations to its use, the most important of which is the ±1 volt common mode range which requires sensing in the ground line. Another factor to consider is that the frequency compensation provided by $R_1 C_1$ and Q1 provides a roll-off pole at approximately 300 Hertz.

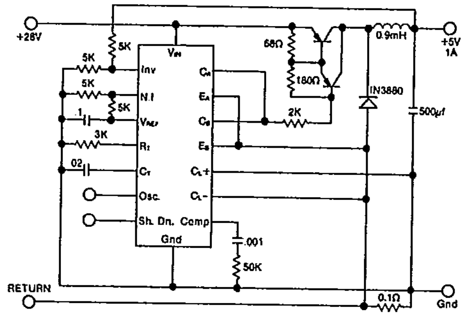
Since the gain of this circuit is relatively low, there is a transition region as the current limit amplifier takes over pulse width control from the error amplifier. For testing purposes, threshold is defined as the input voltage to get 25% duty cycle with the error amplifier signaling maximum duty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

If this current limit circuitry is unused, pins 4 and 5 should both be grounded.



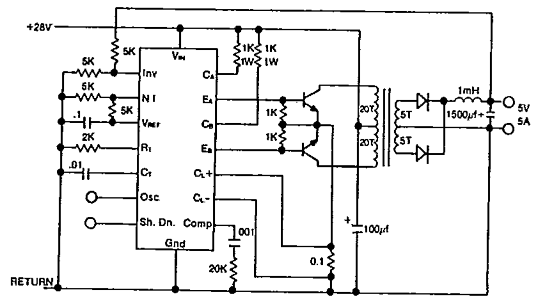
Current Limiting Circuitry of the CS1524

SINGLE-ENDED LC CIRCUIT



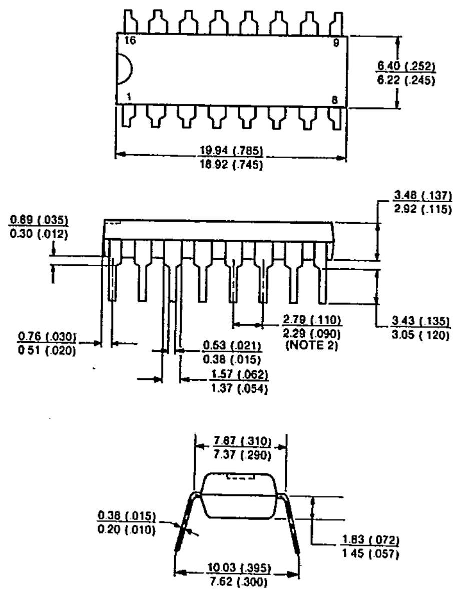
In this conventional single-ended regulator circuit, the two outputs of the CS1524 are connected in parallel for effective 0-90% duty-cycle modulation. The use of an output inductor requires an R-C phase compensation network for loop stability.

PUSH-PULL TRANSFORMER COUPLED CIRCUIT



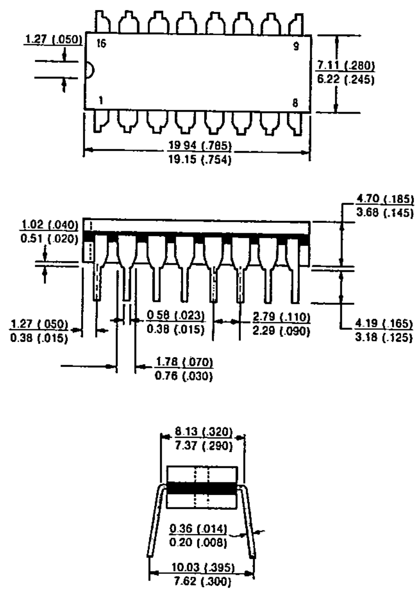
Push-pull outputs are used in this transformer-coupled DC-DC regulating converter. Note that the oscillator must be set at twice the desired output frequency as the CS1524's internal flip-flop divides the frequency by 2 as it switches the P.W.M. signal from one output to the other. Current limiting is done here in the primary so that the pulse width will be reduced should transformer saturation occur.

CS-2524, CS-3524
MECHANICAL SPECIFICATIONS: PLASTIC
16 PIN N PACKAGE



NOTES:
1. DIMENSIONS SHOWN ARE IN MILLIMETERS. THOSE IN PARENTHESES ARE IN INCHES.
2. TOLERANCES ARE NON-ACCUMULATIVE.

CS-1524, CS-2524, CS-3524
MECHANICAL SPECIFICATIONS: CERAMIC (CERDIP)
16 PIN J PACKAGE



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