

LINEAR INTEGRATED CIRCUITS

Regulating Pulse Width Modulators

UC1524
UC2524
UC3524

FEATURES

- Complete PWM Power control circuitry
- Uncommitted outputs for single-ended or push-pull applications
- Low standby current ... 80nA typical
- Interchangeable with SG1524, SG2524 and SG3524, respectively

DESCRIPTION

The UC1524, UC2524 and UC3524 incorporate on a single monolithic chip all the functions required for the construction of regulating power supplies, inverters or switching regulators. They can also be used as the control element for high power output applications. The UC1524 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 output 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 UC1524 is characterized for operation over the full military temperature range of -55°C to +125°C. The UC2524 and UC3524 are designed for operation from -25°C to +85°C and 0°C to +70°C, respectively.

ABSOLUTE MAXIMUM RATINGS (Note 1)

Supply Voltage, V_{CC} (Notes 2 and 3)	40V
Collector Output Current	100mA
Emitter Output Current	100mA
Current Through R_1	30mA
Power Dissipation at $T_A = +25^\circ\text{C}$ (Note 4)	1000mW
Power Dissipation at $T_A = +25^\circ\text{C}$ (Note 5)	1000mW
Thermal Resistance Junction to Ambient	200°C/W
Thermal Resistance Junction to Case	60°C/W
Operating Junction Temperature Range	-55°C to +150°C
Storage Temperature Range	-65°C to +150°C

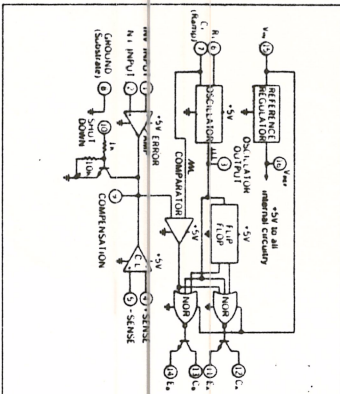
Notes:

1. Over operating free air temperature range unless otherwise noted.
2. All voltage values are with respect to the ground terminal, pin 8.
3. The reference regulator may be bypassed for operation from a maximum supply voltage of 6V in this configuration.
4. Derate at 10mW/°C for ambient temperatures above +50°C.
5. Derate at 10mW/°C for case temperatures above +25°C.

RECOMMENDED OPERATING CONDITIONS

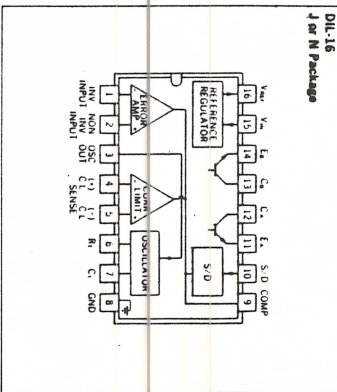
Supply Voltage, V_{CC}	0V to 40V
Reference Output Current	0 to 20mA
Current through R_1	0.03mA to 20mA
Timing Resistor, R_1	1.8kΩ to 100kΩ
Timing Capacitor, C_1	0.001μF to 0.1μF
Operating Ambient Temperature Range	-55°C to +125°C
UC1524	-25°C to +85°C
UC2524	-25°C to +85°C
UC3524	0°C to +70°C

BLOCK DIAGRAM



CONNECTION DIAGRAM

DIL-16
J or N Package



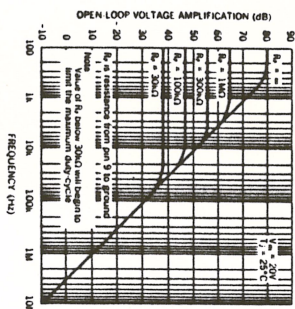
ELECTRICAL CHARACTERISTICS

(Unless otherwise stated, these specifications apply for $T_A = -55^\circ\text{C}$ to $+125^\circ\text{C}$ for the UC1524, -25°C to $+85^\circ\text{C}$ for the UC2524, and 0°C to $+70^\circ\text{C}$ for the UC3524. $V_{CC} = 20\text{V}$, and $I = 20\text{mA}$.)

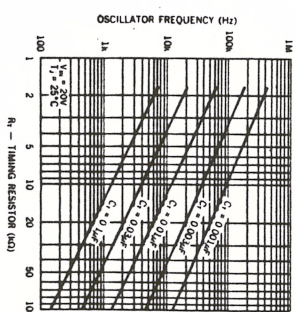
PARAMETER	TEST CONDITIONS						UC1524/UC2524		UC3524		UNITS
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.		
Reference Section											
Output Voltage		4.8	5.0	5.2	4.6	5.0	5.4				V
Line Regulation	$V_{in} = 8$ to 40V		10	20		10	30				mV
Load Regulation	$I_L = 0$ to 20mA		20	50		20	50				mV
Ripple Rejection	$f = 120\text{Hz}$, $T_A = 25^\circ\text{C}$										dB
Short Circuit Current Limit	$V_{out} = 0$, $T_A = 25^\circ\text{C}$		66			66					mA
Temperature Stability	Over Operating Temperature Range		0.3	1		0.3	1				%
Long Term Stability	$T_A = 125^\circ\text{C}$, $t = 1000$ Hrs.		20			20					mV
Oscillator Section											
Maximum Frequency	$C_1 = .001\text{mfd}$, $R_1 = 2\text{k}\Omega$		300			300					kHz
Initial Accuracy	R_1 and C_1 Constant		5			5					%
Voltage Stability	$V_{in} = 8$ to 40V, $T_A = 25^\circ\text{C}$			1			1				%
Temperature Stability	Over Operating Temperature Range			2			2				%
Output Amplitude	Pin 3, $T_A = 25^\circ\text{C}$		3.5			3.5					V
Output Pulse Width	$C_1 = 0.01\text{mfd}$, $T_A = 25^\circ\text{C}$		0.5			0.5					μs
Error Amplifier Section											
Input Offset Voltage	$V_{out} = 2.5\text{V}$		0.5	5		2	10				mV
Input Bias Current	$V_{out} = 2.5\text{V}$		2	10		2	10				μA
Open Loop Voltage Gain			72	80		60	80				dB
Common Mode Voltage	$T_A = 25^\circ\text{C}$		1.8		3.4	1.8		3.4			V
Common Mode Rejection Ratio	$T_A = 25^\circ\text{C}$			70			70				dB
Small Signal Bandwidth	$A_v = 0\text{dB}$, $T_A = 25^\circ\text{C}$		3				3				MHz
Output Voltage	$T_A = 25^\circ\text{C}$		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., $T_A = 25^\circ\text{C}$		190	200	210	180	200	220			mV
Sense Voltage T_A			0.2		+1	-1	0.2		+1		mV/°C
Common Mode Voltage			-1		+1	-1			+1		V
Output Section (Each Output)											
Collector-Emitter Voltage			40			40					V
Collector Leakage Current	$V_{CC} = 40\text{V}$		0.1	50			0.1	50			μA
Saturation Voltage	$I_L = 50\text{mA}$		1	2		1	2		2		V
Emitter Output Voltage	$V_{in} = 20\text{V}$		17	18		17	18		17		V
Rise Time	$R_C = 2\text{k}\Omega$, $T_A = 25^\circ\text{C}$		0.2			0.2			0.2		μs
Fall Time	$R_C = 2\text{k}\Omega$, $T_A = 25^\circ\text{C}$		0.1			0.1			0.1		μs
Total Standby Current	$V_{in} = 40\text{V}$		8	10		8	10		8	10	mA
(Including oscillator charging current, error and current limit dividers, and with outputs open)											

(Excluding oscillator charging current, error and current limit dividers, and with outputs open)

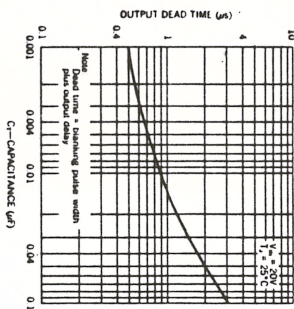
Open-Loop Voltage Amplification
vs Frequency



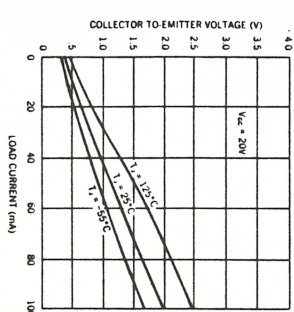
Oscillator Frequency
vs Timing Components



Output Dead Time vs
Timing Capacitance Value



Output Saturation Voltage
vs Load Current



PRINCIPLES OF OPERATION

The UC1524 is a fixed-frequency pulse-width-modulation voltage regulator control circuit. The regulator operates at a frequency determined by one timing resistor (R_1) and one timing capacitor (C_1). R_1 establishes a constant charging current for C_1 . This results in a linear voltage ramp at C_1 , which is fed to the comparator amplifier. The UC1524 contains an on-board 5V regulator that serves as a reference as well as powering the UC1524'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_1 . The resulting modulated pulse out of the high-gain comparator is

TYPICAL APPLICATIONS DATA

Oscillator
The oscillator controls the frequency of the UC1524 and is programmed by R_1 and C_1 according to the approximate formula:

$$f = \frac{1.18}{R_1 C_1}$$

where R_1 is in kilohms
 C_1 is in microfarads
 f is in kilohertz

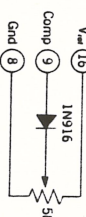
Practical values of C_1 fall between 0.001 and 0.1 microfarad. Practical values of R_1 fall between 1.8 and 100 kilohms. This results in a frequency range typically from 120 hertz to 500 kilohertz.

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_1 . If small values of C_1 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 a greater dead time is required, it should be accomplished by limiting the maximum duty

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 transition times. The width of the blanking pulse is controlled by the value of C_1 . The output may be applied in a push-pull configuration or in a single-ended application in which the base frequency is equal to half that of the oscillator. The output of the error amplifier shares a common circuit to the comparator with the current limiting and shutdown circuit. 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.

Cycle by clamping the output of the error amplifier. This can easily be done with the circuit below:

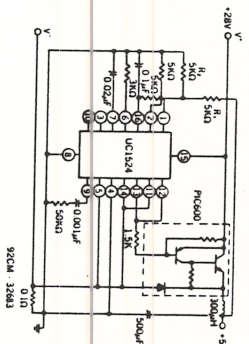


Synchronous Operation

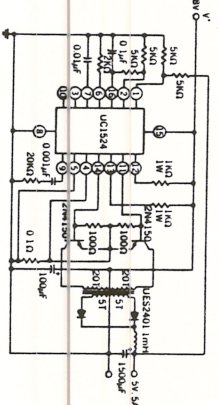
When an external clock is desired, a clock pulse of approximately 3V can be applied directly to the oscillator output terminal. The impedance to ground at this point is approximately 2 kilohms. In this configuration R_1 and C_1 must be selected for a clock period slightly greater than that of the external clock.

If two or more UC1524 regulators are to be operated synchronously, all oscillator output terminals should be tied together, all C_1 terminals connected to a single R_1 terminal, the other R_1 terminals can be left open or shorted to V_{cc} . Minimum lead lengths should be used between the C_1 terminals.

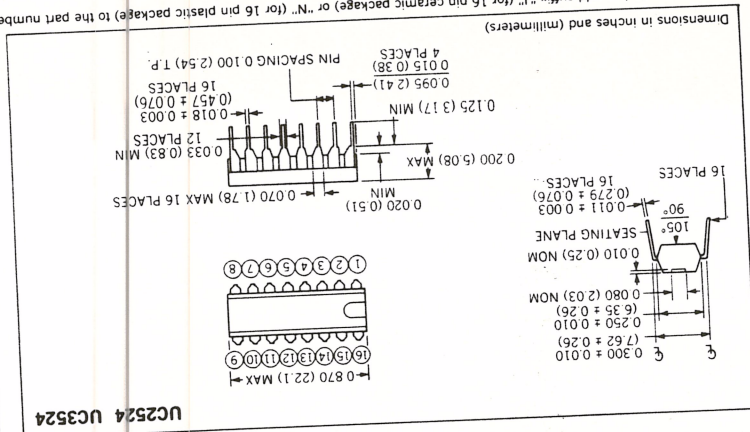
Single-Ended LC Switching Regulator Circuit



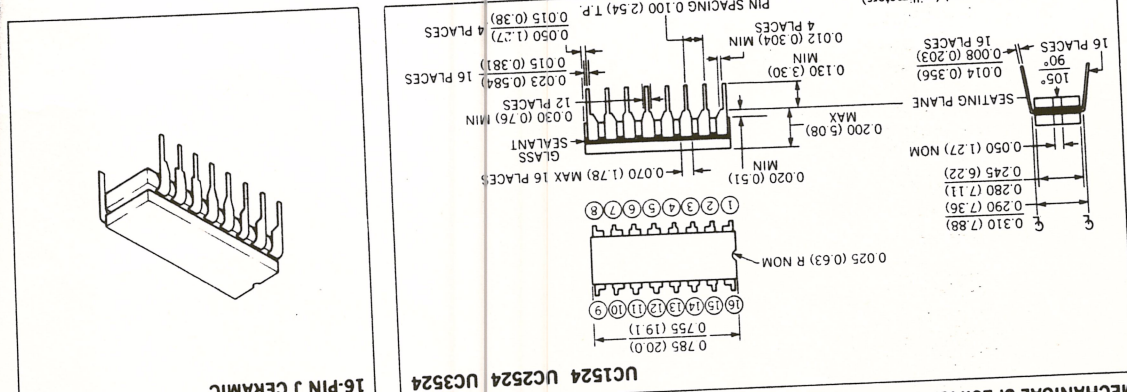
Push-Pull Transformer-Coupled Circuit



Note: When ordering, add suffix "J" (for 16 pin ceramic package) or "N" (for 16 pin plastic package) to the part number.

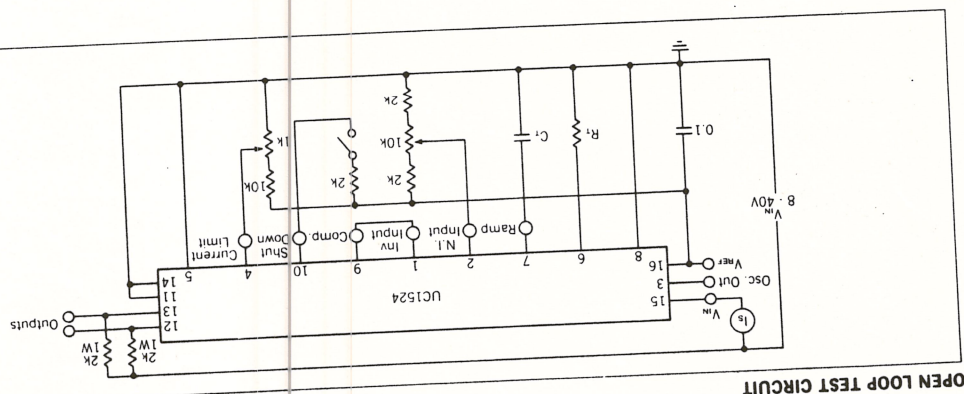


16-PIN N PLASTIC



16-PIN J CERAMIC

MECHANICAL SPECIFICATIONS



OPEN LOOP TEST CIRCUIT

UC1524 UC2524 UC3524