

# Advanced Regulating Pulse Width Modulators

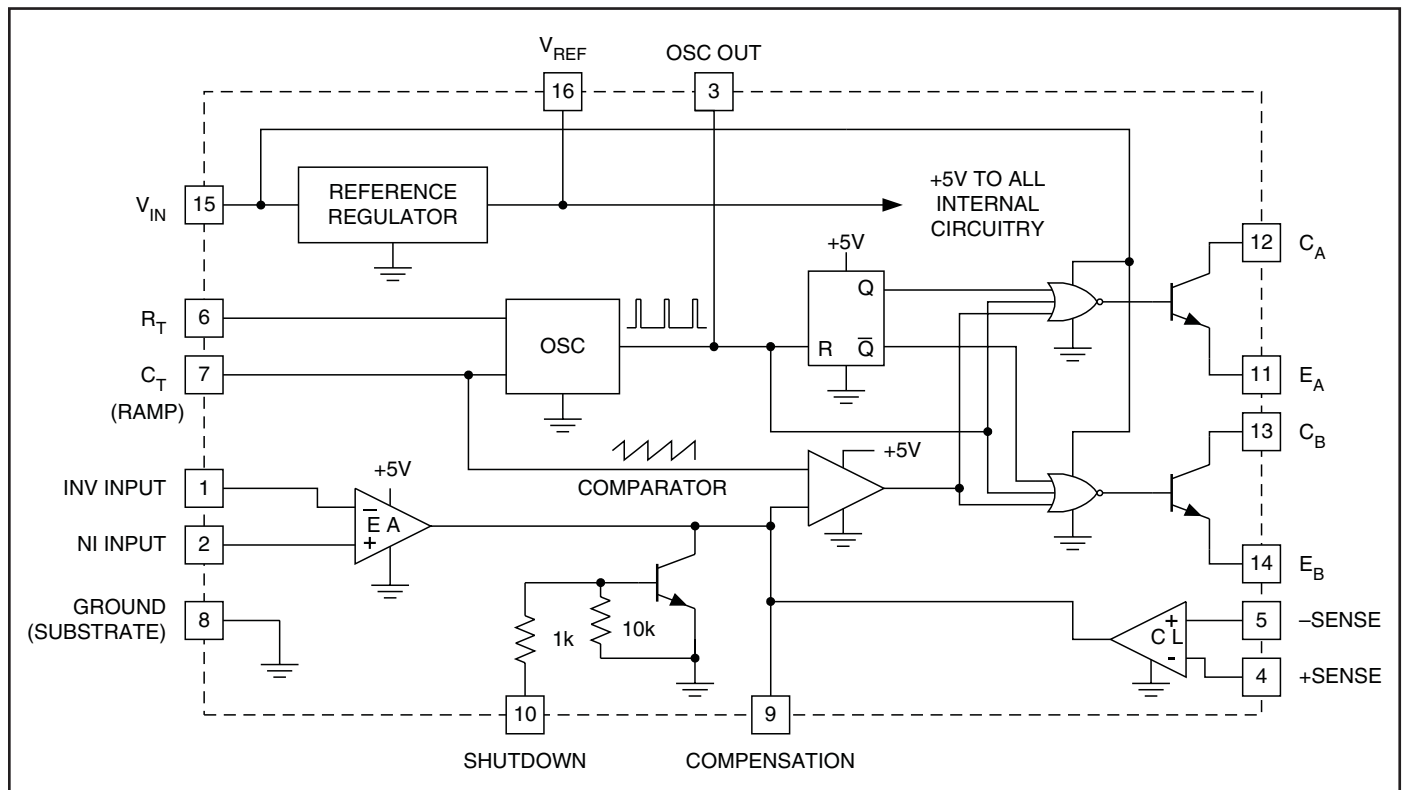
## FEATURES

- Complete PWM Power Control Circuitry
- Uncommitted Outputs for Single-ended or Push-pull Applications
- Low Standby Current...8mA 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 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 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° to +70°C, respectively.

## BLOCK DIAGRAM



## ABSOLUTE MAXIMUM RATINGS (Note 1)

Supply Voltage,  $V_{CC}$  (Notes 2 and 3) . . . . . 40V  
Collector Output Current . . . . . 100mA  
Reference Output Current . . . . . 50mA  
Current Through  $C_T$  Terminal . . . . . -5mA  
Power Dissipation at  $T_A = +25^\circ\text{C}$  (Note 4) . . . . . 1000mW  
Power Dissipation at  $T_C = +25^\circ\text{C}$  (Note 4) . . . . . 2000mW  
Operating Junction Temperature Range . . . . -55°C to +150°C  
Storage Temperature Range . . . . . -65°C to +150°C

Note 1: Over operating free-air temperature range unless otherwise noted.

Note 2: All voltage values are with respect to the ground terminal, pin 8.

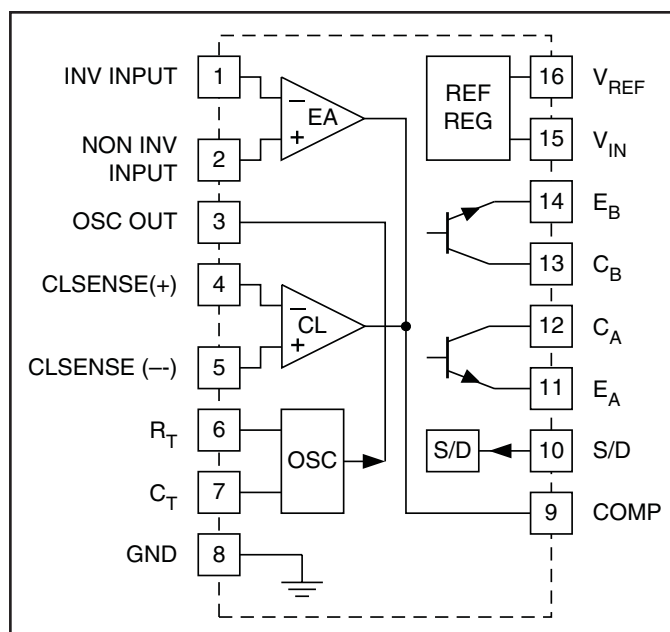
Note 3: The reference regulator may be bypassed for operation from a fixed 5V supply by connecting the  $V_{CC}$  and reference output pins both to the supply voltage. In this configuration the maximum supply voltage is 6V.

Note 4: Consult packaging section of databook for thermal limitations and considerations of package.

## 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,  $R_T$  . . . . . 1.8k $\Omega$  to 100k $\Omega$   
Timing Capacitor,  $C_T$  . . . . . 0.001 $\mu\text{F}$  to 0.1 $\mu\text{F}$   
Operating Ambient Temperature Range  
UC1524 . . . . . -55°C to +125°C  
UC2524 . . . . . -25°C to +85°C  
UC3524 . . . . . 0°C to +70°C

## CONNECTION DIAGRAM



**ELECTRICAL CHARACTERISTICS:** Unless otherwise stated, these specifications apply for  $T_A = -55^\circ\text{C}$  to  $+125^\circ\text{C}$  for the UC1524,  $-25^\circ\text{C}$  to  $+85^\circ\text{C}$  for the UC2524, and  $0^\circ\text{C}$  to  $+70^\circ\text{C}$  for the UC3524,  $V_{IN} = 20\text{V}$ , and  $f = 20\text{kHz}$ ,  $T_A = T_J$ .

| PARAMETER                   | TEST CONDITIONS                                   | UC1524/UC2524 |     |     | UC3524 |     |     | UNITS |
|-----------------------------|---------------------------------------------------|---------------|-----|-----|--------|-----|-----|-------|
|                             |                                                   | MIN           |     | MAX | MIN    |     | MAX |       |
| Reference Section           |                                                   |               |     |     |        |     |     |       |
| Output Voltage              |                                                   | 4.8           | 5.0 | 5.2 | 4.6    | 5.0 | 5.4 | V     |
| Line Regulation             | V <sub>IN</sub> = 8 to 40V                        |               | 10  | 20  |        | 10  | 30  | mV    |
| Load Regulation             | I <sub>L</sub> = 0 to 20mA                        |               | 20  | 50  |        | 20  | 50  | mV    |
| Ripple Rejection            | f = 120Hz, T <sub>J</sub> = 25°C                  |               | 66  |     |        | 66  |     | dB    |
| Short Circuit Current Limit | V <sub>REF</sub> = 0, T <sub>J</sub> = 25°C       |               | 100 |     |        | 100 |     | mA    |
| Temperature Stability       | Over Operating Temperature Range                  |               | 0.3 | 1   |        | 0.3 | 1   | %     |
| Long Term Stability         | T <sub>J</sub> = 125°C, t = 1000 Hrs.             |               | 20  |     |        | 20  |     | mV    |
| Oscillator Section          |                                                   |               |     |     |        |     |     |       |
| Maximum Frequency           | C <sub>T</sub> = .001mfd, R <sub>T</sub> = 2kΩ    |               | 300 |     |        | 300 |     | kHz   |
| Initial Accuracy            | R <sub>T</sub> and C <sub>T</sub> Constant        |               | 5   |     |        | 5   |     | %     |
| Voltage Stability           | V <sub>IN</sub> = 8 to 40V, T <sub>J</sub> = 25°C |               |     | 1   |        |     | 1   | %     |
| Temperature Stability       | Over Operating Temperature Range                  |               |     | 5   |        |     | 5   | %     |
| Output Amplitude            | Pin 3, T <sub>J</sub> = 25°C                      |               | 3.5 |     |        | 3.5 |     | V     |
| Output Pulse Width          | C <sub>T</sub> = .01mfd, T <sub>J</sub> = 25°C    |               | 0.5 |     |        | 0.5 |     | μs    |
| Error Amplifier Section     |                                                   |               |     |     |        |     |     |       |
| Input Offset Voltage        | V <sub>CM</sub> = 2.5V                            |               | 0.5 | 5   |        | 2   | 10  | mV    |
| Input Bias Current          | V <sub>CM</sub> = 2.5V                            |               | 2   | 10  |        | 2   | 10  | μA    |
| Open Loop Voltage Gain      |                                                   | 72            | 80  |     | 60     | 80  |     | dB    |
| Common Mode Voltage         | T <sub>J</sub> = 25°C                             | 1.8           |     | 3.4 | 1.8    |     | 3.4 | V     |

**ELECTRICAL CHARACTERISTICS:** Unless otherwise stated, these specifications apply for  $T_A = -55^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$  for the UC1524,  $-25^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$  for the UC2524, and  $0^{\circ}\text{C}$  to  $+70^{\circ}\text{C}$  for the UC3524,  $V_{IN} = 20\text{V}$ , and  $f = 20\text{kHz}$ ,  $T_A = T_J$ .

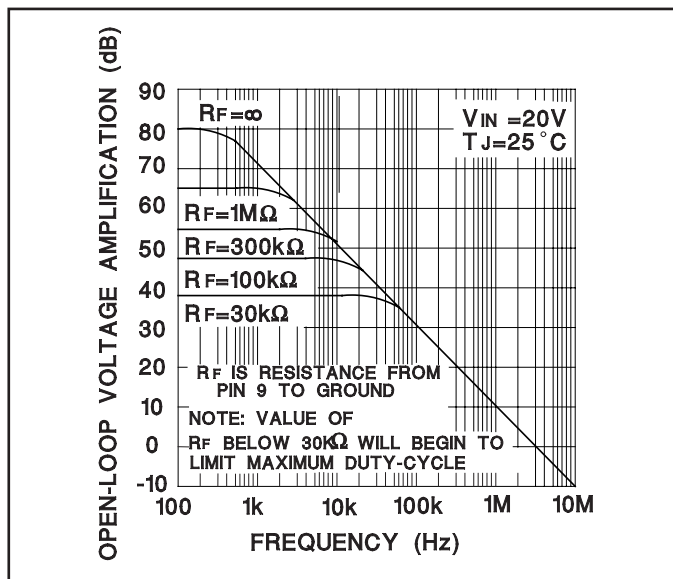
| PARAMETER                       | TEST CONDITIONS                                                            | UC1524/UC2524 |     |     | UC3524 |     |     | UNITS |
|---------------------------------|----------------------------------------------------------------------------|---------------|-----|-----|--------|-----|-----|-------|
|                                 |                                                                            | MIN           |     | MAX | MIN    |     | MAX |       |
| Error Amplifier Section (cont.) |                                                                            |               |     |     |        |     |     |       |
| Common Mode Rejection Ratio     | T <sub>J</sub> = 25°C                                                      |               | 70  |     |        | 70  |     | dB    |
| Small Signal Bandwidth          | A <sub>v</sub> = 0dB, T <sub>J</sub> = 25°C                                |               | 3   |     |        | 3   |     | MHz   |
| Output Voltage                  | T <sub>J</sub> = 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     |
|                                 | 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 <sub>J</sub> = 25°C | 190           | 200 | 210 | 180    | 200 | 220 | mV    |
| Sense Voltage T.C.              |                                                                            |               | 0.2 |     |        | 0.2 |     | mV/°C |
| Common Mode Voltage             | T <sub>J</sub> = -55°C to 85°C for the -1V to 1V Limit                     | -1            |     | +1  | -1     |     | +1  | V     |
|                                 | T <sub>J</sub> = 125°C                                                     | -0.3          |     | +1  |        |     |     | V     |
| Output Section (Each Output)    |                                                                            |               |     |     |        |     |     |       |
| Collector-Emitter Voltage       |                                                                            | 40            |     |     | 40     |     |     | V     |
| Collector Leakage Current       | V <sub>CE</sub> = 40V                                                      |               | 0.1 | 50  |        | 0.1 | 50  | μA    |
| Saturation Voltage              | I <sub>C</sub> = 50mA                                                      |               | 1   | 2   |        | 1   | 2   | V     |
| Emitter Output Voltage          | V <sub>IN</sub> = 20V                                                      | 17            | 18  |     | 17     | 18  |     | V     |
| Rise Time                       | R <sub>C</sub> = 2kΩ, T <sub>J</sub> = 25°C                                |               | 0.2 |     |        | 0.2 |     | μs    |
| Fall Time                       | R <sub>C</sub> = 2kΩ, T <sub>J</sub> = 25°C                                |               | 0.1 |     |        | 0.1 |     | μs    |
| Total Standby Current (Note)    | V <sub>IN</sub> = 40V                                                      |               | 8   | 10  |        | 8   | 10  | mA    |

## PRINCIPLES OF OPERATION

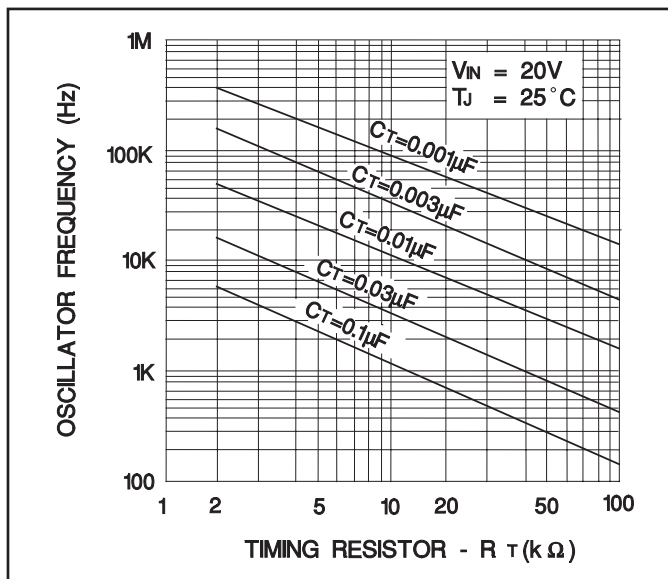
The UC1524 is a fixed-frequency pulse-width-modulation voltage regulator control circuit. The regulator operates at a frequency that is programmed by one timing resistor ( $R_T$ ), and one timing capacitor ( $C_T$ ).  $R_T$  establishes a constant charging current for  $C_T$ . This results in a linear voltage ramp at  $C_T$ , which is fed to the comparator providing linear control of the output pulse width by the error amplifier. The 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  $C_T$ . 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 that of 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.

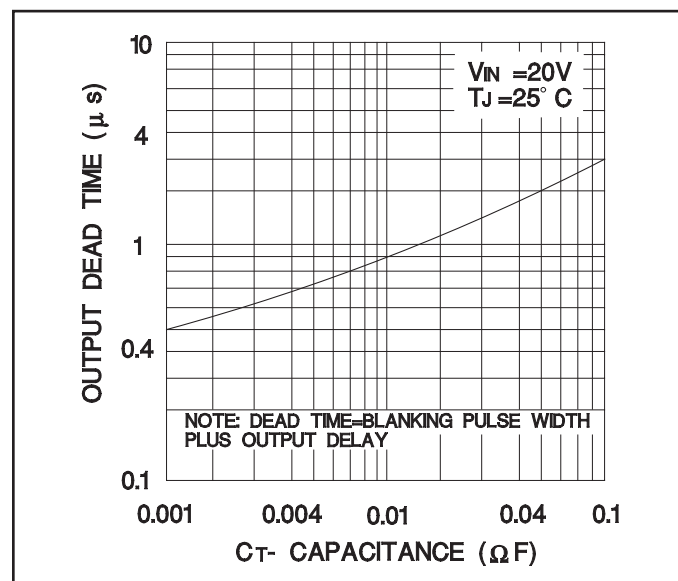
## TYPICAL CHARACTERISTICS



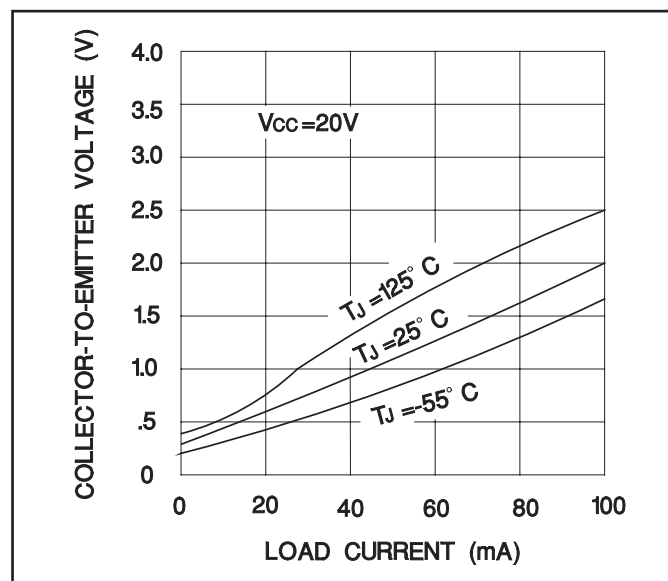
Open-loop voltage amplification of error amplifier vs frequency.



Oscillator frequency vs timing components.



Output dead time vs timing capacitance value.



Output saturation voltage vs load current.



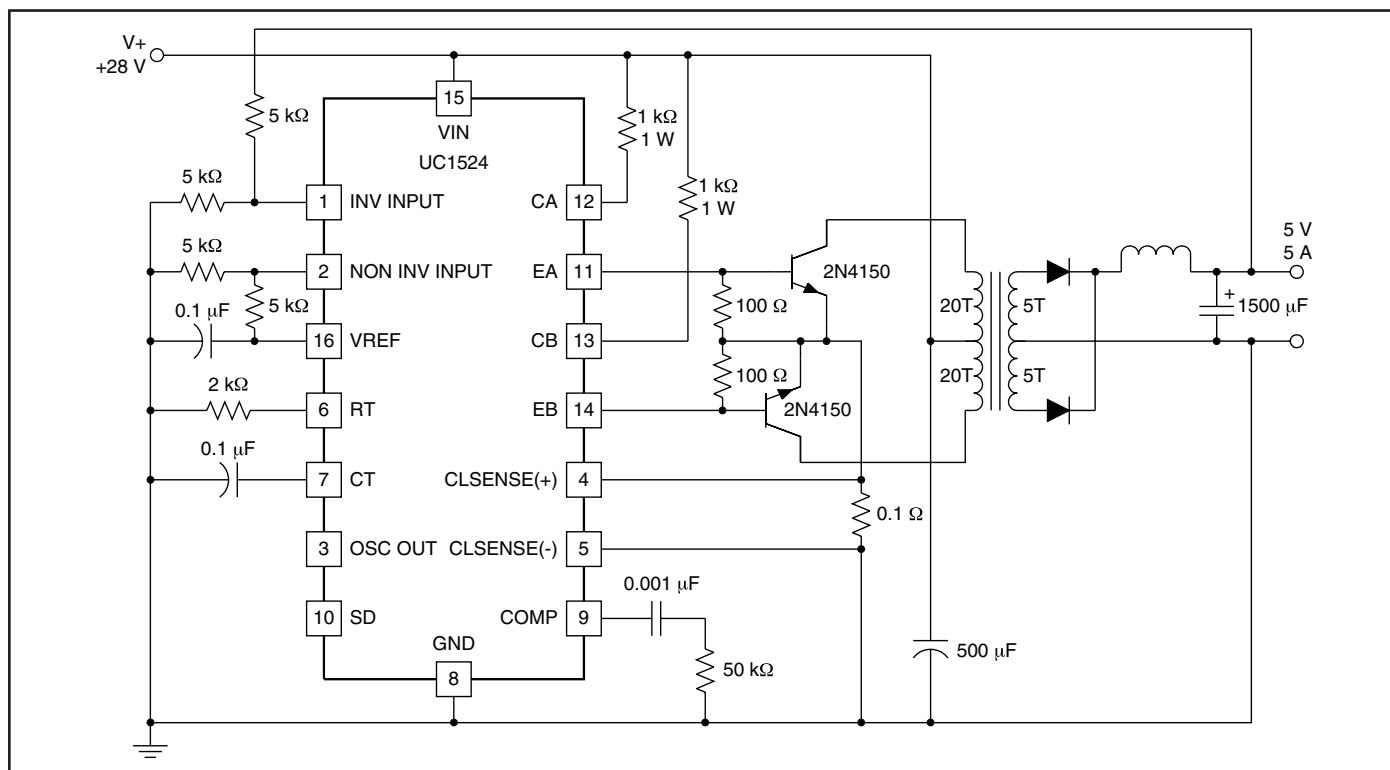


Figure 3. Push-pull transformer coupled circuit.

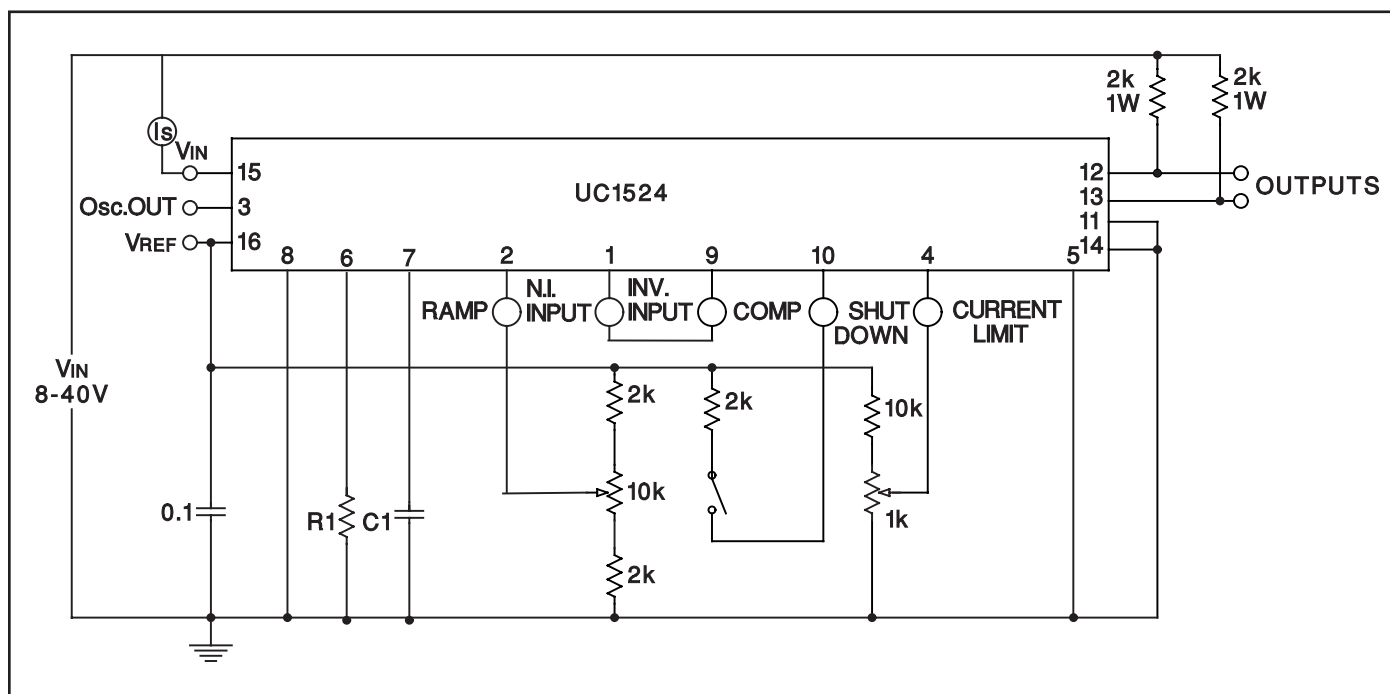


Figure 4. Open loop test circuit.

**PACKAGING INFORMATION**

| Orderable Device | Status <sup>(1)</sup> | Package Type | Package Drawing | Pins | Package Qty | Eco Plan <sup>(2)</sup> | Lead/Ball Finish | MSL Peak Temp <sup>(3)</sup> |
|------------------|-----------------------|--------------|-----------------|------|-------------|-------------------------|------------------|------------------------------|
| UC1524J          | OBSOLETE              | CDIP         | J               | 16   |             | None                    | Call TI          | Call TI                      |
| UC1524J/80937    | OBSOLETE              | CDIP         | J               | 16   |             | None                    | Call TI          | Call TI                      |
| UC1524J883B      | OBSOLETE              | CDIP         | J               | 16   |             | None                    | Call TI          | Call TI                      |
| UC2524DW         | ACTIVE                | SOIC         | DW              | 16   | 40          | None                    | CU NIPDAU        | Level-2-220C-1 YEAR          |
| UC2524DWTR       | ACTIVE                | SOIC         | DW              | 16   | 2000        | None                    | CU NIPDAU        | Level-2-220C-1 YEAR          |
| UC2524J          | OBSOLETE              | CDIP         | J               | 16   |             | None                    | Call TI          | Call TI                      |
| UC2524N          | ACTIVE                | PDIP         | N               | 16   | 25          | None                    | CU SNPB          | Level-NA-NA-NA               |
| UC3524D          | ACTIVE                | SOIC         | D               | 16   | 40          | None                    | CU NIPDAU        | Level-1-220C-UNLIM           |
| UC3524DTR        | ACTIVE                | SOIC         | D               | 16   | 2500        | None                    | CU NIPDAU        | Level-1-220C-UNLIM           |
| UC3524DW         | ACTIVE                | SOIC         | DW              | 16   | 40          | None                    | CU NIPDAU        | Level-2-220C-1 YEAR          |
| UC3524DWTR       | ACTIVE                | SOIC         | DW              | 16   | 2000        | None                    | CU NIPDAU        | Level-2-220C-1 YEAR          |
| UC3524J          | OBSOLETE              | CDIP         | J               | 16   |             | None                    | Call TI          | Call TI                      |
| UC3524N          | ACTIVE                | PDIP         | N               | 16   | 25          | None                    | CU SNPB          | Level-NA-NA-NA               |

<sup>(1)</sup> The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSOLETE:** TI has discontinued the production of the device.

<sup>(2)</sup> Eco Plan - May not be currently available - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**None:** Not yet available Lead (Pb-Free).

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<sup>(3)</sup> MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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